DEPARTMENT OF CITY PLANNING
APPEAL RECOMMENDATION REPORT

City Planning Commission
Date: October 9, 2025
Time: After 8:30 AM
Place: Los Angeles City Hall
Council Chambers, 3rd Floor

And via Teleconference. Information will be provided no later than 72 hours before the meeting on the meeting agenda published at https://planning.lacity.org/about/commissionsboards-hearings and/or by contacting cpc@lacity.org

Public Hearing: Required
Appeal Status: Not further appealable

Expiration Date: N/A
Multiple Approval: No

Case No.: ZA-2025-2976-ZAI-1A
CEQA No.: ENV-2025-3305-CE
Related Case: ZA-2025-2976-ZAI
Council No.: Citywide
Plan Area: Citywide
Certified NC: Citywide
GPLU: N/A
Zone: Citywide

Applicant: City of Los Angeles

Appellants: i) Ty Thompson, Warren Resources Inc. on behalf of Warren E&P, Inc; Warren Resources of California, Inc.; Warren Resources, Inc. and

ii) Matthew Wickersham, Alston & Bird LLP on behalf of E&B Natural Resources Management Corporation, Hillcrest Beverly Oil Corporation, E&B ENR I, LLC, and Elysium Natural Resources, LLC

LOCATION: Citywide

ZAI SUMMARY: A Zoning Administrator's Interpretation (ZAI) applicable to oil/gas well operations in the City of Los Angeles, issued by the Chief Zoning Administrator on June 12, 2025, interpreting the meaning of "well maintenance" in the Los Angeles Municipal Code (LAMC), as activities triggering a "Rework Permit" from the California Geologic Energy Management Division and/or notification per South Coast Air Quality Management District Rule 1148.2 for "Well Rework" and/or "Injection" including one or more of the following activities: acidizing, hydraulic fracturing, gravel packing, maintenance acidizing, matrix acidizing, and acid fracturing.

APPEALS: Appeals of the June 12, 2025 ZAI that:

1. Determined the issuance of the ZAI that defines "well maintenance" is not a "Project" as that term is defined by the California Environmental Quality Act (CEQA) Guidelines, Section 15378;

2. Determined, even assuming that the ZAI is considered a Project, based on the whole of the administrative record, the Project is exempt from CEQA pursuant to CEQA Guidelines, Section 15061(b)(3) (Common Sense Exemption) and Article 19, Section 15308, Class 8 (Actions by Regulatory Agencies for Protection of the Environment), and that there is no substantial evidence demonstrating that any exceptions contained in Section 15300.2 of the State CEQA Guidelines regarding location, cumulative impacts, significant effects or unusual circumstances, scenic highways, or hazardous waste sites, or historical resources applies; and

3. Issued, pursuant to Chapter 1A Section 13A.1.7.D.2. of the LAMC, a ZAI of "well maintenance" relating to oil/gas well operations in the City of Los Angeles.

RECOMMENDED ACTIONS:

1. **Determine** that the issuance of the ZAI that defines "well maintenance" is not a "Project" as that term is defined by the CEQA Guidelines, Section 15378;

2. **Determine** that, even assuming that the ZAI is considered a Project, based on the whole of the administrative record, the Project is exempt from CEQA pursuant to CEQA Guidelines, Section 15061(b)(3)(Common Sense Exemption) and Article 19, Section 15308, Class 8 (Actions by Regulatory Agencies for Protection of the Environment), and that there is no substantial evidence demonstrating that any exceptions contained in Section 15300.2 of the State CEQA Guidelines regarding location, cumulative impacts, significant effects or unusual circumstances, scenic highways, or hazardous waste sites, or historical resources applies; and

3. **Deny** the appeal of Case No. ZA-2025-2976-ZAI and **sustain** the June 12, 2025, ZAI of "well maintenance".

Estineh Mailian
Chief Zoning Administrator

ADVICE TO PUBLIC: *The exact time this report will be considered during the meeting is uncertain since there may be several other items on the agenda. Written communications may be mailed to the *Commission Secretariat, Room 532, City Hall, 200 North Spring Street, Los Angeles, CA 90012* (Phone No. 213-978-1300). While all written communications are given to the Commission for consideration, the initial packets are sent to the week prior to the Commission's meeting date. If you challenge these agenda items in court, you may be limited to raising only those issues you or someone else raised at the public hearing agendized herein, or in written correspondence on these matters delivered to this agency at or prior to the public hearing. As a covered

entity under Title II of the Americans with Disabilities Act, the City of Los Angeles does not discriminate on the basis of disability, and upon request, will provide reasonable accommodation to ensure equal access to these programs, services and activities. Sign language interpreters, assistive listening devices, or other auxiliary aids and/or other services may be provided upon request. To ensure availability of services, please make your request not later than three working days (72 hours) prior to the meeting by calling the Commission Secretariat at (213) 978-1299.

TABLE OF CONTENTS

ZAI Background **Page 1**

Appeal Analysis **Page 16**

Conclusion and Recommendation **Page 46**

Exhibits

Exhibit A: Warren Resources appeal justification (link)
Exhibit B: E&B Natural Resources appeal justification (link)
Exhibit C: Zoning Administrators Interpretation (Case No. ZA-2025-2976-ZAI) (link)
Exhibit D: Rescission of Case No. ZA-2022-8997-ZAI-1A and ZA Memorandum No. 141 (link)
Exhibit E: Modified ZAI: ZA-2022-8997-ZAI-1A (link)
Exhibit F: Rescission of Oil and Gas Drilling Ordinance (Ordinance No. 188,623) (link)
Exhibit G: ZA Memorandum No. 141 (link)
Exhibit H: ZA Memorandum No. 133 (link)
Exhibit I: Oil and Gas Drilling Ordinance (adopted in 2022 and rescinded in 2025; included here for historical context only) (link)
Exhibit J: 1955 Los Angeles Municipal Code - Chapter 13.01 (link)
Exhibit K: Oil Well Decision reference, ZA-1985-0103-O determination (link)
Exhibit L: Oil Well Decision reference, ZA 18129(PA2) determination (link)
Exhibit M: Oil Well Decision reference, ZA 18614(PA3) determination (link)
Exhibit N: California Independent Petroleum Association - Routine Rig Work (link)
Exhibit O: June 2024 Public Health Dimensions of Upstream Oil and Gas Development in California: Scientific Analysis and Synthesis to Inform Science-Policy Decision Making (link)
Exhibit P: 2017 PSE Study on Oil Well Activities (link)
Exhibit Q: CEQA Operator Notices from 2019 (link) and 2023 (link)
Exhibit R: L.A. City Planning emails with Operators on CalGEM Permits [link 1, link 2, link 3]
Exhibit S: Correspondence on Well Maintenance & Land Use Impacts (link)
Exhibit T: Correspondence to Operator Concerning Maintenance Acidizing (link)
Exhibit U: Well Maintenance project & “Odor Event” reference document (link)
Exhibit V: Jefferson Drill Site and Maintenance Acidizing Activities from 2014 (link)
Exhibit W: STAND-LA Letter of Correspondence Regarding Maintenance Acidizing for CF 24-1580 (link)
Exhibit X: E&B Natural Resources Letter of Correspondence for CF 24-1580 (link)

BACKGROUND FOR THE ZONING ADMINISTRATOR INTERPRETATION OF WELL MAINTENANCE

SUMMARY

Before the City Planning Commission is the consideration of two appeals of Case No. ZA-2025-2976-ZAI, a citywide Zoning Administrator's Interpretation (ZAI) applicable to oil and gas well operations in the City of Los Angeles (City). The ZAI, issued by the Chief Zoning Administrator on June 12, 2025, interprets the meaning of "well maintenance" in the Los Angeles Municipal Code (LAMC) as activities triggering a "Rework Permit" from the California Geologic Energy Management Division (CalGEM) and/or notification per South Coast Air Quality Management District (SCAQMD) Rule 1148.2 for "Well Rework" and/or "Injection" including one or more of the following activities: acidizing, hydraulic fracturing, gravel packing, maintenance acidizing, matrix acidizing, and acid fracturing. It is substantively similar to a previous ZAI (Case No. ZA-2022-8997-ZAI-1A), interpreting "well maintenance", approved on appeal by the City Planning Commission on October 4, 2023, and rescinded on May 29, 2025.

In addition to responding to the appeal points raised, this report provides background and context on the need to define well maintenance in the Zoning Code, the process the Chief Zoning Administrator took to reach her interpretation, and the ZAI's relationship to other separate, but related policy matters concerning oil and gas well operations in the City.

BACKGROUND

Regulatory History & New State Legislation

The terms "maintain" and "maintained" as they pertain to the citywide regulation of oil wells have appeared in different versions of the LAMC since at least 1955.[1] LAMC Section 13.01 has applied to well maintenance since at least April 1955. LAMC Section 12.23 C.4 formerly placed limitations on oil wells being "maintained", but this language has since been eliminated from the Zoning Code following the City Council's action to rescind the citywide Oil and Gas Drilling Ordinance No. 187,709 (Oil Ordinance No. 187,709) (adopted in 2022, Council File No. 17-0447-S2).

Below is a brief chronology referencing key regulations and documents relevant to the discussion of this ZAI appeal:

[1] Los Angeles Municipal Code, July 8, 1955, Chapter 1 General Provisions and Zoning, Pages 115-116. <https://drive.google.com/file/d/1EdO-rbshz0zGLjjqo178CQ2K3h3V-sX-/view?usp=sharing>

Dates	Regulation / Document	Exhibit	Description
Apr 8, 1955 - Jan 17, 2023	LAMC Section 13.01 (Oil "O" Drilling Supplemental Use District)	J	The primary Zoning Code provisions regulating oil/gas uses within the City were first established in 1946 and remained in effect until the adoption of the Oil Ordinance No. 187,709 . LAMC Sections 13.01 H and I both mentioned well maintenance since at least April 1955. Of note, Section 13.01 H required operators to file an application with the Los Angeles Department of City Planning (LACP) if they were proposing "to drill, deepen, or maintain" an oil well, requesting "a determination of the conditions under which the operations may be conducted."
Sep 19, 2016 - Jan 17, 2023 & May 29, 2025 - Present	ZA Memo 133	H	Outlines the procedure for the acceptance and processing of discretionary requests pursuant to LAMC Sections 13.01 H and I. From January 2023 to May 2025, ZA Memo 133 was replaced with ZA Memo 141 (discussed below) and, for that period, was no longer applicable, to the extent that LAMC Sections 13.01 H and I were removed from the Zoning Code by way of Oil Ordinance No. 187,709. Upon the rescission of Oil Ordinance No. 187,709 and ZA Memo 141, LAMC Sections 13.01 H and I and its previous references to well maintenance were reinstated. Since then, and to date, ZA Memo 133 is once again the governing document outlining procedures for discretionary well maintenance requests.
Dec 2, 2022 - Jul 16, 2025	Oil and Gas Drilling Ordinance No. 187,709	I	Adopted on December 2, 2022, and effective on January 18, 2023, amending several Zoning Code provisions that regulate oil/gas wells. Most notably, it amended LAMC Section 13.01 and removed LAMC Sections 13.01 H and I, which authorized the Zoning Administrator to review and conditionally approve drilling, deepening, and well maintenance projects. Oil Ordinance No. 187,709 also amended LAMC Section 12.23 C.4 to deem all existing oil/gas wells a legally nonconforming use. Furthermore, it stated that "No existing well for the production of oil, gas or other hydrocarbon substances, which is a nonconforming use, shall be maintained, drilled, re-drilled or deepened, except to prevent or respond to a threat to the public health, safety, or the environment, as determined by the Zoning Administrator". Oil Ordinance No. 187,709 was rescinded on July 16, 2025.
Jan 17, 2023 - May 29, 2025	ZA Memo 141	G	In conjunction with the adoption of Oil Ordinance No. 187,709, ZA Memo 141 established a comprehensive set of procedures and policies for the acceptance and processing of applications for discretionary requests pursuant to LAMC Section 12.23 C.4, at existing non-conforming sites, where work is proposed to either prevent or respond to a threat to public health, safety, or the environment. ZA Memo 141 was rescinded on May 29, 2025.
May 29, 2025	Rescission of Case No. ZA-2022-8997-ZAI-1A	D	In anticipation of the July 16, 2025, rescission of Oil Ordinance No. 187,709, the Chief Zoning Administrator issued a rescission

	and ZA Memo 141		of ZA Memo 141 and Case No. ZA-2022-8997-ZAI-1A on May 29, 2025.
Jun 12, 2025 - Present	Case Nos. ZA-2025-2976-ZAI and ZA-2025-2976-ZAI-1A (2025 Well Maintenance ZAI)	C	The 2025 ZAI interpreting the meaning of "well maintenance" in the LAMC as it relates to oil/gas well operations citywide. This subject ZAI is substantively similar to the aforementioned 2023 well maintenance ZAI. The subject appeal contains similar appeal points to those rejected by the City Planning Commission in 2023.
July 16, 2025	Rescission of Oil and Gas Drilling Ordinance (Ordinance No. 188,623)	F	On July 16, 2025, Ordinance No. 188,623 became effective, rescinding the Oil and Gas Drilling Ordinance (No. 187,709). Rescission of Oil Ordinance No. 187,709 meant that the former language in Sections 12.03, 12.10, 12.23, 12.24, and 13.01 of Chapter 1 of the LAMC, as they existed prior to the adoption of the Ordinance, became effective and enforceable.

As mentioned above, "well maintenance" was first formally interpreted via a Zoning Administrator Interpretation on January 17, 2023, when the Chief Zoning Administrator issued Case No. ZA-2022-8997-ZAI interpreting what drill site activities qualify as "well maintenance." On October 4, 2023, this ZAI was reissued, as modified by the Chief Zoning Administrator, and as adopted by the City Planning Commission, pursuant to appeal Case No. ZA-2022-8997-ZAI-1A.

Also on January 17, 2023, the Chief Zoning Administrator issued ZA Memo 141, establishing application and processing requirements for the Health and Safety Exception for oil and gas drill sites pursuant to LAMC Section 12.23 C.4 (amended by Oil Ordinance No. 187,709, adopted on December 2, 2022, and effective January 18, 2023).

Various parties challenged Oil Ordinance No. 187,709, the 2023 ZAI, and ZA Memo 141 in *Warren E&P, Inc. v. City of Los Angeles*, Los Angeles Superior Court Case No. 23STCP00060, and three related cases.[2] Following trial, the court ruled that Oil Ordinance No. 187,709, the 2023 ZAI, and ZA Memo No. 141 were preempted by state law. The matter was ultimately resolved by stipulation and a stipulated judgment, which required the City to rescind Oil Ordinance No. 187,709, the 2023 ZAI, and ZA Memo No. 141. Pursuant to the stipulation and stipulated judgment, on May 23, 2025, the City Council adopted a draft ordinance to rescind Oil Ordinance No. 187,709. Rescission of said ordinance meant the former language in Sections 12.03, 12.10, 12.23, 12.24, and 13.01 of Chapter 1 of the LAMC, as they existed prior to the adoption of the Ordinance, became effective and enforceable. The Ordinance rescinding Oil Ordinance No. 187,709 became effective on July 16, 2025. Further, to comply with the requirements of the stipulation and stipulated judgment, the Chief Zoning Administrator jointly rescinded Case No. ZA-2022-8997-ZAI-1A and ZA Memo 141 on May 29, 2025.

[2] The other three related lawsuits are: *E & B Natural Resources v. City of Los Angeles*, LASC Case No. 23STCP00070, *Native Oil Producers & Employees of California / Western States Petroleum Association v. City of Los Angeles*, LASC Case No. 23STCP00085; and *National Association of Royalty Owners California, Inc. v. City of Los Angeles*, LASC Case No. 23STCP00106.

On September 25, 2024, after the court issued its preemption ruling in the *Warren* litigation, Governor Newsom signed into law AB 3233, which added Section 3106.1 to the Public Resources Code, allowing local governments to enact and enforce "limitations or prohibitions related to the methods of oil and gas operations or development and the locations of oil and gas operations or development" – notwithstanding any state approval or permit. The Legislature's intent in passing AB 3233 is stated in the bill text: "Protecting public health, safety, and the environment is of the utmost importance to all Californians. In order to protect public health and safety, cities and counties must have the authority to regulate oil and gas operations within their jurisdictions, including operations that may otherwise be approved by the State Oil and Gas Supervisor… Empowering cities and counties to regulate, limit, or prohibit oil and gas operations in their jurisdictions will therefore enable communities to make decisions that align with their needs."

AB 3233 provides relevant context because it reflects a broader legislative trend toward recognizing and strengthening local authority over oil and gas operations. The statute signals a growing number of policies intended to regulate or restrict oil activities that pose potential harms to nearby communities.

Another notable state legislation which became effective on June 28, 2024, was Senate Bill (SB) 1137. SB 1137 was signed by Governor Newsom on September 16, 2022, however, it was temporarily paused due a potential ballot initiative that would have invalidated SB 1137. After the ballot initiative was withdrawn, SB 1137 became effective on June 28, 2024. CalGEM resumed implementation of the new regulations, including a prohibition on new drilling, deepening, and rework (well maintenance) permits if the oil well is within 3,200-feet of a sensitive receptor. SB 1137 contains clear language that CalGEM can issue permits if the oil well activity is necessary to prevent or respond to a threat to public health, safety, or the environment. CalGEM is determining on a case-by-case basis if a scope of work meets the criteria for such a health and safety exception. Like AB 3233, SB 1137 underscores the Legislature's recognition that oil and gas operations near sensitive receptors pose heightened risks and demonstrates the broader policy framework within which the City's interpretation of "well maintenance" operates.

Together, AB 3233 and SB 1137 illustrate a growing legislative trend toward regulating or restricting oil and gas operations that present potential health and safety risks, providing important context for the City's continued role in oil regulation.

As previously discussed, the subject of this appeal is substantively similar to the original well maintenance ZAI adopted by the City Planning Commission in 2023. However, instead of implementing Oil Ordinance No. 187,709, the 2025 ZAI interprets existing terms in LAMC Sections 13.01 H and I to clarify which activities are considered "well maintenance" for purposes of local discretionary review. Unlike the 2023 ZAI, the 2025 ZAI originates from a different set of circumstances in that it relies upon the City's zoning authority to interpret existing regulations that allow for discretionary consideration of maintenance activities.

This interpretation also aligns with recent legislative developments, such as AB 3233 and SB 1137, which reflect a broader policy trend toward recognizing local oversight and restricting oil activities that may pose risks to surrounding communities.

For decades, the City's Zoning Code has recognized well maintenance as a land use intensive activity warranting regulatory oversight to protect the health, safety, and well-being of surrounding communities. As detailed in the sections that follow, the Office of Zoning Administrator (OZA) has a documented history of regulating those maintenance activities, including well recasing and maintenance acidization, with the greatest land use impacts. The 2025 ZAI builds on this record by clarifying the scope of "well maintenance" in the Zoning Code, ensuring consistency in how these activities are reviewed under local land use authority.

Interpreting Well Maintenance in the LAMC

Under Section 13.01, the LAMC requires discretionary approval "to drill, deepen, or maintain" an oil well. While the terms "drill" and "deepen" have clear meaning, "maintain" has required further clarification beyond its references in the Zoning Code.

Prior to the 2023 ZAI, the Zoning Administrator had not yet exercised their authority under LAMC Section 12.21 A.2[3] to formally interpret the scopes of work that would be identified as "well maintenance" activities. Instead, and on a case-by-case basis, the OZA would review an operator's proposed well activity and then determine whether the project was considered well maintenance requiring discretionary review. Interpreting the term "well maintenance" through the 2023 ZAI was an important first step in order to more formally inform operators what maintenance activities would require a Zoning Administrator's review and determination under the Zoning Code. This 2025 ZAI is a continuation of this already established policy.

The ZAI formalizes the types of activities that the Zoning Administrator has historically considered well maintenance (including maintenance acidizing, well recasing, adding perforations, and conversion to electrical submersible pump lifts (ESP), to name a few). The term "well maintenance" has always been determined to encompass oil well activities that have the potential to cause land use impacts, and that would require further discretionary oversight by the Zoning Administrator under LAMC Section 13.01 H. The ZAI does not alter or expand the OZA's historical treatment of the term "well maintenance"; rather, it represents a standardization of a practice previously applied on a case-by-case basis.

[3] When the original 2023 ZAI was issued, the Zoning Administrator's interpretive authority was codified in LAMC Section 12.21 A.2. Following the adoption of the new Zoning Code (Chapter 1A), that authority is now found in Section 13A.1.7.D.2.

Discretionary Review by the OZA

The Zoning Administrator has long had discretion over requests for oil/gas well projects pursuant to the authority outlined in LAMC Sections 13.01 H and I. There are various examples of the Zoning Administrator issuing decisions on requests to conduct oil/gas well activities such as drilling, redrilling, and deepening of wells. For example, on April 22, 1985, the Zoning Administrator approved a request for an operator to drill an oil producing well at the South Torrance Unit site in the Wilmington neighborhood of the City. The determination language includes the following, "...the drilling of a Class A oil well identified as STU C106R as a replacement for a Class A oil well identified as STU C106, which has been abandoned, all within Nonurbanized Oil Drilling District No. 71…"[4] In another example, on March 17, 2009, the Zoning Administrator issued a determination for the Packard Drill Site in the Mid-City neighborhood of the City and included the following language in the determination, "...[approve] methods and conditions controlling drilling and production operations for the re-drilling three (3) oil wells…"[5] In a more recent example, on September 20, 2013, the Zoning Administrator approved the drilling of one new well in the Harbor Gateway neighborhood with the following approval language, "[approve] plans to allow the drilling one new well on an existing semi-controlled site known as 'C-7' in the Joughin Unit in Oil Drilling District U-114…"[6]

In recent years, operators have proposed fewer new drilling projects and instead have focused more on maintenance activities. In fact, 2019 was the last time a discretionary application was filed to drill new wells and 2013 was the last year that a Zoning Administrator approved new drilling in the City. Operators, however, have contacted OZA staff on a regular basis regarding oil/gas well maintenance activities. State and city records illustrate that many oil/gas wells in the City were drilled in the mid-20th century. Due to the aging structural integrity of these oil/gas wells, operators have been relying on specific activities to maintain and/or extend the life of the well. Today, operators must either follow specific permit and/or notification requirements from different state agencies prior to completing specific oil/gas well activities related to well maintenance.

Established Practice

The Zoning Administrator's recent actions to interpret the Zoning Code, in this case with the term, "well maintenance", is a reasonable implementation step within the larger context of regulating oil/gas well activities.

The City often coordinates and has overlapping responsibilities with outside agencies. CalGEM, for example, is the state agency that regulates oil, gas, and geothermal well activities and also, as they describe, "...prioritizes protecting public health, safety, and the environment in its oversight

---

[4] Zoning Administrator's Determination, Case No. ZA-1985-0103-O, April 22, 1985 <https://drive.google.com/file/d/1FcssecKBF7CfyQ6DHeTk53lmt0RvkvgV/view?usp=sharing>

[5] Zoning Administrator's Determination, Case No. ZA-18129(PA2), March 17, 2009 <https://drive.google.com/file/d/10vqQNQFGo5FIKATten8jQsR3mDolV3Gm/view?usp=sharing>

[6] Zoning Administrator's Determination, Case No. ZA 18614(PA3) <https://drive.google.com/file/d/1djf39GCK05bXEzJkFzlQmN4_XwmvKXb2/view?usp=sharing>

of the oil, natural gas and geothermal industries, while working to help California achieve its climate change and clean energy goals."[7] CalGEM requires operators to identify if a local municipality or county acts as the Lead Agency for CEQA review. The OZA, acting on behalf of the City as a Lead Agency for CEQA, reviews oil/gas well projects that may create land use impacts. For example, the OZA is involved with the state review process for projects that require a CalGEM Rework permit for activity such as recasing an oil well. Recasing, which can be a form of a repair project, involves permanently modifying the structural integrity of the oil/gas well, and is a type of project that could result in land use impacts warranting the Zoning Administrator's discretionary approval under the LAMC. Other activities such as sidetracking (horizontal drilling) and converting an oil/gas well from a production well to an injection well all require discretionary review and approval in order for the operator to complete the project. Because these types of projects would trigger discretionary approval, OZA staff, acting on behalf of the City of Los Angeles as the Lead Agency for CEQA, provides input in determining whether there may be potential environmental impacts. CalGEM's deference to the City in relation to these CEQA determinations is one example of an established pattern of the City interpreting the types of maintenance activity that warrant discretionary and CEQA review under the existing regulatory framework.

Additionally, the OZA has advised oil operators on its well maintenance policies for several years and has consistently treated the same types of activities as well maintenance. Below are some examples of these consultations between OZA staff and operators:

Maintenance Activity	Advice
Rework	On January 29, 2020, OZA staff informed E&B Natural Resources that a CalGEM Rework permit to perform recasing on an oil well at the San Vicente Drill Site in the Fairfax District required discretionary review in accordance with LAMC Section 13.01 H and ZA Memo 133. After reviewing the proposed scope of work, OZA staff informed the operator that their project would be considered "well maintenance" and they would need to file an application. The operator submitted this same request to the OZA for the same oil well on December 16, 2021, almost two years after the initial request. OZA staff again advised that the proposed work at the San Vicente Drill Site required a ZA determination. The operator did not file an application for this work.
Rework	OZA staff advised Warren Resources on April 4, 2022, that a request to modify their oil well casing to increase production levels at the Banning Drill Site in the Wilmington neighborhood of the city would require a ZA determination. Staff issued the same guidance for a similar scope of work on a different well also at the Banning Drill Site for Warren Resources on October 21, 2022. The operator did not file an application for either scopes of work.
Rework	On March 23, 2023, the OZA advised Warren Resources that their proposed Rework activity, involving recasing, was considered "well maintenance" for the Banning Drill Site in the Wilmington neighborhood of the City. The operator did not file an application for this work.

[7] California Geologic Energy Management Division landing page. Department of Conservation website, 2025. September 1, 2025<https://www.conservation.ca.gov/calgem>

Maintenance Acidizing	In May 2021, constituents contacted OZA staff concerning a maintenance acidizing project at the Murphy Drill Site in Jefferson Park, South Los Angeles and the concerns associated with such project. Photographic evidence was submitted that showed the amount of heavy-duty tanker trucks arriving into a residential neighborhood. OZA staff would later identify that the project coincided with several odor complaints. The City issued a Letter of Communication in July 2021 documenting that activity which was later identified as maintenance acidizing had been performed and advising that it may require discretionary review. See **Exhibit T** for a copy of that Letter of Communication. The operator did not file an application for this work.[8]

As demonstrated above, the City has historically played a role in regulating well maintenance. Throughout the years, the OZA's policy intentions for well maintenance activities have been clear and consistent. Pursuant to the Zoning Code, the Zoning Administrator has authority to interpret zoning provisions when their meaning is ambiguous or unclear. That authority has validly been exercised both informally, on a case-by-case basis, and formally, through a ZAI. The 2025 ZAI continues this established practice by clarifying which activities qualify as well maintenance and require discretionary review under existing regulations.

Interpretation Methodology

The Chief Zoning Administrator took an informed and purposeful approach in interpreting and clarifying what activities qualify as well maintenance and whether these activities would be subject to discretionary review per the Code. The ZAI is backed by extensive research and consultations with state, regional, and local regulatory agencies involved in the regulation of oil.

Oil/gas well regulations are complex because different agencies regulate different aspects of oil drilling operations. Thus, in addition to the specific interactions referenced below, OZA staff spoke with numerous City of Los Angeles, County of Los Angeles, and state officials to understand the scope of what each respective agency is responsible for in regulating oil/gas wells and well maintenance activities. Staff also spoke with land use officials from neighboring municipalities and counties and reviewed regulations from these nearby entities to better understand their approach to regulating oil/gas wells.

Starting in 2020, OZA staff corresponded and inquired with various government agencies to learn how and why those agencies regulate specific oil well maintenance activities. OZA staff also spoke with various entities including oil/gas well operators, government agency policy managers and regulatory enforcement officials to gain a complete perspective on oil/gas well maintenance regulations, including:

[8] The absence of past case filings reflects the historic difficulty of tracking maintenance acidizing activities, not the absence of authority. Prior to SCAQMD's adoption of Rule 1148.2 in 2013, the City had no formal notification mechanism to identify when maintenance acidizing occurred, unless complaints were filed, and even then it was difficult to confirm the specific activity. Maintenance acidizing was historically difficult to track until SCAQMD adopted Rule 1148.2; prior gaps reflect monitoring limits, not lack of authority.

- Operators
    - In January 2020, OZA staff, at the suggestion of E&B Natural Resources, reviewed the oil and gas well regulations for the City of Carson to evaluate that municipality's CEQA requirements for well maintenance projects.
    - In October 2021, OZA staff met with an oil operators' association to hear about oil rig operations at drill sites across the City.
    - In June 2022, OZA staff met with the operators of the West Pico Drill Site, Pacific Coast Energy Company, for a site visit to observe the facility's operations.
- California Geologic Energy Management Division
    - OZA staff consulted with CalGEM on various topics and subject areas related to oil and gas well activities. The OZA contacted CalGEM for insight on oil/gas well activities, specifically on Rework projects and what CalGEM required from operators prior to issuing permits for proposed activities. OZA staff also spoke with CalGEM staff concerning well stimulation activities such as maintenance acidizing and well servicing activities such as tracer survey projects. OZA staff has also contacted CalGEM to discuss service rig operations and equipment requirements for well maintenance projects.
- South Coast Air Quality Management District
    - OZA staff consulted with agency staff regarding permit and registration requirements for oil and gas sites. OZA staff also spoke with staff to learn more about Rule 1148.2 and requirements for operators when conducting oil well maintenance activities.
- County and Municipal Agencies
    - In January 2022, OZA staff consulted with Santa Barbara County staff and discussed their Planning division's requirements for well maintenance projects.
    - OZA staff also spoke with Ventura County's Planning Division in August 2022 to discuss oil and gas permitting requirements for oil/gas well projects in that county jurisdiction.

During this research, staff gained an in-depth understanding of the routine operations and upkeep of oil drilling facilities and the extent that agencies regulate oil/gas well maintenance activities. Staff learned that various municipalities and counties do not have a clear definition of well maintenance, or a definition for each well maintenance activity. Entities such as Santa Barbara County, Long Beach City, and Ventura County, do not define oil/gas well maintenance activities. CalGEM and SCAQMD also do not have a clear definition for "well maintenance." Furthermore, the state's oil oversight agency, CalGEM, does not have any established list of the different activities that could be interpreted as well maintenance, nor do they define those activities.

Within the City's departments and offices, OZA staff also inquired with senior department staff and officials to understand how well maintenance projects were regulated and/or reviewed in different capacities. OZA staff consulted with the City's Office of Petroleum and Natural Gas Administration and Safety (OPNGAS) regarding well maintenance activities throughout the research process, including as early as December 2019 and as recently as March 2022 to gain

insight on well maintenance projects. OZA staff received and reviewed literature on well maintenance activities from Erica Blyther, the City's Petroleum Administrator. OZA staff also spoke at different times with OPNGAS's former Deputy Petroleum Administrator, Amanda Suter, for background on well maintenance activities and the technical aspects to those operations. Additional research included consultations with Los Angeles Fire Department personnel including Captain Diana Igawa of the Oil Well Unit (formerly Harbor Industrial Unit) and with Royce Long of the Certified Unified Program Agency unit regarding their oversight of oil drill sites.

In October 2021, OZA staff also met with land use representatives on behalf of E&B Natural Resources, E&B Natural Resources staff themselves, and a representative of the California Independent Petroleum Association (CIPA) to discuss well maintenance projects. The operator, the operator's representative, and the CIPA representative shared insight on how well maintenance projects could be regulated from a land use perspective and also shared a three-page document[9] on standard maintenance operations that were performed regularly at drill sites. OZA staff carefully reviewed this material and factored in this content when drafting the ZAI.

The ZAI research also drew on peer-reviewed scientific and academic studies.[10] One study using SCAQMD project data found that maintenance acidizing projects employ many of the same hazardous chemicals as hydraulic fracturing (otherwise known as fracking) and other forms of oil well stimulation.[11] The hazardous chemicals common to fracking and maintenance acidizing pose both environmental and public-health risks (e.g., air pollution and odor nuisances). By documenting this overlap, the study provides substantial evidence that well maintenance projects can pose comparable land use and public health impacts, justifying discretionary review of these "maintenance" projects by the Zoning Administrator under the LAMC.

In addition, the California Oil & Gas Public Health Rulemaking Scientific Advisory Panel report, commissioned by the Department of Conservation, synthesized peer-reviewed research and found increased health risks within 1 kilometer (3,281 feet) of oil and gas wells. This report, titled "Public Health Dimensions of Upstream Oil and Gas Development in California: Scientific Analysis and Synthesis to Inform Science-Policy Decision Making", is relevant not only because it was cited in the ZAI, but also because it served as the scientific basis for SB 1137, which established a 3,200-foot setback between wells and sensitive receptors. The Legislature's reliance on these findings confirms their credibility and relevance.

Other studies cited in the ZAI are likewise valid and relevant. SCAQMD's Rule 1148.2 reporting data documents chemical use, timing, and emissions associated with rework and maintenance

---

[9] California Independent Petroleum Association - Examples of Routine Rig Work. December 15, 2021. <https://drive.google.com/file/d/11VwrLsdTqyAPK6Dda2rBuWJhz4SwZ1Ia/view?usp=sharing>

[10] June 2024 Public Health Dimensions of Upstream Oil and Gas Development in California: Scientific Analysis and Synthesis to Inform Science-Policy Decision Making. California Geologic Energy Management Division, Department of Conservation <https://www.conservation.ca.gov/calgem/Documents/Public%20Health%20Panel%20Final%20Report_20240621.pdf>

[11] Stringfellow WT, Camarillo MK, Domen JK, Shonkoff SBC (2017) Comparison of chemical use between hydraulic fracturing, acidizing, and routine oil and gas development. PLoS ONE 12(4): e0175344. https://doi.org/10.1371/journal. pone.0175344

activities in Southern California. Local assessments conducted by Los Angeles County and the City of Los Angeles link oil and gas operations to respiratory illness, odor, noise, and quality-of-life impacts in surrounding communities. Collectively, these studies and data sources form a robust evidentiary record demonstrating that maintenance activities can create land use and environmental impacts. Together, they provide the rational basis necessary for the City's local land use authority to require discretionary review of well maintenance activities.

One of the other key components to interpreting which activities would fall under "well maintenance" were the concerning experiences that residents encountered within close proximity to these oil drill sites. OZA staff learned of the potential risk to public and environmental health from documented occasions where well maintenance projects created negative land use impacts to sensitive uses within close proximity of an oil well facility. Although both agencies play a role in regulating maintenance activity, SCAQMD and CalGEM have limited scopes of responsibility. SCAQMD is only responsible for regulating air quality impacts, while CalGEM focuses on oil well engineering and safety. Due to their limited scopes, these state agencies are not able to regulate maintenance acidizing and other maintenance activity in a holistic manner in the same way that the City can through zoning. The Zoning Administrator has the unique responsibility of assessing and conditioning all possible land use impacts of maintenance work to fill in where the state lacks oversight (e.g., regulating hours of operation, noise, and traffic, to name a few), all the while providing added transparency for local residents impacted by these land use activities. Below are some occasions when constituents raised valid and clear concerns about these oil well maintenance activities.

- In July 2014, constituents documented negative land use impacts from maintenance acidizing activities at the Jefferson Drill Site, a now decommissioned facility in the Jefferson Park neighborhood of the City.[12] Constituents submitted photographic evidence of damaged landscaping at the drill site allegedly as a result of the local air pollution from the maintenance acidizing activities (see **Exhibit V**). The documentation submitted by constituents to the OZA illustrates the many different chemical treatment tanker trucks and the large-scale operation for the two oil wells where maintenance acidizing was performed.

- As previously mentioned, in May 2021, constituents contacted OZA staff concerning a maintenance acidizing project at the Murphy Drill Site in Jefferson Park, South Los Angeles and the concerns associated with such project. Photographic evidence was submitted that showed a number of heavy-duty tanker trucks arriving into a residential neighborhood. OZA staff would later identify that the project coincided with several odor complaints. (see **Exhibits S and U**)

- In May 2025, constituents spoke at an Energy and Environment Council Committee concerning maintenance acidizing activities (see **Exhibit W**). Constituents submitted both written and verbal testimony highlighting the concerns surrounding the noticing at the

[12] Public Comment. Jefferson Drill Site and SCAQMD Rule 1148.2 Notifications Archived Documents. Redeemer Community Partnership. November 23, 2024. <https://drive.google.com/file/d/12hGM15Nh7wzDxY557e6zzbOhR5zqI1xt/view?usp=sharing>

Banning Drill Site in the Wilmington neighborhood of the City. Constituents furnished a copy of the required mailing notice that Warren E&P, Inc. sent to nearby residents.[13] The notice, dated November 25, 2024, outlines a concise description of the types of oil well activities that are proposed for the wells at the Banning Drill Site. Existing state regulations permit the operators such as Warren E&P, Inc. to issue one mailing notice for up to 39 maintenance acidizing activities within close proximity to sensitive receptors. Concerns raised by constituents highlight the benefits of a quasi-judicial review, and potentially, conditioned approval, of any maintenance acidizing activities. These benefits include a) imposing more strict notification requirements to the City and to local residents and b) expanding on the nature and duration of these intensive oil well activities. Underscoring concerns about inadequate notice, Warren E&P, Inc. was cited by SCAQMD on May 9, 2025, for failure to notify air district officials of rescheduled, cancelled, and new maintenance acidizing activities.

These concerns submitted by constituents informed the ZAI in identifying maintenance acidizing as a type of maintenance activity referred to in the LAMC, which can have potential land use impacts, and which, under existing provisions, falls within the scope of activities that the Zoning Code currently subjects to discretionary review. These instances also underscored the need for a Zoning Administrator's Interpretation to formally interpret what activities would be considered "well maintenance," so as to clearly implement and enforce the intent of the Zoning Code. Thus, the interpretation is reasonable.

The administrative record for this ZAI demonstrates an intentional and methodical process towards arriving at the interpretation of existing terminology in the LAMC. Additional information from the various consultations and meetings with industry and regulatory staff are included in the administrative record.

The Role of the City

In reviewing well maintenance projects, regulatory agencies such as CalGEM and SCAQMD have a responsibility to protect the public welfare, but have narrower purviews than the City, with its comprehensive police powers. Therefore, the Zoning Administrator's authority under the local Zoning Code to review maintenance activities in a more comprehensive manner can help further reduce, if necessary, any land use impacts. Specifically, as it relates to oil and gas extraction, CalGEM focuses on subsurface and near surface activities, whereas SCAQMD regulates the effects on air quality, including emissions and pollutants. These agencies do not regulate other significant land use impacts for oil and gas extraction activities. Such land use impacts include but are not limited to: traffic/transportation circulation, noise decibel levels, aesthetics, and noxious odors resulting from proposed activities conducted at drill sites.

Well maintenance activities, as described herein, may have negative land use impacts on surrounding communities such as elevated noise levels, frequent odor events, increased

[13] Public Comment. Council File No. 24-1580. Standing Together Against Neighborhood Drilling, et. al. May 6, 2025. <https://drive.google.com/file/d/1DUrNEQ-66FsKYjxSg1ui0jPgANLyYJWc/view?usp=sharing>

emissions exposure, spill incidents affecting the public right-of-way, truck traffic congestion on local streets, removal of on-street parking, traffic congestion on local streets, and lack of effective screening for drill site equipment. These are precisely the types of land use impacts that LAMC Sections 13.01 H and I were meant to address to protect the health, safety, and welfare of surrounding neighborhoods and the public. As such, the Zoning Administrator's Interpretation and review of well maintenance activities is consistent with the intent of Sections 13.01 H and I and is meant to implement the pre-existing safeguards in those sections. The Zoning Administrator's interpretation and review of these activities allow for a more comprehensive analysis of proposed well maintenance activities and ability to mitigate any potential impacts, if necessary.

"Maintenance" Interpreted

As previously mentioned, oil and gas wells have been regulated in the LAMC since the mid-20th century. The terms "deepening" and "drilling" have appeared in different versions of the LAMC since at least 1948. In 1955, the first references to "well maintenance" appeared in LAMC Section 13.01 H, requiring operators to seek authorization from the Zoning Administrator to perform maintenance on oil wells with "a determination of the conditions under which the operations may be conducted." These regulations reflect the City's past policies and practice of allowing oil and gas wells in a variety of zones, as long as the effects of the land use could be mitigated through conditions in consideration with the surrounding community.

The aforementioned research on maintenance, coupled with the long-standing practice of identifying oil well maintenance activities that have the greatest land use impacts, helped to inform the Chief Zoning Administrator's interpretation of well maintenance. The ZAI interprets the scope of maintenance activities, while the Code establishes when those activities are subject to discretionary review. The interpretation took an approach that encompassed a wide variety of oil/gas well activities that frequently take place at drill sites and that are also regulated at the State level. These state-regulated activities have already been determined to merit some form of oversight or permitting in order for the operator to complete the well maintenance activity. Because these activities frequently coincide with land use impacts at the local level, the City's interpretation ensures that they are subject to discretionary review where appropriate. Therefore, starting from long-standing state oil/gas well regulations outlined in the California Public Resources Code and SCAQMD rules, the ZAI's well maintenance criteria outlines a two-track qualification for whether an activity is interpreted as "well maintenance" activity.

Under the first track, an activity is considered well maintenance if it requires a CalGEM "Rework permit." Operators must apply for and obtain permits from CalGEM for specific well activities such as, but not limited to: permanently sealing and closing wells, repairing an oil well, or drilling a new well. CalGEM has a specific type of permit for when an operator wants to permanently alter the casing of the oil/gas well and it will affect the structural integrity of said well. This permit is known as a "Rework" permit. Operators must apply to CalGEM for this permit and receive approval before completing the scope of work for said Rework permit. CalGEM requires an environmental review and clearance for all Rework projects prior to any project approval or permit issuance. The requirement to assign a CEQA clearance to Rework projects demonstrates that these types of oil

well activities merit some form of expanded review by agencies, including by local municipalities. Rework activities may require the use of several diesel trucks to the site, idling of said trucks, and the operation of diesel rigs that are all operating in close proximity to the oil wells. These activities are also occurring while opening and closing the oil well which increase the risks of potential hazards, including but not limited to: odor events, decreased air pollution quality, oil well blowouts, and noise. And in fact, because of the increasing impacts on climate change, the documented health impacts of oil wells to sensitive uses, the disproportionate impacts on frontline communities, state legislation – notably, SB 1137 (2022) – only authorizes this type of work when necessary to prevent or respond to a threat to public health, safety, or the environment – evidence that said work has detrimental impacts that must be regulated or restricted.

Well maintenance activities also qualify under a second track pursuant to SCAQMD Rule 1148.2. SCAQMD regulates air quality throughout different Southern California counties including all of the City of Los Angeles. Under Rule 1148.2 ("Notification and Reporting Requirements for Oil/Gas Wells and Chemical Suppliers)," oil/gas well operators must submit an electronic notification to SCAQMD prior to commencing any well activities. These activities can include, but are not limited to: maintenance acidizing, gravel packing, and acid fracturing. Given that these activities could result in an odor event where air quality is impacted, SCAQMD instituted this regulation to regulate what chemicals operators are using during well activities. CalGEM has been issuing Notice of Intention permits since the 1930s, per historical records. SCAQMD's Rule 1148.2 became effective in April 2013.

The ZAI incorporated specific CalGEM and SCAQMD regulations into its interpretation for a variety of reasons. One of the main reasons was familiarity and knowledge of these two key agencies. In addition, the ZAI aligns the description of oil/gas well maintenance activities with how CalGEM and SCAQMD regulate specific activities. Operators must follow numerous rules and standards across different agencies and levels of government, including CalGEM and SCAQMD. Operators are responsible for remaining compliant with those two agencies in particular and it is likely they are already familiar with CalGEM Rework permits and SCAQMD Rule 1148.2 notification rules. All of the oil/gas well operators in the City of Los Angeles have either been operating their drill sites for several years and/or have drill site operations in other parts of California. As a result, they are familiar with CalGEM's statewide policies and understand the process. Operators who have been active in Southern California for years should also be familiar with their obligations pertaining to SCAQMD rules, especially given the heightened attention and visibility to air quality policies. This familiarity is important because it shows that the ZAI does not create new obligations, but formalizes practices operators already follow under state law. By aligning with existing CalGEM and SCAQMD procedures, the ZAI ensures accountability and prevents operators from claiming surprise or lack of notice.

With this background and research, on June 12, 2025, the Chief Zoning Administrator issued an interpretation that well maintenance activities are any scope of work that meets either of the following criteria:

1. A scope of work that requires a Notice of Intention "Rework Permit" to carry out a rework project on a well from CalGEM.

2. A scope of work that requires notification per SCAQMD Rule 1148.2 – "Notification and Reporting Requirements for Oil and Gas Well and Chemical Suppliers" for "Well Rework" and/or "Injection" including one or more of the following activities: acidizing, hydraulic fracturing, gravel packing, maintenance acidizing, matrix acidizing, and acid fracturing.

Applicability

The ZAI applies solely to the Zoning Code provisions that are in effect today, specifically LAMC Sections 13.01 H and I. The interpretation does not extend to any future ordinance, amendment, or regulation that may be adopted by the City Council. By clarifying the meaning of "well maintenance" in the current Code, the ZAI provides guidance for the consistent administration of existing provisions. The ZAI is not linked to any possible future prohibitions or ordinances, as it is limited to interpreting the law as it stands today.

CEQA

This ZAI provides an interpretation of existing terminology in the LAMC that assists in the procedural implementation of LAMC Sections 13.01 H and I. The issuance of this ZAI that interprets "well maintenance" is not a "project" as that term is defined by CEQA Guidelines, Section 15378 as it constitutes an administrative and procedure-making activity to assist in the implementation of the City's preexisting Zoning Code provisions regarding oil well sites. Even assuming that the ZAI is considered a project, the ZAI is exempt under the Class 8 and common sense exemptions. The ZAI identifies the oil well activities that qualify as "well maintenance" in order to implement a review process intended to minimize land use impacts, such as elevated noise levels, frequent odor events, increased emissions exposure, spill incidents affecting the public right-of-way, and truck traffic congestion, among others. Thus, the ZAI is an action taken by a regulatory agency, as authorized by local ordinance, to assure the maintenance, restoration, enhancement, or protection of the environment. Moreover, the ZAI only provides an interpretation of preexisting language in the Zoning Code to assist in the implementation of a previously established application process, and does not have the potential for causing a significant effect on the environment.

APPEAL ANALYSIS

APPEAL SUMMARY

On June 12, 2025, the Chief Zoning Administrator issued a Zoning Administrator's Interpretation interpreting what oil well activities qualify as "well maintenance", as referenced in the LAMC. On June 27, 2025, two appeals against the entire interpretation were filed pursuant to LAMC Section 13A.1.7.D.2 of Chapter 1A by Warren Resources, Inc. (Warren Resources) and E&B Natural Resources Management Corporation (E&B Natural Resources), oil extraction and production companies with active operations in the City.

The two appeals raise a number of the same issues. Accordingly, topical responses have been prepared to address those overlapping points. Each topical response provides a complete discussion of the concern raised and consolidates information from the different comments submitted. Consequently, a particular topical response may provide more information than requested by any individual appeal point.

Topical responses address the following issues:

1. CEQA
2. Zoning Administrator Authority
3. General Plan Consistency
4. Vested Rights
5. Contract Interference
6. The ZAI is Vague and Ambiguous
7. Due Process
8. Preemption
9. Settlement Agreement and Stipulated Judgment
10. Civil Rights Act

APPEAL POINTS AND RESPONSES

The following statements have been summarized from the appeals by Warren Resources. and E&B Natural Resources. The appeals in their entirety have been attached herein for reference, as **Exhibit A** for the Warren Resources appeal and as **Exhibit B** for E&B Natural Resources appeal. Issues raised within each appeal are also numbered. For example, issues relating to CEQA in Warren Resources' appeal are numbered "1-1", "1-2", "1-3", etc.

1. APPEAL TOPIC: CEQA

Summary of Appeal Point

E&B Natural Resources alleges that the 2025 appeal fails to comply with CEQA and constitutes improper piecemealing. Similarly, Warren Resources argues that the adoption of the ZAI violates CEQA.

APPEAL RESPONSE

A. The ZAI is *not* a project per CEQA Guidelines Section 15378.

*This subresponse addresses **Warren Resources' Appeal Points 1-1 and 1-2** and **E&B Natural Resources' Appeal Points 2-2 and 2-3**, and their allegations that the ZAI is a project with impacts that must be analyzed.*

CEQA requires government agencies to consider the environmental consequences of their actions before approving plans and policies or committing to a course of action on a project. Within the context of CEQA, the term "project" has a specific meaning.

Section 15378 of the CEQA Guidelines provides the following definition of a project:

> (a) "Project" means the whole of an action, which has a potential for resulting in either a direct physical change in the environment, or a reasonably foreseeable indirect physical change in the environment, and that is any of the following:
>
> > (1) An activity directly undertaken by any public agency including but not limited to public works construction and related activities clearing or grading of land, improvement to existing public structures, enactment and amendment of zoning ordinances, and the adoption and amendment of local General Plans or elements thereof pursuant to Government Code Sections 65100-65700.
> >
> > (2) An activity undertaken by a person which is supported in whole or in part through public agency contacts, grants subsidies, or other forms of assistance from one or more public agencies.
> >
> > (3) An activity involving the issuance to a person of a lease, permit, license, certificate, or other entitlement for use by one or more public agencies.

The ZAI is not a project under CEQA because it is an administrative action that formalizes an existing interpretation of terminology in the LAMC regarding oil well sites. The Chief Zoning Administrator's interpretation of this terminology is not a project pursuant to CEQA Guidelines Section 15378 because it is not the kind or sort of activity which has the

potential to cause a direct or reasonably foreseeable indirect physical change in the environment. The ZAI's interpretation of the term "well maintenance" is consistent with the intent of the term to include activities at oil/gas well facilities that could result in land use impacts, and that may require further review and approval by the Zoning Administrator under established regulations. Because it does not itself permit or prohibit activities, the ZAI has no potential to cause a physical environmental effect and is not a project subject to CEQA.

The ZAI is also consistent with the manner in which the Zoning Administrator previously interpreted the term "well maintenance" on a case-by-case basis of the LAMC provisions. Prior to the ZAI, the Zoning Administrator reviewed and determined the term well maintenance to include activities such as maintenance acidizing and recasing – activities that trigger a rework permit from CalGEM and/or online notification per SCAQMD Rule 1148.2. In fact, prior to the issuance of the ZAI, the OZA explained to oil well operators that certain oil well activities, including recasing and acidizing of wells, would constitute maintenance under the LAMC and would require review and approval by the Zoning Administrator. See **Exhibit R** for various email correspondence illustrating OZA staff requiring ZA review for different activities that qualify as "well maintenance" and require a ZA determination. Additionally, the OZA has consistently treated CalGEM NOI permits for Rework or redrilling as "well maintenance." Put differently, the ZAI does not alter or expand the scope, intent, or application of the term "well maintenance," as that term is used in the LAMC and as previously applied by the Zoning Administrator.

The appellants' claim that CEQA Guidelines Section 15378(b)(2) does not apply is misplaced. They selectively cite only "purchases of supplies" and "personnel-related actions" as examples of administrative activity, while omitting that the same provision expressly includes "general policy and procedure making." The ZAI is precisely that, a continuation of the City's established practice of clarifying how existing zoning provisions are applied. Rather than creating new regulatory obligations, the ZAI formalizes the consistent case-by-case determinations that the Zoning Administrator has long made regarding maintenance activities. Accordingly, Section 15378(b)(2) confirms that the ZAI is not a project under CEQA.

The appellants claim that the ZAI will have potential indirect or direct impacts on the environment, including to air quality, energy, aesthetics, traffic, odor, noise, mineral resources, geology, and greenhouse gas (GHG) emissions. The appellants argue that these alleged impacts will result from a purported acceleration of well abandonment and from the increased importation of replacement oil. But, the appellants do not identify a causal connection between the ZAI and these alleged impacts and only provide speculation that cannot support an argument that there would be any causal connection between the ZAI and a direct or reasonably foreseeable indirect impacts. (*See Union of Medical Marijuana Patients, Inc. v. City of San Diego* (2019) 7 Cal.5th 1171*; San Francisco Taxi Coal. v. City and County of San Francisco* (9th Cir. 2020) 979 F.3d 1220).

The appellants' further contention that the ZAI will result in a loss of "mineral resources" is misplaced. Petroleum is not considered a mineral resource under CEQA or the Conservation Element of the General Plan. State law (*Pub. Resources Code Sections 2005 and 3501)* likewise excludes petroleum and natural gas from the definition of "mineral."

Even if oil were treated as a mineral resource for purposes of CEQA, the ZAI would not cause a significant impact because it is administrative in nature, does not itself authorize or prohibit extraction, and any alleged consequences such as accelerated abandonment or increased imports are speculative. An argument that the ZAI will change the pre-existing oil well maintenance activities already occurring, and that such changes could result in a direct or reasonably foreseeable indirect impact, is so attenuated as to be grounded in speculation. The ZAI only formalizes the intent and interpretation of the term "well maintenance", to follow past practice. Instead of relying on a case-by-case interpretation, the ZAI provides a formal interpretation of specific oil/gas well activities that would be considered "well maintenance", which under the current Zoning Code may be subject to discretionary review. The ZAI does not change the scope, intent, or impacts of existing regulations, and, in and of itself, cannot effect a change in the environment. The ZAI is providing an interpretation of preexisting language in the Zoning Code and is assisting in the implementation of an established application process. No additional impacts can be attributed to the ZAI and its interpretation of maintenance.[14] In this regard, the ZAI cannot and will not result in a direct or reasonably foreseeable indirect impact on the environment. The interpretation therefore falls within both CEQA Guidelines Section 15378(b)(2), which covers general policy and procedure-making activities, and Section 15378(b)(5), which expressly exempts administrative activities that will not result in environmental impacts.

B. The City did not piecemeal environmental review.

This subresponse addresses ***Warren Resources' Appeal Point 1-3*** *and* ***E&B Natural Resources Appeal Points 2-1*** *and their allegations that the environmental review for the ZAI has been piecemealed.*

The appellants generally allege that LACP has piecemealed the environmental review for the ZAI, but provide no actual evidence or explanation as to how this has occurred as a result of interpreting the phrase "well maintenance" for implementation of the existing Zoning Code.

"Piecemealing" occurs when a public agency separates a single larger project into smaller projects to conduct separate environmental analyses and minimize a project's true impacts. (*Aptos Council v. Cnty. of Santa Cruz* (2017) 10 Cal.App.5th 266, 278.) Two elements must be present: "future expansion or other action . . . : (1) . . . is a reasonably

[14] CEQA Guidelines Section 15378(b)(5) states: *"Project" does not include organizational or administrative activities of governments that will not result in direct or indirect physical changes in the environment.*

foreseeable consequence of the initial project; and (2) the future expansion or action will be significant in that it will likely change the scope or nature of the initial project or its environmental effects." (*Laurel Heights Improvement Assn. v. Regents of Univ. of California* (1989) 47 Cal.3d 376, 396.)

As stated above, the ZAI is not a project under CEQA requiring environmental review. Per LAMC Section 13A.1.7.D.2.b of Chapter 1A, the Chief Zoning Administrator has authority to make an interpretation to administer the code when the meaning of the regulation is not clear, either in general or as it applies to a specific property or situation. In this case, the ZAI is an administrative decision, made in the implementation, administration, or enforcement of regulations that involve the determination of facts and the application of objective standards.

The appellants also argue that the ZAI must be reviewed together with a potential future ordinance that they speculate will ban well maintenance. This argument misstates CEQA requirements. CEQA requires agencies to evaluate the action before them, the "whole of the action", not hypothetical future legislation. If a future ordinance is proposed, it will undergo its own CEQA review. The possibility of a later ordinance does not transform this administrative interpretation into piecemealing or a broader project.

Thus, the appellants' arguments concerning CEQA and the ZAI are not valid. The ZAI is not a project, as it only is an action that interprets existing terminology found in the LAMC to facilitate the City's administration of its own established regulations – it does not have the potential to result in direct or reasonably foreseeable indirect impacts to the physical environment. The approval of the ZAI is not illegal piecemealing, and no additional or subsequent environmental review is required.

C. The ZAI is exempt from CEQA.

*This subresponse addresses **Warren Resources' Appeal Point 1-4** and **E&B Natural Resources' Appeal Points 2-4, 2-5, 2-6, and 2-7**, and their arguments allege that the ZAI is not exempt from CEQA, as it does not qualify for a Class 8 categorical exemption or common sense exemption, and as the ZAI will result in cumulative impacts and constitutes unusual circumstances.*

The ZAI is not a project under CEQA requiring environmental review, as it involves an administrative interpretation of existing regulations found within the Zoning Code. However, even if the ZAI is a project subject to CEQA, the ZAI is exempt under the Class 8 and common sense exemptions. None of the exceptions to categorical exemptions under CEQA Guidelines Section 15300.2 apply. Notably, the ZAI does not have the potential to result in significant cumulative impacts, nor is there a reasonable possibility that the ZAI will have a significant effect on the environment due to unusual circumstances.

The appellants argue that the ZAI does not qualify for a Class 8 categorical exemption because it will limit the ability for oil and gas production facilities to operate and have the potential for significant, adverse impacts to the City's mineral resources, air quality, and GHG. The Class 8 exemption is the appropriate CEQA exemption for the ZAI, as it is an action taken by the City that involves procedures for the protection of the environment. The ZAI interprets a term in the existing Zoning Code, providing a land use interpretation that aligns with the intent and objectives of the City's regulations, which is to protect the public health, peace, and safety of persons residing or working on the premises and in the surrounding area. Although the appellants claim the ZAI will result in significant effects on mineral resources, air quality, and GHG emissions, these claims are speculative and unsupported by evidence.

The ZAI is not circumventing the CEQA process. Instead, it interprets a term found in an existing regulation that requires oil operators proposing well maintenance projects to file for a discretionary review, including an environmental assessment, through the Los Angeles City Planning Department. Appellants have not demonstrated that the ZAI will restrict oil and gas production facility operations or create environmental risks. Rather, the ZAI is consistent with the Department's long-standing practice of treating intensive maintenance activities as discretionary actions when examined on a case-by-case basis.

The ZAI also qualifies for the common sense exemption, Section 15061(b)(3), which applies when it is clear that an action has no possibility of causing a significant environmental effect. The ZAI does not in itself authorize or limit maintenance activity. It only interprets the term "well maintenance," consistent with the City's long-standing practice. There is no reasonable possibility that this interpretation will itself cause a direct or indirect environmental impact.

The appellants argue that the ZAI will accelerate oil well abandonment, but provide no causation or factual support for this conclusory statement. The appellants argue that these alleged impacts will result from a purported acceleration of well abandonment and from the increased importation of replacement oil. But, the appellants do not identify a causal connection between the ZAI and these alleged impacts, and only provide speculation that cannot support an argument that there would be any causal connection between the ZAI and a direct or reasonably foreseeable indirect impacts. (*Union of Medical Marijuana Patients, Inc. v. City of San Diego (*2019) 7 Cal.5th 1171*; San Francisco Taxi Coal. v. City and County of San Francisco* (9th Cir. 2020) 979 F.3d 1220). The argument that the ZAI will change the pre-existing oil well maintenance activities already occurring, and that such changes could result in a direct or reasonably foreseeable indirect impact, is so attenuated as to be grounded in speculation. The ZAI does not compel abandonment or directly affect oil importation. Because the ZAI is an administrative interpretation that does not directly create new environmental impacts, it cannot result in cumulative impacts requiring further CEQA analysis.

The appellants further contend that the ZAI presents "unusual circumstances." The appellants, however, do not identify how the ZAI is an "unusual" exercise of the Zoning Administrator's discretion to provide an interpretation of a pre-existing term in the LAMC. Nor do the appellants identify a reasonable possibility that any alleged environmental impact would result due to any such unusual circumstances. The ZAI does not expand or alter oil well operations; it simply clarifies which activities constitute "well maintenance," a valid and established exercise of the Zoning Administrator's authority pursuant to the LAMC. It applies uniformly citywide and is consistent with other regulatory frameworks like CalGEM rework permits and SCAQMD Rule 1148.2. Thus, the ZAI does not constitute an unusual circumstance, and the unusual circumstances exception does not apply.

D. Other Municipal Oil Regulations in Los Angeles County and Related CEQA Determinations

By way of example, another city in Los Angeles County, the City of Carson, previously adopted an amendment to their oil regulations, and relied on a categorical exemption under CEQA. There was no opposition from oil well companies operating in Carson, including from E&B Natural Resources, one of the appellants here. Carson's oil and gas code amendments, No. 19-15 and No. 20-15 included targeted changes to well stimulation activities including acidizing and hydraulic fracturing (fracking) in addition to new regulations for existing oil well extraction operations. These code amendments were codified by ordinance in 2016. Carson released a Planning Commission staff report in 2015 that discussed proposed municipal code amendments concerning oil and gas well operations. The staff report, dated February 24, 2015, explained that Carson would rely on a Class 8 Categorical Exemption for the code amendment.[15] The staff report additionally explained that the code amendment would regulate more oil well activities and that as a result, would reinforce environmental safeguards. Carson officially determined that the oil amendment was categorically exempt on June 9, 2016 because the amendment would "...enhance regulation of petroleum production and facilities in the City to better protect the environment."[16] One of the appellants here, E&B Natural Resources, operates many active oil wells in Carson. According to a news publication, this appellant never raised any legal concerns for the adoption of a Categorical Exemption for the oil and gas code amendments even though Carson was adopting more restrictive regulations to existing oil wells in the city.[17] Unlike Carson's code amendments, the ZAI does not create new regulations. The ZAI interprets terminology already existing in the LAMC, and formalizes the requirement that oil well operators in the City, not just the appellants, file for a discretionary land use review for specific oil well activities that may cause adverse land use impacts.

---

[15] City of Carson Planning Commission Staff Report for Text Amendment No. 20-15. February 24, 2015. <https://ci.carson.ca.us/content/files/pdfs/planning/sr/2015-02-24/20-15.pdf>

[16] CEQA State Clearinghouse Webpage. Text Amendment No. 19-15. <https://ceqanet.lci.ca.gov/2016068104>

[17] "Carson strikes out at oil industry, adopts toughest regulations in the state". Sandy Mazza, Daily Breeze. September 6, 2017. <https://www.dailybreeze.com/2016/04/06/carson-strikes-out-at-oil-industry-adopts-toughest-regulations-in-the-state/>

2. APPEAL TOPIC: ZONING ADMINISTRATOR AUTHORITY

Summary of Appeal Point

Warren Resources alleges that the Zoning Administrator exceeded the scope of their authority. Similarly, E&B Natural Resources contends that the Zoning Administrator lacks authority to issue the 2025 ZAI.

APPEAL RESPONSE

A. Zoning Administrators hold clear land use authority to interpret the Zoning Code.

*This subresponse addresses **Warren Resources' Appeal Point 2-2** and their arguments that the Zoning Administrator has exceeded their authority in issuing the ZAI and that the ZAI expands the scope of the existing Zoning Code and its regulations for well maintenance.*

Pursuant to the Los Angeles Charter and Administrative Code, Volume 1, Article V (General Provisions Related to Departments - City Planning), Section 561, the Chief Zoning Administrator functions as a lead decision maker within the quasi-judicial agency known as the Office of Zoning Administration. Appointed by the Director of Planning, the Chief Zoning Administrator manages and leads the OZA in investigating and determining all applications for variances from any of the regulations and requirements of the zoning ordinances, and exercise other powers and duties with respect to zoning and land use as prescribed by ordinance. In addition, the Chief Zoning Administrator yields the unique authority to "adopt rules necessary to carry out the requirements prescribed by ordinance and which are not in conflict or inconsistent with those ordinances." (L.A. Charter, art. V. § 561.)

LAMC Section 13A.1.7.D.2 of Chapter 1A empowers the Chief Zoning Administrator to interpret specific uses and zoning regulations, stating in part:

> *"The Zoning Administrator shall have the authority to determine other uses, in addition to those specifically listed in this Chapter and Chapter 1 (General Provisions and Zoning), which may be permitted in each of the various zones, when in his or her judgment, the other uses are similar to and no more objectionable to the public welfare than those listed.*
>
> *The Zoning Administrator shall also have authority to interpret zoning regulations when the meaning of the regulation is not clear, either in general or as it applies to a specific property or situation..."*

In the ZAI, the Chief Zoning Administrator, relying upon the extensive research of well maintenance activities, interprets a zoning regulation that is not clear: what oil/gas well activities are permitted pursuant to the relevant LAMC sections that mention "well maintenance." The Chief Zoning Administrator has historically exercised this same authority for the formal interpretation of other terms, uses and regulations.

The ZAI does not redefine or expand the OZA's historical treatment of the term "well maintenance"; rather, it represents a standardization of a practice previously applied on a case-by-case basis, consistent with the Zoning Code. The appellants argue that the ZAI constitutes an "underground regulation" adopted without the procedures required for a legislative action. This argument lacks merit. Pursuant to LAMC Section 13A.1.7.D.2 of Chapter 1A, the Chief Zoning Administrator is authorized to interpret undefined or ambiguous zoning terms. The ZAI does not amend the Code or create new law; it clarifies an existing provision to ensure consistent application.

Unlike the 2023 ZAI, which was tied to the now-rescinded Oil Ordinance No. 187,709, the 2025 ZAI arises from a different set of circumstances. It relies solely on the City's zoning authority to interpret existing provisions in LAMC Sections 13.01 H and I, regulations that allow for discretionary consideration of maintenance activities.

B. The ZAI followed the proper procedures of the Zoning Code.

*This subresponse addresses **Warren Resources' Appeal Point 2-1, 2-3, and 2-4** and **E&B Natural Resources' Appeal Points 3-1 and 3-2**, and their arguments that no public process was followed prior to the issuance of the ZAI, that the Zoning Administrator lacks authority to issue a citywide ZAI under Chapter 1A of the LAMC, and that Section 1.4.7 of Chapter 1A renders the ZAI ineffective.*

ZAIs are formal land use interpretations from the Zoning Administrator. ZAIs are not code amendments that require a public outreach process. As discussed earlier in this appeal response, the authority and purview of the Chief Zoning Administrator granted in the City Charter and LAMC includes acting in a quasi-judicial capacity and issuing ZAIs. The ZAI is a codified process described in the LAMC Section 13A.1.7.D.2 of Chapter 1A. There are no requirements to issue a draft copy of the ZAI and/or require a staff report for release prior to issuing a citywide ZAI.

Nevertheless, the OZA completed an extensive amount of research concerning land use impacts and well maintenance activities. OZA staff also received, read, and considered feedback from the public, including oil drilling operators, environmental justice advocates, and some of the appellants, regarding the interpretation of "well maintenance." The research and outreach efforts are summarized in this report and are detailed more extensively in the administrative record.

While the LAMC does not require a public hearing or a circulation of a draft report for a ZAI, there is still a process by which an appeal can be made to the Area Planning Commission or the City Planning Commission to address challenges to a Zoning Administrator's Interpretation. On June 27, 2025, the appellants filed timely appeals, which are the subject of the City Planning Commission's decision as the appellate body, as prescribed by the Zoning Code.

The appellants are additionally incorrect in asserting that the ZAI does not apply to areas where Community Plans have not been updated. Effective January 22, 2024, the administrative provisions of the Processes and Procedures Ordinance (Ordinance No. 187,712) became applicable citywide, establishing Chapter 1A, Article 13 of the LAMC and ensuring that all properties are subject to the same processes regardless of the status of their Community Plan updates. This is further evidenced by the cross reference in Section 12.21 A.2 of Chapter 1 pointing to the authority under the ZAI procedures pursuant to Section 13A.1.7.D.2 of Chapter 1A. The ZAI was issued on June 12, 2025, pursuant to these relevant citywide provisions which apply uniformly across the City.

The appellants further assert that the ZAI is ineffective under Chapter 1A of the Zoning Code, pointing to Section 1.4.7 of Chapter 1A.

Section 1.4.7 states:

> *"In recognition of the September 6, 2024 trial court ruling in Warren E&P, Inc. v. City of Los Angeles, Los Angeles Superior Court No. 23STCP00060, and its related cases, all oil production and oil well related regulations in this Chapter 1A, including but not be limited to the provisions in Part 5B. (Use Districts), Part 5C. (Use Rules), Part 5D. (Use Definitions), Sec. 8.2.4. (Oil Drilling Districts (O)), Sec. 14.3. (Glossary), and any related Zoning Administrator Memos and Interpretations shall be ineffective until such time as this Section (Warren E&P, Inc. v. City of Los Angeles and Oil Regulations) is amended."*

Section 1.4.7 applies only to oil regulations found within Chapter 1A. The 2025 ZAI is not related to any Chapter 1A oil regulation; it interprets the meaning of "well maintenance" as used in and in relation to Chapter 1, Section 13.01 H and I, which are long-standing provisions of the City's original Zoning Code. Accordingly, Section 1.4.7 does not render the ZAI ineffective. Appellants' reliance on Section 1.4.7 is therefore misplaced. The Chief Zoning Administrator properly exercised their authority under LAMC Section 13A.1.7.D.2 to clarify an ambiguous term of the Zoning Code. The 2025 ZAI is valid and effective citywide.

3. APPEAL TOPIC: GENERAL PLAN CONSISTENCY

Summary of Appeal Point

Warren Resources alleges that the ZAI is inconsistent with the General Plan.

APPEAL RESPONSE

This appeal point is not applicable because the LAMC does not require general plan consistency findings for the issuance of the ZAI.

*This response addresses **Warren Resources' Appeal Point 3-1** and their assertion that the ZAI is inconsistent with the General Plan by limiting local oil production.*

The LAMC does not require general plan consistency findings for the issuance of the ZAI. The ZAI interprets an existing term found in the LAMC and the ZAI does not create regulations for oil/gas wells that would require such general plan consistency findings.

Warren Resources further asserts that the ZAI is inconsistent with the City's General Plan policies supporting conservation of petroleum resources. This claim is misplaced. Interpretive determinations by the Chief Zoning Administrator do not amend zoning designations or create new policy; they clarify existing provisions to ensure consistent administration. General Plan consistency findings are required when adopting legislative actions such as ordinances or plan amendments, not when issuing administrative interpretations. The ZAI therefore does not implicate General Plan consistency requirements and remains consistent with the City's land use authority to interpret the Zoning Code.

Warren Resources' assertion that the ZAI functions as a prohibition on maintenance activities is not supported. The ZAI does not regulate or determine whether oil and gas production may continue; it is an interpretive action clarifying the meaning of "well maintenance" within the Zoning Code. The interpretation does not itself eliminate or restrict activities that are otherwise authorized under existing law. Allegations that the ZAI will diminish domestic or local production are speculative and not a consequence of the ZAI. Rather, the ZAI provides clarity and consistency by standardizing how the City applies long-standing provisions of the Code.

4. APPEAL TOPIC: VESTED RIGHTS

Summary of Appeal Point

Warren Resources alleges that the ZAI impairs their vested rights. Similarly, E&B Natural Resources claims that the ZAI constitutes a taking of their vested rights.

APPEAL RESPONSE

A. The ZAI does not conflict with operators' vested rights.

*This subresponse addresses **Warren Resources' Appeal Point 4-1** and **E&B Natural Resources' Appeal Point 7-1** and their claims that the ZAI impairs their vested rights.*

The ZAI does not conflict with any operators' vested rights. The ZAI interprets existing terminology referenced in the LAMC and does not impact currently held vested rights. Operators holding valid land use approvals issued under LAMC Section 13.01 H or a variance may continue to extract and produce oil at their respective drill site locations while following all imposed conditions of approval as well as all applicable city, county, state, and federal laws and regulations. Valid entitlements remain fully intact and operators may continue to exercise those rights subject to their conditions and applicable law. The ZAI does not retroactively alter or rescind those approvals.

The ZAI is also not an expansion of discretionary authority. Since 1955, LAMC Section 13.01 has required discretionary approvals for certain types of activity on oil well sites. The ZAI, supplementing existing regulations in the Zoning Code, identifies which future scopes of work, such as recasing or maintenance acidizing, are considered maintenance based on their impacts, consistent with long-standing practice by the OZA to treat those maintenance activities with the greatest potential land use impacts as discretionary.

The appellants argue that the ZAI constitutes a taking of property without just compensation and that it disregards property rights, mineral rights, and operational rights, leading to the abandonment of wells. This claim does not have merit. The ZAI does not deprive operators of all economically beneficial use of their property and therefore does not amount to a regulatory taking. Operators may continue lawful operations under existing approvals and may apply for discretionary Zoning Administrator review for proposed "well maintenance" activities. Thus, the ZAI does not constitute a taking, as its function is limited to an interpretation of an existing LAMC provision.

Under the constitution, no private property shall be taken for public use without the payment of just compensation. U.S. Const. 5th Amend. The ZAI is not an infringement on property rights or an operator's vested rights to operate wells. Rather, the ZAI interprets a term in the LAMC. It does not create requirements or prohibit activities. The ZAI does not extinguish vested rights, interfere unlawfully with contracts, or mandate compensation. It merely interprets a zoning term to ensure consistent administration of the Code. Operators remain free to continue lawful production consistent with their existing approvals and may apply for discretionary review of proposed well maintenance activities.

B. The diminishing asset doctrine is not relevant to the ZAI.

*This subresponse addresses **E&B Natural Resources' Appeal Point 7-2** and their claim that under the diminishing asset doctrine, they have a vested right to produce oil and gas resources until the resource is exhausted or otherwise uneconomical to produce.*

In regard to the diminishing asset doctrine, the ZAI does not deprive operators of access to subsurface minerals, nor does it retroactively alter or rescind those approvals. Instead, it clarifies whether a proposed scope of work qualifies as maintenance in order to determine whether the activity would be subject to an already established discretionary review process under the Zoning Code.

Firstly, because oil and gas are not minerals, their extraction is not mining. Because oil and gas extraction is not mining, the diminishing asset exception, which is specific to mining enterprises, does not apply to oil and gas extraction. (*Hansen Brothers Enterprises, Inc. v. Board of Supervisors* (1996) 12 Cal.4th 533, 553.)

The appellants claim that the interpretation of well maintenance is in and of itself a restriction on those types of activities and that action also violates their legal rights to operate their oil/gas wells. The ZAI is a zoning interpretation of what a specific term means in the City's Zoning Code provisions. The ZAI does not impose a prohibition on well maintenance, but instead clarifies which activities would be considered as "well maintenance" projects, as that term is already used in the Code.

The ZAI does not violate legal rights to continuing oil/gas wells because it merely interprets existing terminology in the City's Zoning Code provisions. The ZAI formalizes existing practice and interpretation of what is considered well maintenance. For example, LACP has consistently treated CalGEM NOI permits for Rework or redrilling as "well maintenance." The ZAI simply creates consistency and standardization of that practice.

C. Warren Resources' Appeal Point 4-2 is a matter that is outside the scope of the ZAI appeal.

*This subresponse addresses **Warren Resources' Appeal Point 4-2** and their argument that the Zoning Administrator should be estopped from defining maintenance activities in a way that restricts their ability to maintain the productive life of its well.*

Appellant Warren Resources claims that the Zoning Administrator should be prevented from interpreting what activities qualify as "well maintenance" because by doing so, the ZAI is breaching requirements imposed onto Warren Resources as part of a previous land use approval. The appellant provides an example that is specific to a drill site operation's land use approval where the Zoning Administrator had allowed specific oil/gas well activities within a permitted timeframe. That land use approval was issued in July 2006 pursuant to Case No. ZA-1972-20725-O-PA1.

This appeal is not the proper place to raise this argument because it is not before the City Planning Commission. Questions and arguments regarding the scope or meaning of site-specific approvals remain within the Zoning Administrator's authority and are not relevant to this citywide appeal. The Zoning Administrator, as is customary with many land use decisions, reserves the right to interpret the intent and practice relating to any approvals and Conditions of Approvals. The Commission's decision is limited to whether the June 12, 2025, ZAI properly interprets "well maintenance" under the LAMC. And to this appeal, the appellant's contention about this site-specific 2006 approval is not relevant to this ZAI appeal.

5. APPEAL TOPIC: CONTRACT INTERFERENCE

Summary of Appeal Point

Warren Resources alleges that the ZAI unlawfully interferes with their contracts. Similarly, E&B Natural Resources argues that the ZAI interferes with their contractual obligations with the City.

APPEAL RESPONSE

The ZAI does not require, implicitly or explicitly, for operators to close operations, nor does it forbid or eliminate all maintenance activities.

*This response addresses **Warren Resources' Appeal Point 4-3** and **E&B Natural Resources Appeal Point 6-1** and their arguments that the ZAI will interfere with the appellants' contracts with private and public entities by eliminating maintenance activities and consequently forcing operators to cease production.*

The appellants argue that the ZAI unlawfully impairs contracts with mineral owners and lease agreements with the City. This claim is misplaced. The ZAI does not impair existing contracts; lease obligations and mineral rights agreements remain enforceable under the law. Rather than terminating or interfering with contractual obligations, the ZAI interprets which activities are considered "well maintenance." The ZAI merely clarifies the scope of activities that are considered maintenance and subject to discretionary review under existing code provisions. Operators remain free to continue lawful production consistent with their existing approvals and retain avenues for discretionary review of proposed maintenance activities. In this respect, operators retain pathways to comply with both their contractual obligations and zoning requirements.

LAMC Section 13.01 H authorizes the Zoning Administrator to review and conditionally approve drilling, deepening, and well maintenance projects. Operators may submit an application to request a review and determination from the Zoning Administrator for new well maintenance activities. Under this review, and as shown by existing practice, these

activities are not necessarily prohibited and may even be permitted pursuant to a Zoning Administrator's determination. Alternatively, operators could seek a general variance, pursuant to LAMC Chapter 1A, Section 13B.5.3, for any type of drilling activity. (*Stolman v. City of Los Angeles* (2013) 114 Cal. App. 4th 916, 926.)

These two discretionary review processes are available to operators for oil/gas well project requests. Operators have the choice to apply for discretionary review pursuant to LAMC Section 13.01-H or a Zone Variance. If operators choose not to apply for any discretionary review process and they elect to cease operations then it is not because of any requirement in the ZAI. An operator's decision to not submit an application to conduct well maintenance and instead to cease operations is a voluntary decision impacting a private agreement.

In this way, the ZAI does not interfere with private contractual obligations, but ensures that any maintenance activity with significant land use impacts is subject to the same review and conditions applicable to all operators.

6. APPEAL TOPIC: THE ZAI IS VAGUE AND AMBIGUOUS

Summary of Appeal Point

E&B Natural Resources alleges that the ZAI, in its current form, must be rejected as vague and ambiguous.

APPEAL RESPONSE

The interpretation of the term maintenance is not vague or ambiguous for incorporating and referencing existing state rules.

*This response addresses **E&B Natural Resources' Appeal Point 1-1** and their assertion that the ZAI is vague and ambiguous for being dependent on SCAQMD Rule 1148.2.*

The appellants claim that the ZAI fails to explain how it interacts with the various provisions of SCAQMD Rule 1148.2, and as such, the ZAI is improperly vague and ambiguous, leaving operators, suppliers, and other individuals involved in oil and gas extraction operations without proper guidance and understanding for how the City will ultimately enforce its Code requirements.

The ZAI outlines what activities would be considered "well maintenance" in a clear and unambiguous manner that both the public and drill site operators can understand. The ZAI states that any scope of work that requires an operator to apply for a CalGEM NOI to Rework permit and/or submit an online notification to SCAQMD pursuant to the agency's Rule 1148.2 standards – and which include activities such as acidizing, hydraulic fracturing, gravel packing, maintenance acidizing, matrix acidizing, and acid fracturing –

would then qualify that proposed scope of work as “well maintenance”, as it is referenced in the LAMC.

These two state rules reflect existing standards that are part of the overall regulatory structure for oil/gas wells, and constitute rules that oil operators know, understand, and comply with as part of their ongoing operations. The ZAI relies on these well-established rules to identify which activities fall within the scope of activities the Zoning Code may subject to discretionary review under its existing regulations. The ZAI’s statement of which oil/gas well projects qualify as well maintenance are activities that operators are already familiar with since those same activities already require additional regulatory compliance by other agencies. The ZAI’s incorporation of these other rules does not render the ZAI vague or ambiguous.

7. APPEAL TOPIC: DUE PROCESS

Summary of Appeal Point

Warren Resources alleges that the ZAI is arbitrary, capricious, lacking in evidentiary support, and an abuse of discretion. E&B Natural Resources further contends that the alleged expanded definition of maintenance in the ZAI is not a legitimate exercise of police power.

APPEAL RESPONSE

A. The ZAI did *not* violate the Appellants’ due process rights. The ZA may interpret the Zoning Code and the ZAI was a result of rigorous, methodical, and valid research.

*This subresponse addresses **Warren Resources’ Appeal Points 5-1 and 5-2** and **E&B Natural Resources’ Appeal Point 5-1 and 5-2** and their claims that the ZAI is arbitrary, capricious, not a reasonable exercise of police power, lacks evidentiary support, and is a violation of due process.*

Zoning Administrator’s Authority and Judicial Deference

The Zoning Administrator has the authority to interpret terms in an already established ordinance and/or Zoning Code provisions. The City’s interpretation of its own ordinance is entitled to deference. (*J. Arthur Properties, II, LLC v. City of San Jose* (2018) 21 Cal.App.5th 480, 486.) Greater deference is appropriate where, as here, there is a record of careful consideration by senior agency officials. (*J. Arthur Properties, supra*, 21 Cal.App.5th at 486.) Interpretations by the Zoning Administrator are made with the clear intent to remain true to the original intent of the LAMC provision. In this specific case, the Chief Zoning Administrator's interpretation of "well maintenance" remains committed to the original intention of the Zoning Code – and that is to review well maintenance projects,

similar to other oil/gas well activities, that may have an impact on the welfare of a community.

In fact, the City's implementation of ZA Memo No. 133, which outlines the discretionary review procedures for drilling, redrilling, and well maintenance projects, has already been determined to not entail a due process violation. In *Youth for Envtl. Justice v. City of L.A., No. B282822, 2019 Cal. App. Unpub. Feb. 15, 2019) ("YEJ v. City of LA"),* an unpublished opinion clearly outlined that additional procedural review steps for oil well projects does not result at all in any due process violations: "...the mere fact that Memorandum 133 may and likely will burden CIPA members' future oil operations does not establish a protected property interest sufficient to claim a due process violation. Rather, Memorandum 133 seeks to guide discretionary decisions that the Los Angeles Municipal Code empowers the City to make, and the memorandum does not injure any protected rights of CIPA members." For the record, one of the appellants, E&B Natural Resources, was a CIPA member at the time of this decision and still is a CIPA member as of this appeal.

Lastly, one of the appellants, E&B Natural Resources, confirms the validity of ZA Memo 133 and the Zoning Administrator's right to conduct public hearings and require environmental review under CEQA for projects pursuant to LAMC Section 13.01 H. On March 24, 2025, the appellant's legal representative highlighted in a letter of correspondence to the Planning and Land Use Management Committee of the Los Angeles City Council that the Zoning Administrator reserves the right to utilize the procedures detailed in ZA Memo 133 with regards to both modifications of previously approved Conditions as well as projects pursuant to LAMC Section 13.01 H (e.g. drilling, redrilling, and well maintenance).[18] The 2025 ZAI is an appropriate tool for the implementation of the Zoning Code. More so, the procedural steps delineated in ZA Memo 133 for well maintenance projects is a valid exercise of the ZA's authority to implement existing regulations under LAMC Section 13.01 H.

Exercise of Police Power

There are other forms of authority granted to Zoning Administrators related to the LAMC that illustrate the discretion granted to these officials. The LAMC gives the Zoning Administrator the authority to grant approval or to disapprove projects, or even modify existing land use approvals for drill sites in order to protect the health, safety, and general welfare of the community. LAMC Sections 13.01 E.2, Chapter 1A 13B.6.2 (formerly 12.27.1), and, historically, 13.01 H and 13.01 I, identify the Zoning Administrator as an appropriate decision maker for projects concerning, and for the oversight of, oil/gas well operations. It is within the Zoning Administrator's authority to review projects and prescribe any land use approvals with necessary conditions to safeguard neighbors and the environment. Thus, the ZAI is a valid exercise of police power.

---

[18] "Opposition to Agenda Item No. 5 (Council File 24-1580), March 25, 2025, PLUM Meeting." Alston & Bird. <https://cityclerk.lacity.org/onlinedocs/2024/24-1466_PC_PM_05-05-2025.pdf>

Research and Evidentiary Support

The record here demonstrates that OZA staff assisted the Chief Zoning Administrator in the research and development of the ZAI. The extensive research encompassed various consultations with regulatory agency staff, correspondence, and data requests in order to develop a thorough understanding of well maintenance activities. As seen in the ZAI's administrative record, OZA staff corresponded and inquired with various city, county, and state officials to discuss the regulation of oil/gas well maintenance activities. OZA staff also spoke with senior managers and inspection officials to gain both a policy and implementation perspective on well maintenance activities. Staff's research includes review of academic articles discussing the effects of oil and gas well activities. Several of the studies referenced in the ZAI and in the administrative record are based in California and Los Angeles and are as recent as June 2024.

One 2017 study discussing the overlap of chemicals across different types of oil well activities, used SCAQMD project data in their analysis. In summary, the authors of this study share that this overlap exists because these chemicals have a propensity to change fluid properties of oil (such as the cohesiveness) and to otherwise increase production of oil within the [oil reservoir] formation. Specific chemicals and acids are also used because they facilitate hydrocarbon production at the oil/gas well sites. This study is directly relevant because it demonstrates that routine maintenance activities utilize many of the same categories of hazardous chemicals as more intensive interventions already recognized and regulated by SCAQMD, including hydraulic fracturing (fracking). By documenting this overlap, the study provides substantial evidence that well maintenance projects can pose comparable land use and public health impacts, justifying discretionary review. The appellants' disagreement with the conclusions of the study does not negate its validity; it remains part of the peer-reviewed, agency-recognized body of research supporting the ZAI.

In addition, the California Oil & Gas Public Health Rulemaking Scientific Advisory Panel report, commissioned by the Department of Conservation, synthesized peer-reviewed research and found increased health risks within 1 kilometer (3,281 feet) of oil and gas wells. This report, titled "Public Health Dimensions of Upstream Oil and Gas Development in California: Scientific Analysis and Synthesis to Inform Science-Policy Decision Making", is relevant not only because it was cited in the ZAI, but also because it served as the scientific basis for Senate Bill 1137, which established a 3,200-foot setback between wells and sensitive receptors. The Legislature's reliance on these findings confirms their credibility and relevance.

Other studies cited in the ZAI are likewise valid and relevant. SCAQMD's Rule 1148.2 reporting data documents chemical use, timing, and emissions associated with rework and maintenance activities in Southern California. Local assessments conducted by Los Angeles County and the City of Los Angeles link oil and gas operations to respiratory illness, odor, noise, and quality-of-life impacts in surrounding communities. Collectively,

these studies and data sources form a robust evidentiary record demonstrating that maintenance activities can create land use and environmental impacts. Together, they provide the rational basis necessary for the City's exercise of its police power to require discretionary review of well maintenance activities.

Appellants further contend that the City has never required discretionary review for maintenance acidizing. However, the absence of past case filings reflects the historic difficulty of tracking such activities, not the absence of authority. Prior to SCAQMD's adoption of Rule 1148.2 in 2013, the City had no formal notification mechanism to rely on to identify when maintenance acidizing occurred, unless complaints were filed, and even then it was difficult to confirm the specific activity. For example, at the Murphy Drill Site the City issued a Letter of Communication documenting that what was later identified as maintenance acidizing had been performed and advising that it may require a discretionary review. With the implementation of SCAQMD Rule 1148.2, the City is now able to consistently identify these activities and apply discretionary review in a clear and transparent manner.

These types of studies illustrate the existing literature on oil well activities, public health, and the environment as it pertains to well maintenance activities. This highlights the need for a ZAI that interprets which oil/gas well activities would qualify as "well maintenance" and be subject to a Zoning Administrator's determination pursuant to procedures already established under LAMC Section 13.01 H.

Coordination with CalGEM and SCAQMD

The ZAI incorporated existing CalGEM and SCAQMD regulations into the interpretation for a variety of reasons. First, well activities that warrant regulatory oversight from the State often result in land use impacts that are regulated at the local level. This enables the City to meet the intent of its local zoning regulations to protect the public health, safety, and environment by requiring discretionary review for maintenance activities that have the greatest land use impacts on communities, while helping to facilitate coordination with State agencies on matters relating to oil well operations. In meeting with different staff, the OZA was able to understand the intent and process of how different agencies, including CalGEM and SCAQMD, regulate oil wells. This insight allowed OZA staff to shape the ZAI interpretation so as not to conflict with existing state regulations. It also supported the interpretation research by ensuring that OZA staff were referencing key terms and programs correctly, including CalGEM and SCAQMD regulations.

The two-track system for determining which activities would be considered "well maintenance" was informed by the fact that two state agencies regulate well maintenance activities. These two state agencies had already decided these activities merited some form of regulation or permitting in order for the operator to complete said well maintenance activity. The processes of these two state regulators allow OZA staff to track and monitor applications to complete these projects. CalGEM is in contact with the OZA on when

Rework projects are submitted for oil wells within the City of Los Angeles. OZA staff are also subscribed to email notifications for when operators submit a notification for a Rule 1148.2 activity that could be considered "well maintenance." This can lead to better inter-agency coordination and enforcement.

Additionally, operators are familiar with how these processes work in regards to oil/gas well operations. Operators must follow numerous rules and standards across different agencies and levels of government, including CalGEM and SCAQMD. Operators are responsible for remaining compliant with those two agencies in particular and it is likely they are already familiar with CalGEM Rework permits and SCAQMD Rule 1148.2 notification rules. All of the oil/gas well operators in the City of Los Angeles have either been operating their drill sites for several years and/or have drill site operations in other parts of California. As a result, it is likely they are familiar with CalGEM's statewide policies and understand the process. Operators who have been active in Southern California for years should also be familiar with their obligations pertaining to SCAQMD rules, especially given the heightened attention and visibility to air quality policies. That is, they are familiar with these activities and would know that if they are applying for a CalGEM Rework permit or submitting a SCAQMD notification – then their activity would be considered "well maintenance" pursuant to the LAMC. This familiarity is important because it shows that the ZAI does not create new obligations but formalizes practices operators already follow under state law. By aligning with existing CalGEM and SCAQMD procedures, the ZAI ensures accountability and prevents operators from claiming surprise or lack of notice.

B. The ZAI also factored in land use impacts from well maintenance activities.

*This subresponse addresses **Warren Resources' Appeal Point 5-2** and their claim that the ZAI lacks evidentiary support in identifying any concrete examples of impacts associated with the activities the ZAI seeks to regulate.*

OZA staff's inquiries with operators, regulatory agency staff, and neighborhood constituents highlighted that certain oil/gas well maintenance activities had greater land use impacts to public and environmental health and welfare. OZA staff consulted with various parties as to what these projects entailed in regards to their project duration, noise levels, off-road machinery involved, number of employees onsite required, and more. OZA staff spoke with a number of agency staff including personnel from CalGEM, SCAQMD, LA City Fire, and OPNGAS – to name a few. While conducting these consultations, it became apparent that while state agencies regulated oil well maintenance activities, these agencies did not have the comprehensive police powers to address certain land use impacts such as hours of operation and noise. For example, SCAQMD and CalGEM have narrower purviews when it comes to regulating maintenance activity – SCAQMD is primarily responsible for regulating air quality impacts, while CalGEM focuses on oil well engineering and safety. Due to their limited scopes, these state agencies are not able to regulate the land use impacts of maintenance activity in a holistic manner in the same way that the City can through zoning. The Zoning Administrator has the unique responsibility

of assessing and conditioning all possible land use impacts of maintenance work to fill in where the state lacks oversight (e.g., regulating hours of operation, noise, and traffic, to name a few), all the while providing added transparency for local residents impacted by these land use activities.

One of the key components to interpreting which activities would fall under "well maintenance" were the concerning experiences that residents encountered within close proximity to these oil drill sites. OZA staff learned of the potential risk to public and environmental health from documented occasions where well maintenance projects created negative land use impacts to sensitive uses within close proximity of an oil well facility. Below are some occasions when constituents raised valid and clear concerns about these oil well maintenance activities.

- In July 2014, constituents documented negative land use impacts from maintenance acidizing activities at the now decommissioned facility, the Jefferson Drill Site in the Jefferson Park neighborhood of the City. Constituents submitted photographic evidence of damaged landscaping at the drill site allegedly as a result of the local air pollution from the maintenance acidizing activities (see **Exhibit V**). The documentation submitted by constituents to the OZA illustrates the many different chemical treatment tanker trucks and the large-scale operation for the two oil wells where maintenance acidizing was performed.

- In May 2021, constituents contacted OZA staff concerning a maintenance acidizing project at the Murphy Drill Site in Jefferson Park, South Los Angeles and the concerns associated with such project. See **Exhibit S** for the email correspondence documents. Photographic evidence was submitted that showed the amount of heavy-duty tanker trucks arriving into a residential neighborhood for the activity that as of July 1, 2023, will now require SCAQMD notification, and as a result, a ZA determination. OZA staff would later identify that the project coincided with several odor complaints. See **Exhibit U** for reference documents on these SCAQMD records on the odor event violation. A SCAQMD inspector would end up categorizing this as an "odor event" and require a root cause analysis of the "odor event" from the operator.

- In May 2025, constituents spoke at an Energy and Environment Council Committee concerning maintenance acidizing activities (see **Exhibit W**). Constituents submitted both written and verbal testimony highlighting the concerns surrounding the noticing at the Banning Drill Site in the Wilmington neighborhood of the City. Constituents furnished a copy of the required mailing notice that Warren E&P, Inc. sent to nearby residents. The notice, dated November 25, 2024, outlines a concise description of the types of oil well activities that are proposed for the wells at the Banning Drill Site. Existing state regulations permit the operators such as Warren E&P, Inc. to issue one mailing notice for up to 39 maintenance acidizing activities within close proximity to sensitive receptors. Concerns raised by

constituents highlight the benefits of a quasi-judicial review, and potentially, conditioned approval, of any maintenance acidizing activities by a) imposing more strict notification requirements to the City and to local residents and b) expanding on the nature and duration of these intensive oil well activities. Underscoring concerns about inadequate notice, Warren E&P, Inc. was cited by SCAQMD on May 9, 2025, for failure to notify air district officials of rescheduled, cancelled, and new maintenance acidizing activities.

These concerns submitted by constituents informed the ZAI in identifying maintenance acidizing (as an example) as a type of maintenance activity referred to in the LAMC, which can have potential land use impacts, and which would fall within the scope of activities that the Zoning Code subjects to discretionary review. These instances also underscored the need for a Zoning Administrator's Interpretation to formally interpret what activities would be considered as "well maintenance" so as to clearly implement and enforce the intent of the Zoning Code. Thus, the interpretation is reasonable.

In addition, Warren Resources' assertion that its well maintenance activities generate minimal land use impacts is unsubstantiated. The ZAI is a citywide interpretation of the Zoning Code and is not limited to Warren Resources' operations. Well maintenance activities, such as acidizing, recasing, or other subsurface interventions, may result in localized impacts including construction traffic, noise, circulation issues, and public disruption, regardless of the operator. The City is not required to demonstrate actual impacts at every individual site in order to exercise its land use authority. The aforementioned examples of maintenance acidizing concerns demonstrate a repeated pattern of maintenance activities warranting regulatory intervention. As the California Supreme Court recognized in *Beverly Oil Co. v. City of Los Angeles* (1953) 40 Cal.2d 552, 558, ordinances regulating oil operations are a valid exercise of local police power, even where they limit a property owner's use of oil-bearing lands. Similarly, in *Hermosa Beach Stop Oil Coalition v. City of Hermosa Beach* (2001) 86 Cal.App.4th 534, 555, the court upheld restrictions on drilling as a justifiable means of protecting public health and the environment. The ZAI simply clarifies which activities require discretionary review so that potential impacts can be assessed and mitigated as appropriate. Ensuring consistent application of this process across all operators is a reasonable exercise of the City's police power and does not violate due process.

The fact that Warren Resources' production equipment is electrically powered does not eliminate the potential for land use impacts from well maintenance activities. Electrical operations may reduce certain emissions but do not address other community impacts such as traffic from service rigs, noise, hours of operation, or safety considerations during maintenance interventions. Courts have consistently held that local governments may regulate oil operations to address public health and safety impacts broadly, without tailoring requirements to individual sites (*Beverly Oil; Hermosa Beach*). The ZAI does not presume unique impacts from Warren Resources' site; instead, it provides a uniform framework for the review of maintenance activities citywide. By clarifying which activities

require discretionary review to maintain an oil well under LAMC Section 13.01 H, the ZAI ensures that all potential impacts of maintenance activity, even at electrically powered facilities, can be evaluated and mitigated through conditions of approval. This approach reflects the City's obligation to regulate oil and gas uses consistently and proactively and is fully consistent with due process requirements.

8. APPEAL TOPIC: PREEMPTION

Summary of Appeal Point

Both appellants allege that the ZAI is preempted by federal and state law.

APPEAL RESPONSE

A. The 2023 ZAI is distinct from the 2025 ZAI.

*This subresponse addresses **Warren Resources' Appeal Point 6-1** and **E&B Natural Resources' Appeal Point 4-1** and their allegations that the procedures outlined in the ZAI mirror those of the 2023 ZAI and are therefore equally preempted by Public Resources Code Section 3106.*

On December 2, 2022, the City Council approved Oil Ordinance No. 187,709, which became effective on January 18, 2023, amending various parts of the LAMC relating to oil drilling. Among other changes, it eliminated LAMC Sections 13.01 H and 13.01 I and amended LAMC Section 12.23 C.4(a) to prohibit well maintenance, drilling, redrilling, and deepening except to prevent or respond to a threat to public health, safety, or the environment, as determined by the Zoning Administrator.

On January 17, 2023, to implement Oil Ordinance No. 187,709, a Zoning Administrator's Interpretation (Case No. ZA-2022-8997-ZAI-1A) was issued interpreting "well maintenance" alongside Zoning Administrator Memorandum No. 141 (ZA Memo 141), which set forth procedures for applying for Health and Safety Exemptions under the Ordinance.

Oil Ordinance No. 187,709, the associated ZAI, and ZA Memo 141 were challenged by oil operators in four related lawsuits, with the lead case being *Warren E&P, Inc. v. City of Los Angeles*, LASC Case No. 23STCP00060. On September 6, 2024, the Superior Court ruled that Oil Ordinance No. 187,709, the associated ZAI, and ZA Memo 141 were preempted by state law on the basis that they conflicted with Public Resources Code Section 3106, which requires the State Supervisor to oversee oil operations and allow operators to utilize all approved methods and practices.

The 2025 ZAI interprets the term "maintenance" for purposes of implementing a preexisting regulation (LAMC Section 13.01 H) while the 2023 ZAI served a different

purpose. Although these are both interpretations of Zoning Code terminology, the LAMC regulations surrounding "maintenance" differ with regards to what maintenance activities are permitted in the City. The 2023 ZAI was issued to accompany an ordinance that directly restricted well maintenance, and which the court found to be preempted. The court's ruling that the prior ordinance was preempted was the basis for finding that the accompanying 2023 ZAI, which defined the term "well maintenance" in the ordinance, was also preempted. The 2025 ZAI, by contrast, was issued to accompany an ordinance that does not prohibit maintenance activities. It interprets terminology that has been referenced in the City's zoning code since 1955 (LAMC Sections 13.01 H and I) for purposes of local land use review, an area within the City's police power.

Importantly, discretionary review under LAMC Section 13.01 H is distinct from Oil Ordinance No. 187,709 that was challenged for preemption. Section 13.01 H does not prohibit operators from conducting well maintenance; it requires that such activities undergo review by the Zoning Administrator, who may approve them subject to conditions. In contrast, the rescinded Oil Ordinance No. 187,709 imposed a prohibition on maintenance, drilling, redrilling, or deepening activities, unless the Zoning Administrator determined that the work was necessary for health or safety reasons. The current ZAI is therefore distinct from the 2023 ZAI because it interprets preexisting regulations that do not ban maintenance, and simply clarifies when discretionary review is required under existing zoning provisions, none of which are preempted by state law.

B. The ZAI is not preempted by state law.

This subresponse addresses ***Warren Resources' Appeal Point 6-2*** *and* ***E&B Natural Resources' Appeal Point 4-2*** *and their arguments that the ZAI interferes with state law.*

Land use and zoning regulations derive from a City's general police power. (California Constitution, Article XI, Section 7.) A land use regulation lies within the City's police power if it is reasonably related to the public welfare. (A*ssociated Home Builders of the Greater Eastbay, Inc. v. City of Livermore* (1976) 18 Cal.3d 582, 600-601.)

Oil drilling activities are regulated by both the state (through CalGEM and SCAQMD) as well as by local zoning ordinances. (*59 Ops.Cal.Atty.Gen.* 461 (1976).) There has, however, been a clear shift in policy direction regarding how local municipalities and counties may regulate oil well activities in their jurisdictions. For example, on September 25, 2024, Governor Newsom signed AB 3233, which authorizes local jurisdictions in California to more strictly regulate, or outright prohibit, oil well projects, notwithstanding any other state law. This new legislation clarifies the understanding that although state agencies such as CalGEM can issue permits for new oil well drilling, local governments can restrict or prohibit such activities without the confusion of whether local rules are preempted by CalGEM's authority on oil well projects. The 2025 ZAI, however, does not prohibit or restrict oil well maintenance activities, such as Rework projects, but it does require–consistent with the Zoning Administrator's existing authority and current practice–

that oil well companies file a discretionary review application in order for the Zoning Administrator to examine proposed well maintenance projects. Thus, the 2025 ZAI does not create new oil regulations or prohibit oil activities that could be permitted under state law, nor does it interfere with the state's authority over oil well operations.

The dual state-local regulatory framework also confirms that the local approval process is already built into the state permitting process, and does not interfere with the state's authority to regulate oil wells. CalGEM is the responsible state agency to issue permits in response to Notices of Intention to drill, rework, or permanently plug and abandon a well. Public Resources Code section 3203.5(a) requires CalGEM to obtain a copy of the local land use authorization before approving a well.

CalGEM, on two separate guidance documents, identifies that it is the operator's responsibility to check with the local agency and identify if there are any local permitting and/or approval requirements.[19] [20] In fact, part of CalGEM's online application portal, WellSTAR, asks the operator whether they have consulted and received approval from the local agency. The City of Los Angeles is the Lead Agency and LACP, on behalf of the City, conducts the CEQA review for oil/gas well projects regarding all Notices of Intention, including well maintenance activities. There have been various occasions when operators, including the appellants, have contacted LACP for CEQA clearance for CalGEM Rework permits.[21] [22] [23] [24] Without CEQA clearance, CalGEM would not issue a permit. This demonstrates the historical practice that CalGEM acknowledges local jurisdiction and CEQA authority as integral to oil well regulation.

Although operators have not yet filed discretionary cases for well maintenance, the City has consistently advised that such activities require a Zoning Administrator determination and CEQA clearance. The absence of applications reflects operator choice, not a lack of City authority.

Importantly, unlike Oil Ordinance No. 187,709 prohibiting maintenance and the 2023 ZAI which interpreted "well maintenance" in the context of those regulations, the 2025 ZAI

---

[19] California Geologic Energy Management Division, Notice to Operators 2019-16, October 24, 2019 <https://www.conservation.ca.gov/calgem/CEQA/Documents/NTO%202019-16%20%28CEQA%20Compliance%29%20ADA.pdf>

[20] California Geologic Energy Management Division, CEQA Guidance for Operators, Project Description, Revised January 5, 2023. <https://www.conservation.ca.gov/calgem/Documents/CEQA_Proj%20Desc%20Guidance%20for%20Operators_Final_20230105.pdf>

[21] Correspondence: S-65 at San Vicente email subject from Ted Cordova to Edber Macedo, Friday, January 17, 2020. <https://drive.google.com/file/d/1tAXOWS6B18wyMzBT-ue9WfZVFxV_pgIN/view?usp=sharing>

[22] Correspondence: WTU Central - CEQA email subject from Ana Tovar to Edber Macedo, Tuesday, March 29, 2022. <https://drive.google.com/file/d/1wsm97c5Z8U3PFL8a_9RuYvou-mjkGpHG/view?usp=sharing>

[23] Correspondence: L.A. City Planning // Additional Information email subject from Mike Guiliani to Edber Macedo, Thursday, July 7, 2022 <https://drive.google.com/file/d/1b8BRZWDWtG1pYE4M2sJPJ7xcSskD5JAR/view?usp=sharing>

[24] Correspondence: CEQA Project Description - WTU 1911i email subject from Ana Tovar to Edber Macedo, Friday, September 9, 2022. <https://drive.google.com/file/d/1CkS37ybFVMye_8LaZl5l9HfUVztHTnWf/view?usp=sharing>

does not impact or dictate which method of drilling or maintenance an operator may choose to use. It neither bans nor prescribes techniques. Instead, the ZAI provides the Zoning Administrator the opportunity to review the proposed oil well maintenance activities, hold a public hearing, and determine if land use conditions, if any, would be necessary to minimize any negative land use effects that may arise from the well maintenance projects.

The ZAI is also not preempted by SCAQMD rules because although some well maintenance activities are already regulated by SCAQMD, those activities may result in land use impacts and evaluating those impacts is within the purview of the local agency, and specifically, in Los Angeles, the Zoning Administrator. SCAQMD Rule 1148.2 is a regulation that outlines requirements for operators who carry out specific oil/gas well activities that impact local air quality. This rule requires operators to provide online notification to SCAQMD of when these projects will take place and disclose the quantity and inventory of chemicals planned for use during the well maintenance activity. SCAQMD does not regulate or impose conditions, nor does it require a CEQA clearance as part of Rule 1148.2 because the agency does not issue permits or approvals for activities that require notification. However, some of the activities that trigger SCAQMD Rule 1148.2 Notification, such as maintenance acidizing, result in impacts that are regulated by the City exercising its local land use authority. The OZA's authority to regulate these activities goes well beyond SCAQMD's oversight over regional air quality, and extends to mitigating such impacts as traffic and circulation, parking, noise, hours of operation, public disruption, and the environmental health of the community – just to name a few. These impacts may be addressed through the imposition of land use conditions or CEQA mitigation measures to reduce environmental impacts.

The ZAI does not provide new regulations or prohibitions on oil operations, nor does it alter the City's pre-existing local authority and regulatory procedures over oil operations– neither of which interfere or conflict with state law.

C. The ZAI is another example of state-local oversight.

*This subresponse addresses **Warren Resources' Appeal Point 6-2** and **E&B Natural Resources' Appeal Point 4-2** and their arguments that the ZAI interferes with state law.*

CalGEM's practice of incorporating local input on permitting is not uncommon and is reasonable given other forms of state deference to local oversight on land uses. For example, alcohol establishments in the City require both a license from the California State Department of Alcoholic Beverage Control (ABC) and also a Conditional Use Permit from the Zoning Administrator – the same decision maker for oil well projects. ABC requires alcohol establishment operators to complete a Zoning Affidavit and verify compliance with local land use regulations, and submit an application for any discretionary review. If the local jurisdiction requires a conditional use permit then ABC factors that information into the processing of the state alcohol license. Similarly, with CalGEM, there is a process set

up by CalGEM, through their application processing, to capture any applicable reviews by the local jurisdiction.

Another example of state-local oversight is how the California Legislature recently passed legislation streamlining housing development, including Accessory Dwelling Units, and LACP has consistently released guidance documents and implementation directives to ensure that local planning requirements do not conflict with streamlining requirements. LACP takes proactive measures to craft local housing development requirements where the Department's policies work parallel to the state's legislation on housing development. Similarly, with well maintenance projects, LACP's intent in its land use regulation of oil/gas wells is to align with state laws, while incorporating relevant local level land use regulations to ensure safe operations at all drill sites in the City. This ZAI's reference to state regulations, to describe and clarify how a term in the Zoning Code can be interpreted, further exemplifies the importance of the relationship between the state and local regulations. It addresses only land use impacts such as traffic, noise, odor, and compatibility with surrounding uses, which fall within the City's police power. In sum, the ZAI complements state oversight while ensuring that local land use impacts remain subject to the City's police power.

D. The validity of AB 3233 is not relevant to and is beyond the scope of this appeal.

*This subresponse addresses **Warren Resources' Appeal Point 6-1** and **E&B Natural Resources' Appeal Point 4-1** and their arguments that AB 3233 is unconstitutional and cannot cure preemption.*

The appellants argue that AB 3233 is unconstitutional. This assertion is speculative. In 2024, the Legislature enacted AB 3233, expressly authorizing local governments to regulate oil and gas operations notwithstanding state permits. AB 3233 has not been overturned or invalidated, and its language is still in full force and effect in terms of the City's authority to regulate oil operations. The merits and validity of AB 3233 are not a matter to be considered by this appellate body.

E. The ZAI is not preempted by federal law.

*This subresponse addresses **Warren Resources' Appeal Point 6-3** and **E&B Natural Resources' Appeal Point 4-3** and their arguments that the ZAI is preempted by federal law.*

The appellants additionally contend that the ZAI is preempted by the federal Safe Drinking Water Act due to CalGEM's primacy over underground injection wells. This argument is misplaced. The ZAI does not regulate the technical operation of injection wells; it simply interprets the pre-existing term "well maintenance," as used in the LAMC provisions that govern local land use impacts associated with well interventions. It seeks to standardize and supplement a pre-existing review process that addresses only land use impacts such

as traffic, noise, odor, and compatibility with surrounding uses, which fall within the City's police power. The appellants have not shown how an interpretation of a pre-existing term would interfere with, create a conflict with, or prevent the application of existing federal law regulating drilling practices.

9. APPEAL TOPIC: SETTLEMENT AGREEMENT AND STIPULATED JUDGMENT

Summary of Appeal Point

Warren Resources alleges that the adoption of the ZAI violates the parties' settlement agreement and stipulated judgment resolving the case of *Warren E&P, Inc. v. City of Los Angeles*.

APPEAL RESPONSE

*This response addresses **Warren Resources' Appeal Point 7-1** and their claim that the ZAI violates the parties' settlement agreement and stipulated judgment resolving the case of Warren E&P, Inc. v. City of Los Angeles.*

The ZAI is an interpretation of the existing Zoning Code and should not be confused with a potential ordinance related to oil and gas drilling activities.

One of the appellants, Warren Resources, alleges that adoption of the ZAI violates the Settlement Agreement and Stipulated Judgement that resolved *Warren E&P, Inc. v City of Los Angeles* (Los Angeles Superior Court Case No. 23STCP00060). The appellant states that they entered into the settlement agreement with the understanding that all parties would work together cooperatively through a public process with reasonable timeframes to craft updated regulations that would meet the City's goals without unnecessarily harming lawful oil and gas production operations. They further claim that the ZAI attempts to circumvent this required process to which the City Council agreed by regulating well maintenance activities in the absence of a new ordinance.

The ZAI does not violate the parties' Stipulation or the Stipulated Judgment. The Stipulation and Stipulated Judgment applies to the adoption of new ordinances regulating oil and gas operations, not to administrative interpretations of existing code provisions. By contrast, the ZAI interprets existing municipal code language related to maintenance that, under existing provisions, falls within the scope of activities that the Zoning Code subjects to discretionary review.

Pursuant to AB 3233, the City is within its authority to consider a potential future ordinance that would prohibit new oil and gas extraction and phase out existing operations citywide. Consistent with the requirements of the Stipulation and Stipulated Judgment, on June 3, 2025, LACP held a virtual stakeholder meeting to discuss a revised draft ordinance related to oil and gas drilling policies. The meeting was publicly announced by LACP to all

previous interested parties. As of the writing of this report, a second stakeholder meeting is scheduled for October 1, 2025, in compliance with the Stipulation and Stipulated Judgment.

10. APPEAL TOPIC: CIVIL RIGHTS ACT

Summary of Appeal Point

E&B Natural Resources alleges that the City is liable for damages under the Civil Rights Act.

APPEAL RESPONSE

The City is *not* liable for damages under the Civil Rights Act (Section 1983).

*This response addresses **E&B Natural Resources' Appeal Point 8-1** and their claim that the City is liable for damages under the Civil Rights Act.*

E&B Natural Resources alleges that the City's regulation of oil operations impairs its constitutional rights, and that it will be entitled to damages under the Civil Rights Act (42 U.S.C. Section 1983). Any prior ordinances, including the rescinded Oil Ordinance No. 187,709, are not at issue in this appeal.

The ZAI does not violate the appellant's constitutional rights. As stated above (see Response to Appeal Point No. 4), the ZAI does not result in an unconstitutional taking of property without just compensation. Moreover, the appellant does not specify how the ZAI violates their due process rights. The appellant does not possess a due process right to a specific interpretation of terminology contained in the City's Zoning Code. E&B Natural Resources has exercised its right to appeal this interpretation under the City's Code, and will be provided a public hearing to have its appeal heard. The availability of this appeal process demonstrates that the City has provided an adequate administrative remedy, including proper notice and an opportunity to be heard, consistent with due process protections.

Nevertheless, this formal interpretation is consistent with past practice. Prior to the issuance of the ZAI, operators who contacted the OZA seeking approval for well maintenance projects were advised to file an application according to the requirements outlined in LAMC Section 13.01 H and ZA Memo 133. The operator was required to follow a specific set of review procedures in order to apply for approval and, if approved, then the operator could complete their proposed project to "drill, deepen, or maintain" a well. The ZAI applies uniformly to all operators and does not single out any entity, further confirming that no constitutional violations subject to the Civil Rights Act have occurred. Consistent with this practice, the ZAI does not prohibit well maintenance activities. Instead, it clarifies which scopes of work are considered maintenance and require discretionary

review under existing provisions and maintains an avenue for operators to seek approval for such activities through that established application and review process.

CONCLUSION AND RECOMMENDATION

For the reasons stated herein, interpretation of well maintenance is a valid action by the Chief Zoning Administrator for the land use regulation of oil/gas wells in the City pursuant to LAMC Section 13A.17.D.2 of Chapter 1A and City Charter Section 561. By interpreting this terminology, the ZAI does not create new law but formalizes a practice long applied by the Office of Zoning Administration. The interpretation ensures clarity and consistency in implementing the LAMC and its intent to oversee "maintenance" activities that may have land use impacts. In this way, the ZAI furthers the purpose of the Zoning Code to protect public health, safety, and the environment from oil/gas well activities that tend to have the highest impacts on communities, a valid exercise of the City's local land use authority.

The ZAI is statutorily valid, constitutional, and consistent with the Zoning Administrator's authority and Zoning Code. It does not conflict with city, county, state, or federal regulations; rather, it complements the roles of CalGEM and SCAQMD by addressing local land use impacts within the City's police power. Importantly, the ZAI does not prohibit oil production or maintenance activities, nor does it compel abandonment of wells. Instead, it clarifies which activities require discretionary review under LAMC Section 13.01 H, providing a pathway for operators to continue lawful operations subject to conditions where necessary. This formalization of long-standing practice ensures transparency, accountability, and consistency across oil well operations.

The ZAI is also consistent with broader state policy trends, including AB 3233 and SB 1137, which reflect legislative recognition of the need for local oversight of oil and gas activities near communities. While the ZAI stands on its own independent authority, these developments underscore its importance in protecting public health and safety.

Therefore, it is recommended that the City Planning Commission deny the appeal, and adopt the Zoning Administrator's Interpretation of "well maintenance", attached as **Exhibit C** to the Appeal Recommendation Report.

Exhibit A

Warren Resources Appeal Justification

APPLICATIONS

APPEAL APPLICATION
Instructions and Checklist

PURPOSE

This application is for the appeal of Los Angeles Department of City Planning determinations, as authorized by the LAMC. For California Environmental Quality Act Appeals, use form CP13-7840. For Building and Safety Appeals and Housing Department Appeals, use form CP13-7854.

RELATED CODE SECTION

Refer to the Letter of Determination (LOD) for the subject case to identify the applicable Los Angeles Municipal Code (LAMC) Section for the entitlement and the appeal procedures.

APPELLATE BODY

Check only one. If unsure of the Appellate Body, check with City Planning staff before submission.

☐ Area Planning Commission (APC) ☑ City Planning Commission (CPC) ☐ City Council

☐ Zoning Administrator (ZA)

CASE INFORMATION

Case Number: ZA-2025-2976-ZAI

APN: n/a - Citywide

Project Address: n/a - Citywide

Final Date to Appeal: 06/27/2025

APPELLANT

Check all that apply.

☑ Person, other than the Applicant, Owner or Operator claiming to be aggrieved

☐ Representative ☐ Property Owner ☐ Applicant ☐ Operator of the Use/Site

APPELLANT INFORMATION

Appellant Name: Warren E&P, Inc.; Warren Resources of California, Inc.; Warren Resources, Inc.

Company/Organization: Warren E&P, Inc.; Warren Resources of California, Inc.; Warren Resources, Inc.

Mailing Address: 625 E. Anaheim Street

City: Wilmington **State:** CA **Zip Code:** 90744

Telephone: 310-494-5343 **E-mail:** tthompson@warrenresources.com

Is the appeal being filed on your behalf or on behalf of another party, organization, or company?

☑ Self ☐ Other: _____

Is the appeal being filed to support the original applicant's position? ☐ **YES** ☑ **NO**

REPRESENTATIVE / AGENT INFORMATION

Name: Ty Thompson

Company/Organization: Warren Resources, Inc.

Mailing Address: 625 E. Anaheim Street

City: Wilmington **State:** CA **Zip Code:** 90744

Telephone: 310-494-5343 **E-mail:** tthompson@warrenresources.com

JUSTIFICATION / REASON FOR APPEAL

Is the decision being appealed in its entirety or in part? ☑ **Entire** ☐ **Part**

Are specific Conditions of Approval being appealed? ☐ **YES** ☑ **NO**

If Yes, list the Condition Number(s) here: _____

On a separate sheet provide the following:

☑ Reason(s) for the appeal

☑ Specific points at issue

☑ How you are aggrieved by the decision

APPLICANT'S AFFIDAVIT

I certify that the statements contained in this application are complete and true.

Appellant Signature: _____ **Date:** 06/26/2025

GENERAL NOTES

A Certified Neighborhood Council (CNC) or a person identified as a member of a CNC or as representing the CNC may not file an appeal on behalf of the Neighborhood Council; persons affiliated with a CNC may only file as an individual on behalf of self.

The appellate body must act on the appeal within a time period specified in the LAMC Section(s) pertaining to the type of appeal being filed. Los Angeles City Planning will make its best efforts to have appeals scheduled prior to the appellate body's last day to act in order to provide due process to the appellant. If the appellate body is unable to come to a consensus or is unable to hear and consider the appeal prior to the last day to act, the appeal is automatically deemed denied, and the original decision will stand. The last day to act as defined in the LAMC may only be extended if formally agreed upon by the applicant.

THIS SECTION FOR CITY PLANNING STAFF USE ONLY

Base Fee: $172

Reviewed & Accepted by (DSC Planner): Ruben Vasquez

Receipt No.: 200276852442 **Date:** 6/27/25

☒ Determination authority notified ☐ Receipt Number

GENERAL APPEAL FILING REQUIREMENTS

If dropping off an appeal at a Development Services Center (DSC), the following items are required. See also additional instructions for specific case types. To file online, visit our Online Application System (OAS).

APPEAL DOCUMENTS

1. Hard Copy

Provide three sets (one original, two duplicates) of the listed documents for each appeal filed.

- ☐ Appeal Application
- ☐ Justification/Reason for Appeal

☐ Copy of Letter of Determination (LOD) for the decision being appealed

2. Electronic Copy

☐ Provide an electronic copy of the appeal documents on a USB flash drive. The following items must be saved as individual PDFs and labeled accordingly (e.g., "Appeal Form", "Justification/Reason Statement", or "Original Determination Letter"). No file should exceed 70 MB in size.

3. Appeal Fee

☐ *Original Applicant.* The fee charged shall be in accordance with LAMC Section 19.01 B.1(a) of Chapter 1 or LAMC Section 15.1.1.F.1.a. (Appeal Fees) of Chapter 1A as applicable, or a fee equal to 85% of the original base application fee. Provide a copy of the original application receipt(s) to calculate the fee.

☑ *Aggrieved Party.* The fee charged shall be in accordance with LAMC Section 19.01 B.1(b) of Chapter 1 or LAMC Section 15.1.1.F.1.b. (Appeal Fees) of Chapter 1A as applicable

4. Noticing Requirements (Applicant Appeals Only)

☐ *Copy of Mailing Labels.* All appeals require noticing of the appeal hearing per the applicable LAMC Section(s). Original Applicants must provide noticing per the LAMC for all Applicant appeals. See the Mailing Procedures Instructions (CP13-2074) for applicable requirements.

SPECIFIC CASE TYPES
ADDITIONAL APPEAL FILING REQUIREMENTS AND / OR LIMITATIONS

DENSITY BONUS (DB) / TRANSIT ORIENTED COMMUNITES (TOC)

Appeal procedures for DB/TOC cases are pursuant to LAMC Section 13B.2.5. (Director Determination) of Chapter 1A or LAMC Section 13B.2.3. (Class 3 Conditional Use) of Chapter 1A as applicable.

- Off-Menu Incentives or Waiver of Development Standards are not appealable.
- Appeals of On-Menu Density Bonus or Additional Incentives for TOC cases can only be filed by adjacent owners or tenants and is appealable to the City Planning Commission.

☐ Provide documentation confirming adjacent owner or tenant status is required (e.g., a lease agreement, rent receipt, utility bill, property tax bill, ZIMAS, driver's license, bill statement).

WAIVER OF DEDICATION AND / OR IMPROVEMENT

Procedures for appeals of Waiver of Dedication and/or Improvements (WDIs) are pursuant to LAMC Section 12.37 I of Chapter 1 or LAMC Section 10.1.10. (Waiver and Appeals) of Chapter 1A as applicable.

- WDIs for by-right projects can only be appealed by the Property Owner.
- If the WDI is part of a larger discretionary project, the applicant may appeal pursuant to the procedures which govern the main entitlement.

[VESTING] TENTATIVE TRACT MAP

Procedures for appeals of [Vesting] Tentative Tract Maps are pursuant LAMC Section 13B.7.3.G. of Chapter 1A.

- Appeals must be filed within 10 days of the date of the written determination of the decision-maker.

NUISANCE ABATEMENT / REVOCATIONS

Appeal procedures for Nuisance Abatement/Revocations are pursuant to LAMC Section 13B.6.2.G. of Chapter 1A. Nuisance Abatement/Revocations cases are only appealable to the City Council.

Appeal Fee

☐ *Applicant (Owner/Operator).* The fee charged shall be in accordance with the LAMC Section 19.01 B.1(a) of Chapter 1 or LAMC Section 15.1.1.F.1.a. (Appeal Fees) of Chapter 1A as applicable.

For appeals filed by the property owner and/or business owner/operator, or any individuals/agents/representatives/associates affiliated with the property and business, who files the appeal on behalf of the property owner and/or business owner/operator, appeal application fees listed under LAMC Section 19.01 B.1(a) of Chapter 1 shall be paid, at the time the appeal application is submitted, or the appeal application will not be accepted.

☐ *Aggrieved Party.* The fee charged shall be in accordance with the LAMC Section 19.01 B.1(b) of Chapter 1 or LAMC Section 15.1.1.F.1.b. (Appeal Fees) of Chapter 1A as applicable.

Justification/Reason Statement

Warren E&P, Inc.; Warren Resources of California, Inc.; and Warren Resources, Inc.; (collectively "Warren")[1] hereby appeals Zoning Administrator Interpretation ZA-2025-2976-ZAI, dated June 12, 2025, purporting to define "maintenance" as it is used in Los Angeles Municipal Code ("LAMC") sections 13.01-H and 13.01-I (the "ZAI"). The ZAI is unlawful and should be rescinded for the reasons described below.

The City of Los Angeles ("City") has gone down this path before, when it adopted a similar, unlawful interpretation of "maintenance" in 2023 that was voided by a court. Nothing has materially changed since the City's last failed attempt to overstep its authority, yet the City continues to try to impose unlawful limitations. More specifically, in January 2023, the Zoning Administrator issued ZA-2022-8997-ZAI (herein, the "2023 ZAI"), purporting to define "maintenance" for oil and gas well sites using language identical to the definition set out in the present ZAI. The 2023 ZAI attempted to define "maintenance" both as it appeared in the LAMC to be revised under the new Oil and Gas Drilling Ordinance, No. 187,709, *and* as it was used in former LAMC section 13.01-H.

After the City adopted the 2023 ZAI, ignoring warnings that the City had overstepped its authority, a Los Angeles Superior Court judge in September 2024 found that Ordinance No. 187,709, the 2023 ZAI, and ZA Memo No. 141 attempted to regulate a matter of statewide concern and were preempted by state law. *Warren E&P, Inc. v. City of Los Angeles*, Los Angeles Superior Court Case No. 23STCP00060 (Sept. 6, 2024). To avoid continued litigation related to damages resulting from the City's violation of the law, the parties entered a stipulated judgment that includes a settlement agreement under which the City agreed to rescind the illegal regulations and conduct meaningful public outreach before adopting new limitations on oil drilling operations. Pursuant to that stipulated judgment, the City rescinded Ordinance No. 187,709, the 2023 ZAI, and the ZA Memo and has held an initial public outreach meeting related to a proposed new ordinance.

The City now attempts to avoid its obligations outlined in the stipulated judgment by issuing the ZAI to redefine "maintenance" as it pertains to oil and gas operations in LAMC sections 13.01-H and 13.01-I. The City's actions improperly usurp the City Council's authority by creating a new definition for "maintenance" that materially changes the meaning of an ordinance the City Council adopted decades ago and without even offering the City Council an opportunity to weigh in on this significant policy change. Further, the ZAI effectively would halt all of the newly defined "maintenance" activities long before the City Council has completed the public process it expressly agreed to undertake in the stipulated judgment prior to adopting any new limitations on oil drilling operations. Not only do the City's actions fly in the face of an agreement the City Council approved of just months ago, but they amount to an end-run around the legislative

---

[1] Warren operates a drilling and production site and holds mineral interests within the City and would be detrimentally affected by the Project. It has a beneficial interest that would be adversely affected by the environmental impacts associated with the Project, and the Project will otherwise have a direct, substantial effect on Warren and its operations. Further, Warren makes these comments on behalf of the public interest, which interest would suffer if the City were not compelled to perform its duties under CEQA.

process for adopting changes to Zoning Code provisions and processes set forth in LAMC Section 13B.1.4.

To achieve its pre-determined outcome outside of a legislative process, the City appears to rely on AB 3233 for its authority to re-do what the superior court has correctly undone. However, this new attempt fails for two main reasons: (1) the ZAI is still unlawful for the reasons set forth in Warren's and other operators' appeals of the 2023 ZAI (which are incorporated herein by reference as if stated in full); and (2) the ZAI is preempted by state and federal law and AB 3233 does not negate the trial court's finding that the City is improperly attempting to regulate a matter of statewide concern.

1. **Adoption of the ZAI Violates CEQA**

The City claims the ZAI is not a "project" under CEQA Guidelines, section 15378 because it is "an administrative and procedure-making activity to assist in the implementation of the City's preexisting Zoning Code provisions regarding oil well sites." ZAI at p. 8. It also claims that even if it were deemed a "project," the ZAI would be exempt from CEQA review "under the Class 8 and common sense exemptions." *Id.*

The ZAI is certainly a "project" within the meaning of CEQA because it is reasonably foreseeable that implementation of the ZAI will result in physical changes in the environment. The ZAI also does not meet any of the exceptions to the definition of a "project," such as a "continuing administrative or maintenance activity" like purchasing supplies, or the creation of government fiscal activities, nor does it fall into the category of "[o]rganizational or administrative activities of government agencies that will not result in direct or indirect physical changes to the environment." CEQA Guidelines, Sections 15378(b)(2); 15378(b)(5). The ZAI creates a new definition for "maintenance" in an effort to regulate activities that are currently allowed under existing zoning regulations. The City's claim that the ZAI is administrative in nature ignores the significant policy shift created by including certain routine activities within the definition of well maintenance requiring discretionary review. Further, the City fails to account for the potential environmental impacts resulting from this substantial change in land use regulation as compared to current law.

In the very same paragraph stating that it is not a project, the ZAI continues to describe that it "provides a definition of oil well maintenance *to implement a review process* intended to minimize land use impacts. . . ." ZAI at p. 8 [emphasis added]. The ZAI additionally states that "[t]he well maintenance activities listed in this ZAI are permitted only when filed, reviewed, and approved, pursuant to both the applicable code section and appropriate procedures as established thereto." *Id.* at 7. By its own terms, then, the ZAI is more than a simple administrative action to clarify a preexisting term in the LAMC. Rather, the ZAI is "*implementing a review process*" providing the City with the ability to deny routine well maintenance activities that have not historically required any such review prior to adoption of the 2023 ZAI and, as to acid maintenance, have not required any such review since the Court ruled that the 2023 ZAI was unlawful.[2] 1-1

[2] Section 15378(a) specifically defines a "Project" as including "enactment and amendment of zoning ordinances." The ZAI is not only effectively an amendment of the zoning code, but as discussed below, is part and parcel to the City's anticipated enactment of a new oil ordinance.

Further, under the City's new review process, all routine well maintenance activities would be subject to a process whereby those activities will likely never be approved. The effect is a de facto ban on all maintenance activities, just as Ordinance No. 187,709 and the 2023 ZAI attempted to do. The City is therefore required to perform a CEQA review to analyze the impacts of this project. Among many others, the impacts analyzed should include: the impact of the project on the availability of mineral resources; the potential geological impacts; the air quality, noise, and GHG impacts derived from accelerated plugging and abandonment of wells throughout the City; and the impacts of the same stemming from increased oil imports and oil tanker activity at the Port of LA.[3] 1-2

Moreover, the ZAI clearly was issued in anticipation of the City's readoption of a new oil and gas ordinance, a draft of which has not been made publicly available, but which will likely mirror Ordinance No. 187,709. Consequently, the ZAI is part of a larger regulatory scheme that certainly constitutes a "project" within the meaning of CEQA. To that end, the City's attempt to issue the ZAI to redefine maintenance before passing an ordinance to ban maintenance is simply a thinly veiled attempt to improperly piecemeal the larger project into smaller segments. But CEQA review must account for the whole project, and "[a]gencies cannot allow environmental considerations to become submerged by chopping a large project into many little ones." *Banning Ranch Conservancy v. City of Newport Beach* (2012) 211 Cal.App.4th 1209, 1222 (internal citations omitted). Reversing the order of operations by issuing the ZAI before readoption of the new ordinance does not cure the piecemealing defects of the City's prior actions. 1-3

Finally, the ZAI is not exempted under CEQA Guidelines, section 15308 (Class 8 exemption). First, there is nothing in the ZAI that would "assure the maintenance, restoration, enhancement, or protection of the environment." CEQA Guidelines, Section 15308. Instead, the ZAI creates uncertainty and risk to the environment by limiting the ability of existing, authorized oil and gas production facilities to operate consistent with state and local law. Even if any categorical exemption may theoretically apply, the "unusual circumstances exception" set forth at section 15300.2(c) would also apply to except the project from any categorical exemption. *See Respect Life South San Francisco v City of South San Francisco* (2017) 15 CA5th 449, 458 [determination whether significant environmental impacts might result from an unusual circumstance identified by the agency is reviewed under the "fair argument" standard]. First, redefining the term "maintenance"—after decades of a different understanding of the term—to give it a new meaning that would require an entirely new review process is itself an unusual "administrative activity." And, given the ultimate (and intended) outcome of the ZAI, there is at least a reasonable possibility of significant environmental impacts, as described above, including most notably, the loss of availability of mineral resources. Together, these exceptions preclude the City from relying on a categorical exemption to avoid analyzing potential impacts associated with adoption of the ZAI, as required by CEQA. 1-4

[3] These potential impacts have been described on numerous occasions including in Warren's previous comment letters addressing Ordinance No. 187,709 and the 2023 ZAI, as well as Warren's Petition for Writ of Mandate in *Warren E&P, Inc. v. City of Los Angeles*, Los Angeles Superior Court Case No. 23STCP00060, all of which are incorporated herein in full by reference.

2. The Zoning Administrator Exceeded the Scope of Its Authority

The City relies on LAMC section 13A.1.7.D.2 of Chapter 1A—the *new* Zoning Code—for the authority of the Zoning Administrator to issue the ZAI as an "interpretation [of] zoning regulations when the meaning of the regulation is not clear . . . ." (ZAI at p. 2.) But the ZAI does not interpret an unclear regulation. Rather, the ZAI provides a wholly new definition of "maintenance" as it is used in Sections 13.01-H and 13.01-I of the long-existing Zoning Code. Indeed, oil and gas operations have taken place in the City under the existing Zoning Code for decades with no confusion over what has constituted maintenance activities requiring review.

In reality, the ZAI is an underground regulation or amendment of the Zoning Code, unlawfully adopted without following the procedures required in the LAMC.[4] No public notice was provided as to the City's intent to issue the ZAI, no draft was provided for public review and comment, and appellants, including Warren, were given just 15 days to file an appeal before the ZAI was to become effective. To the extent the ZAI attempts to regulate and prohibit maintenance activities that the City has allowed without incident or interference on Warren's established drill site for decades under the existing Zoning Code, then, the Zoning Administrator is without authority to do so. 2-1

The Zoning Code provides the Zoning Administrator the authority to interpret zoning regulations when the meaning of the regulation is not clear. Chapter 1A, Section 13A.1.7. The intent of this authority is to allow the Zoning Administrator to provide additional clarification within the scope and intent of the zoning regulation. The ZAI doesn't clarify the meaning of term, but instead materially redefines "well maintenance" to substantially expand the scope of the existing ordinance. As a result, the ZAI fundamentally changes the way that oil and gas production activities are regulated by the City. Such action exceeds the Zoning Administrator's authority. 2-2

Moreover, the ZAI cites to the *new* Zoning Code (Chapter 1A) for its authority, while purporting to define "maintenance" as it is used in Sections 13.01-H and 13.01-I of the *old* Zoning Code. In fact, Chapter 1A is not yet in effect in the Wilmington Harbor area, where Warren is situated, because the Wilmington Harbor Community Plan is not yet updated. (*See* Zoning Code Chapter 1A, *Preface* ["[U]ntil all the Community Plans have been updated and properties remapped using the new zoning system, properties in Community Plan areas not yet updated will be regulated by the provisions of the Zoning Code found in existing *Chapter 1*....."].) 2-3

Significantly, the oil and gas related regulations of Chapter 1A and any related ZAI, are additionally not effective as to Warren (and others) per Section 1.4.7, which acknowledges the lawsuits challenging the since-repealed ordinance and 2023 ZAI, and explicitly states that any such regulations are "ineffective until such time as this Section (related to *Warren v. City of LA*, Case No. 23STCP00060 and its related cases) is amended." The City Council adopted Section 1.4.7 of Chapter 1A specifically to require a legislative amendment to Section 1.4.7, which requires City Council approval, prior to developing and applying any new restrictions on oil and gas production facilities – specifically including any new "Zoning Administrator Memos and Interpretations." Therefore, under the express terms of Section 1.4.7, any ZAI adopted by the 2-4

[4] If the Zoning Administrator were actually given the authority to promulgate rules, it would constitute an unlawful delegation of power to the Zoning Administrator.

City related to oil well regulations is ineffective until the City Council acts. Given this language, it is troubling that the City is now making an end-run around the City Council's explicit direction by attempting to adopt the ZAI without amending Section 1.4.7 through a legislative process as the law requires. 2-4

3. The ZAI is Inconsistent with the General Plan

The ZAI does not even attempt to assert that it is consistent with the City's General Plan, but in any event it is not. Multiple provisions of the City's General Plan and the Wilmington Harbor Community Plan support the continued operations of oil and gas facilities. For example, the Conservation Element, Section 19: Resource Management: Oil, "Objective" is to "conserve petroleum resources and *enable appropriate, environmentally sensitive extraction* . . . so as to protect the petroleum resources for the use of future generations and to reduce the city's dependency on imported petroleum and petroleum products." (Emphasis added.) Similarly, Health Wellness and Equity Element, Policy 5.4 also assumes the continuance of extraction activities within the City: "This policy calls for the City to work with operators to ensure that they have the required permits in place." As for the Wilmington Harbor City Community Plan, Land Use Policies 3-5.1 and 3.5.3 clearly contemplate the continuance of extraction activities, and Policy 3-5.4 provides for the consolidation of oil extraction operations to increase compatibility between oil activities and other land uses. 3-1

Instead of encouraging the continued responsible extraction of oil and gas, the ZAI defines maintenance in a manner that affords the Zoning Administrator complete discretion and authority to deny all lawful maintenance activities on existing wells. As a result, domestic oil and gas production activities will be stymied and safe, reliable local production, which is consistent with the General Plan, will cease. Because the ZAI constitutes a shadow ban on maintenance activities that will result in material impairments to local oil and gas production, it is inconsistent with the General Plan and therefore unlawful.

4. The ZAI Impairs Warren's Vested Rights and Unlawfully Interferes with Warren's Contracts

Warren has performed substantial work and incurred substantial liabilities in good faith reliance upon its vested rights in ZA 20725, and the 2006 and 2008 Plan Approvals issued to Warren in connection therewith, and Warren's agreements with the City. Warren's rights in the Plan Approvals are vested and allow Warren to continue to develop and produce oil, gas and other hydrocarbon substances. Warren also has fully vested rights to complete the development and production of oil and gas resources within the boundaries of ZA 20725 and the Plan Approvals consistent with its long-established plans and substantial investments in reliance thereon. As a result, Warren has fully vested rights to continue its operations. *See, e.g*, *Avco Community Developers, Inc. v. South Coast Regional Com.* (1976) 17 Cal. 3d 785, 791 (Finding that when a property owner has performed substantial work and incurred substantial liabilities in good faith reliance upon an entitlement issued by an agency, the party acquires a vested right to complete the construction of the project.) 4-1

The ZAI's definition of "maintenance" at a basic level confirms that Warren will be unable to undertake certain maintenance activities that the City already has authorized Warren to undertake pursuant to its vested entitlements. Indeed, Warren has long relied on the City's historic 4-1

interpretation of permitted activities and longstanding practice.[5] Routine maintenance activities that are now part of the City's new "review process intended to minimize land use impacts" have historically been allowed pursuant to Warren's existing entitlements. The ZAI creates a new procedure under which the Zoning Administrator can prohibit activities necessary to safely and efficiently operate Warren's lawful use, impairing Warren's vested rights to drill and maintain its wells. *See Hansen Bros. Enters. v. Board of Supervisors* (1996) 12 Cal. 4th 533 (vested rights to develop resources until the resource is exhausted or it is uneconomical to produce). The new required discretionary review of maintenance activities is a sham – the City has no intention of authorizing well maintenance pursuant to the ZAI and will be pursuing adoption of a new permanent ordinance to ban such activities altogether. In practice, the ZAI will affect an unconstitutional taking of Warren's property without just compensation in violation of the California Constitution and United States Constitution. 4-1

Moreover, by effectively eliminating maintenance activities and consequently forcing Warren to eventually cease production because it cannot maintain its wells, the ZAI unlawfully interferes with Warren's contracts with numerous mineral owners (of which the City is aware). The City is therefore liable to Warren for damages for the City's interference with those contracts. For the same reasons, the ZAI violates the Impairment of Contracts provisions in the California Constitution and the United States Constitution. In addition, Warren is a party to various lease agreements with the City for oil and gas operations within the City limits and to that end, the issuance of the ZAI interferes with Warren's rights under those leases, and constitutes a breach. 4-3

5. The ZAI is Arbitrary, Capricious, Lacking in Evidentiary Support, and an Abuse of Discretion

The ZAI is unlawful, arbitrary and capricious, lacking in evidentiary support and constitutes an abuse of discretion, all in violation of the due process clauses of the California Constitution and the United States Constitution. In addition to the CEQA violations and gross expansion of the Zoning Administrator's authority discussed above, the ZAI acts as an underground rule to stymie lawful oil and gas production, while lacking evidence that the activities the ZAI seeks to limit are harmful. The ZAI makes it abundantly clear that the City's overarching goal is to prohibit all production activities, as the research cited by the Zoning Administrator overwhelmingly relates to health risks associated with oil and gas production, not the maintenance activities that the ZAI purports to regulate. ZAI, pp. 4-5. 5-1

The ZAI's only discussion of scientific data reviewed relating to maintenance acidizing is reference to a study that "concluded that there is substantial overlap of the type of chemicals and trade products used in hydraulic fracturing activities and routine maintenance acidizing projects." *Id.* at p. 5. There is no indication that the referenced study cited health concerns associated with lawful, regulated routine maintenance activities. Nor does the ZAI acknowledge that many of the chemicals used in routine maintenance acidizing are the same chemicals used in pool cleaning, an activity that is not regulated by the City's Zoning Code. 5-2

---

[5] Additionally, the Zoning Administrator should be estopped from defining maintenance activities in a way that restricts Warren's ability to maintain the productive life of its wells. Warren reasonably, justifiably, and foreseeably relied on its agreement with the City to consolidate its operations into a central drill site, ZA 20725, and the resulting Plan Approvals when it invested significant resources in the future mineral development of its consolidated site, with the understanding that it would be permitted to maintain, continue and complete that development. 4-2

Further, the ZAI's limited references to scientific evidence do not account for on-the-ground activities in the City. The ZAI imposes severe limitations on safe, effective oil and gas production, because well maintenance activities "may have negative land use impacts on surrounding communities," without citing to any concrete examples of impacts associated with the precise activities the ZAI seeks to regulate. *Id.* at p. 5. 5-2

It also should be noted that Warren's site is all-electric, with emissions that are on par with a fast-food restaurant with a drive-through, and there is no evidence that any negative health impacts stem in any way from its operations. Further, Warren's well maintenance activities are fully contained, as the acid in transported in sealed containers, injected directly into a well, and then left to neutralize within the injection zone. This process has been analogized to the equivalent of cleaning a pool. In fact, the ZAI lacks *any* localized evidence supporting that there are negative health impacts from oil and gas operations generally, let alone from Warren's operations. 5-2

6. The ZAI is Preempted by Federal and State Law

The ZAI is preempted by state law, as Los Angeles Superior Court Judge Curtis Kin ruled in the case of *Warren E&P, Inc. v. City of Los Angeles*, Los Angeles Superior Court Case No. 23STCP00060 (Ruling, Sept. 6, 2024), and it is not saved by AB 3233. 6-1

Relying on the California Supreme Court case of *Chevron U.S.A. Inc. v. County of Monterey* ("*Chevron*"), 15 Cal. 5th 135 (2023), Judge Kin ruled that Ordinance No. 187,709 and the 2023 ZAI were preempted by Public Resources Code Section 3106 ("Section 3106"), which grants the State Oil and Gas Supervisor the authority and mandate to supervise all methods and practices related to the "drilling, operation, maintenance, and abandonment of wells." *Chevron*, 15 Cal. 5th at 143 (quoting Cal. Pub. Res. Code. § 3106(b)) (emphasis added). Indeed, quoting the *Chevron* Court, Judge Kin concluded that the Ordinance and 2023 ZAI were preempted, in part because, "were an oil producer to seek to redrill an existing well or conduct well maintenance in the City, the Ordinance, by vesting authority over such decisions in the Zoning Administrator, has, in all cases, usurped the supervisor's statutorily granted authority to decide whether those methods are suitable ... in each proposed case." (Internal quotation marks and citations omitted.) The procedures outlined in the present ZAI mirror those in the 2023 ZAI and are therefore equally preempted by Section 3106.[6] 6-1

In ruling on Warren's preemption claim, Judge Kin found that the Home Rule Doctrine did not save the Ordinance and ZAI from being preempted because the Ordinance and ZAI attempted to regulate a matter of statewide concern. The Home Rule Doctrine is set out in Article XI, section 5(a) of the California Constitution, and authorizes charter cities to legislate with respect to municipal affairs, but not on matters of statewide concern. Judge Kin concluded that "while the City has a general interest in protecting the health of and environment for its residents, with respect to oil and gas production, the Supervisor is charged with balancing those concerns for all Californians, along with meeting the energy needs of the state. The Court therefore finds that 6-1

[6] Although Judge Kin found conflict preemption in the case of the 2023 ZAI, appellants herein note that the ZAI additionally intrudes on an area of regulation fully occupied by both the Public Resources Code and the SCAQMD Rules, supporting a finding of field preemption as well.

Division 3 of the Public Resources Code, including section 3106, addresses a matter of statewide concern." *Warren E&P, Inc.*, Case No. 23STCP00060 (Ruling, Sept. 6, 2024).

AB 3233 contravenes Article XI, sections 5 and 7 of the Constitution because it purports to give cities and counties the authority regulate oil and gas operations, which conflicts with the state supervisor's goal to strike the balance between the health and environmental concerns of residents against the energy needs of the state. Because that delegation of authority to cities and counties does not support the objective of the statewide concern—which is to strike a meaningful balance—it is invalid and cannot save the ZAI from being preempted by the remainder of the Public Resources Code and specifically Section 3106. 6-1

The ZAI seeks to regulate and restrict maintenance activities by specifically incorporating the type of activities regulated not only by the State and CalGEM, but also the SCAQMD. The SCAQMD has extensive rules regarding the air quality concerns that the City purportedly seeks to address by way of the ZAI. (*See, e.g.*, SCAQMD Rules 1148.1 and 1148.2.) "The Legislature has designated regional air pollution districts as the primary enforcers of air quality regulations." *So. Cal. Gas Co. v. So. Coast Air Quality Mgmt. Dist.* (2012) 200 Cal.App.4th 251, 269. And in fact, these rules are actively implemented and enforced by the SCAQMD. The ZAI thus further improperly seeks to prohibit activities that are comprehensively regulated by the SCAQMD, including activities that Warren relies on to maintain its injection wells for its waterflood operations. "If the preemption doctrine means anything, it means that a local entity may not pass an ordinance, the effect of which is to completely frustrate a broad, evolutional statutory regime enacted by the Legislature." *Fiscal v. City and County of San Francisco* (2008) 158 Cal.App.4th 895, 914–915. As the Legislature has already delegated to other state agencies the regulation of well maintenance, the City lacks the authority or justification to impose unnecessary requirements that would frustrate the state's regulation of such activities and infringe upon the state's authority. 6-2

Further, the ZAI cites AB 3233 as providing local governments with authority to regulate oil and gas operations, presumably as justification for its current attempt to re-do what the Court has undone. But AB 3233 is itself unconstitutional and therefore cannot save the ZAI from preemption (again). The Supreme Court is the final arbiter of constitutional issues, and a Supreme Court decision addressing a constitutional issue cannot be overturned by a legislative enactment. In this case, because the Supreme Court in *Chevron* found preemption was based on the constitutional provisions providing for preemption by state law over conflicting local ordinances, AB 3233—which purports to negate the *Chevron* ruling—is unconstitutional, void, and of no effect. 6-1

The ZAI is additionally preempted by federal law, and specifically the Federal Safe Water Drinking Act, as it conflicts with the federal government's delegation of authority to CalGEM to regulate UIC wells. "Congress intended that states retain authority respecting underground injection so long as it does not impinge on the UIC program administered by the EPA." (*Bath Petroleum Storage, Inc. v. Savas* (N.D.N.Y. 2004) 309 F.Supp.2d 357, 367-368.) To the extent the ZAI regulates the maintenance of injection wells, it is preempted by federal law. Further, to the extent AB 3233 attempts to permit cities and counties to regulate injection wells, the state exceeds the authority delegated to it by the federal government. 6-3

7. **Adoption of the ZAI Violates the Parties' Settlement Agreement and Stipulated Judgment**

Finally, the ZAI should be rescinded because it violates the Stipulation of Entry of Judgment and Writ resolving the case of *Warren E&P, Inc. v. City of Los Angeles*, Los Angeles Superior Court Case No. 23STCP00060. Therein, the court held that Ordinance No. 187,709 and 2023 ZAI related thereto were preempted by state law, and the parties agreed that in the event the City decided to adopt a new ordinance similar or identical to Ordinance No. 187,709, it would conduct two stakeholder meetings at specific intervals of time, providing the parties and the public an opportunity to comment prior to its adoption. Warren entered into the settlement agreement with the City with the understanding that all parties would work together cooperatively through a public process with reasonable timeframes to craft updated regulations that would meet the City's goals without unnecessarily harming lawful oil and gas production operations. The ZAI attempts to circumvent this required process to which the City Council expressly agreed by regulating well maintenance activities in the absence of a new ordinance. As the new ZAI is substantially similar to the 2023 ZAI and a material part of the larger ordinance that the City now intends to readopt, the City too must comply with the public notice and stakeholder meeting requirements of the parties' stipulated judgment as to the new ZAI. Here, as noted above, Warren and others were given no advanced notice of the issuance of the new ZAI and instead were given just 15 days to appeal after the new ZAI was already issued. 7-1

Exhibit B

E&B Natural Resources Appeal Justification

APPLICATIONS

APPEAL APPLICATION
Instructions and Checklist

PURPOSE

This application is for the appeal of Los Angeles Department of City Planning determinations, as authorized by the LAMC. For California Environmental Quality Act Appeals, use form CP13-7840. For Building and Safety Appeals and Housing Department Appeals, use form CP13-7854.

RELATED CODE SECTION

Refer to the Letter of Determination (LOD) for the subject case to identify the applicable Los Angeles Municipal Code (LAMC) Section for the entitlement and the appeal procedures.

APPELLATE BODY

Check only one. If unsure of the Appellate Body, check with City Planning staff before submission.

☐ Area Planning Commission (APC) ☑ City Planning Commission (CPC) ☐ City Council

☐ Zoning Administrator (ZA)

CASE INFORMATION

Case Number: ZA-2025-2976-ZAI

APN: N/A

Project Address: Citywide

Final Date to Appeal: June 27, 2025

APPELLANT

Check all that apply.

☑ Person, other than the Applicant, Owner or Operator claiming to be aggrieved

☐ Representative ☐ Property Owner ☐ Applicant ☐ Operator of the Use/Site

APPELLANT INFORMATION

Appellant Name: E & B Natural Resources Management Corporation, Hillcrest Beverly Oil Corporation (cont'd below)

Company/Organization: (cont'd) E&B ENR I, LLC, and Elysium Natural Resources, LLC

Mailing Address: 1608 Norris Road

City: Bakersfield **State:** CA **Zip Code:** 93308

Telephone: 213-576-1185 **E-mail:** matt.wickersham@alston.com

Is the appeal being filed on your behalf or on behalf of another party, organization, or company?

☑ Self ☐ Other: _____

Is the appeal being filed to support the original applicant's position? ☐ **YES** ☑ **NO**

REPRESENTATIVE / AGENT INFORMATION

Name: Matthew Wickersham

Company/Organization: Alston & Bird LLP

Mailing Address: 350 S. Grand Avenue, 51st Floor

City: Los Angeles **State:** CA **Zip Code:** 90071

Telephone: 213-576-1185 **E-mail:** matt.wickersham@alston.com

JUSTIFICATION / REASON FOR APPEAL

Is the decision being appealed in its entirety or in part? ☑ **Entire** ☐ **Part**

Are specific Conditions of Approval being appealed? ☐ **YES** ☑ **NO**

If Yes, list the Condition Number(s) here: _____

On a separate sheet provide the following:

☑ Reason(s) for the appeal

☑ Specific points at issue

☑ How you are aggrieved by the decision

APPLICANT'S AFFIDAVIT

I certify that the statements contained in this application are complete and true.

Appellant Signature: _____ **Date:** 6/26/25

GENERAL NOTES

A Certified Neighborhood Council (CNC) or a person identified as a member of a CNC or as representing the CNC may not file an appeal on behalf of the Neighborhood Council; persons affiliated with a CNC may only file as an individual on behalf of self.

The appellate body must act on the appeal within a time period specified in the LAMC Section(s) pertaining to the type of appeal being filed. Los Angeles City Planning will make its best efforts to have appeals scheduled prior to the appellate body's last day to act in order to provide due process to the appellant. If the appellate body is unable to come to a consensus or is unable to hear and consider the appeal prior to the last day to act, the appeal is automatically deemed denied, and the original decision will stand. The last day to act as defined in the LAMC may only be extended if formally agreed upon by the applicant.

THIS SECTION FOR CITY PLANNING STAFF USE ONLY

Base Fee: $172

Reviewed & Accepted by (DSC Planner): Ruben Vasquez

Receipt No.: 200276835800 **Date:** 6/27/25

☒ Determination authority notified ☐ Receipt Number

GENERAL APPEAL FILING REQUIREMENTS

If dropping off an appeal at a Development Services Center (DSC), the following items are required. See also additional instructions for specific case types. To file online, visit our Online Application System (OAS).

APPEAL DOCUMENTS

1. Hard Copy

Provide three sets (one original, two duplicates) of the listed documents for each appeal filed.

☑ Appeal Application

☑ Justification/Reason for Appeal

☑ Copy of Letter of Determination (LOD) for the decision being appealed

2. Electronic Copy

☑ Provide an electronic copy of the appeal documents on a USB flash drive. The following items must be saved as individual PDFs and labeled accordingly (e.g., "Appeal Form", "Justification/Reason Statement", or "Original Determination Letter"). No file should exceed 70 MB in size.

3. Appeal Fee

☐ *Original Applicant.* The fee charged shall be in accordance with LAMC Section 19.01 B.1(a) of Chapter 1 or LAMC Section 15.1.1.F.1.a. (Appeal Fees) of Chapter 1A as applicable, or a fee equal to 85% of the original base application fee. Provide a copy of the original application receipt(s) to calculate the fee.

☑ *Aggrieved Party.* The fee charged shall be in accordance with LAMC Section 19.01 B.1(b) of Chapter 1 or LAMC Section 15.1.1.F.1.b. (Appeal Fees) of Chapter 1A as applicable

4. Noticing Requirements (Applicant Appeals Only)

☐ *Copy of Mailing Labels.* All appeals require noticing of the appeal hearing per the applicable LAMC Section(s). Original Applicants must provide noticing per the LAMC for all Applicant appeals. See the Mailing Procedures Instructions (CP13-2074) for applicable requirements.

SPECIFIC CASE TYPES
ADDITIONAL APPEAL FILING REQUIREMENTS AND / OR LIMITATIONS

DENSITY BONUS (DB) / TRANSIT ORIENTED COMMUNITES (TOC)

Appeal procedures for DB/TOC cases are pursuant to LAMC Section 13B.2.5. (Director Determination) of Chapter 1A or LAMC Section 13B.2.3. (Class 3 Conditional Use) of Chapter 1A as applicable.

- Off-Menu Incentives or Waiver of Development Standards are not appealable.
- Appeals of On-Menu Density Bonus or Additional Incentives for TOC cases can only be filed by adjacent owners or tenants and is appealable to the City Planning Commission.

☐ Provide documentation confirming adjacent owner or tenant status is required (e.g., a lease agreement, rent receipt, utility bill, property tax bill, ZIMAS, driver's license, bill statement).

WAIVER OF DEDICATION AND / OR IMPROVEMENT

Procedures for appeals of Waiver of Dedication and/or Improvements (WDIs) are pursuant to LAMC Section 12.37 I of Chapter 1 or LAMC Section 10.1.10. (Waiver and Appeals) of Chapter 1A as applicable.

- WDIs for by-right projects can only be appealed by the Property Owner.
- If the WDI is part of a larger discretionary project, the applicant may appeal pursuant to the procedures which govern the main entitlement.

[VESTING] TENTATIVE TRACT MAP

Procedures for appeals of [Vesting] Tentative Tract Maps are pursuant LAMC Section 13B.7.3.G. of Chapter 1A.

- Appeals must be filed within 10 days of the date of the written determination of the decision-maker.

NUISANCE ABATEMENT / REVOCATIONS

Appeal procedures for Nuisance Abatement/Revocations are pursuant to LAMC Section 13B.6.2.G. of Chapter 1A. Nuisance Abatement/Revocations cases are only appealable to the City Council.

Appeal Fee

☐ *Applicant (Owner/Operator).* The fee charged shall be in accordance with the LAMC Section 19.01 B.1(a) of Chapter 1 or LAMC Section 15.1.1.F.1.a. (Appeal Fees) of Chapter 1A as applicable.

For appeals filed by the property owner and/or business owner/operator, or any individuals/agents/representatives/associates affiliated with the property and business, who files the appeal on behalf of the property owner and/or business owner/operator, appeal application fees listed under LAMC Section 19.01 B.1(a) of Chapter 1 shall be paid, at the time the appeal application is submitted, or the appeal application will not be accepted.

☐ *Aggrieved Party.* The fee charged shall be in accordance with the LAMC Section 19.01 B.1(b) of Chapter 1 or LAMC Section 15.1.1.F.1.b. (Appeal Fees) of Chapter 1A as applicable.

ALSTON & BIRD

350 South Grand Avenue, 51st Floor
Los Angeles, CA 90071
213-576-1000 | Fax: 213-576-1100

Matthew Wickersham Direct: 213-576-1185 matt.wickersham@alston.com

VIA Online Application System
(https://planning.lacity.org/oas)

June 26, 2025

City of Los Angeles Department of City Planning
200 North Spring Street, Room 701
Los Angeles, CA 90012

Re: Justification for E&B's Appeal of Zoning Administrator's Interpretation of Well Maintenance, Case No. ZA-2025-2976-ZAI, ENV-2025-3305-CE

To whom it may concern,

We represent E & B Natural Resources Management Corporation, Hillcrest Beverly Oil Corporation, E&B ENR I, LLC, and Elysium Natural Resources, LLC (collectively, "E&B") regarding E&B's Appeal of the City of Los Angeles Department of City Planning's ("City Planning") "Zoning Administrator's Interpretation" ("ZAI" or "2025 ZAI"), issued on June 12, 2025. This new ZAI is substantially similar to a prior Interpretation issued by the Zoning Administrator on January 17, 2023 ("2023 ZAI"), which was previously declared invalid by the Los Angeles Superior Court and rescinded by the Office of Zoning Administration on May 29, 2025. In a judgment issued on March 21, 2025, the City was enjoined from enforcing the 2023 ZAI.[1]

E&B currently conducts oil and gas operations at several locations within the City of Los Angeles. For example, E&B operates a facility located in the vicinity of San Vicente Boulevard and West Third Street ("San Vicente facility"), Pico Boulevard and Genesee Avenue ("Packard facility") in the City. The San Vicente and Packard facilities collectively extract from 1,297 acres of mineral interests. Additionally, the Murphy facility is located in the vicinity of West Adams Boulevard and Western Avenue, and it extracts from 960 acres of mineral interests. E&B conducts oil production operations within the City in the South Torrance oilfield in the vicinity of East Pacific Coast Highway and Wilmington Boulevard and extracting from 330 acres of mineral interests. E&B also conducts oil production operations within the City in the Wilmington oilfield in the vicinity of W. Sepulveda Boulevard and S. Main Street and extracting from 146 acres of mineral interests. As part of these operations, E&B owns the mineral rights directly in fee or leases

[1] *Warren E&P, Inc. v. City of Los Angeles*, Los Angeles Superior Court, No. 23STCP00060, and related cases.

the mineral rights from royalty owners. As it stands, E&B's vested rights and ability to continue operations are jeopardized by the proposed application of the ZAI as presently drafted.

E&B appeals the ZAI, requesting that the City take the necessary, additional steps to study the environmental impact of this project, complete the required environmental review under the California Environmental Quality Act ("CEQA"), and reconsider the ZAI as it is currently drafted.

I. The ZAI, in its Current Form, Must Be Rejected as Vague and Ambiguous.

The City's Municipal Code requires operators to file an application with the Department of City Planning prior to drilling, deepening or maintaining an oil well. (Los Angeles Municipal Code § 13.01, subd. (H) and (I).) Prior to adoption of the ZAI, the City had interpreted the scope of well maintenance as limited to operations that required approval of a Notice of Intention from the California Geologic Energy Management Division. Now by way of the ZAI, the Zoning Administrator prescribes its "interpret[ation of] what drill site activities qualify as 'well maintenance.'" (ZAI p. 1.) It defines oil well maintenance "as any scope of work that meets either of the following two criteria:

1. A scope of work that requires a Notice of Intention "Rework Permit" to carry out a rework project on a well from the California Geologic Energy Management Division (CalGEM).

2. A scope of work that requires online notification per the South Coast Air Quality Management District's (SCAQMD) Rule 1148.2 – "Notification and Reporting Requirements for Oil and Gas Well and Chemical Suppliers." and/or "Injection" including one or more of the following activities: acidizing, hydraulic fracturing, gravel packing, maintenance acidizing, matrix acidizing, and acid fracturing.

(ZAI, pp. 1-2, footnotes omitted.)

The ZAI is inappropriately vague and ambiguous. The ZAI provides a definition of oil well maintenance that is dependent on the scope of SCAQMD Rule 1148.2. (*See* ZAI, p. 1.) But the ZAI fails to explain how it interacts with the various provisions of Rule 1148.2. As such, the ZAI is improperly vague and ambiguous as drafted, leaving operators, suppliers, and other individuals involved in oil and gas extraction operations without proper guidance and understanding for how the City will ultimately enforce its Code requirements. (*Zubaru v. City of Palmdale* (2011) 192 Cal. App. 4th 289, 308 ["An ordinance must be clear, precise, definite and certain in terms, and an ordinance vague to the extent that its precise meaning cannot be ascertained is invalid . . ."]; *accord City of Imperial Beach v. Escott* (1981) 115 Cal. App. 134, 139.) 1-1

II. The 2025 ZAI Fails to Comply with CEQA and Constitutes Improper Piecemealing.

The Zoning Administrator concluded that the 2025 ZAI is not a project under CEQA, or even if so, that it is exempt under the Class 8 and common-sense exemptions. These conclusions are legally improper and lack substantial evidence.

CEQA applies whenever a government agency approves a discretionary project, defined as "an activity which may cause either a direct physical change in the environment, or a reasonably foreseeable indirect physical change in the environment." (Pub. Res. Code § 21065.) CEQA defines "project" as the "whole of an action" and prohibits segmentation of project activities in an effort to minimize the evaluation of environmental effects. (Cal. Code Regs., tit. 14, § 15378.) "Accordingly, CEQA forbids piecemeal review of the significant environmental impacts of a project." (*Banning Ranch Conservancy v. City of Newport Beach* (2012) 211 Cal. App. 4th 1209, 1222 (internal citations omitted).) "Agencies cannot allow environmental considerations to become submerged by chopping a large project into many little ones." (*Id.*)

In its adoption of the substantially similar ZAI in January 2023, the Zoning Administrator stated that the 2023 ZAI "constitutes an administrative activity to assist in the implementation of the Oil and Gas Drilling Ordinance (Ordinance No. 187,709) adopted by the City Council on December 2, 2022 and which becomes effective on January 18, 2023." (1/17/23 ZAI, ZA-2022-8997-ZAI.) This Ordinance prohibited the use of well maintenance subject to narrow exceptions. While the 2023 Ordinance was also invalidated by the Superior Court and repealed by the City Council, the City has expressed an intent to re-adopt this Ordinance. As the current ZAI is substantively identical to the 2023 ZAI, the CEQA review for the 2025 ZAI must take into account the whole of the action. CEQA requires that "environmental considerations do not become submerged by chopping a large project into many little ones -- each with a minimal potential impact on the environment -- which cumulatively may have disastrous consequences." (*Laurel Heights Improvement Assn. v. Regents of University of California* (1988) 47 Cal.3d 376, 396 [holding that CEQA review must consider the reasonably foreseeable future expansion of the project].) Here, the Zoning Administrator has stated an intent to expand the 2025 ZAI by adopting an ordinance that prohibits well maintenance, which will likely be defined by the 2025 ZAI's new definition. As such, the Zoning Administrator must consider the potential environmental impacts of its revised oil well ordinance at the time that the Zoning Administrator issued the 2025 ZAI. The foreseeable adoption of an ordinance prohibiting well maintenance will result in substantial environmental impacts. Further CEQA review is needed to analyze the potentially significant environmental effects (both direct and cumulative) to air quality, energy, aesthetics, traffic, odor, and noise as a result of the accelerated rate of abandonment activities, and the increased importation of oil to replace the decreased local production.

2-1

Even standing alone, the expanded definition of well maintenance in the 2025 ZAI will make it significantly more difficult for operators to conduct routine well maintenance

2-2

that is essential for the continued operation of the existing oil wells, particularly injection wells. The adoption of the 2025 ZAI will undoubtedly impact the availability of mineral resources in the City and the State since the stated goal of the City is to stop oil production within the City limits. "Mineral resources" are an environmental factor pursuant to CEQA, and the "loss of availability of a known mineral resource that would be a value to the region and the residents of the state" or the "loss of availability of a locally important mineral resource recovery site" constitutes an adverse environmental impact. (Cal. Code Regs., tit. 14, Appendix G, § XII(a), (b); Public Resources Code § 21060.5.) 2-2

The Zoning Administrator incorrectly states that the 2025 ZAI is not a "project" subject to CEQA and is exempt under CEQA Guidelines Section 15378 as an "administrative and procedure-making activity." The promulgation of the ZAI does not appropriately fall under any of the exceptions to the definition of "project' under CEQA. (See Cal. Code Regs., tit. 14, § 15378.) Section 15378(b)(2) relates to "continuing" administrative activities and is described as applying to such things as "purchases of supplies," and "personnel-related actions." Section 15378(b)(5) is described as applying to "organization or administrative activities that will not result in a direct or indirect physical change to the environment." Clearly, these sections do not apply to the 2025 ZAI's restrictions on maintenance activity. 2-3

The Zoning Administrator also relies upon the Class 8 exemption for actions by regulatory agencies for the protection of the environment. The Class 8 exemption only applies to "actions taken by ***regulatory agencies***, as authorized by state or local ordinance, to assure the maintenance, restoration, enhancement, or protection of the environment where the regulatory process involves procedures for protection of the environment." (Cal. Code Regs., tit. 14, § 15308, emphasis added.) The Class 8 exemption also does not apply to actions that improve one element of the environment but have significant effects on another. (*Dunn-Edwards Corp. v. Bay Area Air Quality Management District* (1992) 9 Cal.App.4th 644.) The Zoning Administrator cannot simply "circumvent CEQA merely by characterizing its ordinance[] as environmentally friendly and therefore exempt" under a Class 8 exemption. (*Save the Plastic Bag Coalition v. County of Marin* (2013) 218 Cal.App.4th 209, 219-220.) The 2025 ZAI has the potential for significant, adverse impacts to the City's mineral resources, air quality, and GHG. 2-4

The ZAI is also not subject to the "common sense exemption" under section 15061(b)(2)-(3) of the CEQA Guidelines. This exemption applies "[w]here it can be seen with certainty that there is no possibility that the activity in question may have a significant effect on the environment." (Cal. Code Regs., tit. 14, § 15061(b)(3).) As the ZAI will make it more difficult for operators to maintain their wells within the City, the ZAI will reduce the ability to conduct local oil production within the City. This impact will have a material effect on the availability of mineral resources within the County and, consequently, GHG emissions due to the increased demand for foreign oil and the transport of foreign oil to the County. And importantly, CEQA recognizes that limitations in the access of mineral resources creates a significant environmental impact. (*See* Cal. Code Regs., tit. 14, Appendix G, section XII(a).) Therefore, the Zoning Administrator cannot 2-5

accurately state with certainty that the ZAI has no possibility of causing a significant effect on the environment. 2-5

These exemptions are inapplicable to projects that result in cumulative impacts. (*San Lorenzo Valley Community Advocate for Responsible Education v. San Lorenzo Unified School District* (2006) 139 Cal.App.4th 1356, 1381.) The 2025 ZAI would result in cumulative environmental impacts from the many other restrictions on oil and gas operations concurrently being adopted, including by the City of Los Angeles and the increased setback provisions adopted by SB 1137, Cal. Public Resources Code § 3280 et seq.. 2-6

Further, none of the exemptions apply because the unusual circumstances exception under section 15300.2(c) bars reliance upon any categorical exemption. An unusual circumstance refers to "some feature of the project that distinguishes it from others in the exempt class." (*San Lorenzo Valley Community Advocate for Responsible Education v. San Lorenzo Unified School District* (2006) 139 Cal.App.4th 1356, 1381.) The ZAI present "unusual circumstances" for several reasons. The unusual circumstances exception applies when evidence demonstrates a project will have a significant impact on the environment. (*World Business Academy v. Cal. State Lands Commission* (2018) 24 Cal.App.5th 476, 499.) The ZAI will make it more difficult for operators to maintain their wells, which will restrict development of known mineral resources that would be of value to the region and the residents of the state. This impact to mineral resources constitutes a significant impact on the environment under State CEQA Guidelines. (Cal. Code Regs., tit. 14, Appendix G, section XII(a).) State CEQA Guidelines, Appendix G, section XII(b) similarly finds a resulting significant environmental impact from "the loss of availability of a locally-important mineral resource recovery site delineated on a local general, specific plan or other land use plan[.]" In both respects, the ZAI is easily distinguished from other projects in the exempt class. 2-7

III. The Zoning Administrator Lacks Authority to Issue the 2025 ZAI.

In adopting the 2025 ZAI, the Zoning Administrator relies upon the expanded authority to provide Interpretations that is set forth in Chapter 1A of the Zoning Code. However, Chapter 1A provides that:

> "The new Zoning code will be applied incrementally on a geographic basis through the update of the City's Community Plans…. Eventually, this Zoning Code (Chapter 1A) will supersede and serve as the only Zoning Code for Los Angeles. However in the interim, until all the Community Plans have been updated and properties remapped using the new zoning system, properties in Community Plan areas not yet updated will be regulated by the provisions of the Zoning code found in existing Chapter I. (General Provisions and Zoning) of this LAMC."

3-1

(Zoning Code, Chapter 1A at Preface.)[2]

As new Community Plans have not been adopted in the relevant areas of E&B's operations within the City, then Chapter 1A does not apply and the Zoning Administrator lacks authority to issue a ZAI that is purportedly effective within that portion of the City. 3-1

Even if Chapter 1A applies, a provision of Chapter 1A provides that "any related Zoning Administrator Memos and Interpretations [to oil production and oil well related regulations in Chapter 1A] shall be ineffective until such time as this Section (Warren E&P, Inc. v. City of Los Angeles and Oil Regulations) is amended." (Zoning Code, Chapter 1A, § 1.4.7.) As the 2025 ZAI is clearly related to the City's adoption of oil production and oil well related regulations, the 2025 ZAI would remain ineffective until Section 1.4.7 of Chapter 1A is amended. 3-2

IV. The ZAI Is Preempted by Federal and State Law.

Judge Kin of the Los Angeles Superior Court previously determined that the 2023 ZAI is preempted by state law because it contradicts and is implicitly limited by section 3106 of the Public Resources Code. Judge Kin relied upon the Supreme Court's 2023 decision in *Chevron U.S.A. Inc. v. Cty. of Monterey* (2023) 15 Cal.5th 135 ("*Monterey*"). The decision by the California Supreme Court in the *Monterey* decision specifically held that local governments are preempted from interfering in the regulation of oil and gas operations. As the 2025 ZAI is substantively identical to the 2023 ZAI, the 2025 ZAI is also preempted under state law. 4-1

The ZAI references section 3106.1 to the Public Resources Code, which became effective on January 1, 2025 pursuant to Assembly Bill (AB) 3233. While AB3233 attempts to negate the holding in the *Monterey* decision, the preemption determination made by the Supreme Court in the *Monterey* case was based on the constitutional provisions that provide for preemption by state law over conflicting local ordinances. The California Supreme Court is the final arbiter on these state constitutional issues unless a constitutional amendment is adopted. 4-1

The ZAI is also preempted as its expanded definition of maintenance intrudes on an area "fully occupied" by CalGEM and SCAQMD. The extensive host of State laws and associated regulations clearly reflect an intent to occupy the entire area of oil and gas production. SCAQMD also has extensive rules regarding the air quality concerns that the Zoning Administrator purportedly seeks to address by its new requirements. (*See, e.g.*, SCAQMD Rules 1148.1 and 1148.2.) "The Legislature has designated regional air pollution districts as the primary enforcers of air quality regulations." (*So. Cal. Gas Co. v. So. Coast Air Quality Mgmt. Dist*. (2012) 200 Cal.App.4th 251, 269.) 4-2

[2] Available at https://codelibrary.amlegal.com/codes/los_angeles/latest/lazch1A/zoning.

The ZAI is also preempted by federal law as it will impermissibly intrude upon the regulation of injection wells in the City. The State regulates injection wells pursuant to a delegation of authority from the U.S. Environmental Protection Agency to CalGEM under the federal Safe Drinking Water Act. "Congress intended that states retain authority respecting underground injection so long as it does not impinge on the UIC program administered by the EPA." (*Bath Petroleum Storage, Inc. v. Savas* (N.D.N.Y. 2004) 309 F.Supp.2d 357, 367-368.) "[S]urely the prohibition above prevents such local law from altogether preventing UIC activity." (*EQT Prod. Co. v. Wender* (S.D.W.Va. 2016) 191 F. Supp. 3d 583, 601, affd. on other grounds (4th Cir. 2017) 870 F.3d 322.) Actions by local governments that make it effectively impossible for operators to maintain or continue to use injection wells are preempted by federal law. 4-3

By imposing a convoluted approval process that will result in the effective abandonment of existing oil and gas operations, the ZAI frustrates, contradicts, and intrudes upon federal and state law.

V. The Expanded Definition of Maintenance in the ZAI Is Not a Legitimate Exercise of the Police Power.

Whether standing alone, or in conjunction with any future ordinance prohibiting well maintenance activities, the ZAI is arbitrary, capricious, entirely lacking in evidentiary support, and contrary to established public policy supporting the extraction of oil and gas in the City. Even if the Zoning Administrator has some authority to interpret land use regulations, the City's police power is not unlimited. Land use regulations, such as the ZAI, must be "reasonable in object and not arbitrary in operation [in order to] constitute a valid exercise of that power" and reasonably related to the public welfare, which the Zoning Administrator fails to demonstrate. (*La Mesa v. Tweed & Gambrell Planning Mill* (1956) 146 Cal. App. 2d 762, 768; *Associated Home Builders, Inc. v. City of Livermore* (1976) 18 Cal.3d 582.)5 5-1

For instance, the City published an Oil and Gas Health Report dated July 25, 2019, which confirms that 1.6 billion barrels of recoverable oil and gas reserves remain beneath the City, alone "rivaling the reserves of the Middle Eastern countries, like Saudi Arabia, Iraq, and Kuwait 14,000 miles away." The ZAI will significantly curtail efforts to continue oil and gas operations and will add significant new requirements and procedures to get approval for oil well maintenance. In effect, this will reduce the ability to continue with oil and gas operations. But importantly, these new requirements and procedures placed on oil and gas operations will not eliminate the City's ongoing demand for oil and gas products. To meet demand, every barrel of oil that is not produced within the City must necessarily be produced elsewhere, requiring further expenses and potential negative environmental impacts by instead requiring the importation of oil. Additionally, reliance on foreign oil in the midst of the current geopolitical turmoil will create threats to the stability of the state's economy. 5-2

The ZAI points to a report prepared from CalGEM by the so-called "Science Advisory Panel" ("SAP") that analyzed studies regarding health impacts in proximity to oil and gas operations. The SAP report relied heavily upon studies of hydraulic fracturing or operations in other states without providing any basis to conclude that these operations are relevant to oil and gas operations in California. Further, the SAP report mischaracterizes the results of these studies, ignoring that the studies frequently found no increased risk and that any findings of significance appeared to be the result of confounding factors that were not properly taken into account. In fact, the SAP report admitted that many of the studies could not find a statistically significant association of health impacts in urban areas. (SAP Report at 3-1, 3-24.) It admitted that "residual confounding may explain observed differences in effect estimates between rural versus urban areas." SAP at 3.25. But there was no evidence provided to support an assumption that a proper consideration of these residual confounding factors would result in a finding that oil and gas production in urban areas are causing health impacts, as opposed to a finding that oil and gas production in rural areas are not actually causing health impacts. 5-2

The Zoning Administrator also points to a 2017 report purporting to identify an overlap of chemicals used in hydraulic fracturing and well clean-out operations. However, as well-clean-out operations are conducted in a closed-loop system at a lower pressure than hydraulic fracturing operations, this study is not relevant to justify the ZAI.

The ZAI will ultimately result in the loss of good-paying industry jobs, such as those for which E&B supplies to the City's residents through its oil and gas operations. The Zoning Administrator fails to properly forecast the probable effect of the ZAI, fails to identify the competing interests involved, and fails to justify why the ZAI reflects a reasonable interpretation of the existing zoning regulations.

For these reasons, the ZAI was also issued in violation of the due process protections of the U.S. and California Constitutions. The City may not deprive persons of property rights without due process of law. (Cal. Const., Art. 1, § 7(a); U.S. Const. amend V, XIV; *College Area Renters & Landlord Ass'n v. City of San Diego* (1996) 43 Cal.App.4th 677, 686.) Arbitrary or irrational governmental action that infringes on a property owner's rights violates substantive constitutional due process. (*Lingle v. Chevron U.S.A. Inc.* (2005) 544 U.S. 528, 541; *Arnel Development Co. v. City of Costa Mesa* (1981) 126 Cal.App.3d 330, 337.) In a rush to expand the scope of well maintenance through the ZAI, the Zoning Administrator has failed to demonstrate that current maintenance techniques in the City result in any environmental, health, or safety hazards. Without any viable justification for its actions, the Zoning Administrator lacks any legitimate interest in restricting these operations throughout the City. 5-1

VI. The ZAI Interferes with E&B's Contractual Relations within the City.

Both the U.S. and California Constitutions prohibit the enactment of laws effecting a "substantial impairment" of contracts, which applies to public contracts as well as contracts between private parties. (*Alameda County Sheriff's Assn. v. Alameda County* 6-1

Employees' Retirement Assn. (2020) 9 Cal.5th 1032, 1074.) E&B has contracts with various private parties, which impose obligations on E&B. The ZAI will impair these contracts by making it significantly more difficult to maintain its existing wells, which will undermine E&B's reasonable expectations under the contracts.

E&B has several leases with the City for its oil and gas operations, and the expanded definition of oil well maintenance under the ZAI will result in a breach of those leases. 6-1

VII. The ZAI Constitutes a Taking of E&B's Vested Rights.

The U.S. and California Constitutions provide that private property shall not be taken without just compensation. (U.S. Const. amend. V; Cal. Const., Art. 1, § 19.) These constitutional protections apply to regulatory takings. (*Lucas v. S.C. Coastal Council* (1992) 505 U.S. 1003, 1014.) "The right to remove oil and gas from the ground is a property right." (*Maples v. Kern Cty. Assessment Appeals Bd.* (2002) 103 Cal.App.4th 172, 186.)

E&B has vested property rights by its fee and leasehold ownership in mineral rights and its right to conduct its operations in the City, but the ZAI ignores these rights, significantly curtailing maintenance efforts, which will lead to the abandonment of wells. When dealing with vested property rights, the City cannot terminate E&B's existing operations without either the payment of just compensation or a demonstration that the existing, permitted operations and the associated maintenance are presently constituting a nuisance (which it has not). 7-1

Similarly, E&B's vested oil and gas rights are uniquely situated in the City, and the ZAI limits E&B's ability to properly maintain its oil wells and effectively eliminate the extraction of those resources in the City, without the ability to extract them elsewhere. (*See Los Angeles v. Gage* (1954) 127 Cal.App.2d 442.) The ZAI will effectively work to deprive E&B of the right to engage in the only business for which its subsurface mineral rights are fitted. Under the diminishing asset doctrine, E&B is entitled to produce oil and gas resources under its vested rights until the resource is exhausted or otherwise uneconomical to produce. 7-2

As such, the ZAI imposes an unconstitutional taking of E&B's property as an owner of mineral rights and as an oil and gas operator, along with the property of the landowners and the mineral rights holders in connection to E&B's leasehold interests.

VIII. The City's Liability for Damages Under the Civil Rights Act.

The federal Civil Rights Act, 42 U.S.C. § 1983 ("Section 1983"), provides a cause of action for damages based on claims arising from violations of federal rights. (*Sveen v. Melin* (2018) 138 U.S. 1815, 1822.) The adoption of the ZAI will significantly impair E&B's constitutional rights, including its right to just compensation and due process rights. Accordingly, if the City implements the Zoning Administrator's interpretation of well maintenance, as prescribed by the ZAI, the City will place itself at significant risk of 8-1

liability under Section 1983, including for payment of damages suffered as a result of unreasonably phasing out oil well maintenance, and consequently, oil and gas production in the City. 8-1

For all of these reasons, we urge the City to reconsider the adoption of the ZAI unless and until it cures the numerous legal defects discussed herein.

Sincerely,



Matthew C. Wickersham

Enclosure

Exhibit C

Zoning Administrators Interpretation

(Case No. ZA-2025-2976-ZAI)

OFFICE OF ZONING ADMINISTRATION
200 N. SPRING STREET, ROOM 763
LOS ANGELES, CA 90012-4801
(213) 978-1318

ESTINEH MAILIAN
CHIEF ZONING ADMINISTRATOR

ASSOCIATE ZONING ADMINISTRATORS
JACK CHIANG
HENRY CHU
TIM FARGO
JONATHAN A. HERSHEY, AICP
PHYLLIS NATHANSON
CHRISTINE SAPONARA
COURTNEY SHUM
CHRISTINA TOY LEE
JORDANN TURNER

CITY OF LOS ANGELES
CALIFORNIA

KAREN BASS
MAYOR

LOS ANGELES DEPARTMENT OF CITY PLANNING
EXECUTIVE OFFICES
VINCENT P. BERTONI, AICP
DIRECTOR

KEVIN J. KELLER, AICP
EXECUTIVE OFFICER
SHANA M.M. BONSTIN
DEPUTY DIRECTOR
HAYDEE URITA-LOPEZ
DEPUTY DIRECTOR
ARTHI L. VARMA, AICP
DEPUTY DIRECTOR
LISA M. WEBBER, AICP
DEPUTY DIRECTOR

planning.lacity.org

June 12, 2025

Public Counters

Department of City Planning

Department of Building and Safety

All Interested Parties

CASE NO. ZA-2025-2976-ZAI
ZONING ADMINISTRATOR'S INTERPRETATION

CEQA: ENV-2025-3305-CE

RELATED CASES:
ZA-2022-8997-ZAI-1A,
ZA Memo No. 141,
ZA Memo No.133

LAMC Sections: 13.01-H, 13.01-I

"Well Maintenance"

CITYWIDE

This Zoning Administrator's Interpretation (ZAI) interprets what drill site activities qualify as "well maintenance". This ZAI (ZA-2025-2976-ZAI) replaces a previous ZAI (ZA-2022-8997-ZAI-1A) interpreting "Well Maintenance", dated October 4, 2023, and rescinded on May 29, 2025. **Well maintenance** for oil and gas extraction sites shall be interpreted as any scope of work that meets either of the following two criteria:

1. A scope of work that requires a Notice of Intention "Rework Permit" to carry out a rework project on a well from the California Geologic Energy Management Division (CalGEM).[1]
2. A scope of work that requires notification per the South Coast Air Quality Management District's (SCAQMD) Rule 1148.2 - "Notification and Reporting Requirements for Oil and Gas Well and Chemical Suppliers" for "Well Rework"

[1] Permitting, Forms, and Compliance - Oil and Gas Requirements and Forms, Well Permit Information, Rework/Redrills. California Energy Geologic Management Division, 2022. <https://www.conservation.ca.gov/calgem/for_operators>

and/or "Injection" including one or more of the following activities: acidizing, hydraulic fracturing, gravel packing, maintenance acidizing, matrix acidizing, and acid fracturing.[2]

AUTHORITY OF THE ZONING ADMINISTRATOR TO INTERPRET ZONING REGULATIONS

Section 13A.1.7.D.2 of Chapter 1A of the Los Angeles Municipal Code provides, in pertinent part, as follows:

> "2.b. **Zoning Administrator Interpretation.** The Zoning Administrator shall have authority to interpret zoning regulations when the meaning of the regulation is not clear, either in general or as it applies to a specific property or situation.

CONTEXT

The Los Angeles Municipal Code (LAMC) contains several Zoning Code provisions that regulate oil and gas drill sites. These sites are primarily regulated by LAMC Section 13.01. LAMC Section 13.01-H of Chapter 1 states that any person desiring to "drill, deepen, or **maintain an oil well**…" requires a determination from the Zoning Administrator. The Zoning Code does not specify what activities might constitute a desire to "maintain an oil well."

In the past several decades the Zoning Administrator has reviewed and determined when a proposed scope of work at a drill site qualifies as a well maintenance project on a case by case basis.

LAMC Section 13.01-H and Section 13.01-I, reads as follows (underline added):

> *H. **"Drilling Site Requirements**. Any person desiring to drill, deepen or maintain an oil well in an oil drilling district that has been established by ordinance, or to drill or deepen and subsequently maintain an oil well in the M3 Zone within 500 feet of a more restrictive zone shall file an application in the Department of City Planning on a form provided by the Department, requesting a determination of the conditions under which the operations may be conducted."*
>
> *I. **"Permits.** (Amended by Ord. No. 173,268, Eff. 7/1/00, Oper. 7/1/00.) No person shall drill, deepen or maintain an oil well or convert an oil well from one class to the other and no permits shall be issued for that use, until a determination has been made by the Zoning Administrator or Area Planning Commission pursuant to the procedure prescribed in Subsection H of this section."*

[2] Compliance - Oil and Gas Well Electronic Notification and Reporting (Rule 1148.2) - South Coast Air Quality Management District, 2022. <https://www.aqmd.gov/home/rules-compliance/compliance/1148-2>

This ZAI formally interprets the term, **well maintenance**, as applicable in LAMC Sections 13.01-H and I. More specifically, this ZAI interprets the term "maintain" in the LAMC Sections 13.01-H and I. In the past, the Office of Zoning Administration (OZA) has been asked by operators, advocacy groups, and interested parties to interpret what constitutes well maintenance as it appears in the Zoning Code.

This ZAI formally interprets what the term, well maintenance, entails as needed for the land use regulation of drill sites set forth in LAMC Sections 13.01-H and 13.01-I.

BACKGROUND/ HISTORY

On December 2, 2022, the City Council approved Ordinance No. 187,709, which became effective on January 18, 2023, amending various parts of the LAMC relating to oil drilling. Among other changes, it eliminated LAMC Sections 13.01-H and 13.01-I and amended LAMC Section 12.23-C.4(a) to prohibit well maintenance, drilling, redrilling, and deepening except to prevent or respond to a threat to public health, safety, or the environment, as determined by the Zoning Administrator.

To implement the Ordinance, the Department of City Planning's Office of Zoning Administration (OZA) issued a Zoning Administrator Interpretation (ZAI) defining "well maintenance" (Case No. ZA-2022-8997-ZAI), and a Zoning Administrator Memorandum No. 141 (ZA Memo 141), which set forth the procedures for applying for Health and Safety Exemptions under the Ordinance .

The Oil Ordinance was challenged by oil operators in four related lawsuits, with the lead case being Warren E&P, Inc. v. City of Los Angeles, LASC Case No. 23STCP00060.[3] In addition, on January 30, 2023, an appeal was filed regarding the ZAI (Case No. ZA-2022-8997-ZAI-1A). On September 14, 2023, the City Planning Commission, as the appellate body, adopted a modified Zoning Administrator's Interpretation (Case No. ZA-2022-8997-ZAI-1A), dated October 4, 2023.

On September 6, 2024, Los Angeles Superior Court Judge Curtis A. Kin found that the City's Oil and Gas Drilling Ordinance (Ordinance No. 187,709), the ZAI (Case No. ZA-2022-8997-ZAI-1A), and ZA Memo No. 141 were preempted by state law.

Approximately three weeks later on September 25, 2024, Governor Newsom signed into law Assembly Bill (AB) 3233, which added Section 3106.1 to the Public Resources Code to provide local governments with authority to regulate oil and gas operations, notwithstanding other state law. AB 3233 became effective on January 1, 2025.

As part of the litigation and settlement, the City of Los Angeles rescinded the Oil Ordinance, finaled on June 2, 2025. The Office of Zoning Administration also issued a

[3] "Warren E and P, Inc., et al. v. City of Los Angeles, et al." Council File No. 24-1466, LACityClerk Connect. <cityclerk.lacity.org/lacityclerkconnect/index.cfm?fa=ccfi.viewrecord&cfnumber=24-1466>

rescission of the ZAI (Case No. ZA-2022-8997-ZAI-1A), and ZA Memo No. 141 on May 29, 2025. Upon the rescission of Ordinance No. 187,709, the amended or deleted definitions, paragraphs, subdivisions or subsections of Sections 12.03, 12.20, 12.23, 12.24, and 13.01 of Chapter 1 of the Los Angeles Municipal Code, return to the same language and effect as they had prior to their amendment or deletion by Ordinance No. 187,709.

Another notable state legislation which became effective on June 28, 2024, was Senate Bill (SB) 1137. The bill was signed by Governor Newsom on September 16, 2022, however, it was temporarily paused due to the legislation having qualified for a ballot initiative. After the ballot initiative was withdrawn, SB 1137 became effective on June 28, 2024. CalGEM resumed implementation of the new regulations, including a prohibition on new drilling, deepening, and rework (well maintenance) permits if the oil well is within 3,200-feet of a sensitive receptor. SB 1137 contains clear language that CalGEM can issue permits if the oil well activity is necessary to prevent or respond to a threat to public health, safety, or the environment. CalGEM is determining on a case-by-case basis if a scope of work meets the criteria for such a health and safety exception.

It is necessary to issue this new ZAI to interpret the term well maintenance in relation to the reinstated and reactivated sections of the LAMC noted above, specifically, as found in 13.01-H and 13.01-I.

DISCUSSION

The OZA relied on specific sources to interpret the scopes of work for well maintenance that include, but are not limited to: federal regulatory agency standards, state regulatory agency standards, scientific articles, and engineering publications related to petroleum engineering and oil extraction. The OZA also consulted with the City's Petroleum Administrator, Fire Department, SCAQMD, and CalGEM.

The OZA examined a growing body of research and studies regarding oil and gas wells. On June 21, 2024, the California Oil & Gas Public Health Rulemaking Scientific Advisory Panel, a group commissioned by the California Department of Conservation, published *Public Health Dimensions of Upstream Oil and Gas Development in California: Scientific Analysis and Synthesis to Inform Science-Policy Decision Making* that found adverse health outcomes increase within 1 kilometer (3,281 feet) of oil and gas wells for sensitive receptors (such as residences and child-care centers). These affected communities include low-income neighborhoods and communities of color. Also included and examined in the study was the scientific advisory panel's response (October 2021) to CalGEM regarding the effects of oil extraction and production on

public health, which illustrates the need to better regulate well maintenance activities.[4] This scientific advisory panel, consisting of scientists, engineers, and public health analysts, determined that extraction activities may have negative external effects on the health and well-being of people within the vicinity of such operations. In another study published in April 2017, researchers examined the overlap of the type of chemicals and trade products used in hydraulic fracturing activities and routine maintenance acidizing projects. This 2017 study concluded that there is substantial overlap given the number of similar chemicals used during these activities.[5] This analysis was done specifically using SCAQMD data, which is particularly relevant as this agency also regulates oil drill sites for air emissions and odors. These aforementioned studies confirm the potential negative external effects on community public health and on the environment, and serve as further justification for formally establishing the procedures for a discretionary review for well maintenance activities, consistent with the intent and objectives of Sections 13.01-H and 13.01-I.

In reviewing well maintenance projects, regulatory agencies such as CalGEM and SCAQMD have narrow purviews in what they can regulate. Therefore, the Zoning Administrator's authority under the local zoning code to review maintenance activities in a more comprehensive manner, can help further reduce, if necessary, any land use impacts. Specifically, as it relates to oil and gas extraction, CalGEM focuses on subsurface and near surface activities whereas SCAQMD regulates the effects on air quality, including emissions and pollutants. These agencies do not regulate other significant land use impacts for oil and gas extraction activities. Such land use impacts include, but are not limited to: traffic/transportation circulation, noise decibel levels, aesthetics, and noxious odors resulting from proposed activities conducted at drill sites.

CalGEM requires a state permit known as a "Notice of Intention" permit for specific oil well activities identified by CalGEM.[6] With regards to SCAQMD's Rule 1148.2, that rule requires operators to submit notification to SCAQMD for specific oil well activities and also requires operators to mail notification to sensitive receptors (e.g. residences) within a 1,500-ft. radius of the oil well facility.[7]

Well maintenance activities, as described herein, may have negative land use impacts on surrounding communities such as elevated noise levels, frequent odor events, increased emissions exposure, spill incidents affecting the public right-of-way, truck traffic congestion on local streets, removal of on-street parking, traffic congestion on

[4] "Public Health Dimensions of Upstream Oil and Gas Development in California: Scientific Analysis and Synthesis to Inform Science-Policy Decision Making", California Oil & Gas Public Health Rulemaking Scientific Advisory Panel. Commissioned by the CA Department of Conservation. June 21, 2024 <https://www.conservation.ca.gov/calgem/Documents/Public%20Health%20Panel%20Final%20Report_20240621.pdf>

[5] "Comparison of chemical-use between hydraulic fracturing, acidizing, and routine oil and gas development", Physicians, Scientists, and Engineers for Healthy Energy (funded by UC Berkeley and U.S. Department of Energy grants), Analyzes the usage of chemicals from South Coast AQMD disclosure data and concludes that there is overlap between fracking chemicals and 'maintenance acidizing' chemicals. April, 2017.

[6] Well Permit Information portal, California Geologic Energy Management Division online website, July 2022, https://www.conservation.ca.gov/calgem/for_operators

[7] Compliance - Oil and Gas Well Electronic Notification and Reporting (Rule 1148.2) - South Coast Air Quality Management District, 2022. <https://www.aqmd.gov/home/rules-compliance/compliance/1148-2>

local streets, and lack of effective screening for drill site equipment. These are precisely the types of land use impacts that LAMC Sections 13.01-H and 13.01-I were meant to address to protect the health and safety of surrounding neighborhoods and the public. As such, the Zoning Administrator's interpretation and review of well maintenance activities is consistent with the intent of Sections 13.01-H and 13.01-I, and is meant to implement the pre-existing safeguards in those sections. The Zoning Administrator's interpretation and review of these activities allow for a more comprehensive analysis of proposed well maintenance activities and ability to mitigate any potential impacts, if necessary.

The Zoning Administrator's Interpretation establishes a definition that facilitates the implementation of LAMC Sections 13.01-H and 13.01-I, and further advances the City's goal to prioritize the safety and quality of livability for local residents while providing an opportunity for operators to keep wells functioning in a safe and compliant manner.

Overview of Oil and Gas Well Activities Considered as Well Maintenance

Regulatory standards from agencies, primarily CalGEM and SCAQMD, helped shape the decision to define what activities qualify as well maintenance. Per state regulations, when operators propose to conduct specific well maintenance activities (such as maintenance acidizing or a well recasing), operators are required to apply for a permit and/or submit notification to various regulatory agencies such as SCAQMD or CalGEM.

For example, when an operator wishes to conduct maintenance acidizing on a well, the operator must disclose a chemical use list to SCAQMD and the operator sends an electronic notification of the proposed work to SCAQMD. Members of the public can subscribe to receive these notifications when an operator plans to conduct the proposed maintenance acidizing project or any other project that requires notification pursuant to SCAQMD Rule 1148.2. In this example, under the authority of LAMC Section 13.01-H, and per this ZAI, the Zoning Administrator would review this request for maintenance acidizing because it requires online notification per SCAQMD's Rule 1148.2. As part of the discretionary review pursuant to LAMC Section 13.01-H, the Zoning Administrator could include conditions to minimize land use impacts to the local vicinity.

Implementation per LAMC Section 13.01-H:

ZA Memo 133, dated September 19, 2016, establishes a comprehensive set of procedures and policies for the acceptance and processing of oil drilling applications pursuant to LAMC Section 13.01-H. This Section requires any person (or operator/applicant) seeking to "drill, deepen, or maintain an oil well … [to] file an application in the Department of City Planning…". ZA Memo 133 has been and will continue to be, unless updated, modified, or superseded by other procedures, the guiding document for operators (or applicants) seeking approvals pursuant to LAMC

Section 13.01-H. Operators (or applicants) are required to submit an application for a discretionary review that includes a public hearing, mailing notice, and additional review standards. Since 2016, when ZA Memo 133 was released, the OZA has been engaged in reviewing and determining scopes of work that qualify as maintenance and warrant a discretionary review. The ZA Memo 133, in conjunction with this ZAI and its interpretation of oil well maintenance activities, provide the procedures for implementing the preexisting review criteria set forth in Section 13.01-H.

The well maintenance activities listed in this ZAI are permitted only when filed, reviewed, and approved, pursuant to both the applicable code section and appropriate procedures as established thereto.

DETERMINATION

For the reasons set forth above, "**well maintenance**" is interpreted to include any scope of work that meets any of the following criteria:

1. A scope of work that requires a Notice of Intention "Rework Permit" to carry out a rework project on a well from the California Geologic Energy Management Division (CalGEM).[8]
2. A scope of work that requires notification per the South Coast Air Quality Management District's (SCAQMD) Rule 1148.2 - "Notification and Reporting Requirements for Oil and Gas Well and Chemical Suppliers" for "Well Rework" and/or "Injection" including one or more of the following activities: acidizing, hydraulic fracturing, gravel packing, maintenance acidizing, matrix acidizing, and acid fracturing.[9]

Well Servicing. Repair and servicing work may be carried out on existing wells if the scope of work does not meet the criteria for well maintenance, as described in this ZAI. Work activities conducted on the wells that do not meet the criteria for well maintenance shall be considered well servicing. Examples of well servicing can include projects such as well pump replacement or maintenance of underground and/or aboveground storage tanks that service the oil well operations.

This interpretation shall be published pursuant to the LAMC and administrative practice of the OZA.

[8] Permitting, Forms, and Compliance - Oil and Gas Requirements and Forms, Well Permit Information, Rework/Redrills. California Energy Geologic Management Division, 2022. <https://www.conservation.ca.gov/calgem/for_operators>
[9] Compliance - Oil and Gas Well Electronic Notification and Reporting (Rule 1148.2) - South Coast Air Quality Management District, 2022. <https://www.aqmd.gov/home/rules-compliance/compliance/1148-2>

CEQA

This ZAI provides a definition that assists in the procedural implementation of LAMC Sections 13.01-H and 13.01-I. The issuance of this ZAI that defines "well maintenance" is not a "project" as that term is defined by CEQA Guidelines, Section 15378 as it constitutes an administrative and procedure-making activity to assist in the implementation of the City's preexisting Zoning Code provisions regarding oil well sites. Even assuming that the ZAI is considered a project, the ZAI is nevertheless exempt under the Class 8 and common sense exemptions. The ZAI provides a definition of oil well maintenance to implement a review process intended to minimize land use impacts, such as elevated noise levels, frequent odor events, increased emissions exposure, spill incidents affecting the public right-of-way, and truck traffic congestion, among others. Thus, the ZAI is an action taken by a regulatory agency, as authorized by local ordinance, to assure the maintenance, restoration, enhancement, or protection of the environment. Moreover, the ZAI only provides a definition and interpretation of preexisting language in the Zoning Code to assist in the implementation of a previously-established application process, and does not have the potential for causing a significant effect on the environment.

EFFECTIVE DATE

This determination will become effective after June 27, 2025, unless an appeal is filed with the Department of City Planning. An appeal application must be submitted and paid for before 4:30 PM (PST) on the final day to appeal the determination. Should the final day fall on a weekend or legal City holiday, the time for filing an appeal shall be extended to 4:30 PM (PST) on the next succeeding working day. Appeals should be filed early to ensure the Development Services Center (DSC) staff has adequate time to review and accept the documents, and to allow appellants time to submit payment.

An appeal may be filed utilizing the following options:

Online Application System (OAS): The OAS (https://planning.lacity.org/oas) allows entitlement appeals to be submitted entirely electronically by allowing an appellant to fill out and submit an appeal application online directly to City Planning's DSC, and submit fee payment by credit card or e-check.

Drop off at DSC. Appeals of this determination can be submitted in-person at the Metro or Van Nuys DSC locations, and payment can be made by credit card or check. City Planning has established drop-off areas at the DSCs with physical boxes where appellants can drop off appeal applications; alternatively, appeal applications can be filed with staff at DSC public counters. Appeal applications must be on the prescribed forms, and accompanied by the required fee and a copy of the determination letter.

Appeal applications shall be received by the DSC public counter and paid for on or before the above date or the appeal will not be accepted.

Forms are available online at http://planning.lacity.org/development-services/forms. Public offices are located at:

Metro DSC	Van Nuys DSC
201 N. Figueroa Street Los Angeles, CA 90012 planning.figcounter@lacity.org (213)482-7077	6262 Van Nuys Boulevard Van Nuys, CA 91401 planning.mbc2@lacity.org (818) 374-5050
South LA DSC	**West LA DSC**
(In person appointments available on Tuesdays and Thursdays 8am-4pm only) 8475 S. Vermont Avenue 1st Floor Los Angeles, CA 90044 planning.southla@lacity.org	(CURRENTLY CLOSED) 1828 Sawtelle Boulevard West Los Angeles, CA 90025 planning.westla@lacity.org (310) 231-2901

QR Code to Online Appeal Filing

QR Code to Forms for In-Person Appeal Filing

QR Code to BuildLA Appointment Portal for Condition Clearance

City Planning staff may follow up with the appellant via email and/or phone if there are any questions or missing materials in the appeal submission, to ensure that the appeal package is complete and meets the applicable LAMC provisions.

If you seek judicial review of any decision of the City pursuant to California Code of Civil Procedure Section 1094.5, the petition for writ of mandate pursuant to that section must be filed no later than the 90th day following the date on which the City's decision became final pursuant to California Code of Civil Procedure Section 1094.6. There may be other time limits which also affect your ability to seek judicial review.

ESTINEH MAILIAN
Chief Zoning Administrator
EM:ML:SO:ecm

Exhibit D

Rescission of Case No. ZA-2022-8997-ZAI-1A

and

ZA Memorandum No. 141

OFFICE OF ZONING ADMINISTRATION
200 N. SPRING STREET, ROOM 763
LOS ANGELES, CA 90012-4801
(213) 978-1318

ESTINEH MAILIAN
CHIEF ZONING ADMINISTRATOR

ASSOCIATE ZONING ADMINISTRATORS
JACK CHIANG
HENRY CHU
TIM FARGO
JONATHAN A. HERSHEY, AICP
PHYLLIS NATHANSON
CHRISTINE SAPONARA
COURTNEY SHUM
CHRISTINA TOY LEE
JORDANN TURNER

CITY OF LOS ANGELES
CALIFORNIA

KAREN BASS
MAYOR

LOS ANGELES DEPARTMENT
OF CITY PLANNING
EXECUTIVE OFFICES
VINCENT P. BERTONI, AICP
DIRECTOR

KEVIN J. KELLER, AICP
EXECUTIVE OFFICER
SHANA M.M. BONSTIN
DEPUTY DIRECTOR
HAYDEE URITA-LOPEZ
DEPUTY DIRECTOR
ARTHI L. VARMA, AICP
DEPUTY DIRECTOR
LISA M. WEBBER, AICP
DEPUTY DIRECTOR

planning.lacity.org

May 29, 2025

Public Counters

Department of City Planning

Department of Building and Safety

All Interested Parties

RESCISSION OF:
CASE NO. ZA-2022-8997-ZAI-1A,
ZA MEMORANDUM NO. 141

CITYWIDE

RE: Rescission of Zoning Administrator's Interpretation (ZA-2022-8997-ZAI-1A) and Zoning Administrator Memorandum No. 141

On January 17, 2023, the Chief Zoning Administrator issued Zoning Administrator Interpretation Case No. ZA-2022-8997-ZAI (ZAI) defining what drill site activities qualify as "well maintenance". On October 4, 2023, this ZAI was reissued, as modified by the Chief Zoning Administrator, and as adopted by the City Planning Commission, pursuant to appeal Case No. ZA-2022-8997-ZAI-1A.

Also on January 17, 2023, the Chief Zoning Administrator issued Zoning Administrator Memorandum (ZA Memo) No. 141, establishing application and processing requirements for Health and Safety Exception projects for oil and gas drill sites pursuant to Los Angeles Municipal Code (LAMC) Section 12.23-C4 (Ordinance No. 187,709, adopted on December 2, 2022, and effective January 18, 2023).

Various parties challenged Ordinance No. 187,709, the ZAI, and ZA Memo No. 141 in *Warren E&P, Inc. v. City of Los Angeles*, Los Angeles Superior Court Case No.

23STCP00060, and three related cases.[1] Following trial, the court ruled that Ordinance No. 187,709, the ZAI (Case No. ZA-2022-8997-ZAI-1A) and ZA Memo No. 141 were preempted by state law. The matter was ultimately resolved by stipulation and a stipulated judgment, which requires the City to rescind Ordinance No. 187,709, the ZAI, and ZA Memo No. 141. Pursuant to the stipulation and stipulated judgment, on May 23, 2025, the City Council adopted a draft ordinance to rescind Ordinance No. 187,709. Rescission of Ordinance No. 187,709 means that any language in the LAMC that was deleted or amended by the Ordinance will become void, and the former language in Sections 12.03, 12.10, 12.23, 12.24, and 13.01 of Chapter 1 of the LAMC, as they existed prior to the adoption of the Ordinance, will become effective and enforceable.

To comply with the requirements of the stipulation and stipulated judgment, I hereby RESCIND Zoning Administrator's Interpretation, Case No. ZA-2022-8997-ZAI-1A, and Zoning Administrator Memorandum No. 141.

Case No. ZA-2022-8997-ZAI-1A and ZA Memorandum No. 141 are hereby rescinded, and the matter is received and filed.

ESTINEH MAILIAN
Chief Zoning Administrator



EM:ML:SO:ecm

[1] The other three related lawsuits are: E & B Natural Resources v. City of Los Angeles, LASC Case No. 23STCP00070, Native Oil Producers & Employees of California /Western States Petroleum Association v. City of Los Angeles, LASC Case No. 23STCP00085; and National Association of Royalty OwnersCalifornia, Inc. v. City of Los Angeles, LASC Case No. 23STCP00106.

Exhibit E

Modified ZAI: ZA-2022-8997-ZAI-1A

LOS ANGELES CITY PLANNING COMMISSION

200 North Spring Street, Room 272, Los Angeles, California, 90012-4801, (213) 978-1300
www.planning.lacity.org

LETTER OF DETERMINATION

MAILING DATE: OCTOBER 4, 2023

Case No. ZA-2022-8997-ZAI-1A Council District: All
CEQA: N/A
Plan Area: Citywide

Project Site: Citywide

Applicant: City of Los Angeles

Appellants: Warren E&P, Inc.; Warren Resources of California, Inc.; and Warren Resources, Inc.
Representatives: Megan Sammut, Day Carter Murphy LLP

E&B Natural Resources Management Corporation
Representative: Nicki Carlsen, Alston & Bird LLP

Western States Petroleum Association (WSPA) and Native Oil Producers & Employees of California (NOPEC)
Representative: Sigrid Waggener, Manatt, Phelps & Phillips LLP

At its meeting of **September 14, 2023**, the Los Angeles City Planning Commission took the actions below in conjunction with the approval of the following interpretation:

A Zoning Administrator's Interpretation (ZAI) applicable to all oil/gas well operations in the City of Los Angeles, issued by the Chief Zoning Administrator, interpreting the meaning of "well maintenance" in the Los Angeles Municipal Code (LAMC), as activities triggering a "Rework Permit" from the California Geologic Energy Management Division or notification per South Coast Air Quality Management District Rule 1148.2 for "Well Rework" and/or "Injection" including one or more of the following activities: acidizing, hydraulic fracturing, gravel packing, maintenance acidizing, matrix acidizing, and acid fracturing.

The issuance of this ZAI that defines "well maintenance" is not a "project" as that term is defined by CEQA Guidelines, Section 15378. Even if this ZAI is determined to be a project for purposes of CEQA, it was evaluated in the Initial Study prepared by the City to support the Mitigated Negative Declaration prepared for the Oil and Gas Drilling Ordinance (Ordinance No. 187,709).

1. **Granted** the appeal in part, as to Appeal Point No. 4; and **denied** as to all other appeal points;
2. **Adopted** the attached Modified Zoning Administrator's Interpretation of Well Maintenance dated October 4, 2023;
3. **Found** that the issuance of this ZAI that defines "well maintenance" is not a "project" as that term is defined by CEQA Guidelines, Section 15378. Even if this ZAI is determined to be a project for purposes of CEQA, it was evaluated in the Initial Study prepared by the City to support the Mitigated Negative Declaration prepared for the Oil and Gas Drilling Ordinance (Ordinance No. 187,709); and
4. **Determined** the following regarding the Zoning Administrator's Interpretation (ZAI):

Scope of the ZAI:

- Nearly all of the appeal points raised by Appellants are concerns directed at the Oil and Gas Drilling Ordinance (Ordinance No. 187,709), not the ZAI. The ZAI is the only subject of the City Planning Commission's action.
- Additionally, many of the claims raised in the appeals are about the alleged consequences of the City's Oil and Gas Drilling Ordinance adopted by City Council and ZA Memo 141 – which outlines the procedures for the acceptance and processing of applications for oil drilling approvals under the Health and Safety exception. The Oil and Gas Drilling Ordinance and ZA Memo 141 are outside the scope of this appeal.
- This ZAI does not establish new regulations; the ZAI interprets a zoning term in a regulation which is unclear.

ZA Authority to Interpret:

- The ZAI is a legitimate exercise of the Zoning Administrator's authority pursuant to the City Charter and LAMC Section 12.21 A.2 to interpret zoning regulations, which states, in part, that
  - The Zoning Administrator shall also have authority to interpret zoning regulations when the meaning of the regulation is not clear, either in general or as it applies to a specific property or situation.
  - The phrase "to maintain" and the term "maintenance", respectively, were found in the LAMC both prior to and after the adoption of the Oil and Gas Drilling Ordinance.
  - As such, a ZAI to interpret what "well maintenance" meant in this context was necessary for implementation purposes and appropriate.

Error and Abuse/Arbitrary and Capricious:

- The Chief Zoning Administrator did not err or abuse her discretion in issuing the interpretation defining the terms "to maintain" in prior LAMC Section 13.01-H and I and "maintained" in LAMC Section 12.23-C,4, as amended by Ordinance No. 187,709.
- The ZAI drafted by the Chief Zoning Administrator, and as modified herein, is not an arbitrary or capricious action.
  - The interpretation is backed by rigorous, methodical, and extensive research and consultation with oil regulators and operators – including some of the appellants, as demonstrated in the whole of the administrative record.

The vote proceeded as follows:

Moved:	Millman
Second:	Noonan
Ayes:	Gold, Lawshe, Zamora
Absent:	Cabildo, Choe, Leung, Mack

Vote: **5 – 0**

Cecilia Lamas

Cecilia Lamas, Commission Executive Assistant II
Los Angeles City Planning Commission

Fiscal Impact Statement: There is no General Fund impact as administrative costs are recovered through fees.

Effective Date/Appeals: The decision of the Los Angeles City Planning Commission is final and effective upon the mailing of this determination letter and not further appealable.

If you seek judicial review of any decision of the City pursuant to California Code of Civil Procedure Section 1094.5, the petition for writ of mandate pursuant to that section must be filed no later than the 90th day following the date on which the City's decision became final pursuant to California Code of Civil Procedure Section 1094.6. There may be other time limits which also affect your ability to seek judicial review.

Attachments: Modified Zoning Administrator's Interpretation of Well Maintenance dated October 4, 2023

cc: Estineh Mailian, Chief Zoning Administrator
Courtney Shum, Associate Zoning Administrator
Edber Macedo, City Planning Associate

OFFICE OF ZONING ADMINISTRATION
200 N. SPRING STREET, ROOM 763
LOS ANGELES, CA 90012-4801
(213) 978-1318

ESTINEH MAILIAN
CHIEF ZONING ADMINISTRATOR

ASSOCIATE ZONING ADMINISTRATORS
JACK CHIANG
HENRY CHU
TIM FARGO
JONATHAN A. HERSHEY, AICP
PHYLLIS NATHANSON
CHARLES J. RAUSCH JR.
CHRISTINE SAPONARA
COURTNEY SHUM
CHRISTINA TOY LEE
JORDANN TURNER

CITY OF LOS ANGELES
CALIFORNIA

KAREN BASS
MAYOR

LOS ANGELES DEPARTMENT OF CITY PLANNING
EXECUTIVE OFFICES
VINCENT P. BERTONI, AICP
DIRECTOR
SHANA M.M. BONSTIN
DEPUTY DIRECTOR
ARTHI L. VARMA, AICP
DEPUTY DIRECTOR
LISA M. WEBBER, AICP
DEPUTY DIRECTOR
planning.lacity.org

October 4, 2023

Public Counters

Department of City Planning

Department of Building and Safety

All Interested Parties

CASE NO. ZA-2022-8997-ZAI-1A
ZONING ADMINISTRATOR'S INTERPRETATION

Well Maintenance

CITYWIDE

This Zoning Administrator's Interpretation (ZAI) interprets what drill site activities qualify as "well maintenance". This ZAI (ZA-2022-8997-ZAI-1A) replaces and supersedes previous ZAI (ZA-2022-8997-ZAI) interpreting "Well Maintenance", issued on January 17, 2023. As modified herein, **well maintenance** for oil and gas extraction sites shall be interpreted as any scope of work that meets either of the following two criteria:

1. A scope of work that requires a Notice of Intention "Rework Permit" to carry out a rework project on a well from the California Geologic Energy Management Division (CalGEM).[1]
2. A scope of work that requires notification per the South Coast Air Quality Management District's (SCAQMD) Rule 1148.2 - "Notification and Reporting Requirements for Oil and Gas Well and Chemical Suppliers" for "Well Rework" and/or "Injection" including one or more of the following activities: acidizing,

[1] Permitting, Forms, and Compliance - Oil and Gas Requirements and Forms, Well Permit Information, Rework/Redrills. California Energy Geologic Management Division, 2022. <https://www.conservation.ca.gov/calgem/for_operators>

hydraulic fracturing, gravel packing, maintenance acidizing, matrix acidizing, and acid fracturing.[2]

AUTHORITY OF THE ZONING ADMINISTRATOR TO INTERPRET ZONING REGULATIONS

LAMC Section 12.21-A,2 provides, in pertinent part, as follows:

> "2. **Other Use and Yard Determinations by the Zoning Administrator.** (Amended by Ord. No. 177,103, Eff. 12/18/05.) The Zoning Administrator shall have authority to determine other uses, in addition to those specifically listed in this article, which may be permitted in each of the various zones, when in his or her judgment, the other uses are similar to and no more objectionable to the public welfare than those listed.
>
> The Zoning Administrator shall also have authority to interpret zoning regulations when the meaning of the regulation is not clear, either in general or as it applies to a specific property or situation.

This Section has been interpreted to permit resolution of conflicts between disparate sections of the Code and to provide clarity where ambiguity exists.

BACKGROUND

The LAMC contains several Zoning Code provisions that regulate oil and gas drill sites. These sites are primarily regulated by LAMC Section 13.01. Previous LAMC Section 13.01-H stated that any person desiring to "drill, deepen, or **maintain an oil well**…" requires a determination from the Zoning Administrator. The Zoning Code does not specify what activities might constitute a desire to "maintain an oil well."

In the past several decades the Zoning Administrator has reviewed and determined when a proposed scope of work at a drill site qualifies as a well maintenance project on a case by case basis.

Pertinent previous LAMC Section 13.01-H and Section 13.01-I, read as follows (underline added):

> ***H. "Drilling Site Requirements**. Any person desiring to drill, deepen or maintain an oil well in an oil drilling district that has been established by ordinance, or to drill or deepen and subsequently maintain an oil well in the M3 Zone within 500 feet of a more restrictive zone shall file an application in the*

[2] Compliance - Oil and Gas Well Electronic Notification and Reporting (Rule 1148.2) - South Coast Air Quality Management District, 2022. <https://www.aqmd.gov/home/rules-compliance/compliance/1148-2>

Department of City Planning on a form provided by the Department, requesting a determination of the conditions under which the operations may be conducted."

I. "Permits. (Amended by Ord. No. 173,268, Eff. 7/1/00, Oper. 7/1/00.) *No person shall drill, deepen or maintain an oil well or convert an oil well from one class to the other and no permits shall be issued for that use, until a determination has been made by the Zoning Administrator or Area Planning Commission pursuant to the procedure prescribed in Subsection H of this section."*

Recently, on December 2, 2022, the City Council also approved Ordinance No. 187,709, which became effective on January 18, 2023, amending various parts of the LAMC relating to oil drilling. Among other changes, it eliminated LAMC Sections 13.01-H and 13.01-I and amended LAMC Section 12.23-C.4(a) to prohibit well maintenance, drilling, redrilling, and deepening except to prevent or respond to a threat to public health, safety, or the environment, as determined by the Zoning Administrator.

Amended LAMC Section 12.23-C.4(a) reads as follows (underline added):

"All oil wells (as defined pursuant to LAMC Section 13.01 B), including those operating pursuant to any discretionary permit in all zones, whether by ordinance or approval of a Zoning Administrator, and all oil wells in an M3 Zone, are nonconforming uses as of the effective date of the ordinance. No new well for the production of oil, gas or other hydrocarbon substances may be drilled in any zone. No existing well for the production of oil, gas or other hydrocarbon substances, which is a nonconforming use, shall be maintained, drilled, re-drilled, or deepened, except to prevent or respond to a threat to public health, safety, or the environment, as determined by the Zoning Administrator."

This ZAI interprets **well maintenance** as applicable in both the previous LAMC Sections 13.01-H and I, and the current LAMC Section 12.23-C.4(a). More specifically, this ZAI interprets the term "maintain" in the previous LAMC Sections 13.01-H and I; and the term "maintained" in the current LAMC Section 12.23-C.4(a).

The new ordinance, Ordinance No. 187,709, also amended existing oil drilling regulations and reviews required by the Zoning Administrator, which further raises the need for this interpretation. In the past, the Office of Zoning Administration (OZA) has been asked by operators, advocacy groups, and interested parties to interpret what constitutes well maintenance as it appears in the Zoning Code.

This ZAI formally interprets what the term, well maintenance, entails as needed for the land use regulation of drill sites.

Implementation per LAMC Section 13.01-H:

ZA Memo 133, dated September 19, 2016, established a comprehensive set of procedures and policies for the acceptance and processing of oil drilling applications pursuant to previous LAMC Section 13.01-H. This Section required any person (or operator/applicant) seeking to "drill, deepen, or maintain an oil well … [to] file an application in the Department of City Planning…". ZA Memo 133 was the guiding document for operators (or applicants) seeking approvals pursuant to LAMC Section 13.01-H. Operators (or applicants) were required to submit an application for a discretionary review that includes a public hearing, mailing notice, and additional review standards. Since 2016, when ZA Memo 133 was released, the OZA has been engaged in reviewing and determining scopes of work that qualify as maintenance and warrant a discretionary review. This has mainly been done on a case by case basis, and at times by the request of the operator to the OZA. Other times, OZA staff have informed operators that a discretionary request would be required for well maintenance activities that were performed without consultation or review by the OZA.

Implementation per LAMC Section 12.23-C.4(a):

This ZAI also applies to any requests from operators that wish to complete any scope(s) of work involving well maintenance activities pursuant to LAMC Section 12.23-C.4. The LAMC, pursuant to Ordinance 187,709, was recently amended to prohibit various well activities, including well maintenance, unless the operator can demonstrate that the work is to prevent or respond to a threat to public health, safety, and/or the environment. Operators shall follow the procedures referenced in ZA Memo 141 and complete all required materials.

The well maintenance activities listed in this Interpretation are permitted only when filed, reviewed, and approved, pursuant to both the applicable code section and appropriate procedures as established by the relevant ZA Memos.

DISCUSSION

The OZA relied on specific sources to interpret the scopes of work for well maintenance that include, but are not limited to: federal regulatory agency standards, state regulatory agency standards, scientific articles, and engineering publications related to petroleum engineering and oil extraction. The OZA also consulted with the City's Petroleum Administrator, Fire Department, SCAQMD, and CalGEM.

As a result of this research and consultation, the OZA had initially determined two qualifying criteria for which activities shall be considered as **well maintenance**:

1. A scope of work that requires a Notice of Intention "Rework Permit" to carry out a rework project on a well from CalGEM.
2. A scope of work that requires online notification per SCAQMD's Rule 1148.2 - "Notification and Reporting Requirements for Oil and Gas Well and Chemical Suppliers".

The OZA examined a growing body of research, including those of a scientific advisory panel's response (October 2021) to CalGEM regarding the effects of oil extraction and production on public health[3], which illustrates the need to better regulate well maintenance activities. This scientific advisory panel, consisting of scientists, engineers, and public health analysts, determined that extraction activities may have negative external effects on the health and well-being of people within the vicinity of such operations. In another study published in April 2017, researchers examined the overlap of the type of chemicals and trade products used in hydraulic fracturing activities and routine maintenance acidizing projects. This 2017 study concluded that there is substantial overlap given the number of similar chemicals used during these activities.[4] This analysis was done specifically using SCAQMD data, which is particularly relevant as this agency also regulates oil drill sites for air emissions and odors. These aforementioned studies confirm the potential negative external effects on community public health and on the environment, and serve as further justification for formally establishing the procedures for a discretionary review for well maintenance activities.

In reviewing well maintenance projects, regulatory agencies such as CalGEM and SCAQMD have narrow purviews in what they can regulate. Therefore, the Zoning Administrator's authority under the local zoning code to review maintenance activities in a more comprehensive manner, can help further reduce, if necessary, any land use impacts. Specifically, as it relates to oil and gas extraction, CalGEM focuses on subsurface and near surface activities whereas SCAQMD regulates the effects on air quality, including emissions and pollutants. These agencies do not regulate other significant land use impacts for oil and gas extraction activities. Such land use impacts include, but are not limited to: traffic/transportation circulation, noise decibel levels, aesthetics, and noxious odors resulting from proposed activities conducted at drill sites.

---

[3] "CalGEM Questions for the California Oil and Gas Public Health Rulemaking Scientific Advisory Panel", Physicians, Scientists, and Engineers for Healthy Energy; and Lawrence National Berkeley Laboratory; and UC Berkeley's Department of Environmental Science, Policy, and Management (commissioned by the CA Department of Conservation), Identifies the substantial amount of health risks (both physical and mental health) associated with many elements of oil and gas extraction activity and discusses a buffer as potential harm reduction method. October, 2021.

[4] "Comparison of chemical-use between hydraulic fracturing, acidizing, and routine oil and gas development", Physicians, Scientists, and Engineers for Healthy Energy (funded by UC Berkeley and U.S. Department of Energy grants), Analyzes the usage of chemicals from South Coast AQMD disclosure data and concludes that there is overlap between fracking chemicals and 'maintenance acidizing' chemicals. April, 2017.

Well maintenance activities, as described herein, may have negative land use impacts on surrounding communities such as elevated noise levels, frequent odor events, increased emissions exposure, spill incidents affecting the public right-of-way, truck traffic congestion on local streets, removal of on-street parking, traffic congestion on local streets, and lack of effective screening for drill site equipment. As such, the Zoning Administrator's review allows for a more comprehensive analysis of proposed well maintenance activities and ability to mitigate any potential impacts, if necessary.

The Zoning Administrator's Interpretation advances the City's goal to prioritize the safety and quality of livability for local residents while providing an opportunity for operators to keep wells functioning in a safe and compliant manner.

Overview of Oil and Gas Well Activities Considered as Well Maintenance

Regulatory standards from agencies, primarily CalGEM and SCAQMD, helped shape the decision to define what activities qualify as well maintenance. Per state regulations, when operators propose to conduct specific well maintenance activities (such as maintenance acidizing or a well recasing), operators are required to apply for a permit and/or submit notification to various regulatory agencies such as SCAQMD or CalGEM.

For example, when an operator wishes to conduct maintenance acidizing on a well, the operator must disclose a chemical use list to SCAQMD and the agency sends an electronic notification of the proposed work. Members of the public can subscribe to receive these notifications when an operator plans to conduct the proposed maintenance acidizing project or any other project that requires notification pursuant to SCAQMD Rule 1148.2. In this example, under the previous authority of LAMC Section 13.01-H, and per this ZAI, the Zoning Administrator would review this request for maintenance acidizing because it requires online notification per SCAQMD's Rule 1148.2. As part of the discretionary review pursuant to former LAMC Section 13.01-H, the Zoning Administrator could include conditions to minimize land use impacts to the local vicinity.

In this same example, per this ZAI and upon the effectuation of Ordinance No. 187,709, which eliminates LAMC Section 13.01-H, a request for maintenance acidizing would still require online notification per SCAQMD's Rule 1148.2, and as such, be considered as well maintenance. Per LAMC Section 12.23-C.4(a), this well maintenance scope of work would be prohibited *except* as necessary to prevent or respond to any Health and Safety threats. ZA Memo 141 provides guidance pursuant to requests made to LAMC Section 12.23-C.4(a).

At the time the ZAI was released on January 17, 2023, the proposed SCAQMD rules that would trigger Rule 1148.2 notification, were in line with what was included in the

ZAI and included: hydraulic fracturing, gravel packing, maintenance acidizing, matrix acidizing, and acid fracturing. However, shortly thereafter, the SCAQMD amendments were adopted on February 3, 2023, and the scope of activities requiring notification included the aforementioned activities, and was restructured and expanded to include maintenance acidizing for injection wells, chemical treatment activities, and oil/gas well activities that utilized a workover rig that did not use a Tier 4 Final low emission engine or non-combustion source.

To respond to the amendments of the SCAQMD notification requirements post the release of the ZAI, this modification of the original ZAI further clarifies that any Rule 1148.2 Notification for a Well Activity categorized as "Well Rework" or "Injection" as defined by SCAQMD, and that will perform any of the following activities, will be considered "well maintenance" pursuant to the LAMC: acidizing, hydraulic fracturing, gravel packing, maintenance acidizing, matrix acidizing, and acid fracturing. In summary, these modifications to the ZAI affirm the Chief Zoning Administrator's original intent to include SCAQMD activities, while further clarifying under which circumstances the currently expanded list of SCAQMD activities will be considered "maintenance" for this purpose. With these modifications to the "well maintenance" interpretation criteria incorporated, the ZAI is a straightforward interpretation for operators to understand and follow as part of their oil/gas well operations.

Similarly to SCAQMD's oversight on oil and gas wells, CalGEM requires a Notice of Intention application for projects that will "rework" an existing well[5]; rework on a well can often entail a permanent modification to the well casing. Based on CalGEM's procedures, rework activities can include projects such as liner replacement in the well casing or converting an injection well to a producer well. This ZAI interprets that such proposed rework project would be considered as maintenance activity and as such, subject to review by the Zoning Administrator.

Operators may apply for multiple well maintenance projects, under one application, for a single drill site. Such batched submittals, under one application and at the same time, will allow the Zoning Administrator to assess the entirety of the scope and do a more comprehensive review. Surrounding neighbors and interested parties will also get a better overview of the proposed maintenance activities, with more transparency and predictability. In turn, the operator will have a more timely review and not have to submit multiple applications. Operators shall file applications per the appropriate procedures and applicable code section (e.g. LAMC Section 13.01-H or LAMC Section 12.23-C.4).

[5] Well Permit Information portal, California Geologic Energy Management Division online website, July 2022, https://www.conservation.ca.gov/calgem/for_operators

DETERMINATION

For the reasons set forth above, "**well maintenance**" is interpreted to include any scope of work that meets any of the following criteria:

1. A scope of work that requires a Notice of Intention "Rework Permit" to carry out a rework project on a well from CalGEM.
2. A scope of work that requires notification per the South Coast Air Quality Management District's (SCAQMD) Rule 1148.2 - "Notification and Reporting Requirements for Oil and Gas Well and Chemical Suppliers" for "Well Rework" and/or "Injection" including one or more of the following activities: acidizing, hydraulic fracturing, gravel packing, maintenance acidizing, matrix acidizing, and acid fracturing.[6]

Well Servicing. Repair and servicing work may be carried out on existing wells if the scope of work does not meet the criteria for well maintenance, as described in this ZAI. Work activities conducted on the wells that do not meet the criteria for well maintenance shall be considered well servicing. Examples of well servicing can include projects such as well pump replacement or maintenance of underground and/or aboveground storage tanks that service the oil well operations.

This interpretation shall be published pursuant to the LAMC and administrative practice of the OZA.

CEQA FINDINGS

The issuance of this Zoning Administrator Interpretation ("ZAI") that defines "well maintenance" is not a "project" as that term is defined by CEQA Guidelines, Section 15378 as it constitutes an administrative activity to assist in the implementation of the Oil and Gas Drilling Ordinance (Ordinance No. 187,709) adopted by the City Council on December 2, 2022 and which became effective on January 18, 2023. However, even if this ZAI is determined to be a project for purposes of CEQA; its impacts, if any, were evaluated in the Initial Study prepared by the City to support the Mitigated Negative Declaration (Case No. ENV-2022-4865-MND) prepared for the Oil and Gas Drilling Ordinance.

[6] Compliance - Oil and Gas Well Electronic Notification and Reporting (Rule 1148.2) - South Coast Air Quality Management District, 2022. <https://www.aqmd.gov/home/rules-compliance/compliance/1148-2>

EFFECTIVE DATE

The decision of the City Planning Commission on September 14, 2023, to adopt this Zoning Administrator's determination is final upon the date of this letter, and is not further appealable pursuant to LAMC Section 12.21-A.2.

Notice: *If you seek judicial review of any decision of the City pursuant to California* Code of Civil Procedure Section 1094.5, the petition for writ of mandate pursuant to that section must be filed no later than the 90th day following the date on which the City's decision became final pursuant to California Code of Civil Procedure Section 1094.6. There may be other time limits which also affect your ability to seek judicial review.

ESTINEH MAILIAN

Chief Zoning Administrator



EM:CS:ecm

Exhibit F

Rescission of Oil and Gas Drilling Ordinance
(Ordinance No. 188,623)

ORDINANCE NO. 188623

An ordinance rescinding Ordinance No. 187,709, which prohibited new oil and gas extraction and made existing extraction activities a nonconforming use in all zones.

THE PEOPLE OF THE CITY OF LOS ANGELES
DO ORDAIN AS FOLLOWS:

Section 1. Ordinance No. 187,709, which prohibited new oil and gas extraction and made existing extraction activities a nonconforming use in all zones, is rescinded.

Sec. 2. Upon the rescission of Ordinance No. 187,709, the amended or deleted definitions, paragraphs, subdivisions or subsections of Sections 12.03, 12.20, 12.23, 12.24, and 13.01 of Chapter 1 of the Los Angeles Municipal Code, shall return to the same language and effect as they had prior to their amendment or deletion by Ordinance No. 187,709.

Sec. 3. The City Clerk shall certify to the passage of this ordinance and have it published in accordance with Council policy, either in a daily newspaper circulated in the City of Los Angeles or by posting for ten days in three public places in the City of Los Angeles: one copy on the bulletin board located at the Main Street entrance to the Los Angeles City Hall; one copy on the bulletin board located at the Main Street entrance to the Los Angeles City Hall East; and one copy on the bulletin board located at the Temple Street entrance to the Los Angeles County Hall of Records.

Approved as to Form and Legality

HYDEE FELDSTEIN SOTO, City Attorney

By _____
MARVIN BONILLA
Deputy City Attorney

Date May 5, 2025

File No. 17-0447-S2

m:\real prop_env_land use\land use\jennifer tobkin\oil litigation\council reports\r25-0221 draft ordinance (oil ordinance rescission) (final).docx

The Clerk of the City of Los Angeles hereby certifies that the foregoing ordinance was passed by the Council of the City of Los Angeles.

CITY CLERK

MAYOR

Ordinance Passed May 23, 2025

Approved 06/02/2025

Ordinance Posted: 06/06/2025
Ordinance Effective Date: 07/16/2025

Exhibit G

ZA Memorandum No. 141

OFFICE OF ZONING ADMINISTRATION
200 N. SPRING STREET, ROOM 763
LOS ANGELES, CA 90012-4801
(213) 978-1318

ESTINEH MAILIAN
CHIEF ZONING ADMINISTRATOR

ASSOCIATE ZONING ADMINISTRATORS
JACK CHIANG
HENRY CHU
TIM FARGO
JONATHAN A. HERSHEY, AICP
PHYLLIS NATHANSON
CHARLES J. RAUSCH JR.
CHRISTINE SAPONARA
COURTNEY SHUM
CHRISTINA TOY LEE
JORDANN TURNER

CITY OF LOS ANGELES
CALIFORNIA

KAREN BASS
MAYOR

LOS ANGELES DEPARTMENT OF CITY PLANNING
EXECUTIVE OFFICES
VINCENT P. BERTONI, AICP
DIRECTOR
SHANA M.M. BONSTIN
DEPUTY DIRECTOR
ARTHI L. VARMA, AICP
DEPUTY DIRECTOR
LISA M. WEBBER, AICP
DEPUTY DIRECTOR
planning.lacity.org

ZA MEMORANDUM NO. 141

January 17, 2023

TO: Office of Zoning Administration
Department of City Planning
Department of Building and Safety
All Interested Parties

FROM: Estineh Mailian
Chief Zoning Administrator, Department of City Planning

SUBJECT: **Application and Processing Requirements for Health and Safety Exception Projects for Oil and Gas Drill Sites Pursuant to Los Angeles Municipal Code Section 12.23-C.4**

This Zoning Administrator Memorandum (ZA Memo) is intended to establish a comprehensive set of procedures and policies for the acceptance and processing of applications for projects, at existing non-conforming sites, where drilling, redrilling, deepening, or well maintenance is proposed to either prevent or respond to a threat to public health, safety, or the environment, pursuant to Los Angeles Municipal Code (LAMC) Section 12.23-C.4, adopted by Ordinance No. 187,709, effective on January 18, 2023. This ZA Memo 141 applies to all Citywide oil wells, including those that were formerly by-right operations in the M3 zone.

One pathway, a **Discretionary Health and Safety Exception** application, is a discretionary entitlement process complete with a CEQA determination. This ZA Memo identifies the steps that operators are required to complete prior to commencing proposed scopes of work and outlines the discretionary review procedures and policies for operators. In addition, there is a separate review process, the **Administrative Emergency Health and Safety Exception** review, that is specifically for projects where the operator needs to complete a scope of work or scopes of work due to an imminent emergency threat to public health, safety, and/or the environment. This "imminent emergency" shall be reviewed and processed administratively, the procedures of which are discussed further in this ZA Memo.

I. Background

In 2022, pursuant to City Council instructions in Council File No. 17-0447, the Department of City Planning (DCP) commenced an amendment to the LAMC Zoning Code provisions that govern oil and gas extraction activities in the City. The City Council instructed the DCP, with assistance from the City Attorney, to prepare an ordinance to prohibit new oil and gas extraction activities and to declare existing drill sites and oil wells a nonconforming use in all zones. The resulting ordinance, Ordinance No. 187,709, was adopted on December 2, 2022. This Ordinance will become effective on January 18, 2023. The Ordinance will apply to drill sites that were previously granted discretionary land use approval(s) including by the Zoning Administrator pursuant to LAMC Section 13.01 or that were formerly by-right operations on properties in the M3 zone.

The Ordinance revised different Zoning Code provisions, including changes to LAMC Sections 12.23-C.4 and LAMC 13.01. As pertains to this ZA Memo, the recently approved Ordinance adds language that prohibits new projects at existing drill sites, except when there is a demonstrated threat to public health, safety, or the environment, as determined by the Zoning Administrator and as detailed in the language below:

> ***"12.23-C.4. a)*** *All oil wells (as defined pursuant to LAMC Section 13.01 B), including those operating pursuant to any discretionary permit in all zones, whether by ordinance or approval of a Zoning Administrator, and all oil wells in an M3 Zone, are nonconforming uses as of the effective date of the ordinance. No new well for the production of oil, gas or other hydrocarbon substances may be drilled in any zone. No existing well for the production of oil, gas or other hydrocarbon substances, which is a nonconforming use, shall be maintained, drilled, re-drilled, or deepened, except to prevent or respond to a threat to public health, safety, or the environment, as determined by the Zoning Administrator."*

The above provision prohibits operators from carrying out scopes of work where wells would be maintained, drilled, re-drilled, or deepened, except if it is to prevent or respond to a threat to public health, safety, or the environment. This ZA Memo 141 establishes the procedures and policies for the acceptance and processing of applications for operators who will make requests to complete oil/gas well projects by way of this "Health and Safety exception."

A separate DCP communication, a Zoning Administrator's Interpretation (ZA-2022-8997-ZAI), discusses the interpretation of the term "maintained" as mentioned in LAMC Section 12.23-C.4(a). The ZAI interprets the full scope of what "well maintenance" projects constitute and applies to all LAMC sections where well maintenance is referenced. Specifically, the ZAI applies to well maintenance regulations in the LAMC sections both prior to and after the January 18, 2023 effective date of Ordinance No. 187,709.

Furthermore, ZA Memo 133, which addressed the review procedures and policies for discretionary requests per LAMC Section 13.01-H, is no longer applicable to the extent that LAMC Sections 13.01-H and 13.01-I are removed from the LAMC by way of Ordinance No. 187,709. To the extent that an operator seeks a Health and Safety exception request for a discretionary review, pursuant to LAMC Section 12.23-C.4, for drilling, redrilling, deepening, and/or well maintenance, these requests shall be made according to the procedures outlined in this ZA Memo 141.

Ordinance No. 187,709 adopted changes to the LAMC that deem all existing wells as legally nonconforming uses, as of the effective date of the ordinance. Per this Ordinance, a legally nonconforming well is an existing well that was established and permitted by the California Geologic Energy Management Division (CalGEM) prior to January 18, 2023. As such, these wells are subject to LAMC Section 12.23-C.4 for any future scopes of work. Existing wells that received prior Zoning Administrator approval will remain subject to the previously imposed land use conditions. These Zoning Administrator approvals, or "LAMC Section 13.01 legacy approvals", are subject to both LAMC Section 12.23-C.4 regulations as well as any previously imposed Conditions of Approval.

This Memo does not change or alter any vested rights granted in a LAMC Section 13.01 legacy approval.

II. CEQA Findings

In issuing this Memorandum, the Zoning Administrator makes the following CEQA findings:

The issuance of this ZA Memo 141, establishing procedures for determining whether certain activities related to well operations and maintenance are necessary to protect public health, safety or the environment, is not a "project" as that term is defined by CEQA Guidelines, Section 15378, as it constitutes an administrative activity to assist in the implementation of the Oil and Gas Drilling Ordinance (Ordinance No. 187,709) adopted by the City Council on December 2, 2022 and that which becomes effective on January 18, 2023. However, even if this ZA Memo 141 is determined to be a project for purposes of CEQA, it was evaluated in the Initial Study prepared by the City to support the Mitigated Negative Declaration (Case No. ENV-2022-4865-MND) prepared for the Oil and Gas Drilling Ordinance.

III. Purpose and Intent of Memorandum

This Memorandum is issued with the following intent: LAMC Section 12.23-C.4 prohibits specific well activities, including maintenance, drilling, re-drilling, and deepening, except when those scopes of work are necessary to prevent or respond to a threat to public health, safety, or the environment, as determined by the Zoning Administrator. This ZA Memo outlines the process to review proposed Health and Safety exception projects. This review process serves only as an opportunity for operators to perform necessary scopes of work on the wells. If a Health and Safety exception request is approved, the Zoning Administrator reserves the right, when appropriate and necessary, to establish additional conditions to minimize any potential land use impacts or mitigation measures for any potential environmental effects.

IV. Application Requirements & Procedures

Drill site operators seeking a determination by the Zoning Administrator pursuant to LAMC Section 12.23-C.4 shall abide by one of the following procedures corresponding to the nature of the request:

- **Discretionary Health and Safety Exception Projects:** For projects that propose to maintain, drill, re-drill, or deepen an existing well for oil, gas or other hydrocarbon substances in order to prevent or respond to a threat to public health, safety, or the environment. This will involve a discretionary review, as outlined below, by a Zoning Administrator,

- **Administrative Emergency Health and Safety Exception Projects:** For projects that propose to maintain, drill, re-drill, or deepen an existing well for oil, gas or other hydrocarbon substances and demonstrate an urgent need to commence (as mandated by a regulatory agency, further described below) due to an imminent emergency threat to public health, safety, or the environment. This review will be conducted administratively, as outlined below, by a Zoning Administrator or assigned/delegated City Planning staff.

LAMC Section 12.23-C.4 prohibits existing wells from being maintained, drilled, re-drilled, or deepened, except to prevent or respond to a threat to public health, safety, or the environment. In instances where such work is necessary, the Zoning Administrator will review Discretionary Health and Safety Exception Projects to determine whether it serves to prevent health, safety, and environmental threats and impose conditions of approval or mitigation measures, if warranted. There may, however, be some instances where work, as mandated by a formal order from another agency, is required to be performed on an oil well immediately to curb emergency threats. In such cases, an administrative review will take place to consider applications for Administrative Emergency Health and Safety Exception Projects. This administrative review will only be considered in instances where emergency work needs to be completed immediately as mandated by a regulatory agency in order to prevent and/or respond to threats to public health and negative impacts to the surrounding communities.

These two separate procedures are outlined below:

1. Discretionary Health and Safety Exception Projects

1.1. Application

In accordance with the procedures set forth in this ZA Memo, an operator shall submit all the required application materials for a Health and Safety Exception request and that request shall be subject to a discretionary review by a Zoning Administrator pursuant to LAMC Section 12.23-C.4. This ZA memo creates procedures that correspond with current code section 12.24-M (Plan Approval) until such procedures get superseded by Article 13, Section 13B2.2 (specifically Section H), upon the operative date of the Process and Procedures Ordinance (Ordinance No. 187,712), with the exception of Specialized Requirements for Noticing and Findings as described in this ZA Memo.

1.2. Application Forms

Requested actions will require a DCP Application for Health and Safety Exception Projects for Oil and Gas Drill Sites (Form CP-4077). The operator shall also submit all required information as outlined in the Instructions for Discretionary Health and Safety Exception Projects for Oil & Gas Drill Sites (Form CP-4078).

1.3. CEQA Forms

All applications must include an Environmental Assessment Form (EAF) for Health and Safety Exception Projects for Oil and Gas Drill Sites (Form CP-4077) to determine the appropriate California Environmental Quality Act (CEQA) clearance for the proposed scope(s) of work. The operator will provide all required information related to the EAF in order to assess the appropriate CEQA clearance.

1.4. Fees

Pursuant to LAMC Section 19.01-E, the operator shall pay all applicable fees for a City Planning review of a discretionary Health and Safety Exception request. The fees shall correspond to the current fees described in 19.01-E as "Modification or Review by Zoning Administrator" (pursuant to LAMC Sections 12.24 J., 12.24 L., and 12.24 M.). Upon the operative date of the Process and Procedures Ordinance (Ordinance No. 187,712) the fees shall correspond to "CUP Class 2" (pursuant to Article 13 - Section 13B.2.2 (specifically Subsection H)). Operators shall also pay the applicable fee(s) for Environmental Clearances pursuant to LAMC Section 19.05. All fees are subject to future amendments and annual adjustments.

1.5. Filing

An appointment can be scheduled online and operators shall file their discretionary application only at the Metro Development Services Center Public Counter in Downtown Los Angeles. Once an application is filed, the project is assigned a case number and routed to the appropriate staff members to review and process.

1.6. Specialized Requirements

Notwithstanding the current procedures as described in LAMC Section 12.24-M and in the future, Article 13, Section 13B.2.2

(specifically Section H), upon the operative date of the Process and Procedures Ordinance (Ordinance No. 187,712), and due to the unique nature of well activity requests, discretionary Health and Safety applications are subject to specialized notification requirements, findings, and appeal procedures further detailed in this ZA Memo and described in Sections 1.7 and 1.8 below.

1.7. Notification

Upon receipt of a complete application, the Zoning Administrator shall set the matter for public hearing and conduct the hearing at which evidence and testimony shall be received. Owners and occupants within a 1,500-foot radius of the drill site shall be provided with a mailing notice 24 days in advance of the scheduled public hearing.

1.8. Findings

The Zoning Administrator shall only grant an exception pursuant to LAMC Section 12.23-C.4(a) if the following findings can be made:

1. That the proposed scope of work for a legally nonconforming well will not adversely affect any element of the General Plan, including those which address the prevailing inequities in environmental justice.
2. That the use will not be detrimental to the public health, safety, and welfare of persons residing or working in the general vicinity, and will not be detrimental or injurious to property and improvements in the surrounding neighborhood, especially those identified as disadvantaged communities, as identified on the State of California Environmental Protection Agency Office of Environmental Health Hazard Assessment's CalEnviroScreen.
3. That the use will incorporate infrastructure and safety procedures to prevent disruption and nuisance impacts related to noise, odors, transportation and circulation, and negative land use impacts on the surrounding vicinity.
4. That substantial evidence demonstrates the requested scope of work is necessary to prevent or

respond to a threat to public safety, health, and/or the environment and that the operator has demonstrated that credible threat in their request(s).

1.9. Final Discretionary Determination

The Zoning Administrator shall issue a written determination regarding the requested action(s) and include findings for the determination. This determination shall be final and effective upon the close of the 15-day appeal period pursuant to LAMC Section 12.24-M.2 and upon the operative date of the Process and Procedures Ordinance (Ordinance No. 187,712), per Article 13 - Section 13B.2.2, unless otherwise appealed.

1.10. Appeals

An operator or any other person aggrieved by a decision of the Zoning Administrator may appeal the decision to the Area Planning Commission pursuant to LAMC Section 12.24-M.2 and upon the operative date of the Process and Procedures Ordinance (Ordinance No. 187,712), per Article 13 - Section 13B.2.2.G. All appeals shall be filed within 15 days of the date on the letter of determination on forms provided by the DCP, as also explained in the determination letter. The appellant decision of the Area Planning Commission shall be final and effective as provided in Charter Section 245.

A CEQA action can only be appealed if a non-elected decision-making body makes a determination for a project that is not further appealable. CEQA appeals can be filed pursuant to LAMC Section 11.5.13 and upon the operative date of the Process and Procedures Ordinance (Ordinance No. 187,712), per Article 13 - Section 13B.11. All appeals shall be filed within 15 days of the Project approval becoming final and on forms provided by the DCP.

2. Administrative Emergency Health and Safety Exception Projects

2.1. Application

In accordance with the procedures set forth in this ZA Memo, an operator may submit the documentation for an Administrative Review of an emergency Health and Safety scope of work. This emergency scope of work would only be subject to an

administrative review process. The process will determine whether the emergency Health and Safety scope of work proposed (or completed) was to prevent or respond to an imminent, emergency threat to public health, safety, and/or the environment. These criteria include, but are not limited to:

- Formal order or requirement from any city, county, state, or federal agency indicating that the work is required due to an emergency or imminent threat
- Disaster Response to the California Governor's Office of Emergency Services (CalOES Spill Incident)
- Emergency Response from the County Fire Department's Health and Hazardous Materials Division
- Emergency Response from the City Fire Department
- Formal, written acknowledgement from any city, county, state, or federal agency that operator needs to perform specific oil well activities within an urgent timeframe in order to prevent or respond to an imminent, emergency threat to public health, safety, and/or the environment.

  Projects will be administratively reviewed to determine whether the requested scope of work meets the above criteria.

2.2. Forms

For detailed instructions regarding how to file for a request for the emergency Health and Safety exception, please refer to and complete the Administrative Emergency Health and Safety Exception Projects for Oil & Gas Drill Sites (Form CP-4079). The operator shall complete a checklist and answer all questions in the form. This checklist shall be completed with accurate answers and submitted at time of filing with Administrative Review forms at the Metro Development Services Center.

2.3. Fees

Pursuant to LAMC Section 19.04, the City Planning application fee for an Emergency Health and Safety Exception request shall be paid upon filing and shall correspond to the "Administrative Review - Major" fee amount. This fee is paid in anticipation of the amount of staff time and resources spent on this administrative review process. The Administrative Emergency Health and Safety

Exception review process is administrative in nature (no public hearing, no mailing notices, etc.), but does require detailed review, coordination with various government agencies, and issuance of a determination letter. This aligns with the processes associated with the ADM Major fee in Article 9 of the LAMC and is subject to future amendments and annual adjustments.

2.4. Filing

An appointment can be scheduled online and operators shall file their discretionary application only at the Metro Development Services Center Public Counter in Downtown Los Angeles. Once an application is filed, the project is assigned a case number and routed to the appropriate staff members to review and process.

2.5. Administrative Determination

Upon deeming the submittal package complete, staff shall begin reviewing the information and answers provided in the checklist. Staff reserves the right to clarify with the operator any answers or information provided. The Zoning Administrator or City Planning staff may also contact any city, county, state, or federal agency to discuss the content of what the operator included in this checklist, including the nature of the imminent emergency threat to public health, safety, and/or the environment. Upon verifying that the operator's information constitutes an imminent emergency threat, the operator will be notified and a Letter of Determination will be issued for the administrative record. Upon verifying that the operator's information was not sufficient and/or does not justify that the situation was an imminent emergency threat, the DCP may begin a course of action to remedy the potential and/or confirmed violation(s) of LAMC Section 12.23-C.4.

V. Conclusion

Operators shall follow the procedures and policies outlined above when requesting a review for any scope of work that involves drilling, redrilling, deepening and/or well maintenance for a legally nonconforming well pursuant to LAMC 12.23-C.4. This ZA Memo facilitates the implementation of policies that advance the City's goal of phasing out oil and gas extraction. These new procedures and policies are an extension of the policy goals identified in Ordinance No. 187,709, which aim to eliminate oil drilling from

communities, especially environmental justice communities that have been disproportionately impacted by negative land use effects.

For questions, or to get digital copies of the application and instructions forms for the Health and Safety Exception, please contact the OZA Oil Regulations team at the following email address: Planning.OilDrilling@lacity.org. The application forms will soon be available on our website.

EM:CS:VS:ECM:ds

Exhibit H

ZA Memorandum No. 133

OFFICE OF ZONING ADMINISTRATION

City Hall 200 N. Spring Street, Room 763 Los Angeles, CA 90012

OFFICE OF ZONING ADMINISTRATION

MEMORANDUM

ZA MEMORANDUM NO. 133

September 19, 2016

TO: Office of Zoning Administration
Development Services Centers
Department of Building and Safety
Department of Public Works – Bureau of Engineering
Los Angeles Fire Department
Los Angeles Department of Water and Power

FROM: Linn K. Wyatt
Chief Zoning Administrator

SUBJECT: **APPLICATION AND PROCESSING REQUIREMENTS, INCLUDING CEQA REVIEW, FOR OIL AND GAS APPROVALS PURSUANT TO LOS ANGELES MUNICIPAL CODE SECTION 13.01-H.**

This Memorandum supersedes ZA Memorandum No. 94, dated December 12, 1994, and ZA Memorandum No. 94A, dated March 24, 2000.

This Memorandum is intended to establish a comprehensive set of procedures and policies for the acceptance and processing of applications for oil drilling approvals pursuant to Los Angeles Municipal Code (LAMC) Section 13.01-H and to establish City guidelines for the California Environmental Quality Act (CEQA) review of Section 13.01-H oil drilling applications.

I. Background

The LAMC requires a formal application and a filing fee in conjunction with a request for a determination of conditions for the conduct of oil drilling pursuant to LAMC Section 13.01-H. Other than the requirement for an application and payment of a filing fee, the LAMC contains no express procedural requirements for the determination of conditions under Section 13.01-H for an original approval or for a modification or clarification to a previously approved determination of conditions.

Z.A. Memoranda Nos. 94 and 94A

Historically, as described in ZA Memoranda Nos. 94 and 94A, applicants were permitted to apply for modifications to the original conditions for oil drilling approvals through the use of a more limited review process (similar to a plan approval under LAMC Section 12.24-L and M).

The use of the process outlined in Memoranda Nos. 94 and 94A is no longer permitted for any Section 13.01-H application, including those submitted as a determination of conditions, modification of condition, request for clarification, or related approval. All applicants seeking an approval under Section 13.01-H must follow the application procedures outlined in this Memorandum. All applications seeking any approval under Section 13.01-H will be processed by the City, including the Office of the Zoning Administrator, pursuant to this Memorandum.

Existing Approvals with Modification Procedures

In addition to the above historical process, there are existing active approvals which include conditions establishing a process for subsequent modifications or condition review. An example of one condition reads substantially as follows:

> *Drilling operations for the first X wells identified in the grant clause of the instant determination shall be completed within 36 months from the effective date of this determination. The drilling for the following X wells as hereby authorized shall be subject to a review of plans by the Zoning Administrator, without a public hearing, for the purpose of updating the record with the well identification and path.*

Another condition reads substantially as follows:

> *Review of Conditions. Two years following completion of construction… the applicant shall submit a Plan Approval application for reviewing the effectiveness of these conditions. … The applicant shall submit a 500-foot radius map with accompanying labels for owners and occupants. The Zoning Administrator may set the matter for public hearing if warranted.*

Both of these conditions include processes that are inconsistent with the processes established in this Memorandum. The first condition is inconsistent because it allows for modifications without a public hearing. The second condition is inconsistent because it allows the Zoning Administrator to not set a public hearing for a Plan Approval and implies the notice radius is 500 feet.

To the extent that any existing condition or grant in an existing approval gives the Zoning Administrator discretion in the process to be followed for a modification or condition review, the procedures in this Memorandum shall be followed, in accordance with the findings in Section II and the purpose statements in Section III.

To the extent that any existing condition or grant in an existing approval mandates a procedure that is inconsistent with this Memorandum, the Zoning Administrator shall consider whether a Plan Approval process shall be initiated by the City to revise any conditions to protect the public health, safety and welfare, including any condition establishing a process inconsistent with the purpose of this Memorandum. On the other hand, if an existing condition or provision is not modified through a Plan Approval, then the process outlined in the existing approval shall be followed.

Nothing in this Memorandum is intended to expand the authority the City has to initiate a Plan Approval.

II. Findings

In issuing this Memorandum, the Zoning Administrator makes the following findings:

A. In adopting the California Environmental Quality Act[1], the Legislature declared:

> It is the intent of the Legislature that all agencies of the state government which regulate activities of private individuals, corporations, and public agencies which are found to affect the quality of the environment, shall regulate such activities so that major consideration is given to preventing environmental damage, while providing a decent home and satisfying living environment for every Californian. (Public Resources Code Section 21000(g).

B. The CEQA Guidelines provide that CEQA's basic goal of protecting the environment has two purposes:

(1) avoiding, reducing, or preventing environmental damage where possible by requiring alternatives or mitigation measures; and

(2) providing information to decision-makers and the public concerning the environmental effects of proposed and approved actions. (CEQA guidelines 15002(a).)

C. One oft-repeated purpose of the CEQA Guidelines is to provide for public participation, including as set forth in Section 15201:

> Public participation is an essential part of the CEQA process. Each public agency should include provisions in its CEQA procedure for wide public involvement, formal and informal, consistent with its existing activities and procedures, in order to receive and evaluate public reactions to environmental issue related to the agency's activities. Such procedure should include, wherever possible,

[1] Public Resources Code, Sections 21000, *et seq*.

making environmental information available in electronic format on the Internet, on the web site maintained and utilized by the public agency.

D. Although CEQA does not require formal hearings at any state of the environmental review process, section 15202 provides that:

...

(b) If an agency provides a public hearing on its decision to carry out or approve a project, the agency should include environmental review as one of the subjects for the hearing.

(c) A public hearing on the environmental impact of a project should usually be held when the lead agency determines it would facilitate the purposes and goals of CEQA to do so. The hearing may be held in conjunction with and as part of normal planning activities.

...

(f) A public agency may include, in its implementing procedures, procedures for the conducting of public hearings pursuant to this section. The procedures may adopt existing notice and hearing requirements of the public agency for regularly conducted legislative, planning, and other activities.

E. Applications for oil and gas projects under LAMC Section 13.01-H have the potential to create unique risks and hazards to have the potential for significant and immediate impacts on the health, safety, and welfare of the residents in and around the project site through increased noise, odor, dust, traffic, and other disturbances, as well as the potential to significantly impact the City's air, water, soil, biological quality, geology, water, stormwater and wastewater infrastructure, transportation, emergency response plans and other aesthetic values and community resources.

F. People living and working within the land use and environmental impact range of oil and gas operations and activities have a substantial interest in participating in a public hearing on 13.01-H approvals.

G. Section 13.01-H provides authority for the Zoning Administrator to condition, approve or deny a Section 13.01-H application under the City's police powers to protect public health, safety and welfare and to issue and implement reasonable procedures to process Section 13.01-H applications consistent with the requirements for due process.

III. Purpose and Intent of Memorandum

This Memorandum is issued with the following intent:

- Ensure that the City complies with all legal requirements of CEQA in approving Section 13.01-H projects;
- Provide all parties that may be impacted by a project subject to a Section 13.01-H application an opportunity to participate in a public hearing;
- Meet the intent of CEQA in the review and approval of CEQA findings and determinations, to provide adequate public participation;
- Ensure that staff has time to adequately consider and respond to, if necessary, evidence submitted on a Section 13.01-H application and its related environmental findings (including the CEQA Guideline Section 15300.2 exceptions) prior to the issuance of any decision;
- Provide decision-makers and City Staff, and the public with the information and data needed for adequate decision-making under CEQA and Section 13.01-H;
- Ensure that Section 13.01-H applications are processed efficiently;
- Ensure that applicants, staff, and the public can rely on a consistent practice in reviewing Section 13.01-H applications;
- Provide for transparent disclosure and participation process; and
- Ensure that the city's processing and approvals pursuant to 13.01-H will not result in adverse effects to public health, safety, and welfare

IV. Application Requirements

The original case number shall be used for the plan approval request. Before an application may be deemed complete, the applicant must submit:

1) A completed "Land Use Application For Oil & Gas Project Conditional Approval" (CP Form CP-7834) with all required attachments, as specified in the application and the Instructions (CP Form CP-7833.)
2) A completed Environmental Assessment Form for Oil and Gas Projects (EAF-O, CP-7832), with all required attachments.
3) The filing fee pursuant to LAMC Section 19.01.

V. Processing Section 13.01-H Applications

A. CEQA Review

The following review procedures are intended to provide guidelines to implement CEQA on all Section 13.01-H applications. Nothing in this Memorandum or the guidelines provided herein are intended to conflict with CEQA. To the extent that these guidelines are silent or ambiguous, the Zoning Administrator shall fall back on the requirements and intent of CEQA. To the extent that these guidelines impermissibly conflict with CEQA, the provisions of CEQA control. Nothing in these Guidelines is intended to conflict with the Permit Streamlining Act, Gov't Code Section Government Code § 65920 et seq.

1. Preliminary Review for Exemptions

No categorical exemption forms will be processed for consideration or issued at the Planning Department Development Services. The applicant shall submit a complete EAF-O form with their application, which shall be reviewed by the Zoning Administrator. The Zoning Administrator will conduct a preliminary review to determine whether the application qualifies for an exemption from environmental review pursuant to CEQA. The Zoning Administrator may require the applicant to provide additional supporting materials from the applicant to support the use of a categorical exemption.

An application to drill, re-drill, deepen, or convert a well is not eligible for a categorical exemption and shall require an Initial Study or an EIR as described in section V.A.2. All other projects may be reviewed to determine if the project is exempt under any applicable categorical exemption in CEQA Guidelines Section 15300-15333 or any City Guidelines (adopted pursuant to CEQA). If a project is determined not to fall into any categorical exemption based on the project description, an Initial Study shall be prepared pursuant to section V.A.2. If the project falls within a categorical exemption, the Zoning Administrator shall determine if, based upon the whole of the record, any exception to any exemption under CEQA Guidelines, Section 15300.2, applies to the project, including, but not limited to the following:

> Cumulative Impact. All exemptions for these classes are inapplicable when the cumulative impact of successive projects of the same type in the same place, over time is significant.
>
> Significant Effect. A categorical exemption shall not be used for an activity where there is a reasonable possibility that the activity will have a significant effect on the environment due to unusual circumstances.

If the project is determined to be categorically exempt (CE) and no exceptions apply, the Zoning Administrator shall do all of the following:

- Give the public hearing notice required in section V.B., including a notice of an intent to adopt a categorical exemption to all property owners and occupants within a 1,500-foot radius of the project site's outer boundary, and provide for a 35-day comment period on the project, prior to approval. The public hearing may be held during the comment period. The hearing notice (with the notice of intent to adopt a CE) must be provided in English and Spanish.

- If after the 35-day comment period, or any time prior to making a decision on the project, the Zoning Administrator determines that substantial evidence does not support the use of the exemption, including from the existence of an exception in Section 15300.2, the Zoning Administrator shall require an Initial Study to be prepared consistent with the procedures outlined herein.

- Alternatively, if the Zoning Administrator finds after the 35-day comment period, or any time prior to making a decision on the project, that additional information and analysis is required to determine if the categorical exemption is supported with substantial evidence, and the applicant desires the City to use a categorical exemption rather than a prepare an Initial Study, the Zoning Administrator may require the applicant to submit additional information or documents and/or technical studies or reports, including requiring the applicant to hire independent consultants to prepare any necessary technical studies or reports or peer review any prepared studies or reports. If after reviewing any additional documents, reports or studies, required by the Zoning Administrator, it is determined that a categorical exemption is not supported by substantial evidence, an Initial Study shall be prepared.

- If the use of the categorical exemption is supported by substantial evidence in the record at the time of the decision, the Zoning Administrator shall ensure the record contains a memorandum or narrative substantiating the use of the categorical exemption, including explaining how substantial evidence in the administrative record supports the use of the exemption, and that the Zoning Administrator considered whether any exception to an exemption under CEQA Guidelines Section 15300.2 is applicable, including providing where necessary an explanation or evidence to demonstrate that any comments submitted on the intent to adopt the Categorical Exemption do not provide substantial evidence that an exception applies or the exemption does not apply.

2. Initial Study Determination

For any project that does not qualify for a categorical exemption, including any project to drill, redrill, or convert a well, an Initial Study must be completed.

Nothing in this subsection is intended to require the preparation of an Initial Study, when a preliminary review of the project demonstrates an EIR is clearly required, pursuant to CEQA Guidelines Section 15060(d).

The Initial Study must be prepared by an environmental consultant with the qualifications and experience required in this Memorandum. The Zoning Administrator may require the applicant to provide any additional documents, information or technical studies or reports necessary to complete the environmental review of the project, including requiring the applicant to hire an independent contractor to prepare or peer review technical studies or reports. The Initial Study shall comply with Section 15063 of the CEQA Guidelines and be prepared using Appendix G to the CEQA Guidelines and any City issued procedures or guidelines.

If the Initial Study shows both of the following Health Impact Assessment Criteria apply, the Zoning Administrator shall also require a Health Impact Assessment (HIA), as defined in Subsection V.A.5., before preparing the environmental clearance for the project:

- one or more of the air or hazards impact thresholds on Appendix G identified as III(a), III(b), III(d), VIII(a),VIII(b), VIII(c),or VIII(g) are found to be "less than significant impact with mitigation"; and
- the project is within 1,500 feet of any sensitive receptors, as defined by SCAQMD.

After the Initial Study is completed (and the HIA, if necessary), the Zoning Administrator will determine whether the proposed environmental clearance for the proposed project is a Negative Declaration (ND) or a Mitigated Negative Declaration (MND) or whether an EIR is required pursuant to sections 15065 or 15064 of the CEQA Guidelines.

If the Initial Study demonstrates that all of the impact areas will have no impact or less than significant impact, the Zoning Administrator may prepare a ND. (Note: if the Health Impact Assessment Criteria apply, a ND could not be prepared because the Initial Study identified significant impact requiring mitigation.)

If the Initial Study (and the HIA, if required) demonstrates that the project will not result in a significant impact with mitigation imposed, the Zoning Administrator may prepare a MND.

If the Initial Study (and the HIA, if required) demonstrates that the project may result in a significant impact to the environment that cannot be mitigated to less than significant, the Zoning Administrator shall require the preparation of an EIR. In determining whether an EIR is required, the Zoning Administrator shall review and consider all of the following CEQA Guidelines, without limitation to any other applicable requirements of CEQA:

- 15064 (guidelines on determining significant impacts),
- 15064.4 (guidelines on determining greenhouse gas impacts),
- 15064.5 (guidelines on determining cultural and archaeological impacts), and
- 15065 (guidelines requiring consideration of Mandatory Findings of Significance, including subsection (a)(4): "The environmental effects of a project will cause substantial adverse effects on human beings, either directly or indirectly.")

If an ND or MND is issued, the Zoning Administrator shall publish a Notice of Intent to Adopt an ND or MND pursuant to CEQA Guidelines Section 15073, prepare the ND or MND findings (and the Mitigation Monitoring Program for a MND) and process the application pursuant to Section IV. The Public Hearing notice sent in section V.B. will include a statement that the City has published a Notice of Intent to Adopt an ND or MND and include a link to the City's website where the Notice of Intent is published. The Notice of Intent to Adopt an ND or MND shall be published on the City's website in English and Spanish.

If the Initial Study demonstrates the project requires an Environmental Impact Report (EIR), the Zoning Administrator shall follow the procedures in section V.A.3.

3. Environmental Impact Report

If an EIR is to be prepared on a project, in addition to any other requirements of CEQA, the City will require all of the following:

- Provide the Notice of Preparation to all property owners and occupants within a 1,500-foot radius of the project site's outer boundary; and
- Prepare a Health Impact Assessment, as defined in section V.A.5., if not already prepared, and provide a relevant summary of the Health Impact Assessment in the EIR where appropriate to inform the required analysis. The Health Impact Assessment shall be considered in any certification of the EIR and the approval, conditional approval, or denial of the Section 13.01-H application.

An environmental consultant with qualifications and experience provided in section V.A.4 must prepare the EIR. The EIR must be prepared and certified in compliance with CEQA, including but not limited, CEQA Guideline Sections 15080-15097, 15120-15155.

4. Environmental Consultant Qualifications

The City shall ensure that any environmental consultant that is preparing an Initial Study, MND, ND, or an EIR on a 13.01-H project has the following qualifications and experience:

- The Project Manager has at least seven (7) years' experience preparing CEQA documents.
- The Project Manager has prepared and/or reviewed at least five (5) EIRs for projects involving oil and gas drilling or production.
- The consultant or consultant team, including any subcontractors, have demonstrated training, knowledge, and experience in the following topic areas as they specifically relate to oil and gas projects: environmental health, public health, hazardous materials, air quality, GHG emissions, water quality, geology, noise, traffic, aesthetics, and risk and safety issues.
- In the case of EIRs or MNDs requiring Health Impact Assessments, the consultant team, including any subcontractors, has at least five (5) years' experience in preparing Health Impact Assessments. The consultant who prepares the HIA shall be familiar with accepted HIA process and content including, but not limited to, the "Minimum Elements and Practice Standards for Health Impact Assessment," Version 3.

The City shall ensure that all environmental consultants have copies of this Memorandum prior to preparation of any Initial Study, ND, MND or EIR.

5. Health Impact Assessment (HIA)

A HIA is defined as follows:

> A study of the project for the surrounding vicinity identifying pollution and population indicators, such as, but not limited to, those analyzed in the

California Communities Environmental Health Screening Tool; the number of people affected by the project; short term or permanent impacts caused by the project; likelihood that impacts will occur; and recommended mitigation measures.

Any HIA required under these procedures shall be used to inform whether an EIR is required and whether to approve, condition, or deny the application under Section 13.01-H.

B. Public Participation

The Zoning Administrator will hold a public hearing on all Section 13.01 applications prior to project approval.

Notice of this public hearing must be sent to all property owners and occupants within a 1,500-foot radius of the project site's outer boundary, in English and Spanish. For projects being approved with a CE, ND or MND, the Notice of Intent to Adopt a CE, ND or MND may be combined with the public hearing notice.

C. Final Determination

Notices of final decisions will be issued to the applicant, all residents abutting the project site, and all individuals who request such notice.

All Zoning Administrator Section 13.01-H Determinations may be appealed to the Area Planning Commission. The Area Planning Commission decision is final. All CEQA determinations by the Zoning Administrator or the Area Planning Commission are subject to appeal to the City Council pursuant to Public Resources Code Section 21151(c).

Nothing in this Memorandum is intended to limit the Zoning Administrator's express and inherent authority to administer LAMC Section 13.01-H.

LKW:lw

Exhibit I

Oil and Gas Drilling Ordinance

(Adopted in 2022 and Rescinded in 2025;

Included Here for Historical Context Only)

ORDINANCE NO. _____

An ordinance amending Sections 12.03, 12.20, 12.23, 12.24, and 13.01 of the Los Angeles Municipal Code (LAMC) to prohibit new oil and gas extraction and make existing extraction activities a nonconforming use in all zones.

WHEREAS, activities related to oil and gas extraction operations are associated with many potential health and safety impacts, especially when they occur in close proximity to sensitive uses such as schools, day cares, elder care facilities, adult residential facilities, parks, hospitals, or residences;

WHEREAS, frontline communities and communities of color have suffered from historical injustices caused by exposure to known public health and safety hazards of oil drilling;

WHEREAS, activities related to oil and gas extraction operations have negative effects on surrounding communities that include land use impacts such as elevated noise levels, frequent odor events, increased emissions exposure, spill incidents affecting the public right-of-way, truck traffic congestion on local streets, removal of on-street parking, and lack of effective screening for drill site equipment;

WHEREAS, a priority has been placed on the national, statewide, and local levels to become energy efficient and independent;

WHEREAS, the City is prioritizing policies addressing climate change and increased awareness of environmental justice to promote equity and clean air for all neighborhoods;

WHEREAS, a core principle of zoning in Los Angeles is to protect citizens' health, safety, and welfare;

WHEREAS, though the Conservation Element provides a map of the various oil fields in the City and discusses petroleum as a resource, the City does not consider petroleum to be a mineral resource of local importance and considers the activities associated with its extraction to be detrimental to public health and safety and the environment;

WHEREAS, the City's determination that the activities associated with oil extraction are detrimental to public health and safety and the environment is reflected in recent City initiatives and ordinances such as the Green New Deal (Council File No. 19-0156), Clean Up Green Up (Ordinance No. 184,246) and in policies included in the updates to the Health and Safety elements of the City's General Plan adopted on November 24, 2021, including Health Element policy 5.4 and Safety Element policies 1.2.2 and 1.2.7;

WHEREAS, this ordinance is consistent with Conservation Element, Section 19 policies 1 and 3 to "encourage conservation of petroleum," and to "protect neighborhoods from potential accidents and subsidence associated with [petroleum] drilling, extraction and transport operations…;" and

WHEREAS, although oil production was a defining feature of Los Angeles' early development, the need to improve the City's overall livability takes priority.

NOW, THEREFORE,

THE PEOPLE OF THE CITY OF LOS ANGELES DO ORDAIN AS FOLLOWS:

Section 1. Section 12.03 of the LAMC is amended to delete the definition of TEMPORARY GEOLOGICAL EXPLORATORY CORE HOLE.

Sec. 2. Subdivision 17 of Subsection A of Section 12.20 of the LAMC is amended to read as follows:

17. **(None)**

Sec. 3. Subdivision 4 of Subsection C of Section 12.23 of the LAMC is amended to read as follows:

4. Oil Wells.

(a) All oil wells (as defined pursuant to LAMC Section 13.01 B), including those operating pursuant to any discretionary permit in all zones, whether by ordinance or approval of a Zoning Administrator, and all oil wells in an M3 Zone, are nonconforming uses as of the effective date of the ordinance. No new well for the production of oil, gas or other hydrocarbon substances may be drilled in any zone. No existing well for the production of oil, gas or other hydrocarbon substances, which is a nonconforming use, shall be maintained, drilled, re-drilled, or deepened, except to prevent or respond to a threat to public health, safety, or the environment, as determined by the Zoning Administrator.

(b) The operation of all such wells~~,~~ shall cease within 20 years from the effective date of the ordinance deeming such uses nonconforming.

(c) After the time period set forth in LAMC Section 12.23 C.4(b), all nonconforming oil wells shall be abandoned in a manner consistent with and in strict accordance with all applicable local, state, and federal laws, regulations, rules, and standards.

(d) If an oil well is abandoned, or its operation is discontinued or idled for a continuous period of one year, such use shall be deemed terminated.

(e) A well operator as defined by Public Resources Code Section 3237 shall comply with the mitigation measures and mitigation monitoring program adopted with this ordinance in the plugging and abandoning of all wells.

Sec. 4. Subdivision 18 of Subsection U of Section 12.24 of the LAMC is amended to read as follows:

18. **(None)**

Sec. 5. Subdivision 47 of Subsection W of Section 12.24 of the LAMC is amended to read as follows:

47. **(None)**

Sec. 6. Subsection A of Section 13.01 of the LAMC is amended to read as follows:

A. Application. The provisions of this section shall apply to the districts established by ordinance and to remain until said district is terminated in accordance with City Charter Section 558. The provisions of this section shall not apply to the location of subterranean gas holding areas or oil wells which are operated as a public utility regulated by the California Public Utilities Commission

Sec. 7. Subsection B of Section 13.01 of the LAMC is amended to read as follows:

B. Definitions – For the purpose of this section the following words and phrases are defined:

"Controlled Drilling Site" shall mean that particular location within an oil drilling district in an "Urbanized Area" upon which surface operations for the drilling, deepening or operation of an oil well or any incidental operation are, subject to the conditions prescribed by written determination by the Zoning Administrator.

"Drilling and Production Site in the Los Angeles City Oil Field Area" shall mean locations within an oil drilling district in the "Los Angeles City Oil Field Area" upon which surface operations for the drilling, deepening or operation of an oil well or any operation incident thereto, are subject to the conditions prescribed by written determination by the Zoning Administrator.

"Los Angeles City Oil Field Area" shall mean all land in the City within the areas identified on the maps in Ordinance No. 156,166 located in Council File

No. 80-3951 and shall include all oil producing zones beneath those areas but no deeper than the third zone beneath the surface of the earth.

"Nonurbanized Area" shall mean all those portions of the City which the City Planning Commission or Council has determined will not be detrimentally affected by the drilling, maintenance, or operation of oil wells. In making its determination, the City Planning Commission, or the Council on appeal, shall give due consideration to the amount of land subdivided, the physical improvements, the density of population and the zoning of the district.

"Oil Well" shall mean any well or hole already drilled, being drilled or to be drilled into the surface of the earth which is used or intended to be used in connection with coring, or the drilling for prospecting for or producing petroleum, natural gas or other hydrocarbon substances, or is used or intended to be used for the subsurface injection into the earth of oil field waste, gases, water or liquid substances, including any such existing hole, well or casing which has not been abandoned in accordance with the requirements of Article 7 of Chapter 5 of the Los Angeles Fire Code except any well operated by a public utility regulated by the California Public Utilities Commission.

"Oil Well Class I or A" shall mean any oil well drilled, conditioned, arranged, used or intended to be used for the production of petroleum.

"Oil Well Class II or B" shall mean any oil well drilled, conditioned, arranged, used or intended to be used only for the subsurface injection into the earth of oil field waste, gases, water or liquid substances.

"Producing Zone" shall mean a reservoir or series of reservoirs of sufficient thickness and productivity of hydrocarbons as to form an economic source of supply and which is segregated from other reservoirs or series of reservoirs by natural boundaries or barriers to such an extent as to make its separate development either economically or mechanically desirable in accordance with good oil field practice.

"Urbanized Area" shall mean all land in the City, except land in the M3 Zone, and land which has been determined to be "Nonurbanized Area" by the City Planning Commission or Council or land located in the "Los Angeles City Oil Field Area."

Sec. 8. Subsection C of Section 13.01 of the LAMC is amended to read as follows:

C. (None)

Sec. 9. Subsection D of Section 13.01 of the LAMC is amended to read as follows:

D. (None)

Sec. 10. Subsection E of Section 13.01 of the LAMC is amended to read as follows:

E. Standard Conditions. These Standard Conditions remain only to the extent that they are incorporated by ordinance through the establishment of an oil drilling district:

1. Non–urbanized Areas. Each oil drilling district established in a non–urbanized area shall be subject to the following conditions:

(a) Each district shall contain a net area of one acre or more which shall be composed of contiguous parcels of land that may be separated by an alley or walk, except that a district may contain an area of less than one acre where it is surrounded on all sides by streets.

(b) Each drilling site in any district shall contain a net area of one acre or more and shall be composed of contiguous parcels of land which may be separated only by an alley or walk. A drilling site may contain less than one acre of area where it is surrounded on all sides by public or approved private streets.

Only one oil well Class I or A may be established or maintained on each acre of land, except that there may be one oil well Class I or A on any land surrounded on all sides by public or approved private streets. Provided, however, in determining conditions for drilling pursuant to former Subsection H, the Zoning Administrator may permit surface operations for more than one oil well Class I or A in a semi-controlled drilling site where the additional wells are to be bottomed under adjacent land in a drilling district in lieu of surface operations. There shall be no less than one net acre of land in the combined drill site and production site for each well in a semi-controlled drilling site. The Zoning Administrator shall require a site of more than one acre for each oil well where a larger area is required in the particular oil drilling district. The Zoning Administrator may require larger minimum drilling sites or production areas when reasonably necessary in the public interest for a particular oil producing section.

Where drilling sites greater than one acre are required and two or more lessees or oil drilling developers in a block or area have at least one net acre each, but all lessees or developers do not have the greater area required for drilling under these regulations, the Zoning Administrator shall equitably allocate permitted wells among the competing lessees or developers. Where necessary, the lessee or developer having control of the larger portion of the property shall be given preference. In those situations outlined above, in addition to the proration required by Paragraph (d) of this subdivision, the Zoning Administrator shall require that the lessee

or developer who is authorized to drill the well shall offer an equitable consolidation agreement to the lessee or developer who has not been permitted to drill. This consolidation agreement shall contain an offer in writing, open for acceptance for 30 days, giving the other lessees or developers a choice of either:

(i) a lease on terms and conditions agreed upon, or on substantially the same terms and conditions contained in leases owned by the applicant; or,

(ii) a consolidation agreement agreed upon providing that each lessee or developer shall contribute to the cost of drilling and operation of the well and share in the production from the well in the proportion that the area of his property bears to the total area in the drilling unit.

(c) No public street, alley, walk or way shall be included in determining the net area within any district or drilling site.

(d) Where the drilling site is so located as to isolate any parcel of land in the drilling district in such a manner that it could not be joined with any other land so as to create another drilling site of the area required in the particular district in which it is located, the Zoning Administrator shall require, as a condition to the drilling and production on the drilling site, that the owner, lessee or permittee or his or her successor shall pay to the owners of the oil and gas mineral rights in each isolated parcel, a pro-rata share of the landowners' royalty in all of the oil and gas produced from the drilling site, the share to be in that proportion as the net area of the isolated parcel is to the total net area of the drilling site plus the area of all the isolated parcels, provided that the landowners' royalty shall be determined in accordance with any existing contracts for payments to the landowners of the drilling site, but, in no event, as to the owner of the isolated parcel or parcels, shall it be less than a 1/6th part of the oil and gas produced and saved from the drilling site.

2. Urbanized Areas. Each oil drilling district established in an urbanized area shall be subject to the following conditions:

(a) Each district shall be not less than 40 acres in area, including all streets, ways and alleys within the boundaries thereof.

(b) Not more than one controlled drill site shall be permitted for each 40 acres in any district and that site shall not be larger than two acres when used to develop a district approximating the minimum size; provided, however, that where the site is to be used for the development of larger oil drilling districts or where the Zoning Administrator requires that more than

one oil drilling district be developed from one controlled drilling site, the site may be increased, at the discretion of the Zoning Administrator when concurred in by the Board of Fire Commissioners, by not more than two acres for each 40 acres included in the district or districts.

(c) The number of oil wells Class I or A which may be drilled and operated from any controlled drilling site may not exceed one well to each five acres in the district or districts to be explored from said site.

Notwithstanding the above, should the City Council determine that an urbanized oil drilling district contains more than one producing zone, the City Council may then authorize, by ordinance, the drilling of additional oil wells Class I or A, not to exceed one well per five acres for each identified producing zone, and specify the maximum number of wells to be drilled as the result of such authorization.

(d) Each applicant, requesting a determination by the Zoning Administrator prescribing the conditions controlling drilling and production operations, as provided in former Subsection H of this section, must have proprietary or contractual authority to drill for oil under the surface of at least 75 percent of the property in the district to be explored.

(e) Each applicant or his or her successor in interest shall, within one year from the date the written determination is made by a Zoning Administrator prescribing the conditions controlling drilling and production operations as provided in former Subsection H of this section, execute an offer in writing giving to each record owner of property located in the oil drilling district who has not joined in the lease or other authorization to drill the right to share in the proceeds of production from wells bottomed in the district, upon the same basis as those property owners who have, by lease or other legal consent, agreed to the drilling for and production of oil, gas or other hydrocarbon substances from the subsurface of the district. The offer hereby required must remain open for acceptance for a period of five years after the date the written determination is made by a Zoning Administrator. During the period the offer is in effect, the applicant, or his or her successor in interest, shall impound all royalties to which the owners or any of them may become entitled in a bank or trust company in the State of California, with proper provisions for payment to the record owners of property in the district who had not signed the lease at the time the written provisions were made by a Zoning Administrator, but who accepts the offer in writing within the five-year period. Any such royalties remaining in any bank or trust company at the time the offer expires which are not due or payable as provided above shall be paid pro-rata to those owners who, at the time of the expiration, are otherwise entitled to share in the proceeds of the production.

(f) The entire controlled drilling site shall be adequately landscaped, except for those portions occupied by any required structure, appurtenance or driveway, and all landscaping shall be maintained in good condition at all times. Plans showing the type and extent of the landscaping shall be first submitted to and approved by the Zoning Administrator.

(g) Each applicant requesting a determination by a Zoning Administrator prescribing the conditions controlling drilling and production operations, as provided in former Subsection H of this section, shall post in the Office of Zoning Administration a satisfactory corporate surety bond (to be approved by the City Attorney and duplicates to be furnished to him or her) in the sum of $5,000 in favor of the City of Los Angeles, conditioned upon the performance by the applicant of all of the conditions, provisions, restrictions and requirements of this section, and all additional conditions, restrictions or requirements determined and prescribed by a Zoning Administrator. No extension of time that may be granted by a Zoning Administrator or any change or specifications or requirements that may be approved or required by him or her or by any other officer or department of the City or any other alteration, modification of waiver affecting any of the obligations of the grantee made by any City authority or by any other power or authority whatsoever shall be deemed to exonerate either the grantee or the surety on any bond posted pursuant to this section.

(h) If a Zoning Administrator determines, after first receiving a report and recommendation from the Board of Public Works or its designee, that oil drilling and production activities within the district have caused or may cause subsidence in the elevation of the ground within the district or in the immediate vicinity, then after consulting with recognized experts in connection with that problem and with those producing hydrocarbons from the affected area, he or she shall have the authority to require the involved oil producer or producers to take corrective action, including re-pressurizing the oil producing structure or cessation of oil drilling and production.

(i) A Zoning Administrator may impose additional conditions or require corrective measures to be taken if he or she finds, after actual observation or experience with drilling one or more of the wells in the district, that additional conditions are necessary to afford greater protection to surrounding property.

3. (None)

4. Los Angeles City Oil Field Area. Each oil drilling district established in the Los Angeles City Oil Field Area shall be subject to the following conditions:

(a) The boundary of each district shall follow the center line of city streets as far as practicable;

(b) Each district shall include the streets, ways, and alleys within the boundaries thereof and shall be substantially compact in area;

(c) The drilling, pumping, redrilling, repairing, maintenance or other servicing of any new oil well Class I or A in said district shall be conducted only on a Drilling and Production Site in the Los Angeles City Oil Field Area upon which site at least one Class I or A oil well was (i) in existence on January 24,1982; and (ii) had not been abandoned in accordance with State Division of Oil and Gas regulations prior to January 24,1982; and (iii) has a Los Angeles Fire Department Serial Number, which number was in existence on January 24, 1982.

(d) The number of new oil wells Class I or A permitted on such a Drilling and Production Site in the Los Angeles City Oil Field Area shall not exceed one well to each acre in the District;

(e) Each applicant, requesting a determination by the Zoning Administrator prescribing the conditions controlling new drilling and production operations as provided in former Subsection H must have proprietary or contractual authority to drill for oil under the surface of at least 75% of the total land area of the property in the district to be explored.

(f) Within one year from the date the written determination is made by a Zoning Administrator prescribing the conditions controlling drilling and production operations, as provided in former Subsection H, each applicant or his or her successor in interest shall offer in writing to each record owner of property located in the oil drilling district who has not joined in the lease or other authorization to drill, the right to share in proceeds of production from new wells bottomed in the district upon the same basis as those property owners who have, by lease or other legal consent, agreed to the drilling for and production of oil, gas or other hydrocarbon substances from the sub-surface of the district. The offer hereby required must remain open for acceptance for a period of five years after the date the written determination is made by a Zoning Administrator. During the period the offer is in effect, the applicant, or his or her successor in interest, shall impound all royalties to which the owners or any of them may become entitled in a bank or trust company in the State of California, with proper provisions for payment to the record owners of property in the district who had not signed the lease at the time the written determination was made by a Zoning Administrator, but who accepts the offer in writing within the five-year period. Any royalties remaining in any bank or trust company at the time the offer expires which are not due or payable as provided above shall

be paid pro-rata to those owners who, at the time of the expiration, are otherwise entitled to share in the proceeds of the production.

(g) The entire site upon which new oil wells are to be drilled shall be adequately fenced and landscaped; plans showing the type and extent of the landscaping shall be first submitted to and approved by the Zoning Administrator.

(h) Each applicant requesting a determination by a Zoning Administrator prescribing the conditions controlling drilling and production operations, as provided in former Subsection H, shall post in the Office of Zoning Administration a satisfactory corporate surety bond (to be approved by the City Attorney and duplicates to be furnished by him or her) in the sum of $5,000 in favor of the City of Los Angeles, conditioned upon the performance by the applicant of all of the conditions, provisions, restrictions, and requirements of this section, and all additional conditions, restrictions, or requirements determined and prescribed by a Zoning Administrator. No extension of time that may be granted by a Zoning Administrator or any change of specifications or requirements that may be approved or required by him or her or by any other officer or department of the City or any other alteration, modification or waiver affecting any of the obligations of the grantee made by any city authority or by any other power or authority whatsoever shall be deemed to exonerate either the grantee or the surety of any bond posted pursuant to this section.

(i) If a Zoning Administrator determines, after first receiving a report and recommendation from the Board of Public Works or its designee, that oil drilling and production activities within the district have caused or may cause subsidence in the elevation of the ground within the district or in the immediate vicinity, then after consulting with recognized experts in connection with the problem and with those persons producing hydrocarbons from the affected area, he or she shall have the authority to require the involved oil producer or producers to take corrective action, including re-pressurizing the oil producing structure or cessation of oil drilling and production.

(j) A Zoning Administrator may impose additional conditions or require corrective measures to be taken if he or she finds, after actual observation or experience with drilling one or more of the wells in the district, that additional conditions are necessary to afford greater protection to surrounding property.

Sec. 11. Subsection F of Section 13.01 of the LAMC is amended to read as follows:

F. Additional Conditions. In addition to the standard conditions applying to oil drilling districts, the Council, by ordinance, or the Zoning Administrator may have imposed other conditions in each district as deemed necessary and proper. These Additional Conditions remain to the extent that they were incorporated by reference in an ordinance or into approvals issued by the Zoning Administrator under former Subsection H and I of Section 13.01 prior to the effective date of this ordinance.

Some of these additional conditions, which may have been imposed in the ordinance establishing the districts or by the Zoning Administrator in determining the drilling site requirements, and which may have been applied by reference, are as follows:

1. That all pumping units established in said district shall be installed in pits so that no parts thereof will be above the surface of the ground.

2. That all oil produced in said district shall be carried away by pipe lines or, if stored in said district, shall be stored in underground tanks so constructed that no portion thereof will be above the surface of the ground.

3. That the operator of any well or wells in the district shall post in the Office of Zoning Administration a $5,000 corporate surety bond conditioned upon the faithful performance of all provisions of this article and any conditions prescribed by a Zoning Administrator. No extension of time that may be granted by a Zoning Administrator, or change of specifications or requirements that may be approved or required by him or her or by any other officer or department of the City, or other alteration, modification or waiver affecting any of the obligations of the grantee made by any City authority shall be deemed to exonerate either the grantee or the surety on any bond posted as required in this article.

4. That the operators shall remove the drilling rig from each well within thirty (30) days after the drilling of said well has been completed, and thereafter, when necessary, such completed wells shall be serviced by portable drilling rigs.

5. That the drilling site shall be fenced or landscaped as prescribed by the Zoning Administrator.

6. **(None)**

7. That, except in case of emergency, no materials, equipment, tools or pipe used for either drilling or production operations shall be delivered to or removed from the drilling site, except between the hours of 8:00 A.M. and 8:00 P.M. of any day.

8. That adequate fire fighting apparatus and supplies, approved by the Fire Department, shall be maintained on the drilling site at all times during drilling and production operations.

9. That no refining process or any process for the extraction of products from natural gas shall be carried on at a drilling site.

10. **(None)**

11. **(None)**

12. **(None)**

13. That no more than one well shall be bottomed in each five (5) acres of the drilling district.

14. That no new oil wells shall be spudded in after the President of the United States, or other proper authority, has declared that a state of war no longer exists.

15. **(None)**

16. **(None)**

17. That any person requesting a determination by the Zoning Administrator prescribing the conditions under which oil drilling and production operations shall be conducted, as provided in former Subsection H, shall agree in writing on behalf of him or herself and his or her successors or assigns, to be bound by all of the terms and conditions of this article and any conditions prescribed by written determination by the Zoning Administrator; provided, however, that the agreement in writing shall not be construed to prevent the applicant or his or her successors or assigns from applying at any time for amendments pursuant to this Article or to the conditions prescribed by the Zoning Administrator, or from applying for the creation of a new district or an extension of time for drilling or production operations.

18. That all production equipment used shall be so constructed and operated that no noise, vibration, dust, odor or other harmful or annoying substances or effect which can be eliminated or diminished by the use of greater care shall ever be permitted to result from production operations carried on at any drilling site or from anything incident thereto to the injury or annoyance of persons living in the vicinity; nor shall the site or structures thereon be permitted to become dilapidated, unsightly or unsafe. Proven technological improvements in methods of production shall be adopted as they, from time to time, become available if capable of reducing factors of nuisance or annoyance.

19. Wells which are placed upon the pump shall be pumped by electricity with the most modern and latest type of pumping units of a height of not more than sixteen (16) feet. All permanent equipment shall be painted and kept in neat condition. All production operations shall be as free from noise as possible with modern oil operations.

20. All drilling equipment shall be removed from the premises immediately after drilling is completed, sump holes filled, and drilling or service rigs removed within sixty (60) days after the completion of the well.

21. That, subject to the approval of the Board of Fire Commissioners, the operators shall properly screen from view all equipment used in connection with the flowing or pumping of wells.

22. Upon the completion of the drilling of a well the premises shall be placed in a clean condition and shall be landscaped with planting of shrubbery so as to screen from public view as far as possible, the tanks and other permanent equipment, such landscaping and shrubbery to be kept in good condition.

23. That not more than two wells may be drilled in each city block of the drilling district and bottomed under that block. However, at the discretion of the Zoning Administrator, surface operations for additional wells may be permitted in each of the blocks where each additional well is to be directionally drilled and bottomed under an adjacent block now or hereafter established in an oil drilling district in lieu of a well drilled on the adjacent block and under a spacing program which will result in not exceeding two wells bottomed under each block.

24. That not more than one (1) well shall be drilled in each city block of the drilling district; provided, however, that a second well may be drilled in that block bounded by "L", Gulf Avenue, Denni Street and Wilmington Boulevard, only in the event said second well be directionally drilled or whipstocked so that the bottom of the hole will be bottomed under the (Gulf Avenue School property located in the block bounded by "L" Street, Roman Avenue, Denni Street and Gulf Avenue, and in lieu of a well which might otherwise be permitted to be drilled in said last mentioned block.

25. That not more than one (1) well may be drilled in each city block of the drilling district.

26. That all power operations other than drilling in said district shall at all times be carried on only by means of electrical power, which power shall not be generated on the drilling site.

27. **(None)**

28. **(None)**

29. That not more than two (2) wells may be drilled in each city block of the drilling district; provided, however, that two (2) additional wells may be drilled in each of the following described blocks: (a) the block bounded by Q Street, Lakme Avenue, Sandison Street and Broad Avenue; and (b) the block bounded by Sandison Street, Lakme Avenue, Broad Avenue and the southerly boundary of Tract No. 1934, but only if such additional wells are directionally drilled or whipstocked so that they will be bottomed under the Hancock–Banning High school property, located in the block bounded by Delores Street, Broad Avenue, Pacific Coast Highway and Avalon Boulevard, in lieu of the four (4) wells which might otherwise be permitted to be drilled in the last mentioned block.

30. **(None)**

31. Not more than four (4) controlled drilling sites shall be permitted in this district, and such sites shall not be larger than two (2) acres.

32. The number of wells which may be drilled to any oil sand from the controlled drilling site shall not exceed one (1) well to each five (5) acres in the district, but in no event shall there be more than one (1) well to each two and one-half (2 1/2) acres.

33. That drilling operations shall be commenced within, ninety (90) days from the effective date the written determination is made by the Zoning Administrator or Area Planning Commission, or within any additional period as the Zoning Administrator may, for good cause, allow and thereafter shall be prosecuted diligently to completion or else abandoned strictly as required by law and the premises restored to their original condition as nearly as practicable as can be done. If a producing well is not secured within eight (8) months, the well shall be abandoned and the premises restored to its original condition, as nearly as practicable as can be done. The Zoning Administrator, for good cause, shall allow additional time for the completion of the well.

34. That an internal combustion engine or electrical equipment may be used in the drilling or pumping operations of the well, and if an internal combustion engine is used, that mufflers be installed on the mud pumps and engine so as to reduce noise to a minimum, all of said installations to be done in a manner satisfactory to the Fire Department and to the Zoning Administrator.

35. **(None)**

36. That not more than two (2) production tanks shall be installed for each producing well, neither one of which shall have a rated capacity in excess of one thousand (1,000) barrels; provided, however, that if in the opinion of the Zoning Administrator it is necessary in order to provide for the maximum safety of operations or to decrease the number of individual production tank settings on any

property, the Zoning Administrator may increase the number of such production tanks to not more than three (3), having a greater capacity not to exceed two thousand (2,000) barrels each. The Zoning Administrator shall permit such wash tanks or heating facilities as may appear necessary to ship or remove production from the premises. The plans for said tank or tanks, including the plot plan showing the location thereof on the property, shall be submitted to and approved in writing by the Zoning Administrator before said tank or tanks and appurtenances are located on the premises; and that said tank or tanks and appurtenances shall be kept painted and maintained in good condition.

37. All waste substances such as drilling muds, oil, brine or acids produced or used in connection with oil drilling operations or oil production shall be retained in water–tight receptors from which they may he piped or hauled for terminal disposal in a dumping area specifically approved for such disposal by the Los Angeles Regional Water Pollution Control Board No. 4.

38. Any wells drilled shall be cased tight to bedrock or effective means satisfactory to the State Oil and Gas Supervisor used to prevent vertical movement of groundwater.

39. The applicant shall provide the Department of Water and Power and the State Oil and Gas Supervisor with a precise plot plan of the drilling plant and roads leading thereto, and to make such safeguards as the Department deems necessary to assure the safety of the existing 50" water main which crosses the district involved.

40. The Department of Water and Power of the City of Los Angeles shall be permitted to review and inspect methods used in the drilling and producing operations and in the disposal of waste, and shall have the right to require changes necessary for the full protection of the public water supply.

41. **(None)**

42. That the number of wells which may be drilled to any oil sand shall not exceed one (1) well to each five (5) acres in the district, but in no event shall there be more than one (1) well to each two and one–half acres.

43. That drilling, pumping and other power operations shall at all times be carried on only by electrical power and that such power shall not be generated on the controlled drilling site or in the district.

44. That an internal combustion engine or steam-driven equipment may be used in the drilling or pumping operations of the well, and, if an internal combustion engine or steam-driven equipment is used, that mufflers be installed on the mudpumps and engine; and that the exhaust from the steam-driven machinery be expelled into one of the production tanks, if such tanks are

permitted, so as to reduce noise to a minimum, all of said installations to be found in a manner satisfactory to the Fire Department and Zoning Administrator.

45. That drilling operations shall be carried on or conducted in connection with only one well at a time in any one such district, and such well shall be brought in or abandoned before operations for the drilling of another well are commenced; provided, however, that the Zoning Administrator may permit the drilling of more than one well at a time after the discovery well has been brought in.

46. That all oil drilling and production operations shall be conducted in such a manner as to eliminate, as far as practicable, dust, noise, vibration or noxious odors, and shall be in accordance with the best accepted practices incident to drilling for and production of oil, gas and other hydrocarbon substances. Proven technological improvements in drilling and production methods shall be adopted as approved by the Zoning Administrator, as they may become, from time to time, available, if capable of reducing factors of nuisance and annoyance.

47. That all parts of the drilling or service rig above the drilling or service rig floor not reasonably necessary for ingress and egress including the elevated portion thereof used as a hoist, shall be enclosed with fire-resistive soundproofing material approved by the Fire Department and the Zoning Administrator, and the same shall be painted or stained so as to render the appearance of said drilling or service rig as unobtrusive as practicable.

48. That all tools, pipe and other equipment used in connection with any drilling or production operations shall be screened from view, and all drilling operations shall be conducted or carried on behind a solid fence, which shall be maintained in good condition at all times and be painted or stained so as to render such fence as unobtrusive as practicable.

49. That no materials, equipment, tools or pipe used for either drilling or production operations shall be delivered to or removed from the controlled drilling site except between the hours of 8:00 o'clock a.m. and 6:00 o'clock p.m., on any day, except in case of emergency incident to unforeseen drilling or production operations, and then only when permission in writing has been previously obtained from the Zoning Administrator.

50. That no earthen sumps shall be used.

51. That within sixty (60) days after the drilling of each well has been completed, and said well placed on production, or abandoned, the drilling or service rig, all boilers and all other drilling equipment shall be entirely removed from the premises unless such drilling or service rig and appurtenant equipment is to be used within a reasonable time limit determined by the Administrator for the drilling of another well on the same controlled drilling site.

52. That no oil, gas or other hydrocarbon substances may be produced from any well hereby permitted unless all equipment necessarily incident to such production is completely enclosed within a building, the plans for said building to be approved by the Department of Building and Safety and the Fire Department. This building shall be of a permanent type, of attractive design and constructed in a manner that will eliminate as far as practicable, dust, noise, noxious odors and vibrations or other conditions which are offensive to the senses, and shall be equipped with such devices as are necessary to eliminate the objectionable features mentioned above. The architectural treatment of the exterior of such a building shall also be subject to the approval of the Administrator.

53. That no oil, gas or other hydrocarbon substances may be produced from any well hereby permitted where same is located within or immediately adjoining subdivided areas where ten (10) percent of the lots or subdivided parcels of ground, within one-half (1/2) mile radius thereof, are improved with residential structures, unless all equipment necessarily incidental to such production is countersunk below the natural surface of the ground and such installation and equipment shall be made in accordance with Fire Department requirements.

54. That there shall be no tanks or other facilities for the storage of oil erected or maintained on the premises and that all oil products shall be transported from the drilling site by means of an underground pipe line connected directly with the production pump without venting products to the atmospheric pressure at the production site.

55. That not more than two production tanks shall be installed on said drilling site, neither one of which shall have a rated capacity in excess of one thousand (1000) barrels; that the plans for said tank or tanks, including the plot plans showing the location thereof on the property, shall be submitted to and approved in writing by the Administrator before said tank or tanks and appurtenances are located on the premises, and that said tank or tanks and appurtenances shall be kept painted and maintained in good condition at all times.

56. That any production tanks shall be countersunk below the natural surface of the ground and the installation thereof shall be made in accordance with safety requirements of the Fire Department.

57. That no refinery, dehydrating or absorption plant of any kind shall be constructed, established or maintained on the premises at any time.

58. That no sign shall be constructed, erected, maintained or placed on the premises or any part thereof, except those required by law or ordinance to be displayed in connection with the drilling or maintenance of the well.

59. That suitable and adequate sanitary toilet and washing facilities shall be installed and maintained in a clean and sanitary condition at all times.

60. That any owner, lessee or permittee and their successors and assigns, must at all times be insured to the extent of one hundred thousand dollars ($100,000) against liability in tort arising from drilling or production, or activities or operations incident thereto, conducted or carried on under or by virtue of the conditions prescribed by written determination by the Zoning Administrator as provided in former Subsection H of this section. The policy of insurance issued pursuant hereto shall be subject to the approval of the City Attorney, and duplicates shall be furnished to him. Each such policy shall be conditioned or endorsed to cover such agents, lessees or representatives of the owner, lessee or permittee as may actually conduct drilling, production or incidental operations permitted by such written determination by the Administrator.

61. **(None)**

62. All onshore drilling and production installations or facilities shall be removed and the premises restored to their original conditions after all oil and gas wells have been abandoned, unless the City Planning Commission determines otherwise.

63. **(None)**

64. **(None)**

Sec. 12. Subsection G of Section 13.01 of the LAMC is amended to read as follows:

G. (None)

Sec. 13. Subsection H of Section 13.01 of the LAMC is amended to read as follows:

H. (None)

Sec. 14. Subsection I of Section 13.01 of the LAMC is amended to read as follows:

I. (None)

Sec. 15. Subsection J of Section 13.01 of the LAMC is amended to read as follows:

J. (None)

Sec. 16. Subsection K of Section 13.01 of the LAMC is amended to read as follows:

K. Maintenance of Drilling and Production Sites. The following regulations shall apply to existing nonconforming oil wells within the City of Los Angeles, including oil wells operating pursuant to any zone variance, whether by ordinance or approval of a Zoning Administrator, and all oil wells in an M3 Zone which are within 500 feet of a more restrictive zone, until such uses are required to cease operations pursuant to LAMC Section 12.23 C.4:

1. All stationary drilling and service rigs, including their floors and foundations, shall be removed within 30 days after completion or abandonment of the well (notwithstanding any other provisions of this Code to the contrary)

2. The motors, engines, pumps and tanks of all such oil wells shall be sealed so that no offensive or obnoxious odor or fumes can be readily detected from any point on adjacent property.

3. The well pumping equipment for such wells shall be muffled or soundproofed so that the noise emanating therefrom, measured from any point on adjacent property, is no more audible than surrounding street traffic, commercial or industrial noises measured at the same point.

4. The maximum height of the pumping units for such wells shall not exceed 15 feet above existing grade level.

5. The site of such wells shall be so landscaped, fenced or concealed that the well and all of its appurtenant apparatus is reasonably protected against public entry, observation or attraction.

Sec. 17. **SEVERABILITY.** If any portion, subsection, sentence, clause or phrase of this ordinance is for any reason held by a court of competent jurisdiction to be invalid, such a decision shall not affect the validity of the remaining portions of this ordinance. The City Council hereby declares that it would have passed this ordinance and each portion or subsection, sentence, clause and phrase herein, irrespective of the fact that any one or more portions, subsections, sentences, clauses or phrases be declared invalid.

Sec. 18. The City Clerk shall certify to the passage of this ordinance and have it published in accordance with Council policy, either in a daily newspaper circulated in the City of Los Angeles or by posting for ten days in three public places in the City of Los Angeles: one copy on the bulletin board located at the Main Street entrance to the Los Angeles City Hall; one copy on the bulletin board located at the Main Street entrance to the Los Angeles City Hall East; and one copy on the bulletin board located at the Temple Street entrance to the Los Angeles County Hall of Records.

Approved as to Form and Legality

MICHAEL N. FEUER, City Attorney

By _____
JENNIFER K. TOBKIN
Deputy City Attorney

Date 11.17.22

File No. 17-0447-S2

Pursuant to Charter Section 559, I **approve** this ordinance on behalf of the City Planning Commission and recommend that it be adopted.

_____
VINCENT P. BERTONI, AICP
Director of Planning

Date November 17, 2022

m:\real prop_env_land use\land use\jennifer tobkin\oil drilling advice\cf 17-0447\ordinance\22.11.17 draft oil ordinance final.docx

The Clerk of the City of Los Angeles hereby certifies that the foregoing ordinance was passed by the Council of the City of Los Angeles.

CITY CLERK

MAYOR

Ordinance Passed December 2, 2022

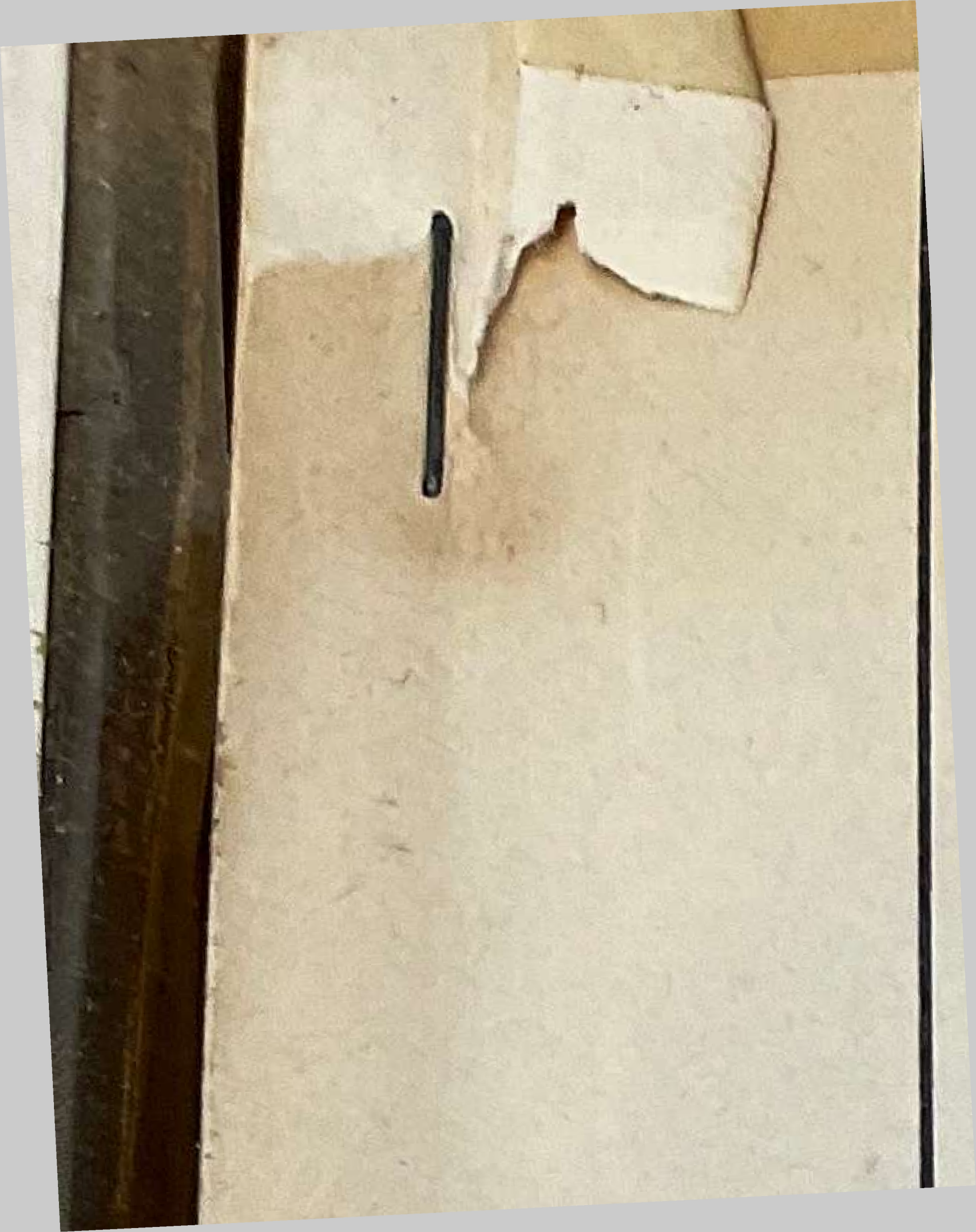
Approved 12/08/2022

Posted Date: 12/09/2022
Ordinance Effective Date: 01/18/2023

Exhibit J

1955 Los Angeles Municipal Code - Chapter 13.01





PAGE

52

53

or land, owned, operated or controlled by any person, corporation or governmental agency, including the City of Los Angeles, except the buildings, structures or land used for governmental purposes by the United States of America or by the State of California.

SEC. 12.35. ZONING OF ANNEXED OR UNZONED AREAS:

All land or territory annexed to the City after the effective date of this Article shall immediately become classified in the "R1" Zone and the "Zoning Map" shall thereupon be amended to indicate such land or territory in the "R1" Zone without additional procedure.

Any land or territory in the City which is not indicated on the "Zoning Map" in any zone shall be classified in the same zone as that existing on the side of the street opposite such unzoned land or territory, and the "Zoning Map" shall thereupon be amended to indicate said zoning as herein required without additional procedure. Where uncertainty exists as to the zoning classification to be indicated on the map, such zoning shall be determined by the Commission by written decision.



ing that involved in the proposed district shall also be notified in the same manner as herein provided.

After the conclusion of any hearing conducted by an Examiner, he shall submit his report thereon to the Commission within such period of time as may be fixed by the Commission.

4. **Decision by Commission and Council** – The Director of Planning shall investigate all proposals to establish districts and shall make a report thereon to the Commission.

Upon receipt of the reports of the Director and Examiner the Commission shall consider the proposal to establish the district, and may approve or disapprove the same, either in whole or in part. If approved, either in whole or in part, an ordinance to establish the district, as approved by the Commission, shall be presented to the Council and may be adopted by a majority vote of the Council. If such proposed district is disapproved by the Commission, its action thereon shall be final, except that an appeal may be taken to the Council, which shall then review the action of the Commission and may adopt an ordinance establishing the district only by a two-thirds vote of the entire membership of the Council. The Commission shall act on any application for the establishment of a district within 40 days from the date the same is filed and it shall not be necessary to hold more than one public hearing thereon. This time limit may be extended, by mutual consent of the applicant and the Commission, for an additional period of not to exceed 20 days. In the event the Commission shall fail to act within the specified time limit the Commission shall be deemed to have approved the establishment of the district as requested in the application, and the secretary shall advise the Council accordingly.

5. **Disapproval – Appeal to Council** – Any owner or lessee of property included in a proposed district which has been disapproved by the Commission, may appeal to the Council. Such appeal shall be filed in duplicate with the City Clerk within 20 days from the date of mailing the notification of disapproval to the applicant, or within 20 days from the action of the Commission disapproving a proposal initiated by the Commission or Council. An appeal shall set forth specifically wherein the Commission's findings and decision were in error. The City Clerk shall transmit one copy of the appeal to the Commission and thereupon the Commission shall transmit the file with a report to the Council disclosing why the proposal to establish the district was disapproved.

SEC. 13.01. "O" OIL DRILLING DISTRICTS:

A. **APPLICATION** – The provisions of this section shall apply to the districts wherein the drilling of oil wells or the production therefrom of oil, gases or other hydrocarbon substances, is permitted. The provisions of this section shall not apply to property in the "M3" Zone, nor to the location of subterranean gas holding areas which are operated as a public utility and which are regulated by the provisions of Sec. 12.24 of this Code.

B. **DEFINITIONS** – For the purpose of this section, the following words and phrases are defined:

"OIL WELL" shall mean any well or hole already drilled, being drilled or to be drilled into the surface of the earth which is used or intended to be used in connection with coring, or the drilling for, prospecting for, or producing petroleum, natural gas, or other hydrocarbon

be substantially compact in area, and the boundaries thereof shall follow public streets, ways or alleys so far as may be practicable.

E. STANDARD CONDITIONS

1. **Nonurbanized Areas** – Each oil drilling district established in a nonurbanized area shall be subject to the following conditions:

(a) Each district shall contain a net area of one acre or more which shall be composed of contiguous parcels of land that may be separated by an alley or walk, except that a district may contain an area of less than one acre where it is surrounded on all sides by streets.

(b) Each drilling site in any district shall contain a net area of one acre or more and shall be composed of contiguous parcels of land which may be separated only by an alley or walk. A drilling site may contain less than one acre of area where it is surrounded on all sides by public or approved private streets. Only one oil well Class A may be established or maintained on each acre of land, except that there may be one oil well Class A on any land surrounded on all sides by public or approved private streets.

(c) No public street, alley, walk or way shall be included in determining the net area within any district or drilling site.

(d) Where the drilling site is so located as to isolate any parcel of land in the drilling district in such manner that it could not be joined with any other land so as to create another drilling site of the area required in the particular district in which it is located, the Administrator shall require, as a condition to the drilling and production on such drilling site that the owner, lessee or permittee or his successor shall pay in lawful money of the United States to the owners of the oil and gas mineral rights in each isolated parcel, a pro rata share of the landowners' royalty in all of the oil and gas produced from said drilling site, said share to be in that proportion as the net area of the isolated parcel is to the total net area of the drilling site plus the area of all such isolated parcels; provided that the landowners' royalty shall be determined in accordance with any existing contracts for such payments to the landowners of the drilling site, but, in no event, as to the owner of such isolated parcel or parcels, shall it be less than a 1/6th part of the oil and gas produced and saved from said drilling site.

2. **Urbanized Areas** – Each oil drilling district established in an urbanized area shall be subject to the following conditions:

(a) Each district shall be not less than 40 acres in area, including all streets, ways and alleys within the boundaries thereof.

(b) Not more than one controlled drilled site shall be permitted for each 40 acres in any district and such site shall not be larger than two acres when used to develop a district approximating the minimum size; provided, however, that where such site is to be used for the development of larger oil drilling districts or where the Administrator requires that more than one oil drilling district be developed from one controlled drilling site, such site may be increased, at the discretion of the Administrator when concurred in by the Board of Fire Commissioners, by not more than two acres for each 40 acres included in said district or districts.

(c) The number of oil wells Class A which may be drilled and oper-

either the grantee or the surety on any bond posted pursuant to this Section.

F. ADDITIONAL CONDITIONS – In addition to the standard conditions applying to oil drilling districts, the Council, by ordinance, or the Administrator, may impose such other conditions in each district as it deems necessary and proper. In its report to the Council relative to the establishment of a district, the Commission may suggest conditions for consideration.

Some of these additional conditions, which may be imposed in the ordinance establishing the districts or by the Administrator in determining the drilling site requirements, and which may be applied by reference hereto, are as follows:

1. That all pumping units established in said district shall be installed in pits so that no part thereof will be above the surface of the ground.

2. That all oil produced in said district shall be carried away by pipe lines or, if stored in said district, shall be stored in underground tanks so constructed that no portion thereof will be above the surface of the ground.

3. That the operator of any well or wells in the said district shall post with the Administrator a $5,000 corporate surety bond conditioned upon the faithful performance of all provisions of this Article and any conditions prescribed by the Administrator hereunder. No extension of time that may be granted by the Administrator, or change of specifications or requirements that may be approved or required by him or by any other officer or department of the City, or other alteration, modification or waiver affecting any of the obligations of the grantee made by any City authority, shall be deemed to exonerate either the grantee or the surety on any bond posted as herein required.

4. That the operators shall remove the derrick from each well within thirty (30) days after the drilling of said well has been completed, and thereafter, when necessary, such completed wells shall be serviced by portable derricks.

5. That the drilling site shall be fenced or landscaped as prescribed by the Administrator.

7. That, except in case of emergency, no materials, equipment, tools or pipe used for either drilling or production operations shall be delivered to or removed from the drilling site, except between the hours of 8:00 A.M. and 8:00 P.M. of any day.

8. That adequate fire fighting apparatus and supplies, approved by the Fire Department, shall be maintained on the drilling site at all times during drilling and production operations.

9. That no refining process or any process for the extraction of products from natural gas shall be carried on at a drilling site.

13. That no more than one well shall be bottomed in each five (5) acres of the drilling district.

14. That no new oil wells shall be spudded in after the President of the United States, or other proper authority, has declared that a state of war no longer exists.

17. That any person requesting a determination by the Administrator prescribing the conditions under which oil drilling and production oper-

at all times be carried on only by means of electrical power, which power shall not be generated on the drilling site.

29. That not more than two (2) wells may be drilled in each city block of the drilling district; provided, however, that two (2) additional wells may be drilled in each of the following described blocks, (a) the block bounded by "Q" Street, Lakme Avenue, Sandison Street and Broad Avenue and (b) the block bounded by Sandison Street, Lakme Avenue, Broad Avenue and the southerly boundary of Tract No. 1934, but only if such additional wells are directionally drilled or whipstocked so that they will be bottomed under the Hancock-Banning High School property, located in the block bounded by Delores Street, Broad Avenue, Pacific Coast Highway and Avalon Boulevard, in lieu of the four (4) wells which might otherwise be permitted to be drilled in the last mentioned block.

31. Not more than four (4) controlled drilling sites shall be permitted in this district, and such sites shall not be larger than two (2) acres.

32. The number of wells which may be drilled to any oil sand from the controlled drilling site shall not exceed one (1) well to each five (5) acres in the district, but in no event shall there be more than one (1) well to each two and one-half (2½) acres.

33. That drilling operations shall be commenced within ninety (90) days from the effective date the written determination is made by the Administrator or Board, as provided in Section 13.00 of the Los Angeles Municipal Code, or within such additional period as the Administrator may, for good cause, allow and thereafter shall be prosecuted diligently to completion or else abandoned strictly as required by law and the premises restored to their original condition as nearly as practicable so to do. If a producing well is not secured within eight (8) months, the well shall be abandoned and the premises restored to its original condition, as nearly as practicable so to do. The Administrator, for good cause, shall allow additional time for the completion of the well.

34. That an internal combustion engine or electrical equipment may be used in the drilling or pumping operations of the well, and if an internal combustion engine is used, that mufflers be installed on the mud pumps and engine so as to reduce noise to a minimum, all of said installations to be done in a manner satisfactory to the Fire Department.

36. That not more than two (2) production tanks shall be installed for each producing well, neither one of which shall have a rated capacity in excess of one thousand (1,000) barrels; provided, however, that if in the opinion of the Administrator it is necessary in order to provide for the maximum safety of operations or to decrease the number of individual production tank settings on any property, the Administrator may increase the number of such production tanks to not more than three (3), having a greater capacity not to exceed two thousand (2,000) barrels each. The Administrator shall permit such wash tanks or heating facilities as may appear necessary to ship or remove production from the premises. The plans for said tank or tanks, including the plot plan showing the location thereof on the property, shall be submitted to and approved in writing by the Administrator before said tank or tanks and appurtenances are located on the premises; and that said tank or tanks and appurtenances shall be kept painted and maintained in good condition.

37. All waste substances such as drilling muds, oil, brine or acids pro-

or stained so as to render the appearance of said derrick as unobtrusive as practicable.

48. That all tools, pipe and other equipment used in connection with any drilling or production operations shall be screened from view, and all drilling operations shall be conducted or carried on behind a solid fence, which shall be maintained in good condition at all times and be painted or stained so as to render such fence as unobtrusive as practicable.

49. That no materials, equipment, tools or pipe used for either drilling or production operations shall be delivered to or removed from the controlled drilling site except between the hours of 8:00 o'clock A.M. and 6:00 o'clock p.m., on any day, except in case of emergency incident to unforseen drilling or production operations, and then only when permission in writing has been previously obtained from the Administrator.

50. That no earthen sumps shall be used.

51. That within sixty (60) days after the drilling of each well has been completed, and said well placed on production, or abandoned, the derrick, all boilers and all other drilling equipment shall be entirely removed from the premises unless such derrick and appurtenant equipment is to be used within a reasonable time limit determined by the Administrator for the drilling of another well on the same controlled drilling site.

52. That no oil, gas or other hydrocarbon substances may be produced from any well hereby permitted unless all equipment necessarily incident to such production is completely enclosed within a building, the plans for said building to be approved by the Department of Building and Safety and the Fire Department. This building shall be of a permanent type, of attractive design and constructed in a manner that will eliminate as far as practicable, dust, noise, noxious odors and vibrations or other conditions which are offensive to the senses, and shall be equipped with such devices as are necessary to eliminate the objectionable features mentioned above. The architectural treatment of the exterior of such building shall also be subject to the approval of the Administrator.

53. That no oil, gas or other hydrocarbon substances may be produced from any well hereby permitted where same is located within or immediately adjoining subdivided areas where ten (10) per cent of the lots or subdivided parcels of ground, within one-half (½) mile radius thereof, are improved with residential structures, unless all equipment necessarily incidental to such production is countersunk below the natural surface of the ground and such installation and equipment shall be made in accordance with Fire Department requirements.

54. That there shall be no tanks or other facilities for the storage of oil erected or maintained on the premises and that all oil produced shall be transported from the drilling site by means of an underground pipe line connected directly with the producing pump without venting products to the atmospheric pressure at the production site.

55. That not more than two production tanks shall be installed on said drilling site, neither one of which shall have a rated capacity in excess of one thousand (1000) barrels; that the plans for said tank or tanks, including the plot plan showing the location thereof on the property, shall be submitted to and approved in writing by the Administrator before said tank or tanks and appurtenances are located on the premises; and that

this section and to other provisions of this Chapter relating to zoning. All such conditions previously imposed by the Administrator in accordance with the provisions of this Chapter are continued in full force and effect.

The Administrator shall make his written determination within 20 days from the date of filing of an application and shall forthwith transmit a copy thereof to the applicant.

The determination shall become final after an elapsed period of ten days from the mailing of the notification to the applicant, unless an appeal therefrom is filed within such period, in which case the provisions of Sec. 12.28, concerning the filing and consideration of appeals shall apply.

I. **PERMITS**—No person shall drill, deepen or maintain an oil well or convert an oil well from one class to the other and no permits shall be issued therefor, until a determination has been made by the Administrator or Board pursuant to the procedure prescribed in subsection H of this section.

J. **TERMINATION OF DISTRICTS** – Any ordinance establishing the districts defined in this Section, shall become null and void one year after the effective date thereof, unless oil drilling operations are commenced and diligently prosecuted within such one-year period. Further, such ordinance shall become null and void one year after all wells in the district have been abandoned as required by law.

Zoning ordinance, prohibiting drilling of wells on tracts recently included in residential zone not an unreasonable exercise of police power and does not deprive lessee which acquired lease prior to zoning of property without due process.

Marblehead Land Co. v. City of Los Angeles, 47 Fed. 2d 528.
Cromwell-Franklin Oil Co. v. Oklahoma City, 14 F.S. 370.
Beverly Oil Co. v. City of Los Angeles, 40 Cal. 2d 552.
Pacific Palisades Assn. v. City Huntington Beach, 196 Cal. 211.

SEC. 13.02. "S" ANIMAL SLAUGHTERING DISTRICTS:

A. **APPLICATION** – The provisions of this Section shall apply to the districts wherein animal slaughtering is permitted.

B. **CONDITIONS** – In the ordinance establishing an animal slaughtering district, the Council may impose such conditions as it deems necessary and proper. In its report to the Council relative to the establishment of a district, the Commission may suggest conditions for consideration.

C. **INITIATIVE ORDINANCE** – The following Initiative Ordinance No. 10,909 (N.S.) was approved December 5, 1904, by a majority of qualified electors of this City; which ordinance was amended by Ordinance No. 36,675 (N.S.), approved by a majority of qualified electors of this City, June 5, 1917. The placing of this ordinance as amended in this Code shall not be construed as altering, amending or repealing said ordinance or amendment. Any violation of the provisions of this ordinance as amended shall not be deemed to be a violation of any of the provisions of this Code, but shall be deemed to be a violation of said ordinance as amended and shall be punishable as therein provided.

ORDINANCE NO. 10,909
(New Series)
AS AMENDED BY ORDINANCE NO. 36,675
(New Series)

Exhibit K

Oil Well Decision Reference,

ZA-1985-0103-O Determination

FRANKLIN P. EBERHARD
CHIEF ZONING ADMINISTRATOR

ASSOCIATE ZONING ADMINISTRATORS
CHARLES V. CADWALLADER
JAMES J. CRISP
WILLIE H. GERARD
ROBERT JANOVICI
WILLIAM LILLENBERG
LOUIS J. MUTO
JACK C. SEDWICK

CITY OF LOS ANGELES
CALIFORNIA

TOM BRADLEY
MAYOR

DEPARTMENT OF
CITY PLANNING
CALVIN S. HAMILTON
DIRECTOR

KEI UYEDA
DEPUTY DIRECTOR

**OFFICE OF
ZONING ADMINISTRATION**

ROOM 600, CITY HALL
LOS ANGELES, CA 90012
485-3851

April 22, 1985

Mobil Oil Corporation
12631 East Imperial Highway
Santa Fe Springs, CA 90670
Attn: W. A. Miller

Department of Building and Safety

Re: CASE NO. ZA 85-0103(O)
CONDITIONS CONTROLLING
DRILLING AND PRODUCTION
OPERATIONS
630 West Lomita Boulevard
Wilmington-Harbor City
Planning Area
Zone R1-1-0
D. M. 4906
C. D. No. 15
EIR: Exempt

In the matter of the application of W. A. Miller on behalf of the Mobil Oil Corporation, for a determination of the conditions controlling drilling and production operations to be followed in the drilling of a single Class A oil well, please be advised that based upon the findings of fact hereinafter set forth and by virtue of the authority contained in Section 98 of the City Charter and Section 13.01 of the Municipal Code, the Zoning Administrator hereby establishes said conditions on a site described as portions of Lot G of the Partition of the Rancho Los Palos Verdes and parts of Lots 5 and 6 of Pecks Subdivision of Lots J and H of Rancho Los Palos Verdes, all as more fully described in the legal description attached to the file, located at 630 West Lomita Boulevard, Wilmington-Harbor City Planning Area, but only insofar as said conditions are necessary to control:

> the drilling of a Class A oil well identified as STU C106R as a replacement for a Class A oil well identified as STU C106, which has been abandoned, all within Nonurbanized Oil Drilling District No. 71,

with said conditions stipulated as follows:

1. That all of the conditions set forth in Section 13.01 E-1 and Condition Nos. 3, 4, 9, 18, 19, 22, 37 and 46 of Section 13.01F of the Municipal Code shall be strictly complied with as though stated herein.

2. That only electrical power or internal combustion engines may be used in the operation of the drilling equipment and mudpumps, and if internal combustion engines are used, mufflers must be installed on the engines and mudpumps so as to reduce the noise to a minimum. Further, a sound baffle wall at least 10 feet in height shall be installed along the easterly and southerly sides of the drill site in a manner to provide for maximum sound attenuation. In addition, approximately 8 feet, measured vertically, of soundproofing material shall be installed around three sides of the crown block at the top of the rig mast and on three sides of the derrickman's platform located approximately half way up the drill rig.

Furthermore, the activities and equipment shall be so operated that the noise or sound level created by the drilling operations and the handling of pipe and other equipment will not be materially detrimental to the occupants of residential developments to the east and southeast.

3. That all lighting on the site shall be so directed and shielded as to eliminate any potential glare which might affect drivers utilizing the adjoining freeway.

4. That the drilling of the well shall be conducted in accordance with good oil field practice and the latest techniques and refinements in equipment and material shall be used.

5. That the latest and most effective blow-out prevention equipment shall be installed and maintained in connection with the drilling of the well.

6. That the Department of Water and Power of the City of Los Angeles shall be permitted to review and inspect the method used in drilling operations and in the disposal of waste and shall have the right to require changes necessary for full protection of the public water supply.

7. That the driveway access and parking and trucking areas associated with the drilling operation shall be suitably dustproofed with oil or other dust inhibitors as necessary to prevent the creation of dust.

8. That all truck movement, including the delivery of pipe and other materials to the drill site, shall be accomplished during the daylight hours and all non-essential operations shall be curtailed to the extent possible during the hours of darkness.

9. That this action shall in no way be considered as authorizing additional drilling procedures other than that associated with the single Class A production well herein authorized.

The applicant's attention is called to the fact that this grant is not a permit or license and that any permits and licenses required by law must be obtained from the proper public agency. Furthermore, if any condition of this grant is violated or not complied with, then this grant shall be subject to revocation as provided in Section 12.27 of the Municipal Code. In the event the property is to be sold, leased, rented or occupied by any person or corporation other than yourself, it is incumbent that you advise them regarding the conditions of this grant. The Zoning Administrator's determination in this matter will become effective after May 7, 1985, unless an appeal therefrom is filed with the Board of Zoning Appeals. Any appeal must be filed on the prescribed forms, accompanied by the required fee and received and receipted at a Public Office of the Department of City Planning on or before the above date or the appeal will not be accepted.

FINDINGS OF FACT

After thorough consideration of the statements contained in the application, the plans and documents submitted therewith, and a review of Ordinance No. 101,793 and Case Nos. ZA 12701, 20054, 21449, ZV 78-448, ZV 79-025 and ZV 81-349, all of which are by reference made a part hereof, as well as personal knowledge of the property and the surrounding district, I find as follows:

1. The subject site is a level, triangular-shaped parcel of land, approximately ½ acre in size, located on the southwest corner of Anaheim Street and Lomita Boulevard. The site is classified in the R1-1-0 Zone and is part of Nonurbanized Oil Drilling District No. 71 as established by Ordinance No. 101,793, dated August 21, 1953.

   A review of information attached to the file indicates that oil drilling and water injection activities have been undertaken within the involved district since its establishment in 1953, with the last case of record being Case No. ZV 81-349, dated October 14, 1981, which established conditions for controlling drilling and production operations for one Class A oil well on the involved site. At the present time, it is the intention of the applicant to drill a replacement Class A oil well identified as STU C106R in close proximity to an abandoned Class A oil well identified as STU C106. The drill site will be located approximately 950 feet southerly of the centerline of Lomita Boulevard and 420 feet westerly of the centerline of Figueroa Street. Since extraction and injection activities can only be undertaken in an oil drilling district after conditions controlling drilling and production operations have been established, the subject request has been filed seeking a Zoning Administrator's determination for this purpose.

   In the opinion of the Associate Zoning Administrator, the drilling of Class A Oil Well STU C106R is reasonable under the conditions imposed. The drill site is located on the westerly boundary of the site within 200 feet of the Harbor Freeway right-of-way and is well removed from adjacent residential properties. In addition, drilling operations will only be for a temporary time period of approximately 24 days based upon a 24-hour-day drilling program. The creating of an oil drilling district implies that extraction and injection activities will occur, of which drilling is a part, and the conditions imposed by this determination are designed to protect the general public and adjacent properties and improvements from adverse environmental consequences. A categorical exemption has been issued for the project, dated January 28, 1985, and it is noted that the project site is not located in a hazard area subject to the provisions of the Flood Hazard Management Specific Plan.

JAMES J. CRISP
Associate Zoning Administrator

JJC:su

cc: Director of Planning
County Assessor
Councilwoman Joan Milke Flores
Fifteenth District
Department of Water and Power
City Administrative Officer
Fire Department
Adjoining Property Owners

Exhibit L

Oil Well Decision Reference,

ZA 18129(PA2) Determination

MICHAEL LOGRANDE
CHIEF ZONING ADMINISTRATOR

ASSOCIATE ZONING ADMINISTRATORS
PATRICIA BROWN
R. NICOLAS BROWN
SUE CHANG
ANIK CHARRON
LARRY FRIEDMAN
LOURDES GREEN
ERIC RITTER
LINN K. WYATT
MICHAEL S.Y. YOUNG
MAYA E. ZAITZEVSKY

CITY OF LOS ANGELES
CALIFORNIA

ANTONIO R. VILLARAIGOSA
MAYOR

DEPARTMENT OF
CITY PLANNING

S. GAIL GOLDBERG, AICP
DIRECTOR

OFFICE OF
ZONING ADMINISTRATION
200 N. SPRING STREET, 7TH FLOOR
LOS ANGELES, CA 90012
(213) 978-1318
FAX: (213) 978-1334
www.lacity.org/PLN

March 17, 2009

Steven P. Rusch (A)(O)
Plains Exploration & Production Company
5640 South Fairfax Avenue
Los Angeles, CA 90056

Edgar G. Salazar (R)
5640 South Fairfax Avenue
Los Angeles, CA 90056

CASE NO. ZA 18129(PA2) and
Yard Case No. 14549
APPROVAL OF PLANS
5707 West Pico Boulevard
Wilshire Planning Area
Zone : C4-1-O and R1-1-O
D. M. : 129B177
C. D. : 10
CEQA : ENV-2008-2157-CE
Legal Description : Lots 1-8.
Tract 26319

Pursuant to Section 13.01-H of the Los Angeles Municipal Code, I hereby APPROVE:

Methods and conditions controlling drilling and production operations for the re-drilling of three (3) oil wells identified as P-3A, P-48B, and P-38B of the Packard drill site within Urbanized Oil Drilling District Nos. U-122, U-127 and U-159, respectively, and

Plans to modify Condition Nos. 3, 5, and 9 of Case No. ZA 18129, dated June 9, 1966 to allow:

a. the landscape buffer along portion of the northerly and westerly property lines to observe a setback of 22 feet in lieu of the originally required 25 feet, and

b. the installation of a sound attenuation wall observing a maximum height of 20 feet 1-3/4 inches, and length of 95 feet 11 inches outside the existing northerly masonry perimeter wall, and a length of 59 feet 11 inches outside the existing westerly masonry perimeter wall, and

c. deliveries to be made by entering and exiting through the driveway on either Genessee Avenue or Spaulding Avenue without passing through the drilling building,

Pursuant to Section 13.01-H of the Los Angeles Municipal Code, I hereby DENY:

Plans to modify Condition No. 4 of Case No. ZA 18129, dated June 9, 1966, to allow the placement outside of the drilling building of selected components associated with the drilling operations, and

Pursuant to Charter Section 562 and Section 12.27-U of the Los Angeles Municipal Code, I hereby APPROVE:

Plans to modify Condition No. 1 of Yard Case No. 14549, dated June 9, 1966 to allow the landscape buffer along portion of the northerly property line to observe a setback of 22 feet in lieu of the originally required 25 feet,

upon the following additional terms and conditions:

1. The existing and proposed well corridors shall be in substantial conformance with plot plans submitted and attached to the file identified as "Exhibit No. A-1" dated April 30, 2008.

2. All terms and conditions specified under extant Case No. ZA 18129 and Yard Case No. 14549, as may have been modified by subsequent determinations of methods and conditions, shall be strictly complied with, except as authorized by this grant.

3. Drilling operations may be conducted seven days per week on a 24 hour basis, including any nationally recognized holiday. Drilling operations shall be completed either within 90 days (approximately 30 days per well) from the effective date of this determination or within 90 days from the actual commencement of re-drilling operations for the first well, allowing for approximately 30 days per well, in which case a drilling log shall be maintained by the applicant and provided to the Zoning Administrator, with substantiating documents, to determine compliance with the approved schedule. Drilling days need not be consecutive.

4. The authorized use shall be conducted at all times with due regard for the character of the surrounding district, and the right is reserved to the Zoning Administrator to impose additional corrective conditions, if, in the opinion of the Zoning Administrator, such conditions are proven necessary for the protection of persons in the neighborhood or occupants of adjacent property.

5. Prior to the issuance of any permits relative to this approval, the applicant shall post a 24 hour Hotline telephone number on the exterior of the premises. Said number shall be readily observable from the adjacent residential development along both Genessee and Spaulding Avenues and shall be easily observable from the exterior of the premises. The hotline shall be maintained as a means for residents of the area to report noise or other problems that may occur as a result of the proposed drilling operation.

6. There shall be no nighttime maintenance of drilling equipment permitted after 7 p.m. except in the case of a well response problem or an emergency.

7. All drilling equipment shall be insulated so as to reduce noise resulting from the proposed re-drilling. Insulation shall be maintained on the drilling apparatus during the entire period that the subject wells are being re-drilled.

8. During the period proposed for the re-drilling, pipe shall not be pulled from any of the wells prior to 7 a.m. or after 7 p.m. except in the case of a well response problem or an emergency.

9. In order to reduce the amount of noise emanating from the site, all drilling and reworking operations at the site shall be carried on only by electrical power and such power shall not be generated on the controlled drilling site.

10. All audible loud speakers and paging systems shall be turned off during the hours between 7 p.m. and 7 a.m. except for emergencies.

11. All tools, pipe and other equipment used in connection with the drilling or reworking operations shall be stored on the site within the enclosed portion of the site and shall not be stored or kept in any exterior area adjacent to any residential use.

12. Personnel using the parking lot adjacent to the residential area on Spaulding Avenue shall only utilize the lot for parking purposes. There shall be no loitering, eating, playing of radios or loud music or similar activities permitted in the parking lot at any time.

13. A copy of these conditions and related plans shall be maintained on site at all times. A designated person shall be responsible for being familiar with these conditions and for their enforcement at all times, particularly between the hours of 7 p.m. and 7 a.m.

14. All operations shall be conducted within the 135-foot high acoustically treated drilling structure and noise from all drilling operations shall not exceed average street noise (70dBA).

15. As further amplification of Condition No. 49 of Section 13.01-F of the Municipal Code, except for actual drilling and production operations, which may be conducted twenty-four hours a day, seven days a week, no work, including delivery of materials, shall be conducted on the property between the hours of 7 p.m. of one day and 7 a.m. of the following day or on Sundays. While actual drilling operations are being conducted between the hours of 7 p.m. of and 7 a.m., the applicant shall operate its facility in "Quiet Mode." "Quiet Mode" shall mean that where possible, operation components shall be covered with acoustical shields/material, that all audible backup alarms shall be disabled and replaced with a spotter for safety purposes; the applicant's employees and contractors shall be prohibited from yelling,

except during an emergency, and the Derrick Man and Driller shall communicate by walkie-talkie only when the Derrick Man is on the derrick; no horns shall be used to signal for time for connection or to summon crew (except that a horn may be used for emergency purposes only). The applicant shall conduct on-site meetings to inform all personnel of quiet mode operations.

In case of an emergency, all restrictions on the hours of operations shall be suspended for as long as is necessary to resolve the emergent situation, and for no longer.

Notwithstanding the foregoing, during the period necessary to set up and move the drilling rig on and off the premises, and to conduct drilling or re-drilling operations as herein authorized, heavy ("permitted" oversize/overweight load) truck deliveries shall be permitted from 7 a.m. to 7 p.m., on week days, none during weekends and holidays.

16. A sound attenuation wall, not to exceed 20-foot 1-3/4-inch in height, shall be erected adjacent to the existing block wall on the north and west sides of the site as shown on Exhibit 'A-2', attached). The sound wall material shall have a minimum STC rating of 25.

17. The sound wall and drilling building gates and doors shall be closed at all times except for material delivery or pick up.

18. To verify and document sound level compliance, continuous sound level measurement and monitoring shall be completed during all drilling activity periods.

19. Vehicular Access

The following traffic mitigation plans shall be implemented for the operation of the site:

- The operator shall designate a traffic control coordinator who will be responsible for oversight of the traffic mitigation measures.

- All access doors, including personnel access doors, shall be kept closed between the hours of 7 p.m. and 7 a.m. At all other times exterior doors shall remain closed except when actually in use for ingress or egress of personnel, supplies, vehicles or equipment.

- The applicant shall instruct all delivery personnel to approach and depart the site via Pico Boulevard in order to reduce traffic impact on the residential streets adjacent to the project. Vehicles making deliveries or pickups at the site shall enter the site at one of the Avenues and exit the site at the other Avenue from or to Pico Boulevard and not utilize the Avenues northerly of the site.

a. During normal operations (Exhibit 'A-3')

1) There shall be no delivery or removal of materials, tools, or pipe used for drilling on the site prior to 7 a.m. or after 7 p.m. except in the case of a well response problem or an emergency.

2) Deliveries shall be pre-arranged: when the current truck has finished unloading and is actually leaving the site, the next truck driver shall be called and informed of access to the site with instructions regarding the proper access gate.

3) Delivery vehicles shall be prohibited from blocking any public or private driveway or idling in the proximity of any residence.

4) Delivery vehicles shall be prohibited from driving past the site's northerly property line on either Spaulding or Genessee Avenues.

5) All trucking companies shall acknowledge receipt of these conditions and plans in writing.

b. During Drilling Mobilization, Operations and Demobilization (Exhibit 'A-4')

1) There shall be no delivery or removal of materials, tools, or pipe used for drilling on the site prior to 7 a.m. or after 7 p.m. except in the case of a well response problem or an emergency.

2) The applicant shall give all abutting property owners written notice (in both English and Spanish), served by mail at least seven days prior to the dates when heavy truck traffic will commence related to moving the rig in for the drilling or redrilling of wells. Further, to reduce congestion to the residential neighborhoods abutting the drillsite, the applicant shall employ flag men during periods of heavy truck traffic and the applicant's employees and contractors shall be prohibited from parking on Pico Blvd., Genesee Avenue or Spaulding Avenue during the period when the facility is being prepared and/or utilized for drilling and re-drilling purposes.

3) Delivery trucks shall be staged off-site so as to eliminate wait time to enter the facility. If there is not sufficient room within the interior of the facility to accommodate a given delivery truck, the applicant shall not call for the delivery of such truck unless and until another delivery truck parked within the facility has actually left the facility. The maximum number of oversize/overweight truck deliveries allowed for moving the drilling rig on and off the premises shall not exceed 20 loads per day for a period of five days. Except for the five days required to move the drilling rig on and off the premises, the number of "permitted" truck deliveries per day (week days only, none on weekends and holidays) shall be limited to a maximum of ten. The

number of "non-permitted" truck deliveries per day (week days only) shall be limited to a maximum of ten. The number of "non-permitted" truck deliveries per day (weekends and holidays only) shall be limited to a maximum of five.

4) One of the driveways shall pass through the oil drilling building. All loading and unloading of drilling pipe and other equipment used in the drilling operations shall be conducted within said building except when the load cannot pass through the drilling building. The delivery may be made by entering into the drilling building by either Spaulding or Genessee Avenues and exiting the building onto the same Avenue and proceeding southerly towards Pico Boulevard.

5) The drilling company shall confirm the permitted route to the drill site with the traffic control coordinator, as well as the return route to the staging area.

6) Delivery vehicles shall be prohibited from blocking any public or private driveway or idling in the proximity of any residence.

7) Delivery vehicles shall be prohibited from driving past the site's northerly property line on either Spaulding or Genessee Avenues.

8) All trucking companies shall acknowledge receipt of these conditions and plans in writing.

9) During rig mobilization and demobilization, the applicant shall employ two flag persons and a coordinator who will record and control the truck traffic.

10) During rig mobilization and demobilization movements, arrangements shall be made by the applicant for a Los Angeles Traffic Control Officer to be on site to ensure compliance with this plan and assist in controlling truck traffic.

11) During drilling mobilization, de-mobilization and operations, personnel shall be required to carpool to the drill site in order to reduce the number of vehicles using the parking lot located on the east side of Spaulding Avenue.

20. Prior to the start of the drilling equipment mobilization, the site's pre-drilling ambient ground and air-borne vibration level shall be measured and documented. Ground-borne vibration levels, measured in peak particle velocity (ppv) levels in inches per second (ips) in the vertical (z) direction shall be measured with portable VM Profound Vibration Meters. The peak velocity levels shall be logged every five seconds over the duration of the measurement survey. Air-borne vibration levels, measured as low frequency sound levels below 100 hz, shall be measured with a Bruel & Kajer Model 2250 Sound Level Analyzer. The low frequency sound levels

shall be measured and logged every second over the duration of the measurement survey. Both the ground-borne and air-borne vibration level surveys shll be completed at a minimum of three locations within the site and at three off-site locations in the adjacent residential neighborhood. The measured ground-borne and air-borne vibration levels shall be utilized as a baseline for comparing drilling vibration impact levels at the site during drilling operations.

21. At the start of the drilling operations, a ground-borne and air-borne vibration level survey shall be completed both at the Site and adjacent residential neighborhood to measure and document drilling generated vibration levels. The measured operational vibration levels will be compared to the measured pre-drilling vibration levels to verify that no ground-borne or air-borne vibrations are being generated from the drilling operations.

22. Prior to the start-up of the drilling rig mud shaker units, rubber isolation pads shall be installed between the shaker unit and the support base.

    In the case where any ground-borne vibration is observed, the source generation equipment shall have isolators installed to prevent energy transfer into the ground. In the case of any air-borne low frequency sounds being measured, the source equipment will have sound barriers installed on the equipment. Additional ground-borne and air-borne measurements shall be completed after mitigation measures are completed to verify and document vibration level compliance during all drilling activity periods.

23. The applicant shall maintain and implement all necessary measures included in its current Spill Prevention Control and Countermeasures (SPCC) Plan dated June 2005.

24. A landscape plan, together with an automated irrigation plan, prepared by a licensed landscape architect or licensed landscape contractor shall be prepared to the satisfaction of the Zoning Administrator showing planting material the objective of which is to minimize the visual impact of the existing and proposed walls, as well as the aesthetic coverage of any remaining ground area between the walls and the public sidewalk, and improved landscaping of the setback area adjacent to Pico Boulevard.

OBSERVANCE OF CONDITIONS - TIME LIMIT - LAPSE OF PRIVILEGES - TIME EXTENSION

All terms and Conditions of the approval shall be fulfilled before the use may be established. The instant authorization is further conditional upon the privileges being utilized within two years after the effective date of approval and, if such privileges are not utilized or substantial physical construction work is not begun within said time and carried on diligently to completion, the authorization shall terminate and become void. A Zoning Administrator may extend the termination date for one additional period not to exceed one year, prior to the termination date of the period, if a written request on appropriate forms, accompanied by the applicable fee is filed therefore with a public Office of the Department

of City Planning setting forth the reasons for said request and a Zoning Administrator determines that good and reasonable cause exists therefore.

TRANSFERABILITY

This authorization runs with the land. In the event the property is to be sold, leased, rented or occupied by any person or corporation other than yourself, it is incumbent upon you to advise them regarding the conditions of this grant.

VIOLATIONS OF THESE CONDITIONS, A MISDEMEANOR

Section 12.29 of the Los Angeles Municipal Code provides:

> "A variance, conditional use, adjustment, public benefit or other quasi-judicial approval, or any conditional approval granted by the Director, pursuant to the authority of this chapter shall become effective upon utilization of any portion of the privilege, and the owner and applicant shall immediately comply with its Conditions. The violation of any valid Condition imposed by the Director, Zoning Administrator, Area Planning Commission, City Planning Commission or City Council in connection with the granting of any action taken pursuant to the authority of this chapter, shall constitute a violation of this chapter and shall be subject to the same penalties as any other violation of this Code."

Every violation of this determination is punishable as a misdemeanor and shall be punishable by a fine of not more than $1,000 or by imprisonment in the county jail for a period of not more than six months, or by both such fine and imprisonment.

APPEAL PERIOD - EFFECTIVE DATE

The applicant's attention is called to the fact that this grant is not a permit or license and that any permits and licenses required by law must be obtained from the proper public agency. Furthermore, if any Condition of this grant is violated or if the same be not complied with, then the applicant or his successor in interest may be prosecuted for violating these Conditions the same as for any violation of the requirements contained in the Municipal Code. The Zoning Administrator's determination in this matter will become effective after APRIL 1, 2009, unless an appeal therefrom is filed with the City Planning Department. It is strongly advised that appeals be filed early during the appeal period and in person so that imperfections/incompleteness may be corrected before the appeal period expires. Any appeal must be filed on the prescribed forms, accompanied by the required fee, a copy of the Zoning Administrator's action, and received and receipted at a public office of the Department of City Planning on or before the above date or the appeal will not be accepted. **Forms are available on-line at www.lacity.org/pln**. Public offices are located at:

Figueroa Plaza
201 North Figueroa Street,
4th Floor

Marvin Braude San Fernando
Valley Constituent Service Center
6262 Van Nuys Boulevard, Room 251

Los Angeles, CA 90012
(213) 482-7077

Van Nuys, CA 91401
(818) 374-5050

If you seek judicial review of any decision of the City pursuant to California Code of Civil Procedure Section 1094.5, the petition for writ of mandate pursuant to that section must be filed no later than the 90th day following the date on which the City's decision became final pursuant to California Code of Civil Procedure Section 1094.6. There may be other time limits which also affect your ability to seek judicial review.

NOTICE

The applicant is further advised that all subsequent contact with this office regarding this determination must be with the Zoning Administrator who acted on the case. This would include clarification, verification of condition compliance and plans or building permit applications, etc., and shall be accomplished **BY APPOINTMENT ONLY**, in order to assure that you receive service with a minimum amount of waiting. You should advise any consultant representing you of this requirement as well.

FINDINGS OF FACT

After thorough consideration of the statements contained in the application, the plans submitted therewith, the report of the Zoning Analyst thereon, the statements made at the public hearing on August 11, 2008, all of which are by reference made a part hereof, as well as knowledge of the property and surrounding district, I find as follows:

BACKGROUND

REQUESTS

With this application, the applicant is requesting the following:

1. Pursuant to Section 13.01-H of the Los Angeles Municipal Code, approval of

   A. Methods and conditions controlling drilling and production operations for the re-drilling of three (3) oil wells identified as P-3A, P-48B, and P-38B of the Packard drill site within Urbanized Oil Drilling District Nos. U-122, U-127 and U-159 respectively, and

   B. Plans to modify Condition Nos. 3, 4, 5, and 9 of Case No. 18129, dated June 9, 1966 to allow:

      1. the landscape buffer along portion of the northerly property line to observe a setback of 22 feet 9 inches in lieu of the originally required 25 feet, and

      2. the installation of a sound attenuation wall observing a maximum height of 20 feet 1-3/4 inches, and length of 92 feet 11 inches outside the existing northerly masonry perimeter wall, and

3. the placement outside of the drilling building of selected components associated with the drilling operations, and

4. deliveries to be made by entering and exiting through the driveway on either Genessee Avenue or Spaulding Avenue without passing through the drilling building, and

2. Pursuant to Charter Section 562 and Section 12.27-U of the Los Angeles Municipal Code, approval of:

plans to modify Condition No. 1 of Yard Case No. 14549, dated June 9, 1966 to allow the landscape buffer along portion of the northerly property line to observe a setback of 22 feet 9 inches in lieu of the originally required 25 feet.

PUBLIC INPUT

A public hearing on the matter was held on August 11, 2008, where the applicant's representatives presented the requests and responded to questions of the Zoning Administrator regarding details of the proposals. One person spoke in support of the requests. Six persons spoke in opposition to the requests. One person expressed no opposition, but concerns about the same issues raised by other speakers. A representative of the Council District Office expressed no position at that time, supporting the imposition of mitigation measures, including the wrapping around of the sound wall, a maximum of 90-day drilling period, no idling truck on public streets, the utilization of traffic control officers when needed, and landscaping of the setback areas.

At the close of the public hearing, the matter was taken under advisement with instructions to the applicant to report on the noise, and traffic mitigation plans, as well as possible vibration issues, and present the results to interested neighbors. Such studies were conducted over the following months, with the resulting reports submitted to the Zoning Administrator in September and November 2008. A meeting between eight neighbors, two representatives of the Council District Office and five representatives of the applicant was held on November 17, 2008 where traffic, noise and vibration mitigation measures were presented to the neighbors and the Council District Office, as requested.

Correspondence was received as follows:

In opposition:

- One petition with 123 signatures, accompanied by a log and photographs of nuisances associated with operation of the site

- Two letters, including one providing feedback from the meeting held between the applicant and the neighbors on November 17, 2008, the latter of which accompanied by a copy of a White Paper on Potential Exposure-related Human Health Effects of Oil and Gas Development , prepared by the University of Colorado, Denver and Colorado State University, dated September 15, 2008.

Major points in opposition:

- Drilling noise and vibration
- Hazardous emissions/spills
- Traffic congestion
- Emergency vehicle access impaired by oversized vehicles
- Pedestrian safety
- Health and Safety concerns
- Loss of property values

FINDINGS

1. The subject site, known as the Packard Drill Site, is located on a level, rectangular-shaped parcel of land facing on the north side of Pico Boulevard for a distance of approximately 300 feet, siding on the west side of Spaulding Avenue and the east side of Genessee Avenue for a distance of 250 and 233 feet respectively. The property is classified in the C4-1-O and R1-1-O Zones and is developed with a controlled drill site identified as the Packard Drill Site. The drilling portion of the site, in the C4 Zone adjacent to Pico Boulevard, is enclosed with an architecturally designed, acoustically treated, office-styled structure which attains a height of 135 feet. The northerly portion of the site, in the R1 Zone, is occupied with open production pit and sump pump areas, two buildings housing the machinery room and the control room respectively, and an on-site surface parking area located between the two buildings. The applicant further utilizes an open surface parking area located easterly across Spaulding Avenue from the site, at 1348 Spaulding Avenue for its employee parking.

   A review of the past record and information attached to the file indicates that oil drilling and oil production have occurred on the site since 1967 in accordance with the terms and conditions of Case No. ZA 18129 and Yard Case No. 14549, both approved on June 9, 1966. In February 1975, Case No. ZA 21616, allowed the expansion of the facility and the optional use of diesel or gas powered equipment in the drilling, re-drilling or workover of the oil wells. In addition, over time, various plan approvals have been filed and approved for re-drilling of wells and other activities. The most recent of these plan approvals dated February 4, 2002, approved the re-drilling of 8 Class A wells within this drill site.

   A. <u>Re-drilling of three wells</u>

   Three oil wells identified as P-3A, P-48B, and P-38B of the Packard drill site are requested to be authorized to be re-drilled to bottom within Urbanized Oil Drilling District Nos. U-122, U-127 and U-159 respectively.

   Urbanized Oil Drilling District No. U-122 was established by Ordinance No. 130,118, which authorized the Zoning Administrator to permit drilling and production from a maximum of seven (7) production wells. Currently, there is one active production well bottomed in U-122. Well No. P-3 is currently an idle water injection well. The

applicant requests the authority to re-drill Well No. P-3 as Well No. P-3A and to convert it from a Class "B" well to a Class "A" well. Upon approval of this application and drilling of the proposed well, there will be a total of two (2) production wells bottomed in U-122.

Urbanized Oil Drilling District No. U-127 was established by Ordinance No. 130,No. 411, which authorized the Zoning Administrator to permit drilling and production from a maximum of eight (8) production wells. Currently, there are four (4) active production wells in U-127. Well No. P-48A is an idle injection well bottomed in U-122. The applicant requests the authority to re-drill Well No. P-48A as Well No. P-48B to bottom in U-127 and convert it from a Class "B" well to a Class "A" well. Upon approval of this application and drilling of the proposed well, there will five (5) production wells bottomed in U-127.

Urbanized Oil Drilling District No. U-159 was established by Ordinance No. 136,467, which authorized the Zoning Administrator to permit drilling and production from a maximum of five (5) production wells. Currently, there is one (1) active production well in U-159. Well No. P-38 is an idle injection well bottomed in U-121. The applicant requests the authority to re-drill Well No. P-38 as Well No. P-38A to bottom in U-159 and convert it from a Class "B" well to a Class "A" well. Upon approval of this application and drilling of the proposed well, there will two (2) production wells bottomed in U-159.

B. Confirmation of drilling 24 hours a day, 7 days a week.

Such request is consistent with the approval in the original ZA Case No. 18129, and with the last Plan Approval dated February 4, 2002. Further it is consistent with approvals granted to other controlled drill sites within the City. To mitigate noise levels during drilling operations, sound mitigation controls were placed on the controlled drill site with the original approval of plans in 1966 and additional sound controls were put into place in the February 2002 Plan Approval. The applicant discussed the project with Council District Office and agreed to install further sound mitigation controls similar to those recently imposed on drilling operations at the Jefferson and Murphy Controlled Drill Sites. These mitigation measures address limitation on hours of operation, number and type of truck deliveries permitted, and other general measures to ensure a “quiet” mode of operation.

C. Installation of Sound Attenuation Wall and
D. Reduced landscape setback along the Northerly boundary of the facility.

The original approval of the drilling site under authority of Case No. ZA 18129 and Yard Case No. 14549, both dated June 9, 1966, involved the vacation of an alley that once separated the four commercial lots fronting on Pico Boulevard from the four residential lots fronting on Genesee and Spaulding Avenues. Condition Nos.5 and 3 in Case No. ZA 18129 and Condition No.1 in Yard Case No. 14549, instituted a 25-foot landscaped setback requirement along approximately three-quarters of the northerly boundary of the drill site, beginning where Genesee Avenue meets the northerly property line. Along a portion of said northerly property line, the drill site

facility is enclosed within a masonry perimeter wall 10 feet 8 inches high, which continues directly into the north facing wall of the machinery room (compressor building) where the northerly wall rises to the height of 21 feet 8 inches.

In order to further reduce the possible impact of the facility on the surrounding neighborhood, and to reduce ambient noise levels coming from the production pit in the northwesterly corner of the facility, the applicant proposes to install a sound attenuation wall immediately adjacent and parallel to the existing masonry perimeter wall along portion of the existing perimeter wall on the northerly side of the site, and to reduce the 25-foot setback to 22 feet 9 inches. At the public hearing, and at the request of several neighbors and the Council District Office, the proposal was slightly extended to have the wall wrap around the westerly portion of the site, and the setback reduced to 22 feet. A sound report prepared by a consultant hired by the applicant discussing the benefits of the proposed sound wall was submitted as part of the application. The sound study (attached to the file) concludes that the proposed sound wall will reduce noise to the residential neighborhood to the north of the facility between 10 and 25dB, depending on the frequency of the noise source, and further concludes that for typical compressor noise spectrum this would be the equivalent to a 19dB (A) noise reduction.

The proposed sound wall is constructed of lightweight, modular panels, with a solid outer face on one side and an open grid pattern on the inside face. The panels are 6 inches deep and contain sound absorbing materials. The sound wall will be placed 2 feet 3 inches to 3 feet from the most northerly and westerly faces of the existing site perimeter masonry wall and will rise to the height of 20 feet, 1 3/4 inches. The sound wall will be set back 22 feet from the respective property lines, with the setback area and the wall attractively landscaped to minimize the visual impact of the wall as seen from a public standpoint.

There are currently three mature trees within the existing landscaped setback, outside the masonry wall. The trees were planted in 1966 as part of an approved landscape design and now stand above 20 feet in height. The proposed installation of the sound wall will not require these trees to be removed. Moreover, they will significantly obscure the view of the proposed wall from the residential properties to the north of the facility.

The installation of the sound wall will require a small reduction in the landscape set back from 25 feet to 22 feet. Currently, there is approximately 6,440 square feet of landscaping along the northwest corner of the property site (where Genesee meets the northerly perimeter of the facility). There is also approximately 8,900 square feet of landscaping along the southerly property line facing Pico Boulevard. By reducing the northerly set back from 25 feet to 22 feet, there will be a loss of approximately 209 square feet of landscaping.

To accommodate the installation of the proposed sound attenuation wall, Condition Nos. 5 and 3 in Case No. ZA 18129 and Condition No.1 in Yard Case No. 14549 need to be modified to reduce the required landscape setback to 22 feet. More specifically, Conditions Nos. 5 and 3 in Case No. ZA 18129 and Condition No.1 in

Yard Case No. 14549 need be modified by replacing the words "25 feet" by the words "22 feet" wherever they appear.

Denial of the request would result for the applicant in practical difficulties and unnecessary hardship inconsistent with the general purpose and intent of the zoning regulations in that it would prevent the installation of a significant improvement to the mitigation measures necessary to minimize the noise impact of the permitted site's activity.

Special circumstances apply to the property, namely a use of land, permitted since 1966, depending on the location of a natural resource not under human control, said use of land being in close proximity to residential uses. Since this activity first being permitted at this location, new sound attenuation materials and measures have been discovered which, once installed will improve the integration of the facility in its immediate environment.

Similar sound attenuation measures have been installed on other property in the City which are occupied by similar oil drilling and production operations. Denying the request would deprive the applicant of a property right otherwise granted under similar circumstance to owners of other property in the City.

The granting of the request will not be materially detrimental to the public welfare or injurious to the property or improvements in the same zone or vicinity in which the property is located and will to the contrary result in a significant improvement of the mitigation measures implemented to address the noise impact of the operation on the immediate surroundings.

Finally, the granting of the request is consistent with the objectives and policies of the General Plan, which aim at maintaining a compatibility of land uses adjacent to each other, inasmuch as the area is located within a designated Oil District and the use has been permitted at this location since 1966. Improved mitigation of eventual impact(s) of a use on its immediate surroundings is consistent with the efforts to achieve compatibility between adjacent land uses.

E. Placement of selected drilling equipment and facilities

Condition No. 4 in the original plan approval in Case No. ZA 18129 requires *"That all oil drilling operations including oil drilling machinery, mud pumps and shakers, mud tanks, pipe racks, generators and similar facilities in connection with the actual drilling of the proposed oil wells and the later cleaning out and servicing of the oil wells on the site shall be performed entirely within an attractively designed and maintained soundproofed building .... "*

The applicant requests that Condition No.4 be modified to permit certain ancillary drilling equipment and facilities to be housed and operated outside of the drilling building, as follows:

Equipment	Description	Height
Top Drive Support House (TDSU House)	Distributes Electrical Power	8′
SCR House	Converts electrical AC power Distributes to drilling rig electrical motors	8'
Parts House	Storage compartment for rig Parts and supplies	8'
Change House	Crew clothes change area	8'
Mobile office trailers (2)	Trailer house for PXP and drilling Operator supervisors (12' high with A/C units)	10'
Accumulator	Electric Motor for tri-plex charging pump	5'

The applicant states that none of above mentioned equipment exceeds the height of the existing perimeter wall, except the air conditioning units on top of the mobile office trailers, and that none of the equipment will be visible from outside the drill site. The mobile office trailers would be placed between the existing office structure and the compressor building, and would be fully obscured by those buildings. To address any potential for added noise which may be attributable to this equipment, the applicant commissioned a sound report from a consultant (attached to the file), and indicates that all sound mitigation measures recommended in said report would be implemented.

Contrarily to the other requests made as part of this application, this element is denied. Besides the concern for additional noise and the proposed mitigation measures for such impacts, which would need to further include limited hours of operation for said equipment, a careful review of the proposed site plan shows the proposed equipment located in the northerly driveway and the westerly interior setback area of the property. As such they effectively block the northerly driveway from any other use, including possible access for emergency vehicles should the need arise. As it currently stands, the driveway is about 15 feet wide at its narrowest. The proposed equipment would occupy from 8 to 10 feet of said driveway. Additionally the two proposed mobile trailers would be located over an existing parking area thereby removing approximately five on-site parking spaces. At this point, this Zoning Administrator does not feel comfortable allowing blocking of the northerly driveway and more noise generating uses to be located outside of the insulated building, which would result in a significant intensification of the use of the property, without adequate further environmental review pursuant to CEQA (California Environmental Quality Act). It must be noted here that the instant application is processed under a Categorical Exemption from CEQA, Class 5,

Category 23, described as the granting or renewal of a variance or conditional use for a non-significant use of land. While all other portions of this application pertain to the approval of current operations and improved mitigation measures, this portion of the request reaches far beyond the current intensity of use of the site, and could not reasonably be approved under the instant Categorical Exemption from CEQA.

F. Vehicular access to the drill site.

Condition No. 9 of the original grant (Case No. ZA 18129) requires that *"vehicles making deliveries or pick-ups at the site shall enter the site at one* of *the Avenues and exit at the other Avenue from or to Pico Boulevard and not utilize the Avenues northerly* of *the drilling site. Furthermore, that one of the driveways shall pass through the oil drilling building and with all loading and unloading* of *drilling pipe and other equipment used in the drilling operations conducted within said building."*

The applicant requests relief from Condition No.9 to permit the delivery of equipment from Genesee Avenue and/or Spaulding Avenue and exiting the drilling building from the same driveway without passing through the drilling building. The pass-through driveway feature of the drilling building was appropriate in 1966 when it was designed. However, due to changes in the dimensions of drilling rigs and corresponding changes in the length and other dimensions of the trailers used to transport the drilling rigs, some of the truck loads cannot pass through the drilling building. In such cases, the applicant requests the authority to back into the drilling building through either the Genesee Avenue or Spaulding Avenue gate and to exit from the same gate onto the same Avenue and continue southerly onto Pico Boulevard. The applicant currently anticipates the need to utilize this procedure for 10 loads, however, the actual number of loads that will be affected cannot be accurately estimated. Therefore, the applicant requests that the condition be modified to permit said procedure whenever the size of the load requires the procedure.

In light of the above, Condition No. 19-B(4) of this grant modifies original Condition No. 9 to allow drilling related deliveries to be made by entering into the drilling building from either Genesee Avenue or Spaulding Avenue and exiting the building onto the same Avenue and proceeding southerly towards Pico Boulevard when the load cannot pass through the drilling building.

2. With the proposed re-drilling of three existing wells at the subject controlled drill site the applicant intends to resolve downhole problems. More specifically some of the wells are almost dry. Once dry, wells need to be re-drilled at a different subsurface site, the surface location remaining the same. The re-drilling will allow the applicant to tap into another area a few miles below the surface that will yield more oil. Without such re-drilling wells are not fully operational. It is for this purpose that the subject request has been filed seeking terms and conditions controlling drilling and production operations. The additional requests pertaining to the installation of a new sound attenuation wall, clarification of hours of operation for the drilling activities, and modification of some of the vehicular access procedures for the site, basically consist of an updating of the mode of operation of the facility inasmuch as new

material is being developed and utilized over the years. The request for installation of additional equipment outside the drilling building is however denied as detailed above as it constitutes a significant intensification of the use of the site without the benefit of adequate assessment of any possible environmental impact.

3. The re-drilling of the wells is appropriate. It is a normal and necessary function of petroleum operations to re-drill from established drill sites not only to find and extract additional reserves or to correct subsidence problems, but also to correct extraction problems which occur from time to time. The proposed re-drilling will be undertaken one well at a time extending over a period of approximately 90 days.

   The installation of the sound attenuation wall, modification of vehicular access for some drilling related deliveries, and clarification of hours of operation, is also appropriate as all should result in an improved operation benefitting from and improved with currently available technology, materials and associated procedures. The proposed improvements further aim at addressing past issues of impacts of the operations on the immediate area.

   As detailed above, the same argument cannot be made for the approval of the location of additional equipment outside the drilling building. As such this portion of the request is hereby denied.

4. All re-drilling operations will be conducted on the controlled drill site. To maintain reasonable noise levels state of the art drilling equipment and technology will be utilized. The applicant will utilize an electric powered drilling rig, and all re-drilling operations will be conducted within the 135 foot high, acoustically treated drilling structure. The enclosure consists of an acoustically treated, drilling structure. The soundproofing of the structure is composed of foam fiber composite material inserted between two pieces of corrugated sheet metal. The foam fiber composite material ranges between 3/4 to 1-1/2 inches in thickness, depending upon location. The external enclosure of the drill site will be further improved with the construction of the new sound attenuation wall as proposed and approved. New vibration and traffic mitigation measures will be implemented as stipulated in the conditions of approval of this grant in addition to the currently in place Spill Prevention Control and Countermeasures Plan.

5. The Packard Drill site has been operated in substantial conformance with previously imposed conditions. The applicant continues to demonstrate responsive control over problems that arise from time to time, as shown by the proposal to install the new sound attenuation wall. Those impacts on adjacent properties that have been identified are being remedied by conditions that are now being imposed on the requested re-drilling project. Placement of additional equipment outside the drilling building is denied at this point without an adequate environmental clearance pursuant to CEQA in order to properly assess and mitigate any possible impact on the surrounding environment.

   The applicant is responsible for maintaining control of the drill site and informing the drilling and other contractors of the conditions imposed herein. A separate

application will be made with the City of Beverly Hills for those oil wells that bottom out within that jurisdiction, if any.

6. In a time where dependence on foreign oil comes at an increased social, economical and political cost, this approval, by encouraging and facilitating local oil production, under strict controls as to the possible impacts it may have on the immediate vicinity of the production site, will be of direct benefit to the public as a whole. Upon completion of the re-drilling operation, production activities will be resumed under applicable terms and conditions of this and previous grants.

ADDITIONAL MANDATORY FINDINGS

7. The National Flood Insurance Program rate maps, which are a part of the Flood Hazard Management Specific Plan adopted by the City Council by Ordinance No. 172,081, have been reviewed and it has been determined that this project is located in Zone X, The flood insurance rate zone that correspond to areas outside the 1-percent annual chance floodplain, area of 1-perrcent annual chance sheet flow flooding where average depths are less than 1-foot, areas of 1-percent annual chance stream flooding where the contributing drainage area is less than 1 square mile, or areas protected from the 1-percent annual chance flood by levees. No Base Flood elevations or depths are shown within this zone. Insurance purchase is not required in this zone.

8. On May 29, 2008, the project was issued a Notice of Exemption (Article III, Section 3, City CEQA Guidelines), log reference ENV 2008-2157-CE, for a Categorical Exemption, Class 5, Category 23, City CEQA Guidelines, Article VII, Section 1, State EIR Guidelines, Section 15100. I hereby adopt that action.

ANIK CHARRON
Associate Zoning Administrator
Direct Telephone No. (213) 978-1307

AC:lmc

cc: Councilmember Herb Wesson
Tenth District
Adjoining Property Owners
County Assessor

1353 S Spaulding Ave

Permit Application #: **08020 - 20000 - 02718**

Nonbldg-New Commercial Plan Check	City of Los Angeles - Department of Building and Safety **08020 - 20000 - 02718** **CLEARANCE SUMMARY WORKSHEET**	Plan Check #: B08VN09209FO Plans Filed in: VAN NUYS Printed on: 12/03/09 09:44:42

IMPORTANT: This summary documents the clearance(s) required prior to permit issuance. Most clearance(s) are granted electronically, however this form will also be completed so that in the event of a computer outage, there is evidence of the clearance action(s). Keep this form with all other documents necessary to obtain the permit.

INSTRUCTIONS

APPLICANT / REPRESENTATIVE: You are advised to initiate the approval process for the following permit application clearance(s) marked as "Not Cleared" as soon as possible. The time to obtain approval from some departments (such as the City Planning Department) may be time-consuming. The address and phone number of the specific agency corresponding to the "**Address Code:**" shown for each clearance is indicated at the end of this form and it is recommended that you call before appearing in person. Remember to bring a copy of the permit application to the clearance agency for their reference. A "Cleared" condition requires no further action on your part.

CLEARANCE AGENCIES: For city agencies, perform electronic clearance action(s) using PCIS **and** complete this form. For non-city agencies or PCIS outages, complete this form.

Description of Work: NEW 20FT HIGH DECORATED WALL AROUND REFINERY EQUIPMENT PER ZA 18129(PA2)	Building & Safety Contact Plan Check Office: VAN NUYS PC Engineer: Dean Lee

Status	Clearance Description and New Status
Cleared	**Agency: City Planning Department** **Address Code: 2** **Description:** Zoning Administrator Case #:18129(PA2)/ZA 14549(03/17/09) Electronic Clearance ☒ By (UserID): 11788 Date: 11/17/09 Phone: Comments: Plans provided are consistent with original plans submitted and stamped with ZA18129 PA2. Also covenant is recorded on 11-17-09.
Cleared	**Agency: Department of Building and Safety** **Address Code: 4** **Description:** Approval of Disabled Access corrections Electronic Clearance ☒ By (UserID): NMEDRANO Date: 11/18/09 Phone: Comments:

End of Clearance(s) for 08020-20000-02718. Refer to "ADDRESS CODES" sheet for clearance agency address/phone information.

Exhibit M

Oil Well Decision Reference,

ZA 18614(PA3) Determination

LINN K. WYATT
CHIEF ZONING ADMINISTRATOR

ASSOCIATE ZONING ADMINISTRATORS
R. NICOLAS BROWN
SUE CHANG
LOURDES GREEN
CHARLES J. RAUSCH, JR.
JIM TOKUNAGA
FERNANDO TOVAR
DAVID S. WEINTRAUB
MAYA E. ZAITZEVSKY

CITY OF LOS ANGELES
CALIFORNIA

ERIC GARCETTI
MAYOR

DEPARTMENT OF
CITY PLANNING

MICHAEL J. LOGRANDE
DIRECTOR

OFFICE OF
ZONING ADMINISTRATION
200 N. SPRING STREET, 7TH FLOOR
LOS ANGELES, CA 90012
(213) 978-1318
FAX: (213) 978-1334
www.planning.lacity.org

September 20, 2013

Rey Javier (A)
Brea Canon Oil Co., Inc.
23903 South Normandie Avenue
Harbor City, CA 90710

Normandie Properties, LLC (O)
23903 South Normandie Avenue
Harbor City, CA 90710

L. Rae Connet (R)
PetroLand Services
13030 Inglewood Avenue, #105
Hawthorne, CA 90250

CASE NO. ZA 18614(PA3)
APPROVAL OF PLANS
23903 South Normandie Avenue
Wilmington-Harbor City Planning Area
Zone : [Q]MR1-1VL-O
D. M. : 42B197
C. D. : 15
CEQA : ENV 2013-1659-CE
Legal Description : PT Joughin et al
541.85 Acres, Plat of "Lot 5 F" of
Palos Verdes Partition of 1882

Pursuant to Los Angeles Municipal Code Section 13.01-H, I hereby APPROVE:

plans to allow the drilling of one new oil well on an existing semi-controlled site known as "C-7" in the Joughin Unit in Oil Drilling District U-114 and bottoming in adjacent Oil Drilling District U-115 in the [Q]MR1-1VL-O Zone,

upon the following additional terms and conditions:

1. All other use, height and area regulations of the Municipal Code and all other applicable government/regulatory agencies shall be strictly complied with in the development and use of the property, except as such regulations are herein specifically varied or required.

2. The use and development of the property shall be in substantial conformance with the plot plan submitted with the application and marked Exhibit "A", except as may be revised as a result of this action.

3. The authorized use shall be conducted at all times with due regard for the character of the surrounding district, and the right is reserved to the Zoning Administrator to impose additional corrective Conditions, if, in the Administrator's opinion, such Conditions are proven necessary for the protection of persons in the neighborhood or occupants of adjacent property.

4. All graffiti on the site shall be removed or painted over to match the color of the surface to which it is applied within 24 hours of its occurrence.

5. A copy of the first page of this grant and all Conditions and/or any subsequent appeal of this grant and its resultant Conditions and/or letters of clarification shall be printed on the building plans submitted to the Development Services Center and the Department of Building and Safety for purposes of having a building permit issued.

6. The applicant shall defend, indemnify and hold harmless the City, its agents, officers, or employees from any claim, action or proceedings against the City or its agents, officers, or employees relating to or to attack, set aside, void or annul this approval which action is brought within the applicable limitation period. The City shall promptly notify the applicant of any claim, action, or proceeding and the City shall cooperate fully in the defense. If the City fails to promptly notify the applicant of any claim action or proceeding, or if the City fails to cooperate fully in the defense, the applicant shall not thereafter be responsible to defend, indemnify, or hold harmless the City.

7. Except as authorized by this grant, all applicable terms and conditions specified under extant Case No. ZA 18614 shall be strictly complied with including Section 13.01-E.2(g), (h), (i), and Condition Nos. 5, 7, 8, 9, 17, 18, 37, 40, 46, 50, 58 and 59 of Section 13.01-F of the Municipal Code as required by reference made a part of the conditions of ZA 18614.

8. Prior to the issuance of any permits relative to the subject grant, the applicant shall provide evidence of compliance with the conditions required by ZA 18614 and subsequent grants to the Development Services Center.

9. Prior to the commencement of drilling operations, sound attenuation walls with a minimum height of 32 feet shall be installed between the individual drill sites and any nearby residential units.

10. Drilling operations may be conducted seven days per week on a 24-hour basis, including any nationally recognized holiday. Drilling operations shall be completed either within 90 days from the *effective* date of this determination or within 60 days from the actual commencement of drilling operations for the first well, in which case a drilling log shall be maintained by the applicant and provided to the Development Services Center with substantiating documents to determine compliance with the approved schedule.

11. All drilling equipment shall be removed from the premises immediately after drilling is completed, sump holes filled, and derricks removed within 60 days after the completion of the well. Upon the completion of the drilling of wells, the premises shall be placed in a clean condition.

12. Wells, which are placed upon the pump, shall be pumped by electricity with the most modern and latest type of pumping units of a height of not more than 16 feet. All permanent equipment shall be painted and kept in neat condition. All production operations shall be as free from noise as possible with modern oil operations.

13. There shall be no tanks or other facilities for the storage of oil erected or maintained on the premises and that all oil products shall be transported from the drilling site by means of an underground pipe line connected directly with the production pump without venting products to the atmosphere at the production site. No refinery,

dehydrating or absorption plant of any kind shall be constructed, established or maintained on the premises at any time.

14. Noise generated on-site shall not exceed the decibel levels stated in the Citywide Noise Ordinance. There shall be no loitering, playing of radios or loud music, or similar activities permitted on site or in the area adjacent to the project site at any time. No audible speakers or paging systems shall be permitted except for emergencies.

15. All tools, pipe and other equipment used in connection with the drilling operation and production shall be stored on the site within the enclosed portion of the site and shall not be stored or kept in any exterior area adjacent to residential use or public right-of-way.

16. The applicant shall identify a contact person and provide a 24-hour "hot line" telephone number for any inquiries or complaints from the community regarding the subject facility. Prior to the utilization of this grant, the phone number and the name of contact person shall be posted at the entrances on Normandie Avenue, Oakheath Place and Oakhorne Drive such that is readily visible from the exterior of the premises. The hot line shall be: responded to within 24 hours of any complaints/inquiries received on this hot line, and documented in a log, which shall provide information about when the calls were received, returned and the action taken at a minimum, and shall be available for review by the Department of Building and Safety, the Fire Department and/or any other responsible agencies upon request.

17. All lighting shall be shielded and directed onto the site. No floodlighting is permitted. This Condition shall not preclude the installation of low-level security lighting.

18. The applicant/business operator shall be responsible for maintaining free of litter the area adjacent to the premises, over which they have control.

19. The Conditions of this grant shall be retained on the premises at all times and be immediately provided upon request of any responsible agencies.

20. The conditions of the subject grant shall be provided to the employees and contractors for their review. Prior to the utilization of the grant, a statement signed by the employees and contractors stating that they reviewed and agree to comply with the conditions shall be submitted to the Development Services Center.

21. The access to the site shall be kept closed at all times except for normal passage of the employees and contractors, emergency personnel or material delivery or pick up.

22. Prior to the issuance of any permits relative to the subject grant, the applicant shall provide the Department of Water and Power with a precise plot plan of the drilling plant and roads leading thereto, and to make such safeguards as the Department deems necessary to assure the safety of the existing 50-inch water main which crosses the district involved. The Department of Water and Power shall be permitted to review and inspect methods used in the drilling and producing operations and in the disposal of waste, and shall have the right to require changes necessary for the full protection of the public water supply.

23. At any time during the period of validity of this grant, should documented evidence be submitted showing continued violation of any condition of this grant, resulting in an unreasonable level of disruption or interference with the peaceful enjoyment of the adjoining and neighboring properties, the Zoning Administrator reserves the right to require the applicant to file for a plan approval application together with associated fees pursuant to LAMC Section 19.01-C, the purpose of which will be to hold a public hearing to review the applicant's compliance with and the effectiveness of these conditions. The applicant shall prepare a radius map and cause a notification to be mailed to all owners and occupants of properties within a 500-foot radius of the property, the Council Office, and the Los Angeles Police Department corresponding Division. The applicant shall also submit a summary and any supporting documentation of how compliance with each condition of this grant has been attained. Upon this review the Zoning Administrator may modify, add or delete conditions, and reserves the right to conduct this public hearing for nuisance abatement/revocation purposes.

24. Prior to the issuance of any permits relative to this matter, a covenant acknowledging and agreeing to comply with all the terms and conditions established herein shall be recorded in the County Recorder's Office. The agreement (standard master covenant and agreement form CP-6770) shall run with the land and shall be binding on any subsequent owners, heirs or assigns. The agreement with the conditions attached must be submitted to the Development Services Center for approval before being recorded. After recordation, a certified copy bearing the Recorder's number and date shall be provided to the Zoning Administrator for attachment to the subject case file.

OBSERVANCE OF CONDITIONS - TIME LIMIT - LAPSE OF PRIVILEGES

All terms and conditions of the approval shall be fulfilled before the use may be established. The instant authorization is further conditional upon the privileges being utilized within three years after the effective date of approval and, if such privileges are not utilized or substantial physical construction work is not begun within said time and carried on diligently to completion, the authorization shall terminate and become void.

TRANSFERABILITY

This authorization runs with the land. In the event the property is to be sold, leased, rented or occupied by any person or corporation other than yourself, it is incumbent upon you to advise them regarding the conditions of this grant.

VIOLATIONS OF THESE CONDITIONS, A MISDEMEANOR

Section 12.29 of the Los Angeles Municipal Code provides:

> "A variance, conditional use, adjustment, public benefit or other quasi-judicial approval, or any conditional approval granted by the Director, pursuant to the authority of this chapter shall become effective upon utilization of any portion of the privilege, and the owner and applicant shall immediately comply with its Conditions. The violation of any valid Condition imposed by the Director, Zoning Administrator, Area Planning Commission, City Planning Commission or City Council in connection with the granting of any action taken pursuant to the authority of this chapter, shall

constitute a violation of this chapter and shall be subject to the same penalties as any other violation of this Code."

Every violation of this determination is punishable as a misdemeanor and shall be punishable by a fine of not more than $2,500 or by imprisonment in the county jail for a period of not more than six months, or by both such fine and imprisonment.

APPEAL PERIOD - EFFECTIVE DATE

The applicant's attention is called to the fact that this grant is not a permit or license and that any permits and licenses required by law must be obtained from the proper public agency. Furthermore, if any Condition of this grant is violated or if the same be not complied with, then the applicant or his successor in interest may be prosecuted for violating these Conditions the same as for any violation of the requirements contained in the Municipal Code. The Zoning Administrator's determination in this matter will become effective after OCTOBER 7, 2013, unless an appeal therefrom is filed with the City Planning Department. It is strongly advised that appeals be filed early during the appeal period and in person so that imperfections/incompleteness may be corrected before the appeal period expires. Any appeal must be filed on the prescribed forms, accompanied by the required fee, a copy of the Zoning Administrator's action, and received and receipted at a public office of the Department of City Planning on or before the above date or the appeal will not be accepted. **Forms are available on-line at http://planning.lacity.org**. Public offices are located at:

Figueroa Plaza
201 North Figueroa Street,
4th Floor
Los Angeles, CA 90012
(213) 482-7077

Marvin Braude San Fernando
Valley Constituent Service Center
6262 Van Nuys Boulevard, Room 251
Van Nuys, CA 91401
(818) 374-5050

If you seek judicial review of any decision of the City pursuant to California Code of Civil Procedure Section 1094.5, the petition for writ of mandate pursuant to that section must be filed no later than the 90th day following the date on which the City's decision became final pursuant to California Code of Civil Procedure Section 1094.6. There may be other time limits which also affect your ability to seek judicial review.

NOTICE

The applicant is further advised that all subsequent contact with this office regarding this determination must be with the Zoning Administrator who acted on the case. This would include clarification, verification of condition compliance and plans or building permit applications, etc., and shall be accomplished **BY APPOINTMENT ONLY**, in order to assure that you receive service with a minimum amount of waiting. You should advise any consultant representing you of this requirement as well.

FINDINGS OF FACT

After thorough consideration of the statements contained in the application, the plans submitted therewith, the report of the Zoning Analyst thereon, the statements made at the public hearing on August 8, 2013, all of which are by reference made a part hereof, as well as knowledge of the property and surrounding district, I find that the requirements for

authorizing a conditional use plan approval under the provisions of Section 13.01-H have been established by the following facts:

BACKGROUND

The site is a 30,930 square-foot roughly triangular parcel of land, with approximately 913 feet of frontage along the west side of Normandie Avenue, and a maximum depth of approximately 801 feet. The subject property is improved with oil wells, associated equipment, asphalt pavement and fencing, with a wall and landscaping along the Normandie Avenue frontage. Separating the site and the single-family dwellings to the north is a brick wall, except where Oakhome Drive and Oakheath Place abut the property, where there is a chain link fence with wooden slats topped with barbed wire. The site is accessed exclusively from Normandie Avenue.

The applicant requests approval to drill one new well, which will be slant drilled to reach deposits in an adjacent drilling district. Drilling is expected to be completed within 60 days after drilling operations commence. Drilling will be conducted 24 hours per day, seven days per week, until completed, in compliance with the conditions of approval of the previous grants on the site. Well Josephine No. 8, shown on the plot plan, is the well proposed to be drilled subject to this determination.

Properties to the north are zoned R1-1XL-O and are improved with single-family dwellings. Properties to the east are located within the boundaries of unincorporated Los Angeles County are improved with single-family dwellings. Properties to the west are zoned [Q]MR1-1VL-O and are improved with the Burlington Northern Santa Fe Railroad right-of-way.

The Wilmington-Harbor City Community Plan Map designates the property for Limited Manufacturing land uses with corresponding zones of CM, MR1, M1, P and Height District No. 1 VL. The property is within ZI-2130 Harbor Gateway State Enterprise Zone, and ZI-1195 State of California (Division of Oil and Gas) Approval.

Normandie Avenue, adjoining the property to the east is a Major Highway Class II with a width of 80 feet and is fully improved.

Previous zoning related actions on the site include:

Case No. ZA 18641(PA2) - On June 3, 2013, an application was submitted concurrently with the subject case for an Approval of Plans to allow the drilling of three new oil wells on an existing semi-controlled drill site known as "C-7" in the Joughin Unit in Oil Drilling District U-114 in the [Q]MR1-1VL Zone.

Case No. ZA 18614(PA1) - On May 10, 2013, the Zoning Administrator approved plans to allow the drilling of two new oil wells and oil production within the semi-controlled drill site known as "C-6" of the Joughin Unit, located within Oil Drilling District No. U-114, and located on property zoned [Q]MR1-1VL-O

Case Nos. ZA 18614 and ZA 18750 - On June 8, 1970, filed as an Approval of Plans application, the Zoning Administrator approved the equipment layout and site development plan for semi-controlled drill site A-3.

Case No. ZA 18750 - On April, 13, 1967, the Zoning Administrator approved a variance from the provisions of Article 2, Chapter 1 of said Code on an approximately 90-acre area, insofar as said variance is necessary to permit in addition to the accessory facilities and uses authorized under Case No. ZA 18614 in connection with oil wells drilled upon or bottomed under Oil Drilling District No. 114.

Case No. ZA 18614 - On February 17, 1967, the Zoning Administrator approved the drilling, bottoming and production of wells under the involved portion of Oil Drilling District No. 114 and the above-referred-to pending Torrance 1-65 Addition to the city of Los Angeles, if and when annexed to the City, from surface locations outside the city of Los Angeles or in the adjoining M3 Zone to the north, if the respective surface location has been properly authorized for such use by the governmental entity having jurisdiction thereof.

PUBLIC HEARING

A public hearing was held on August 8, 2013 in the Hearing Room of the San Pedro Municipal Building. In attendance were the applicant's representative, two members of the applicant's corporate office, one member of the public and two representatives of Council District 15. The staff of the Brea Canon Oil Company gave a brief overview of their operation, and their plans for the existing site. They are drilling a total of four new wells. Because one of the wells slant drills into an adjoining field, it is subject to a second Plan Approval (PA3) which is also being held today and is the subject of this determination. The Torrance Oil Field, of which this site is a part, is the 7th largest oil drilling district in the County. This site was chosen for the drilling of the new wells because it has the fewest impacts on neighboring properties. Brea Canon plans to drill a slant well which will access an adjoining oil field (Josephine 8) for the production of petroleum. There will be no oil refinery facilities on site and the produced oil will be transported to a designated area through underground pipelines. During the operational phase after the wells are drilled, one staff member will visit the site daily for maintenance. We will drill on the site 24 hours per day, 7 days a week. This will enable us to do the drilling quickly and with as little noise impact on the area as possible. The well sites will be surrounded by portable sound walls which will absorb any noise made by the drilling machinery. The walls will be 32 feet high on portable poles, and they will be taken down when drilling is complete. Any night lighting required at the drill site will be directed toward the machinery and will be behind the temporary walls.

A representative of the Harbor City Neighborhood Council spoke and stated that the Council fully supported the application. The representative lived in the area of the wells and stated that noise from the site had not been a problem. Most of the local noise is created by trains on the adjacent rail road line.

The representatives of Council District 15 spoke in favor of the application. They stated that there were many oil companies in the District both extracting oil and refining it. Brea Canon has run a clean operation and works well with the local neighbors. They have contributed both time and money to neighborhood projects. We support the application.

FINDINGS

Following is a delineation of the findings and the application of the relevant facts to same:

1. The subject site is within Oil Drilling District No. 114, which was established by Ordinance No. 133,281 in 1966. The subject property is improved with asphalt paving, an electrical panel, pits covered with grates and fencing along the perimeter.

   On February 17, 1967, pursuant to Sections 13.01-F and H of the Municipal Code and under Case No. ZA 18614, the Chief Zoning Administrator approved the Determination of Conditions and Methods of Operation under which existing oil wells may be maintained, semi-controlled drill sites may be established for drilling additional wells and centralized maintenance and production sites for the various wells may be established on an approximately 156-acre area comprising a major portion of the non-urbanized Oil Drilling District 114. The subject site is identified in the 1967 grant as Production Site No. 3 in Drill Site C-7 of the Joughin Unit.

   Oil drilling, injection and production activities have been undertaken on the site since 1967 in accordance with the terms and conditions of Case No. ZA 18614. No other public comments were received from the community indicating that the existing operation of the oil production site has resulted in adverse impacts to the surrounding properties.

   In a time where dependence on foreign oil comes at an increased social, economic and political cost, this approval, by encouraging and facilitating local oil production, under strict controls as to the possible impacts it may have on the immediate vicinity of the production site, will be of direct benefit to the public as a whole. Upon completion of the drilling operation, production activities will be permitted under the applicable terms and conditions of this and previous grants.

2. The applicant stated that Brea Canon Oil company has been and continues to be a responsible operator with an exemplary safety record. Oil District 114 contains approximately 156 acres and a total of 62 oil producing wells are permitted based on a ratio of one well per 2-1/2 acres. Currently there are 23 oil wells within District 114 and the proposed additional well on the subject site will result in a total of 29 wells.

   The applicant stated that the drilling phase of the project will be completed within 60 days and pumping units will not exceed 16 feet in height. The grant includes mitigation measures to mitigate the noise and potential impacts that are associated with drilling operation and oil production. The conditions of the prior grant and applicable rules and regulations of Section 13.01 of the Municipal Code are included as the conditions of the subject grant by reference in order to ensure the proposed drilling and oil production on the site do not result in adverse impacts to the surrounding properties. Given the extent of the required conditions and considering that the applicant has demonstrated its ability to operate the existing operation of the oil production without creating detrimental impacts to the community, drilling of oil wells and adding one more well at this location are not expected to result in detrimental impacts to the surrounding properties.

3. The granting of the request is consistent with the objectives and policies of the General Plan, which aim to maintain a compatibility of land uses adjacent to each other, inasmuch as the area is located within a designated Oil District and the use has been permitted at this location since 1967. As conditioned, the grant will not result in a change to the character of the surrounding properties.

3. The granting of the request is consistent with the objectives and policies of the General Plan, which aim to maintain a compatibility of land uses adjacent to each other, inasmuch as the area is located within a designated Oil District and the use has been permitted at this location since 1967. As conditioned, the grant will not result in a change to the character of the surrounding properties.

ADDITIONAL MANDATORY FINDINGS

4. The National Flood Insurance Program rate maps, which are a part of the Flood Hazard Management Specific Plan adopted by the City Council by Ordinance No. 172,081, have been reviewed and it has been determined that this project is located in Zone C, areas of minimal flooding.

5. On June 26, 2013, the subject project was issued a Notice of Exemption (Subsection c, Section 2, Article II, City CEQA Guidelines), log reference ENV 2013-1659-CE, for a Categorical Exemption, Class 5, Category 23. Article III, Section 1, City CEQA Guidelines (Sections 15300-15333, State CEQA Guidelines). I hereby adopt that action.

Inquiries regarding this matter shall be directed to Michael O'Brien, Planning Staff for the Office of Zoning Administration.

MICHAEL O'BRIEN
Project Planner
Direct Telephone No. (213) 978-1346

CHARLES J. RAUSCH, JR
Associate Zoning Administrator

CJR:MOB:lmc

cc. Councilmember Joe Buscaino
Fifteenth District
Adjacent Property Owners

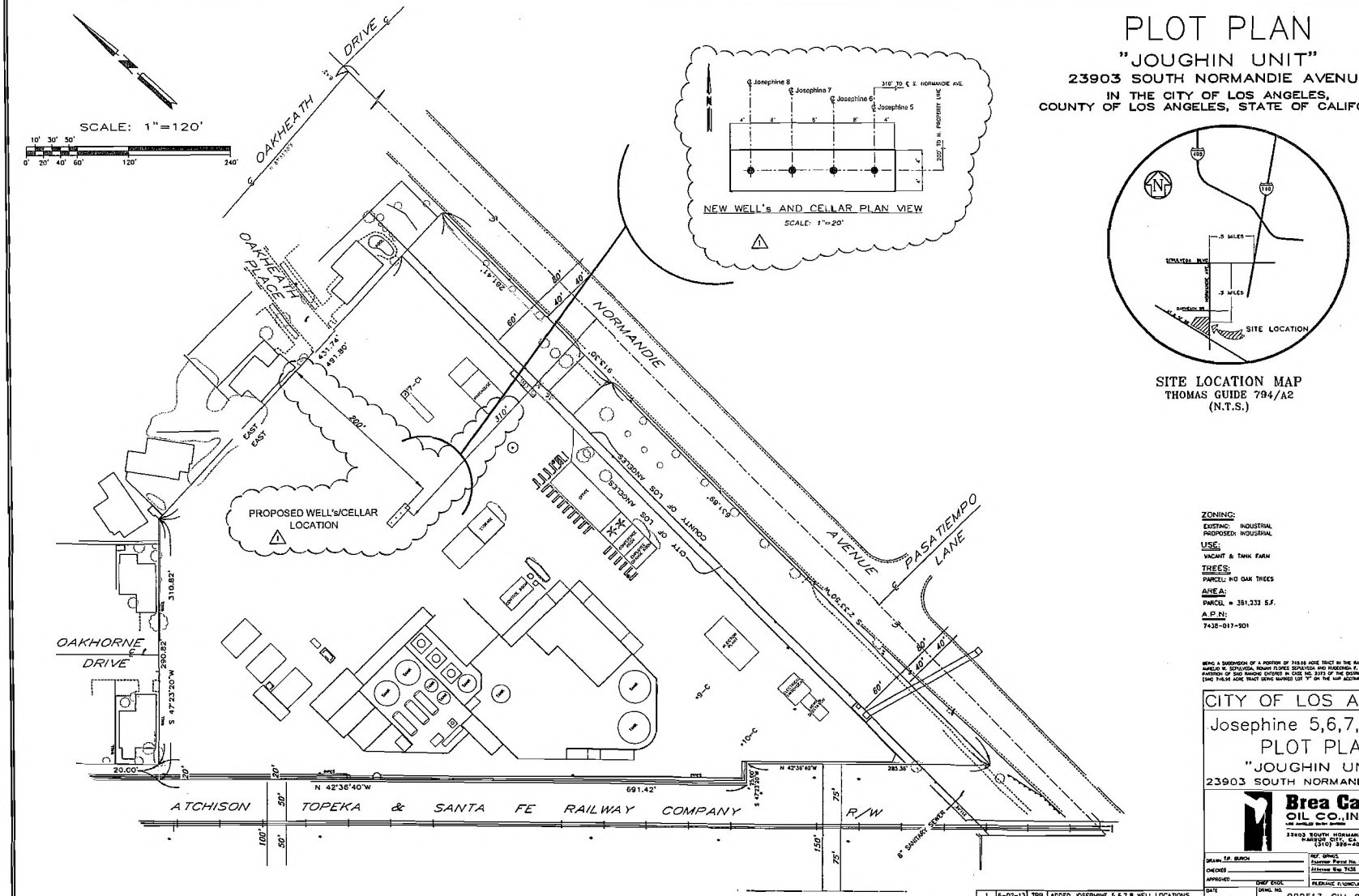
EXHIBIT "A"
Page No. 1 of
Case No.

EXHIBIT 1

PLOT PLAN

"JOUGHIN UNIT"

23903 SOUTH NORMANDIE AVENUE
IN THE CITY OF LOS ANGELES,
COUNTY OF LOS ANGELES, STATE OF CALIFORNIA



ZONING:
EXISTING: INDUSTRIAL
PROPOSED: INDUSTRIAL

USE:
VACANT & TANK FARM

TREES:
PARCEL: NO OAK TREES

AREA:
PARCEL = 381,232 S.F.

A.P.N:
7438-017-901

BEING A SUBDIVISION OF A PORTION OF 7438.66 ACRE TRACT IN THE RANCHO PALOS VERDES, ALLOTED TO AURELIO M. SOTOMAYOR, ROMAN FLORES SOTOMAYOR AND MARGARITA V. SOTOMAYOR BY A DECREE IN PARTITION OF SAID RANCHO ENTERED IN CASE NO. 3273 OF THE DISTRICT COURT OF SAID COUNTY, SAID 7438.66 ACRE TRACT BEING MARKED LOT "F" ON THE MAP ACCOMPANYING SAID DECREE.

CITY OF LOS ANGELES
Josephine 5,6,7,8 Wells
PLOT PLAN
"JOUGHIN UNIT"
23903 SOUTH NORMANDIE AVENUE

Brea Cañon OIL CO., INC.
23903 SOUTH NORMANDIE AVENUE
HARBOR CITY, CA. 90710
(310) 326-4900

DRAWN: T.P. BURCH	REF. DRWGS.
CHECKED	Assessor Parcel No. (APN) 7438017901
APPROVED	Assessor Map 743G
CHIEF ENGR.	FILENAME P:\DWG\JOUGHIN\2013\JOUGHPRINCIPAL.DWG

DATE	DRWG. NO.	REV. NO.
06-01-13	082513-CIV-01	1
SCALE 1"=60'	PROJ. NO. AFE-0000	CO. NO. 01

REV.	DATE	BY	DESCRIPTION
1	6-02-13	TPB	ADDED JOSEPHINE 5,6,7,8 WELL LOCATIONS

REVISIONS

EXHIBIT "A"
Page No. 1 of 1
Case No. ZA 18614 (PA3)

ZA 18614 - PA3

Exhibit N

California Independent

Petroleum Association - Routine Rig Work

General Procedure Injector Equipment Change

Well work required due to:	Replace or add injection equipment. Clean out wellbore as needed to put well on injection
Equipment/personnel on site:	Level 4 workover rig- 4 man crew.
Typical hours to complete:	36-60 hours

1. Move production rig to well location. *(6 hours)*
2. Conduct well checks and install safety equipment applicable for job. *(4 hours)*
3. Remove injection packer and tubing from well. *(10 hours)*
4. Clean out sand or debris in wellbore by chemical or mechanical methods. *(0-24 hours)*
5. Install tubing and injection packer, test per regulatory requirements. *(10 hours)*
6. Remove well safety equipment. Put well on injection. *(6 hours)*

General Procedure Artificial Lift Change

Well work required due to:	Failed pump equipment. Replace pump equipment and clean out wellbore as needed to return well to production.
Equipment/personnel on site: **Job dependent:**	Level 4 workover rig- 4 man crew Tuboscope/hydraulic test truck- 1 man Mud pump, coil tubing – 1-4 man
Typical hours to complete:	36-60 hours

1. Move production rig to well location. *(6 hours)*
2. Conduct safety checks on well and install safety equipment applicable for job. *(4 hours)*
3. Remove rods, pump, and tubing from well. *(10 hours)*
4. Clean out sand or debris in wellbore by chemical or mechanical methods. *(0-24 hours)*
5. Install pump, tubing, and rods. *(10 hours)*
6. Remove equipment. Return well to production. *(6 hours)*

General Procedure Well Abandonment

Well work required due to: Abandon wellbore.

Equipment/personnel on site: Level 4 workover rig- 4 man rig crew
Job dependent: Mud pump, coil tubing – 1-4 man
Fishing tools- 1 man

Typical hours to complete: 68-200 hours

1. Move production rig to well location. *(6 hours)*
2. Conduct safety checks on well and install any safety equipment applicable for job. *(4 hours)*
3. Remove rods, pump, and tubing from well. *(10 hours)*
4. Clean out sand or debris in wellbore by chemical or mechanical methods. *(0-60 hours)*
5. Place cement inside well isolate all fluid from the reservoir being able to enter well. *(12-48 hours)*
6. Place holes in the wellbore at the BFW (base of freshwater) so that cement can placed outside and inside the wellbore. *(12-24 hours)*
7. Place holes in the wellbore +/- 100 ft below ground so that cement can placed outside and inside the wellbore. *(12-24 hours)*
8. With wellbore full of cement, weld a cap to the well and burry minimum of 5ft below ground level. *(12-24 hours)*

Exhibit O

June 2024 Public Health Dimensions of Upstream Oil and Gas Development in California:

Scientific Analysis and Synthesis to Inform

Science-Policy Decision Making

Public Health Dimensions of Upstream Oil and Gas Development in California: Scientific Analysis and Synthesis to Inform Science-Policy Decision Making

June 21, 2024

California Oil & Gas Public Health Rulemaking Scientific Advisory Panel

Principal Investigators

Seth B.C. Shonkoff, PhD, MPH — *PSE Healthy Energy, University of California, Berkeley, Lawrence Berkeley National Laboratory*

Rachel Morello-Frosch, PhD, MPH — *University of California, Berkeley, School of Public Health and Department of Environmental Science, Policy and Management*

Expert Panel Members

Joan Casey, PhD, MA — *Columbia School of Public Health*

Nicole Deziel, PhD, MHS — *Yale School of Public Health*

Dominic DiGiulio, PhD — *PSE Healthy Energy, University of Colorado**

Stephen Foster, PhD — *Geosyntec Consultants***

Jo Kay Ghosh, PhD — *South Coast Air Quality Management District****

Gretchen Goldman, PhD, MS — *Union of Concerned Scientists*****

Robert Harrison, MD, MPH — *University of California, San Francisco*

Jill Johnston, PhD — *University of Southern California*

Kenneth Kloc, PhD, MPH — *CalEPA Office of Environmental Health Hazard Assessment*

Lisa McKenzie, PhD, MPH — *Colorado School of Public Health, University of Colorado Anschutz Medical Campus*

Thomas McKone, PhD — *University of California, Berkeley*

Mark Miller, MD, MPH — *CalEPA Office of Environmental Health Hazard Assessment, University of California, San Francisco*

Andrea Polidori, PhD — *South Coast Air Quality Management District*

**Served as an Expert Panel Member until February 3, 2023*

***Served as an Expert Panel Member until May 18, 2023*

****Served as an Expert Panel member until August 6, 2021*

*****Served as an Expert Panel Member until July 5, 2021*

Acknowledgements

The report was prepared with assistance from researchers at PSE Healthy Energy and the University of California, Berkeley.

PSE Healthy Energy

Lee Ann L. Hill, MPH – Research Team Lead
Drew Michanowicz, DrPH, MPH, CPH
Robert Rossi, PhD
Eric Lebel, PhD
Jessie M. Jaeger, MPH, MCP
Jeremy Domen, MS

University of California, Berkeley

David J.X. González, PhD
Lauren Baehner, MPH
Nicholas Depsky, MS

This report was prepared for the California Geologic Energy Management Division (CalGEM) with funding from CalGEM.

Public Health Dimensions of Upstream Oil and Gas Development in California: Scientific Analysis and Synthesis to Inform Science-Policy Decision Making

Table of Contents – Full Report

Executive Summary	Findings, Conclusions and Recommendations
Chapter 1	Introduction
Chapter 2	Stressors Associated with Upstream Oil and Gas Development
Chapter 3	Peer-Reviewed Epidemiological Literature Evaluating Upstream Oil and Gas Development
Chapter 4	Oil and Gas-Associated Air Pollution, Health Risks and Approaches to Emission Control
Chapter 5	Potential Impact to Public Health from the Management and Disposal of Produced Water
Chapter 6	Legacy Oil and Gas Infrastructure: Implications for Public Health
Chapter 7	Proximity Analysis of Oil and Gas Development and Human Populations in California

Acronyms and Abbreviations

EXECUTIVE SUMMARY

Findings, Conclusions, and Recommendations

The primary role of the California Oil and Gas Public Health Rulemaking Scientific Advisory Panel ("Panel") is to provide subject matter expertise to the California Geologic Energy Management Division (CalGEM) to inform the agency's rulemaking process. The specific charge of the Panel is to evaluate and synthesize the best available peer-reviewed science and publicly available data on the public-health dimensions of upstream oil and gas development in order to draw well-informed findings, conclusions, and recommendations. The Panel reached consensus regarding all findings, conclusions, and recommendations in this report.[1]

In developing recommendations, the Panel was guided by the principle of "defense in depth," for which the deployment of multiple independent, yet redundant factors of safety is seen as a fundamental strategy to safeguard public health. This principle has been widely adopted across industries and issue areas.[2,3] Implementation of multiple preventative or attenuation strategies is necessary to mitigate public-health risks associated with upstream oil and gas development in California.[4] The concept of defense in depth is particularly important with respect to the management of off-normal events that cannot be immediately controlled.

Findings, conclusions, and recommendations from this report follow below. *Findings* are results ascertained from scientific evidence and data and reflect an unbiased synthesis of facts. Findings are included with direct references to supporting material in corresponding chapters of this report. *Conclusions* are panel-consensus deductions based on the *findings*. *Recommendations* are statements of actions needed to address the *findings* and *conclusions*.

---

[1] Consensus means that all Panel members reviewed the findings, conclusions, and recommendations and affirmatively agreed that the scientific evidence supports them. Panel members had the opportunity to prepare a dissenting assessment, but no one did so. This report reflects the perspective of the Panel members and not necessarily those of their employers or the institutions with which they are affiliated.

[2] International Nuclear Safety Advisory Group. (1996). *Defense in Depth in Nuclear Safety: A Report by the International Nuclear Safety Advisory Group (INSAG-10)*. International Atomic Energy Agency.

[3] U.S. NRC (United States Nuclear Regulatory Commission). (2021). *Defense in depth*.

[4] Deziel, N. C., McKenzie, L. M., Casey, J. A., McKone, T. E., Johnston, J. E., Gonzalez, D. J. X., Shonkoff, S. B. C., & Morello-Frosch, R. (2022). Applying the hierarchy of controls to oil and gas development. *Environmental Research Letters*, *17*(7), 071003. https://doi.org/10.1088/1748-9326/ac7967

SUMMARY FINDING 1.

As the distance between human-occupied residences and upstream oil and gas development operations decreases, or the density of wells and production volume increases, the likelihood of adverse health outcomes increases. Studies, including those in California, consistently show increased potential for exposure to air pollution and noise, as well as increased risk for several adverse health outcomes in populations living within and beyond 1 kilometer (km) (~0.62 miles or 3,281 feet [ft]) of oil and gas well sites. Certain groups face disproportionate exposures to oil and gas development sites. Compared to the overall California population, Hispanic, non-Hispanic Black, and non-Hispanic Asian communities, as well as populations of lower socioeconomic status, are more likely to live within 1 km (3,281 ft) of at least one active well and live in areas with the highest density of oil and gas wells.[5]

Finding 1.1. Various chemical and physical stressors are associated with upstream oil and gas development activities, including air pollutants, surface-water and groundwater contaminants, vibration, noise, and odors. The impact of these stressors generally attenuates as distance from the source increases. The degree of attenuation depends on the properties of the specific stressor *(Chapter 2, Section 2.4)*.

Finding 1.2. Although no peer-reviewed noise studies related to upstream oil and gas development activities have been conducted in California, studies elsewhere have measured elevated noise levels during all oil and gas development phases at levels associated with adverse health effects out to 1,000 ft [305 meters (m)] from multi-well oil and gas sites, even with sound walls in place *(Chapter 2, Section 2.3.1).*

Finding 1.3. More than 72 peer-reviewed epidemiological studies conducted across the United States and Canada — six conducted in California — and published through July 15, 2023, evaluated the associations between upstream oil and gas development and several adverse health outcomes. This body of evidence consistently indicates that human populations residing *closer* to upstream oil and gas development experience a greater risk of decreased respiratory function and adverse perinatal outcomes compared to those living farther away (*Chapter 3, Section 3.3.2.1*). Additionally, higher *density* of upstream oil and gas development in the vicinity of residences is associated with greater respiratory and perinatal health risks compared to lower density of oil and gas development. Finally, higher *production volume of oil and gas* is associated with increased risk of adverse respiratory and perinatal health impacts. These trends have

[5] This section contains language about the panel's level of certainty regarding the results reported in the epidemiologic literature. This language only appears in the epidemiology section as the panel conducted a full review of the literature and is therefore able to make this designation.

been observed in urban and rural settings *(Chapter 3, Section 3.5)*. For other health outcomes, including cancer, cardiovascular disease, sexually transmitted infections, and mental and behavioral health, there are limited studies and more research is needed to evaluate the consistency of relationships (*Chapter 3, Sections 3.3.2.4–3.3.2.7; Appendix C*). Strengths and limitations vary by study and are discussed in *Chapter 3, Section 3.4.1*.

Finding 1.4. The Panel identified six peer-reviewed epidemiological studies in California that evaluated associations between upstream oil and gas development and adverse respiratory, perinatal, and neurological outcomes. These studies observed associations between upstream oil and gas development and diagnosed asthma, reduced lung function, and reduced fetal growth at distances of up to 1 km (~0.62 miles or 3,281 ft). Studies in California evaluating the relationship between upstream oil and gas development and risk of preterm birth reported inconsistent results. One California study did not observe an association between upstream oil and gas development and migraine headaches *(Chapter 3, Section 3.5)*.

Finding 1.5. Air-quality research in California has found above-background-level concentrations of non-methane volatile organic compounds (NMVOCs), toxic air contaminants (TACs), and ozone precursors near upstream oil and gas development sites. For each additional well drilling site upwind of U.S. Environmental Protection Agency (EPA) air quality monitors, the concentrations of fine particulate matter ($PM_{2.5}$) increased by 2.35 (standard error [SE]: 0.78) $\mu g/m^3$ (micrograms per cubic meter) for wells within 2 km (6,562 ft); ozone (O_3) by 0.31 (SE: 0.06) parts per billion (ppb) for wells within 2–3 km (6,562–9,843 ft); and nitrogen dioxide (NO_2) by 2.27 (SE: 1.40) ppb for wells within 1 km (3,281 ft). For each additional active well upwind of the monitor, these authors also found 1.93 (SE: 0.43) $\mu g/m^3$ of $PM_{2.5}$, 0.62 (SE: 0.12) ppb of NO_2, and 0.04 (SE: 0.02) ppb carbon (C) of NMVOCs. These models compared monitors to themselves on days when there was and was not drilling or production activities upwind, and also controlled for time trends and geographic differences. In a study in Los Angeles, concentrations of TACs, such as benzene and n-hexane, were elevated at 0.5 km (1,640 ft) from upstream oil and gas sites, the farthest distance evaluated. Methane, which can sometimes be used to indicate the presence of other oil and gas-related air pollutants, was also measured at concentrations above background. Oil and gas production facilities have periods of active production as well as idle periods, such that emissions from wells greatly differ depending on the phase. Findings from this study suggest that oil and gas drilling during the active phase contributed 23.7% of the total NMVOCs measured, while the idle period only contributed 0.6% (*Chapter 4, Section 4.2.2*).

Finding 1.6. An estimated 3 million California residents (8% of the population) live within 1 km (3,281 ft) of at least one active-producing[6] oil and/or gas well. Based on satellite imagery, an estimated 670,000 residentially zoned buildings, or 6% of all California buildings, are within 1 km (3,281 ft) of at least one active-producing well. Many sensitive receptors, defined as schools (pre-K to 12th grade), childcare facilities, healthcare facilities, senior care facilities, correctional facilities, parks, and residential buildings, are also located in close proximity to oil and gas development in California *(Chapter 7, Sections 7.4 & 7.6; see Table ES-1 below)*.

Finding 1.7. A relatively small proportion of active producing oil and gas wells in California have a school, childcare facility, healthcare facility, senior care facility, correctional facility, or park within 1 km (3,281 ft). For example, an estimated 6,006 active-producing wells (7.2% of all wells) are within 1 km (3,281 ft) of at least one school. Similarly, 2,377 wells (~3% of all wells) are responsible for all of the co-location with healthcare facilities at the 1 km (3,281 ft) distance. Over 30,000 (36%) active-producing wells, however, are located within 1 km (3,281 ft) of residential buildings in California *(Chapter 7, Section 7.4.3)*.

Finding 1.8. An estimated 1,663 (2%) active-producing wells are within 100 ft (30 m) of at least one home (n=3,661 homes). California State Fire Code regulation *§ 5706.3* prohibits location of oil and gas wells within 100 ft (30 m) of any building not necessary to the operation of the well, however, local jurisdictions may amend the regulation *(Chapter 7, Section 7.4.5)*.

[6] Active-producing oil or gas wells were defined as *active* if reported as active, new, or idle and *producing*; i.e., a well that was part of a class where at least 1% of wells of that type produced hydrocarbons, indicating that the well was capable of producing.

Table ES-1. Residents and sensitive receptors in proximity to at least one of the 83,000 active-producing oil and gas wells in California, January 2021. For purposes of this report, sensitive receptors include schools (pre-K to 12th grade), childcare facilities, healthcare facilities, senior care facilities, correctional facilities, parks, and residential buildings.

Buffer Distance	Number of Residents	Under 5 years old	Over 64 years old	Schools (pre-K to 12th grade)	Child-care Facilities	Health-care Facilities	Senior care Facilities	Correct-ional Facilities	Parks	Residential Buildings
Statewide Total	**38,984,806**	**2,698,315**	**5,352,812**	**22,452**	**8,867**	**2,131**	**7,246**	**408**	**4,983**	**12,577,497**
500 ft (152 m)	219,681	15,110	30,959	226	68	25	44	7	90	44,994
1,000 ft (305 m)	590,116	39,476	82,984	439	122	59	118	9	154	123,167
1,500 ft (457 m)	1,032,255	68,909	143,807	668	218	87	176	15	208	221,262
2,000 ft (610 m)	1,551,743	103,736	212,905	990	336	116	237	18	276	334,816
2,500 ft (762 m)	2,123,961	141,733	287,705	1,293	451	156	324	21	344	461,246
3,281 ft (1 km)	3,080,713	205,027	412,674	1,749	659	207	466	28	461	673,068
5,280 ft (1.6 km; 1 mile)	5,772,699	384,810	760,877	3,245	1,262	364	832	55	841	1,260,567

Finding 1.9. The statewide analysis of parcel and census data (2015–2019 American Community Survey) shows that the proportions of Hispanic, non-Hispanic Black, and non-Hispanic Asian people, linguistically isolated households, renters, individuals without a high school diploma, and populations with household incomes below two times the federal poverty line were higher in areas within 1 km (3,281 ft) of at least one active-producing well compared to the overall proportion of each of these groups in California (*see Figure ES-1 below*).

Additionally, compared to non-Hispanic White Californians, non-Hispanic Black Californians are 87% more likely to reside within 1 km (3,281 ft) of at least one active-producing oil and gas well. Similarly, the proportion of Hispanic Californians living within 1 km (3,281 ft) of at least one active-producing oil and gas well is 42% higher than non-Hispanic White people.

Findings indicate that compared to non-Hispanic White and more socioeconomically advantaged populations, non-Hispanic Black, non-Hispanic Asian, and Hispanic populations and those of lower socioeconomic status were more likely to live near upstream oil and gas development activities where exposures to stressors are likely to be higher *(Chapter 7, Section 7.4.1)*.

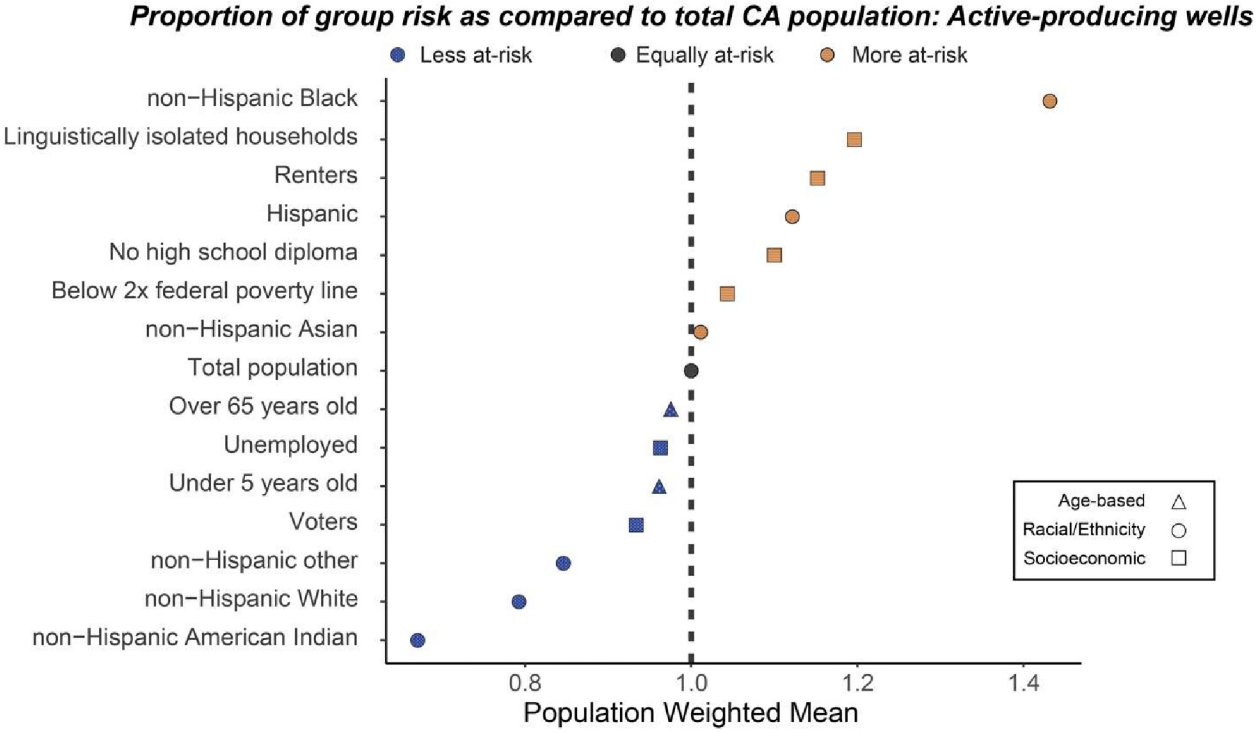


Figure ES-1. Distributional inequities of demographic groups living within 1 km (3,281 ft) of active-producing oil and gas wells as compared to state population totals. Orange markers indicate a population-weighted mean greater than one, indicating a level of subgroup overrepresentation in areas that contain upstream oil and gas development within 1 km (3,281 ft). Blue markers indicate a level of subgroup underrepresentation in areas that contain upstream oil and gas development within 1 km (3,281 ft).

Finding 1.10. Among California's 8,057 census tracts, 157 (1.9%) contained 10 or more wells per square km (0.39 square mi). Sixty-four of these 157 census tracts (~41%) have a CalEnviroScreen 3.0[7] score that designates them as a disadvantaged community with disproportionate socioeconomic, health, and environmental burdens, in addition to the burdens associated with upstream oil and gas development. Because a quarter of all California census tracts are designated as disadvantaged communities based on CalEnviroScreen scores, this finding indicates that disadvantaged communities are overrepresented (1.6 times more common) in census tracts that contain 10 or more wells per square km (0.39 square mi) *(Chapter 7, Section 7.4.4).*

Finding 1.11. 95% of California's active-producing wells are spatially clustered in three air basins. Spatial clustering or high well density suggests that proximity to one well likely means proximity to many wells. For example, 21 healthcare facilities have more than 100 active-producing wells within 1 km (3,281 ft), and 14 facilities have more than 200. Similarly, 107 schools have over 100 wells within 1 km (3,281 ft) (and 33 of these schools have over 300 wells within 1 km (3,281 ft) *(Chapter 7, Section 7.4.3)*.

Finding 1.12. An estimated 400,000 — or roughly 1 in 100 (1%) — California residents live within 1 km (3,281 ft) of an active produced-water disposal pond and wells designated as "Water Disposal" in CalGEM's "All Wells" dataset.[8] Within this distance are an estimated 98,700 residentially-zoned buildings, 239 schools (pre-K to 12th grade), 91 senior care facilities, and 26 healthcare facilities. Emissions of NMVOCs have been measured from produced-water ponds in California; however, the distances that these compounds travel and their corresponding atmospheric concentrations have not been assessed. Moreover, publicly available data with accurate drinking-water well spatial locations in California have not been available. This hinders the ability to evaluate the risk of drinking water contamination from subsurface migration of fluids from produced water disposal processes *(Chapter 7, Section 7.4.2 & 7.4.3)*.

Finding 1.13. Setback regulations in several states have exemption and conditional exception mechanisms that allow operators to apply for variances and drill oil and gas wells within regulated setback distances. In some Texas cities, variances have resulted in 80% of new well pads being located within regulated setback distances. Largely due to variances and landowner consent, the passage of a strengthened setback regulation in Pennsylvania did not alter the siting of wells near buildings. One out of every 13.7 unconventional oil and gas wells was drilled within the regulated setback distance after passage of the regulation *(Chapter 7, Section 7.2.5)*.

---

[7] CalEnviroScreen 3.0. https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30

[8] Wells designated as "Water Disposal" in CalGEM's "All Wells" dataset. https://www.conservation.ca.gov/calgem/maps.

Conclusion 1.1. Exposure to upstream oil and gas development is associated with a range of adverse health effects. In particular, the Panel concludes with a high level of certainty (*see Box 1*) that there is a causal relationship between close residential proximity to upstream oil and gas development and adverse perinatal and respiratory outcomes. The Panel derived this level of certainty from the consistency of results across multiple studies that were conducted using different methodologies, in different locations, with diverse populations, and during different time periods. In California, epidemiological studies have shown statistically significant[9] associations between upstream oil and gas development and adverse health outcomes at distances of 1 km (3,281 ft) and beyond. Epidemiological studies conducted in other oil and gas regions in the United States and Canada have also consistently shown statistically significant associations between upstream oil and gas development and adverse health outcomes within and beyond 1 km (3,281 ft).

Box 1.
The Panel applied the Bradford Hill Criteria for causation *(see Chapter 3, Section 3.3.2.1)* to evaluate the strength of the epidemiological evidence for determining a causal relationship between oil and gas development and adverse human health outcomes. The Bradford Hill criteria are widely used in the field of epidemiology to assess the strength of evidence to assess causality. Where the Bradford Hill Criteria supported a causal relationship and where there was Panel agreement, the Panel concluded with a high level of certainty that there is a causal relationship. The Panel applied these criteria to draw conclusions on whether causal relationships exist between geographic proximity to oil and gas development activities and adverse health outcomes.

Conclusion 1.2. The human health risks associated with chemical and physical stressors emitted by upstream oil and gas sites (air and water pollutants, noise, etc.) can be reduced by establishing greater setback distances between upstream oil and gas development and sensitive receptors, whether it be a human receptor or a receptor

[9] Individual studies often define statistical significance as a p-value that is less than 0.05 or a confidence interval that does not include the null (e.g., 1). However, weight-of-evidence assessments regarding causal relationships between exposures and health outcomes require a holistic assessment of the epidemiological evidence (e.g., by applying the Bradford Hill criteria, as discussed in *Box 1 below* and in *Chapter 3*), and considering size, consistency, and direction of effect, rather than relying solely on dichotomous determinations of statistical significance in individual studies.

relevant to human exposure (e.g., an aquifer that is currently used or in the future could be used for drinking water).

Conclusion 1.3. The human health risks associated with chemical and physical stressors emitted by upstream oil and gas development can be reduced by lowering the density of oil and gas sites around human receptors or receptors relevant to human exposure (e.g., an aquifer that is currently used or in the future could be used for drinking water).

Conclusion 1.4. The 1,663 active-producing wells in California located within 100 ft (30 m) of residential buildings are out of compliance with California State Fire Code regulation *§ 5706.3,* unless they have an exemption, potentially exposing people in these buildings to increased health and safety risks.

Conclusion 1.5. Upstream oil and gas development operations in California are disproportionately located in disadvantaged communities. Disadvantaged communities may be more vulnerable to the adverse health effects of oil and gas development due to concurrent exposures to other environmental hazards and social stressors.

Conclusion 1.6. Exemptions, variances, and consent waivers to setback regulations can weaken well-siting requirements and diminish the public health protections for communities and other sensitive receptors.

Recommendation 1.1. ***Implement a health-protective minimum surface setback.*** Implementing minimum surface setbacks between upstream oil and gas operations and human receptors is critical to protect public health. To mitigate health risks associated with upstream oil and gas development, California should implement a health-protective, minimum surface setback distance between upstream oil and gas development and human populations. Based on the existing epidemiological literature, including studies conducted in California, and the additional factors outlined below, the setback distance should be at least 1 km (3,281 ft). In communities with higher well density, high hydrocarbon production volumes, dense ancillary oil and gas development infrastructure, and the presence of other environmental hazards and socioeconomic stressors, a larger setback should be applied.

Decision-making regarding the appropriate health-protective minimum surface setback distance should consider the following:

- **Multiple stressors associated with upstream oil and gas development** (e.g., noise, odor, vibration, air pollution, water pollution), rather than solely mitigating health and safety impacts of an individual stressor (e.g., only air pollution).
- **Inclusion of an additional margin of safety** to account for the vulnerabilities of particular population subgroups (e.g., children, pregnant people, those with

chronic illnesses, and the elderly) and given the potential for off-normal events (e.g., blowouts, loss of containment events, and accidental releases) that cannot be immediately controlled or consistently prevented. Decisions on a health-protective minimum surface setback distance should be made with particular attention to the locations of sensitive receptors, including but not limited to schools (pre-K to 12th grade), childcare facilities, healthcare facilities, senior care facilities, correctional facilities, parks, and residential buildings.

- **Existing environmental and socioeconomic burdens experienced by communities that may enhance vulnerability to the adverse health effects of oil and gas development activities**. Upstream oil and gas siting decisions and setback requirements should be informed by and account for data-driven metrics used to assess the cumulative burden of communities (e.g., CalEnviroScreen) to ensure that the additional burden associated with upstream oil and gas development is not placed on disadvantaged communities.
- **Because exemptions and conditional exceptions for minimum surface setback requirements will likely diminish health protections for communities and other sensitive receptors, such exemptions and exceptions should be avoided.**

Recommendation 1.2. Limit the density of wells and associated infrastructure, especially near human populations. The weight of the scientific evidence indicates that the risk of adverse health outcomes (e.g., adverse perinatal outcomes, and respiratory outcomes) increases with higher oil and gas well density and hydrocarbon production volume. Thus, in addition to setback requirements, decision-makers should also consider the following:

- Limit upstream oil and gas development in areas with existing oil and gas wells near human populations. Such measures could include rotating temporary well shut-ins and ancillary infrastructure site shut downs, and establishing production volume limits within a certain distance of human populations.
- Require closure and proper abandonment of existing oil and gas operations within 100 ft (30 m) of residential buildings, in particular those that are not exempt from California State Fire Code regulation *§ 5706.3*.
- Review the status and regulatory compliance of all oil and gas operations located within 100 ft (30 m) of residential buildings.

SUMMARY FINDING 2.

There are limited publicly available data on the chemical composition, rates, and amounts of air pollutant emissions from upstream oil and gas development infrastructure. These types of data are necessary to properly assess pollutant

dispersion and community exposures and to respond to air pollution impacts from normal and off-normal release events.

Finding 2.1. There are limited publicly available data on the chemical composition of gases emitted from upstream oil and gas development. These gases include, but are not limited to, natural gas and vapors (gaseous form of volatilized liquids). The sources of these gases include, but are not limited to, the production string of wells; condensate tanks; gas-gathering infrastructure; gas-processing plants; idle, abandoned, and idle-deserted oil and gas wells; and other ancillary infrastructure. *(Chapter 4, Section 4.2.1).*

Conclusion 2.1. Effective risk management of normal and off-normal conditions in upstream oil- and gas-development infrastructure requires timely, accurate, and publicly available data on the chemical composition of emissions from oil and gas infrastructure. The limitations in existing data hinder the ability of regulators, risk managers, and researchers to track emissions and assess pollutant dispersion, community exposures, and risks to human health associated with California's upstream oil and gas development.

Recommendation 2.1. Require regular sampling and reporting of the composition of gas releases from upstream oil and gas development, hydrocarbon storage, and associated infrastructure including, but not limited to, the gas in the production string of wells; gas pre- and post-glycol dehydration, gases and vapors in condensate tanks; gas in gas-gathering lines and associated infrastructure; gas in gas-processing plants; and gas in idle, abandoned, and idle-deserted oil and gas wells. Reported gas composition data should include adequate characterization of the identities, concentrations, and amounts of toxic air contaminants at health-relevant units (e.g., the part per billion (ppb) level) and should be based on actual gas testing (e.g., EPA Method TO-15) instead of algorithms, estimates, or emissions factors. Because of the substantial variability of gas composition across geological layers, operators should be required to disclose production-string gas composition down to the oil and/or gas producing formations within individual oil and gas fields or the oil/gas geologic pool-level, whichever is smaller. Gas composition data from active infrastructure should be reported at regular intervals, preferably quarterly, and be made publicly available online in a digitally accessible format (e.g., .csv with metadata). Gas composition data from legacy infrastructure (e.g., abandoned wells) should also be reported at regular intervals, up to once a year. Pollutant dispersion and exposure information should also be collected to support an analysis of public health risk.

SUMMARY FINDING 3.

There are multiple and differing disclosure requirements across a range of California jurisdictions. While public disclosure requirements for chemicals used

in oil and gas development in California have increased, publicly available data on the identities and quantities of chemicals used in various oil and gas development activities remain incomplete. These activities include routine well maintenance and clean-outs, drilling, and well stimulation. Many of the chemicals known to be used in oil and gas development activities are associated with human health risks, while numerous other reported chemicals have unknown or poorly understood toxicity.

Finding 3.1. Chemical use in upstream oil and gas development is widespread and not restricted to hydraulic fracturing and well stimulation. As discussed in the California Council on Science and Technology (CCST) Senate Bill 1281 Report,[10] 630 unique chemical additives were used in upstream oil and gas operations in California from 2011 to 2018 with an additional 489 chemicals that lacked Chemical Abstract Service Registry Numbers (CASRN) and could not be definitively identified. Many disclosed chemicals lack basic toxicological and physicochemical-properties information *(Chapter 2, Section 2.2.4)*.

Finding 3.2. An analysis of four existing chemical disclosure datasets representing various well activities and geographic regions in California revealed overlap of chemicals. For 630 chemicals with CASRN, 316 were reported in more than one dataset, with 178 chemicals reported in three or more datasets. The overlap in reported chemical use across well activities indicates that the use of chemicals is widespread in California oil and gas development and is not limited to a particular region, well activity, or recovery method (*Chapter 2, Section 2.2.4*).

Finding 3.3. Federal regulations and regulations in other states have prohibited the use of specific chemical additives in hydraulic fracturing. Effective January 15, 2021, the Colorado Code of Regulations (*§ 404-1-437)* prohibits the use of 22 specific compounds in hydraulic fracturing fluids because these compounds posed the greatest risks to public health based on toxicity and their mobility and persistence in groundwater *(Chapter 2, Section 2.5.2)*.

Finding 3.4. Downhole physicochemical conditions, including high temperatures and pressures and the presence of petroleum hydrocarbons and other compounds, can alter biodegradation potentials, subsurface reactions, and degradation products. The formation of degradation products from chemicals used in upstream oil and gas development is poorly understood, but the subsurface reactions of some chemicals used

[10] California Council on Science and Technology. (2019). *An Assessment of Oil and Gas Water Cycle Reporting in California: Evaluation of Data Collected Pursuant to California Senate Bill 1281*. https://ccst.us/reports/oil-and-gas-water-cycle-reporting/.

in California oilfields are known to produce degradation products that are more toxic than their parent compounds *(Chapter 5, Section 5.3.3)*.

Finding 3.5. A total of 232 chemical additives (out of 630) reportedly used in California oilfields are volatile and pose potential risks to air quality and human health. Out of these 232 volatile compounds, 176 have slow to moderate atmospheric oxidation rates (half-lives >2 hours), indicating increased potential for longer-range atmospheric transport and subsequent inhalation exposure *(Chapter 4, Appendix D)*.

Conclusion 3.1. Available toxicological and physicochemical data suggest there are potential human health risks associated with chemical use in upstream oil and gas development. Data gaps regarding chemical mass or volumes used, toxicity, physicochemical properties, and environmental fate and transport prevent the characterization of hazards and risks for many disclosed chemical additives. Chemical additives without CASRN cannot be definitively identified or evaluated for potential human health hazards and impacts.

Conclusion 3.2. Existing data show that a variety of chemicals are used in upstream oil and gas development across regions, recovery methods, and well activities. Current regulations concerning chemical disclosure or the prohibition of chemical additives that apply only to specific recovery methods (i.e., hydraulic fracturing and well stimulation) overlook potential risks related to chemical use in drilling, routine maintenance, and other recovery methods and well activities.

Conclusion 3.3. Collection and public reporting of chemical usage, along with chemical properties and toxicity data, are required to properly assess and respond to potential chemical releases to air and water.

Recommendation 3.1. Require chemical disclosure and community notifications for chemical additives (including mixtures) added to fluids used for well drilling, treatment, rework, and maintenance operations in all upstream oil and gas operations, not just for well stimulation and activities where produced water is discharged to the surface. CASRN, mass, concentration, and volume data should be required for all chemical disclosures, including proprietary chemicals. Timing of chemical use should also be reported. These chemical disclosures should be made publicly available in a digital format. It is important to have consistent disclosure requirements across all oil and gas development in California.

Recommendation 3.2. Fully disclose and restrict the use of chemical additives in upstream oil and gas development with the greatest risks to public health based on toxicity

and their mobility and persistence in groundwater, and implement green-chemistry principles to replace these additives and poorly characterized chemicals with less-hazardous compounds. Colorado House Bill 1348, signed by Colorado Governor Polis in June 2022, provides a model for implementing disclosure requirements for any chemical that may be used in oil and gas production to enable the public and regulators to evaluate the environmental and public health impacts of these chemicals and to encourage less-toxic alternatives. This bill also includes explicit restrictions on the use of per- and polyfluoroalkyl substances (PFAS).

Recommendation 3.3. Comprehensive toxicological, environmental, and physico-chemical profiles should be developed for chemicals used in upstream oil and gas development that are missing key data needed to determine human health hazards and for risk assessment. Prioritization of chemicals for review should be based on usage frequency, mass used, and the potential for human and environmental exposure. Given the complexity of prioritizing chemicals with limited information, agencies should consider enlisting independent subject-matter experts to help conduct this task.

SUMMARY FINDING 4.

Upstream oil and gas development is associated with emissions of volatile organic compounds (VOCs). These VOCs include both greenhouse gases and toxic air contaminants, including methane and non-methane VOCs (NMVOCs). Exemptions for emission control and leak detection and repair (LDAR) requirements exist for heavy oil development facilities and for small producers across California. The justification for these exemptions is based in part on the assumption that methane emissions from these operations represent a small fraction of the total *methane* emissions from all upstream oil and gas development in California. While methane can be a reasonable indicator for NMVOCs when the source is methane-rich (e.g., natural gas processing plants, natural gas gathering infrastructure, etc.), methane is not a reliable indicator for NMVOCs when the source is not methane-rich (e.g., condensate tanks, heavy oil flashing, and produced water management and disposal). Methane cannot be used as the sole indicator for NMVOC emissions from sources that do not emit methane (e.g., diesel engines and other combustion sources) or emissions of criteria of air pollutants such as particulate matter and nitrogen oxides.

Finding 4.1. Methane and NMVOCs are emitted during upstream oil and gas development. Many of the NMVOCs emitted are toxic air contaminants or ground-level ozone precursors. Because both methane and some NMVOCs have a common source, certain infrastructure components, such as wellheads, gas pipelines, and gas processing

plants, have emission profiles with high methane/non-methane hydrocarbon (NMHC) ratios. However, other components, such as condensate tanks and produced water ponds, have emission profiles with far lower methane/non-methane hydrocarbon ratios, and methane is not a reliable indicator of NMVOCs that are not hydrocarbons. While diesel engines used for transport, pumps and other purposes do not emit methane and have a zero methane:NMHC ratio, they do emit criteria air pollutants (CAPs), toxic air contaminants, and other air pollutants *(Chapter 4, Sections 4.2.1 and 4.4.1)*.

Finding 4.2. Studies conducted on oil and gas development outside of California identified several NMVOCs, including toxic air contaminants such as n-hexane, benzene, ethylbenzene, toluene, and xylenes, as methane co-pollutants. Significant correlations were also found among emissions of benzene and toluene, benzene and m- & p-xylene, and toluene and m- & p-xylene. Many of the NMVOCs identified as methane co-pollutants in other oil- and gas-producing states have been detected in emissions from, and atmospheric concentrations near, upstream oil and gas development in California (e.g., benzene, toluene, ethylbenzene, xylenes, and alkanes) *(Chapter 4, Sections 4.2.1; 4.4.1; and 4.5)*.

Finding 4.3. In California, regulatory exemptions from vapor recovery, LDAR, and equipment change-out requirements have been established based on methane and NMVOC emissions from specific upstream oil and gas sources. These exemptions include, but are not limited to (1) a statewide zero-bleed/zero-emission standards exemption for existing low bleed (<6 standard cubic feet per hour) natural-gas driven pneumatic devices installed prior to January 1, 2016, (2) an exemption from the statewide 95% vapor recovery requirement for low-throughput separators and condensate tank systems, and (3) an exemption from the statewide LDAR requirement for upstream oil and gas infrastructure components associated with heavy oil (API gravity <20) *(Chapter 4, Section 4.4)*.

Finding 4.4. The closure of the exemptions from statewide zero-bleed/zero-emission standards for existing low-bleed pneumatic devices and vapor recovery requirements for low-throughput separators and condensate tank systems listed in Finding 4.3 would reduce NMVOC emissions by an estimated 15 tons per year (tpy) from 50 existing natural gas powered pneumatic devices and 208 tpy from ~2,200 small throughput separator and tank systems. Additionally, the California Air Resources Board states that heavy oil components (API gravity <20) exempt from LDAR account for less than 1% of hydrocarbon emissions from leaking components *(Chapter 4, Section 4.4)*.

Conclusion 4.1. While exemptions discussed in Findings 4.3 and 4.4 represent a small fraction of NMVOC emissions from the statewide upstream oil and gas development sector, these emissions may be meaningful risk of NMVOC exposure in areas with

concentrated exempt infrastructure or when this infrastructure exists in close proximity to human populations.

Conclusion 4.2. LDAR focused on monitoring for methane is useful when monitoring equipment with emissions that have high methane/non-methane hydrocarbon ratios. In this context, methane can be a reasonable indicator of the presence of TACs and other NMVOCs that are intermixed with methane. However, when monitoring emissions from infrastructure or processes containing gases with low methane/non-methane ratios (e.g., condensate tanks, produced water management and disposal, etc.) or little to no methane content (e.g., combustion from diesel engines, combustion emission from natural gas-powered equipment, etc.), methane is not a reliable indicator of TAC and other NMVOC emissions and there is likely no surrogate for these situations. LDAR approaches that focus on measurement of large suites of air pollutant species may be more comprehensive and appropriate for various applications when gas composition is uncertain.

Recommendation 4.1. Enforced vapor recovery and LDAR regulations provide tools to enhance detection and reductions of emissions of methane and NMVOCs, including toxic air contaminants and ozone precursors to the atmosphere. Deploy measures to reduce emissions of toxic air contaminants, and ozone precursors associated with new and existing upstream oil and gas development. These measures include, but are not limited to, the following LDAR and emission control measures:

- Require zero-bleed/zero-emission all pneumatic devices across upstream oil and gas development operations regardless of when they were installed. The Colorado Department of Public Health and the Environment's Air Quality Control Commission's updated *Regulation Number 7: Control of Ozone via Ozone Precursors and Control of Hydrocarbons via Oil and Gas Emissions (Emissions of Volatile Organic Compounds and Nitrogen Oxides)* includes requirements for the use of zero-bleed and zero-emission pneumatic control devices at oil and gas well sites, both for new and modified sources as well as for existing sources, retroactively. This Colorado rule provides precedent and guidance for updated rules in California.
- Remove the "small producer" exemptions for separators and condensate tank systems and require them to comply with the 95% vapor control standard, both at the local and regional district levels and within California's Oil and Gas Methane Regulation.
- Remove the heavy oil exemption (crude oil with API gravity <20) from California's Oil and Gas Methane Regulation Leak Detection & Repair (LDAR) requirements.

Recommendation 4.2. Require air quality monitoring and leak detection and response plans that monitor for air pollutants that are relevant and appropriate for the infrastructure being monitored. Methane may be a useful surrogate for TACs and other pollutants of

concern (e.g., toxic air contaminants, ozone precursors) from infrastructure that contains gases with high methane/non-methane hydrocarbon ratios, but is not appropriate as a surrogate when monitoring infrastructure containing gases with lower methane:non-methane hydrocarbon ratios.

SUMMARY FINDING 5.

Produced water contains compounds that are known to be hazardous to human health. Produced water handling and disposal in California has been documented to impact groundwater that is currently or could in the future be used for domestic consumption or agricultural irrigation in California.

Finding 5.1. Organic compounds, such as benzene, as well as salts from unlined produced water ponds have migrated into the subsurface and impacted the quality of regional aquifers in California at distances beyond 2.5 miles (4 km or 13,200 ft). These regional aquifers provide beneficial uses to municipalities and agriculture in California *(Chapter 5, Section 5.5).*

Finding 5.2. Discharge of produced water to the surface (surface spills and discharge to unlined produced water ponds, in particular) pose greater potential for human exposure to chemicals in produced water than subsurface recycling and disposal of produced water via Class II injection wells with proper zonal isolation *(Chapter 5, Section 5.5–5.8)*.

Finding 5.3. While at a smaller scale in recent years, disposal of produced water containing high concentrations of total dissolved solids, heavy metals and volatile organic compounds into unlined produced water ponds continues throughout the southern portion of the San Joaquin Valley. These disposal practices have documented subsurface pathways to groundwater resources that are used for drinking water and agricultural supply. Groundwater monitoring at and near unlined produced-water-pond facilities is relatively sparse, but where monitoring has been undertaken, impact to groundwater has been observed *(Chapter 5, Section 5.5)*.

Finding 5.4. Past and present locations of intentional discharges of produced water to surface water (onshore) cannot be traced in the CalGEM or California Integrated Water Quality System (CIWQS) databases. As a result, locations of potential impact to surface water and sediment are unknown *(Chapter 5, Section 5.6)*.

Finding 5.5. There is no publicly accessible database that contains up-to-date reporting of the volumes of crude oil and produced water spills in California. Additionally, the California Office of Emergency Services (CalOES) database often contains non-specific location data, and operators often report spills as mixtures of produced water and crude

oil and sometimes report *de minimis* spills in non-specific measurements (e.g., teaspoons, drops) *(Chapter 5, Section 5.7)*.

Conclusion 5.1. An understanding of produced water composition is essential to assess and manage its potential for human health hazards, risks, and impacts. The lack of publicly available data on the composition of produced water across geographic and geological space and by operator hinders the ability of researchers and risk managers to conduct health-protective produced-water management and to responsibly identify opportunities for reuse of produced water outside of the oilfield.

Conclusion 5.2. Disposal of produced water in unlined produced-water ponds poses risks to California groundwater resources that currently or in the future could be used for public and agricultural water supplies. Groundwater monitoring at and near unlined produced-water-pond facilities is relatively sparse, but where monitoring has been undertaken, impact to groundwater has been observed and documented in California.

Conclusion 5.3. Past and present locations of produced water discharge to surface water must be known in order to determine the types and concentrations of contaminants in surface water and sediment attributable to produced water disposal.

Conclusion 5.4. The ability to reliably characterize and analyze statewide volumes of spilled crude oil and produced water is hindered by the lack of a centralized, analysis-ready database.

Recommendation 5.1. Disposal of produced water in unlined produced-water ponds should be prohibited. Monitoring of subsurface plumes of produced water from existing pond facilities should continue and be expanded in a systematic fashion that prioritizes facilities at most risk of contaminating aquifers that meet the definition of an underground source of drinking water (USDW) or currently or in the future could be used for domestic consumption or agricultural irrigation.

Recommendation 5.2. Comprehensive chemical analyses including targeted and non-targeted bioanalytical tests should be conducted to evaluate the chemical composition, toxicity, carcinogenicity, and other chemical hazards of produced water discharged to the surface or injected into Class II wells where out-of-zone migration is shown to occur. Requirements for these analyses should be consistent statewide and recorded in a publicly available digital database.

Recommendation 5.3. Ensure that the definition of protected groundwater during disposal of produced water into produced-water ponds is consistent with the definition of an Underground Source of Drinking Water utilized in California's Underground Injection Control (UIC) program pursuant to the Safe Drinking Water Act, and for hydraulic

fracturing pursuant to Senate Bill 4 (2013). Currently this is <10,000 milligrams per liter (mg/L) total dissolved solids (TDS).

Recommendation 5.4. Establish a comprehensive database of past and present locations of produced-water disposal to surface water and associated annual and cumulative volumes of this disposal.

Recommendation 5.5. Ensure that the California Office of Emergency Services database of spill volume estimates is updated with actual spill volumes (e.g., these values are referred to as "corrected" spill volumes by California Office of Emergency Services) in a timely manner. A centralized, accessible, database of produced water spills should be maintained by the California Office of Emergency Services. Operators should be required to submit separate volumes of spill substances (i.e., distinct volumes of produced water, and crude oil), in standardized measurement units (e.g., barrels or gallons) and include accurate reporting of the latitude and longitude of the spill.

SUMMARY FINDING 6.

Idle, idle-deserted, and abandoned oil and gas wells and other legacy upstream oil and gas infrastructure pose potential near and long-term health risks that are poorly characterized due to limited data and reporting.

More data for these legacy systems can inform and prioritize well plugging and other remediation efforts. A framework for the prioritization of remediation depends on access to key metrics such as surrounding population density, demographics, groundwater resources, propensity or magnitude of leakage, etc.

Finding 6.1. Human health hazards and potential risks from legacy upstream oil and gas infrastructure and pipelines include the release of oil, gas, produced water, radioactive scale (which is considered technologically enhanced naturally-occurring radioactive material, or TENORM), and legacy pipeline treatment chemicals (e.g., polychlorinated biphenyls [PCBs]). Corrosion and weathering of pipeline bodies, welds, and pipeline coatings release heavy metals and hazardous materials such as asbestos *(Chapter 6, Section 6.6)*.

Finding 6.2. Current regulations for the handling and management of oil- and gas-related NORM/TENORM in California are lacking. In recent years, improperly abandoned legacy pipelines in California have resulted in events that released crude oil and oil-water mixtures to the surface, potentially exposing nearby communities to hazards *(Chapter 6, Section 6.6)*.

Finding 6.3. Idle, abandoned, removed, idle-deserted, and deserted pipelines are not required to be reported by operators in pipeline management plans submitted to CalGEM. Information on abandoned legacy infrastructure will depend on requirements from other regulatory agencies or datasets *(Chapter 6, Section 6.6).*

Finding 6.4. CalGEM reports approximately 126,000 plugged and abandoned oil and gas wells in California. However, recent assessments found that the number of abandoned wells is under-reported by 17% or more. There are an estimated 2,500 to 5,000 idle-deserted wells in the state *(Chapter 6, Section 6.6)*.

Finding 6.5. The majority of studies of emissions from idle and abandoned wells in California focus on methane. Studies that have measured non-methane volatile organic compounds or emissions from idle or abandoned wells in California are limited in scope and geographic coverage *(Chapter 6, Section 6.5.1)*.

Finding 6.6. Previous studies of methane emissions from abandoned and idle wells in California have found that most emissions come from a small number of wells that are "super-emitters." Despite this evidence, there are no long-term monitoring requirements of fugitive emissions from abandoned, idle, and idle-deserted wells *(Chapter 6, Section 6.6)*.

Conclusion 6.1. Abandoned legacy infrastructure and pipelines pose hazards and potential risks to the public and these are inadequately documented, assessed, and regulated.

Conclusion 6.2. The assessment of health hazards and risks associated with idle, idle-deserted, and abandoned wells and associated legacy infrastructure (e.g., pipelines) requires accurate information about the number, location, and type of each well, in addition to the composition of gas and liquids emitted and leaking from this infrastructure.

Conclusion 6.3. Mass, rate, and chemical composition of methane and non-methane volatile organic compound emissions from idle and abandoned wells and ancillary infrastructure in California are not well-characterized. Currently available emissions data is inadequate to reliably assess the hazards, risks, and potential impacts of abandoned and idle wells on air and water quality and human health. Loss of abandoned well integrity that results in emissions to the atmosphere or contamination of water resources may go undetected for extended periods of time due to the lack of environmental monitoring.

Recommendation 6.1. Agencies with jurisdiction, including CalGEM, should continue to develop a thorough inventory to compile and maintain records of abandoned legacy infrastructure. Specific locations of all wells, flowlines, gathering lines, pipelines, tanks, and other infrastructure abandoned in-place should be recorded and maintained in a digital database. A process for public access to this database that complies with current

security and regulatory requirements should be established. A risk-based decision-making framework should also be developed for in-place pipeline abandonment that accounts for nearby human populations, groundwater resources, future land use, and potential hazards such as PCBs, TENORM, asbestos, and measures of structural integrity of wells, pipelines, and other infrastructure. Science-informed TENORM and PCB thresholds that trigger cleanup requirements should be adopted. Operators that own abandoned pipelines and infrastructure should be required to verify proper abandonment procedures.

Recommendation 6.2. Examine historical records and develop a thorough inventory of abandoned wells in the State, including legacy wells abandoned before current plugging and remediation requirements. Efforts to identify and prioritize idle-deserted wells for plugging and abandonment should be expanded. Sites with idle-deserted or abandoned infrastructure that is sited in areas slated for redevelopment should undergo relevant environmental testing, including studies to assess methane and non-methane volatile organic compound flux, and potential soil and groundwater contamination.

Recommendation 6.3. Additional studies should be conducted to assess the composition of gas contained in and emitted from abandoned, idle, and idle-deserted wells. These studies will equip researchers and risk managers with the data required to evaluate health hazards, risks, and impacts of emissions from this infrastructure in California (e.g., health-relevant concentrations at the part-per-billion (ppb) level using EPA Method TO-15). Samples should be collected directly from production string, bradenhead, or other wellhead features. Random sampling should be undertaken to better characterize the distribution and variability of toxic air contaminants in gas from legacy wells across geographic and geological space. These data should be compiled in a database that also contains other well characteristics such as spud date, date of abandonment or abandonment status, and well depth. Investigations should be undertaken to locate and mitigate potential super-emitters to the atmosphere or wells where lack of zonal isolation is more likely to lead to migration of gas and fluids in the subsurface.

CHAPTER ONE

Introduction

Table of Contents

1.0 California Oil & Gas Public Health Rulemaking Process **1**

1.1 Purpose and scope this report **2**

Box 1. Underground gas storage in California **4**

Box 2. Occupational health dimensions of upstream oil and gas development in California **5**

1.2 Report overview **6**

References **6**

Appendix A **8**

California Oil & Gas Public Health Rulemaking Scientific Advisory Panel **8**

October 1, 2021 Panel Responses to CalGEM Questions **8**

Figures

Figure 1.1. Oil and natural gas systems. Source: Adapted from U.S. Environmental Protection Agency and American Gas Association (US EPA, 2016) 3

1.0 California Oil & Gas Public Health Rulemaking Process

On October 12, 2019, Governor Gavin Newsom signed into law Assembly Bill 1057 (AB 1057), which renamed the oil and gas regulatory body from the Division of Oil, Gas, and Geothermal Resources (DOGGR) to the California Geologic Energy Management Division (CalGEM) and specified that "provisions relating to oil and gas conservation include protecting public health and safety and environmental quality" (Limón, 2019).

To fulfill the health and safety requirements of AB 1057, CalGEM is undertaking a formal rulemaking that will update protections for communities near oil and gas production operations. CalGEM has also convened the California Oil & Gas Public Health Rulemaking Scientific Advisory Panel (or "Panel"), which consists of public health experts, to provide Division staff with relevant scientific information and recommendations (CA DOC, 2019). CalGEM retained Rachel Morello-Frosch, PhD, MPH, of UC Berkeley, as the principal investigator (PI) of the Panel, along with Seth B.C. Shonkoff, PhD, MPH, of PSE Healthy Energy, UC Berkeley, and the Lawrence Berkeley National Laboratory, as the co-PI. In consultation with CalGEM, the PIs identified and enlisted recognized public health experts from across the United States to participate in the California public health oil and gas rulemaking.

The Advisory Panel is composed of 15 members (including the two PIs) with expertise in:

- public health,
- environmental health science,
- exposure assessment,
- epidemiology,
- toxicology,
- engineering,
- preventative medicine,
- pediatric medicine,
- air and water pollution,
- source, fate, and transport,
- spatial data analysis,
- human health hazard and risk assessment, and
- occupational and environmental medicine.

Panel member biographies are included in Appendix A. The tasks of the Advisory Panel generally include:

- Providing relevant scientific information and data from the peer-reviewed literature to guide and support CalGEM's rulemaking decisions, and
- Providing expert analysis, opinions, and recommendations related to a wide variety of public health questions that arise during preparation of the rulemaking documentation.

The Panel has prepared this report to accomplish the above stated tasks, and to delineate its findings, conclusions, and recommendations. More specifically, to prepare this report the Panel:

- Synthesized existing scientific research recommendations and science-based policy recommendations regarding public health and upstream oil and gas development (OGD);

- Reviewed additional peer-reviewed scientific literature and government reports on the public health dimensions of OGD in California and other oil and gas regions in North America; and
- Compiled science-based findings, conclusions, and recommendations regarding public health hazards, risks, and impacts of upstream OGD.

1.1 Purpose and scope this report

In this report, the Scientific Advisory Panel evaluates the human health hazards, risks and impacts associated with *upstream*, *onshore* OGD in California (**Figure 1.1**). The Panel used three key questions to guide their research efforts:

1. What are the hazards, exposures, and human health risks and impacts associated with oil and gas development in the State of California?
2. What are the exposure pathways through which OGD hazards pose risks and impacts to human health and safety?
3. How far do these identified human health and safety risks and impacts extend from oil and gas development processes, and how can these risks and impacts be further mitigated?

The scope of this report covers the life cycle of upstream OGD activities, including field and near-field infrastructure and activities associated with well pad development, well stimulation and completion, well maintenance, well plugging, oil and gas production, underground gas storage, produced water and recovered fluids, and legacy infrastructure and abandonment (**Box 1**).

The report does not cover the midstream and downstream life cycles of oil and gas and thus excludes the manufacturing of materials or equipment used in OGD, transport of produced oil and gas to refineries or utilities, and refining or end-use combustion of hydrocarbons as fuel or chemical feedstock. While upstream OGD releases greenhouse gases that contribute to climate change, this report does not focus on climate change-related public health impacts. Additionally, this report does not focus on occupational health dimensions of upstream OGD, although this topic is discussed briefly in **Box 2**.

The Panel compiled published scientific literature and data available through June 8, 2022, that focused on upstream OGD in the United States and Canada. However, numerous epidemiological studies focused on upstream oil and gas development were published throughout the development of this report. As such, "Chapter 3 — Peer-reviewed Epidemiological Literature Assessing Upstream Oil and Gas Development" was updated to include studies published through July 15, 2023. Additionally, "Chapter 4 — Oil and Gas-Associated Air Pollution, Health Risks and Approaches to Emission Control" briefly mentions CalGEM's 2024 Request for Information regarding "technologies and processes that can be used to effectively ensure leaks associated with oil and gas operations are being detected" (CalGEM, 2024).

Sources considered in this report included peer-reviewed studies, government reports, and white papers authored or commissioned by academic and research institutions, government agencies, or expert panels.

The Panel reached consensus regarding all findings, conclusions, and recommendations in this report. Consensus means that all panel members reviewed the findings, conclusions, and recommendations and affirmatively agreed that the scientific evidence supports them. Panel members had the opportunity to prepare a dissenting assessment, but no one did so. This report reflects the perspective of the Panel members and not necessarily those of their employers or the institutions with which they are affiliated.

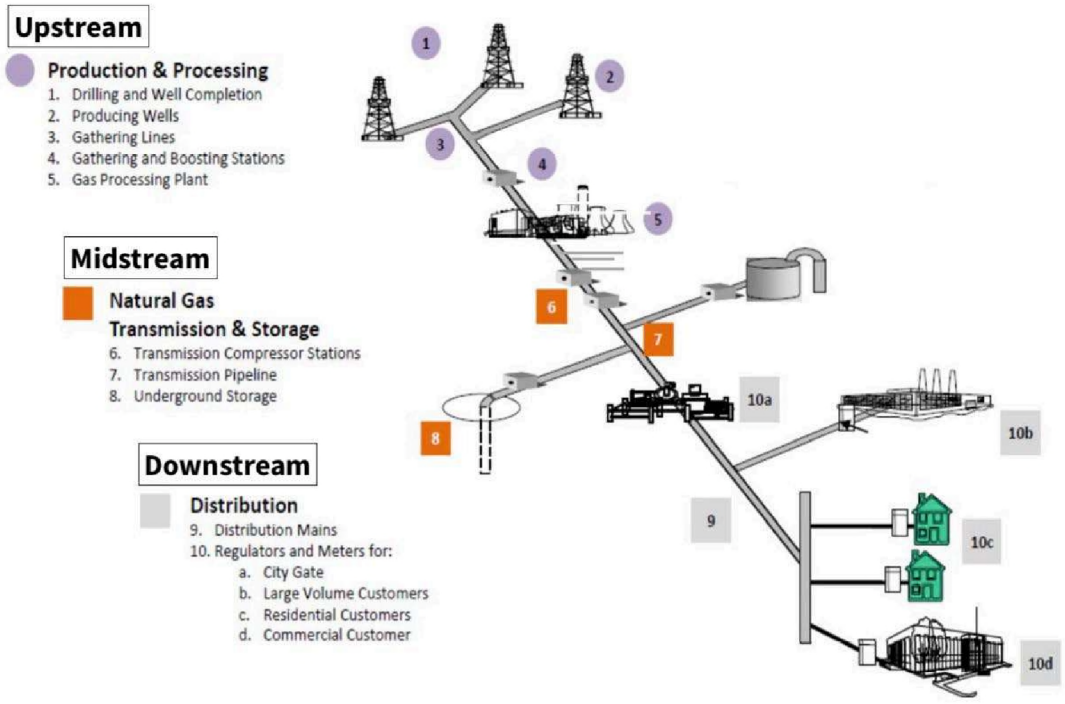


Figure 1.1. Oil and natural gas systems. Source: Adapted from U.S. Environmental Protection Agency and American Gas Association (US EPA, 2016).

Box 1. Underground gas storage in California

There are currently 12 active underground gas storage (UGS) facilities in California (Long et al., 2018). At UGS facilities, natural gas is injected downhole into subsurface reservoirs, stored, and withdrawn for later use. Additionally, wells located at some of these UGS facilities also produce oil.

Given that many UGS facilities have active oil and/or gas wells, and because of some overlap in the emissions and health hazards between UGS and upstream oil and gas development wells, some activities at UGS facilities fall within the scope of this report. However, storage of natural gas that has already been extracted and transferred by pipeline to the storage site is outside of our scope.

In this report, we summarize existing public health findings, conclusions, and recommendations from previous assessments on UGS (Shonkoff et al., 2017) and highlight ongoing efforts to address public health dimensions of UGS in California (e.g., the Aliso Canyon Disaster Health Study) (LACDPH, 2021). Our approach to UGS sites with active oil/gas wells is to focus on defining setback boundaries based on the location and properties of the on-site OGD wells. Although we do not make recommendations specific to UGS facilities, we highlight where UGS facilities are similar to upstream OGD (i.e., with regards to geologic features), and also where UGS operations are different from upstream OGD in the scope of any rulemaking.

Box 2. Occupational health dimensions of upstream oil and gas development in California

The oil and gas industry relies on a workforce of employees and contractors to support upstream OGD operations. Because workers may come into close contact with many chemical and physical hazards associated with OGD, worker health is an important consideration for these operations. Few studies have examined the occupational health dimensions of OGD operations in California.

The *Independent Scientific Assessment on Well Stimulation in California* briefly examined occupational health dimensions associated with OGD in California (Long et al., 2015). These occupational hazards may be associated with well stimulation, such as exposure to respirable crystalline silica (i.e., fine crystalline silica dust or particles) and chemical additives used in hydraulic fracturing, or hydrochloric and hydrofluoric acid used in acid fracturing and matrix acidizing. Occupational health hazards are also associated with general oil and gas industry operations, including but not limited to exposure to toxic air pollutants (Shonkoff et al., 2015). In certain cases, oxygen deficiency and inhalation of hydrocarbon gases and vapors (e.g., hydrogen sulfide) have resulted in sudden death among oil and gas workers in the United States (Harrison et al., 2016).

The *Independent Scientific Assessment on Well Stimulation in California* included the following conclusions and recommendations regarding occupational health hazards and OGD:

> *"Conclusion 6.4. Hydraulic fracturing and acid stimulation operations add some occupational hazards to an already hazardous industry. Studies done outside of California found workers in hydraulic fracturing operations were exposed to respirable silica and VOCs, especially benzene, above recommended occupational levels. The oil and gas industry commonly uses acid along with other toxic substances for both routine maintenance and well stimulation. Well-established procedures exist for safe handling of dangerous acids.*
>
> *….*
>
> *Recommendation 6.4. Assess occupational health hazards from proppant use and emission of volatile organic compounds. Conduct California-based studies focused on silica and volatile organic compounds exposures to workers engaged in hydraulic-fracturing-enabled oil and gas development processes based on NIOSH occupational health findings and protocols."*

Since the publication of Long et al. (2015), at least one health risk assessment has evaluated air pollutant concentrations near oil and gas sites during well stimulation activities. This assessment reported that measured air pollutant concentrations during well stimulation activities did not exceed occupational-based health standards (Shonkoff & Hill, 2020). Of note, this assessment did not evaluate silica exposures.

1.2 Report overview

This report is organized into key topic areas relevant to assessing human health hazards, exposures, risks and impacts associated with upstream, onshore OGD. Each report chapter is briefly described below.

- **Executive Summary — Findings, Conclusions, and Recommendations:** A synthesis of key findings, conclusions, and recommendations based on the report chapters.
- **Chapter 1 — Introduction:** Describing the scope of this report and the approach of the Advisory Panel.
- **Chapter 2 — Stressors Associated with Upstream Oil and Gas Development:** An overview of chemical and physical stressors associated with OGD, with a particular focus on California.
- **Chapter 3 — Peer-Reviewed Epidemiological Literature Assessing Upstream Oil and Gas Development:** A review of the epidemiological studies relevant to assessing the association between upstream OGD and adverse health effects.
- **Chapter 4 — Oil and Gas-Associated Air Pollution, Health Risks and Approaches to Emission Control:** A review of air pollution associated with upstream oil and gas sources; air quality health risk assessments; and best available emission control strategies.
- **Chapter 5 — Produced Water Management and Health:** A review of produced water management approaches employed in California and their relevance to public health.
- **Chapter 6 — Legacy Oil and Gas Infrastructure:** A review of abandoned, idle, and orphaned wells in California, including existing research and identified research gaps on methane and air pollutant emissions.
- **Chapter 7 — California Proximity Analysis:** A proximity analysis is used to characterize populations and sensitive receptor sites located near existing OGD in California.

References

CA DOC (California Department of Conservation). (2019, November 19). *California Announces New Oil and Gas Initiatives*. https://www.conservation.ca.gov/index/Pages/News/California-Establishes-Moratorium-on-High-Pressure-Extraction.aspx

CalGEM (California Geologic Energy Management Division). (2024). Geologic Energy Management Laws and Rulemaking - Public Comment Period Opens for Leak Detection at Oil and Gas Operations. https://www.conservation.ca.gov/calgem/laws-regulations.

California State Legislature. (2019). Assembly Bill 1057. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200AB1057

Harrison, R. J., Retzer, K., Kosnett, M. J., Hodgson, M., Jordan, T., Ridl, S., & Kiefer, M. (2016). Sudden Deaths Among Oil and Gas Extraction Workers Resulting from Oxygen Deficiency and Inhalation of Hydrocarbon Gases and Vapors—United States, January 2010–March 2015. *MMWR. Morbidity and Mortality Weekly Report*, *65*(1), 6–9. https://doi.org/10.15585/mmwr.mm6501a2

LACDPH (Los Angeles County Department of Public Health). (2021). *Aliso Canyon Disaster Health Research Study*. http://publichealth.lacounty.gov/eh/healthresearch/

Limón, M. (2019). *Bill Text—AB-1057 Oil and gas: Geologic Energy Management Division: Wells and facilities: Disposition and acquisition notices: Indemnity bonds and remediation: Additional security: Civil penalty.* https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200AB1057

Long, J. C. S., Birkholzer, J. T., & Feinstein, L. C. (2015). *An Independent Scientific Assessment of Well Stimulation in California: Executive Summary—An Examination of Hydraulic Fracturing and Acid Stimulations in the Oil and Gas Industry Volume I*. https://ccst.us/reports/an-independent-scientific-assessment-of-well-stimulation-in-california-volume-1/

Long, J. C. S., Birkholzer, J. T., Mace, A. J., Brady, S. E., Arthur, J. D., Duren, R. M., Edson, K., Jackson, R. B., Jerrett, M. L. B., Meshkati, N., Perfect, S. A., Thorn, T., Traina, S. J., Wara, M. W., Elder, C. M., Greenblatt, J. B., & Oldenburg, C. M. (2018). *Long-Term Viability of Underground Natural Gas Storage in California: An Independent Review of Scientific and Technical Information*. California Council on Science and Technology. https://ccst.us/wp-content/uploads/Full-Technical-Report-v2_max.pdf

Shonkoff, S. B. C., Maddalena, R. L., Hays, J., Stringfellow, W. T., Wettstein, Z. S., Harrison, R., Sandelin, W., & McKone, T. E. (2015). Chapter 6: Potential Impacts of Well Stimulation on Human Health in California. In *An Independent Scientific Assessment of Well Stimulation in California, Volume II: Generic and Potential Environmental Impacts of Well Stimulation Treatments*. California Council on Science and Technology. https://ccst.us/wp-content/uploads/160708-sb4-vol-II-6-1.pdf

Shonkoff, S. B. C., Hill, L. L., Czolowski, E. D., Prasad, K., Hammond, S. K., & McKone, T. E. (2017). Chapter 1, Section 1.4: Human health hazards, risks and impacts associated with underground natural gas storage in California. In *Long-Term Viability of Underground Natural Gas Storage in California: An Independent Review of Scientific and Technical Information.* California Council on Science and Technology. https://ccst.us/wp-content/uploads/Chapter-1-v2-Section-1-4.pdf

Shonkoff, S. B. C., & Hill, L. L. (2020). *Analysis of Air Monitoring Data Collected During Oil Field Well Stimulation Treatments in California: Implications for Human Health.* Prepared for the California Air Resources Board and the California Environmental Protection Agency

(Agreement Number 18ISD029). https://ww2.arb.ca.gov/sites/default/files/2021-05/PSE_Final_Report.pdf

US EPA (U.S. Environmental Protection Agency). (2016). Control Techniques Guidelines for the Oil and Natural Gas Industry. *EPA-453/B-16-001*. https://www.epa.gov/sites/production/files/2016-10/documents/2016-ctg-oil-and-gas.pdf

Appendix A.

California Oil & Gas Public Health Rulemaking Scientific Advisory Panel

https://www.conservation.ca.gov/calgem/Documents/public-health/Biographies%20(Draft%201).pdf

October 1, 2021 Panel Responses to CalGEM Questions

https://www.conservation.ca.gov/calgem/Documents/public-health/Public%20Health%20Panel%20Responses_FINAL%20ADA.pdf

CHAPTER TWO

Stressors Associated with Upstream Oil and Gas Development

Table of Contents

2.0 Abstract **1**

2.1 Introduction **1**

2.2 Chemical stressors **2**

2.2.1 Petroleum hydrocarbons and metals **2**

2.2.2 Products of combustion **3**

2.2.3 Odorous compounds **3**

2.2.3.1 Hydrogen sulfide (H_2S) **4**

2.2.3.2 Mercaptans and other odorants **4**

2.2.3.3 Complaints of odors near oil and gas sites **5**

2.2.4 Chemical additive usage in upstream oil and gas development **6**

2.2.4.1 Physicochemical and toxicological properties of disclosed chemicals **7**

2.2.4.2 Comparison of chemical use between datasets **11**

2.2.4.3 Chemical additive transformation **12**

2.3 Physical stressors **13**

2.3.1 Noise **13**

2.3.1.1 Noise exposure and human health **13**

2.3.1.2 Noise levels observed near oil and gas sites **14**

2.3.2 Light **17**

2.3.3 Radioactive materials **18**

2.3.4 Induced seismicity **19**

2.3.5 Explosions, fires **19**

2.4 Conceptual overview of stressor attenuation by distance **20**

2.5 Discussion **22**

2.5.1 Comparison of stressors from unconventional and conventional oil and gas development **22**

2.5.2 Current chemical use policies 23
2.6 Summary **24**
References **25**
Appendix B **42**
B.1. Chemical additives used in oil and gas development **42**
Description of chemical additive disclosure databases for upstream oil and gas development **42**
Key studies of chemical disclosure datasets **43**
B.2. Equations relevant to attenuation of stressors **47**
Air emissions **47**
Surface water releases **48**
Subsurface releases (groundwater) **49**
Attenuation of sound and noise **51**
Attenuation of vibrations **53**

Figures

Figure 2.1. Venn diagram showing overlap in the number of chemicals with a CASRN used in SCAQMD, AB 1328, CalGEM, and FracFocus datasets. Source: Adapted from Shonkoff et al. (2021) 12
Figure 2.2. Overview illustration of the transport and attenuation of stressors off-site from oil and gas operations. 21
Figure 2.3. A hypothetical illustration of potential attenuation by offsite distance for a range of stressors. The relative distance is the actual distance divided by a considered distance. Developed from material presented in the following sources: Turner (1970), Martin (1976), Domenico and Palaciauskas (1982), Domenico and Robbins (1985), Lamancusa (2000, 2002, 2009), Jirka and Weitbrecht (2005), van Leeuwen et al. (2007), Nicholls (2009), Truty et al. (2019). 22

Tables

Table 2.1. Corresponding Texas Commission on Environmental Quality (TCEQ) short-term and long-term effects screening levels for select mercaptans and other odorants. Source: TCEQ (2018) 5
Table 2.2. Upstream oil and gas development chemical usage datasets and associated timeframes used for analysis. Source: Adapted from Shonkoff et al. (2021). 8

Table 2.3. Number of chemicals disclosed in oil and gas datasets, classified by data availability or presence on international and national priority lists. Source: Shonkoff et al. (2021). 10

Table 2.4. Summary of audible noise measurements by distances from oil and gas well sites (dBA).[1] 16

Table 2.5. Summary of low vibrational noise measurements by distance from oil and gas well site (dBC).[1] 17

2.0 Abstract

Upstream oil and gas development (OGD) is responsible for the introduction of both chemical and physical stressors to nearby communities that can impact public health. Chemical stressors from OGD include petroleum hydrocarbons such as benzene, toluene, ethylbenzene, and xylene (BTEX), heavy metals, products of combustion such as criteria air pollutants, odorous compounds, and chemical additives. Physical stressors include noise, light, radioactive materials, induced seismicity, and explosions or fires. Communities may be exposed to varying combinations of multiple stressors.

Although the majority of OGD in California is considered conventional, California has placed policy, regulatory, and scientific emphasis on unconventional OGD, including hydraulic fracturing, matrix acidizing, and acid fracturing. However, most of the impacts associated with unconventional OGD are caused by exposure to stressors from oil and gas production enabled by unconventional extraction methods. Thus, many stressors are intrinsic to both conventional and unconventional OGD, including emissions of radioactive materials and hazardous air pollutants such as BTEX, the use of chemical additives, and noise pollution, odors, and landscape disruption.

The risks associated with chemical and physical stressors from upstream OGD are dependent on the distance between the source and the receptor, whether it be a human receptor or a receptor relevant to human exposure (e.g., a drinking water well). The risk associated with stressors from upstream OGD can be attenuated by increasing the distance between the source and the receptor.

2.1 Introduction

In this chapter, we characterize various stressors associated with upstream oil and gas development (OGD). A stressor is any chemical, physical, or biological entity that can modulate normal functioning or induce an adverse response (NRC, 2012; IPCS, 2004). Below, we discuss chemical and physical stressors[1] associated with upstream OGD and present information specific to upstream OGD in California when available. In this chapter, we also discuss how chemical and physical stressors associated with upstream OGD activities may be attenuated by distance from an upstream OGD source.

Chemical stressors are defined as substances with potential harmful properties (e.g., toxicity, flammability, carcinogenicity) that may be released into environmental media (e.g., air, water, soil) and may pose a risk to human health and/or the environment. These include chemicals that are found in petroleum reservoirs, emitted from upstream OGD activities, and additives used to facilitate well maintenance and oil and gas production. Further discussion of relevant

[1] Given that there is a limited literature on the biological hazards (e.g., hazards that stem from a biological source) associated with upstream OGD, biological hazards were not considered in this report.

environmental exposure pathways and potential health risks of chemical stressors associated with upstream OGD emitted to *air* and *water* are discussed in Chapters 4 and 5, respectively.

Physical stressors generally involve the propagation of energy and therefore include noise, light, radioactive materials, induced seismicity, explosions associated with upstream OGD.

2.2 Chemical stressors

Chemical stressors associated with upstream OGD include toxic compounds recognized as air pollutants and drinking water contaminants. These include petroleum hydrocarbons and metals, products of combustion, odorous compounds (reduced sulfur compounds), and chemical additives used during routine oil and gas activities and during well stimulation activities. Below, we discuss the health relevance of various types of chemical stressors associated with upstream OGD.

2.2.1 Petroleum hydrocarbons and metals

Petroleum reservoirs contain hundreds of petroleum hydrocarbons, which make up the largest fraction of petroleum. Petroleum hydrocarbons include hazardous compounds such as benzene, toluene, ethylbenzene, and xylene (BTEX), and various alkanes (e.g., n-hexane) with known or suspected toxic effects. For example, benzene is a known human carcinogen and hematological toxicant, and chronic exposures to ethylbenzene, toluene, and xylene, and n-hexane, have been associated with carcinogenicity, neurotoxicity, and/or reproductive toxicity (National Cancer Institute, 2019; OEHHA, 2019). BTEX compounds also have been associated with endocrine activity and can impact hormone production, mimic hormones, or inhibit hormone signaling (Bolden et al., 2018). Many petroleum hydrocarbons, such as BTEX and n-hexane, are volatile organic compounds (VOCs) and are recognized as toxic air contaminants (TACs) in the State of California (CARB, 2021a); Benzene, toluene, ethylbenzene, and n-hexane are also listed as carcinogens and/or reproductive toxicants by the State of California through Prop 65 (OEHHA, 2022). Additionally, a number of petroleum hydrocarbons that are volatile organic compounds (VOCs) are precursors that lead to the secondary formation of ground-level ozone, a federally recognized criteria air pollutant associated with adverse respiratory impacts (US EPA, 2015).

Oil and gas bearing formations can also contain high levels of naturally occurring trace metals that can be mobilized and brought to the surface during oil and gas production (CCST et al., 2015; Piper & Isaacs, 1995). Crude oil, natural gas, and produced water may all contain trace metals (Cachia et al., 2018; CCST et al., 2015; Lord, 1991), some of which are hazardous to human health. Cadmium, lead, arsenic, selenium, and nickel are trace metals commonly found in crude oil and are recognized as known human carcinogens and developmental and reproductive toxicants, or are associated with other toxic effects (Lord, 1991; Schreiber & Cozzarelli, 2021; USGS, 2019).

Many petroleum hydrocarbons and metals found in petroleum sources are also recognized as drinking water contaminants and have maximum contaminant levels established for drinking water to protect public health (e.g., benzene; SWRCB, 2020).

2.2.2 Products of combustion

Diesel-powered equipment or gas turbines used during drilling and well stimulation activities (e.g., hydraulic fracturing); flaring or the controlled burning of natural gas from flare stacks; and diesel trucks used to transport equipment and waste products can impair local air quality by emitting incomplete combustion byproducts (e.g., fine particulate matter ($PM_{2.5}$), black carbon, BTEX, nitrogen oxides, carbon monoxide, and formaldehyde) (Johnson et al., 2018; Chen et al., 2022). Exposure to diesel exhaust near oil and gas sites is a recognized respiratory health hazard and diesel-associated particulate matter is a known human carcinogen (CARB, 2021b; McCawley, 2013, 2015).

A recent study monitored particulate matter smaller than 2.5 microns ($PM_{2.5}$) and black carbon at residences located between 715 to 1,288 ft (218 to 393 m) from the sound wall of a large multiwell pad (Allshouse et al., 2019). Hydraulic fracturing activities had the highest median levels of $PM_{2.5}$ and black carbon compared to other well activity phases at these distances (Allshouse et al., 2019). A modeling study of emissions near well pads in Pennsylvania estimated that ambient air concentrations of $PM_{2.5}$ exceeded the U.S. EPA National Ambient Air Quality Standards beyond the state setback distance of 500 ft (152 m), with exceedances increasing as density of wells on a single pad increases (Banan & Gernand, 2018). The flaring of excess natural gas or associated gas during oil and gas production also results in a variety of products of combustion, including black carbon, $PM_{2.5}$, polycyclic aromatic hydrocarbons, and other non-methane hydrocarbons (Schade & Roest, 2018; Weyant et al., 2016).

Additionally, particulate matter and ground-level ozone are criteria air pollutants that arise as secondary air pollutants when oil and gas-associated air pollutants interact with other reactive compounds in the atmosphere and with combustion products from equipment and trucks. For example, VOCs and nitrogen oxides released into the atmosphere can react in the presence of sunlight to form ground-level ozone (CARB, 2020). It is estimated that in 2025, the total number of premature deaths in California attributable to oil and gas sector particulate matter and ozone precursor emissions will be 72 (57–130, 95% confidence interval) (Fann et al. 2018).

2.2.3 Odorous compounds

Odorous compounds associated with upstream oil and gas activities include sulfur-based compounds that occur naturally in petroleum reservoirs, such as hydrogen sulfide (H_2S) and various mercaptans. Odorous compounds can adversely impact the physical and mental health of those experiencing odors, as well as interfere with daily activities and social well-being. Broadly, epidemiological studies have associated malodors with acute physical symptoms such as headaches, nausea, eye and throat irritation, respiratory symptoms including wheeze, and psychosocial stress (Avery et al., 2004; Heaney et al., 2011; Horton et al., 2009; Schiffman et al., 1995; Schiffman et al., 2005). Additionally, some odorous compounds, such as H_2S, are acutely toxic.

2.2.3.1 Hydrogen sulfide (H_2S)

Hydrogen sulfide (H_2S) is an odorous gas with a low odor threshold, which means it can be perceived by human smell at low concentrations ranging from 8 to 130 parts per billion (ppb) (NRC, 2010). Most human organ systems are susceptible to the toxic effects of H_2S, particularly mucus membranes, the central nervous system, the respiratory system, the cardiovascular system, and the gastrointestinal system (Reiffenstein et al., 1992). Exposure to H_2S is associated with known acute health symptoms, including irritation of the eyes, nose, and throat, nausea, vomiting, and headaches (OSHA, n.d., 2005). Exposure to concentrations of H_2S as low as 100 parts per million (ppm) may cause death after 48 hours while concentrations of 500 ppm or greater can lead to rapid collapse, unconsciousness, and death (OSHA, n.d., 2005).

The California Environmental Protection Agency (CalEPA) Office of Environmental Health Hazard Assessment has adopted an acute reference exposure level (REL) for exposure to H_2S for nervous system effects of 30 ppb and a chronic REL for long-term exposure associated with respiratory effects of 8 ppb (OEHHA, 2019). One study found that low-level exposures of 7 ppb H_2S resulted in an increase in emergency room visits (Finnbjornsdottir et al., 2016).

Elevated concentrations of H_2S have been detected near oil and gas sites outside of California. In a community-based monitoring study conducted across five states with oil and gas activities, Macey et al. (2014) reported concentrations of H_2S that significantly exceeded federal health-based guidance values for H_2S. Additionally, a study near the Barnett Shale in Texas found that 32 lease sites (8.0%) had H_2S concentrations greater than 4.7 ppb just beyond the fence line (492–1968 ft away, 150–600 m) with the peak concentration reaching 137 ppb (Eapi et al., 2014). Measured concentrations generally did not correlate well with site characteristics (natural gas production volume, number of wells, or condensate production).

H_2S has also been detected near oil and gas sites in California (Brandt et al., 2015; CARB, 2019; Lillis et al., 2007; Sahagun, 2013a, 2013b; see Chapter 4). Cases of H_2S migration to the surface have been documented in California, posing risks in confined spaces without monitoring. For example, the Edward R. Roybal Learning Center in Los Angeles was developed over part of former Los Angeles City Oil Field and required extensive monitoring and mitigation for H_2S from gas migration (Chilingar & Endres, 2005).

2.2.3.2 Mercaptans and other odorants

Mercaptans are naturally occurring sulfur compounds found in crude oil and natural gas (Krzyzanowski, 2012). Mercaptans in crude oil come in a variety of forms and, along with H_2S, are responsible for the "rotten egg smell" reported near upstream oil and gas facilities (Krzyzanowski, 2012). Exposure to mercaptans and other sulfur-based odorants may result in irritation of the eyes, nose, and throat, coughing, nasal congestion, shortness of breath, nausea, dizziness, stomach discomfort, and headaches, even at "very low levels." The Texas Commission on Environmental Quality (TCEQ) established interim short-term (1 hour) and long-term (1 year) effects screening levels (ESLs) for various mercaptan and odorant compounds (TCEQ, 2018) (**Table 2.1**). According to TCEQ, short-term ESLs are established to "protect against short-term

health effects from discontinuous exposure, nuisance odor, and harmful effects in plants" and long-term ESLs "protect against long-term health effects and plant damage"(TCEQ, 2015).

Table 2.1. Corresponding Texas Commission on Environmental Quality (TCEQ) short-term and long-term effects screening levels for select mercaptans and other odorants. Source: TCEQ (2018).

Mercaptan or other odorant	CASRN	TCEQ Short-Term Effects Screening Levels, ppb (µg/m^3)	TCEQ Long-Term Effects Screening Levels, ppb (µg/m^3)
methyl mercaptan	74-93-1	0.99 (1.9)	0.5 (1)
ethyl mercaptan	75-08-1	0.4 (1)	0.5 (1.3)
n-propyl mercaptan	107-03-9	1.2 (3.7)	0.5 (1.6)
isopropyl mercaptan	75-33-2	0.45 (1.4)	0.58 (1.8)
tert-butyl mercaptan	75-66-1	0.089 (0.33)	0.49 (1.8)
n-butyl mercaptan	109-79-5	0.73 (2.7)	0.49 (1.8)
pentyl mercaptan	110-66-7	0.02 (0.1)	0.5 (2)
tetrahydrothiophene	110-01-0	500 (1,800)	50 (180)
dimethyl sulfide	75-33-2	3 (7.6)	10 (25)

2.2.3.3 Complaints of odors near oil and gas sites

Odors are a common complaint for residents living near OGD sites and numerous studies examining populations living near OGD document self-reported health symptoms with perceived odors (see Chapter 3). California has 35 air districts and residents report odor complaints to the air district responsible for regulating air quality in their region. For example, residents near the Allenco Energy Inc. oil and gas production facility in South Los Angeles reported almost 300 odor complaints to the South Coast Air Quality Management District (SCAQMD) between 2010 and 2014, resulting in over 150 inspections and 18 Notices of Violation (NOV), including six NOVs for nuisance due to odors (SCAQMD, 2015a).

Upon report of nuisance odor complaints, the SCAQMD will assign an investigator to inspect the suspected location of the odor and determine a potential source (SCAQMD, 2021). Specifically, under Rule 1148.1 – Oil and Gas Production Wells,

> "a facility is required to submit a Specific Cause Analysis when there are three or more complaints by different individuals from different addresses, and the source of the odor is verified by District personnel. If this provision is triggered three times within a six-month period, the facility is further required to submit an Odor Mitigation Plan with specific provisions for odor monitoring and mitigation that are spelled out in the rule" (SCAQMD, 2015b).

A recent investigation found that H_2S levels were absent or low at the 15 upstream oil and gas production sites in unincorporated Los Angeles County, based on available data, and no odor complaints were reported for those sites in SCAQMD's database (MRS Environmental, 2017). However, the presence of H_2S varied based on specific oil field conditions, and more environmental data are needed to characterize the extent of H_2S exposures in the Los Angeles Basin. A recent report by the Los Angeles County Department of Public Health stated: "Depending on the type of operations and proximity of people nearby, some EIRs (environmental impact reports) and HIAs (health impact assessments) reviewed for this report concluded that odor events would lead to significant and unavoidable impacts to residents living nearby while others provided evidence that odor mitigation plans would alleviate odor impacts for nearby residents" (LACDPH, 2018). In addition, effects related to odors may be unavoidable at distances out to 1,000 ft (305 m) during loss of containment events, regardless of standard mitigation efforts (LACDPH, 2018). LACDPH (2018) also notes that odors will likely not present a hazard at a distance of 1,500 ft (457 m) from an oil and gas site, though no justification through complaint reporting or dispersion modeling was provided for this determination.

Many complaints near upstream OGD sites in other oil and gas regions are related to noise and odors. Equitable response to complaints is important to consider. A recent study conducted in Pennsylvania found that while the number of complaints filed were similar in counties with different racial demographics, counties with a higher proportion of racial minorities were associated with fewer confirmed impairments, highlighting the possible inequities in addressing oil and gas complaints (Clark et al., 2021). Data on complaints associated with noise, odors, and air pollution are currently not publicly available in California. Furthermore, no peer-reviewed studies have evaluated exposure to noise, light, and odors associated with oil and gas development in California, nor have widespread assessments of complaints been conducted.

2.2.4 Chemical additive usage in upstream oil and gas development

Chemical additives are used throughout the well drilling, construction, completion, and rework[2] process to aid in well cleanout, modify fluid viscosity, and to control pH, clay, corrosion, scale buildup, and microbial activity. Chemicals are also reportedly used for ancillary purposes, such as to mask or neutralize odorous compounds (Fleming & Kim, 2017). Exposure to chemical additives used in upstream oil and gas development may result from accidental spills and leaks, releases to the air during chemical mixing and operations, groundwater contamination, and volatilization from produced water (CCST et al., 2015) Additionally, chemical additives may also transform through environmental degradation or during wastewater treatment (CCST et al. 2015; Kahrilas et al. 2015, 2016). Below we discuss chemical additive usage in California, knowns and unknowns about chemical additive toxicity, downhole chemical transformations, and implications for chemical disclosure and public health.

There are four major sources of publicly available chemical disclosures for oil and gas operations in California: the South Coast Air Quality Management District (SCAQMD), FracFocus, the California Geologic Energy Management Division (CalGEM), and the Central Valley Regional

[2] Rework is any operation subsequent to drilling that involves deepening, redrilling, plugging, or permanently altering in any manner the casing of a well or its function (CalGEM, 2019).

Water Quality Control Board (CVRWQCB). A summary of these four datasets is provided in **Table 2.2.** More information about each of these datasets is provided in Appendix B. It is important to note that the available chemical disclosure datasets are limited in both geographic coverage and the types of oil and gas development activities included because the combined datasets do not cover all upstream oil and gas development activities on a statewide basis. No datasets include the use of chemicals for ancillary purposes, such as odor control agents.

The most recent cross-analysis of all available chemical disclosure datasets was done by the California Council on Science and Technology (CCST). The analysis found 630 unique chemical additives with a Chemical Abstract Service Registry Number (CASRN) were used in California from 2011 to 2018, with an additional 489 chemicals that lacked a CASRN and could not be definitively identified (Shonkoff et al., 2021). Because chemicals and formulations without a CASRN cannot be definitively identified, it cannot be determined if a formulation reported in one dataset (e.g. anionic surfactants) is the same one reported in another dataset based on name alone, resulting in an overestimate of reported chemicals without a CASRN. Previous studies of chemical disclosure datasets are summarized in Appendix B, Table B.1.

2.2.4.1 Physicochemical and toxicological properties of disclosed chemicals

In previous studies of chemical disclosure in California, chemical additives were classified according to the availability of key toxicological and physicochemical properties and their inclusion in federal and state lists of chemicals of concern (CCST et al., 2015; Shonkoff et al., 2021; Stringfellow et al. 2017). The compiled results of these studies are summarized below and in **Table 2.3**.

When experimental values for physicochemical properties and biodegradability were not available, previous studies used U.S. EPA EPI (Estimation Program Interface) Suite™ models to estimate relevant properties (CCST et al., 2015; Shonkoff et al., 2021; Stringfellow et al. 2017). Estimations from EPI Suite™ models, such as BIOWIN™, AOPWIN™, KOWWIN™, KOAWIN™, and HENRYWIN™, are generally accepted by United States regulatory authorities when experimental data are unavailable, and are widely used by the scientific community as inputs for modeling the environmental fate of chemicals (Aronson et al., 2006; Gouin & Harner, 2003; Rücker & Kümmerer, 2012; Scheringer, 2010; Scheringer et al., 2006; Sühring et al., 2020; Wania & Dugani, 2003).

Table 2.2. Upstream oil and gas development chemical usage datasets and associated timeframes used for analysis. Source: Adapted from Shonkoff et al. (2021).

Dataset Name	Source	Timeframe of analysis	Region	Description
FracFocus	Ground Water Protection Council, Interstate Oil and Gas Compact Commission	2011–2018	Analysis limited to California	Composition of hydraulic fracturing fluids. Combines FracFocus 1.0, 2.0, and 3.0 data for completeness.
CalGEM[1]	CalGEM	2014–2018	California	Composition of well stimulation fluids, including, but not limited to, hydraulic fracturing fluids, matrix acidizing fluids, acid fracturing fluids, and recovered fluids within 60 days following the cessation of a well stimulation treatment. Includes disclosures under both interim and final Senate Bill 4 regulations.
SCAQMD	SCAQMD	2013–2018	Los Angeles, Orange, Riverside, San Bernardino Counties	Chemical additives used in routine oil and gas activities (well drilling, well completion, and well reworks) and well stimulation (hydraulic fracturing and matrix acidizing). Does not include enhanced oil recovery, refining, transmission, or storage activities.
AB 1328	CVRWQCB	2014–2018	Southern San Joaquin Valley	All chemical additives used in petroleum production, treatment, and transportation processes that generate produced water for irrigation. Includes wells producing under primary, secondary, and enhanced oil recovery (cyclic steaming, steam flooding, and water flooding). Includes data from operators and their chemical suppliers.

1. CalGEM was formerly known as the Division of Oil, Gas, and Geothermal Resources (DOGGR).
Abbreviations: SCAQMD – South Coast Air Quality Management District; CalGEM – California Geologic Energy Management Division; AB – Assembly Bill, CVRWQCB – Central Valley Regional Water Quality Control Board).

A significant number of chemical additives were included in key federal and state lists of chemicals of concern. Thirty-six chemicals were classified as known or probable human carcinogens by the International Agency for Research on Cancer (IARC), and 40 were listed in Prop 65 assessments as chemicals known to cause cancer or reproductive harm. Fifty-one chemicals were classified as Clean Air Act hazardous air pollutants (HAPs) and 70 were considered toxic air contaminants (TACs) by the California Air Resources Board (CARB). An additional 24 chemicals were listed on U.S. EPA Drinking Water Standards and Health Advisories (DWSHA) tables and 118 chemicals were on the Agency for Toxic Substances and Disease Registry (ATSDR) Substance Priority List. Thirty-eight chemicals were classified as Globally Harmonized System of Classification and Labeling of Chemicals (GHS) category 1 or 2 for acute oral or inhalation toxicity, that is, they are considered highly toxic and potentially fatal by these routes of exposure (United Nations, 2021).

Major data gaps remain regarding the physicochemical, biodegradability, and chronic toxicity properties of chemicals with a CASRN. Approximately 75% of chemical additives with a CASRN did not have available chronic toxicity data, 28% did not have available acute toxicity data, 41% were not readily biodegradable or did not have any biodegradability data, and 37% did not have any data on key physicochemical properties. These chemical properties are important to determine environmental fate and transport and potential human health impacts. It is important to note that the absence of data regarding chemical toxicity is not evidence that there are no potential negative human health impacts.

In summary, many chemicals used in upstream OGD operations in California are disclosed and several can be characterized with regard to human health impacts. However, there are still a significant number of chemical additives that are not disclosed or not sufficiently characterized to assess their potential human health impacts. Statewide policies that require all oil and gas operators to disclose the identities and amounts of chemical additives used, regardless of the type of upstream oil and gas development activity or recovery method, would help close data gaps and facilitate future hazard and risk assessments. Chemical additives are generally absent from air monitoring risk assessments of upstream OGD; however, previous assessments have found that some compounds will readily evaporate (Shonkoff et al., 2019) and may be a hazard to human health (Chapter 4, Appendix D).

Table 2.3. Number of chemicals disclosed in oil and gas datasets, classified by data availability or presence on international and national priority lists. Source: Shonkoff et al. (2021).

		Datasets				
Chemical Information Category		**FracFocus 1.0, 2.0, 3.0[1]**	**SCAQMD**	**AB 1328[2]**	**CalGEM**	**All Datasets Combined**
Identification	Proprietary/Trade Secret	82	327	80	0	489
	Chemicals with CASRN	315	324	285	272	630
Toxicity	No Acute Toxicity Data	70	89	63	57	180
	GHS Category 1 or 2 (Acute oral or inhalation toxicity)	19	20	18	14	38
	No Chronic Toxicity Data	227	232	198	199	476
Biodegradation	No biodegradability data	53	61	53	47	132
	Not readily/not inherently biodegradable	54	51	45	55	127
Carcinogens	IARC Group 1, 2A, 2B	19	18	25	17	36
	California Prop 65	19	19	33	16	40
	NTP Known or anticipated carcinogen	12	12	19	11	25
Air Pollutants	Clean Air Act Hazardous Pollutant	21	24	31	24	51
	CARB Toxic Air Contaminant List	33	36	45	36	70
	CARB Hot Spots List	34	39	47	36	74
Other Priority Lists	European Commission endocrine disrupting chemical	3	3	1	2	3
	OSPAR Substance of Possible Concern List	2	2	2	2	3
	EU REACH Substance of Very High Concern	7	4	3	4	8
	ATSDR Substance Priority List	58	77	81	50	118
	US EPA DWSHA	14	11	20	12	24
	US EPA CCL4	5	6	8	4	11

Chemical Information Category		Datasets				
		FracFocus 1.0, 2.0, 3.0[1]	SCAQMD	AB 1328[2]	CalGEM	All Datasets Combined
Physical Chemical	No physicochemical properties (log K_{ow}, log K_{oc}, K_H, and vapor pressure)	91	123	97	77	233

1. All proprietary/trade secret chemicals for the FracFocus dataset were reported in FracFocus 1.0 or 2.0, prior to 2016.
2. Number of proprietary chemicals and chemicals with CASRN do not reflect the updated AB 1328 dataset released in 2021 (CVRWQCB et al., 2021).

Abbreviations: CASRN - Chemical Abstracts Service Registry Number; GHS - the Globally Harmonized System of Classification and Labelling of Chemicals; IARC - International Agency of Research on Cancer; NTP - National Toxicology Program; CARB - California Air Resources Board; EU REACH - European Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals; ATSDR - Agency of Toxic Substances and Disease Registry; US EPA DWSHA - Drinking Water Standard and Health Advisories; US EPA CCL4 - United States Environmental Protection Agency Contaminant Candidate List 4; SCAQMD - South Coast Air Quality Management District; CalGEM - California Geologic Energy Management Division; AB - Assembly Bill.

2.2.4.2 Comparison of chemical use between datasets

An analysis of chemical use among the various chemical disclosure datasets revealed significant overlap among all datasets and is presented in **Figure 2.1**. (Stringfellow et al., 2017; Shonkoff et al., 2021). Of the 630 chemicals with a CASRN, 316 were reported in more than one dataset, with 178 chemicals reported in three or more datasets. The remaining 314 chemicals were unique to one dataset. Both the SCAQMD and AB 1328 datasets contained more than 100 unique chemicals with a CASRN that were not reported in any other datasets. The majority of chemical additives in the FracFocus and CalGEM datasets were identified in both datasets; this overlap is likely due to the fact that both datasets include hydraulic fracturing activities. Chemicals reported without a CASRN were not included in this comparison because (1) they could not be uniquely identified, and (2) any comparison between datasets based on the reported name alone would be inaccurate.

The significant overlap in chemical usage across datasets indicates the use of some chemical additives is widespread and not limited to a particular region, recovery method, or well activity. As such, the potential health implications of chemical usage in upstream OGD may exist across different regions, recovery methods, and activities. Current regulations concerning chemical disclosure or the prohibition of select chemical additives that only apply to specific upstream OGD activities (e.g., well stimulation) may overlook the potential health implications from the use of the same chemical additives in other well activities and recovery methods. Additionally, because roughly half of all chemicals with a CASRN were unique to a single dataset, the lack of universal chemical disclosure for all upstream oil and gas activities prevents a thorough assessment of the potential health implications of OGD chemical usage.

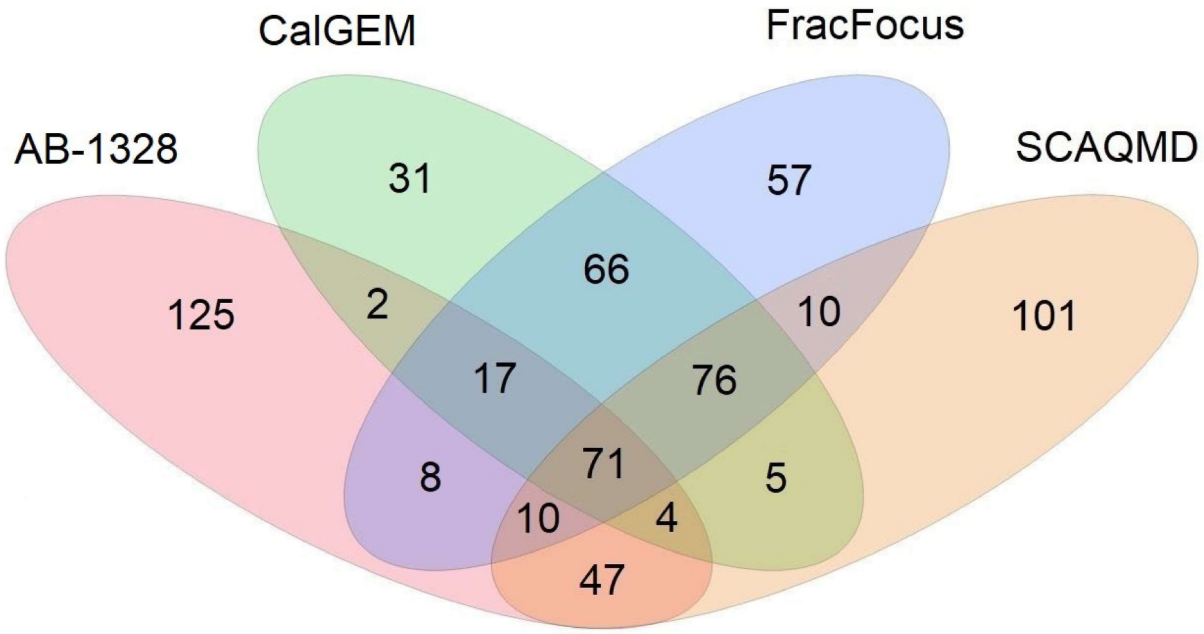


Figure 2.1. Venn diagram showing overlap in the number of chemicals with a CASRN used in SCAQMD, AB 1328, CalGEM, and FracFocus datasets. Source: Adapted from Shonkoff et al. (2021).

2.2.4.3 Chemical additive transformation

Chemical additives used in oil and gas production have the potential to undergo subsurface chemical transformations through reactions with other additives, naturally occurring compounds, or microbes, and then return to the surface via flowback and produced water (Kahrilas et al., 2016; Kortenkamp et al., 2007; Teuschler & Hertzberg, 1995; Wilkinson et al., 2000). Although degradation pathways and products have been established for some chemical additives under standard state conditions, downhole conditions — including high temperatures and pressures — can result in altered biodegradation potentials and unexpected chemical reactions and degradation products (CCST, 2015; Kahrilas et al., 2015). For example, chemicals used in hydraulic fracturing in California (guar gum, borate and zirconium crosslinkers, and oxidative breakers) can form various di- and trihalomethane compounds in simulated downhole conditions (Sumner & Plata, 2019). Additionally, some relatively nontoxic chemical additives may transform into more toxic or more environmentally persistent compounds (Kahrilas et al., 2015). Although poorly understood, the products of downhole chemical transformations can pose risks to human health when released to the environment (Abdullah et al., 2017). Chemical additive disclosures do not capture these potential chemical transformations.

Chemical transformations may also occur as a result of subsequent treatment and disposal. Water disinfection byproduct (DBP) precursors have been identified in untreated oil and gas produced water (Harkness et al., 2015; Liberatore et al., 2017; Parker et al., 2014). When produced water is released into surface waters, DBPs have been detected downstream from points of discharge (Hladik et al., 2014). Toxicity of various regulated and unregulated DBPs has been noted in the literature (Liberatore et al., 2017). As such, conducting produced water monitoring for disclosed

chemicals is appropriate, but may not provide conclusive results with respect to the toxicological profile of any given source of produced water. The deployment of monitoring approaches that can provide information on DBPs and other transformation byproducts, or non-targeted water monitoring methods that assess the toxicity and mutagenicity of water without identifying specific chemical mechanisms (e.g., bioassays), may help to close these data gaps. These monitoring approaches are most important for discharge of produced water to the surface and for produced water reuse outside of the oilfield.

It is also possible, and likely, that some portion of chemical transformation products that return to the surface will volatilize from produced water and become airborne pollutants. However, because transformation products are expected to either remain in the subsurface or initially return to the surface with flowback or produced water, chemical additive transformations are discussed in further detail in Chapter 5. Emissions from produced water are also discussed in Chapter 5.

2.3 Physical stressors

In this section we discuss physical stressors associated with OGD, including noise, light, radioactive materials, induced seismicity, and explosions and fires.

2.3.1 Noise

Noise, one of the most common complaints of residents near oil and gas well sites, is emitted from trucks and equipment during oil and gas well site operations. Noise has been measured 100–1,800 ft (30–550 m) from oil and gas well sites at levels known to negatively impact sleep, cardiovascular health, and child behavior and well-being (Blair et al., 2018; Ferrar et al., 2013; Collier-Oxandale et al., 2020).

2.3.1.1 Noise exposure and human health

Chronic noise at levels ranging from 55 to 65 dBA[3] can disturb sleep. Daytime noise in the range of 65 dBA has been associated with objective measures of shorter nighttime sleep duration, less slow wave sleep, and lower sleep efficiency (Chen et al., 2018). Additional studies examining nighttime noise and sleep found that outdoor, nighttime noise levels above 55 dBA were linked to higher odds of self-reported insomnia (Halonen et al., 2012) and patients in hospital rooms with 24-hour noise levels of ~64 dBA had disrupted sleep quality (Park et al., 2014). There is a strong body of evidence linking disturbed sleep, especially short sleep duration, to hypertension and cardiovascular disease (Aziz et al., 2017; Cappuccio et al., 2011; Cappuccio & Miller, 2017; Drager et al., 2017; Itani et al., 2017; Javaheri & Redline, 2017; Jike et al., 2018; Khan & Aouad, 2017; Kim et al., 2019; Knutson, 2010; Lunsford-Avery et al., 2018; St-Onge et al., 2016; Yin et al., 2017). A recent meta-analysis indicates that traffic noise increases the risk of sleep disorders that may act as important mediators in the relationship between noise and cardiovascular disease (Basner & McGuire, 2018).

[3] A-weighted decibel (dBA) is an expression of the relative loudness of sounds as perceived by the human ear.

Additionally, exposure to chronic noise starting at 40 dBA can negatively impact cardiovascular health. Starting at 40, 45, and 50 dBA, the risk of incident atrial fibrillation, hypertension, and coronary heart disease increases by 6-8% per increase of 10 dBA (Hahad et al., 2019). Simulated aircraft noise at night with peak levels of 60 dBA were associated with elevated epinephrine and blood pressure, impaired endothelial function, and lower sleep quality (Schmidt et al. 2013; 2015). Specifically, the researchers observed that an 8 dBA increase in simulated aircraft noise was associated with 4.1 mmHg (millimeters of mercury) increase in systolic blood pressure (Schmidt et al. 2015). Older adults may be particularly susceptible and vulnerable to noise exposures. For each 10 dBA increase in A-weighted noise, starting at 55 dBA, stroke risk increases 14% in adults ≥65 years (Hahad et al., 2019). A meta-analysis of 24 field studies on noise and sleep determined that individuals in their fifties are most vulnerable to the adverse effects of noise on sleep (Miedema & Vos, 2007). Many aging adults have limited social ties and financial resources, which reduce the ability to respond resiliently to mitigate the impacts of environmental conditions such as noise disturbance (Administration for Community Living, 2019; Fernandez et al., 2002; Meyer, 2017; Ngo, 2001). Aging adults tend to spend more time at home and are more likely to become housebound (Qiu et al., 2010; US Bureau of Labor Statistics, 2019).

Several studies indicate that noise exposures may negatively impact child behavior and well-being. A meta-analysis of three studies, Schubert et al., (2019) found a 10% increase in inattention/hyperactivity symptoms and 9% increase in total behavioral symptoms per 10 dB increase in exposure to road noise. A study in Norway identified a 36% increase in sleep disturbances in girls per 10 dB increase in road traffic noise (Weyde et al., 2017a). Average road noise exposure between ages 3 to 8 years was associated with a 1.3% increase in inattention per 10 dB increase in average noise exposure, indicating a potential cumulative effect from long term exposures (Weyde et al., 2017b). Finally, a recent meta-analysis of noise exposures and cognitive ability concludes that there is limited evidence that chronic noise exposures could impact cognitive performance in school children (Clark et al., 2020).

2.3.1.2 Noise levels observed near oil and gas sites

Noise is one of the most common complaints from residents near oil and gas well sites. Between 35 to 55% of participants in a Marcellus Shale region survey reported noise as a perceived stressor from OGD (Ferrar et al., 2013). In Colorado, 123 out of 330 complaints reported to the Colorado Oil and Gas Conservation Commission in 2015 were noise concerns (Blair et al., 2018).

While there are currently no health-based guidelines for environmental noise from oil and gas sites, the World Health Organization Guidelines for the European Region recommend that noise from traffic, railways, aircraft, and wind turbines not exceed 45–54 dBA over a 24-hour period and 40–45 dBA at night (World Health Organization, 2018). For context, a whisper is measured at 25 dBA, a vacuum cleaner at 75 dBA, and a jet engine at 100 ft (30 m) at 140 dBA (Yale University Environmental Health and Safety, 2021). Studies in Colorado, Pennsylvania, Texas, and West Virginia have documented noise levels exceeding WHO guidelines for the European regions. At this time, there are no peer-reviewed studies evaluating noise levels near oil and gas development in California. **Table 2.4** and **Table 2.5** summarize results from published studies on noise levels around oil and gas well sites in the United States. Appendix B provides explanations of noise

measurements. Early evaluation of noise around oil and gas well sites reported audible noise levels ranging from 47–87 dBA at 100–1000 ft (30–305 m) from oil and gas well sites with no sound mitigation in place (Witter et al., 2013; Hays et al., 2017). A later study, documenting both audible and low frequency vibrational noise, reported noise levels at 350 ft (107 m) from oil and gas well sites ranging from 41–72 dBA and 58–82 dBC[4] without a sound wall, and 57–59 dBA and 67–76 dBC with a sound wall (Radtke et al., 2017). In more recent and comprehensive studies, Blair et al. (2018) and Allshouse et al. (2019) continuously measured audible noise and low frequency vibrational noise at four Colorado homes located 715–1805 ft (218–500 m) from the perimeter of a 22 oil and gas well site with a sound wall in place throughout development and into production. These sets of noise measurements included a combination of noise from multi-well site equipment and truck traffic moving supplies to and from the site. During all phases of development and production, audible noise exceeded the WHO's daytime (45–54 dBA) and nighttime (40–45 dBA) guidelines, as well as levels known to affect sleep, cardiovascular health, and child behavior and wellbeing (50 dBA) (Basner et al., 2014; Hume et al., 2012). Additionally, low frequency noise exceeded a 65 dBC suggested threshold, which is based on a limited literature on the health effects of low frequency vibrational noise (Blair et al., 2018; Broner, 2010; Hays et al., 2017). Notably, noise levels were well above the predevelopment levels of 42.8 dBA and 55.8 dBC. Once well pad development transitioned to the ~30-year production phase, noise levels still exceeded 53 dBA and 72 dBC, an increase of 10 dBA and 16 dBC, respectively, from pre- to post- site development. Exceedances occurred both day and night on all days of the week. Increased nighttime noise is a particular concern because people are more likely to be at home and thus adversely impacted.

[4] C-weighted decibels (dBC) rely on a type of frequency weighting that is used when measuring the amount of noise in an environment and is primarily used for peak measurements or for measuring noise above 100 decibels.

Table 2.4. Summary of audible noise measurements by distances from oil and gas well sites (dBA).[1]

State	Study	Distance from site (feet)	Truck traffic (dBA)	Site preparation and/or drilling (dBA)	Drilling (dBA)	Hydraulic fracturing (dBA)	Hydraulic fracturing and/or Well Completions (dBA)	Production (dBA)
	Without Sound Wall							
Texas	Hayes et al. (2017)	100	-	-	75–87	-	-	-
Texas	Hayes et al. (2017)	200	-	-	71–79	-	-	-
Texas	Hayes et al. (2017)	300	-	-	65–74	-	-	-
Colorado	Radtke et al. (2017)	350	-	-	63–66	65–72	62–65	41–59
Texas	Hayes et al. (2017)	400	-	-	60–71	-	-	-
Texas	Hayes et al. (2017)	500	-	-	56–68	-	-	-
Colorado	Witter et al. (2013)	500	-	-	56–60	-	-	-
Texas	Hayes et al. (2017)	600	-	-	54–59			
West Virginia	Hayes et al. (2017)	625	56–73	58–69	54	47–60	55–61	
Texas	Hayes et al. (2017)	700	-	-	51–55	-	-	-
Texas	Hayes et al. (2017)	800	-	-	51–54	-	-	-
Wyoming	Hayes et al. (2017)	984	-	-	52.5	-	-	-
Colorado	Witter et al. (2013)	1,000	-	-	65–69	-	-	-
	With Sound Wall							
Colorado	Radtke et al. (2017)	350	-	-	57–59	59	-	-
Colorado	Allshouse et al. (2019)	715	-	-	38.4–75.2	-	-	
Colorado	Allshouse et al. (2019)	737	-	-	38.3–90.4	40.2–76.7	39.2–91.9	37.6–79.0
Colorado	Allshouse et al. (2019)	868	-	-	37.2–78.9	37.6–79.0	36.6–92.5	36.5–92.3
Colorado	Allshouse et al. (2019)	1,288	-	-	35.9–74.5	-	-	-
Colorado	Blair et al. (2018)	1,050–1,805	-	35.9–89.2	-	-	-	-

- Not measured

[1] A-weighted decibel (dBA) is an expression of the relative loudness of sounds as perceived by the human ear. The World Health Organization Guidelines for the European Region recommend that noise from traffic, railways, aircraft, and wind turbines not exceed 45–54 dBA in the daytime and 40–45 dBA at night (World Health Organization, 2018).

Table 2.5. Summary of low vibrational noise measurements by distance from oil and gas well site (dBC).[1]

State	Study	Distance from center of site (feet)	Drilling (dBC)	Hydraulic Fracturing (dBC)	Hydraulic Fracturing and Well Completions (dBC)	Production (dBC)
Without Sound Wall						
Colorado	Radtke et al. (2017)	350	77–80	77–82	76–77	58–74
With Sound Wall						
Colorado	Radtke et al. (2017)	350	67–76	73–74	-	-
Colorado	Allshouse et al. (2019)	715	56.2–98.5	-	-	-
Colorado	Allshouse et al. (2019)	737	57.1–106.4	60.4–98.2	57.5–107.6	55.8–101.0
Colorado	Allshouse et al. (2019)	868	52.4–96.6	57.5–106.5	55.5–106.2	54.0–106.7
Colorado	Allshouse et al. (2019)	1,288	54.5–96.4	-	-	-

- Not measured

[1] C-weighted decibels (dBC) rely on a type of frequency weighting that is used when measure the amount of noise in an environment and is primarily used for peak measurements of for measuring noise above 100 decibels.

2.3.2 Light

Artificial light at night (ALAN) may emanate from oil and gas sites (Boslett et al., 2021). ALAN associated with upstream oil and gas activity presents a potential hazard with a range of acute and chronic health risks, particularly for communities with heavy drilling operations.

More generally, health impacts from exposure to ALAN are associated with symptoms of mental health disorders, increased risk of mortality, and sleep deprivation, which can cause secondary effects such as reduced cognitive function and reduced productivity (Chepesiuk, 2009; Touitou et al., 2017). In addition, exposure to ALAN has been associated with elevated incidence of cancer, including breast cancer, as well as metabolic and mood disorders (Chepesiuk, 2009; Walker et al., 2020). While the evidence is sparse, studies suggest this association between cancer and ALAN may be due to disruptions to the circadian and neuroendocrine systems, thus promoting tumor growth (Chepesiuk, 2009; Walker et al., 2020). Disruptions to the circadian system are also associated with cardiovascular disease, depression, and insomnia (Chepesiuk, 2009; Walker et al., 2020).

A small number of peer-reviewed studies have examined ALAN associated with oil and gas activities. The peer-reviewed literature includes five studies, two of which were conducted in Pennsylvania (Ferrar et al., 2013; Perry, 2013); one in the Bakken Shale region (North Dakota, Montana, Canada) (Boslett et al., 2021); one in the Guernsey and Noble Counties of Ohio (Fisher et al., 2018); and one in West Virginia (McCawley, 2013).

Studies focused on OGD show that various sensory stimuli, including ALAN, noise, and vibrations from drilling operations, may contribute to psychosocial stress (Ferrar et al., 2013; Fisher et al., 2018); anxiety and depression due to changes in quality of life (Perry, 2013); and sleep deprivation and poor physical and mental health (Boslett et al., 2021; Fisher et al., 2018). In the case of Boslett et al. (2021), the authors found sufficient evidence to suggest that the rapid expansion of unconventional oil and natural gas development within rural communities has led to a significant

increase of ALAN. One study found no association between drilling activity and increased ALAN (McCawley, 2013). To date, no peer-reviewed studies evaluating OGD and light pollution, or complaints related to upstream OGD and light, have been conducted in California.

2.3.3 Radioactive materials

Oil and gas production can transport naturally occurring radioactive materials (NORM) from the subsurface to the surface (US EPA, 2022a). NORM that becomes environmentally accessible or concentrated due to human activities is referred to as technologically enhanced naturally occurring radioactive materials (TENORM) (US EPA, 2022a). Exposure to radiation can result in impaired lung function, oxidative stress, increased blood pressure, and can increase the risk of cancers, especially among sensitive populations such as children and fetuses (Deziel et al., 2022; Li et al., 2018; Nyhan et al., 2018, 2019; US EPA, 2022b).

Elevated levels of TENORM are commonly found in waste products associated with oil and gas activities, such as solid waste and drill cuttings, and in produced water (US EPA, 2000a, 2022a). TENORM may also accumulate as scale in pipes and other upstream infrastructure, complicating the decommissioning process (US EPA, 2022a). Various radioactive compounds found in oil and gas waste streams, such as radium-226 and radon-222, are particularly persistent in the environment because radium-226 — with a 1,600-year half-life — is continuously produced from the very long-lived uranium-238, and the short-lived radon-222 and its progeny are continuously produced from the decay of radium-226 (US EPA, 2000b). Due to exemption of oil and gas waste from Subtitle C of the Resource Conservation and Recovery Act (RCRA), oil and gas exploration and production waste is not designated as hazardous waste and is therefore not required to be disposed of at hazardous waste facilities (US EPA, 2002). Radioactive compounds present challenges in waste treatment and disposal. Disposal of OGD waste in landfills (despite sometimes exceeding landfill standards) is a common practice in some states such as Pennsylvania (Hill et al., 2019). Recently, New York State, which had accepted oil and gas waste from Pennsylvania oil and gas activities, decided to halt the practice unless the waste meets non-hazardous designation (N.Y. Senate Bill S3392, 2020).

Radioactive materials released into the environment can also spread through airborne transport (Li et al., 2020). For example, radon-222 decay products react with atmospheric gases and water and attach to airborne particles (Brager et al., 1991; Li et al., 2020; Yamada et al., 2004). A recent study that considered wells primarily in shale formations in the eastern half of the United States detected increased gross beta-particle radiation downwind of unconventional oil and gas wells in various parts of the country (Li et al., 2020).

In a 1996 study of oilfield TENORM in California, radiation measurements were taken in 70 oil and gas fields through the state, and 124 samples from sites expected to have elevated TENORM levels were analyzed for radionuclides (DHS Radiologic Health Branch & DOGGR, 1996). Although the majority of radiation measurements and samples were at or near background levels (<5 pCi/g [picocuries per gram] of radium), elevated levels of TENORM (>5 pCi/g) were found in upstream pipe scale, tank bottoms, sludge, water filters and softeners, and natural gas processing equipment such as gas lines where propane was being distilled (DHS Radiologic Health Branch & DOGGR, 1996). Overall, the study concluded that TENORM from oil and gas development is

expected to have a low impact on public health during normal operations; however, precautions may be needed to limit worker exposure during operations, site cleanup, and decommissioning (DHS Radiologic Health Branch & DOGGR, 1996).

TENORM can be present in upstream pipelines that transport both produced water and oil/gas from the wellhead (DHS Radiologic Health Branch & DOGGR, 1996). From an exposure viewpoint, the immediate concern regarding exposure to TENORM is gamma radiation exposure from contaminated scale in buried pipelines, because beta and alpha particles will not travel any appreciable length in soil. However, the primary, long-term concern is future land use management and the possibility of redevelopment in areas with buried pipelines (Pipeline Abandonment Steering Committee, 1996). Excavation during redevelopment may disturb TENORM-contaminated pipelines, increasing the potential for gamma radiation exposure and the mobilization of TENORM as dust. Radon-222 gas may also accumulate in overlaying buildings, increasing the potential for exposure. See Chapter 6 for more details on exposure to legacy TENORM.

2.3.4 Induced seismicity

To facilitate oil and gas production, certain extraction techniques (e.g., hydraulic fracturing) and the disposal of produced water (down Class II Underground Injection Control disposal wells), require injection of fluids and material into the subsurface under high pressure. Pressurized injection into the subsurface can result in human-caused earthquakes, also referred to as induced seismicity (Skoumal et al., 2018). Induced seismicity has been attributed to hydraulic fracturing operations for oil and gas production and underground injection of produced water for disposal in other areas in North America (Schultz & Wang, 2020; Skoumal et al., 2018; Wang et al., 2020). In addition to physical hazards and safety risks, seismic events may also contribute to increased psychological responses, including anxiety (Casey et al., 2018). In California, there have been no reported cases of induced seismicity associated with produced water injection. However, it is difficult to distinguish between California's frequent natural earthquakes and those possibly caused by produced water injection; generally, this is easier to investigate anthropogenic sources of seismicity in areas with very low natural seismicity rates (Long et al., 2015). Some studies have found evidence of induced seismicity from fluid injections in California; however, the results were inconclusive (Goebel et al., 2015; Goebel & Shirzaei, 2021; McClure et al., 2017).

2.3.5 Explosions, fires

Another safety aspect of upstream oil and gas production is the potential for explosions and fires during production and processing. Due to the various flammable, explosive materials and potential ignition sources (e.g., electrical shocks, sparks caused by mechanical friction) often found at oil and gas well sites, fires and explosions occasionally occur during oil and gas operations (Blair et al., 2017).

Blair et al. (2017) assessed the frequency of explosions and fires at active well sites in Colorado and Utah and found 183 events reported between 2006 to 2015, with 116 in Colorado and 67 in Utah. The number of wells where fires and explosions were reported encompassed only 0.03% and 0.07% of active wells in Colorado and Utah, respectively. Even so, these events can lead to

fatalities and critical injuries, as demonstrated by a review conducted by the U.S. Occupational Safety and Health Administration of reported fire and explosion events near oil and gas sites. A review of 77 fire and explosion incidents by Puskar (2014) reported to the U.S. Occupational Safety and Health Administration found that oil and gas operations resulted in 42 deaths and 87 injuries between 2010–2014.

Haley et al. (2016) investigated historical events and published modeling and air pollution data and concluded that setback distances ranging from 150 to 1,500 ft (46 to 457 m) in the Marcellus, Barnett, and Niobrara shale plays do not appear sufficient to protect public health and safety from explosions and radiant heat from uncontrolled fire from OGD activities. The authors note that the (now outdated) setback distance of 350 ft (107 m) from an outdoor recreational area in Colorado would result in second degree burn blisters after 22 seconds of exposure to a fire incident at an oil and gas site.

2.4 Conceptual overview of stressor attenuation by distance

Intensity of many exposures decrease with distance, although the potential for dispersion and degree of attenuation varies by stressor. We present evidence for the attenuation of stressors by distance for the following stressors: pollutant emissions to air, surface water, and the subsurface environment; noise; and vibrations. **Figure 2.2** provides a conceptual overview of the dispersion of stressors off site from oil and gas operations.

The attenuation, or reduction of intensity, of a stressor by distance varies by the type of stressor and the specific properties of the stressor of interest. For example, physical agents like noise and radiation that emanate from a point source theoretically attenuate following the inverse distanced squared or "r-squared rule" (Lamancusa, 2000). However, in reality there are other factors that influence the attenuation. For the propagation of sound through air, the influence of sound wave reflection and refraction, as well as wind, can alter the theoretical noise propagation. Other stressors we consider — vibration and pollutant emissions to air, water, and the subsurface — have attenuation rates different from inverse-distance squared, but typically greater than a simple linear decay. **Figure 2.3** provides an illustration of the theoretical attenuation that one might expect as a function of relative distance for different categories of stressors. Equations used to derive each attenuation curve are described in Appendix B.

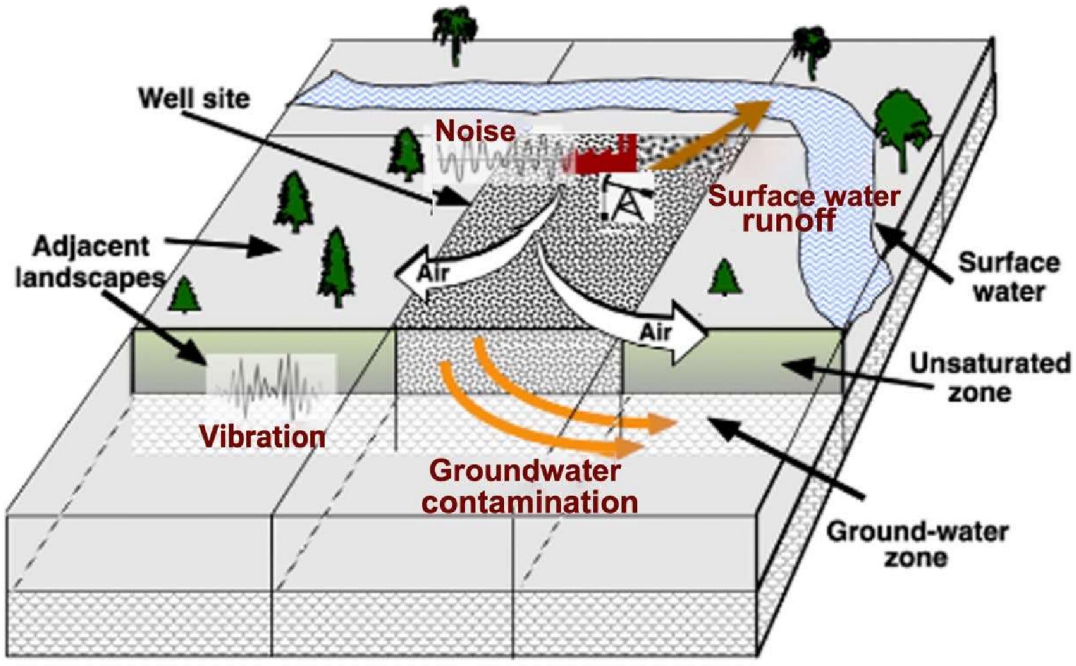


Figure 2.2. Overview illustration of the transport and attenuation of stressors off-site from oil and gas operations.

Figure 2.3 shows theoretically — in the absence of reflection, refraction, and wind effects — how sound (or noise) attenuation out to a relative[5] distance of 4.5 has the most rapid decay of intensity with relative distance, tracking a true or approximate r-squared-decay relationship. Vibration follows an exponential decay and initially attenuates more slowly than sound. For the two examples of air dispersion, one for neutral conditions and one for stable air, we see an attenuation that closely tracks r-squared decay and exponential decay, falling off initially roughly r-squared, but then flattening out to linear dilution that tapers off at greater distance. For groundwater (Domenico & Robbins, 1985) and surface water (van Leeuwen & Vermeire, 2007), the long-term attenuation with distance is much flatter, with an initial near-field r-squared dilution, but trends to a shallow curve best described as $1/\sqrt{r}$. This implies that over long periods, subsurface plumes have a long reach. However, even in short time frames the plume capture zone is wide enough to be short relative to the distance to the nearest groundwater well. It is important to note that while **Figure 2.3** provides a framework to consider attenuation of a range of stressors by distance, additional factors (e.g., directional dispersion, topography, atmospheric stability, mitigation measures impacting sound reflection) ultimately impact the true attenuation of stressors on a site-specific basis.

[5] Considered in relation or in proportion to something else.

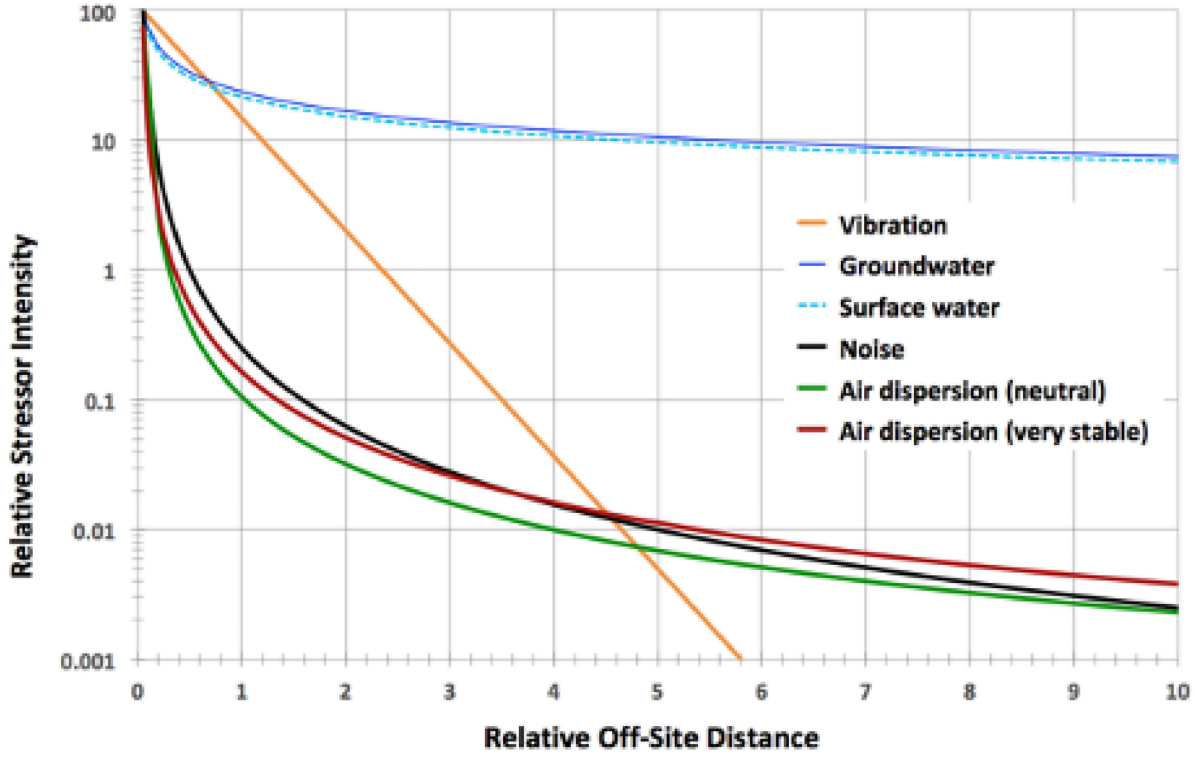


Figure 2.3. A hypothetical illustration of potential attenuation by offsite distance for a range of stressors. The relative distance is the actual distance divided by a considered distance. Developed from material presented in the following sources: Turner (1970), Martin (1976), Domenico and Palaciauskas (1982), Domenico and Robbins (1985), Lamancusa (2000, 2002, 2009), Jirka and Weitbrecht (2005), van Leeuwen et al. (2007), Nicholls (2009), Truty et al. (2019).

2.5 Discussion

Below we provide additional discussion on (1) a comparison of stressors from unconventional and conventional oil and gas development, and (2) current policies limiting chemical usage in oil and gas development to protect public health.

2.5.1 Comparison of stressors from unconventional and conventional oil and gas development

Although definitions of conventional and unconventional OGD may differ across different regulatory and policy landscapes, the majority of OGD in California is often considered conventional, involving vertical drilling at shallower depths into target geologies that hold migrated hydrocarbons. These attributes of development are often considered in contrast to unconventional OGD, which involves horizontal directional drilling in deeper wells to access source rock formations and increasing the permeability of these tight formations using mostly hydraulic fracturing. In addition, unconventional operations are often accompanied with greater masses of material inputs (e.g., water, chemical additives, proppants) and a greater magnitude of liquid and solid waste outputs (e.g., flowback fluids and produced water). It should be noted, however, that

hydraulic fracturing that takes place in California often uses fluids (gels) with higher concentrations of well stimulation chemicals than those fluids used in high-volume slick water hydraulic fracturing of source rock in other parts of the United States (Long et al., 2015).

However, many stressors are intrinsic to both conventional and unconventional OGD (Hill et al., 2019; Jackson et al., 2014; Lauer et al., 2018; Stringfellow et al., 2017; Zammerilli et al., 2014). $PM_{2.5}$ and nitrogen oxides emissions result from the use of diesel-powered equipment and trucks. Hazardous air pollutants such as BTEX occur naturally in oil and gas formations, regardless of the type of extraction method employed. Noise pollution, odors, and landscape disruption are inherent to OGD. Investigations in other oil and gas states have noted radioactivity on particles downwind from unconventional oil and gas wells (Li et al., 2020) and in sediment downstream of water treatment plants that treat waste from conventional as well as unconventional oil and gas operations (Burgos et al., 2017; Lauer et al., 2018). Additionally, a recent evaluation of chemical usage during OGD in California found significant overlap in chemical additives used for well stimulation (including hydraulic fracturing) and those used in routine activities, such as well maintenance (Stringfellow et al., 2017).

California has placed policy, regulatory, and scientific emphasis on well stimulation activities, including hydraulic fracturing, matrix acidizing, and acid fracturing. The *2015 Independent Scientific Assessment on Well Stimulation in California*, which focused primarily on well stimulation activities pursuant to Senate Bill 4 (2013), had the following key conclusion: "The majority of impacts associated with hydraulic fracturing are caused by the indirect impacts of oil and gas production enabled by the hydraulic fracturing" (Long et al., 2015). Indirect impacts relevant to human health for the purposes of the study included "proximity to any oil production, including stimulation-enabled production, could result in hazardous emissions to air and water, and noise and light pollution that could affect public health" (Long et al., 2015).

2.5.2 Current chemical use policies

There are examples of restricting chemical usage in oil and gas development in the United States. Under the Safe Drinking Water Act, diesel fuels are prohibited from being used in hydraulic fracturing in the United States unless operators obtain permits under the Class II Underground Injection Control (UIC) program (US EPA, 2014). A review of permitting and oversight by the U.S. EPA in 2017 found no cases of operators applying for permits for use of diesel fuels in hydraulic fracturing (US EPA, 2017). Studies confirm that diesel fuels have not been reported in hydraulic fracturing chemical disclosures in California since 2011, although a report by the U.S. Congress found 26,466 gallons (100,184 liters) of hydraulic fracturing fluids containing diesel fuels were used in California between 2005–2009 (Waxman et al., 2011). Restrictions on diesel fuel use do not apply to non-hydraulic fracturing activities (US EPA, 2016). Diesel fuel (kerosene [CASRN: 8008-20-6]) is used as a component of work-over fluid in operations in the southern San Joaquin Valley that provide produced water for irrigation (Shonkoff et al., 2016).

Effective January 15, 2021, the Colorado Code of Regulations (Colo. Code Regs. § 404-1-437) prohibits the use of 22 specific compounds in hydraulic fracturing fluids because these compounds posed the greatest risks to public health based on toxicity and their mobility and persistence in groundwater (Appendix B, Table B.2). This list was based on hydraulic fracturing

compounds identified by Rogers et al. (2015) that posed the greatest risks to public health based on their mobility and persistence in groundwater. Not all chemicals identified by Rogers et al. (2015) were prohibited; polysorbate 80 was not prohibited due to its frequency of use in Colorado and relatively lower risk to human health. It is important to note that these 22 chemicals are prohibited as chemical additives, but not in base fluids, allowing for the reuse and recycling of produced water that may naturally contain these compounds (§ 404-1-437). Seventeen of the 22 prohibited chemicals are used in upstream oil and gas development in California. Colorado House Bill 1348 (2022) provides a model for implementing disclosure requirements for any chemical that may be used in oil and gas production. This enables the public and regulators to evaluate the environmental and public health impacts of these chemicals and to encourage less-toxic alternatives. This bill also includes explicit restrictions on the use of per- and polyfluoroalkyl substances (PFAS).

2.6 Summary

Various chemical and physical stressors are associated with upstream oil and gas development activities, including air pollutants, surface water and groundwater contaminants, vibration, noise, and odors. Communities living near OGD operations may be exposed to combinations of stressors. Chemical stressors include compounds naturally occurring in petroleum reservoirs, such as petroleum hydrocarbons (e.g., BTEX), metals, chemical additives used in the OGD processes, and odorous compounds. Upstream OGD activities, including the use of diesel equipment, trucks and flaring, also emit combustion products that are classified as toxic air contaminants or federally designated criteria air pollutants. Emissions of various volatile organic compounds from upstream oil and gas activities can result in the secondary formation of ground-level ozone, another criteria air pollutant.

Chemical additives are used during routine activities (e.g., well maintenance), as well as during well stimulation (e.g., hydraulic fracturing). Between 2011 to 2018, 630 different chemical additives with CASRN were identified as used in oil and gas operations in California. Of these compounds, 40 (6%) are Prop 65 carcinogens, 70 (11%) are toxic air contaminants, and 38 (6%) are identified for acute or chronic toxicity. While chemical additive disclosure in OGD operations is helpful to identify potential environmental and health hazards, chemical additive use and subsequent concentrations of additives in produced water and flowback varies greatly across time and geographic, geological, and operator space. Additionally, relatively non-toxic chemical additives that are degradable may transform into more toxic or more environmentally persistent compounds.

Physical stressors associated with upstream OGD include noise pollution, artificial light at night (ALAN), radioactive materials, induced seismicity, explosions, and fires. Noise near oil and gas sites has been observed at levels associated with annoyance, sleep disturbance, and cardiovascular disease. Studies focused on OGD show that various sensory stimuli, including ALAN, noise, and vibrations from drilling operations, may contribute to psychosocial stress, anxiety, and depression due to changes in quality of life, and to sleep deprivation and poor physical and mental health. Oil and gas development can also introduce naturally occurring

radioactive materials (NORM) to the surface. In addition to physical hazards and safety risks, induced seismicity also contributes to increased psychological responses, including anxiety (Casey et al., 2018), though induced seismicity associated with OGD has not been documented in California.

Finally, the impact of these stressors generally attenuates as distance from the source increases. The degree of attenuation is dependent on the properties of the specific stressor. Therefore, the risks associated with chemical and physical stressors stemming from upstream oil and gas sites may be attenuated by establishing a distance between the oil and gas source and the receptor, whether it be a human receptor or a receptor relevant to human exposure (e.g., a drinking water well). While risk attenuation by distance varies by stressor, all stressors are reduced as the distance between the source and the receptor increases.

References

Abdullah, K., Malloy, T., Stenstrom, M. K., & Suffet, I. H. (2017). Toxicity of acidization fluids used in California oil exploration. *Toxicological and Environmental Chemistry*, *99*(1), 78–94. https://doi.org/10.1080/02772248.2016.1160285

Administration for Community Living. (2019). *2018 Profile of Older Americans*. U.S. Department of Health and Human Services. https://acl.gov/news-and-events/announcements/now-available-2018-profile-older-americans

Agency for Toxic Substances and Disease Registry. (2005). *Public Health Assessment Guidance Manual - Homepage*. https://www.atsdr.cdc.gov/hac/phamanual/pdfs/phagm_final1-27-05.pdf

Allshouse, W. B., McKenzie, L. M., Barton, K., Brindley, S., & Adgate, J. L. (2019). Community Noise and Air Pollution Exposure During the Development of a Multi-Well Oil and Gas Pad. *Environmental Science & Technology*, *53*(12), 7126–7135. https://doi.org/10.1021/acs.est.9b00052

Aronson, D., Boethling, R., Howard, P., & Stiteler, W. (2006). Estimating biodegradation half-lives for use in chemical screening. *Chemosphere*, *63*(11), 1953–1960. https://doi.org/10.1016/j.chemosphere.2005.09.044

Avery, R. C., Wing, S., Marshall, S. W., & Schiffman, S. S. (2004). Odor from industrial hog farming operations and mucosal immune function in neighbors. *Archives of Environmental Health*, *59*(2), 101–108. https://doi.org/10.3200/AEOH.59.2.101-108

Aziz, M., Ali, S. S., Das, S., Younus, A., Malik, R., Latif, M. A., Humayun, C., Anugula, D., Abbas, G., Salami, J., Elizondo, J. V., Veledar, E., & Nasir, K. (2017). Association of Subjective and Objective Sleep Duration as well as Sleep Quality with Non-Invasive Markers of Sub-Clinical Cardiovascular Disease (CVD): A Systematic Review. *Journal of Atherosclerosis and Thrombosis*, *24*(3), 208–226. https://doi.org/10.5551/jat.36194

Banan, Z., & Gernand, J. M. (2018). Evaluation of gas well setback policy in the Marcellus Shale region of Pennsylvania in relation to emissions of fine particulate matter. *Journal of the Air & Waste Management Association*, *68*(9), 988–1000. https://doi.org/10.1080/10962247.2018.1462866

Basner, M., Babisch, W., Davis, A., Brink, M., Clark, C., Janssen, S., & Stansfeld, S. (2014). Auditory and non-auditory effects of noise on health. *The Lancet*, *383*(9925), 1325–1332. https://doi.org/10.1016/S0140-6736(13)61613-X

Basner, M., & McGuire, S. (2018). WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Effects on Sleep. *International Journal of Environmental Research and Public Health*, *15*(3). https://doi.org/10.3390/ijerph15030519

Blair, B. D., McKenzie, L. M., Allshouse, W. B., & Adgate, J. L. (2017). Is reporting "significant damage" transparent? Assessing fire and explosion risk at oil and gas operations in the United States. *Energy Research & Social Science*, *29*, 36–43. https://doi.org/10.1016/j.erss.2017.04.014

Blair, B. D., Brindley, S., Dinkeloo, E., McKenzie, L. M., & Adgate, J. L. (2018). Residential noise from nearby oil and gas well construction and drilling. *Journal of Exposure Science & Environmental Epidemiology*, *28*(6), 538–547. https://doi.org/10.1038/s41370-018-0039-8

Bolden, A. L., Schultz, K., Pelch, K. E., & Kwiatkowski, C. F. (2018). Exploring the endocrine activity of air pollutants associated with unconventional oil and gas extraction. *Environmental Health*, *17*. https://doi.org/10.1186/s12940-018-0368-z

Boslett, A., Hill, E., Ma, L., & Zhang, L. (2021). Rural light pollution from shale gas development and associated sleep and subjective well-being. *Resource and Energy Economics*, *64*, 101220. https://doi.org/10.1016/j.reseneeco.2021.101220

Brager, G., Nero, A., & Tien, C. (1991). Transport and deposition of indoor radon decay products—I. Model development and validation. *Atmospheric Environment. Part B. Urban Atmosphere*, *25*(3), 343–358. https://doi.org/10.1016/0957-1272(91)90006-Z

Brandt, A., Millstein, D., Jin, L., & Englander, J. (2015). Air Quality Impacts from Well Stimulation. In *An Independent Scientific Assessment of Well Stimulation in California*. https://ccst.us/wp-content/uploads/160708-sb4-vol-II-3-1.pdf

Broner, N. (2010). A Simple Criterion for Low Frequency Noise Emission Assessment. *Journal of Low Frequency Noise, Vibration and Active Control*, *29*(1), 1–13. https://doi.org/10.1260/0263-0923.29.1.1

Burgos, W. D., Castillo-Meza, L., Tasker, T. L., Geeza, T. J., Drohan, P. J., Liu, X., Landis, J. D., Blotevogel, J., McLaughlin, M., Borch, T., & Warner, N. R. (2017). Watershed-Scale Impacts from Surface Water Disposal of Oil and Gas Wastewater in Western Pennsylvania. *Environmental Science & Technology, 51*(15), 8851–8860. https://doi.org/10.1021/acs.est.7b01696

Cachia, M., Bouyssiere, B., Carrier, H., Garraud, H., Caumette, G., & Le Hécho, I. (2018). Characterization and comparison of trace metal compositions in natural gas, biogas, and biomethane. *Energy & Fuels, 32*(5), 6397–6400. https://doi.org/10.1021/acs.energyfuels.7b03915

Cal. Assembly Bill 1328 (2017) (Limón, sponsor). Oil and Gas: Wells. https://legiscan.com/CA/text/AB1328/id/1636015

Cal. Pub. Res. Code (P.R.C). § 3160. (2023). https://codes.findlaw.com/ca/public-resources-code/prc-sect-3160/

Cal. Code of Reg. Title 14, § 1788. Required Public Disclosures. https://www.law.cornell.edu/regulations/california/14-CCR-1788

Cal. Senate Bill No. 4 (2013) (Pavley, sponsor). Oil and Gas: Well Stimulation. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB4

CalGEM (California Geologic Energy Management Division). (2019). *Permitting, Forms, and Compliance—Oil and Gas Requirements and Forms—Well Permit Information—Rework/Redrills*. https://www.conservation.ca.gov/calgem/for_operators

CalGEM. (2020). *Management Statutes & Regulations* (testimony of CalGEM). https://www.conservation.ca.gov/index/Documents/CALGEM-SR-1%20Web%20Copy.pdf

CalGEM. (2021). *Well Stimulation Disclosure Database*. https://wellstar-public.conservation.ca.gov/General/Home/PublicLanding

Cappuccio, F. P., Cooper, D., D'Elia, L., Strazzullo, P., & Miller, M. A. (2011). Sleep duration predicts cardiovascular outcomes: A systematic review and meta-analysis of prospective studies. *European Heart Journal*, *32*(12), 1484–1492. https://doi.org/10.1093/eurheartj/ehr007

Cappuccio, F. P., & Miller, M. A. (2017). Sleep and Cardio-Metabolic Disease. *Current Cardiology Reports*, *19*(11), 110. https://doi.org/10.1007/s11886-017-0916-0

CARB (California Air Resources Board). (2019). *SNAPS Lost Hills Mid-Monitoring Update—October 2019*. https://ww2.arb.ca.gov/resources/documents/snaps-lost-hills-mid-monitoring-update-october-2019

CARB. (2020). *What is Ozone?* https://ww2.arb.ca.gov/resources/fact-sheets/what-ozone

CARB. (2021a). *CARB Identified Toxic Air Contaminants*. https://ww2.arb.ca.gov/resources/documents/carb-identified-toxic-air-contaminants

CARB. (2021b). *Summary: Diesel Particulate Matter Health Impacts*. https://ww2.arb.ca.gov/resources/summary-diesel-particulate-matter-health-impacts

Casey, J. A., Goldman-Mellor, S., & Catalano, R. (2018). Association between Oklahoma earthquakes and anxiety-related Google search episodes: *Environmental Epidemiology*, *2*(2), e016. https://doi.org/10.1097/EE9.0000000000000016

CCST, Lawrence Berkeley National Laboratory, & Pacific Institute. (2015). *An Independent Scientific Assessment of Well Stimulation in California, Volume 2*. California Council on Science and Technology. http://ccst.us/projects/hydraulic_fracturing_public/SB4.php

CVRWQCB (Central Valley Regional Water Quality Control Board), Mahoney, J. G., Asami, R. T., & Stringfellow, W. T. (2021). *Draft Food Safety Project White Paper On the Reuse of Oil Field Produced Water for Irrigation of Food Crops In Central Kern County, California*. https://www.waterboards.ca.gov/centralvalley/water_issues/oil_fields/food_safety/data/white_paper/foodsafety_whitepaper.pdf

Chen, C., McCabe, D. C., Fleischman, L. E., & Cohan, D. S. (2022). Black Carbon Emissions and Associated Health Impacts of Gas Flaring in the United States. *Atmosphere*, *13*(3), 385. https://doi.org/10.3390/atmos13030385

Chen, Y., Tsai, P., Wu, J., Guo, Y., & Lin, C. (2018). 0367 Will Daytime Environmental Noise Exposures Induce Nighttime Sleep Disturbance? *Sleep*, *41*(suppl_1), A140–A141. https://doi.org/10.1093/sleep/zsy061.366

Chepesiuk, R. (2009). Missing the Dark: Health Effects of Light Pollution. *Environmental Health Perspectives*, *117*(1), A20–A27. https://doi.org/10.1289/ehp.117-a20

Chilingar, G. V., & Endres, B. (2005). Environmental hazards posed by the Los Angeles Basin urban oilfields: An historical perspective of lessons learned. *Environmental Geology*, *47*(2), 302–317. https://doi.org/10.1007/s00254-004-1159-0

Clark, C., Crumpler, C., & Notley, H. (2020). Evidence for Environmental Noise Effects on Health for the United Kingdom Policy Context: A Systematic Review of the Effects of Environmental Noise on Mental Health, Wellbeing, Quality of Life, Cancer, Dementia, Birth, Reproductive Outcomes, and Cognition. *International Journal of Environmental Research and Public Health*, *17*(2), 393. https://doi.org/10.3390/ijerph17020393

Clark, C. J., Warren, J. L., Kadan-Lottick, N., Ma, X., Bell, M. L., Saiers, J. E., & Deziel, N. C. (2021). Community concern and government response: Identifying socio-economic and demographic predictors of oil and gas complaints and drinking water impairments in Pennsylvania. *Energy Research & Social Science*, *76*, 102070. https://doi.org/10.1016/j.erss.2021.102070

Collier-Oxandale, A., Wong, N., Navarro, S., Johnston, J., & Hannigan, M. (2020). Using gas-phase air quality sensors to disentangle potential sources in a Los Angeles neighborhood. *Atmospheric Environment*, *233*, 117519. https://doi.org/10.1016/j.atmosenv.2020.117519

Colo. Code Reg. § 404-1-437 (2021). *Hydraulic Fracturing Chemical Additives, 2.* https://casetext.com/regulation/colorado-administrative-code/department-400-department-of-natural-resources/division-404-oil-and-gas-conservation-commission/rule-2-ccr-404-1-practice-and-procedure/section-2-ccr-404-1-437-hydraulic-fracturing-chemical-additives

Colo. House Bill 1348 (2022). *Oversight Of Chemicals Used In Oil & Gas.* https://leg.colorado.gov/bills/hb22-1348

DHS (Department of Health Services) Radiologic Health Branch & DOGGR (Department of Conservation Division of Oil, Gas, and Geothermal Resources). (1996). *A Study of NORM Associated with Oil and Gas Production Operations in California*. Sacramento, CA.

Deziel, N.C., Clark, C.J., Casey, J.A., Bell, M.L., Plata, D.L. & Saiers, J.E. (2022). Assessing Exposure to Unconventional Oil and Gas Development: Strengths, Challenges, and Implications for Epidemiologic Research. *Current Environmental Health Reports, (9),* 436–450. https://doi.org/10.1007/s40572-022-00358-4

Domenico, P. A., & Palciauskas, V. V. (1982). Alternative Boundaries in Solid Waste Management. *Groundwater*, *20*(3), 303–311. https://doi.org/10.1111/j.1745-6584.1982.tb01351.x

Domenico, P. A., & Robbins, G. A. (1985). A New Method of Contaminant Plume Analysis. *Groundwater*, *23*(4), 476–485. https://doi.org/10.1111/j.1745-6584.1985.tb01497.x

Drager, L. F., McEvoy, R. D., Barbe, F., Lorenzi-Filho, G., & Redline, S. (2017). Sleep Apnea and Cardiovascular Disease. *Circulation*, *136*(19), 1840–1850. https://doi.org/10.1161/CIRCULATIONAHA.117.029400

Eapi, G. R., Sabnis, M. S., & Sattler, M. L. (2014). Mobile measurement of methane and hydrogen sulfide at natural gas production site fence lines in the Texas Barnett Shale. *Journal of the Air & Waste Management Association*, *64*(8), 927–944. https://doi.org/10.1080/10962247.2014.907098

Fann, N., Baker, K. R., Chan, E. A. W., Eyth, A., Macpherson, A., Miller, E., & Snyder, J. (2018). Assessing Human Health PM2.5 and Ozone Impacts from U.S. Oil and Natural Gas Sector Emissions in 2025. *Environmental Science & Technology*, *52*(15), 8095–8103. https://doi.org/10.1021/acs.est.8b02050

Fernandez, L. S., Byard, D., Lin, C.-C., Benson, S., & Barbera, J. A. (2002). Frail elderly as disaster victims: Emergency management strategies. *Prehospital and Disaster Medicine*, *17*(2), 67–74. https://doi.org/10.1017/s1049023x00000200

Ferrar, K. J., Kriesky, J., Christen, C. L., Marshall, L. P., Malone, S. L., Sharma, R. K., Michanowicz, D. R., & Goldstein, B. D. (2013). Assessment and longitudinal analysis of health impacts and stressors perceived to result from unconventional shale gas development in the Marcellus Shale region. *International Journal of Occupational and Environmental Health*, *19*(2), 104–112. https://doi.org/10.1179/2049396713Y.0000000024

Finnbjornsdottir, R. G., Carlsen, H. K., Thorsteinsson, T., Oudin, A., Lund, S. H., Gislason, T., & Rafnsson, V. (2016). Association between Daily Hydrogen Sulfide Exposure and Incidence of Emergency Hospital Visits: A Population-Based Study. *PLOS ONE*, *11*(5), e0154946. https://doi.org/10.1371/journal.pone.0154946

Fisher, M. P., Mayer, A., Vollet, K., Hill, E. L., & Haynes, E. N. (2018). Psychosocial implications of unconventional natural gas development: Quality of life in Ohio's Guernsey and Noble Counties. *Journal of Environmental Psychology*, *55*, 90–98. https://doi.org/10.1016/j.jenvp.2017.12.008

Fleming, J., C., & Kim, C. (2017). *The Top 12 Air Toxics Used for Neighborhood Oil Drilling in Los Angeles: Danger Next Door.* Center for Biological Diversity. https://www.biologicaldiversity.org/publications/papers/DangerNextDoor.pdf

Goebel, T., Hauksson, E., Aminzadeh, F., & Ampuero, J.-P. (2015). An objective method for the assessment of fluid injection-induced seismicity and application to tectonically active regions in central California. *Journal of Geophysical Research: Solid Earth*, *120*(10), 7013–7032. https://doi.org/10.1002/2015JB011895

Goebel, T. H., & Shirzaei, M. (2021). More Than 40 yr of Potentially Induced Seismicity Close to the San Andreas Fault in San Ardo, Central California. *Seismological Society of America*, *92*(1), 187–198. https://doi.org/10.1785/0220200276

Gouin, T., & Harner, T. (2003). Modelling the environmental fate of the polybrominated diphenyl ethers. *Environmental International*, *29*(6), 717–724. https://doi.org/10.1016/S0160-4120(03)00116-8

Groundwater Protection Council, & Interstate Oil and Gas Compact Commission. (2019). *FracFocus Chemical Disclosure Registry*. http://fracfocus.org

Hahad, O., Kröller-Schön, S., Daiber, A., & Münzel, T. (2019). The Cardiovascular Effects of Noise. *Deutsches Ärzteblatt International*, *116*(14), 245–250. https://doi.org/10.3238/arztebl.2019.0245

Haley, M., McCawley, M., Epstein, A. C., Arrington, B., & Bjerke, E. F. (2016). Adequacy of Current State Setbacks for Directional High-Volume Hydraulic Fracturing in the Marcellus, Barnett, and Niobrara Shale Plays. *Environmental Health Perspectives*, *124*(9), 1323–1333. https://doi.org/10.1289/ehp.1510547

Halonen Jaana I., Vahtera Jussi, Stansfeld Stephen, Yli-Tuomi Tarja, Salo Paula, Pentti Jaana, Kivimäki Mika, & Lanki Timo. (2012). Associations between Nighttime Traffic Noise and Sleep: The Finnish Public Sector Study. *Environmental Health Perspectives*, *120*(10), 1391–1396. https://doi.org/10.1289/ehp.1205026

Harkness, J. S., Dwyer, G. S., Warner, N. R., Parker, K. M., Mitch, W. A., & Vengosh, A. (2015). Iodide, Bromide, and Ammonium in Hydraulic Fracturing and Oil and Gas Wastewaters: Environmental Implications. *Environmental Science & Technology, (49)*3, 1955–1963. https://doi.org/10.1021/es504654n

Hays, J., McCawley, M., & Shonkoff, S. B. C. (2017). Public health implications of environmental noise associated with unconventional oil and gas development. *Science of The Total Environment*, *580*, 448–456. https://doi.org/10.1016/j.scitotenv.2016.11.118

Heaney, C. D., Wing, S., Campbell, R. L., Caldwell, D., Hopkins, B., Richardson, D., & Yeatts, K. (2011). Relation between malodor, ambient hydrogen sulfide, and health in a community bordering a landfill. *Environmental Research*, *111*(6), 847–852. https://doi.org/10.1016/j.envres.2011.05.021

Hill, L. L., Czolowski, E. D., DiGiulio, D., & Shonkoff, S. B. C. (2019). Temporal and spatial trends of conventional and unconventional oil and gas waste management in Pennsylvania, 1991–2017. *Science of The Total Environment*, *674*, 623–636. https://doi.org/10.1016/j.scitotenv.2019.03.475

Hladik, M. L., Focazio, M. J., & Engle, M. (2014). Discharges of produced waters from oil and gas extraction via wastewater treatment plants are sources of disinfection by-products to receiving streams. *Science of The Total Environment*, *466–467*, 1085–1093. https://doi.org/10.1016/j.scitotenv.2013.08.008

Horton, R. A., Wing, S., Marshall, S. W., & Brownley, K. A. (2009). Malodor as a Trigger of Stress and Negative Mood in Neighbors of Industrial Hog Operations. *American Journal of Public Health*, *99*(Suppl 3), S610–S615. https://doi.org/10.2105/AJPH.2008.148924

Hume, K. I., Brink, M., & Basner, M. (2012). Effects of environmental noise on sleep. *Noise and Health*, *14*(61), 297. https://doi.org/10.4103/1463-1741.104897

IPCS (International Programme on Chemical Safety). 2004. IPCS Risk Assessment Terminology Part 1: IPCS/OECD Key Generic Terms used in Chemical Hazard/Risk Assessment and Part 2: IPCS Glossary of Key Exposure Assessment Terminology. https://www.inchem.org/documents/harmproj/harmproj/harmproj1.pdf

Itani, O., Jike, M., Watanabe, N., & Kaneita, Y. (2017). Short sleep duration and health outcomes: A systematic review, meta-analysis, and meta-regression. *Sleep Medicine*, *32*, 246–256. https://doi.org/10.1016/j.sleep.2016.08.006

Jaakkola, J. J., Paunio, M., Virtanen, M., & Heinonen, O. P. (1991). Low-level air pollution and upper respiratory infections in children. *American Journal of Public Health*, *81*(8), 1060–1063. https://doi.org/10.2105/AJPH.81.8.1060

Jackson, R. B., Vengosh, A., Carey, J. W., Davies, R. J., Darrah, T. H., O'Sullivan, F., & Pétron, G. (2014). The Environmental Costs and Benefits of Fracking. *Annual Review of Environment and Resources*, *39*(1), 327–362. https://doi.org/10.1146/annurev-environ-031113-144051

Javaheri, S., & Redline, S. (2017). Insomnia and Risk of Cardiovascular Disease. *Chest*, *152*(2), 435–444. https://doi.org/10.1016/j.chest.2017.01.026

Jike, M., Itani, O., Watanabe, N., Buysse, D. J., & Kaneita, Y. (2018). Long sleep duration and health outcomes: A systematic review, meta-analysis and meta-regression. *Sleep Medicine Reviews*, *39*, 25–36. https://doi.org/10.1016/j.smrv.2017.06.011

Jirka, G. H., & Weitbrecht, V. (2005). Mixing Models for Water Quality Management in Rivers: Continuous and Instantaneous Pollutant Releases. In *Water Quality Hazards and Dispersion of Pollutants*. https://doi.org/10.1007/0-387-23322-9_1

Johnson, D., Heltzel, R., Nix, A., Darzi, M., & Oliver, D. (2018). Estimated Emissions from the Prime-Movers of Unconventional Natural Gas Well Development Using Recently Collected In-Use Data in the United States. *Environmental Science & Technology*, *52*(9), 5499–5508. https://doi.org/10.1021/acs.est.7b06694

Kahrilas, G. A., Blotevogel, J., Stewart, P. S., & Borch, T. (2015). Biocides in Hydraulic Fracturing Fluids: A Critical Review of Their Usage, Mobility, Degradation, and Toxicity. *Environmental Science & Technology*, *49*(1), 16–32. https://doi.org/10.1021/es503724k

Kahrilas, G. A., Blotevogel, J., Corrin, E. R., & Borch, T. (2016). Downhole Transformation of the Hydraulic Fracturing Fluid Biocide Glutaraldehyde: Implications for Flowback and Produced Water Quality. *Environmental Science & Technology*, *50*(20), 11414–11423. https://doi.org/10.1021/acs.est.6b02881

Kempen, E. van, Casas, M., Pershagen, G., & Foraster, M. (2018). WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Cardiovascular and Metabolic Effects: A Summary. *International Journal of Environmental Research and Public Health*, *15*(2), 379. https://doi.org/10.3390/ijerph15020379

Khan, M. S., & Aouad, R. (2017). The Effects of Insomnia and Sleep Loss on Cardiovascular Disease. *Sleep Medicine Clinics*, *12*(2), 167–177. https://doi.org/10.1016/j.jsmc.2017.01.005

Kim, J. H., Hayek, S. S., Ko, Y.-A., Liu, C., Samman Tahhan, A., Ali, S., Alkhoder, A., Gafeer, M. M., Choudhary, F., Bhimani, R., Delawalla, S., Choudhary, M., Hartsfield, D. J., Bliwise, D. L., & Quyyumi, A. A. (2019). Sleep Duration and Mortality in Patients With Coronary Artery Disease. *The American Journal of Cardiology*, *123*(6), 874–881. https://doi.org/10.1016/j.amjcard.2018.11.057

Knutson, K. L. (2010). Sleep duration and cardiometabolic risk: A review of the epidemiologic evidence. *Best Practice & Research Clinical Endocrinology & Metabolism*, *24*(5), 731–743. https://doi.org/10.1016/j.beem.2010.07.001

Kortenkamp, A., Faust, M., Scholze, M., & Backhaus, T. (2007). Low-Level Exposure to Multiple Chemicals: Reason for Human Health Concerns? *Environmental Health Perspectives*, *115*(Suppl 1), 106–114. https://doi.org/10.1289/ehp.9358

Krzyzanowski, J. (2012). Environmental pathways of potential impacts to human health from oil and gas development in northeast British Columbia, Canada. *Environmental Reviews*, *20*(2), 122–134. https://doi.org/10.1139/a2012-005

LACDPH (Los Angeles County Department of Public Health). (2018). *Public Health and Safety Risks of Oil and Gas Facilities in Los Angeles County*. http://publichealth.lacounty.gov/eh/docs/ph_oilgasfacilitiesphsafetyrisks.pdf

Lamancusa, J. S. (2000). *The Physics of Noise. Course Materials published for ME 458: Engineering Noise Control, Pennsylvania State University.*

Lamancusa, J. S. (2002). *Vibration Isolation. Course Materials published for ME 458: Engineering Noise Control, Pennsylvania State University.*

Lamancusa, J. S. (2009). *Outdoor Sound Propagation. Course Materials published for ME 458: Engineering Noise Control, Pennsylvania State University.*

Lauer, N. E., Warner, N. R., & Vengosh, A. (2018). Sources of Radium Accumulation in Stream Sediments near Disposal Sites in Pennsylvania: Implications for Disposal of Conventional Oil and Gas Wastewater. *Environmental Science & Technology*, *52*(3), 955–962. https://doi.org/10.1021/acs.est.7b04952

Leeuwen, C. J. van, & Vermeire, T. G. (2007). *Risk Assessment of Chemicals: An Introduction*. Springer Science & Business Media. https://link.springer.com/book/10.1007/978-1-4020-6102-8

Li, L., Blomberg, A. J., Spengler, J. D., Coull, B. A., Schwartz, J. D., & Koutrakis, P. (2020). Unconventional oil and gas development and ambient particle radioactivity. *Nature Communications*, *11*(1), 5002. https://doi.org/10.1038/s41467-020-18226-w

Li, W., Nyhan, M. M., Wilker, E. H., Vieira, C. L., Lin, H., Schwartz, J. D., Gold, D. R., Coull, B. A., Aba, A. M., Benjamin, E. J., & others. (2018). Recent exposure to particle radioactivity and biomarkers of oxidative stress and inflammation: The Framingham Heart Study. *Environment International*, *121*, 1210–1216. https://doi.org/10.1016/j.envint.2018.10.039

Liberatore, H. K., Plewa, M. J., Wagner, E. D., VanBriesen, J. M., Burnett, D. B., Cizmas, L. H., & Richardson, S. D. (2017). Identification and Comparative Mammalian Cell Cytotoxicity of New Iodo-Phenolic Disinfection Byproducts in Chloraminated Oil and Gas Wastewaters. *Environmental Science & Technology Letters*, *4*(11), 475–480. https://doi.org/10.1021/acs.estlett.7b00468

Lillis, P., Warden, A., Claypool, G., & Magoon, L. (2007). Chapter 10: Petroleum Systems of the San Joaquin Basin Province—Geochemical Characteristics of Gas Types. In *USGS Professional Paper 1713; Petroleum Systems and Geologic Assessment of Oil and Gas in the San Joaquin Basin Province, California*. https://pubs.usgs.gov/pp/pp1713/10/pp1713_ch10.pdf

Long, J. C. S., Birkholzer, J. T., & Feinstein, L. C. (2015). *An Independent Scientific Assessment of Well Stimulation in California: Executive Summary—An Examination of Hydraulic Fracturing and Acid Stimulations in the Oil and Gas Industry Volume I*. https://ccst.us/reports/an-independent-scientific-assessment-of-well-stimulation-in-california-volume-1/

Lord, C. J. (1991). Determination of trace metals in crude oil by inductively coupled plasma mass spectrometry with microemulsion sample introduction. *Analytical Chemistry*, *63*(15), 1594–1599. https://doi.org/10.1021/ac00015a018

Lunsford-Avery, J. R., Engelhard, M. M., Navar, A. M., & Kollins, S. H. (2018). Validation of the Sleep Regularity Index in Older Adults and Associations with Cardiometabolic Risk. *Scientific Reports*, *8*(1), 14158. https://doi.org/10.1038/s41598-018-32402-5

Macey, G. P., Breech, R., Chernaik, M., Cox, C., Larson, D., Thomas, D., & Carpenter, D. O. (2014). Air concentrations of volatile compounds near oil and gas production: A community-based exploratory study. *Environmental Health*, *13*(1), 82. https://doi.org/10.1186/1476-069X-13-82

Martin, D. O. (1976). Comment On"The Change of Concentration Standard Deviations with Distance". *Journal of the Air Pollution Control Association*, *26*(2), 145–147. https://doi.org/10.1080/00022470.1976.10470238

McCawley, M. (2013). *Air, noise, and light monitoring results for assessing environmental impacts of horizontal gas well drilling operations (ETD-10-project)*. West Virginia Department of Environmental Protection. https://dep.wv.gov/oil-and-gas/Documents/OOG%20studies%20update%20and%20minimization%20strategies%20Chakrabarty%20Oct.%2030,%202013.pdf

McCawley, M. (2015). Air Contaminants Associated with Potential Respiratory Effects from Unconventional Resource Development Activities. *Seminars in Respiratory and Critical Care Medicine*, *36*(3), 379–387. https://doi.org/10.1055/s-0035-1549453

McClure, M., Gibson, R., Chiu, K.-K., & Ranganath, R. (2017). Identifying potentially induced seismicity and assessing statistical significance in Oklahoma and California. *Journal of Geophysical Research: Solid Earth*, *122*(3), 2153–2172. https://doi.org/10.1002/2016JB013711

Meyer, M. A. (2017). Elderly Perceptions of Social Capital and Age-Related Disaster Vulnerability. *Disaster Medicine and Public Health Preparedness*, *11*(1), 48–55. https://doi.org/10.1017/dmp.2016.139

Miedema, H. M. E., & Vos, H. (2007). Associations Between Self-Reported Sleep Disturbance and Environmental Noise Based on Reanalyses of Pooled Data From 24 Studies. *Behavioral Sleep Medicine*, *5*(1), 1–20. https://doi.org/10.1207/s15402010bsm0501_1

MRS Environmental. (2017). *Los Angeles Oil and Gas Strike Team Oil and Gas Facility Compliance Review Project*. Prepared for the County of Los Angeles. https://planning.lacounty.gov/wp-content/uploads/2022/10/Final_Phase_I_Report.zip

National Cancer Institute. (2019, January 14). *Cancer-Causing Substances—Benzene*. https://www.cancer.gov/about-cancer/causes-prevention/risk/substances/benzene

National Research Council (US) Committee on Acute Exposure Guideline Levels. (2010). *Acute Exposure Guideline Levels for Selected Airborne Chemicals: Volume 9*. National Academies Press. http://www.ncbi.nlm.nih.gov/books/NBK208162/

Ngo, E. B. (2001). When Disasters and Age Collide: Reviewing Vulnerability of the Elderly. *Natural Hazards Review*, *2*(2), 80–89. https://doi.org/10.1061/(ASCE)1527-6988(2001)2:2(80)

Nicholls, K. (2009). Estimating the potential impact of cable percussion piling—Technical note. *Ground Engineering*, 44–45. https://cdn.ca.emap.com/wp-content/uploads/sites/9/2009/10/GE-Oct-2009-Estimating-the-potential-impact-of-cable-percussion-piling-Nicholls.pdf

NRC (National Research Council). (2012). *Exposure Science in the 21st Century: A Vision and a Strategy*. Committee on Acute Exposure Guideline Levels. https://doi.org/10.17226/13507

Nyhan, M. M., Coull, B. A., Blomberg, A. J., Vieira, C. L., Garshick, E., Aba, A., Vokonas, P., Gold, D. R., Schwartz, J., & Koutrakis, P. (2018). Associations between ambient particle radioactivity and blood pressure: The NAS (Normative Aging Study). *Journal of the American Heart Association*, *7*(6), e008245. https://doi.org/10.1161/jaha.117.008245

Nyhan, M. M., Rice, M., Blomberg, A., Coull, B. A., Garshick, E., Vokonas, P., Schwartz, J., Gold, D. R., & Koutrakis, P. (2019). Associations between ambient particle radioactivity and lung function. *Environment International*, *130*, 104795. https://doi.org/10.1016/j.envint.2019.04.066

N.Y. Senate Bill S3392 (2020, August 3). https://www.nysenate.gov/legislation/bills/2019/s3392

OEHHA (Office of Environmental Health Hazard Assessment). (2019, November). *Acute, 8-hour and Chronic Reference Exposure Level (REL) Summary*. https://oehha.ca.gov/air/general-info/oehha-acute-8-hour-and-chronic-reference-exposure-level-rel-summary

OEHHA. (2022). Proposition 65. https://oehha.ca.gov/proposition-65

OSHA (Occupational Safety and Health Administration). (n.d.). *Hydrogen Sulfide—Hazards*. Retrieved July 12, 2022, from https://www.osha.gov/hydrogen-sulfide/hazards

OSHA. (2005). *OSHA Fact Sheet—Hydrogen Sulfide (H2S)* (DSG 10/2005; p. 2). U.S. Department of Labor. https://www.osha.gov/sites/default/files/publications/hydrogen_sulfide_fact.pdf

Park, M. J., Yoo, J. H., Cho, B. W., Kim, K. T., Jeong, W.-C., & Ha, M. (2014). Noise in hospital rooms and sleep disturbance in hospitalized medical patients. *Environmental Health and Toxicology*, *29*, e2014006. https://doi.org/10.5620/eht.2014.29.e2014006

Parker, K. M., Zeng, T., Harkness, J., Vengosh, A., & Mitch, W. A. (2014). Enhanced Formation of Disinfection By-Products in Shale Gas Wastewater-Impacted Drinking Water Supplies. *Environmental Science & Technology*, *48*(19), 11161–11169. https://doi.org/10.1021/es5028184

Perry, S. L. (2013). Using Ethnography to Monitor the Community Health Implications of Onshore Unconventional Oil and Gas Developments: Examples from Pennsylvania's Marcellus Shale. *NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy*, *23*(1), 33–53. https://doi.org/10.2190/NS.23.1.d

Pipeline Abandonment Steering Committee. (1996). *Pipeline Abandonment—A Discussion Paper on Technical and Environmental Issues*. Pipeline Abandonment Steering Committee. https://www.cer-rec.gc.ca/en/applications-hearings/pipeline-abandonment/pipeline-abandonment-discussion-paper-technical-environmental-issues.html#a1

Piper, D. Z., & Isaacs, C. M. (1995). *Geochemistry of minor elements in the Monterey Formation, California: Seawater chemistry of deposition*. https://pubs.usgs.gov/publication/pp1566

Puskar, J. R. (2014). Fires & Explosions in the Fracking World—Where, Why, & How to Minimize Risks. Paper presented at the ASSE Professional Development Conference and Exposition, Dallas, TX. https://onepetro.org/ASSPPDCE/proceedings-abstract/ASSE15/All-ASSE15/ASSE-15-769/76998

Qiu, W. Q., Dean, M., Liu, T., George, L., Gann, M., Cohen, J., & Bruce, M. L. (2010). Physical and mental health of homebound older adults: An overlooked population. *Journal of the American Geriatrics Society*, *58*(12), 2423–2428. https://doi.org/10.1111/j.1532-5415.2010.03161.x

Radtke, C., Autenrieth, D. A., Lipsey, T., & Brazile, W. J. (2017). Noise characterization of oil and gas operations. *Journal of Occupational and Environmental Hygiene*, *14*(8), 659–667. https://doi.org/10.1080/15459624.2017.1316386

Reiffenstein, R. J., Hulbert, W. C., & Roth, S. H. (1992). Toxicology of hydrogen sulfide. *Annual Review of Pharmacology and Toxicology*, *32*, 109–134. https://doi.org/10.1146/annurev.pa.32.040192.000545

Rogers, J. D., Burke, T. L., Osborn, S. G., & Ryan, J. N. (2015). A Framework for Identifying Organic Compounds of Concern in Hydraulic Fracturing Fluids Based on Their Mobility and Persistence in Groundwater. *Environmental Science & Technology Letters*, *2*(6), 158–164. https://doi.org/10.1021/acs.estlett.5b00090

Rücker, C., & Kümmerer, K. (2012). Modeling and predicting aquatic aerobic biodegradation – a review from a user's perspective. *Green Chemistry*, *14*, 875–887. https://doi.org/DOI: 10.1039/c2gc16267a

Sahagun, L. (2013a, September 21). Chemical odor, kids' nosebleeds, few answers in South L.A. neighborhood. *Los Angeles Times*. https://www.latimes.com/local/la-me-0922-oil-20130922-story.html

Sahagun, L. (2013b, November 9). EPA officers sickened by fumes at South L.A. oil field. *Los Angeles Times*. https://www.latimes.com/local/la-me-1109-fumes-20131109-story.html

SCAQMD (South Coast Air Quality Management District). (2015a). *Rule 1148.2 Notification and Reporting Requirements for Oil and Gas Wells and Chemical Suppliers*. http://www.aqmd.gov/docs/default-source/rule-book/reg-xi/rule-1148-2.pdf?sfvrsn=6

SCAQMD. (2015b). *Rule 1148.1 – Oil and Gas Production Wells*. http://www.aqmd.gov/docs/default-source/rule-book/reg-xi/rule-1148-1.pdf

SCAQMD. (2018). *Jurisdiction*. https://www.aqmd.gov/nav/about/jurisdiction

SCAQMD. (2021). *Smoke, Dust, Odor*. Reporting Odor Nuisances. http://www.aqmd.gov/home/air-quality/complaints/smoke-dust-odor

Schade, G. W., & Roest, G. (2018). Source apportionment of non-methane hydrocarbons, NO_x and H_2S data from a central monitoring station in the Eagle Ford shale, Texas. *Elementa: Science of the Anthropocene*, *6*(1), 35. https://doi.org/10.1525/elementa.289

Scheringer, M., MacLeod, M., & Wegmann, F. (2006). *Analysis of Four Current POP Candidates with the OECD Pov and LRTP Screening Tool*. ETH Zürich, Institute for Chemical and Bioengineering. https://ethz.ch/content/dam/ethz/special-interest/chab/icb/set-dam/documents/downloads/POP-Candidates-OECD-Tool.pdf

Scheringer, M. (2010). *Procedure for estimating chemical properties and chemical concentrations in different media of an environmental fate model*. ETH Zürich, Institute for Chemical and Bioengineering. http://www.ipcp.ethz.ch/Armenia/Using_EpiSuite_and_Box_Models.pdf

Schiffman, S. S., Miller, E. A., Suggs, M. S., & Graham, B. G. (1995). The effect of environmental odors emanating from commercial swine operations on the mood of nearby residents. *Brain Research Bulletin*, *37*(4), 369–375. https://doi.org/10.1016/0361-9230(95)00015-1

Schiffman, S. S., Studwell, C. E., Landerman, L. R., Berman, K., & Sundy, J. S. (2005). Symptomatic Effects of Exposure to Diluted Air Sampled from a Swine Confinement Atmosphere on Healthy Human Subjects. *Environmental Health Perspectives*, *113*(5), 567–576. https://doi.org/10.1289/ehp.6814

Schmidt F. P., Basner M., Kröger G., Weck S., Schnorbus B., Muttray A., et al. (2013). Effect of nighttime aircraft noise exposure on endothelial function and stress hormone release in healthy adults. *European Heart Journal 34:3508-3514a*. https://doi.org/10.1093/eurheartj/eht269

Schmidt F., Kolle K., Kreuder K., Schnorbus B., Wild P., Hechtner M., et al. (2015). Nighttime aircraft noise impairs endothelial function and increases blood pressure in patients with or at high risk for coronary artery disease. *Clinical Research in Cardiology 104, 23-30*. https://doi.org/10.1007%2Fs00392-014-0751-x

Schreiber, M. E., & Cozzarelli, I. M. (2021). Arsenic release to the environment from hydrocarbon production, storage, transportation, use and waste management. *Journal of Hazardous Materials*, 411, 125013. https://doi.org/10.1016/j.jhazmat.2020.125013

Schubert, M., Hegewald, J., Freiberg, A., Starke, K. R., Augustin, F., Riedel-Heller, S. G., Zeeb, H., & Seidler, A. (2019). Behavioral and Emotional Disorders and Transportation Noise among Children and Adolescents: A Systematic Review and Meta-Analysis. *International Journal of Environmental Research and Public Health*, *16*(18), 3336. https://doi.org/10.3390/ijerph16183336

Schultz, R., & Wang, R. (2020). Newly emerging cases of hydraulic fracturing induced seismicity in the Duvernay East Shale Basin. *Tectonophysics*, *779*, 228393. https://doi.org/10.1016/j.tecto.2020.228393

Shonkoff, S. B. C., Stringfellow, W. T., & Domen, J. K. (2016). *Preliminary Hazard Assessment of Chemical Additives Used in Oil and Gas Fields that Reuse Their Produced Water for Agricultural Irrigation in The San Joaquin Valley of California*. PSE Healthy Energy, Inc. https://www.psehealthyenergy.org/wp-content/uploads/2022/11/Preliminary_Results_13267_Disclosures_FINAL-1.pdf

Shonkoff, S. B. C., Domen, J. K., & Hill, L. L. (2019). *Human health and oil and gas development: An assessment of chemical usage in oil and gas activities in the Los Angeles Basin and the City of Los Angeles*. PSE Healthy Energy, Inc. https://www.psehealthyenergy.org/wp-content/uploads/2022/08/Chemical-Assessment.pdf

Shonkoff, S. B. C., Hill, L. L., & Domen, J. K. (2021). California Produced Water Quality: Implications for Human Health and the Environment. In *Assessment of Oil and Gas Water Cycle Reporting in California. Evaluation of Data Collected Pursuant to California Senate Bill 1281, Phase II Report*. California Council on Science and Technology. https://ccst.us/wp-content/uploads/CCST-SB-1281-Phase-II-Full-Report-FINAL.pdf

Skoumal, R. J., Ries, R., Brudzinski, M. R., Barbour, A. J., & Currie, B. S. (2018). Earthquakes Induced by Hydraulic Fracturing Are Pervasive in Oklahoma. *Journal of Geophysical Research-Solid Earth*, *123*(12), 10918–10935. https://doi.org/10.1029/2018JB016790

Soriano, M. A., Siegel, H. G., Gutchess, K. M., Clark, C. J., Li, Y., Xiong, B., Plata, D. L., Deziel, N. C., & Saiers, J. E. (2020). Evaluating Domestic Well Vulnerability to Contamination From Unconventional Oil and Gas Development Sites. *Water Resources Research*, *56*(10), e2020WR028005. https://doi.org/10.1029/2020WR028005

St-Onge, M.-P., Grandner, M. A., Brown, D., Conroy, M. B., Jean-Louis, G., Coons, M., Bhatt, D. L., & American Heart Association Obesity, Behavior Change, Diabetes, and Nutrition Committees of the Council on Lifestyle and Cardiometabolic Health; Council on Cardiovascular Disease in the Young; Council on Clinical Cardiology; and Stroke Council. (2016). Sleep Duration and Quality: Impact on Lifestyle Behaviors and Cardiometabolic Health: A Scientific Statement From the American Heart Association. *Circulation*, *134*(18), e367–e386. https://doi.org/10.1161/CIR.0000000000000444

Stringfellow, W. T., Camarillo, M. K., Domen, J. K., Sandelin, W. L., Varadharajan, C., Jordan, P. D., Reagan, M. T., Cooley, H., Heberger, M. G., & Birkholzer, J. T. (2017). Identifying chemicals of concern in hydraulic fracturing fluids used for oil production. *Environmental Pollution*, *220*, 413–420. https://doi.org/10.1016/j.envpol.2016.09.082

Stringfellow, W. T., Camarillo, M. K., Domen, J. K., & Shonkoff, S. B. C. (2017). Comparison of chemical-use between hydraulic fracturing, acidizing, and routine oil and gas

development. *PLOS ONE*, *12*(4), e0175344. https://doi.org/10.1371%2Fjournal.pone.0175344

Sühring, R., Scheringer, M., Rodgers, T., Jantunen, L., & Diamond, M. (2020). Evaluation of the OECD POV and LRTP screening tool for estimating the long-range transport of organophosphate esters. *Environmental Science Processes & Impacts*, *20*, 207. https://pubs.rsc.org/en/content/articlelanding/2020/em/c9em00410f#!divAbstract

Sumner, A. J., & Plata, D. L. (2019). Oxidative breakers can stimulate halogenation and competitive oxidation in guar-gelled hydraulic fracturing fluids. *Environmental Science & Technology*, *53*(14), 8216–8226. https://doi.org/10.1021/acs.est.9b01896

SWRCB (California State Water Resources Control Board). (2020). *MCLs, DLRs, PHGs, for Regulated Drinking Water Contaminants*. https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/mclreview/mcls_dlrs_phgs.pdf

TCEQ (Texas Commission on Environmental Quality). (2015). *TCEQ Guidelines to Develop Toxicity Factors* (RG-442). https://www.tceq.texas.gov/downloads/toxicology/publications/rg-442.pdf

TCEQ. (2018). *Texas Air Monitoring Information System (TAMIS) database*. https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=report.main

Teuschler, L. K., & Hertzberg, R. C. (1995). Current and future risk assessment guidelines, policy, and methods development for chemical mixtures. *Toxicology*, *105*(2–3), 137–144. https://doi.org/10.1016/0300-483x(95)03207-v

Touitou, Y., Reinberg, A., & Touitou, D. (2017). Association between light at night, melatonin secretion, sleep deprivation, and the internal clock: Health impacts and mechanisms of circadian disruption. *Life Sciences*, *173*, 94–106. https://doi.org/10.1016/j.lfs.2017.02.008

Trickey, K., Hadjimichael, N., & Sanghavi, P. (2020). Public reporting of hydraulic fracturing chemicals in the USA, 2011–18: A before and after comparison of reporting formats. *The Lancet Planetary Health*, *4*(5), e178–e185. https://doi.org/10.1016/S2542-5196(20)30076-0

Truty, A., Pilecki, Z., Stypula, K., Wiśniowski, R., Koziol, K., & Streyczek, S. (2019). Assessment of Ground Vibrations Inducted by Gas and Oil Well Drilling Using Numerical Simulations. *Archives of Mining Sciences*, *64*(2), 447–461. http://dx.doi.org/10.24425/ams.2019.128694

Turner, D. B. (1970). *Workbook of Atmospheric Dispersion Estimates*. Office of Air Programs, U.S. Environmental Protection Agency. https://nepis.epa.gov/Exe/ZyNET.exe/9101GKEZ.TXT?ZyActionD=ZyDocument&Client=EPA&Index=Prior+to+1976&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&

United Nations. (2021). *Globally Harmonized System of Classification and Labelling of Chemicals (GHS) Ninth Revised Edition.* ST/SG/AC.10/30/Rev.9. https://unece.org/transport/standards/transport/dangerous-goods/ghs-rev9-2021

US Bureau of Labor Statistics. (2019). *American Time Use Survey—2018 Results*. https://www.bls.gov/tus/

US EPA (U.S. Environmental Protection Agency). (1985). *Development of Statistical Distributions or Ranges of Standard Factors Used in Exposure Assessments*. Office of Health and Environmental Assessment, US EPA/600/8-85/010. https://nepis.epa.gov/Exe/ZyNET.exe/91007IEM.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1981+Thru+1985&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=

US EPA. (2000a). *Evaluation of EPA's Guidelines for Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM),* EPA 402-R-00-01. https://www.epa.gov/sites/production/files/2015-04/documents/402-r-00-001.pdf

US EPA. (2000b). *Radionuclides (including Radon, Radium and Uranium)*. https://www.epa.gov/sites/default/files/2016-09/documents/radionuclides.pdf

US EPA. (2002). *Exemption of Oil and Gas Exploration and Production Wastes from Federal Hazardous Waste Regulations*. 41. https://yosemite.epa.gov/oa/eab_web_docket.nsf/Attachments%20By%20ParentFilingId/945EF425FA4A9B4F85257E2800480C65/$FILE/28%20-%20RCRA%20E%26P%20Exemption.pdf

US EPA. (2014). *Permitting Guidance for Oil and Gas Hydraulic Fracturing Activities Using Diesel Fuels: Underground Injection Control Program Guidance #84* (EPA 816-R-14-001). https://www.epa.gov/sites/production/files/2015-05/documents/revised_dfhf_guid_816r14001.pdf

US EPA. (2015). *Health Effects of Ozone Pollution*. https://www.epa.gov/ground-level-ozone-pollution/health-effects-ozone-pollution

US EPA. (2016). *Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States (Final Report)*, EPA-600-R-16-236. https://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=332990

US EPA. (2017). *Memorandum: Review of Diesel Fuels Hydraulic Fracturing Permitting and Oversight in Response to Office of the Inspector General Recommendations*. https://www.epa.gov/sites/production/files/2017-03/documents/thompkins_to_wd_oig_report.pdf

US EPA. (2022a). *TENORM: Oil and Gas Production Wastes*. https://www.epa.gov/radiation/tenorm-oil-and-gas-production-wastesvan

US EPA. (2022b). *Radiation Health Effects*. https://www.epa.gov/radiation/radiation-health-effects

USGS (U.S. Geological Survey). (2019). *Linking Selenium Sources to Ecosystems: Refining*. https://www.usgs.gov/mission-areas/water-resources/science/linking-selenium-sources-ecosystems-refining#overview

Walker, W. H., Bumgarner, J. R., Walton, J. C., Liu, J. A., Meléndez-Fernández, O. H., Nelson, R. J., & DeVries, A. C. (2020). Light Pollution and Cancer. *International Journal of Molecular Sciences*, *21*(24), 9360. https://doi.org/10.3390/ijms21249360

Wang, B., Harrington, R. M., Liu, Y., Kao, H., & Yu, H. (2020). A Study on the Largest Hydraulic-Fracturing-Induced Earthquake in Canada: Observations and Static Stress-Drop Estimation. *Bulletin of the Seismological Society of America*, *110*(5), 2283–2294. https://doi.org/10.1785/0120190261

Wania, F., & Dugani, C. (2003). Assessing the long-range transport potential of polybrominated diphenyl ethers: A comparison of four multimedia models. *Environmental Toxicology and Chemistry*, *22*(6), 1252–1261. https://pubmed.ncbi.nlm.nih.gov/12785581/

Waxman, H. A., Markey, E. J., & DeGette, D. (2011). https://fossil.energy.gov/app/DocketIndex/docket/DownloadFile/142

Weyant, C. L., Shepson, P. B., Subramanian, R., Cambaliza, M. O. L., Heimburger, A., McCabe, D., Baum, E., Stirm, B. H., & Bond, T. C. (2016). Black carbon emissions from associated natural gas flaring. *Environmental Science & Technology*, *50*(4), 2075–2081. https://doi.org/10.1021/acs.est.5b04712

Weyde, K. V., Krog, N. H., Oftedal, B., Evandt, J., Magnus, P., Øverland, S., Clark, C., Stansfeld, S., & Aasvang, G. M. (2017a). Nocturnal Road Traffic Noise Exposure and Children's Sleep Duration and Sleep Problems. *International Journal of Environmental Research and Public Health*, *14*(5), 491. https://doi.org/10.3390/ijerph14050491

Weyde, K. V., Krog, N. H., Oftedal, B., Magnus, P., Øverland, S., Stansfeld, S., Nieuwenhuijsen, M. J., Vrijheid, M., de Castro Pascual, M., & Aasvang, G. M. (2017b). Road traffic noise and children's inattention. *Environmental Health*, *16*(1), 127. https://doi.org/10.1186/s12940-017-0337-y

Wilkinson, C. F., Christoph, G. R., Julien, E., Kelley, J. M., Kronenberg, J., McCarthy, J., & Reiss, R. (2000). Assessing the risks of exposures to multiple chemicals with a common mechanism of toxicity: How to cumulate? *Regulatory Toxicology and Pharmacology: RTP*, *31*(1), 30–43. https://doi.org/10.1006/rtph.1999.1361

Witter, R. Z., McKenzie, L., Stinson, K. E., Scott, K., Newman, L. S., & Adgate, J. (2013). The Use of Health Impact Assessment for a Community Undergoing Natural Gas Development. *American Journal of Public Health*, *103*(6), 1002–1010. https://doi.org/10.2105/AJPH.2012.301017

World Health Organization. (2018). *Environmental noise guidelines for the European Region.* https://www.who.int/europe/publications/i/item/9789289053563

Yale University Environmental Health and Safety. (2021). *Decibel Level Comparison Chart.* https://ehs.yale.edu/sites/default/files/files/decibel-level-chart.pdf

Yamada, Y., Fukutsu, K., Tokonami, S., Ishikawa, T., Zhuo, W., Furukawa, M., & Yonehara, H. (2004). *Size measurements of radon decay products by diffusion method.* National Institute of Radiological Sciences. https://www.osti.gov/etdeweb/servlets/purl/20555917

Yin, J., Jin, X., Shan, Z., Li, S., Huang, H., Li, P., Peng, X., Peng, Z., Yu, K., Bao, W., Yang, W., Chen, X., & Liu, L. (2017). Relationship of Sleep Duration With All-Cause Mortality and

Cardiovascular Events: A Systematic Review and Dose-Response Meta-Analysis of Prospective Cohort Studies. *Journal of the American Heart Association*, *6*(9). https://doi.org/10.1161/JAHA.117.005947

Zammerilli, A., Murray, R., Davis, T., & Littlefield, J. (2014). *Environmental impacts of unconventional natural gas development and production*, DOE/NETL-2014/1651.

Appendix B.

B.1. Chemical additives used in oil and gas development

Description of chemical additive disclosure databases for upstream oil and gas development

Operators performing well stimulation treatments in California are required to submit chemical usage data to the California Geologic Energy Management Division (CalGEM) (CalGEM, 2020). In this context, well stimulation treatments are defined as hydraulic fracturing and acid well stimulation, but do not include "steam flooding, water flooding, or cyclic steaming and do not include routine well cleanout work, routine well maintenance, routine removal of formation damage due to drilling, bottom hole pressure surveys, or routine activities that do not affect the integrity of the well or the formation" (CalGEM, 2020). Under California Public Resources Code (P.R.C) § 3160 (2023) operators must disclose all chemical components of mixtures, including trade secrets. Individual chemical components are not linked to a chemical mixture; mixtures and their components are listed separately to allow for chemical disclosure while protecting proprietary industry information. Well stimulation chemical data submitted to CalGEM are publicly available for download from the WellSTAR website as the Well Stimulation Disclosure Dataset (CalGEM, 2021).

The South Coast Air Quality Management District (SCAQMD) is the primary air pollution control agency for Orange County and urban portions of Los Angeles, Riverside, and San Bernardino counties (SCAQMD, 2018). The SCAQMD requires oil and gas operators within its jurisdiction to report chemical usage for well drilling, completion, and rework, which includes activities such as hydraulic fracturing, acid fracturing, matrix acidizing, maintenance acidizing, and gravel packing (SCAQMD, 2015a). To date, the SCAQMD is the only known regulatory agency that requires the disclosure of chemical use in conventional oil and gas operations and provides the most complete picture of chemical usage in California. In 2015, SCAQMD updated Rule 1148.2 to dissociate trade names from individual chemical ingredients, bringing reporting in line with well stimulation and hydraulic fracturing disclosure requirements and encouraging additional chemical disclosure.

FracFocus is a national online database of chemical disclosures for hydraulic fracturing operations nationwide and is maintained by the Groundwater Protection Council and Interstate Oil and Gas Compact Commission (Groundwater Protection Council & Interstate Oil and Gas Compact Commission, 2019). Since its founding in 2011, FracFocus has undergone two major revisions, referred to as FracFocus 2.0 (November 2012 to 2016) and FracFocus 3.0 (June 2016 to present). There is overlap in data submissions during transition periods between different versions of FracFocus. Each revision standardized and updated reporting, data validation, and data access. Most notably, the launch of FracFocus 3.0 in 2016 integrated a new "systems approach" to chemical reporting, where chemical ingredients were dissociated from trade names, allowing for increased disclosure while maintaining proprietary information (Groundwater Protection Council & Interstate Oil and Gas Compact Commission, 2019; Trickey et al., 2020). In 2015, California made it mandatory for operators to report chemical usage in hydraulic fracturing operations to FracFocus, before which reporting was voluntary (CalGEM, 2020).

In 2016, the Central Valley Regional Water Quality Control Board (CVRWQCB), under the authority of California Water Code Section 13267, requested chemical disclosures from seven oil and gas operators in the southern San Joaquin Valley that provide produced water for agricultural reuse (CVRWQCB et al., 2021). Initial chemical disclosures were obtained for a period from January 2014 to June 2016 from Deer Creek, Mount Poso, Jasmin, Kern Front, and Kern River oil fields, where enhanced oil recovery (EOR) operations are commonplace. In 2017 and 2018, the CVRWQCB requested two years of additional chemical usage data from both operators and chemical suppliers under the authority of California Assembly Bill 1328 (AB 1328). CVRWQCB staff compiled data on the identities of oil field additives and periodically posted updated lists on their website. Due to concerns surrounding trade secret information, mass and frequency of use data could not be released to the public (CVRWQCB et al., 2021). The combined dataset from the CVRWQCB will be referred to as the AB 1328 dataset in this report. In February of 2021, CVRWQCB and the Food Safety Expert Panel released a draft final report which included a final list of chemical additives from June 2019. This recently updated list was not included in the analysis of chemical additives in Chapter 2.

Key studies of chemical disclosure datasets

Key studies of chemical usage disclosure datasets are summarized in Appendix B, Table B.1. One of the first major studies to examine chemical usage in upstream oil and gas was done by the California Council on Science and Technology (CCST) (2015) as part of an independent scientific assessment of well stimulation treatments in California, pursuant to Senate Bill 4. This study was limited to hydraulic fracturing and well stimulation activities and found major data gaps regarding the disclosure of chemical identities and available toxicological and physicochemical data necessary for assessing chemical hazards and risks. Follow up studies of chemical use in the SCAQMD and the AB 1328 datasets provided similar results regarding chemical disclosure and the overall lack of available chemical characterization (Shonkoff et al., 2016, 2019; Stringfellow et al., 2017). The analysis of chemical usage in hydraulic fracturing by the U.S. EPA (US EPA, 2016) is a valuable resource for nationwide chemical use in hydraulic fracturing, but does not provide in-depth state level analysis of chemical use beyond identifying the top 20 most frequently reported chemicals used in California.

The most recent cross analysis of all available chemical disclosure datasets was done by the CCST and included data from 2011 to the end of 2018 (Shonkoff et al., 2021). The estimated number of chemicals without CASRN is likely an overestimate because chemicals without CASRN cannot be uniquely identified, and due to the timeframe of the study. The CCST study included data from early FracFocus 1.0 and 2.0 submissions for completeness; some chemical additives were only reported in these early submissions. Many of the early studies of the FracFocus database were performed prior to the implementation of FracFocus 3.0 and California laws requiring the decoupling of chemical ingredients from trade names (Cal. Code of Regs Title 14 § 1788, Cal. Pub. Res. Code § 3160). These studies listed numerous proprietary and trade secret formulations that could not be identified (CCST et al., 2015; Stringfellow et al., 2017; US EPA, 2016). Analyses of forms submitted to FracFocus 3.0 in California since 2016 found no valid cases of chemical information withholding (Trickey et al., 2020; Shonkoff et al., 2021); any reported instances of chemical withholding since 2016 were from mislabeled entries. Additionally, the

CCST study did not include the most recent draft report from the CVRWQCB, which updates the AB 1328 dataset with only 18 trade secret chemicals (CVRWQCB et al., 2021), compared to the 80 in the CCST report (Shonkoff et al., 2021).

Table B.1 Key studies examining chemical usage in oil and gas development in California.

Chemical Data Source	Oil and Gas Activity	Timeframe	Region	Findings	Study
FracFocus 1.0	Hydraulic Fracturing	Jan 2011–Feb 2013	Nationwide	20 Most frequently reported chemicals for hydraulic fracturing in California	US EPA (2016)
FracFocus 1.0, 2.0	Hydraulic Fracturing	Jan 2011–May 2014	Statewide	338 chemicals total 228 with CASRN	CCST et al. (2015); Stringfellow et al. (2017)
CalGEM Notices of Intent and Completion Reports	Acidizing treatments	Dec 2013–May 2015	Statewide		
SCAQMD	Acidizing	Jun 2013–Jun 2014	Los Angeles Basin	78 chemicals	
AB 1328 (CVRWQCB)	Enhanced oil recovery (steam flooding)	Jan 2014–Jun 2016	Southern San Joaquin Valley	173 chemicals total 107 with CASRN	Shonkoff et al. (2016)
SCAQMD	Well drilling Well completion Well rework	Jun 2013–Sep 2015	Los Angeles Basin	548 chemicals total 525 chemicals used in routine oil and gas (249 with CASRN) 24% of which also used in hydraulic fracturing in California	Stringfellow et al. (2017)

Chemical Data Source	Oil and Gas Activity	Timeframe	Region	Findings	Study
SCAQMD, CalGEM	Acidizing treatments	Apr 2013–Aug 2015	Statewide	~200 chemicals with CASRN 90 trade secrets	Abdullah et al. (2017)
SCAQMD	Well drilling Well completion Well rework	Jun 2013–Aug 2018	Los Angeles Basin	651 chemicals total 324 with CASRN	Shonkoff et al. (2019)
FracFocus 1.0, 2.0, 3.0; CalGEM; SCAQMD; AB 1328 (CVRWQCB)	Well drilling Well completion Well rework Well stimulation Enhanced oil recovery	2011–2018	Statewide	1,119 chemicals total 630 with CASRN	Shonkoff et al. (2021)
AB 1328 (CVRWQCB)	Enhanced oil recovery (steam flooding)	Up to Jun 2019	Southern San Joaquin Valley	324 with CASRN 18 trade secret	CVRWQCB et al. (2021)

Abbreviations: CASRN – Chemical Abstracts Service Registry Number; SCAQMD – South Coast Air Quality Management District; CalGEM – California Geologic Energy Management Division; AB – Assembly Bill, CVRWQCB – Central Valley Regional Water Quality Control Board.

Table B.2. Chemical additives prohibited in hydraulic fracturing activities in Colorado as of January 15, 2021.

Ingredient Name	CAS #
Benzene	71-43-2
Lead	7439-92-1
Mercury	7439-97-6
Arsenic	740-38-2
Cadmium	7440-43-9
Chromium	7440-47-3
Ethylbenzene	100-41-4
Xylene	1330-20-7
1,3,5-trimethylbenzene	108-67-8
1,4-dioxane	123-91-1
1-butanol	71-36-3
2-butoxyethanol	111-76-2
N,N-dimethylformamide	68-12-2
2-ethylhexanol	104-76-7
2-mercaptoethanol	60-24-2
Benzene, 1,1'-oxybis-,tetrapropylene derivatives, sulfonated, sodium salts (BOTS)	119345-04-9
Butyl glycidyl ether	2426-08-6[1]
Quaternary ammonium compounds, dicoco alkyldimethyl, chlorides (QAC)	61789-77-3
Bis hexamethylene triamine penta methylene phosphonic acid (BMPA)	35657-77-3
Diethylenetriamine penta (methylene- phosphonic acid) (DMPA)	15827-60-8
FD&C blue no. 1	3844-45-9
Tetrakis (triethanolaminato) zirconium (IV) (TTZ)	101033-44-7

[1]Originally listed as "8-6-2426" in the text of the Final Draft of the Amended 400 Series Rules.

B.2. Equations relevant to attenuation of stressors

Air emissions

Substances in outdoor (or ambient) air are dispersed by atmospheric advection and diffusion. The magnitude of attenuation by advection/dispersion depends on meteorological parameters that include wind parameters — direction, velocity, and turbulence — and thermal properties that relate to atmospheric stability and mixing depth. The standard models for estimating the time and spatial distribution of point sources of contamination in the atmosphere are the Gaussian statistical solutions of the atmospheric diffusion equation. These models are obtained from the solution of the classical differential equation for time-dependent diffusion in three dimensions. The standard solution for the downwind concentration as discussed by (Turner, 1970) is:

$$C(x,y,z) = \frac{Q}{2\pi u \sigma_y \sigma_z} \exp\left(-\frac{y^2}{2\sigma_y^2}\right)\left[\exp\left(-\frac{(z-H)^2}{2\sigma_z^2}\right) + \exp\left(-\frac{(z+H)^2}{2\sigma_z^2}\right)\right] \quad (2.6)$$

Where C(x,y,z) is the contaminant concentration, in g/m^3 at a position x downwind, y crosswind and z vertically from the source; Q is the contaminant source strength, g/s; x is the distance (m) downwind and z is the distance (m) in air above the source; u is the ground-surface wind speed in m/s, H is the height of the release, in m; and σ_y and σ_z are, respectively vertical and horizontal dispersion parameters (in m). Figure B.1 provides an illustration of downwind dispersion processes.

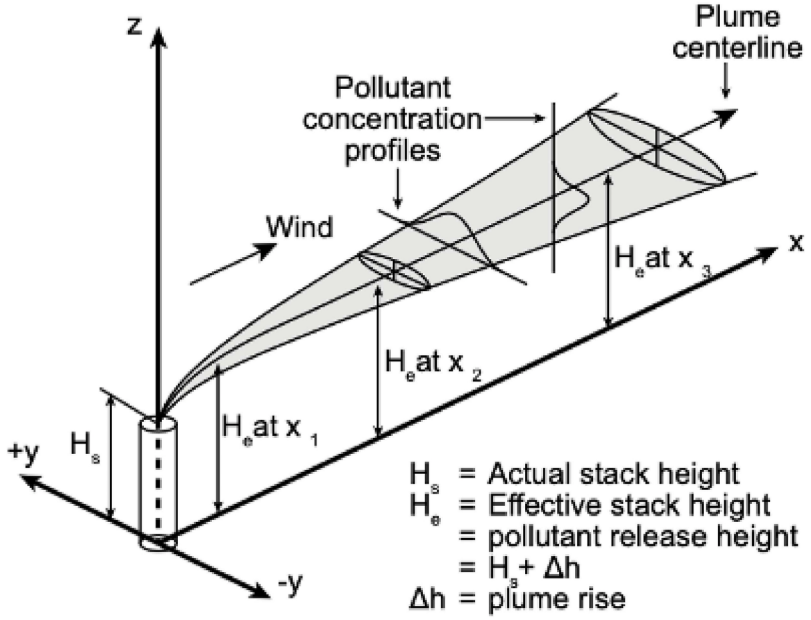


Figure B.1. An illustration of atmospheric dispersion processes and the parameters of equation 2.1. Source: http://en.wikipedia.org/wiki/Atmospheric_dispersion_modeling

In order to assess the attenuation of the concentration downwind from a ground-level release (H=0), along the plume centerline (y=0) and at ground level (z=0), we can simplify Equation 2.1 to the following form:

$$C(x,0,0) = \frac{Q}{2\pi u \sigma_y \sigma_z} \qquad (2.1)$$

The dispersion coefficients σ_y and σ_z are functions of the atmospheric stability class and the downwind distance x from the air pollutant emission source. There are six stability classes used for air dispersion modeling:

1 (or A) = very unstable
2 (or B) = moderately unstable
3 (or C) = slightly unstable
4 (or D) = neutral
5 (or E) = somewhat stable
6 (or F) = stable

The magnitude of the σ_y and σ_z dispersion coefficients can be estimated using the empirical equations reported by (Martin, 1976). The turbulent mixing under stability category 1 provides the best atmospheric dilution, whereas the stable air and low mixing depth fund in stability condition 6 provides the least amount of dilution with distance.

We use equation 2.1 with both neutral (1) and stable (6) conditions to calculate the attenuation profile provided in **Figure 2.3**.

Surface water releases

Releases of chemical substances to surface water are dispersed and impacted by flow rates, advection/diffusion-based dispersion, deposition to sediments, and transformation processes. Mathematical models are frequently used to estimate the distribution of a chemical in surface water after a spill or from a continuous release. In van Leeuwen and Vermeire (2007), the authors describe the models as ranging from a simple equation to highly sophisticated models for evaluating an entire river/lake system. Jirka and Weitbrecht (2005) have described and modeled the hydrodynamics of an effluent continuously discharging into a receiving water body. In their description there is a “near-field” region close to the source where source characteristics determine initial dispersion. Once the plume has become well mixed, far-field conditions are attained. In this region the water flow, eddy diffusivity, and surface water dimensions will control trajectory and dilution of the well dispersed plume. For our comparison of attenuation in different media, we focus on this far-field behavior. In this region, Jirka and Weitbrecht (2005) suggest a simple model to assess the change in concentration with distance x. In this formulation, the maximum pollutant concentration c_{max} (g/m^3) as a function of distance x (m) along the flow direction is given by:

$$c_{max} = 2\frac{Q_{col}}{h\sqrt{4\pi E_y U x}} \qquad (2.2)$$

where Q_{co} is the pollutant mass flux of the source (g/s), h is the depth of the surface water (m), E_y is the lateral turbulent diffusivity (m^2/s), and U is the average flow of the surface water (m/s). The factor 2 on the right-hand side signifies the reflection effect of the impermeable riverbank. Jirka and Weitbrecht (2005) estimate Ey as function of h and U.

$$E_y = 0.00525\ Uh \qquad (2.3)$$

The processes represented in this model are illustrated in Figure B.2. We use this model to examine the expected trend of dilution with distance in surface waters and to develop the profile for surface water attenuation provided in **Figure 2.3**. Compared to other off-site transport processes, dilution in surface water is much slower and follows a $1/\sqrt{x}$ trend rather than the more rapid $1/x^2$ or exponential attenuations of other stressors.

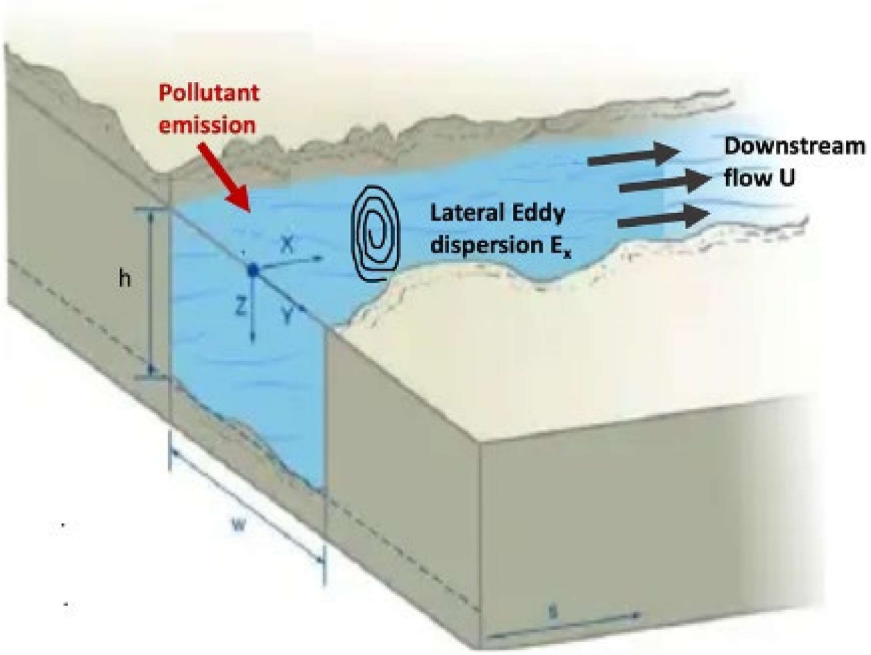


Figure B.2. An illustration of first-order pollutant transport and attenuation in surface water.

Subsurface releases (groundwater)

In order to estimate the dilution of contaminants in groundwater, we make use of a contaminant plume analysis model described by Domenico and Robbins (1985), which is an extension of an earlier model posed by Domenico and Palciauskas (1982). The latter model has been used by the U.S. EPA (1985) to assess off-site transfers of contaminants at hazardous waste sites. Both of these models have been widely used and cited.

Domenico and Robbins (1985) developed an analytical expression for contaminant transport from a finite source in a continuous flow regime. They adapted this model to solving the problem of the extended pulse approximation to the continuous finite source problem. Their analytical solution is

derived from solving the time-dependent, three-dimensional dispersion/advection mass balance equation that applies to the transport of contaminants in an aquifer in the absence of transformation processes.

Figure B.3 illustrates the leaching of contaminants from an oil/gas site down through the unsaturated zone and into the saturated zone where transport is lateral. This figure provides a conceptual diagram of the model we use for off-site transport in the saturated zone. For a pulse of contaminant introduced at concentration C_0 to ground water at x = 0 across the width Y and to a depth Z, Domenico & Robbins (1985) have shown that the solution to the dynamic mass-balance equations for the contaminant plume centerline is:

$$C(x,y,z,t) =$$

$$C(x,0,0,t) = \frac{C_0}{2}\ \mathrm{erfc}\left[\frac{x - v_c t}{2\sqrt{D_{lc} t}}\right] \times \mathrm{erf}\left[\frac{Y}{4\sqrt{D_{tc} x / v_c}}\right] \times \mathrm{erf}\left[\frac{Z}{4\sqrt{D_{tc} x / v_c}}\right] \quad (2.3)$$

where v_c is the is the mean flow velocity of the contaminant in the aquifer, m/d; D_{lc} and D_{tc} are the longitudinal (lc) and transverse (tc) macro-dispersion coefficients for a contaminant species in the saturated zone water, m^2/d; efrc is the complementary error function; and erf the standard error function.

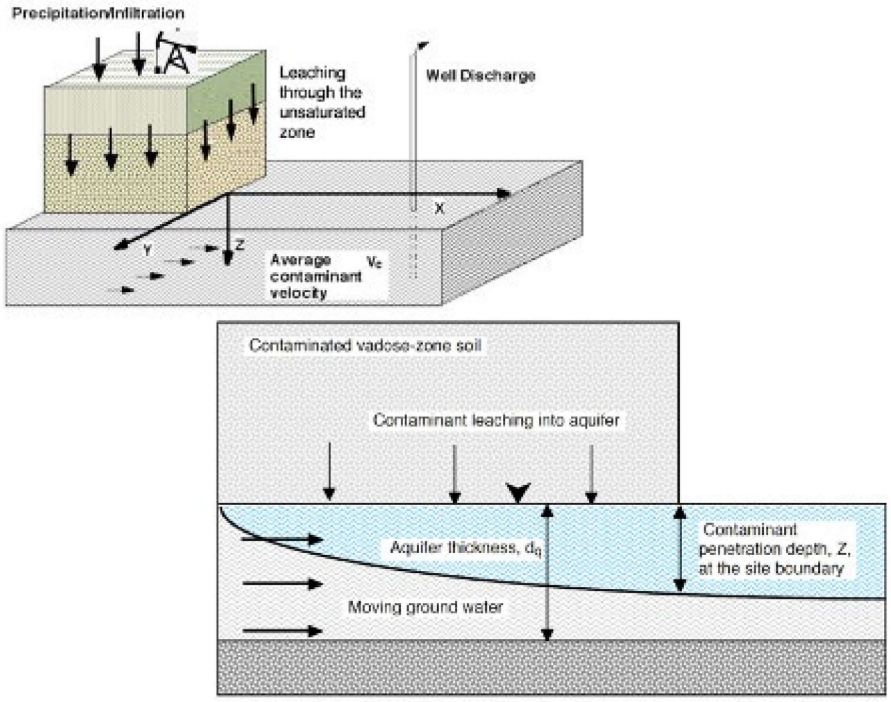


Figure B.3. Conceptual diagram of the model we use for off-site transport in the saturated zone.

Domenico and Robbins (1985) have shown that for a steady state concentration at x << vct for C_0 continuous or for the maximum concentration at any point x along the centerline for a pulse input, Equation 2.3 becomes:

$$C(x,0,0, \text{ at } t_{max}) = C_0 \ \text{erf}\left[\frac{Y}{4\sqrt{D_{tc}x/v_c}}\right] \times \text{erf}\left[\frac{Z}{4\sqrt{D_{tc}x/v_c}}\right] \quad (2.4)$$

When the contaminant spread is confined within an aquifer of thickness d_q, then Domenico and Palciauskas (1982) have shown that the appropriate form of equation 2.4 is

$$C(x,0,0, \text{ at } t_{max}) = C_0 \ \text{erf}\left[\frac{Y}{4\sqrt{D_{tc}x/v_c}}\right] \times \frac{Z}{d_q} \quad (2.5)$$

We use this equation to determine the relative dilution of contaminants in the subsurface environment as a function of distance x off site. This equation was used to construct the curve in **Figure 2.3** showing the sensitivity of groundwater attenuation to distance. Because of our focus on relative dilution, the shape of the curve is effectively independent of the other parameter values in equation 2.5. Of note, a recent assessment of drinking water wells near upstream oil and gas sites found that long-range transport of pollutants in groundwater is unlikely (Soriano et al., 2020).

Attenuation of sound and noise

As sound propagates through air (or any elastic medium), it causes measurable fluctuations in pressure, velocity, temperature, and density. The transfer of fluctuating pressure through a medium such as air can be visualized as waves of increasing pressure as shown in Figure B.4. The distance between wave peaks is the wavelength. The relationship among the speed of sound, its frequency, and wavelength is

$$v_w = f\lambda \quad (2.6)$$

where v_w is the speed of sound, f is its frequency, and λ is its wavelength.

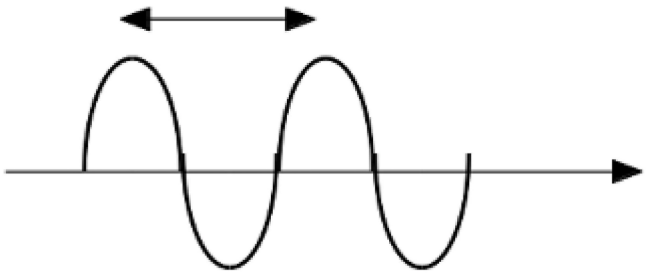


Figure B.4. An illustration of sound waves propagating through a conducting medium.

Sound propagates out from a source as planar waves, along a linear path, or as spherical waves outward on a spherical front. An example of a plane wave is a speaker at the end of a long tube. The sound pressure remains constant as the sound moves along the tube and there is little attenuation of sound intensity. Spherical spreading of waves is observed propagating out from a point source and large medium such as air or water. If we have a point sound source the sound pressure will be constant anywhere on a sphere surrounding the source. The sound pressure will diminish as we travel away from the source. This spherical propagation is illustrated in Figure B.5.

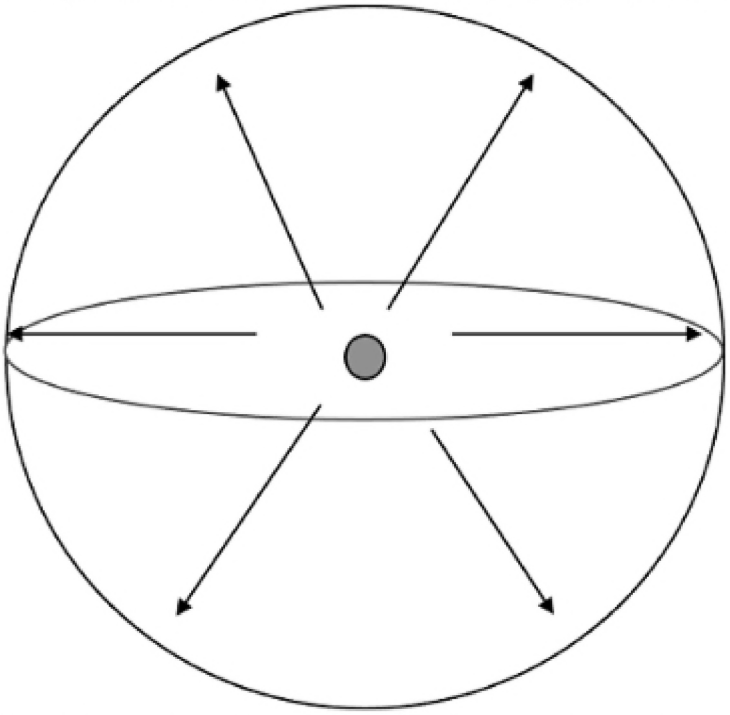


Figure B.5. An illustration of the propagation of sound intensity outward from the source on the surface of a sphere.

Conservation of energy requires that the sound power P_0 in watts (W) at the source is conserved over the surface of the expanding sphere such that the sound intensity I in (W/m^2) follows the relationship (Lamancusa, 2000):

$$P_0 = 4\pi r^2 I(r) \qquad (2.7)$$

Or

$$I(r) = P_0/[4\pi r^2] \qquad (2.8)$$

An alternate and commonly used scale for measuring sound intensity is the decibel (dB) scale. In this scale, the threshold of hearing is assigned a sound level of 0 dB; this sound corresponds to an intensity of $1x10^{-12}$ W/m^2. To calculate dB intensity at any other intensity, one takes the logarithm of the ratio of the observed intensity to the 0 dB intensity of $1x10^{-12}$ W/m^2 and multiplies this logarithm by 10. So, for example, a sound intensity of $1x10^{-8}$ W/m^2, is equivalent to 40 dB.

Sound intensity measured in W/m^2 will attenuation as $1/r^2$, whereas sound intensity in dB will attenuate linearly from the source because dB are measured on a logarithmic scale.

In a real atmosphere, sound (and noise) propagation "deviates from spherical due to a number of factors, including absorption of sound in air, non-uniformity of the propagation medium due to meteorological conditions (refraction and turbulence), and interaction with an absorbing ground and solid obstacles (such as barriers)" (Lamancusa, 2000). So in actual situations it is possible to get additional attenuation. But our interest here is in the general pattern and bounding estimates.

Attenuation of vibrations

Equipment and oil/gas recovery operations generate vibrations, which may or may not be associated with off-site transfer of noise. At oil/gas operations, vibrations travel to surrounding buildings and homes through the ground. Vibrations are described by the same source-path-receiver model as sound (Lamancusa, 2002). The source is a mechanical or fluid disturbance, generated internally by mechanical equipment. The path is the airborne, structural, or subsurface route by which the vibration is transmitted to the receiver. The receiver is a residence or other building, which provides the responding system, generally having many resonant frequencies that can potentially be excited by vibration frequencies generated by the source.

In a detailed numerical assessment of ground vibrations induced by gas and oil well drilling, Truty et al. (2019) have developed a method based on measurements of ground vibrations induced by a specific type of drilling system at a reference site. Nicholls (2009) reports that vibrations in soil (or rock) are attenuated exponentially based on the attenuation factors of soil (rock) and follow relationship of the form:

$$V_{ac} = a \exp(-bx) \qquad (2.9)$$

Where V_{ac} is the vibration intensity expressed as peak particle velocity (PPV) in m/s and a and b are empirical parameters, and x is the distance from the vibration source. The parameter a reflects intensity at the source and b expresses the capacity of the rock/soil to absorb vibration energy.

Nicholls (2009) presented the results of vibration monitoring during different drilling activities at a number of sites. The Nicholls data sets were typically gathered at distances of between 5 m (16 ft) and 50 m (164 ft) from the drilling rig. It was noted that, for some activities, at a distance of 50 m (164 ft), the vibration was deemed negligible. The presented data points to the possibility of a significant drop in vibration intensity occurring at or about 15 m (49 ft) from the drilling rig. Figure B.6 shows the exponential regression developed by Nicholls (2009) for their collected data. The dots are observations and the fitted line is $V_{ac} = 3.0466 \exp(-0.062x)$

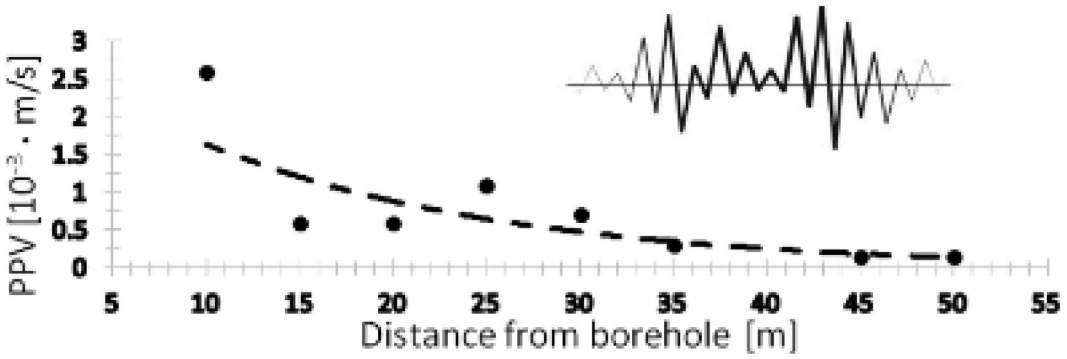


Figure B.6. An illustration of the exponential decay of vibration acceleration from oil and gas operations as a function of distance from the source. Source: Nicholls (2009).

CHAPTER THREE

Peer-Reviewed Epidemiological Literature Evaluating Upstream Oil and Gas Development

Table of Contents

3.0. Abstract **1**

3.1. Introduction **1**

3.2. Approach **3**

3.2.1 Scope of review **3**

3.3. Results **5**

3.3.1 Surrogates of exposure to upstream oil and gas development **8**

3.3.2 Summary of epidemiologic studies related to specific health endpoints **16**

3.3.2.1 Epidemiological studies provide evidence that supports a causal relationship between oil and gas development and adverse perinatal and respiratory health outcomes **16**

3.3.2.2 Perinatal outcomes **23**

3.3.2.3 Respiratory outcomes **57**

3.3.2.4 Mental and behavioral health outcomes **65**

3.3.2.5 Cancer **69**

3.3.2.6 Cardiovascular outcomes **74**

3.3.2.7 Other adverse health outcomes **79**

3.4. Discussion **90**

3.4.1 Strengths and limitations of environmental epidemiological research evaluating health risks and impacts associated with oil and gas development **90**

3.4.1.1. Exposure assessment **90**

3.4.1.2. Addressing confounding factors **91**

3.4.1.3. Study design **92**

3.4.2 Broad consideration of the epidemiological literature across time and space **93**

3.4.3 Disproportionate exposures and health risks **95**

3.4.4 Strategies to reduce human health hazards, risks, and impacts from upstream OGD activities **95**

3.5. Summary **98**

References **99**

Appendix C **110**

C.1. List of Key Terms for Literature Search **110**

C.2. Summary of studies evaluating sexually transmitted infections **110**

Figures

Figure 3.1. Identification of epidemiological studies on the association between oil and gas development and adverse health outcomes. 4

Figure 3.2. Number of peer-reviewed epidemiological studies conducted in each state or region (top panel); number of peer-reviewed epidemiological studies by health outcome category (bottom panel). 6

Figure 3.3. Location and timeframe of data used for each epidemiological study. Studies are organized by state, by publication year, and then alphabetically by first author last name. 7

Figure 3.4. Summary of studies assessing the association between upstream oil and gas development and preterm birth (<37 weeks gestation). 27

Figure 3.5. Summary of associations in the peer-reviewed literature between upstream oil and gas development and differences in term birth weight (>37 weeks gestation). 30

Figure 3.6. Summary of associations in the peer-reviewed literature between upstream oil and gas development and congenital heart defects. 34

Figure 3.7. Summary of associations in the peer-reviewed literature between upstream oil and gas development and neural tube defects 38

Figure 3.8. Summary of associations in the peer-reviewed literature between upstream oil and gas development and cleft defects 40

Figure 3.9. Summary of epidemiological studies on associations in between upstream oil and gas development and lower respiratory effects, including but not limited to mild asthma exacerbations and asthma-related hospitalizations. 60

Figure 3.10. Potential effect of imprecise exposure estimates on a hypothetical exposure-response relationship. Source: Adapted from Seixas & Checkoway (1995). 92

Figure 3.11. Hierarchy of controls to reduce public health harms from oil and gas development activities Source: Figure 1, Deziel et al. (2022b). 96

Tables

Table 3.1. Approach to exposure assessment and statistically significant findings by distance for each study. Studies are ordered by sequentially applied the following criteria: alphabetically by

state/region, alphabetically by health outcome category, chronologically by year, and alphabetically by first author's last name. For more detail on each study, please see **Tables 3.3–3.8**..... 9

Table 3.2. Application of the Bradford Hill Criteria for Causation to the peer-reviewed epidemiological literature on the relationship between oil and gas development and adverse perinatal and respiratory health outcomes..... 19

Table 3.3. Summary of epidemiological studies that evaluate upstream oil and gas development and adverse perinatal health outcomes in the United States and Canada. Studies are categorized by state and then chronologically by publication year..... 44

Table 3.4. Summary of epidemiological studies on association between upstream oil and gas development and adverse respiratory health outcomes in the United States. Studies are categorized by state and then chronologically by publication year. 61

Table 3.5. Summary of epidemiological studies of the association between upstream oil and gas development and mental and behavioral health outcomes in the United States and Canada. Studies are categorized by state and then chronologically by publication year. 66

Table 3.6. Summary of epidemiological studies on the association between upstream oil and gas development and cancer in the United States and Canada. Studies are categorized by state and then chronologically by publication year. 71

Table 3.7. Summary of epidemiological studies that evaluate upstream oil and gas development and cardiovascular outcomes in the United States and Canada. Studies are categorized by state and then chronologically by publication year..... 76

Table 3.8. Summary of epidemiological studies that evaluate upstream oil and gas development and other adverse health outcomes in the United States and Canada. Studies are categorized by health outcome, by state and then chronologically by publication year..... 83

Table 3.9. Advantages and disadvantages of oil and gas development (OGD) control strategies from an environmental public health perspective. Source: Table 1, Deziel et al. (2022b). 97

3.0. Abstract

A large body of epidemiologic studies has evaluated the relationship between oil and gas development (OGD) and adverse health outcomes. Seventy-two peer-reviewed studies published online between January 1, 2009, and July 15, 2023, were conducted in the United States and Canada. The most studied adverse health outcomes related to OGD are perinatal outcomes (n=25 studies) and respiratory outcomes (n=11). Six studies were conducted in California (not including national studies that included California) and evaluate perinatal outcomes (n=3), respiratory outcomes (n=2), and migraine headaches (n=1).

Epidemiologic studies in the United States and Canada provide evidence that human populations residing closer to OGD, in communities with higher density of OGD and higher production volume of oil and gas, are at increased risk of adverse health impacts compared to those living farther away or in less dense or lower production areas. The relationship between upstream OGD and health is strongest for adverse perinatal and respiratory outcomes, and the Scientific Advisory Panel ("Panel") concludes with a high level of certainty that there is a causal relationship between close geographic proximity to OGD and adverse perinatal and respiratory outcomes. For other health outcomes there remains a paucity of studies, and therefore more research is needed to evaluate the consistency of relationships.

Studies conducted in California observed associations between upstream OGD and diagnosed asthma, reduced lung function, and reduced fetal growth at distances up to 1 km (0.62 miles or 3,281 ft) and beyond, and assessed exposure to OGD using well distance, density, and production volume near participant homes. In particular, two California studies also focused on urban/rural differences in adverse birth outcomes and found stronger associations between OGD and adverse fetal growth outcomes in rural areas. Findings have been consistent across multiple epidemiologic studies that were conducted using different methodologies, in different locations, with diverse populations, and during different time periods. In general, studies within and outside of California have handled confounding, or unmeasured factors that might bias results, using appropriate statistical methods. Despite constraints inherent in environmental epidemiology, specifically, the reliance on observational study designs and surrogate measures of population-level exposure (such as proximity measures), retrospective cohort and case-control study designs used in most of the published studies have accounted for both spatial and temporal aspects of past exposures, as well as complex exposure scenarios. The surrogates of exposure to OGD, such as proximity, cumulative well density, and production volume, used in many studies are appropriate aggregate measures of the potential chemical, physical, and social stressors and exposure pathways associated with OGD. In summary, studies conducted within and outside California find associations between OGD and adverse health outcomes, particularly for perinatal and respiratory outcomes.

3.1. Introduction

In this chapter, we summarize peer-reviewed epidemiological studies evaluating associations between upstream oil and gas development (OGD) and adverse health outcomes in the United

States and Canada, including but not limited to studies conducted in California. We also discuss how the existing body of epidemiological literature can inform public health rulemaking regarding OGD in California.

Epidemiology is the study of the distribution and determinants of health-related variables in specific populations (US DHHS, 2012). Environmental epidemiology studies seek to assess relationships between exposures to certain chemicals, physical agents, or other hazards and adverse health effects — and measure and characterize the strength of observed relationships (i.e., the exposure-response relationship). Environmental epidemiological studies also examine exposures and health outcomes in real-world settings, as opposed to other study designs (e.g., randomized control trials that assess the effectiveness of drug treatments) that can be used in more controlled, clinical settings. While an individual epidemiological study alone cannot establish causality, collectively, a body of epidemiological evidence may support a causal association between an exposure and a health outcome.

In recent years, numerous peer-reviewed epidemiological studies have focused on upstream OGD and adverse health outcomes in the United States and Canada. Previous technical reports examining the public health dimensions of OGD in California have highlighted the need for more health studies specific to California (Long et al., 2015; Shonkoff & Hill, 2019), while noting, "Given the increasingly expansive body of health literature on the topic, consider promulgating health-protective policies based on the existing literature" (Shonkoff & Hill, 2019).

While additional peer-reviewed studies conducted in California have been published since Long et al. (2015) and Shonkoff and Hill (2019), the broader body of literature, including but not limited to studies conducted in California, can inform the California oil and gas public health rulemaking process. Although the geological and regulatory landscape in California may differ from other locations, many chemical stressors (e.g., hazardous air pollutants) and physical stressors (e.g., noise) that can contribute to adverse health outcomes are intrinsic to both conventional and unconventional OGD regardless of geographic location (for more information see Chapter 2, Section 2.5.1).

Furthermore, while California has placed policy, regulatory, and scientific emphasis on well stimulation activities (e.g., hydraulic fracturing, matrix acidizing, and acid fracturing), the 2015 Independent Scientific Assessment on Well Stimulation in California concluded, "The majority of impacts associated with hydraulic fracturing are caused by the indirect impacts of oil and gas production enabled by the hydraulic fracturing" (Long et al., 2015). Indirect impacts relevant to human health for the purposes of the study included, "proximity to any oil production, including stimulation-enabled production, could result in hazardous emissions to air and water, and noise and light pollution that could affect public health" (Long et al., 2015). For these reasons, this chapter includes peer-reviewed epidemiological studies conducted throughout the United States and Canada. California studies are placed within the broader context of the literature, and the body of evidence is considered holistically.

3.2. Approach

Below, we briefly describe our approach to compiling and screening peer-reviewed studies for inclusion in this review.

3.2.1 Scope of review

We identified peer-reviewed epidemiological studies that evaluate upstream OGD and adverse health outcomes in the United States and Canada. Two search engines were used to obtain peer-reviewed studies: the Clarivate Analytics Web of Science database (WOS) advanced search tool and the PSE Healthy Energy Repository for Oil and Gas Energy Research (ROGER)[1] (Clarivate, 2020; PSE Healthy Energy, 2020). The full list of keywords used to search WOS can be found in Appendix C, List S1. Studies housed in ROGER are classified by impact category (e.g., climate, air quality, water quality, health). Studies from the health impact category were evaluated for inclusion in this assessment.

Epidemiological studies included in this review met the following criteria:

- Published in a peer-reviewed journal (print or online).
- Available in English.
- Published online between January 1, 2009, and July 15, 2023.
- Study area in the United States or Canada.
- Evaluated associations between upstream OGD and adverse health outcomes and upstream biomarkers of adverse health outcomes (herein referred to as adverse health outcomes).

Occupational health studies, health risk assessments, and health studies focused on measures of perception, subjective well-being, and quality of life were not included in this review.

The WOS search identified 2,882 peer-reviewed articles published between January 1, 2009, and July 15, 2023. The "Health" folder in PSE's ROGER database contained 263 citations as of July 15, 2023. When duplicate records between the two databases were considered, 3,024 unique articles remained. Of these, 110 articles were identified as having met our inclusion criteria after review of the title and abstract. After full text review, 38 studies were excluded as they did not meet our inclusion criteria (e.g., studies were review papers, commentaries, non-epidemiological studies). A total of 72 epidemiological studies were included in this assessment (**Figure 3.1**). Studies were categorized by health endpoint and were summarized in tables and figures.

[1] PSE Healthy Energy maintains the Repository for Oil and Gas Energy Research, a database of peer-reviewed studies relevant to assessing the impacts of shale and tight gas development. Studies that focus on oil and gas development in shale regions are also included in this database.

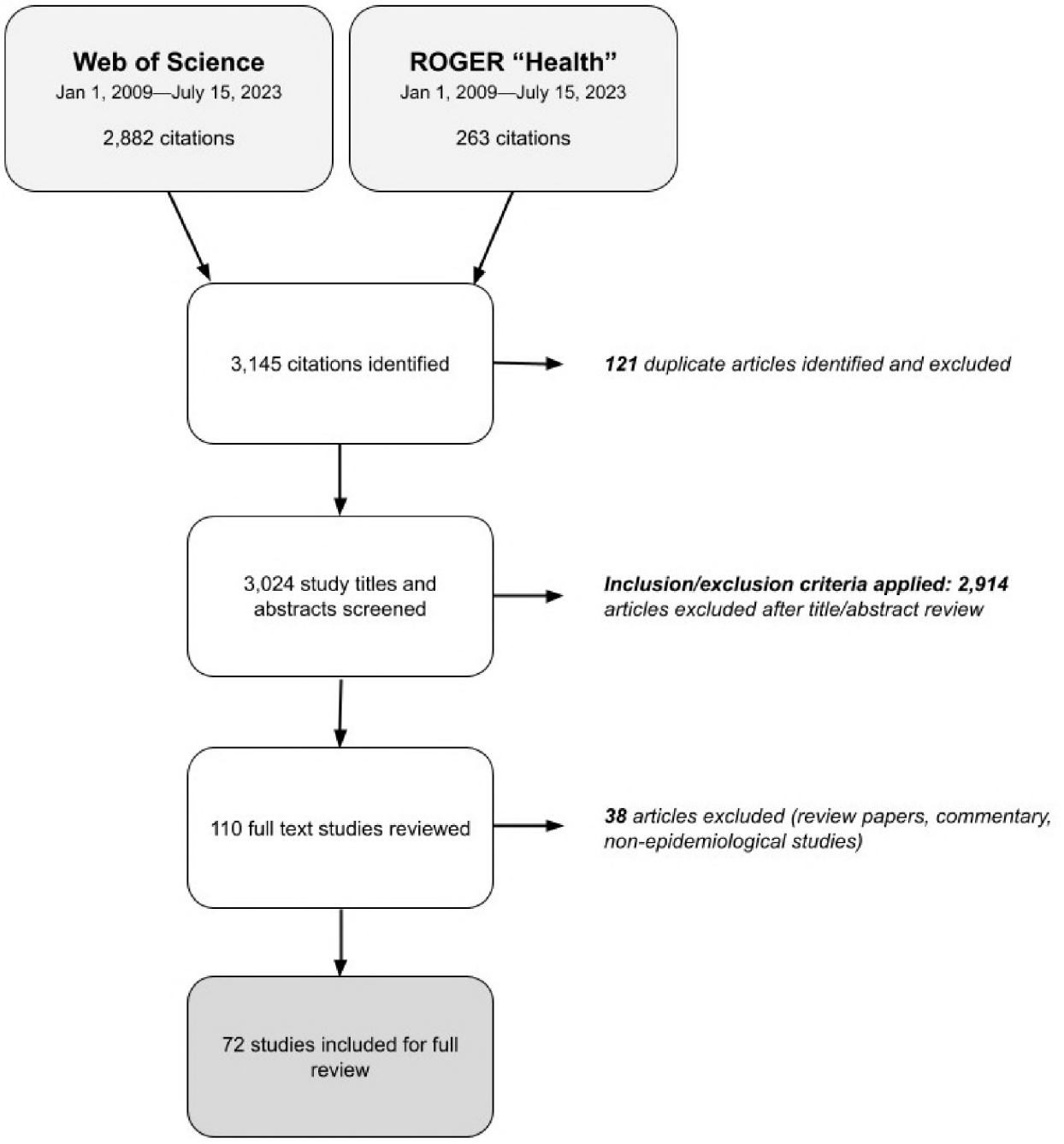


Figure 3.1. Identification of epidemiological studies on the association between oil and gas development and adverse health outcomes.[2]

[2] We applied methods based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to identify studies focused on upstream oil and gas development and health (Sarkis-Onofre et al., 2021).

3.3. Results

We identified 72 peer-reviewed epidemiological studies that evaluated upstream oil and gas development and adverse health outcomes in oil and gas regions in the United States and Canada that were published between January 1, 2009, and July 15, 2023. These studies were conducted in California, Colorado, North Dakota, New York, Ohio, Oklahoma, Pennsylvania, Texas, and West Virginia in the United States, and Alberta and British Columbia in Canada (**Figure 3.2**, top panel). The health outcomes included adverse birth outcomes (perinatal), cancer, respiratory and cardiovascular health, non-outcome specific hospitalizations, mental and behavioral health, additional self-reported health symptoms and health outcomes, and sexually transmitted infections[3] (**Figure 3.2**, bottom panel). Studies included in this review evaluated exposures and health outcomes using health data collected between 1990 and 2021 (**Figure 3.3**).

[3] Studies that evaluate sexually transmitted infections and oil and gas development evaluate dynamics occurring at the community level, rather than at specific upstream oil and gas sites, which are the primary focus of this report. For that reason, these studies are included in overall study counts, but are discussed in more detail in Appendix C.

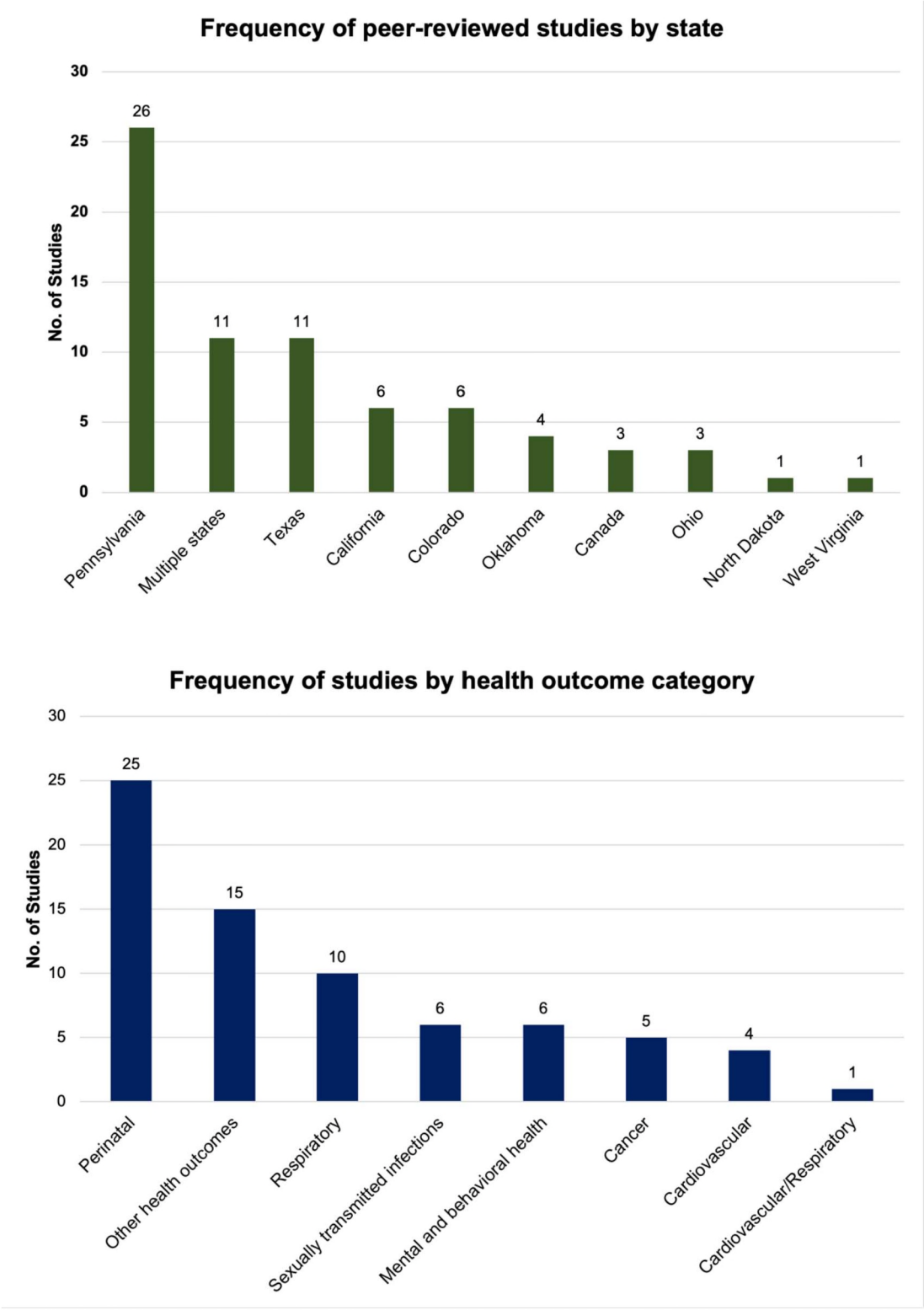


Figure 3.2. Number of peer-reviewed epidemiological studies conducted in each state or region (top panel); number of peer-reviewed epidemiological studies by health outcome category (bottom panel).

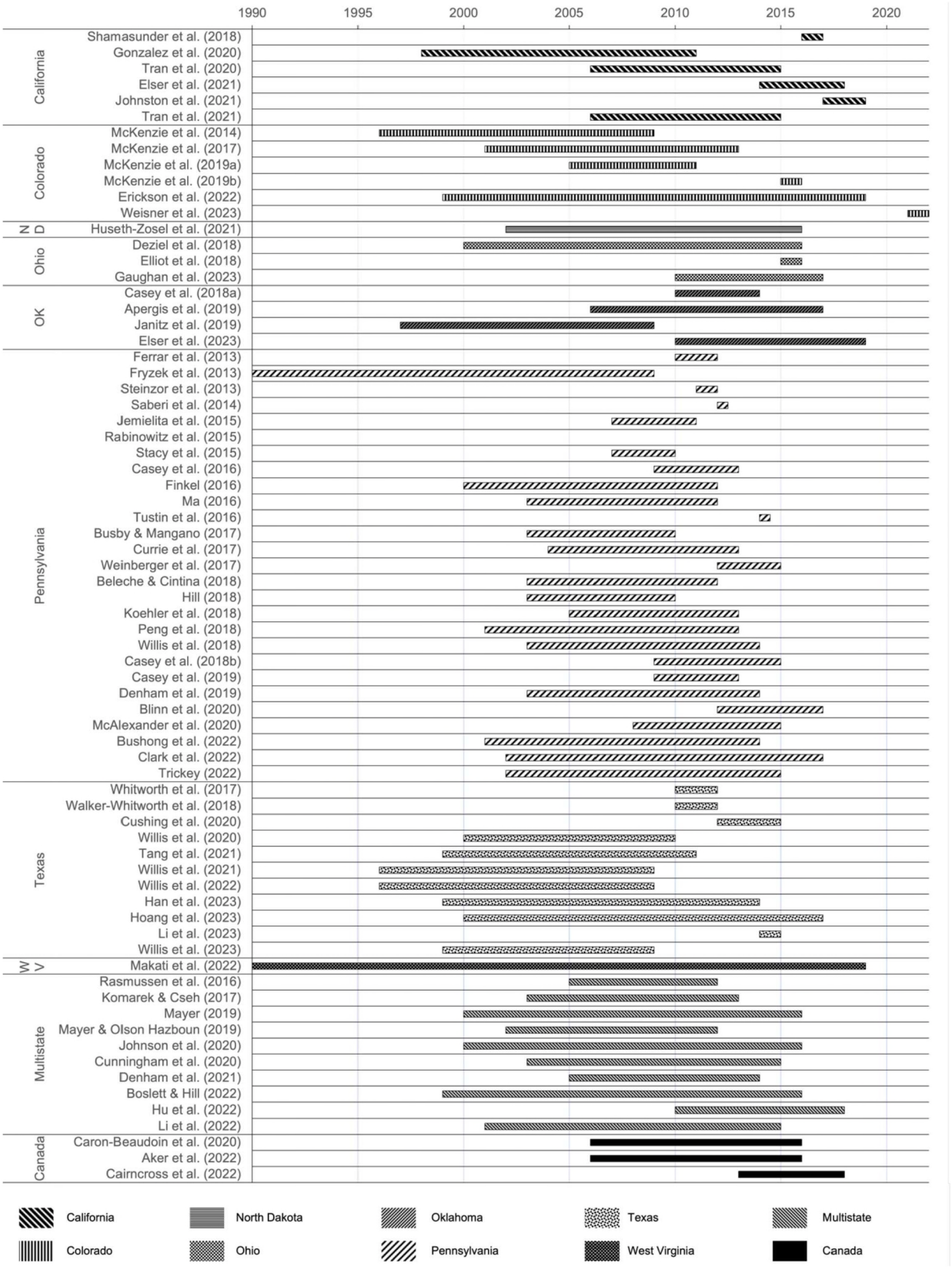


Figure 3.3. Location and timeframe of data used for each epidemiological study. Studies are organized by state, by publication year, and then alphabetically by first author last name.

3.3.1 Surrogates of exposure to upstream oil and gas development

Epidemiological studies included in this report utilize different spatial surrogates of exposure to upstream OGD. This may include assessments of exposure to OGD at the individual level (e.g., linear distance between an individual residence and nearby wells), or at the broader, area level (e.g., the number of wells in the county or zip code where participants reside). The variables that each study considered in aggregate assessments of exposure are summarized in **Table 3.1.**

An approach to assessing exposure to oil and gas wells employed in several of the studies is to quantify oil and gas activities within a given distance of a study participant, or receptor. In these studies, researchers count the number of wells within a specific distance of a study subject's residence (e.g., 1 km, 3,281 ft), or measure the cumulative volume of oil and gas production (i.e., barrels of oil equivalent, BOE) at all wells within a specified distance. One approach to characterize individual exposure to oil and gas activities is inverse-distance weighting (IDW). This measure accounts for the number of wells within a given radius of a residence and the distance (linear or squared) of each well from the residence, while applying greater weights for wells that are closer to the residence. Essentially, the IDW metric captures both proximity to and density of wells near a participant's residence (McKenzie et al., 2014).[4] Some studies use IDW methods that also account for specific phases of well development (e.g., pad preparation, drilling, stimulation, production volume) and other well characteristics (e.g., well depth). Researchers applying IDW or other proximity measures as an indicator of exposure to oil and gas development are typically interested in identifying people with high exposure and comparing their risk of adverse health outcomes to people who were unexposed to wells. It should be noted that in the context of IDW, exposure to wells is approximating the exposure OGD activities that include wells, but also the ancillary equipment and processes that support oil and gas production at these wells.

These proximity-based metrics have the advantages of being scalable (i.e., feasible to apply to large geographic areas or populations), the ability to apply assess exposures retrospectively; and to serve as an aggregate measure of the multitude of physical and chemical stressors potentially emitted from oil and gas development (Deziel et al., 2022a). Aggregation is a particularly useful feature because exposures to multiple hazards are likely, and the dominant stressor may not be known and may differ from well to well. However, the proximity-based metrics are limited in that they do not distinguish exposures to specific hazards, such as benzene and are not designed to estimate exposure levels of specific hazards.

California studies indicate that measuring proximity to oil and gas wells effectively represents exposure to a mix of ambient air pollutants associated with adverse health outcomes, including volatile organic compounds, fine particulate matter, and ozone (Garcia-Gonzales et al., 2019, Gonzalez et al., 2022).

Results presented in Section 3.3.2 and subsections below are organized by health endpoint category. Endpoints are discussed in order of number of available studies, beginning with health endpoints that have the largest number of studies.

[4] McKenzie et al. (2014), the first study to use IDW methods as a surrogate for exposure to upstream oil and gas development, explains, "an IDW well count of 125 wells/mile [1.6 km] could be computed from 125 wells each located 1 mile [1.6 km] from the maternal residence or 25 wells each located 0.2 miles [0.32 km] from the maternal residence."

Table 3.1. Approach to exposure assessment and statistically significant findings by distance for each study. Studies are ordered by sequentially applied the following criteria: alphabetically by state/region, alphabetically by health outcome category, chronologically by year, and alphabetically by first author's last name. For more detail on each study, please see **Tables 3.3–3.8**.

Author (Year)	State	Health outcome category	Distance evaluated (ft)	Distance evaluated (km)	Statistically significant finding for adverse health outcome?	Statistically significant findings for adverse health outcome at ≤1 km (3,281 ft)	Statistically significant findings for adverse health outcome at >1 km (3,281 ft)
Elser et al. (2021)	CA	Other - Migraine headache	32,808	10	No (not for oil and gas findings)	≤1 km (3,281 ft) not specifically evaluated.	No
Gonzalez et al. (2020)	CA	Perinatal	32,808	10	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes
Tran et al. (2020)	CA	Perinatal	3,281	1	Yes	Yes	Not evaluated.
Tran et al. (2021)	CA	Perinatal	3,281	1	Yes	Yes	Not evaluated.
Shamasunder et al. (2018)	CA	Respiratory	1,500	0.46	Yes	Yes	Not evaluated.
Johnston et al. (2021)	CA	Respiratory and self-reported symptoms	656, 3,281	1	Yes	Yes	Not evaluated.
Aker et al. (2022)	Canada	Mental and behavioral health	8,202, 16,404, 32,808	2.5, 5, 10	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes

Author (Year)	State	Health outcome category	Distance evaluated (ft)	Distance evaluated (km)	Statistically significant finding for adverse health outcome?	Statistically significant findings for adverse health outcome at ≤1 km (3,281 ft)	Statistically significant findings for adverse health outcome at >1 km (3,281 ft)
Caron-Beaudoin et al. (2020)	Canada	Perinatal	8,202, 16,404, 32,808	2.5, 5, 10	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes
Cairncross et al. (2022)	Canada	Perinatal	32,808	10	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes
McKenzie et al. (2017)	CO	Cancer	52,821	16.1	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes
McKenzie et al. (2019a)	CO	Perinatal	52,800	16.1	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes
McKenzie et al. (2019b)	CO	Cardio-vascular	52,493	16.1	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes
McKenzie et al. (2014)	CO	Perinatal	52,800	16.1	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes
Erickson et al. (2022)	CO	Perinatal	N/A - County-level[1]	N/A - County-level[1]	Yes	N/A - County-level[1]	N/A - County-level[1]
Weisner et al. (2023)	CO	Self-reported symptoms	<5,280–>10,560	<1.61–>3.22	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes
Mayer (2019)	OH	Other - All-cause mortality	N/A - County-level[1]	N/A - County-level[1]	Yes	N/A - County-level[1]	N/A - County-level[1]
Gaughan et al. (2023)	OH	Perinatal	32,808	10	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes
Casey et al. (2018a)	OK	Mental and behavioral health	N/A - Distance not specified[2]	N/A - Distance not specified[2]	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes[3]
Elser et al. (2023)	OK	Mental and behavioral health	N/A - County-level[1]	N/A - County-level[1]	Yes	N/A - County-level[1]	N/A - County-level[1]

Author (Year)	State	Health outcome category	Distance evaluated (ft)	Distance evaluated (km)	Statistically significant finding for adverse health outcome?	Statistically significant findings for adverse health outcome at ≤1 km (3,281 ft)	Statistically significant findings for adverse health outcome at >1 km (3,281 ft)
Apergis et al. (2019)	OK	Perinatal	3,281–65,617	1–20	Yes	Yes	Yes
Janitz et al. (2019)	OK	Perinatal	10,560	3.2	No	≤1 km (3,281 ft) not specifically evaluated.	No
Elliot et al. (2018)	PA	Other - Self-reported symptoms/ outcomes	16,404	5	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes
Fryzek et al. (2013)	PA	Cancer	N/A - County-level[1]	N/A - County-level[1]	Yes	N/A - County-level[1]	N/A - County-level[1]
Finkel (2016)	PA	Cancer	N/A - County-level[1]	N/A - County-level[1]	Yes	N/A - County-level[1]	N/A - County-level[1]
Clark et al. (2022)	PA	Cancer	6,562, 16,404, 32,808	2, 5, 10	No	≤1 km (3,281 ft) not specifically evaluated.	No
McAlexander et al. (2020)	PA	Cardio-vascular	N/A - Distance not specified[2]	N/A - Distance not specified[2]	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes[3]
Casey et al. (2018b)	PA	Mental and behavioral health	N/A - Distance not specified[2]	N/A - Distance not specified[2]	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes[3]
Casey et al. (2019)	PA	Mental and behavioral health	N/A - Distance not specified[2]	N/A - Distance not specified[2]	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes[3]
Li et al. (2022)	PA	Other - All-cause mortality	N/A - ZIP Code-level[4]	N/A - ZIP Code-level[4]	Yes	N/A - ZIP Code-level[4]	N/A - ZIP Code-level[4]
Makati et al. (2022)	PA	Other - ANCA-associated vasculitis	N/A - County-level[1]	N/A - County-level[1]	Yes	N/A - County-level[1]	N/A - County-level[1]

Author (Year)	State	Health outcome category	Distance evaluated (ft)	Distance evaluated (km)	Statistically significant finding for adverse health outcome?	Statistically significant findings for adverse health outcome at ≤1 km (3,281 ft)	Statistically significant findings for adverse health outcome at >1 km (3,281 ft)
Jemielita et al. (2015)	PA	Other - Non-outcome-specific hospitalizations	N/A - ZIP Code-level[4]	N/A - ZIP Code-level[4]	Yes	N/A - ZIP Code-level[4]	N/A - ZIP Code-level[4]
Denham et al. (2019)	PA	Other - Non-outcome-specific hospitalizations	N/A - County-level[1]	N/A - County-level[1]	Yes	N/A - County-level[1]	N/A - County-level[1]
Ferrar et al. (2013)	PA	Other - Self-reported symptoms/ outcomes	N/A - Distance not specified[2]	N/A - Distance not specified[2]	Statistical significance not assessed.	Statistical significance not assessed.	Statistical significance not assessed.
Steinzor et al. (2013)	PA	Other - Self-reported symptoms/ outcomes	See note[6]	See note[6]	Yes	Yes	See note[6]
Saberi et al. (2014)	PA	Other - Self-reported symptoms/ outcomes	N/A - Distance not specified[2]	N/A - Distance not specified[2]	Statistical significance not assessed.	Statistical significance not assessed.	Statistical significance not assessed.
Rabinowitz et al. (2015)	PA	Other - Self-reported symptoms/ outcomes	3,281–6,562	1–2	Yes	Yes	No
Tustin et al. (2016)	PA	Other - Self-reported symptoms/ outcomes	N/A - Distance not specified[2]	N/A - Distance not specified[2]	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes[3]
Blinn et al. (2020)	PA	Other - Self-reported symptoms/ outcomes	16,404	5	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes
Stacy et al. (2015)	PA	Perinatal	52,800	16.1	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes

Author (Year)	State	Health outcome category	Distance evaluated (ft)	Distance evaluated (km)	Statistically significant finding for adverse health outcome?	Statistically significant findings for adverse health outcome at ≤1 km (3,281 ft)	Statistically significant findings for adverse health outcome at >1 km (3,281 ft)
Casey et al. (2016)	PA	Perinatal	N/A - Distance not specified[2]	N/A - Distance not specified[2]	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes[3]
Ma (2016)	PA	Perinatal	N/A - ZIP Code-level[4]	N/A - ZIP Code-level[4]	Yes	N/A - ZIP Code-level[4]	N/A - ZIP Code-level[4]
Busby and Mangano (2017)	PA	Perinatal	N/A - County-level[1]	N/A - County-level[1]	Yes	N/A - County-level[1]	N/A - County-level[1]
Currie et al. (2017)	PA	Perinatal	3,281–49,213	1–15	Yes	Yes	Not evaluated.
Hill (2018)	PA	Perinatal	6,562–16,404	2– 5	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes
Koehler et al. (2018)	PA	Respiratory	3,281, >6,562, >52,800	1, >2, >16.1	Yes	Yes	Yes
Peng et al. (2018)	PA	Respiratory	N/A - County-level[1]	N/A - County-level[1]	Yes	N/A - County-level[1]	N/A - County-level[1]
Willis et al. (2018)	PA	Respiratory	N/A - ZIP Code-level[4]	N/A - ZIP Code-level[4]	Yes	N/A - ZIP Code-level[4]	N/A - ZIP Code-level[4]
Bushong et al. (2022)	PA	Respiratory	N/A - County-level[1]	N/A - County-level[1]	Yes	N/A - County-level[1]	N/A - County-level[1]
Denham et al. (2021)	PA / NY	Cardio-vascular	N/A - County-level[1]	N/A - County-level[1]	Yes	N/A - County-level[1]	N/A - County-level[1]
Trickey (2023)	PA / NY	Cardio-vascular and respiratory	N/A - ZIP Code-level[4]	N/A - ZIP Code-level[4]	Yes	N/A - ZIP Code-level[4]	N/A - ZIP Code-level[4]
Rasmussen et al. (2016)	PA / NY	Respiratory	See note[5]	See note[5]	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes[4]

Author (Year)	State	Health outcome category	Distance evaluated (ft)	Distance evaluated (km)	Statistically significant finding for adverse health outcome?	Statistically significant findings for adverse health outcome at ≤1 km (3,281 ft)	Statistically significant findings for adverse health outcome at >1 km (3,281 ft)
Hoang et al. (2023)	TX	Cancer	N/A - Spatial cluster analysis[7]	N/A - Spatial cluster analysis[7]	?	N/A - Spatial cluster analysis[7]	N/A - Spatial cluster analysis[7]
Whitworth et al. (2017)	TX	Perinatal	2,640–52,800	0.8–16.1	Yes	Yes	Yes
Walker Whitworth et al. (2018)	TX	Perinatal	2,640	0.8	Yes	Yes	Not evaluated.
Cushing et al. (2020)	TX	Perinatal	16,404	5	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes
Tang et al. (2021)	TX	Perinatal	3,281–24,606	1–7.5	Yes	Yes	Yes
Willis et al. (2021)	TX	Perinatal	3,281–32,808	1–10	Yes	Yes	Yes
Willis et al. (2022)	TX	Perinatal (Maternal)	3,281–32,808	1–10	Yes	Yes	No
Han et al. (2023)	TX	Perinatal	N/A - County-level[1]	N/A - County-level[1]	Yes	N/A - County-level[1]	N/A - County-level[1]
Willis et al. (2023)	TX	Perinatal	6,562–16,404	5	Yes	≤1 km (3,281 ft) not specifically evaluated.	Yes
Willis et al. (2020)	TX	Respiratory	N/A - ZIP Code-level[4]	N/A - ZIP Code-level[4]	Yes	N/A - ZIP Code-level[4]	N/A - ZIP Code-level[4]
Li et al. (2023)	TX	Respiratory	N/A - Census block group-level[8]	N/A - Census block group-level[8]	Yes	N/A - Census block group-level[8]	N/A - Census block group-level[8]

Author (Year)	State	Health outcome category	Distance evaluated (ft)	Distance evaluated (km)	Statistically significant finding for adverse health outcome?	Statistically significant findings for adverse health outcome at ≤1 km (3,281 ft)	Statistically significant findings for adverse health outcome at >1 km (3,281 ft)
Weinberger et al. (2017)	WV	Other - Self-reported symptoms/ outcomes	3,281	1	Statistical significance not assessed.	Statistical significance not assessed.	Statistical significance not assessed.
Hu et al. 2022	United States	Cardio-vascular	N/A - State-level[9]	N/A - State-level[9]	Yes	N/A - State-level[9]	N/A - State-level[9]
Mayer & Olson Hazboun (2019)	United States	Mental and behavioral health	N/A - County-level[1]	N/A - County-level[1]	No	N/A - County-level[1]	N/A - County-level[1]
Boslett & Hill (2022)	United States	Other – Mortality	N/A - County-level[1]	N/A - County-level[1]	Yes	N/A - County-level[1]	N/A - County-level[1]

[1] N/A - County-level: Not applicable - exposure and outcome assessed at the county level rather than at the individual-level where distance from oil and gas sites can be evaluated.

[2] N/A - Unspecified: Exposure and outcome assessed without specification of distance from oil and gas sites.

[3] Exposure assessment methods reliant on inverse-distance weighting (IDW) often do not specify distance, but it is highly likely that studies reliant on these methods evaluated distances from oil and gas development beyond 1 km (3,281 ft).

[4] N/A - ZIP Code-level: Not applicable - exposure and outcome assessed at the ZIP code-level rather than at the individual-level where distance from oil and gas sites can be evaluated.

[5] Distance for exposure categories not specified in detail. Patients in the highest exposure group lived a median of 19 km (62,336 ft) from closest well vs. 63 km (206,693 ft) for patients in the lowest group.

[6] Residents in "gas patches." Questionnaire included proximity to three gas facilities (within 1,500 ft [457 m] & outside this radius), including compressor and pipeline stations, gas-producing wells, and impoundment or waste pits. Proximity was assumed to be less than 1 km (3,281 ft), but it is unclear if surveyed residents resided >1 km (3,281 ft).

[7] N/A - Spatial cluster analysis: Studies did not include individual-level evaluations of exposures and outcomes where distance from oil and gas sites can be evaluated.

[8] N/A - Census block group-level: Li et al. (2023) evaluated exposure and outcome at the census block group-level rather than at the individual-level where distance from oil and gas sites can be evaluated.

[9] N/A - State-level: Hu et al. (2022) evaluated exposure and outcome at the state-level rather than at the individual-level where distance from oil and gas sites can be evaluated.

3.3.2 Summary of epidemiologic studies related to specific health endpoints

The following sections summarize the findings from the peer-reviewed epidemiologic literature on the association between upstream OGD and adverse health outcomes. In Section 3.3.2.1, we first discuss the criteria used and the general evidence that supports a causal relationship between oil and gas development and adverse perinatal and respiratory health outcomes. In subsequent sections, we describe the specifics of studies on adverse perinatal outcomes (Section 3.3.2.2) and respiratory outcomes (Section 3.3.2.3). The following sections include other studied health endpoints: mental and behavioral health outcomes (Section 3.3.2.4); cancer (Section 3.3.2.5); cardiovascular outcomes (Section 3.3.2.6); and other health outcomes (Section 3.3.2.7). For all health-endpoint specific sections, we first summarize any findings from studies conducted in California and then those conducted elsewhere in the United States and Canada.

3.3.2.1 Epidemiological studies provide evidence that supports a causal relationship between oil and gas development and adverse perinatal and respiratory health outcomes

Below, we discuss how the body of epidemiological studies on the relationship between upstream OGD and perinatal and respiratory outcomes meets the nine Bradford Hill Criteria for Causation (Hill, 1965; Lucas & McMichael, 2005). The Bradford Hill Criteria are used to evaluate the strength of epidemiological evidence for determining a causal relationship between an exposure and observed effect. After applying these criteria, the Panel concludes with a high level of certainty that there is a causal relationship between close geographic proximity to OGD and adverse perinatal and respiratory outcomes (**Table 3.2**). We have a high level of certainty in the findings from the body of epidemiological studies for perinatal and respiratory health outcomes because of the consistency of results across multiple studies conducted using different methodologies, in different locations, with diverse populations, and during different time periods (see **Table 3.4** below). Most of these studies entail robust analyses, such as longitudinal and case-control study designs that establish temporality based on large sample sizes. These studies also control for potential individual and area-level confounders, apply rigorous statistical modelling techniques, and conduct sensitivity analyses to assess the robustness of effects. A variety of pollutants (e.g., fine particulate matter [$PM_{2.5}$] and toxic air contaminants) and other upstream OGD stressors are associated with these same adverse birth outcomes (Dzhambov & Lercher, 2019; Nieuwenhuijsen et al., 2017; Shapiro et al., 2013) and adverse respiratory effects (Guarnieri & Balmes, 2014), further strengthening the evidence of the link between upstream OGD and these health outcomes. Therefore, the totality of the epidemiological evidence provides a high level of certainty for a causal relationship between residential exposure to upstream OGD and poor perinatal outcomes. Additionally, the epidemiologic evidence base provides a high level of certainty for a causal relationship between residential exposure to upstream OGD and adverse respiratory outcomes.

Oil and gas development and perinatal outcomes

Perinatal outcome studies provide the largest (25 studies)[5] and strongest body of evidence linking upstream OGD exposure during the sensitive prenatal period with adverse health effects. Twenty-four of 25 studies that examine perinatal effects found increased risk of at least one adverse birth outcome in those most exposed to upstream OGD (measured using metrics including, but not limited to proximity, well density, and production volume). Adverse perinatal outcomes, including preterm births, low birth weight, small-for-gestational age births, and congenital malformations, increase the risk of mortality and long-term developmental problems in newborns (Liu et al., 2012; Vogel et al., 2018) as well as longer term morbidity through adulthood (Baer et al., 2016; Barker, 1995; Carmody & Charlton, 2013; Frey & Klebanoff, 2016).

Recent studies in California have reported associations between exposure to upstream OGD and adverse birth outcomes, considering wells under production using conventional methods as well as enhanced oil recovery including cyclic steam injection, steam flooding and water flooding — methods that do not meet the definition of unconventional development (Gonzalez et al., 2020; Tran et al., 2020). Similar findings regarding adverse birth outcomes have been reported for upstream unconventional OGD (UOGD) in California (Tran et al., 2021) and in Colorado, Ohio, Oklahoma, Pennsylvania and Texas (Apergis et al., 2019; Casey et al., 2016; Cushing et al., 2020; Gaughan et al., 2023; Gonzalez et al., 2020; Han et al., 2023; Hill, 2018; McKenzie et al., 2019; Stacy et al., 2015; Tang et al., 2021; Walker Whitworth et al., 2018; Whitworth et al., 2017). Further, a handful of epidemiological studies have explicitly examined potential differences in associations between conventional or unconventional oil or natural gas development and adverse birth outcomes. For example, Apergis et al. (2019) reported statistically significant associations between increased conventional and unconventional well count within 1 km (3,281 ft) of the residence and reductions in infant health index in Oklahoma.

Oil and gas development and respiratory outcomes

Respiratory health outcomes are the second most studied health outcomes in the epidemiological literature examining upstream OGD, with 11 peer-reviewed studies published to date.[6] Two peer-reviewed studies in California found an association between upstream OGD and self-reported and physician-diagnosed asthma, reduced lung function, and self-reported acute respiratory symptoms (e.g., recent wheeze) (Johnston et al., 2021; Shamasunder et al., 2018). Nine studies in other oil and gas regions (New York, Pennsylvania, and Texas) reported an association between upstream OGD and asthma exacerbations, asthma hospitalizations, and other respiratory symptoms or outcomes (Bushong et al., 2022; Koehler et al., 2018; Li et al., 2023; Peng et al., 2018; Rabinowitz et al., 2015; Rasmussen et al., 2016; Trickey et al., 2023; Willis et al., 2018, 2020). Many criteria air pollutants (e.g., $PM_{2.5}$, ozone, nitrogen oxides) and toxic air contaminants emitted from upstream OGD have a well-established body of scientific literature

[5] Apergis et al. (2019); Busby and Mangano (2017); Caron-Beaudoin et al. (2020); Cairncross et al. (2022); Casey et al. (2016); Currie et al. (2017); Cushing et al. (2020); Gonzalez et al. (2020); Erickson et al. (2022); Hill (2018); Janitz et al. (2019); Ma (2016); McKenzie et al. (2014, 2019); Stacy et al. (2015); Tang et al. (2021); Tran et al. (2020, 2021); Walker Whitworth et al. (2018); Whitworth et al. (2017); Willis et al. (2021); Willis et al. (2022).

[6] Bushong et al. (2022); Johnston et al. (2021); Koehler et al. (2018); Peng et al. (2018); Rabinowitz et al. (2015); Rasmussen et al. (2016); Shamasunder et al. (2018); Willis et al. (2018, 2020).

indicating that exposure to these pollutants causes an increased risk of development and exacerbation of respiratory disease (Bolden et al., 2015; Ferrero et al., 2014). While most studies did not evaluate both conventional and unconventional OGD, Willis et al. (2020) found that both conventional and unconventional natural gas development at the ZIP code-level were associated with pediatric asthma hospitalizations in Texas.

Table 3.2. Application of the Bradford Hill Criteria for Causation to the peer-reviewed epidemiological literature on the relationship between oil and gas development and adverse perinatal and respiratory health outcomes.

Criteria for causation (Bradford-Hill)	Description of criteria	Perinatal health studies	Respiratory health studies
Strength of Association	Environmental studies commonly report modest effects sizes (i.e., relative to active tobacco smoking or alcohol consumption). A small magnitude of association can support a causal relationship; a larger association may be more convincing.	Reported effect sizes are in ranges similar to other well-established environmental reproductive and developmental hazards, such as $PM_{2.5}$ (Dadvand et al., 2013; Li et al., 2020a). Some studies, particularly those in California, have found stronger effect estimates for upstream OGD exposures among socially marginalized groups (e.g., Cushing et al., 2020; Gonzalez et al., 2020; Tran et al., 2020, 2021).	Reported effect sizes are in ranges similar to other well-established environmental respiratory hazards. For example, effect sizes in reductions in lung function by Johnston et al. (2021) are similar in magnitude to reductions in lung function associated with secondhand smoke exposure among women (Eisner, 2002) and reductions in lung function among adults living near busy roadways (e.g., Kan et al., 2007).
Consistency	Consistent findings observed by different people in different places with different samples strengthens the likelihood of an effect.	Adverse birth outcomes have been observed in multiple studies using multiple methods in different populations at different times and locations (e.g., California, Canada, Ohio, Oklahoma, Pennsylvania, Colorado, Texas). While there is some variation in findings by specific perinatal outcomes, the overall body of evidence is highly consistent in supporting the association between upstream OGD and adverse perinatal outcomes.	Various respiratory health outcomes are evaluated in the literature. For asthma — the most commonly studied respiratory health outcome — studies across California, Pennsylvania, and Texas consistently show an association between upstream OGD and asthma-related metrics (asthma prevalence, exacerbations, pediatric hospitalizations) (e.g., Koehler et al., 2018; Li et al., 2023; Rasmussen et al., 2016; Shamasunder et al., 2018; Willis et al., 2018, 2020).

Criteria for causation (Bradford-Hill)	Description of criteria	Perinatal health studies	Respiratory health studies
Specificity	Causation is likely if there is no other likely explanation.	All peer-reviewed birth outcome studies included in our review controlled for other potential confounders by accounting or adjusting for other individual-level or area-level factors (e.g., other air pollution sources, neighborhood socioeconomic status) in the analysis (e.g., Casey et al., 2016; Gaughan et al., 2023; McKenzie et al., 2014, 2019; Tran et al., 2020, 2021; Willis et al., 2023). Other studies applied statistical modeling approaches such as difference-in-differences that account for temporal and spatial trends that may confound observed effects (e.g., Willis et al., 2021).	Most respiratory health studies have controlled for other potential explanatory or confounding factors by accounting or adjusting for other individual-level (e.g., smoking status) or area-level factors (e.g., other air pollution sources) in the analysis (Johnston et al., 2021; Koehler et al., 2018; Peng et al., 2018; Rabinowitz et al., 2015; Rasmussen et al., 2016; Willis et al., 2020; Willis et al., 2018), or in the study design, such as utilizing a difference-in-difference methodology (Peng et al., 2018; Willis et al., 2018).
Temporality	Exposure precedes the disease.	Most birth outcomes studies have proper temporal alignment between exposure and outcome and use a retrospective cohort, case control or other study design that allows retroactive assessment of exposures to OGD occurring before the onset of disease. They do not consider exposure that occurred at the time of disease or oil and gas wells drilled after the disease.	Some respiratory health studies do not allow for assessments of exposure that predate disease. However, of the studies with the proper temporal alignment (e.g., Johnston et al., 2021; Koehler et al., 2018; Peng et al., 2018; Rasmussen et al., 2016; Willis et al., 2018), authors report statistically significant associations between OGD and oral corticosteroid medication orders, asthma hospitalizations, and asthma-related emergency department visits.
Biological Gradient (Dose-Response)	Greater exposure leads to a greater likelihood of the outcome.	Some studies have found dose-response relationships based on oil and gas production volume categories or metrics of inverse distance weighting and/or oil and gas well density in California and elsewhere (Casey et al., 2016; McKenzie et al., 2014, 2019; Tang et al., 2021; Tran et al., 2020, 2021).	Larger reductions in lung function observed with decreased distance from active oil development sites (Johnston et al., 2021).

Criteria for causation (Bradford-Hill)	Description of criteria	Perinatal health studies	Respiratory health studies
Plausibility	The exposure pathway and biological mechanism is plausible based on other knowledge.	Individual health-damaging chemical pollutants are well-understood to be emitted from upstream OGD (e.g., $PM_{2.5}$, benzene) and established as contributing to increased risk for the same adverse perinatal outcomes observed in the epidemiology studies. Stressors associated with upstream OGD (e.g., psychosocial stress; Casey et al., 2019) can also contribute to increased adverse perinatal outcomes.	Many air pollutants associated with upstream OGD are well-known to contribute to respiratory morbidity and mortality, including exacerbations of existing respiratory conditions (Guarnieri & Balmes, 2014).
Coherence	Causal inference is possible only if the literature or substantive knowledge supports this conclusion.	In particular, the body of peer-reviewed literature is converging towards singular directions for adverse perinatal outcomes.	The body of peer-reviewed literature points in a singular direction for adverse respiratory health outcomes.
Experiment	Causation is a valid conclusion if researchers have seen observed associations in prior experimental studies.	N/A - Human population-based experimental studies are not available due to ethical issues.	N/A - Human population-based experimental studies are not available due to ethical issues.

Criteria for causation (Bradford-Hill)	Description of criteria	Perinatal health studies	Respiratory health studies
Analogy	For similar programs operating, similar results can be expected to bolster the causal inference concluded.	Pollutants well known to be emitted during upstream OGD including benzene, toluene and 1,3-butadiene are listed as reproductive or developmental toxicants under Proposition 65 and thus are recognized as such by the State of California (CA EPA OEHHA, 2021). EPA's current Integrated Science Assessments conclude that the evidence is suggestive of, but is not sufficient to infer, a causative relationship between birth outcomes, including preterm birth and low birth weight, and $PM_{2.5}$ and long-term ozone exposures (US EPA, 2019, 2020). Additionally, increased stress during pregnancy can alter fetal growth and length of gestation (Fink et al., 2012).	The U.S. EPA's current Integrated Science Assessments of particulate matter and tropospheric ozone conclude that there is a causal relationship between respiratory outcomes, including asthma, and short-term ozone exposure. There is also likely a causal relationship between respiratory outcomes, including asthma, both short- and long-term $PM_{2.5}$ exposure, and long-term ozone exposure (US EPA, 2019, 2020).

3.3.2.2 Perinatal outcomes

Perinatal outcomes are the most common health outcomes evaluated in the peer-reviewed literature in the context of oil and gas development. Twenty-five studies examine the association between upstream oil and gas development and perinatal outcomes (**Table 3.3**). Three studies were conducted in California (described directly below; Gonzalez et al., 2020; Tran et al., 2020, 2021) and 22 studies were conducted in other oil and gas regions, including Colorado (McKenzie et al., 2014, 2019; Erickson et al., 2022), Ohio (Gaughan et al., 2023); Oklahoma (Apergis et al., 2019; Janitz et al., 2019), Pennsylvania (Busby and Mangano, 2017; Casey et al., 2016; Currie et al., 2017; Hill, 2018; Ma, 2016; Stacy et al., 2015), and Texas (Cushing et al., 2020; Han et al., 2023; Tang et al., 2021; Walker-Whitworth et al., 2018; Whitworth et al., 2017; Willis et al., 2021, 2022, 2023). These studies evaluate potential exposures and perinatal outcomes over more than two decades, from 1996 to 2019.

Below we first present studies conducted in California, and then discuss findings by specific perinatal health endpoint, including preterm birth, low birth weight, term birth weight, small for gestational age, congenital malformations, congenital heart defects, neural tube defects and oral clefts, infant health index, low Apgar score, fetal death, and maternal outcomes including high-risk pregnancy and gestational hypertension and eclampsia.

Perinatal outcome studies conducted in California

Three California studies evaluated the associated upstream OGD and perinatal outcomes (preterm birth, low birth weight, term birth weight, small for gestational age) (Gonzalez et al., 2020; Tran et al., 2020, 2021).[7] These studies focus on exposures and perinatal outcomes between 1998 and 2015.

Gonzalez et al. 2020

Gonzalez et al. (2020) conducted a case-control study to evaluate the association between exposure to oil and gas wells and preterm birth risk in the San Joaquin Valley between 1998 and 2011. In this type of study, researchers compare the exposure to upstream OGD between two groups that differ by the health outcome of interest (in this case, preterm birth). The authors assessed exposure using an inverse-distance squared metric of wells in pre-production and active wells within 10 km (6.2 miles) of maternal residence. For each pregnancy, the authors assessed exposure separately for each trimester, then categorized exposure into four bins: unexposed, low, medium, and high exposure. In statistical analyses, the authors compared unexposed births with births that had high exposure. The authors statistically controlled for maternal age, education, race/ethnicity, parity, prenatal care, insurance provider, neighborhood-level poverty, and birth year. Furthermore, the authors divided preterm birth cases into three categories based on gestational age: 20–27 weeks (very early preterm births), 28–31 weeks (early), and 32–36 (moderate). The authors found statistically significantly higher risk of early preterm birth (28–31 weeks) with high exposure to wells compared to unexposed births. In analyses stratified by maternal race/ethnicity and maternal education, the risk was confined to and heightened among

[7] Outcomes are defined and studies are discussed in detail in subsections below.

early preterm births to Hispanic and non-Hispanic Black mothers, and to mothers with 12 or fewer years of education attainment. The results were robust to sensitivity analyses testing assumptions in the exposure assessment and models, as well as accounting for co-exposure to traffic-related pollutants. In a secondary analysis, Gonzalez et al. (2020) found evidence of significantly higher $PM_{2.5}$ and coarse particulate matter (PM_{10}) concentrations at monitors close to drilling sites compared to "unexposed" monitors located farther away. These authors did not aim to precisely estimate specific impacts of drilling or operating wells on concentrations of $PM_{2.5}$ or PM_{10}. Rather, they aimed to determine whether there was an observable increase in concentrations of these pollutants using ground-based monitors, establishing a plausible etiologic pathway from residential proximity to wells to elevated preterm birth risk. In a follow-up study using a more robust study design, the same authors corroborated the findings of marginal increases in $PM_{2.5}$ and PM_{10} concentrations downwind of drilling sites and active wells (Gonzalez et al., 2022).

Tran et al. 2020

Tran et al. (2020) undertook a retrospective cohort study of 2,918,089 births from 2006 to 2015 among mothers living within 10 km (6.2 miles) of at least one production oil and gas well in the Sacramento Valley, San Joaquin Valley, South Central Coast, and South Coast Air Basins to assess the association between exposure to active oil and gas productive and inactive oil and gas wells and adverse perinatal outcomes. The authors defined exposure as residing within 1 km (3,281 ft) of at least one active or inactive oil and gas well at time of delivery. The authors further defined exposure to active wells using the cumulative volume of oil and gas production (in barrels of oil equivalent, or BOE) at all active wells within 1 km (3,281 ft) during pregnancy. Exposure to inactive wells was characterized as the count of inactive wells within 1 km (3,281 ft) of the residence during pregnancy. Associations between proximity to inactive wells were found to be null. However, results showed that mothers living in rural areas and within 1 km (3,281 ft) of at least one active oil and gas well had higher odds of impaired fetal growth. Exposure to higher production volumes in rural areas was associated with a significantly higher odds of low birth weight (LBW), small-for-gestational age (SGA) births as well as lower average birth weight. Associations with LBW and SGA were elevated but attenuated in urban areas. No statistically significant associations were observed for preterm birth in either rural or urban areas. Residual confounding may explain observed differences in effect estimates between rural versus urban areas. For example, air and water pollution concentrations could differ regionally based on dispersion and hydrological transport patterns. Additionally, individual factors that could not be measured such as maternal occupation, housing quality, indoor air quality, dependence on groundwater sources for drinking water, and underlying population sensitivity to upstream OGD-related pollutants may have contributed to differences in effect estimates between rural and urban settings. The authors controlled for community-level factors (geographic setting, concentrations of modeled NO_2 to account for emission sources other than oil and gas, and income) and individual-level factors for infants (sex, month/year of birth) and mothers (age, race/ethnicity, educational attainment, Kotelchuk index of prenatal care, and child parity). In sensitivity analyses, accounting for pre-pregnancy body mass index, smoking during pregnancy, and exposure to Toxic Release Inventory facilities did not substantially change effect estimates (<10%) compared to the main model. This suggests that the associations were not spuriously associated with exposure to oil and gas wells due to uncontrolled confounders.

Tran et al. 2021

Tran et al. (2021) conducted a retrospective cohort study of 979,961 births to pregnant people in eight California counties (Colusa, Fresno, Glenn, Kern, Los Angeles, Orange, Santa Barbara, and Ventura) with hydraulic fracturing (HF) between 2006 and 2015. Exposed individuals had at least one oil and gas well hydraulically fractured within 1 km (3,281 ft) of their residence during pregnancy. The reference (unexposed) population had no wells within 1 km (3,281 ft), but at least one oil/gas well within 10 km (6.2 miles). Analyses assessed associations between HF and low birth weight, preterm birth, small for gestational age birth and term birth weight. Fewer than 1% of mothers (n=1,192) were exposed to HF during pregnancy. Among rural mothers, HF exposure was associated with significantly increased odds of low birth weight and small for gestational age birth, and significantly lower term birth weight. Among urban mothers, HF exposure was positively associated with small for gestational age birth, inversely associated with preterm birth, and not significantly associated with the other birth outcomes. As discussed above, residual confounding may explain observed differences in effect estimates between rural versus urban areas. The authors controlled for community-level factors (geographic setting, concentrations of modeled nitrogen dioxide [NO_2] to account for emission sources other than oil and gas, and income) and individual-level factors for infants (sex, month/year of birth) and mothers (age, race/ethnicity, educational attainment, Kotelchuk index of prenatal care, and child parity).

Peer-reviewed study findings by perinatal health endpoint

Below we discuss findings by specific perinatal health endpoint, including preterm birth, low birth weight, term birth weight, small for gestational age, congenital anomalies, congenital heart defects, neural tube defects and oral clefts, infant health index, low Apgar score, fetal death, and maternal outcomes including high-risk pregnancy and gestational hypertension and eclampsia.

Preterm birth

Preterm birth, defined as less than 37 weeks of gestation, is one of the most commonly evaluated adverse birth outcomes in the peer-reviewed literature. Thirteen studies examine the association between upstream OGD and preterm birth; three studies were conducted in California (described above) (Gonzalez et al., 2020; Tran et al., 2020, 2021), and ten additional studies were conducted in other oil and gas regions including Colorado (McKenzie et al., 2014; Erickson et al., 2022); Pennsylvania (Casey et al., 2016; Hill, 2018; Stacy et al., 2015); Texas (Cushing et al., 2020; Walker Whitworth et al., 2018; Whitworth et al., 2017); and Canada (Cairncross et al., 2022; Caron-Beaudoin et al., 2020). These studies evaluated potential exposures and outcomes over two decades, from 1996 to 2018.

Eight of the 13 studies examining preterm birth report a positive association between upstream OGD and preterm birth. In addition to one study in California (Gonzalez et al., 2020), six of these studies across two oil and gas regions (Pennsylvania and Texas) found statistically significant increases in preterm birth among infants born to mothers in the highest exposed groups living in proximity to upstream OGD (**Figure 3.4**) (Cairncross et al., 2022; Casey et al., 2016; Cushing et al., 2020; Hill, 2018; Walker Whitworth et al., 2018; Whitworth et al., 2017). One study reported increases in preterm birth that were not statistically significant (Caron-Beaudoin et al., 2022). The

studies evaluated proximity to upstream OGD at distances within 2,640 ft (0.8 km) from at least one oil and gas site to out beyond 10 miles (16.1 km). For example, two studies conducted in Texas found preterm birth rates significantly increased with exposure to upstream OGD within 2,640 ft (0.8 km) during the drilling phase, production phase, as well as all phases of OGD (**Figure 3.4**) (Walker Whitworth et al., 2018; Whitworth et al., 2017). These findings were observed in the Barnett Shale region of Texas, with effects remaining significant up to 10 miles (16.1 km) for those in the highest exposure tertile (Walker Whitworth et al., 2018; Whitworth et al., 2017). Similarly, a study conducted in Alberta, Canada, found that, mothers living within 10 km (6.2 miles) of more than 100 hydraulically fractured wells during one year prior to conception through birth of their child had a significantly increased risk of preterm birth (Cairncross et al., 2022).

Four studies report null associations between preterm birth and upstream OGD: two in California (Tran et al., 2020, 2021), one in Pennsylvania (Stacy et al., 2015), and one in Colorado (Erickson et al., 2022). Finally, one study, which was the first to examine upstream OGD and adverse birth outcomes, reported a statistically significant inverse association between upstream OGD and preterm birth in Colorado (McKenzie et al., 2014). The inverse association between upstream OGD and preterm birth observed in some studies may be due to residual confounding from area-level socioeconomic characteristics or environmental factors. Additionally, a live birth bias may occur if exposed mothers (compared with unexposed mothers) were more likely to experience fetal loss (Bruckner and Catalano, 2018; Goin et al., 2021)

McKenzie et al. (2014) reported findings that appear to contradict other, more recent studies. This may be due to different methodologies to estimate exposure to OGD, as well as the availability of additional information to control for factors such as prenatal care and healthcare usage during pregnancy. Time periods examined across these studies also vary, potentially contributing to the differences in findings between studies. Of note, the study period relied upon by McKenzie et al. (2014) included live births occurring between 1996–2009, whereas Stacy et al. (2015) and Tran et al. (2020) evaluated exposures using more recent health records, with study periods spanning from 2007–2010 and 2006–2015, respectively.

Study (Year)	State	Years of Data	Hydrocarbon Type	Exposure Metric	Radius*	Comparison	Exposure Category**
Gonzalez et al. (2020)	CA	1998 - 2011	Oil and natural gas	IDW (distance)	<32,808 ft	0 wells (<10 mi)	3rd quantile
							2nd quantile
							1st quantile
Tran et al. (2020)	CA	2006 - 2015	Oil and natural gas	No. of wells (inactive rural)	<3,281 ft	0 wells	3rd tertile (6+ wells rural)
							2nd tertile (2-5 wells rural)
							1st tertile (1 well rural)
				Production (active rural)	<3,281 ft	0 BOE	2nd tertile (>100 BOE/day rural)
							1st tertile (1-100 BOE/day rural)
				No. of wells (inactive urban)	<3,281 ft	0 wells	3rd tertile (6+ wells urban)
							2nd tertile (2-5 wells urban)
							1st tertile (1 well urban)
				Production (active urban)	<3,281 ft	0 BOE	2nd tertile (> 100 BOE/day urban)
							1st tertile (1-100 BOE/day urban)
Tran et al. (2021)	CA	2006 - 2015	Oil and natural gas	No. of wells	<32,808 ft	0 wells (<1 km)	Exposed group (1+ HF well rural)
							Exposed group (1+ HF well urban)
Cushing et al. (2020)	TX (Eagle Ford)	2012 - 2015	Oil and natural gas	No. of wells	<16,404 ft	0 wells	3rd tertile (27-954 wells)
							2nd tertile (9-26 wells)
							1st tertile (1-8 wells)
Walker-Whitworth et al. (2018)	TX (Barnett)	2010 - 2012	Oil and natural gas	IDW (squared-distance drilling)	<2,640 ft	0 wells (<0.5 mi)	3rd tertile (drilling)
							2nd tertile
							1st tertile
				IDW (squared-distance production)	<2,640 ft	0 wells (<0.5 mi)	3rd tertile (production)
							2nd tertile
							1st tertile
Whitworth et al. (2017)	TX (Barnett)	2010 - 2012	Oil and natural gas	IDW (squared-distance)	<2,640 ft	0 wells (<10 mi)	3rd tertile
							2nd tertile
							1st tertile
					<10,560 ft	0 wells (<10 mi)	3rd tertile
							2nd tertile
							1st tertile
					<52,800 ft	0 wells (<10 mi)	3rd tertile
							2nd tertile
							1st tertile
Casey et al. (2016)	PA	2009 - 2013	Oil and natural gas	UOGD activity z-score	None	1st quartile	4th quartile
							3rd quartile
							2nd quartile
McKenzie et al. (2014)	CO	1996 - 2009	Oil and natural gas	IDW (distance)	<5,280 ft	0 wells (<10 mi)	3rd tertile (126–1,400 wells/mi)
							2nd tertile (3.63–125 wells/mi)
							1st tertile (1–3.62 wells/mi)
Caron-Beaudoin et al. (2020)	Canada	2006 - 2016	Oil and natural gas	IDW (distance)	<8,202 ft	1st quartile	4th quartile
							3rd quartile
							2nd quartile
					<16,404 ft	1st quartile	4th quartile
							3rd quartile
							2nd quartile
					<32,808 ft	1st quartile	4th quartile
							3rd quartile
							2nd quartile

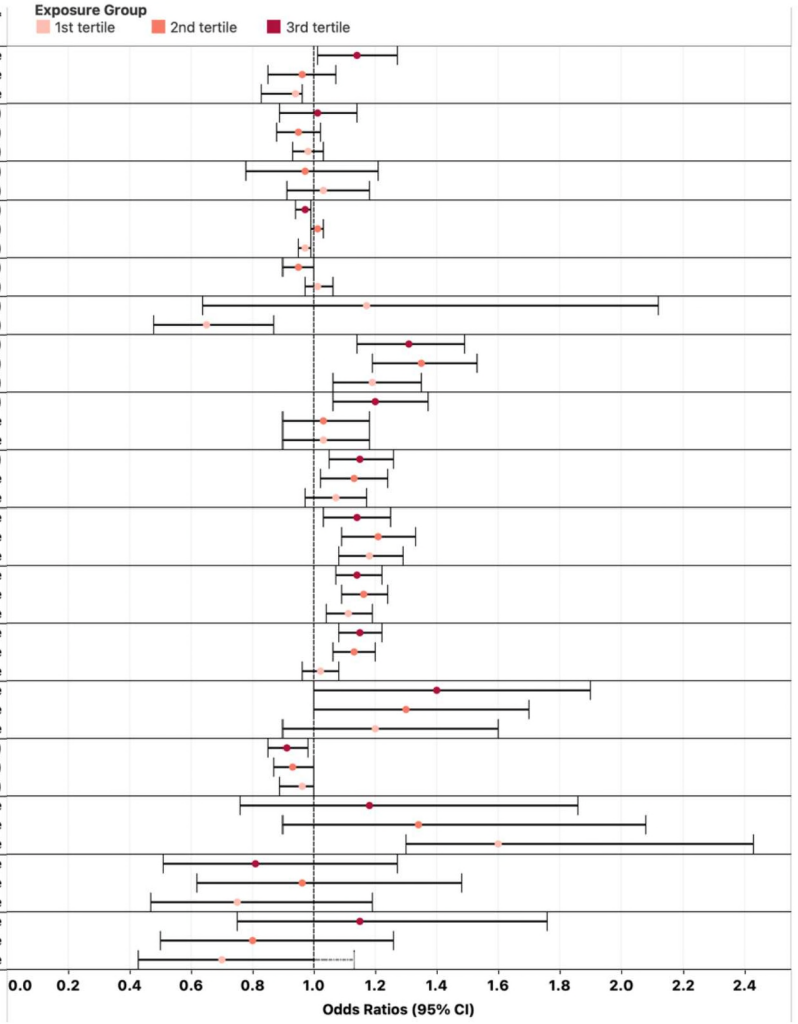


Figure 3.4. Summary of studies assessing the association between upstream oil and gas development and preterm birth (<37 weeks gestation).

* Radius represents the distance used to define exposed individuals.

** The exposure category represents the name of the category as defined by the original study. To provide visual comparability, we standardized each exposure group into tertiles: the 1st tertile indicates low activity, the 2nd tertile indicates medium activity, and the 3rd tertile indicates high activity. Quantiles/quartiles were fitted in the same fashion.
Note: Results from Cairncross et al. (2022) did not include estimated odds ratios (or risk ratios) for preterm birth but rather specific subtypes: spontaneous vs. indicated. It was therefore excluded from the figure. Erickson et al. (2022) did not include estimated odds ratios (or risk ratios) but rather reported prematurity hazards ratios. Stacy et al. (2015) displays odds ratios for all tertiles in figure form only. Additionally, Hill (2018) assessed prematurity but did not provide comparable effect estimates. Therefore, these four studies were excluded from the figure.
Abbreviations: BOE = barrels of oil equivalent; HF = hydraulically fractured; IDW = inverse distance weighted; UOGD = unconventional oil and gas development.

Low birth weight

In addition to two studies in California (Tran et al., 2020, 2021), four additional studies conducted in Colorado (McKenzie et al., 2014), Pennsylvania (Currie et al., 2017; Hill, 2018), and Oklahoma (Apergis et al., 2019) evaluated exposure to upstream OGD and low birth weight (birth weight of <2500 g, <5.51 lbs). These studies evaluated upstream OGD and low birth weight from 1996 to 2017. Five of six studies found a statistically significantly higher risk of low birth weight in the highest activity category for oil and gas communities compared to those individuals located farther away (Apergis et al., 2019; Currie et al., 2017; Hill, 2018; Tran et al., 2020, 2021). One study conducted in Colorado, McKenzie et al. (2014), found a statistically significant lower risk of low birth weight associated with exposure to upstream oil and gas development, an inverse relationship similar to that observed for preterm birth in the same study (discussed above).

Term birth weight

Thirteen peer-reviewed studies examine exposure to upstream OGD development and differences in birth weight, including two studies in California (Tran et al., 2020, 2021), two studies in Colorado (McKenzie et al., 2014; Erickson et al., 2022), one in Oklahoma (Apergis et al., 2019), four studies in Pennsylvania (Casey et al., 2016; Currie et al., 2017; Hill, 2018; Stacy et al., 2015), three studies in Texas (Cushing et al., 2020; Whitworth et al., 2017; Willis et al., 2021), and one study in British Columbia (Caron-Beaudoin et al., 2020). These studies evaluated upstream OGD and term birth weight across these different geographic regions between 1996 and 2019.

Nine of 13 studies report a statistically significant inverse association between exposure to upstream OGD and term birth weight (>37 week gestation) in California, Oklahoma, Pennsylvania, Texas, and British Columbia (Apergis et al., 2019; Caron-Beaudoin et al., 2020; Casey et al., 2016; Currie et al., 2017; Cushing et al., 2020; Stacy et al., 2015; Tran et al., 2020; 2021; Willis et al., 2021). Studies that examine mean birth weight *at term* under varying distances and levels of activity are summarized in **Figure 3.5**. Whitworth et al. (2017) found no association for term birth weight, and — similar to findings for low birth weight and preterm birth — McKenzie et al. (2014) observed a statistically significant positive association between term birth weight and exposure to upstream OGD. These results are consistent with Erickson et al. (2022), an ecological study that reported a strong positive association between term birth weight and well density and birth weight and production, but a negative association to their interaction effect.

Small for gestational age birth

Compared to low birth weight, fewer studies have examined small for gestational age birth — or birthweight less than the country sex-specific 10th percentile of weight for each week of gestation. Of these 10 studies, four (40%) report a positive association, including two studies in California (Tran et al., 2020, 2021), one in Alberta, Canada (Cairncross et al., 2022) and two studies in Pennsylvania (Hill, 2018; Stacy et al., 2015); five studies report null associations for small for gestational age (Caron-Beaudoin et al., 2020; Casey et al., 2016; Cushing et al., 2020; Whitworth et al., 2017; Willis et al., 2021).

Study (Year)	State	Years of Data	Hydrocarbon Type	Exposure Metric	Comparison	Radius*	Exposure Category**
Willis et al. (2021)	TX	1996 - 2009	Oil and natural gas	Residential proximity to drilling	Far from wells (3-10km)	<3,281 ft	3rd tertile (<3,281 ft)
						3,281 ft-6,562 ft	2nd tertile (3,281 ft-6,562 ft)
						6,562 ft -9,843 ft	1st tertile (6,562 ft -9,843 ft)
Cushing et al. (2020)	TX (Eagle Ford)	2012 - 2015	Oil and natural gas	No. of wells	0 wells	<16,404 ft	3rd tertile (27-954 wells)
							2nd tertile (9-26 wells)
							1st tertile (1-8 wells)
Whitworth et al. (2017)	TX (Barnett)	2010 - 2012	Natural gas	IDW (squared-distance)	0 wells (<10 mi)	<2,640 ft	3rd tertile
							2nd tertile
							1st tertile
						<10,560 ft	3rd tertile
							2nd tertile
							1st tertile
						<52,800 ft	3rd tertile
							2nd tertile
							1st tertile
Tran et al. (2021)	CA	2006 - 2015	Oil and natural gas	No. of wells	0 wells (<1 km)	<32,808 ft	Exposed group (1+ HF well urban)
							Exposed group (1+ HF well rural)
Tran et al. (2020)	CA	2006 - 2015	Oil and natural gas	Production (Active Rural)	0 BOE	<3,281 ft	2nd tertile (>100 BOE/day rural)
							1st tertile (1-100 BOE/day rural)
				No. of wells (Rural)	0 wells	<3,281 ft	3rd tertile (6+ wells rural)
							2nd tertile (2-5 wells rural)
							1st tertile (1 well rural)
				Production (Active Urban)	0 BOE	<3,281 ft	2nd tertile (> 100 BOE/day urban)
							1st tertile (1-100 BOE/day urban)
				No. of wells (Urban)	0 wells	<3,281 ft	3rd tertile (6+ wells urban)
							2nd tertile (2-5 wells urban)
							1st tertile (1 well urban)
Hill (2018)	PA	2003 - 2010	Natural gas	Well density	Pre-drilling	<8,202 ft	Post-drilling
				Well location	Pre-drilling	<8,202 ft	Post-drilling
Casey et al. (2016)	PA	2009 - 2013	Natural gas	UOGD activity z-score	1st quartile	None	4th quartile
							3rd quartile
							2nd quartile
McKenzie et al. (2014)	CO	1996 - 2009	Natural gas	IDW (distance)	0 wells (<10 mi)	<5,280 ft	3rd tertile (126–1,400 wells/mi)
							2nd tertile (3.63–125 wells/mi)
							1st tertile (1–3.62 wells/mi)
Caron-Beaudoin et al. (2020)	Canada	2006 - 2016	Oil and natural gas	IDW (distance)	1st quartile	<8,202 ft	4th quartile
							3rd quartile
							2nd quartile
						<16,404 ft	4th quartile
							3rd quartile
							2nd quartile
						<32,808 ft	4th quartile
							3rd quartile
							2nd quartile

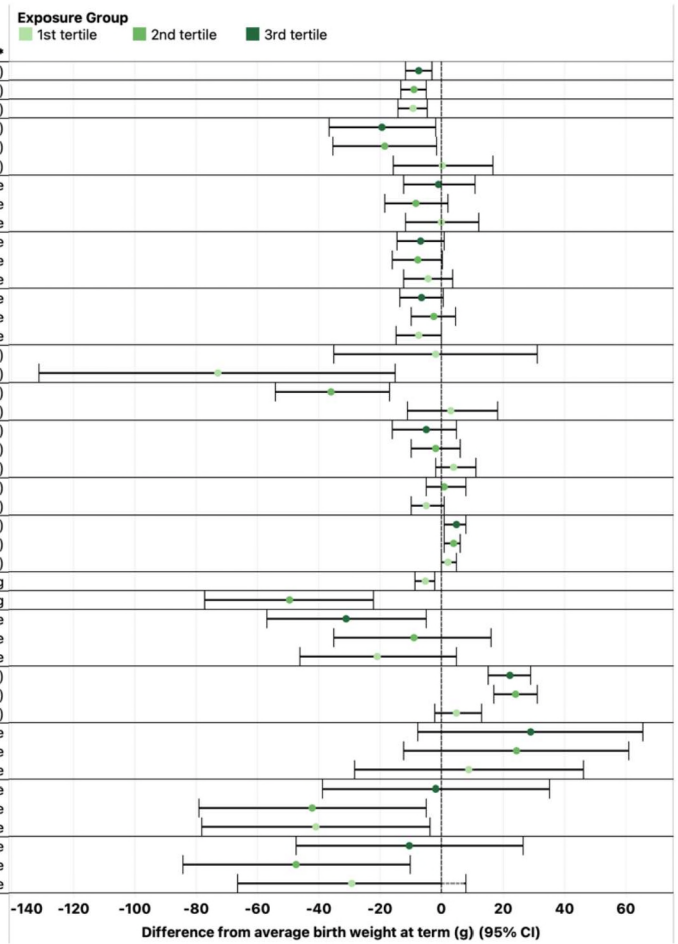


Figure 3.5. Summary of associations in the peer-reviewed literature between upstream oil and gas development and differences in term birth weight (>37 weeks gestation).

* Radius represents the distance used to define exposed individuals.

** The exposure category represents the name of the category as defined by the original study. To provide visual comparability, we standardized each exposure group into tertiles: the 1st tertile indicates low activity, the 2nd tertile indicates medium activity, and the 3rd tertile indicates high activity. Quantiles/quartiles were fitted in the same fashion.

Note: The figure only includes studies with estimated odds ratios for birth weight in grams at term, defined as any birth that occurs >37 weeks gestation. Studies that did not explicitly mention evaluation of differences in birthweight *at term* were omitted from this figure (Apergis et al., 2019; Currie et al., 2017; Erickson et al., 2022; Stacy et al., 2015).

Abbreviations: BOE = barrels of oil equivalent; IDW = inverse distance weighted; UOGD = unconventional oil and gas development.

Congenital anomalies

Nine studies assess the association between upstream OGD and congenital anomalies from 1996 to 2018 (Gaughan et al., 2023; Han et al., 2023; Hill, 2018; Janitz et al., 2019; Ma, 2016; McKenzie et al., 2014, 2019a; Tang et al., 2021; Willis et al., 2023, Cairncross et al. 2022). Because congenital anomalies include etiologically different types of birth defects, we summarize and present study results by total, non-specific birth defects, as well as the three most specific types of birth defects evaluated: congenital heart, neural tube, and oral cleft defects.

Total, non-specific congenital anomalies

Six studies considered total, non-specific congenital anomalies. Three of these were ecological studies and had mixed findings. The other three were retrospective cohort studies that observed increased risk of congenital anomalies within 5 and 10 km (3.1 and 6.2 mi) of upstream OGD.

Ecological studies. Two studies, Hill (2018) and Ma (2016) considered all congenital anomalies among infants born to mothers in Pennsylvania. Post-drilling, Hill (2018) found a non-statistically significant decrease in congenital anomalies among infants born to mothers living within 2.5 km (8,202 ft) of an active oil and gas well. Ma (2016) found that the odds of congenital anomalies were higher among infants born in ZIP codes with unconventional natural gas development as compared to infants born in ZIP codes without unconventional natural gas development. However, prevalence of birth defects decreased in ZIP codes with and without unconventional natural gas development after drilling occurred.

Han et al. (2023) conducted an ecological study of four Texas counties with active OGD, and with the highest gas production in the Barnett Shale area from 1999–2014 (Tarrant, Johnson, Wise, and Denton counties [listed from highest to lowest production 1999–2014]). Han et al. (2023) also observed that the risk of total birth defects increased with the annual county -level annual natural gas production as a proxy measure of exposure to OGD and estimated standardized morbidity ratios (SMR), accounting for maternal age and race/ethnicity as well as other demographic factors by county for various study periods (1999–2002, 2003–2006, 2007–2010, 2011–2014). For total birth defects, Tarrant County had an elevated SMR in each time period, Johnson County in three, and Wise County in one. Denton County did not differ from the expected number of cases.

While some of these studies indicates a decrease in rates of congenital anomalies over time, each study examines exposures and outcomes at the group-level (e.g., the ZIP code or county level), as opposed to examining proximity to well sites or well density near maternal residence. Therefore, these studies do not examine exposures to OGD as granularly as the retrospective cohort and case-control studies that evaluate exposure at the individual level. Additionally, the grouping of all types of congenital defects together pushes the result towards the null, which makes it more difficult to detect associations.

Retrospective cohort studies: Cairncross et al. (2022), Gaughan et al. (2023), and Willis et al. (2023) undertook retrospective cohort studies and considered all congenital anomalies among infants born to mothers in Alberta, Ohio, and Texas, respectively, using data from birth defect registries and birth registries. Cairncross et al. (2022) compared presence to absence of an oil

and gas well that underwent hydraulic fracturing one year prior to the conception through birth within 10 km (6.2 mi) of the birth residence. Results showed statistically significant increased odds of major congenital anomalies for children with a birth residence within 10 km (6.2 mi) of an oil and gas well that was hydraulically fractured. Gaughan et al. (2023) compared presence to absence of an unconventional oil and gas well within a 10 km (6.2 mi) buffer of the birth residence, as well as presence to absence unconventional oil and gas well hydrologically upgradient of the birth residence within the 10 km (6.2 mi) buffer of the birth residence. Results showed increased odds of any structural birth defect for children with presence of an unconventional oil and gas well in the 10 km (6.2 mi) buffer, and less precise increased odds for children with presence of an upgradient unconventional oil and gas well in the 10 km (6.2 mi) buffer. Willis et al. (2023) examined upstream OGD-related exposures using tertiles of inverse distance-squared weighting within 5 km (3.1 mi) for drilling site count, gas production, oil production, and produced water, compared to infants born to mothers living within 5 km (3.1 mi) of future drilling sites that were not yet operating during the pregnancy period (temporal comparison group). Results showed increased odds of any congenital anomaly in the highest tertile exposure group for site well count, oil production, gas production, and produced water, although associations did not follow a consistent exposure-response pattern across tertiles. Using a spatial comparison group of mothers living 5–10 km (3.1–6.1 mi) away from an upstream OGD site revealed attenuated, but still increased, odds of any congenital anomaly. While these three studies improve on the ecological design by evaluating exposure and congenital anomalies at the individual level, the grouping of all types of congenital defects together pushes the result towards the null, which makes it more difficult to detect associations.

A subset of analyses in the Gaughan, Willis, and Han studies, in addition to four other studies examined specific subsets of congenital malformations. The most commonly evaluated malformations included congenital heart defects, neural tube defects, and oral clefts.

Congenital heart defects

All seven studies that evaluated associations between upstream OGD and congenital heart defects report increased risk of congenital heart defects increasing levels of and/or proximity to OGD within 1–16.1 km (0.6–10 mi) of the birth residence. Four retrospective cohort and two case-control studies observed increased odds of congenital heart defects with increased upstream OGD.

The Han et al. (2023) ecological study described previously observed increased risks of atrial septal defects, ventricular septal defects, and patent ductus arteriosus in three, one, and two out of the four selected Texas counties. They also observed that risks of atrial septal defects and patent ductus arteriosus increased with annual natural gas production volumes. No significant associations of increased natural gas production were found with ventricular septal defects.

In the Gaughan et al. (2023) Ohio study described previously, non-statistically significant increased rates of congenital heart defects as a whole increased with presence of an unconventional oil and gas well within 10 km of the birth residence. The Willis et al. (2023) Texas study described previously found consistently increased odds of cardiac and circulatory anomalies, across tertiles of all upstream OGD exposure metrics using a temporal comparison,

with results attenuated using a spatial comparison group. In another Texas study, Tang et al. (2021) employed a case-control design to examine congenital heart defects among infants born to mothers living within 1 km (3,281 ft), 3 km (1.8 mi), and 7.5 km (4.7 mi) of an active Texas oil and gas well during the year of birth. The authors found significantly increased odds of aortic valve stenosis, hypoplastic left heart syndrome, and pulmonary valve atresia or stenosis among those living within 1 km (3,281 ft), 3 km (1.8 mi), and 7.5 km (4.7 mi) of an active oil and gas well and exposed to the highest density of natural gas activity.

Results in Colorado and Oklahoma are consistent with the Texas and Ohio studies. In Colorado, McKenzie et al. (2014) employed a retrospective cohort design to compare tertiles of inverse distance weighted sums of oil and gas wells within 16.1 km (10 mi) of birth residence to absence of any OGD within 16.1 km (10 mi). They reported a statistically significant, monotonically increasing risk of congenital heart defects with increasing inverse distance weighted sum of oil and gas wells within 16.1 km (10 mi) of the birth residence In a follow up Colorado study, McKenzie et al. (2019a) employed a nested case control design to examine the relationship between more specific congenital heart defects and the inverse distance weighted oil and gas well count, adjusted for intensity of oil and gas activity. They also consider other major air population sources in the analysis. Similar to their first study, they observed a statistically significant monotonic increase in odds of total congenital heart defects, with increasing intensity adjusted inverse distanced weighted counts of oil and wells, within 16.1 km (10 mi) of the birth residence. They also observed a positive, though not statistically significant, association between upstream OGD and specific congenital heart defects, including aortic artery and valve defects, pulmonary artery and valve defects, conotruncal defects, and tricuspid valve defects. In Oklahoma, Janitz et al. (2019) conducted a retrospective cohort study to compare inverse distance weighted counts of actively producing natural gas wells within two miles (3.2 km) of the birth residence. While they did not find an association between upstream OGD and critical congenital heart defects as a whole; when broken out by specific defect, the authors found non-statistically significant but increased rates of common truncus, transposition of the great arteries, pulmonary valve atresia and stenosis, tricuspid valve atresia and stenosis, interrupted aortic arch, and total anomalous pulmonary venous connection among children living in areas of upstream OGD.

Studies that evaluated congenital heart defects are summarized in **Figure 3.6**

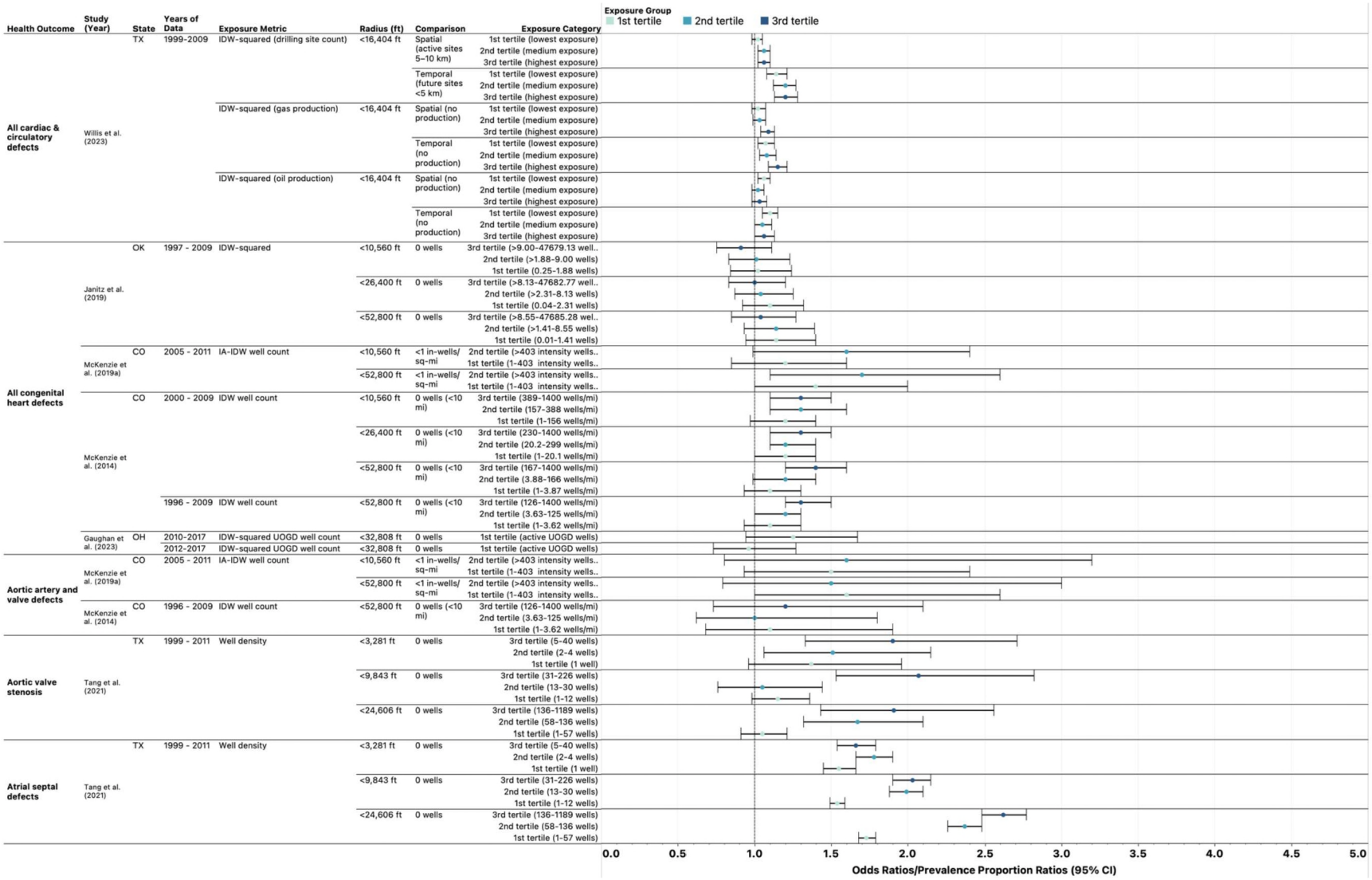


Figure 3.6. Summary of associations in the peer-reviewed literature between upstream oil and gas development and congenital heart defects. See notes on last series of forest plots that comprise Figure 3.6.

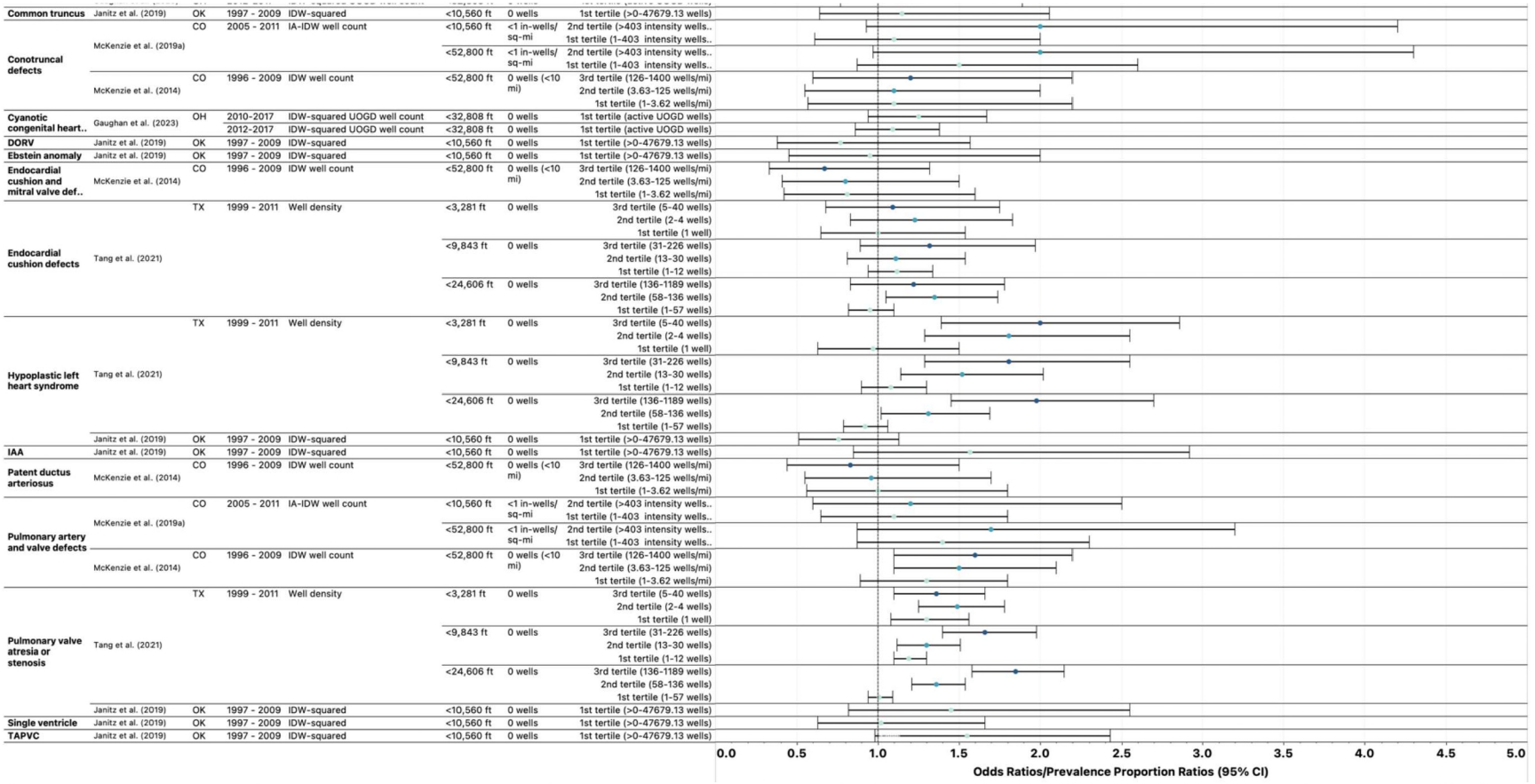


Figure 3.6. ***continued*** Summary of associations in the peer-reviewed literature between upstream oil and gas development and congenital heart defects. See notes on last series of forest plots that comprise Figure 3.6.

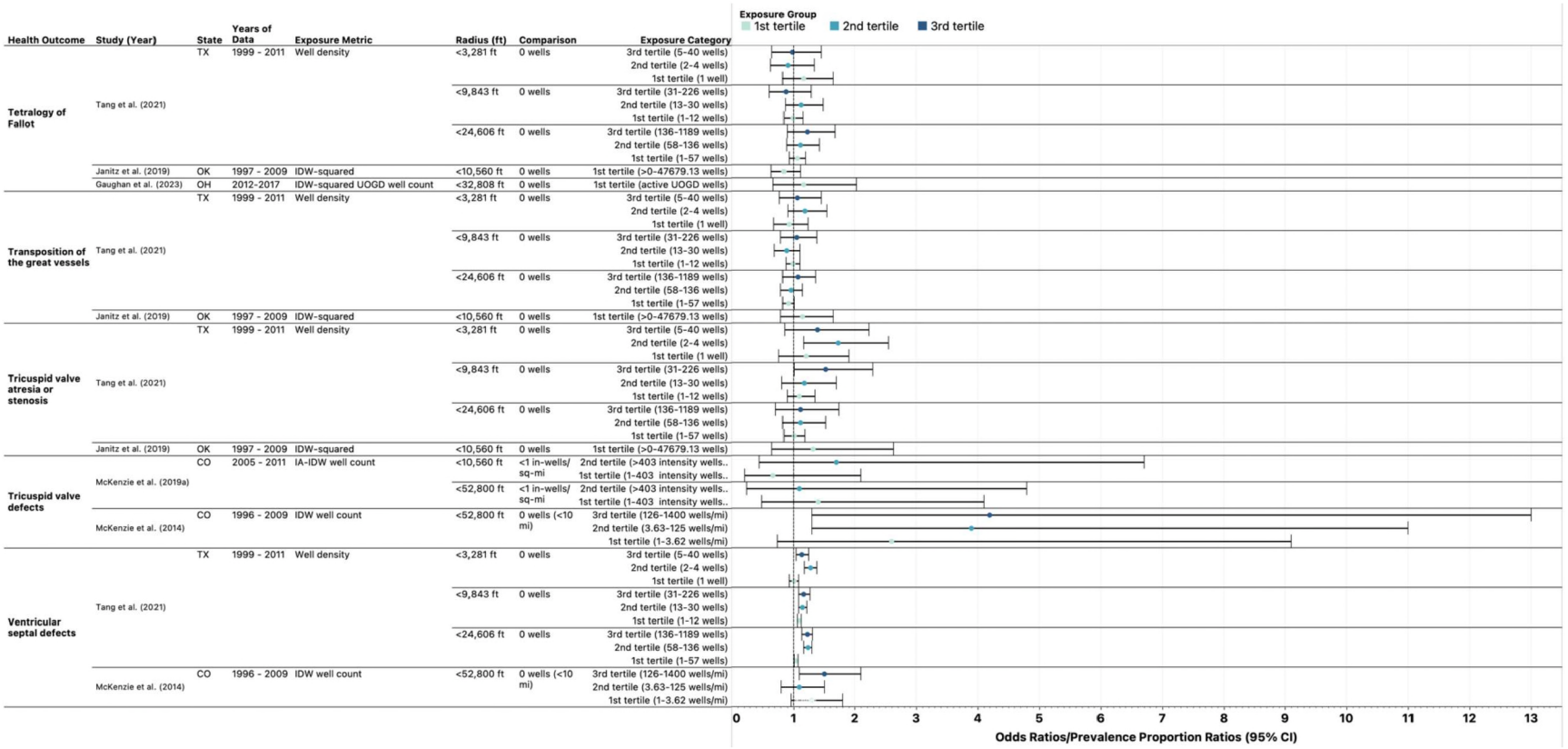


Figure 3.6. ***continued*** Summary of associations in the peer-reviewed literature between upstream oil and gas development and congenital heart defects.

* Radius represents the distance used to define exposed individuals.
** The exposure category represents the name of the category as defined by the original study. To provide visual comparability, we standardized each exposure group to tertiles, with the 1st tertile representing low activity, the 2nd tertile representing medium activity, and the 3rd tertile representing high activity. Quantiles/quartiles were fitted in the same fashion.
Note: Results from Han et al. (2023) did not include estimated odds ratios (or risk ratios) and was therefore excluded from the figure.
Abbreviations: BOE = barrels of oil equivalent; DORV = Double outlet right ventricle; IA-IDW = intensity-adjusted inverse distance weighted; IDW = inverse distance weighted; IAA = Interrupted Aortic arch TAPVC = Total anomalous pulmonary venous connection; UNGD = unconventional natural gas development.

Neural tube defects

Five out of six studies that evaluated neural tube defects and upstream OGD found that the risk of neural tube defects increased with increasing level activity and/or proximity to upstream OGD within 1–16.1 km (0.6–10 mi) of the birth residence.

The Han et al (2023) ecological study described previously observed increased risks of severe microcephaly and hydrocephaly without spina bifida in two out of four selected Texas counties. They did not observe that risks of microcephaly or hydrocephaly without spina bifida increased with annual natural gas production volumes.

Four retrospective cohort studies and one case-control study examined neural tube defects (Janitz et al., 2019; McKenzie et al., 2014; Tang et al., 2021; Willis et al., 2023). In Ohio, the previously described Gaughan et al. (2023) study found elevated odds of neural tube defects among women living within 10 km of upstream OGD sties. The previously described Tang et al. (2021) Texas study found significantly increased odds of spina bifida and anencephaly, two subtypes of neural tube defects. The previously described Janitz et al. (2019) study found that among children living in Oklahoma within two miles (3.2 km) of natural gas activity, prevalence of neural tube defects was increased compared to children exposed to zero wells, though these findings were not statistically significant. The previously described McKenzie et al. (2014) study found significantly increased odds of neural tube defects in children exposed to the highest level of oil and gas activity compared to children exposed to no active gas wells within a 10-mile (16.1 km) radius. While the sample size was small, findings were statistically significant, indicating a potential association. However, the previously described Willis et al. (2023) study did not find significant associations of neural tube defects among Texas infants living within 5 km (3.1 mi) of OGD sites using multiple exposure metrics as well as a temporal or spatial comparison group.

Studies that evaluated neural tube defects are summarized in **Figure 3.7.**

Oral cleft defects

Five previously described studies examined associations between oral cleft defects and upstream OGD (Janitz et al., 2019; McKenzie et al., 2014; Tang et al., 2021, Gaughan et al., 2023, Willis et al., 2023). Mckenzie et al. (2014), Janitz et al. (2019), Tang et al. (2021), and Willis et al. (2023) found no association between upstream OGD and oral cleft defects. Studies that evaluated cleft defects are summarized in **Figure 3.8.**

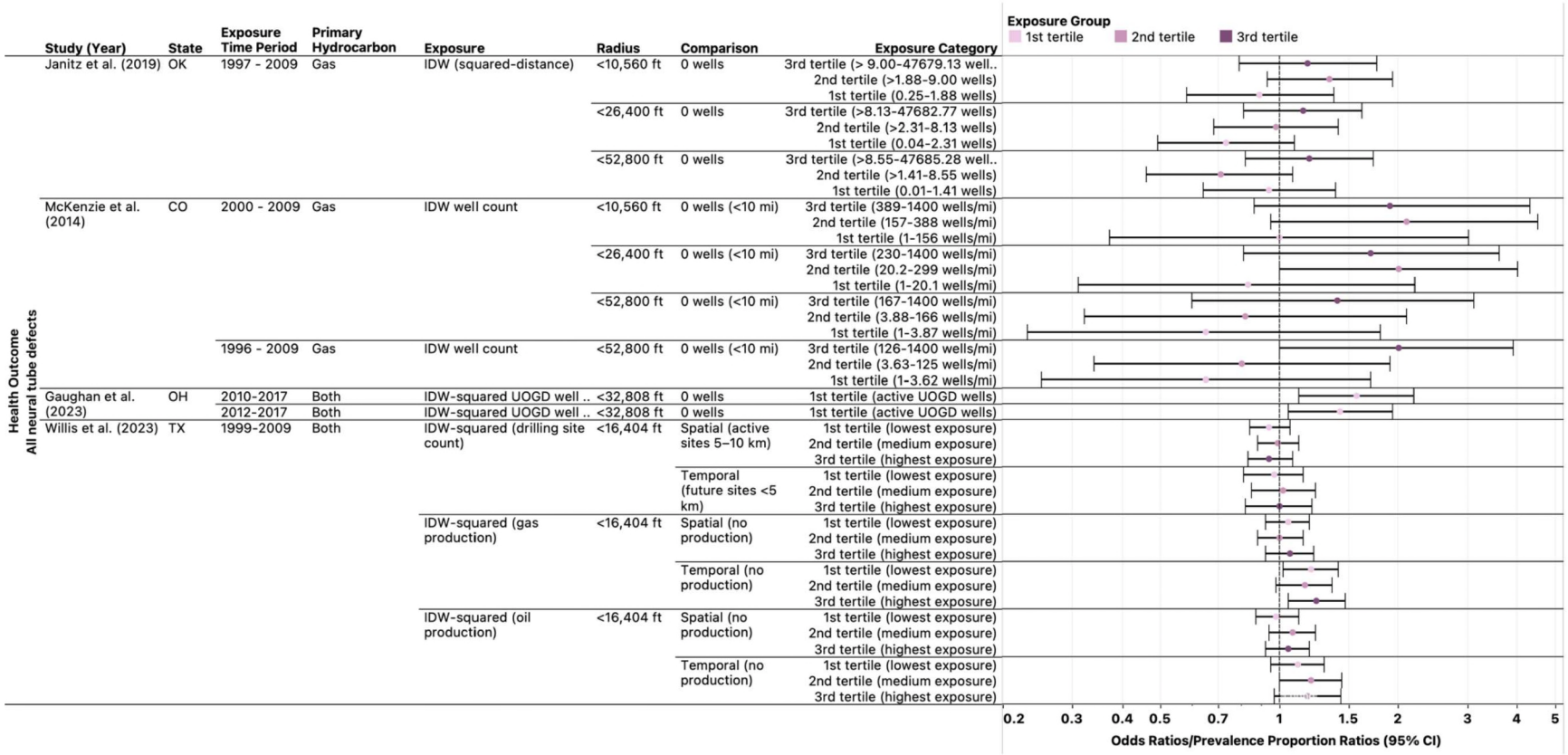
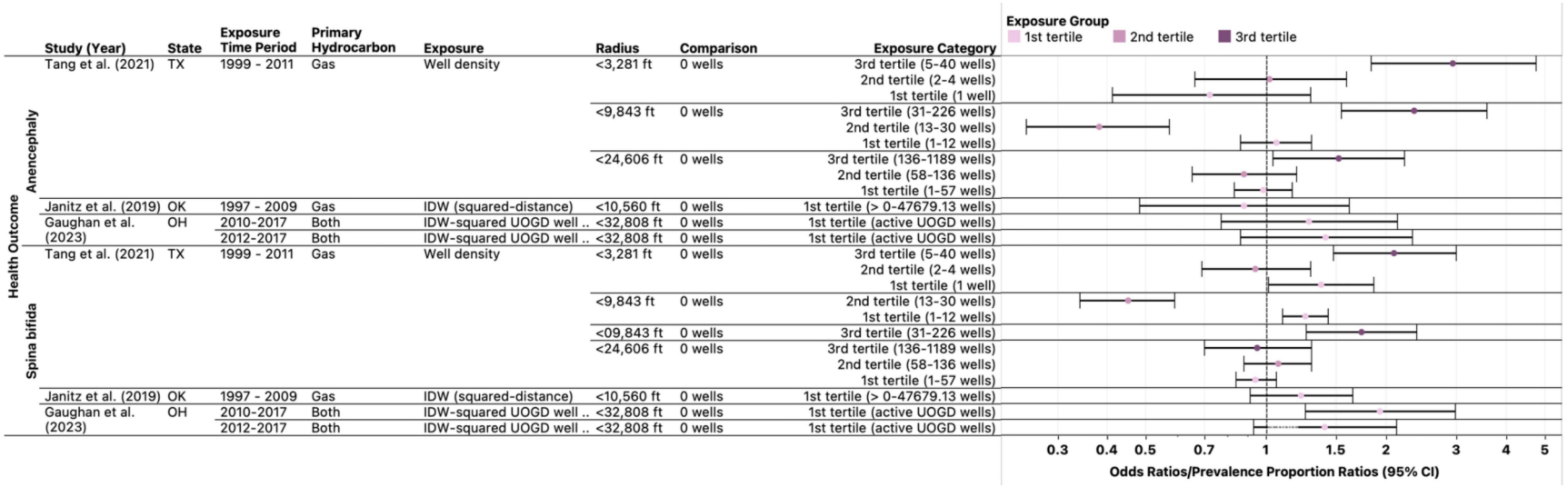


Figure 3.7. Summary of associations in the peer-reviewed literature between upstream oil and gas development and neural tube defects

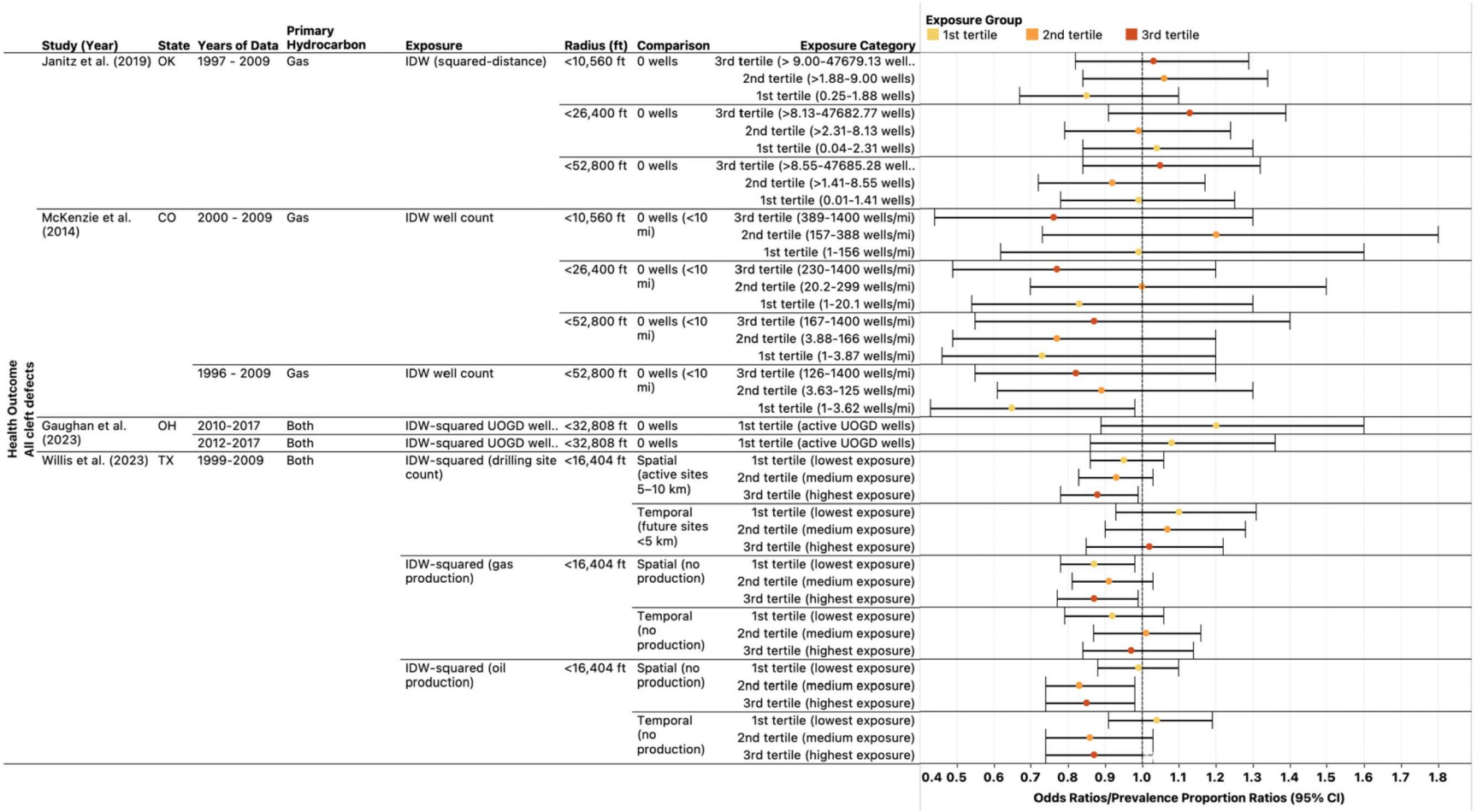
* Radius represents the distance used to define exposed individuals.
** The exposure category represents the name of the category as defined by the original study. To provide visual comparability, we standardized each exposure group to tertiles, with the 1st tertile representing low activity, the 2nd tertile representing medium activity, and the 3rd tertile representing high activity. Quantiles/quartiles were fitted in the same fashion.
Abbreviations: IDW = inverse distance weighted; UNGD = unconventional natural gas development.



Health Outcome	Study (Year)	State	Exposure Time Period	Primary Hydrocarbon	Exposure	Radius	Comparison	Exposure Category
Anencephaly	Tang et al. (2021)	TX	1999 - 2011	Gas	Well density	<3,281 ft	0 wells	3rd tertile (5-40 wells)
								2nd tertile (2-4 wells)
								1st tertile (1 well)
						<9,843 ft	0 wells	3rd tertile (31-226 wells)
								2nd tertile (13-30 wells)
								1st tertile (1-12 wells)
						<24,606 ft	0 wells	3rd tertile (136-1189 wells)
								2nd tertile (58-136 wells)
								1st tertile (1-57 wells)
	Janitz et al. (2019)	OK	1997 - 2009	Gas	IDW (squared-distance)	<10,560 ft	0 wells	1st tertile (> 0-47679.13 wells)
	Gaughan et al. (2023)	OH	2010-2017	Both	IDW-squared UOGD well ..	<32,808 ft	0 wells	1st tertile (active UOGD wells)
			2012-2017	Both	IDW-squared UOGD well ..	<32,808 ft	0 wells	1st tertile (active UOGD wells)
Spina bifida	Tang et al. (2021)	TX	1999 - 2011	Gas	Well density	<3,281 ft	0 wells	3rd tertile (5-40 wells)
								2nd tertile (2-4 wells)
								1st tertile (1 well)
						<9,843 ft	0 wells	2nd tertile (13-30 wells)
								1st tertile (1-12 wells)
						<09,843 ft	0 wells	3rd tertile (31-226 wells)
						<24,606 ft	0 wells	3rd tertile (136-1189 wells)
								2nd tertile (58-136 wells)
								1st tertile (1-57 wells)
	Janitz et al. (2019)	OK	1997 - 2009	Gas	IDW (squared-distance)	<10,560 ft	0 wells	1st tertile (> 0-47679.13 wells)
	Gaughan et al. (2023)	OH	2010-2017	Both	IDW-squared UOGD well ..	<32,808 ft	0 wells	1st tertile (active UOGD wells)
			2012-2017	Both	IDW-squared UOGD well ..	<32,808 ft	0 wells	1st tertile (active UOGD wells)

Figure 3.7. *continued* Summary of associations in the peer-reviewed literature between upstream oil and gas development and neural tube defects

* Radius represents the distance used to define exposed individuals.
** The exposure category represents the name of the category as defined by the original study. To provide visual comparability, we standardized each exposure group to tertiles, with the 1st tertile representing low activity, the 2nd tertile representing medium activity, and the 3rd tertile representing high activity. Quantiles/quartiles were fitted in the same fashion.
Abbreviations: IDW = inverse distance weighted; UNGD = unconventional natural gas development.



Study (Year)	State	Years of Data	Primary Hydrocarbon	Exposure	Radius (ft)	Comparison	Exposure Category
Janitz et al. (2019)	OK	1997 - 2009	Gas	IDW (squared-distance)	<10,560 ft	0 wells	3rd tertile (> 9.00-47679.13 well..
							2nd tertile (>1.88-9.00 wells)
							1st tertile (0.25-1.88 wells)
					<26,400 ft	0 wells	3rd tertile (>8.13-47682.77 wells)
							2nd tertile (>2.31-8.13 wells)
							1st tertile (0.04-2.31 wells)
					<52,800 ft	0 wells	3rd tertile (>8.55-47685.28 well..
							2nd tertile (>1.41-8.55 wells)
							1st tertile (0.01-1.41 wells)
McKenzie et al. (2014)	CO	2000 - 2009	Gas	IDW well count	<10,560 ft	0 wells (<10 mi)	3rd tertile (389-1400 wells/mi)
							2nd tertile (157-388 wells/mi)
							1st tertile (1-156 wells/mi)
					<26,400 ft	0 wells (<10 mi)	3rd tertile (230-1400 wells/mi)
							2nd tertile (20.2-299 wells/mi)
							1st tertile (1-20.1 wells/mi)
					<52,800 ft	0 wells (<10 mi)	3rd tertile (167-1400 wells/mi)
							2nd tertile (3.88-166 wells/mi)
							1st tertile (1-3.87 wells/mi)
		1996 - 2009	Gas	IDW well count	<52,800 ft	0 wells (<10 mi)	3rd tertile (126-1400 wells/mi)
							2nd tertile (3.63-125 wells/mi)
							1st tertile (1-3.62 wells/mi)
Gaughan et al. (2023)	OH	2010-2017	Both	IDW-squared UOGD well..	<32,808 ft	0 wells	1st tertile (active UOGD wells)
		2012-2017	Both	IDW-squared UOGD well..	<32,808 ft	0 wells	1st tertile (active UOGD wells)
Willis et al. (2023)	TX	1999-2009	Both	IDW-squared (drilling site count)	<16,404 ft	Spatial (active sites 5–10 km)	1st tertile (lowest exposure)
							2nd tertile (medium exposure)
							3rd tertile (highest exposure)
						Temporal (future sites <5 km)	1st tertile (lowest exposure)
							2nd tertile (medium exposure)
							3rd tertile (highest exposure)
				IDW-squared (gas production)	<16,404 ft	Spatial (no production)	1st tertile (lowest exposure)
							2nd tertile (medium exposure)
							3rd tertile (highest exposure)
						Temporal (no production)	1st tertile (lowest exposure)
							2nd tertile (medium exposure)
							3rd tertile (highest exposure)
				IDW-squared (oil production)	<16,404 ft	Spatial (no production)	1st tertile (lowest exposure)
							2nd tertile (medium exposure)
							3rd tertile (highest exposure)
						Temporal (no production)	1st tertile (lowest exposure)
							2nd tertile (medium exposure)
							3rd tertile (highest exposure)

Figure 3.8. Summary of associations in the peer-reviewed literature between upstream oil and gas development and cleft defects

* Radius represents the distance used to define exposed individuals.
** The exposure category represents the name of the category as defined by the original study. To provide visual comparability, we standardized each exposure group to tertiles, with the 1st tertile representing low activity, the 2nd tertile representing medium activity, and the 3rd tertile representing high activity. Quantiles/quartiles were fitted in the same fashion.

Abbreviations: IDW = inverse distance weighted; UNGD = unconventional natural gas development.

Health Outcome	Study (Year)	State	Years of Data	Primary Hydrocarbon	Exposure	Radius (ft)	Comparison	Exposure Category
Cleft lip	Tang et al. (2021)	TX	1999 - 2011	Gas	Well density	<3,281 ft	0 wells	3rd tertile (5-40 wells)
								2nd tertile (2-4 wells)
								1st tertile (1 well)
						<9,843 ft	0 wells	3rd tertile (31-226 wells)
								2nd tertile (13-30 wells)
								1st tertile (1-12 wells)
						<24,606 ft	0 wells	3rd tertile (136-1189 wells)
								2nd tertile (58-136 wells)
								1st tertile (1-57 wells)
	Janitz et al. (2019)	OK	1997 - 2009	Gas	IDW (squared-distance)	<10,560 ft	0 wells	1st tertile (>0-47679.13 wells)
	Gaughan et al. (2023)	OH	2010-2017	Both	IDW-squared UOGD well..	<32,808 ft	0 wells	1st tertile (active UOGD wells)
			2012-2017	Both	IDW-squared UOGD well..	<32,808 ft	0 wells	1st tertile (active UOGD wells)
Cleft palate	Tang et al. (2021)	TX	1999 - 2011	Gas	Well density	<3,281 ft	0 wells	3rd tertile (5-40 wells)
								2nd tertile (2-4 wells)
								1st tertile (1 well)
						<9,843 ft	0 wells	3rd tertile (31-226 wells)
								2nd tertile (13-30 wells)
								1st tertile (1-12 wells)
						<24,606 ft	0 wells	3rd tertile (136-1189 wells)
								2nd tertile (58-136 wells)
								1st tertile (1-57 wells)
	Janitz et al. (2019)	OK	1997 - 2009	Gas	IDW (squared-distance)	<10,560 ft	0 wells	1st tertile (>0-47679.13 wells)
	Gaughan et al. (2023)	OH	2010-2017	Both	IDW-squared UOGD well..	<32,808 ft	0 wells	1st tertile (active UOGD wells)
			2012-2017	Both	IDW-squared UOGD well..	<32,808 ft	0 wells	1st tertile (active UOGD wells)

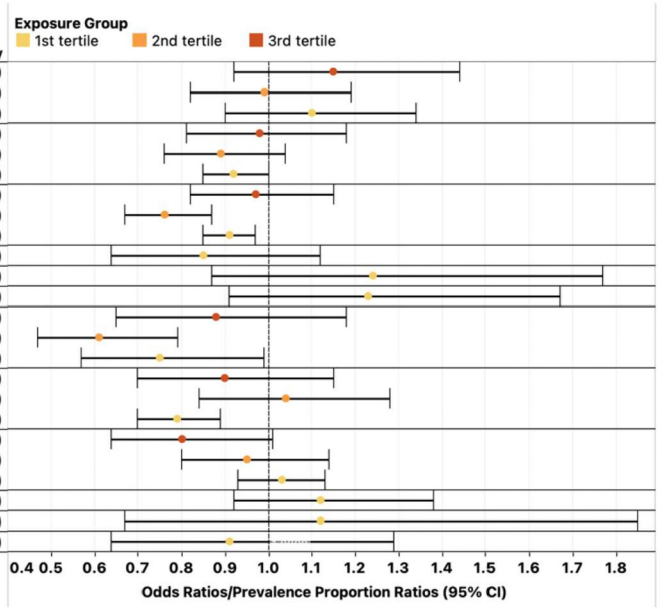


Figure 3.8. *continued* Summary of associations in the peer-reviewed literature between upstream oil and gas development and cleft defects

* Radius represents the distance used to define exposed individuals.
** The exposure category represents the name of the category as defined by the original study. To provide visual comparability, we standardized each exposure group to tertiles, with the 1st tertile representing low activity, the 2nd tertile representing medium activity, and the 3rd tertile representing high activity. Quantiles/quartiles were fitted in the same fashion.
Abbreviations: IDW = inverse distance weighted; UNGD = unconventional natural gas development.

Infant health index

Three studies examined the relationships between upstream OGD and the infant health index, a composite value that combines multiple factors (e.g., birth weight, prematurity, any congenital anomalies, presence of abnormal conditions) (Apergis et al., 2019; Currie et al., 2017; Hill, 2018). Infant health index values range from 0 to 1; the higher the infant health index value, the more positive the assessment of infant health at birth is (Apergis et al., 2019). Two studies were conducted in Pennsylvania (Currie et al., 2017; Hill, 2018), and one in Oklahoma (Apergis et al., 2019) for infants born between 2003 and 2017.

Apergis et al. (2019) evaluated effects of upstream OGD on infant health using data from 2006–2017 in Oklahoma. The authors found statistically significant decreases in the infant health index up to 20 km (12 mi) from hydraulically fractured oil and gas wells, with the largest decreases seen at the closest distance examined of 1km (3,281 ft). The authors also found smaller decreases in the infant health index up to 20 km (12 mi) from oil and gas wells that were not hydraulically fractured.

Results in Pennsylvania are consistent with findings in Oklahoma. Currie et al. (2017) found statistically significant decreases in the infant health index up to 3 km (1.9 mi) from hydraulically fractured oil and gas wells, with the largest decreases within 1 km (3,281 ft). Similarly, Hill (2018) found a statistically significant increase in the probability of an adverse health outcome at birth within 2.5 km (1.5 mi) of hydraulically fractured shale gas well activity post-drilling.

Low Apgar score

Two studies conducted in Pennsylvania examined low Apgar scores in relation to upstream OGD between 2003 and 2013 (Casey et al., 2016; Hill, 2018). Five-minute American Pediatric Gross Assessment Record (Apgar) scores are determined through clinician-rated review of five health dimensions at birth (heart rate, breathing effort, muscle tone, reflexes, color); each score is summed together to produce a final Apgar score ranging from 0 to 10, with lower values representing poorer infant health (Hill, 2018). Infants with low Apgar scores often require respiration support. Casey et al. (2016) defines a "low" Apgar score as any score <7, whereas Hill (2018) defines it as any score <8.

Relying on health records from 2009 to 2013, Casey et al. (2016) found no association with low Apgar score (<7) and upstream OGD. However. Hill (2018) found that the introduction of shale gas development significantly increased low Apgar score (<8) prevalence for those living within 2.5 km (1.5 mi) of hydraulically fractured shale gas wells. These differences may be due to the authors' definition of low Apgar score; Casey et al. (2016) findings considering a low Apgar score as <7 may be more clinically relevant, as clinicians usually deem scores <7 as less healthy (ACOG, 2015).

Fetal death

Two studies assessed fetal death and upstream OGD between 2003 and 2012 (Busby & Mangano, 2017; Whitworth et al., 2017). Busby and Mangano (2017) assessed county-level infant deaths and unconventional OGD in Pennsylvania and found a significant increase in infant

mortality in the 10 counties where hydraulic fracturing was present. Whitworth et al. (2017) conducted a retrospective cohort study in the Barnett Shale region of North Texas by assessing individual exposure to active oil and gas wells and fetal death. Adjusted models found increased odds of infant mortality among those living within a half-mile (2,640 ft, 0.8 km) of oil and gas activity in the highest exposure category. These effects were also observed for women living within two miles (3.2 km) of oil and gas activity in the second tertile of exposure.

High-risk pregnancy

Casey et al. (2016) evaluated adverse birth outcomes in Pennsylvania between 2009 and 2013 and also evaluated physician-reported high-risk pregnancy, a maternal health outcome, as a secondary endpoint. The authors hypothesized that natural gas development exposures could contribute to the occurrence of high-risk pregnancies through effects to the pulmonary and cardiovascular systems (Casey et al., 2016). The authors found that exposure to unconventional natural gas development was significantly associated with 30% increased odds of physician-reported high-risk pregnancy when comparing the highest level of activity to the lowest.

Gestational hypertension and eclampsia

Willis et al. (2022) examined associations between residential proximity to oil and gas extraction and hypertensive conditions during pregnancy in Texas. Using a difference-in-differences framework and adjusting for potential confounders (see **Table 3.3**), the study found that pregnant women living within 1 km (3,281 ft) of an active oil and gas well had 5% increased odds of gestational hypertension and 26% increased odds of eclampsia when compared to pregnant women living far away from extraction activities (>10 km; >6.2 mi). Significantly increased odds were not found for pregnant women living within 1–2 km (3,281–6,561 ft) or 2–3 km (6,561–9,842 ft) of an active oil and gas well (Willis et al., 2022).

Table 3.3. Summary of epidemiological studies that evaluate upstream oil and gas development and adverse perinatal health outcomes in the United States and Canada. Studies are categorized by state and then chronologically by publication year.

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
California								
Gonzalez et al. (2020)	San Joaquin Valley, CA	Oil & natural gas	NIH, March of Dimes Prematurity Research Center at Stanford University	Case-control	IDW[2] index of new and active wells within 10 km (32,808 ft) radius of maternal residence	225,374 births 27,913 cases 197,461 controls 1998–2011 California OSHPD	Mother's age, education, ethnicity/race, parity, and insurance payer, prenatal care access, neighborhood-level poverty	**Exposure during 1st or 2nd trimester:** Preterm birth (20–27 weeks) △ Preterm birth (28–31 weeks) ▲ Preterm birth (32–36 weeks) ⇔ **Exposure during 3rd trimester:** Preterm birth (32–36 weeks) ⇔
Tran et al. (2020)	San Joaquin Valley, South Central Coast & South Coast Air Basins, CA	Oil & natural gas	CARB, the 11th Hour Project, NIEHS, UC Berkeley, SAGE-IGERT Fellowship, NSF	Retrospective cohort	Exposure was defined as having one active or inactive well within 1 km (3,281 ft) of maternal residence at time of delivery; participants included residents with at least one well within 10 km (32,808 ft) Exposure to active wells was characterized by total production volume - barrels of oil and barrels of oil equivalent natural gas (BOE); exposure to inactive wells was characterized by well count	2,918,089 births 2006–2015 California Department of Public Health	Mother's age, education, race/ethnicity, prenatal care, infant sex, and birth month/year, neighborhood level concentration of wealth/poverty as measured by index of concentration at the extremes, neighborhood level traffic-related air pollution	**Active Wells (rural):** ***No BOE vs. >100 BOE/day*** Low birth weight ▲ Preterm birth ⇔ Small for gestational age ▲ Mean term birth weight ▼ **Inactive Wells (rural):** ***0 wells vs. 6+ wells*** Low birth weight ⇔ Preterm birth ⇔ Small for gestational age ⇔ Mean term birth weight ⇔ **Active Wells (urban):** ***No BOE vs. >100 BOE/day*** Low birth weight ⇔ Preterm birth ⇔ Small for gestational age ▲ Mean term birth weight ⇔ **Inactive Wells (urban):** ***0 wells vs. 6+ wells*** Low birth weight ⇔ Preterm birth ⇔ Small for gestational age ⇔ Mean term birth weight ▲

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Tran et al. (2021)	Glenn, Colusa, Fresno, Kern, Santa Barbara, Los Angeles, Ventura, Orange counties, CA	Oil and gas	CARB, 11th Hour Project, NIEHS	Retrospective cohort	Exposed individuals had at least one well hydraulically fractured within 1 km (3,281 ft) of residence during pregnancy.	979,961 births to mothers in eight California counties with HF 2006–2015 California Department of Public Health	Infant covariates — sex, month and year of conception based on date of last menstrual period. Maternal covariates — age, race/ethnicity, educational attainment, Kotelchuck index of prenatal care, parity	**Adjusted OR, rural** Low birth weight ▲ Preterm birth △ Small for gestational age ▲ **Mean difference, rural** Term birth weight ▼ **Adjusted OR, urban** Low birth weight ▽ Preterm birth ▼ Small for gestational age △ **Mean difference, rural** Term birth weight ▽
Canada								
Caron-Beaudoin et al. (2020)	North-eastern British Columbia, Canada	Natural gas	Canadian Institutes of Health Research	Retrospective cohort	UNGD activity metric – IDW sum of wells with a spud date earlier than delivery date for 2.5, 5, 10 km (8,202, 16,404, 32,808 ft) buffers around each postal code centroid	5,018 births 2006–2015 Perinatal Data Registry and Northern Health (healthcare provider in Northeastern British Columbia)	Mother's age at delivery, prior poor pregnancy outcome, complications during current pregnancy, parity, stillbirth, singleton, multiple birth count for current pregnancy, infant's birth date, infant's biological sex assigned at birth, prior and current history of depression and mental health concerns, use of alcohol and drugs or tobacco during current pregnancy, exposure to second-hand smoke during pregnancy	**Postal code well density/proximity 4th quartile to reference (2.5 km, 8,202 ft)** Preterm birth △ (2nd quartile ▲) Birth weight ▽ Head circumference △ Small for gestational age ▽ **Postal code well density/proximity (5 km, 16,404 ft)** Preterm birth ▽ Birth weight ▽ (2nd and 3rd quartile▼) Head circumference △ Small for gestational age ▽ **Postal code well density/proximity (10 km, 32,808 ft)** Preterm birth △ Birth weight ▽ (3rd quartile ▼) Head circumference △ Small for gestational age ▽

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Cairncross et al. (2022)	Alberta, Canada	Unconventional oil & gas	New Frontiers in Research Fund	Retrospective cohort	Residents living within 10 km (32,808 ft) of 100+ hydraulically fractured wells during first year of pregnancy or preconception	26,193 people 34,873 pregnancies 2013–2018 Alberta Health & Alberta Health Services	Age at delivery, multiple births (i.e., twins, triplets), infant sex, obstetric comorbidities, area-level socioeconomic status	**100+ wells vs. 1-24 wells within 10 km (32,808 ft):** Spontaneous preterm birth ▲ Indicated preterm birth △ Small for gestational age ▲ Severe neonatal mortality/morbidity △
Colorado								
McKenzie et al. (2014)	Rural areas in CO; towns <50,000 residents	Natural gas	Department of Environmental and Occupational Health, Colorado School of Public Health	Retrospective cohort	UNGD activity metric – IDW well count (wells/mi) within 10-mile (52,800 ft; 16.1 km) radius of maternal residence	124,842 births 1996–2009 CDPHE Health Statistics, Colorado Responses to Children with Special Needs registry	Mother's age, education, ethnicity/race, child parity, tobacco and alcohol use, infant sex, residential elevation	**Highest exposure category vs. 0 wells within 10 miles (16.1 km)** Congenital heart defects ▲ (Increased prevalence of pulmonary artery and valve defects/PAV defects by 60%, ventricular septal defects/VSDs by 50%, tricuspid valve defects/ TVDs by 400%) Neural tube defects ▲ Oral clefts ▽ Preterm birth ▼ Term low birth weight ▼ Mean term birth weight ▲
McKenzie et al. (2019a)	34 CO counties with 20 or more wells drilled	Oil & natural gas	American Heart Association	Case-control (nested)	IA-IDW (well intensity/mi^2) considering wells and O&G facilities other than wells (compressor stations, tank farms, gathering lines) within 10-mile (52,800 ft) radius of each maternal residence	3,324 mother-infant pairs 2005–2011 Colorado Responds to Children with Special Needs birth defects registry	Mother's age, child parity, Socioeconomic status index, sex, IDW count of O&G facilities other than wells, IA-IDW count for air pollution sources not associated with O&G activities (continuous)	**Exposure during 3 months prior to conception:** Any congenital heart defects ▲ Aortic artery and valve defects △ Pulmonary artery and valve defects △ Conotruncal defects △ Tricuspid valve defects ▽ **Exposure during 2 months prior to conception:** Any congenital heart defects ▲ Aortic artery and valve defects △ Pulmonary artery and valve defects ▲ Conotruncal defects △ Tricuspid valve defects ▽

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
McKenzie et al. (2019a) *(continued)*	34 CO counties with 20 or more wells drilled	Oil & natural gas	American Heart Association	Case-control (nested)	IA-IDW (well intensity/mi^2) considering wells and O&G facilities other than wells (compressor stations, tank farms, gathering lines) within 10-mile (52,800 ft) radius of each maternal residence	3,324 mother-infant pairs 2005–2011 Colorado Responds to Children with Special Needs birth defects registry	Mother's age, child parity, Socioeconomic status index, sex, IDW count of O&G facilities other than wells, IA-IDW count for air pollution sources not associated with O&G activities (continuous)	**Exposure during 1 month prior to conception:** Any congenital heart defects ▲ Aortic artery and valve defects △ Pulmonary artery and valve defects △ Conotruncal defects △ Tricuspid valve defects ▽ **Exposure during 1st gestational month:** Any congenital heart defects ▲ Aortic artery and valve defects △ Pulmonary artery and valve defects △ Conotruncal defects △ Tricuspid valve defects ▽ **Exposure during 2nd gestational month**: Any congenital heart defects ▲ Aortic artery and valve defects △ Pulmonary artery and valve defects △ Conotruncal defects △ Tricuspid valve defects △
Erickson et al. (2022)	Five CO counties where hydraulic fracturing occurs	Un-conventional oil & natural gas	Not disclosed	Ecological	County-wide well density and production activity	252,502 birth records 1999–2019 CDPHE Vital Birth Statistics registry	Population density, age, gender, race, education, income	**High vs. low well density** Birthweight ▼ Prematurity ⇔ **High vs. low production** Birthweight ▼ Prematurity ⇔ **High vs. low well density/production** Birthweight ▼ Prematurity ▲

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Ohio								
Gaughan et al. (2023)	Ohio	Unconventional oil & gas	U.S. EPA, NIH, Yale Cancer Center, National Cancer Institute	Retrospective	IDW[2] index within 5 km, and 10 km (6.2 mi) for active UOG wells; IDups: the inverse distance to the nearest upgradient active UOG well	965,236 live births 2010–2017 Ohio Department of Health Birth Records Ohio Connections for Children with Special Needs (OCCSN) birth defects surveillance system	infant sex, birth year, season of birth, maternal age, maternal race, maternal ethnicity, maternal educational attainment, maternal marital status, maternal smoking status during pregnancy, maternal alcohol use during pregnancy, parity (nulliparous, one or more previous live births), primary payer for delivery (Medicaid, private insurance), use of federal Women Infants and Children (WIC) program, pre-pregnancy body mass index (BMI), whether a mother received prenatal care, and maternal hypertension or diabetes, urbanicity/rurality, Social Vulnerability Index, air pollution ($PM_{2.5}$), nearby cropland	**Any UOG wells within 10 km (6.2 mi):** Any structural defect △ Any CHD △ Any NTD ▲ Oral clefts △ Limb reduction ▲ Hypospadias ▼

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Oklahoma								
Apergis et al. (2019)	OK Statewide	Oil & natural gas	Not disclosed	Empirical analysis with Dumitrescu-Hurlin causality test and (long-run) Pooled Mean Group method	Number of conventional or unconventional (fracking) wells within 0–1 km (0–3,281 ft), 1–5 km (3,281–16,404 ft), 5–10 km (16,404–32,808 ft), or 10–20 km (32,808 ft–65,617 ft) of maternal residence	556,794 birth observations 2006–2017 Birth certificates from Oklahoma Health Department	Mother's age, education, ethnicity/race, child parity	**0–1 km (0–3,281 ft) from fracturing vs. > 20 km (65,617 ft):** Total birth weight ▼ Low birth weight ▲ Health index ▼ *Lower health index represents decline in infant health* **1–5 km (3,281–16,404 ft) from fracturing:** Total birth weight ▼ Low birth weight ▲ Health index ▼ **5–10 km (16,404–32,808 ft) from fracturing:** Total birth weight ▽ Low birth weight ▲ Health index ▼ **10–20 km (32,808 ft–65,617 ft) from fracturing:** Total birth weight ▽ Low birth weight △ Health index ▼ **0–1 km (0–3,281 ft) from conventional drilling vs. > 20 km:** Total birth weight ▽ Low birth weight △ Health index ▼ **1–5 km (3,281–16,404 ft) from conventional drilling:** Total birth weight ▽ Low birth weight △ Health index ▽ **5–10 km (16,404–32,808 ft) from conventional drilling:** Total birth weight ▽ Low birth weight ⇔ Health index ▽ **10–20 km (32,808 ft–65,617 ft) from conventional drilling:** Total birth weight ⇔ Low birth weight ⇔ Health index ▽

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Janitz et al. (2019)	OK Statewide	Natural gas	NIH, National Institute of General Medical Sciences	Retrospective cohort	IDW well count of actively produced wells within 2 miles (3.2 km; 10,499 ft) of maternal residence during month of delivery	476,600 births 1997–2009 Oklahoma State Department of Health, Oklahoma Birth Defects Registry	Birth year, infant sex, maternal race/ethnicity, gestational age at delivery, birth weight, maternal age, marital status, parity, prenatal care, tobacco use during pregnancy, education	Neural tube defects △ Oral clefts ⇔ Congenital heart defects ▽ Common truncus △ Transposition of the great arteries △ Pulmonary valve atresia and stenosis△ Tricuspid valve atresia and stenosis △ Interrupted aortic arch △ Total anomalous pulmonary venous connection △ Double outlet right ventricle ▽ Ebstein's anomaly ▽ Hypoplastic left heart syndrome ▽ Coarctation of aorta ▽ Tetralogy of Fallot ▽
Pennsylvania								
Stacy et al. (2015)	Marcellus Shale, PA	Natural gas	Heinz Endowments	Retrospective cohort	IDW well count within 10 miles (52,800 ft; 16.1 km) of maternal residence	15,451 births 2007–2010 Pennsylvania Department of Health	Mother's age, education, pre-pregnancy weight, prenatal care, smoking status, gestational diabetes, WIC, race, child parity, infant sex	Small for gestational age ▲ Mean birth weight ▼ Preterm birth ⇔
Casey et al. (2016)	Central & Northeast PA	Natural gas	NIEHS, Degenstein Foundation, Robert Wood Johnson Foundation, NSF	Retrospective cohort	IDW[2] considering distance of well to maternal residence, phases of well activity (pad development, drilling, hydraulic fracturing, production volume)	10,946 neonates 2009–2013 Geisinger Health System	Neonate sex, gestational age, birth season/year, mother's age, race/ethnicity, insurance coverage, smoking status, BMI, parity, antibiotic use, receipt of medical assistance	Preterm birth ▲ High-risk pregnancy ▲ Low 5-min Apgar score ⇔ Small for gestational age ⇔ Mean term birth weight ▼ Mean term birth weight adjusted for birth year ⇔

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Ma (2016)	Marcellus Shale PA	Natural gas	Not disclosed	Ecological	Zip code-level presence or absence of UOG wells spudded by conception date	1,401,813 births 2003–2012 Pennsylvania vital birth registry records (birth certificate data)	Maternal smoking status, age at delivery, highest education level, self-designated race, maternal pre-pregnancy body mass index, primary payor for delivery, WIC during pregnancy, pre- and during pregnancy diabetes status, hypertension status, infection during pregnancy status	**Zip codes with UNGD vs. zip codes without UNGD (adjusted OR)** Any birth defects ▲ Structural birth defects ▲ Functional or developmental birth defects ▲ **Zip codes with UNGD pre-drilling vs. zip codes with UNGD post-drilling (difference in prevalence rate)** Any birth defects ▼
Busby and Mangano (2017)	Marcellus Shale, PA	Natural gas	Not disclosed	Ecological	Rate ratio comparison (2007-2010 and 2003-2006) for 10 counties with highest UOG drilling activity, combined, regionally, and statewide	98,941 births and 431 infant deaths 2003–2010 Pennsylvania Department of Health (PADOH)	Not considered	**Early infant deaths** 10 counties with heaviest fracking activity ▲ 5 northeastern fracked counties ▲ 5 southwestern counties ▲
Currie et al. (2017)	PA Statewide	Oil and natural gas	John D. & Catherine T. MacArthur Foundation, US EPA	Retrospective cohort & difference-in-differences	Proximity of maternal residence to wells where conception occurs after spud date — buffer of 0–1 km (0–3,281 ft) as "Near", and 3–15km (9,843–49,213 ft) as "Far"	1,125,748 births 2004–2013 Certificate of Live Births	Mother's age, education, ethnicity/race, marital status, child parity	**0–1 km (0–3,281 ft) vs 3–15 km (9,843–49,213 ft)** Low birth weight ▲ Mean term birth weight ▼ Infant health index ▼ *Lower health index represents decline in infant health*
Hill (2018)	PA Statewide	Natural gas	Cornell Population Center	Retrospective cohort & differences in differences	Proximity of maternal residence to wells (<2km, <2.5km, <3km, <3.5km, <4km, <4.5km, <5km) (<6,562–16,404 ft) and well density at 2.5 km (8,202 ft). Birth pre-drilling (unexposed) and post drilling (exposed).	1,098,884 births 2003–2010 Vital statistics natality & mortality data	Mother's age, education, ethnicity/race, marital status, WIC status, insurance type, previous risky pregnancy, smoking status, birth month/year, gender	**2.5 km (8,202 ft) of a well compared to 2.5 km (8,202 ft) of a permitted, but not yet drilled, well** Low birth weight ▲ Mean term birth weight ▼ Small for gestational age ▲ Apgar score <8 ▲

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Hill (2018) *(continued)*	PA Statewide	Natural gas	Cornell Population Center	Retrospective cohort & differences in differences	Proximity of maternal residence to wells (<2km, <2.5km, <3km, <3.5km, <4km, <4.5km, <5km) (<6,562–16,404 ft) and well density at 2.5 km (8,202 ft). Birth pre-drilling (unexposed) and post drilling (exposed).	1,098,884 births 2003–2010 Vital statistics natality & mortality data	Mother's age, education, ethnicity/race, marital status, WIC status, insurance type, previous risky pregnancy, smoking status, birth month/year, gender	**Well density at 2.5 km (8,202 ft)** Low birth weight ▲ Mean term birth weight ▼ Premature birth ▲
Texas								
Whitworth et al. (2017)	Barnett Shale, TX	Natural gas	NIEHS, NIOSH	Retrospective cohort	UNGD-activity metrics - IDW sum of active wells ½ mile (2,640 ft; 0.8 km), 2 miles (10,560 ft; 3.2 km), 10 miles (52,800 ft; 16.1 km) from material residence	158,894 births 2010–2012 Texas Department of State Health Services	Mother's age, race/ethnicity, education, BMI, parity, smoking, prenatal care, previous risky pregnancy, infant sex	**$^1/_2$ mile (2,640 ft; 0.8 km):** Preterm birth ▲ SGA ⇔ Fetal deaths △ Mean birth weight ⇔ **2 miles (10,640 ft; 3.2 km):** Preterm birth ▲ SGA ▽ Fetal deaths △ Mean birth weight ▽ **10 miles (52,800 ft; 16.1 km):** Preterm birth ▲ SGA ▽ Fetal deaths ▲ Mean birth weight ▽
Walker Whitworth et al. (2018)	Barnett Shale, TX	Natural gas	NIH, NIEHS, NIOSH	Case-control	UNGD-activity metric – IDW^2 count of wells in drilling phase within ½ mile (2,640 ft; 0.8 km) of maternal residence; sum of IDW sum of natural gas produced from wells within ½ mile (2,640 ft; 0.8 km) of maternal residence	163,827 births 2010–2012 Texas Department of State Health Services	Mother's age, race/ethnicity, education, parity, smoking status, BMI, infant sex, previously poor pregnancy outcome, prenatal care	**Drilling/Production (all pregnancy):** All Preterm birth ▲ Extremely Preterm birth ▲ Very Preterm birth △ Moderately Preterm birth ▲ **<u>Drilling</u>** **1st or 2nd trimester:** All Preterm birth ▲ **3rd trimester:** All Preterm birth △

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Walker Whitworth et al. (2018) *(continued)*	Barnett Shale, TX	Natural gas	NIH, NIEHS, NIOSH	Case-control	UNGD-activity metric – IDW[2] count of wells in drilling phase within ½ mile (2,640 ft; 0.8 km) of maternal residence; sum of IDW sum of natural gas produced from wells within ½ mile (2,640 ft; 0.8 km) of maternal residence	163,827 births 2010–2012 Texas Department of State Health Services	Mother's age, race/ethnicity, education, parity, smoking status, BMI, infant sex, previously poor pregnancy outcome, prenatal care	**Production:** **1st trimester:** All Preterm birth ▲ **2nd trimester:** All Preterm birth △ **3rd trimester** All Preterm birth ▽
Cushing et al. (2020)	Eagle Ford Shale, TX	Oil & gas	NIH, NIEHS	Retrospective cohort	Number of wells and number of satellite observations of flaring activity during pregnancy within 5 km (16,404 ft) of maternal residence	23,487 births 2012–2015 Texas Department of State Health Services Center for Health Statistics	Mother's age, education, ethnicity/race, BMI, birthplace, prenatal care usage, smoking status, insurance coverage, child parity, birth year/season, high-risk pregnancy	*Results from adjusted model (Model 2) shown below* **27-954 wells within 5 km (16,404 ft) vs. 0 wells:** Preterm birth ▲ Small for gestational age ⇔ Gestational age in days ▼ Mean term birth weight ▼ **≥10 flares within 5 km (16,404 ft) vs. 0 flares:** Preterm birth ▲ Small for gestational age ⇔ Gestational age in days ▼ Mean term birth weight ▽
Tang et al. (2021)	TX Statewide	Natural gas	UC Irvine Program in Public Health	Case-control	Yearly active well density within 1 km (3,281 ft), 3 km (9,843 ft), and 7.5 km (24,606 ft) of maternal residence for year of birth	52,995 cases 642,399 controls 1999–2011 Texas Department of State Health Services Texas Birth Defects Registry	Mother's smoking status, plurality of birth, age, race/ethnicity, education status, median household income, urbanicity in 2010, average daily vehicle miles traveled for all trucks by county	*p-values for trend tests of adjusted odds ratios, p <0.01 below* **Well density within 1 km (3,281 ft) buffer, 3 km (9,843 ft) buffer, and 7.5 km (24,606 ft) buffer:** Atrial Septal Defect ▲ Aortic Valve Stenosis ▲ Hypoplastic Left Heart Syndrome ▲ Pulmonary Valve Atresia/Stenosis ▲ Ventricular Septal Defect ▲ **Well density within 1 km buffer:** Anencephaly ▲ Tricuspid Valve Atresia/Stenosis ▲

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Willis et al. (2021)	TX Statewide	Oil & gas	NIH, NIEHS, NCATS	Retrospective cohort & difference-in-differences	Residential proximity near [0–1 km (0–3,281 ft), 1–2 km (3,281–6,562 ft), 2–3 km (6,562–9,843 ft)] vs. far [3–10 km (9,843 ft–32,808 ft)] from active/future drill site; births before drilling (unexposed) vs. births during drilling (exposed)	2,598,025 mother-infant pairs 1999–2009 Texas Department of State Health Services Vital Statistics Program	Birth year/month, infant sex, mother's age, race/ethnicity, & educational attainment, nulliparous, prenatal care received, smoking during pregnancy, weight gain during pregnancy, diabetes diagnosis, gestational hypertension diagnosis, eclampsia diagnosis, infant gestational age, regional location, income, employment, distance to highways, census place	**Mothers living 0–1 km (0–3,281 ft) vs. 3–10 km (9,843 ft–32,808 ft) from current/future drilling site (Model 3)** Term birth weight ▼ Small for gestational age ⇔ **1–2 km (3,281–6,562 ft) & 2–3 km (6,562–9,843 ft) vs. 3–10 km (9,843 ft–32,808 ft) from current/future drilling site** Term birth weight ▼ Small for gestational age ⇔
Willis et al. (2022)	TX Statewide	Oil & gas	NIH, NIEHS, NCATS	Retrospective cohort & difference-in-differences	Residential proximity near [0–1 km (0–3,281 ft), 1–2 km (3,281–6,562 ft), 2–3 km (6,562–9,843 ft)] vs. far [3-10 km (9,843 ft–32,808 ft)] from active/future drill site; births before drilling (unexposed) vs. births during drilling (exposed)	2,845,144 mothers 1999–2009 Texas Department of State Health Services Vital Statistics Program	Birth year/month, infant sex, gestational age, mother's age, race/ethnicity, mother's education, nulliparous, prenatal care received, smoking and mother's weight during pregnancy, distance to major roadways	**Mothers living 0–1 km (0–3,281 ft) vs. 3–10 km (9,843 ft–32,808 ft) from current/future drilling site (Fully adjusted model)** Gestational hypertension ▲ Eclampsia ▲ **1–2 km (3,281–6,562 ft) vs. 3–10 km (9,843 ft–32,808 ft) from current/future drilling site** Gestational hypertension ⇔ Eclampsia △ **2–3 km (6,562–9,843 ft) vs. 3–10 km (9,843 ft–32,808 ft) from current/future drilling site** Gestational hypertension ⇔ Eclampsia ⇔

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Han et al. (2023)[2]	Barnett Shale, TX (Denton, Johnson, Tarrant, Wise Counties)	Hydraulic fracturing	None	Ecological	Billions cubic feet gas produced from hydraulic fracturing per county	1999–2014 Texas Birth Defects Registry Four counties versus statewide rates	county, time period	**Standardized Morbidity Ratios (SMR) of total birth defects:** **Denton County:** 1999-2002 ⇔ 2003-2006 ⇔ 2007-2010 ⇔ 2011-2014 ⇔ **Johnson County:** 1999-2002 ⇔ 2003-2006 ▲ 2007-2010 ▲ 2011-2014 ▲ **Tarrant County:** 1999-2002 ▲ 2003-2006 ▲ 2007-2010 ▲ 2011-2014 ▲ **Wise County:** 1999-2002 ⇔ 2003-2006 ▲ 2007-2010 ⇔ 2011-2014 ⇔
Willis et al. (2023)	TX	Oil & gas	NIH	Retrospective cohort	IDW^2 index within 5 km (16,4040 ft) for drilling site count, gas production, oil production, and produced water	2,234,138 births 86,315 cases 2,147,823 controls 1999–2009 Texas Department of State Health Services Vital Statistics Database & Birth Defects Registry	infant sex, gestational age, birth weight, maternal age, maternal race and ethnicity, maternal education, maternal smoking, maternal alcohol usage, prenatal care initiated, census tract unemployment, census tract percent White population, census tract median household income, distance to nearest highways, birth year, county	**Temporal comparison, IDW^2 well count within 5 km (16,404 ft):** All defects ▲ > 1 site ▲ Cardiac and circulatory ▲ Central nervous system ⇔ Eye and ear ▲ Gastrointestinal ⇔ Genitourinary ▲ Musculoskeletal ⇔ Oral clefts ⇔ Respiratory ⇔ Chromosomal ↑▲

[1] Associations from studies that tested for statistical significance are represented using the following symbols: ▲=significant increase, ▼= significant decrease, ▽= non-significant decrease, △= non-significant increase, ⇔ = null findings/no association. Studies that did not test for statistical significance are noted in the table and results are briefly summarized. Unless explicitly stated, the summary of outcomes represents results from comparing the highest tertile/quantile/quartile/highest exposure category to the lowest exposure category. In other words, the increase or decrease in a health outcome is the highest exposure group compared to the lowest (or reference category).

[2] Han et al. (2023). For findings from this study for specific congenital anomalies by year and by county, please see Han et al. (2023), Table 4.

Abbreviations: Barrels of oil and barrels of oil equivalent natural gas (BOE); body mass index (BMI); California Air Resources Board (CARB); Colorado Department of Public Health and the Environment (CDPHE); inverse distance weighted (IDW); intensity adjusted inverse distance weighted well intensity (IA-IDW); National Center for Advancing Translational Science (NCATS); National Institute for Occupational Safety and Health (NIOSH); National Institute of Environmental Health Sciences (NIEHS); National Institutes of Health (NIH); National Science Foundation (NSF); California Office of Statewide Health and Planning (OSHPD); Pennsylvania Department of Health (PADOH); Systems Approach to Green Energy-Integrative Graduate Education and Research Traineeship (SAGE-IGERT); University of California (UC); unconventional natural gas development (UNGD), unconventional oil and gas (UOG); United States Environmental Protection Agency (US EPA).

3.3.2.3 Respiratory outcomes

Eleven studies examine the association between upstream OGD and respiratory outcomes (Bushong et al., 2022; Johnston et al., 2021; Koehler et al., 2018; Li et al., 2023; Peng et al., 2018; Rabinowitz et al., 2015; Rasmussen et al., 2016; Shamasunder et al., 2018; Willis et al., 2018; 2020; Trickey et al., 2023). Two studies were conducted in California (described directly below: Johnston et al., 2021; Shamasunder et al., 2018) and nine studies were conducted in other oil and gas regions, including Pennsylvania (Bushong et al., 2022; Koehler et al., 2018; Peng et al., 2018; Rabinowitz et al., 2015; Willis et al., 2018), Texas (Li et al., 2023; Willis et al., 2020), and across multiple states (Pennsylvania and New York: Rasmussen et al., 2016; Trickey et al., 2023). These studies evaluate potential exposures and respiratory outcomes from 2005 to 2019.

Below we first present studies conducted in California, and then discuss findings regarding the most examined respiratory outcome, asthma.

Respiratory outcome studies conducted in California

Two studies conducted in California evaluated the associated upstream OGD and respiratory outcomes (Shamasunder et al., 2018; Johnston et al., 2021). These studies focused on upstream OGD exposures and respiratory outcomes between 2016 and 2019.

Shamasunder et al. (2018)

Shamasunder et al. (2018) conducted household health surveys between March and May 2016 using questions from a validated health questionnaire within two 1,500 ft (457 m) buffer areas surrounding the Jefferson and AllenCo oil production sites in the City of Los Angeles. The authors found that self-reported physician-diagnosed asthma rates were elevated within both buffer zones compared to sub-county and county-level surveys (e.g., the California Health Interview Survey of Service Planning Area 6). Asthma prevalence was higher in one buffer zone (West Adams near the Jefferson drill site) than in Los Angeles County in aggregate. The authors reported that 45% of residents surveyed were unaware of nearby oil development. The study also included *in situ* monitoring for methane near a site with oil wells. Prior research has found that methane emissions from oil and gas wells are associated with emissions of air toxics, including non-methane volatile organic compound (VOC) emissions. However, there were no efforts to determine the source of emissions as part of this study. Subsequent studies have reported elevated concentrations of ambient air pollutants, including non-methane VOCs, near oil and gas wells in Los Angeles (Collier-Oxandale et al., 2020; Garcia-Gonzales et al., 2019; Gonzalez et al., 2022; Okorn et al., 2021). While this study compared localized asthma rates to sub-county and county-level surveys, the authors were not able to control for additional sources of air pollution or other variables associated with asthma prevalence. It also relies on self-reported data, which can be subject to bias.

Johnston et al. (2021)

Johnston et al. (2021) evaluated lung function and self-reported acute health symptoms among residents living near one active oil development site and one idle oil development site in the Las

Cienegas oil field in South Los Angeles between January 2017 and August 2019. The authors used a cross-sectional study design: an observational study comparing measured health outcomes at one time point (i.e., without assessing temporal variation). Johnston et al. (2021) surveyed 961 study participants ages 5 and over who were residents living within 1 km (3,281 ft) of an *active* oil development site (with 28 wells) in the Jefferson Park neighborhood and within 1 km (3,281 ft) of an *idle* oil development site (with 21 wells) in the North University Park neighborhood. Additionally, the authors assessed lung function of 747 residents using spirometry. Residents living near the active oil development site self-reported significantly higher odds of recent wheeze, sore throat, chest tightness, eye and nose irritation, dizziness, and ringing of the ears as compared to residents living near the idle oil development site. Residents who lived closer to both oil development sites had reductions in lung function; lung function decreased for every 100 m (328 ft) closer to the site. The investigators also assessed differences in lung function between participants living at distances of <150 m (492 ft), <200 m (656 ft), and <400 m (1,312 ft) from the active and idle oil development sites compared to those living farther away. They also evaluated differences in lung function among participants living downwind from wells out to 1 km (3,281 ft) from oil development sites (the farthest distance assessed), compared to residents living less than 1 km (3,281 ft) and upwind from the oil development sites. Across all analyses, participants living closer to both oil development sites (active and idle) had reductions in lung function. The reduction in lung function was greatest among participants living near and downwind of the active oil development site compared to the idle oil development site. The findings of reduced lung function among residents downwind of oil and gas wells, compared to those living farther away and upwind, were adjusted for participant age, height, weight, sex, race/ethnicity, proximity to freeway, recent cold/flu, asthma status, smoking status, indoor exposure to environmental tobacco smoke, and season.

Asthma

Asthma is the most commonly studied respiratory health outcome in the epidemiological literature focused on upstream OGD. Eight studies conducted outside of California examined asthma exacerbations and hospitalizations, with five focused in Pennsylvania, one focused in Pennsylvania and New York (multiple states), and two focused in Texas (Bushong et al., 2022; Koehler et al., 2018; Li et al., 2023; Peng et al., 2018; Rabinowitz et al., 2015; Rasmussen et al., 2016; Willis et al., 2020, 2018). These studies examined upstream OGD and asthma-related outcomes between 2000 and 2014.

Studies in Pennsylvania have found that upstream OGD is associated with increased pediatric hospitalizations for asthma, increased rates of mild asthma exacerbations[8], and increased rates of lower respiratory symptoms, including mild asthma exacerbations[9] (**Figure 3.9**) (Koehler et al., 2018; Peng et al., 2018; Rabinowitz et al., 2015; Rasmussen et al., 2016; Willis et al., 2018). Consistent with findings observed from studies focused on Pennsylvania, in Texas, Willis et al. (2020) also observed an increased odds of pediatric asthma hospitalizations associated with natural gas development, for both conventional drilling and unconventional drilling activities, and

[8] Defined by the presence of new oral corticosteroid prescriptions.

[9] Defined as new oral corticosteroid medication orders, asthma/COPD, chronic bronchitis, chest wheeze/whistling, shortness of breath, and/or chest tightness.

increased well production volumes. Furthermore Li et al. (2023) observed an increase in asthma rates in census block with higher counts of oil and natural gas wells in Texas.

As shown in **Figure 3.9** below, two studies conducted in Pennsylvania found an association with increased rates of mild asthma exacerbations and oil and gas exposure within 1 km (3,281 ft) of a well compared to those living greater than 2 km (1.2 mi) away (Koehler et al., 2018; Rabinowitz et al., 2015). This is consistent with another Pennsylvania study, which found a significant positive association between asthma hospitalization rates and annual well density (Bushong et al., 2022). Similarly, Rasmussen et al. (2016) found that those living next to the densest areas of oil and gas production in the Marcellus Shale region had significantly increased odds of mild asthma exacerbation compared to those living near lower-density activity. This result was found to be significant during all four phases of development (pad development, drilling, stimulation, and production). In addition to mild asthma exacerbations, Rasmussen et al. (2016) also found that those living in the highest quartile of residential unconventional natural gas development activity for all four phases (pad development, drilling, stimulation, production) had significantly higher odds of moderate and severe types of asthma exacerbations (emergency department visits, and hospitalizations, respectively) than those in the lowest quartile.

This is consistent with another Pennsylvania study (Willis et al., 2018), which found a significant positive association between pediatric asthma hospitalization rates and annual well density. Using a similar methodological approach in Texas, Willis et al. (2020) also found that both conventional and unconventional natural gas development at the ZIP code level was associated with pediatric asthma hospitalizations. Overall, all studies found upstream OGD was associated with increased asthma-related outcomes.

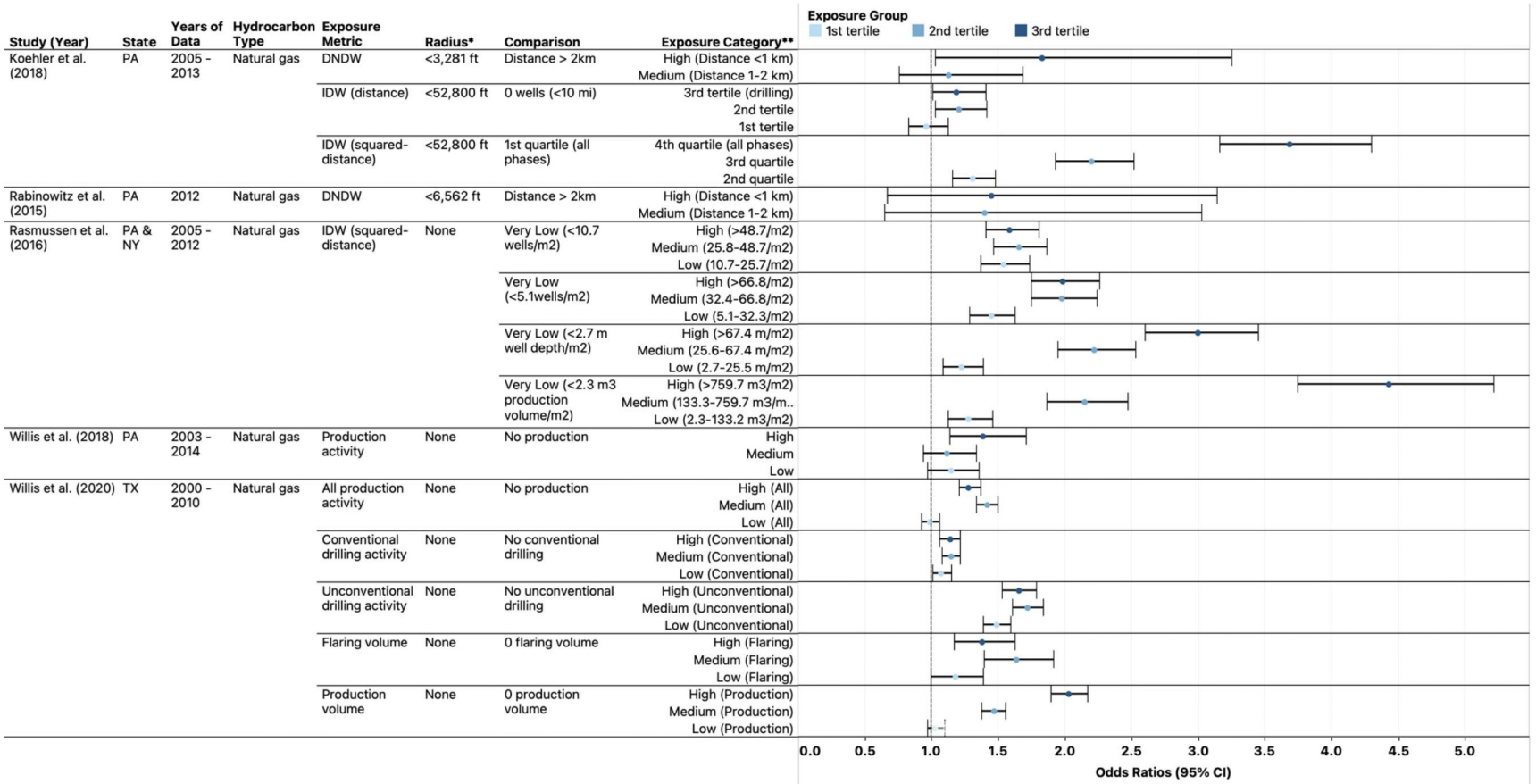


Figure 3.9. Summary of epidemiological studies on associations in between upstream oil and gas development and lower respiratory effects, including but not limited to mild asthma exacerbations and asthma-related hospitalizations.

* Radius represents the distance used to define exposed individuals. Studies that have no radius did not utilize a buffer distance when defining their study population.

** The exposure category represents the name of the category as defined by the original study. To provide visual comparability, we standardized each exposure group to tertiles, with the 1st tertile representing low activity, the 2nd tertile representing medium activity, and the 3rd tertile representing high activity. Quantiles/quartiles were fitted in the same fashion.

Note: Results from Shamasunder et al. (2018), Bushong et al. (2022), Li et al. (2023), and Trickey et al. (2023) did not include estimated odds ratios (or risk ratios) and were therefore excluded from the figure.

Abbreviations: DNDW = distance to nearest drilled well; IDW = inverse distance weighted; mild asthma exacerbations = new oral corticosteroid medication orders; lower respiratory symptoms = mild asthma exacerbations defined as new oral corticosteroid medication orders, asthma/COPD, chronic bronchitis, chest wheeze/whistling, shortness of breath, or chest tightness.

Table 3.4. Summary of epidemiological studies on association between upstream oil and gas development and adverse respiratory health outcomes in the United States. Studies are categorized by state and then chronologically by publication year.

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
California								
Shama-sunder et al. (2018)	South Los Angeles, CA West Adams & University Park	Oil	11th Hour Project, NSF	Self-reported survey (validated question-naire; physician - reported asthma)	1,500 ft (457 m) buffer around two oil development sites.	205 surveys at randomly sampled residences 813 residents March–May 2016 Self-reported outcome	Not considered	**1,500 ft (457 m) from site vs. Los Angeles County:** Asthma diagnosis ▲ (West Adams) Asthma diagnosis △ (University Park) Asthma emergency department visit ⇔ **1,500 ft (457 m) from site vs. California Health Interview Survey of Service Planning Area 6 (SPA6):** Asthma diagnosis ▲ (West Adams & University Park) Asthma emergency department visit ⇔
Johnston et al. (2021)	South Los Angeles, CA North University Park & Jefferson Park	Oil	NIEHS	Cross-sectional (self-reported survey with lung function measurements)	1 km (3,281 ft) buffer around two oil development sites, one with 28 active wells (Jefferson Park) and one with 21 idle wells (North University Park)	961 residents from 488 addresses 747 valid spirometry tests 2017–2019 Self-reported symptoms & spirometry measurements	Age, sex, height, age-height interaction, race/ethnicity, weight, recent flu/cold, proximity to freeway, asthma status smoking status, indoor exposure to environmental tobacco smoke, season, wind direction (downwind vs. upwind)	**Lung function findings** Significantly lower lung function was found among residents living near O&G development (<200 m, 656 ft) and downwind (200–1,000 m, 656–3,281 ft). **For self-reported acute health symptoms findings, see Table 3.8.**

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Pennsylvania								
Rasmus-sen et al. (2016)	Marcellus Shale (PA, NY)	Natural gas	NIEHS, Degenstein Foundation, Robert Wood Johnson Foundation, NSF	Case-control (nested)	UNGD activity metric – IDW^2 method considering pad preparation, spud, stimulation, and production phases *Patients in the highest exposure group lived a median of 19 km (62,336 ft) from closest well vs. 63 km (206,693 ft) for patients in the lowest group.	35,508 patients 2005–2012 Geisinger Health System	Age, season, smoking status, obesity status, medical assistance, type 2 diabetes, sex, race/ethnicity	**Pad:** Asthma hospitalizations ▲ Asthma emergency department visits △ Oral corticosteroid medication orders ▲ **Spud:** Asthma hospitalizations ▲ Asthma emergency department visits ▲ Oral corticosteroid medication orders ▲ **Stimulation:** Asthma hospitalizations ▲ Asthma emergency department visits ▲ Oral corticosteroid medication orders ▲ **Production:** Asthma hospitalizations ▲ Asthma emergency department visits ▲ Oral corticosteroid medication orders ▲
Koehler et al. (2018)	Northeast, Northcentral, Northwest, Southwest PA	Natural gas	NIEHS, Degenstein Foundation, Robert Wood Johnson Foundation, NSF	Case-control	DNDW (distance to nearest drilled well) < 1 km (3,281 ft) to >2 km (6,562 ft) IDW considers drilling phase for wells <10 miles (52,800 ft) of residence; IDW^2 considers four phases: pad preparation, drilling, stimulation, production, & compressors	13,196 cases 18,693 controls 2005–2013 Geisinger Health System *Study relied on data from Rasmussen et al. (2016) but was considered a separately published analysis as it utilized different exposure assessment strategies.*	Age, sex, race/ethnicity, history of asthma, smoking status, season, medical assistance, obesity status, distance/distance-squared to nearest major and minor arterial roads, max temperature and max temperature-squared on the day prior to the event, community socioeconomic deprivation	**DNDW <1 km (3,281 ft) vs. >2 km (6,562 ft):** Oral corticosteroid medication orders ▲ **IDW (Drilling):** Oral corticosteroid medication orders ▲ **$\underline{IDW^2}$:** **All phases & compressor engines:** Oral corticosteroid medication orders ▲ **Production volume only:** Oral corticosteroid medication orders ▲

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Peng et al. (2018)	Marcellus Shale, PA	Unconven-tional natural gas	Not disclosed	Difference-in-differences	County-level active well count	804 observations 2001–2013 Pennsylvania Health Care Cost Containment Council	County-level proportion of type of insurance, female patients, race/ethnicity, types of admission; county-level Charlson index, unemployment rate, poverty rate, median household income, population density, coal production, number of conventional wells, conventional production, age-distribution	**Well drilled in the last year (year fixed effects, county specific linear trends)** *Full sample (Age 5+) & partial (Age 65+)* Pneumonia ▲ Acute myocardial infarction ⇔ COPD ⇔ Asthma ⇔ Upper respiratory infections ⇔
Willis et al. (2018)	Rural counties located in Marcellus Shale, PA	Unconven-tional natural gas	NIH Office of the Director	Difference-in-differences	Newly spudded wells, ever-spudded wells, cumulative count of wells ever drilled by zip code for unconventional and/or conventional oil and gas development.	15,837 pediatric asthma-related hospitalizations 2003–2014 Pennsylvania Health Care Cost Containment Council Inpatient Discharge Data	Non-UNGD respiratory hazards	**Highest tertile of exposure to unconventional drilling vs. unexposed** Pediatric asthma hospitalizations ▲ **Newly spudded wells** Pediatric asthma hospitalizations ▲ **Ever-spudded wells in zip code** Pediatric asthma hospitalizations ▲
Bushong et al. (2022)	PA Statewide	Unconven-tional oil & natural gas	NIH	Difference-in-differences	Cumulative annual well density at the county-level	62 of 67 counties 2001–2014 PA-DOH & PA-DEP asthma hospitalization rates	$PM_{2.5}$ pollution, smoking prevalence, people <65 years old who are uninsured, household income, race/ethnicity, educational attainment	**Increased well density in urban & rural counties:** Asthma hospitalization rate ▲
Trickey et al. (2023)	Three Northern Pennsylva nia Counties and eight New York Counties	Unconven-tional oil & gas	University of Chicago and Argonne National Laboratories	Difference-in-differences	UOG activity in zip code (binary variable)	61,152 Medicare enrollees in 2015 2002–2015 Hospitalisation data (MedPAR) of 100% of Medicare fee-for-service beneficiaries	None. Modeling method controls for time-invariant confounders by design.	**Any diagnosis of COPD and bronchiectasis (hospitalizations):** 2010 ⇔ 2011 ⇔ 2012 ▲ 2013 ▲ 2014 ▲ 2015 ⇔

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Texas								
Willis et al. (2020)	Zip codes overlaying shale regions, TX	Natural gas	NIH, NIEHS, NCATS	Ecological	Cumulative count of natural gas drilling sites per km^2 in zip code by quarter, with vertical vs. horizontal/directional sub-analysis; volume of natural gas flared (MCF) in zip code per quarter; volume of natural gas produced (MCF) in zip code by quarter	54,956 hospitalizations in 1,249 zip codes 2000–2010 Texas Department of State Health Services Inpatient Public Use Data File	Population density <18 years old, percent population identifying as Hispanic, NATA respiratory hazard index, percent unemployed, percent of population below poverty line, median household income, count of spudded drilling sites by zip code from 1990–1999	*Temporal & spatial fixed effects model (Model 3) results shown below* **Pediatric asthma hospitalizations** All drilling ▲ Conventional △ Unconventional ▲ Flaring volume ▼ Production volume ▲
Li et al. (2023)	(Dallas/Fort Worth Metropolitan Area (Collin, Dallas, Denton, and Tarrant Counties)	Natural gas	None declared	Spatial cluster analysis of census tracts, Cross Sectional	Urban gas drilling: Aggregated counts of wells in census block group (not clear if these were well being drilled)	Asthma hospital visits for adults (18–65 years). No population size provided. 2014 Dallas/Fort Worth Hospital Council Foundation hospital records	Age, socio-economic characteristics, transportation, housing conditions, and land use	**Incidence of adult asthma exacerbations (Model 4) by demographic variable:** # Adult males ⇔ # Black ▲ Median HH income ▼ # No HS diploma ▲ Adult density ▼ Median age ▼ Well counts ▲ Proximity to HWY ⇔ AVG speed ⇔ Road density ▲ AVG COM distance ▲ # Work at home ▼ #Pub transit users ▲ House before 1979 ▲ Gas heating house ▲ Elec heating house ▲ Park/Rec density ⇔ Tim/farm density ▼

[1] Associations from studies that tested for statistical significance are represented using the following symbols: ▲=significant increase, ▼= significant decrease, ▽= non-significant decrease, △= non-significant increase, ⇔ = null findings/no association. Studies that did not test for statistical significance are noted in the table and results are briefly summarized. Unless explicitly stated, the summary of outcomes represents results from comparing the highest tertile/quantile/quartile/highest exposure category to the lowest exposure category. In other words, the increase or decrease in a health outcome is the highest exposure group compared to the lowest (or reference category).

Abbreviations: COPD (chronic obstructive pulmonary disease); thousand cubic feet (MCF); National Air Toxics Assessment (NATA); National Center for Advancing Translational Science (NCATS); National Institute of Environmental Health Sciences (NIEHS); National Institutes of Health (NIH); National Science Foundation (NSF); Pennsylvania Department of Environmental Protection (PADEP); Pennsylvania Department of Health (PADOH); unconventional natural gas development (UNGD).

3.3.2.4 Mental and behavioral health outcomes

Six studies evaluated the association between upstream OGD and mental and behavioral health outcomes between 2002 and 2019 (Aker et al., 2022; Casey et al., 2018a; Casey et al., 2018b; Casey et al., 2019; Elser et al., 2023; Mayer & Olson Hazboun, 2019; **Table 3.5**). No studies on mental or behavioral health outcomes were conducted in California.

In Pennsylvania, Casey et al. (2018b) found that exposure to unconventional natural gas development was associated with mild depressive symptoms and overall depression symptoms among adults in the highest exposure category as compared to the lowest exposure category. Casey et al. (2018b) also examined disordered sleep among adults but found no association between exposure to unconventional OGD and disordered sleep. Also in Pennsylvania, Casey et al. (2019) found that antenatal anxiety and depression was associated with exposure to unconventional natural gas development among mothers in the highest exposure category, with a stronger association observed among mothers receiving medical assistance (an indicator of low family income).

One study conducted in British Columbia, Canada, examined the association between proximity and density of unconventional natural gas wells and mental illness and substance use among mothers who gave birth between 2006 and 2016 using an IDW metric (Aker et al., 2022). Results from this study show that the second and third quartiles of the 10 km (32,808 ft) IDW are associated with increased odds of depression when compared to the first quartile. This association was not found when comparing the fourth quartile to the first, however. Furthermore, the authors found no significant associations for the 2.5 km (8,202 ft) IDW exposure metric (Aker et al., 2022). Another study examining alcohol consumption and oil and gas production across the United States found county-level oil production was associated with a slight, but statistically non-significant increase in heavy drinking and binge drinking among males in the United States (Mayer & Olson Hazboun, 2019). This study reported no association with gas production and a slight, but non-significant decrease in alcohol consumption among females (Mayer & Olson Hazboun, 2019).

Seismic activity has increased in Oklahoma and other states due to wastewater injection from OGD activities (Alghannam, 2020; Keranen et al., 2008; Weingarten et al., 2015). In Oklahoma, Casey et al. (2018a) found a positive association between the occurrence of upstream OGD related earthquakes and Google searches focused on anxiety, suggesting that seismic activity induced by oil and gas-related wastewater injection may elicit a psychological response in Oklahoma residents. Additionally, Elser et al (2023) undertook a retrospective cohort study with repeated measures to evaluate the association between felt earthquakes (≥magnitude 4) and anxiety disorders in Oklahoma between 2010 and 2019. Results showed a positive association between the frequency of felt earthquakes and healthcare encounters for stress disorders. For every additional five felt earthquakes in the preceding six months, there was an increased odds of a healthcare encounter for stress disorder, after adjusting for age and sex. The study did not observe an association between the frequency of felt earthquakes and combined anxiety disorders, adjustment reaction, anxiety dissociative and somatoform disorders, or physical symptoms of anxiety.

Table 3.5. Summary of epidemiological studies of the association between upstream oil and gas development and mental and behavioral health outcomes in the United States and Canada. Studies are categorized by state and then chronologically by publication year.

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Aker et al. (2022)	North-eastern British Columbia Canada	Natural Gas	Canadian Institutes of Health Research	Retrospective cohort	UNGD activity metric – IDW sum of wells for 2.5, 5, 10 km (8,202, 16,404, 32,808 ft) buffers around each postal code centroid	6,278 mothers 2006–2016 Northern Health (healthcare provider in Northeastern British Columbia)	Tobacco use, second-hand smoke exposure during pregnancy, mother's age at delivery & postal code, prior adverse pregnancy outcomes, complications during pregnancy, number of previous pregnancies, still birth, singleton, multiple birth count for pregnancy, infant's birth date & biological sex assigned at birth, gestational age at delivery, Apgar scores (1, 5 and 10 min), birthweight, head circumference	**IDW well density/proximity (2.5 km, 8,202 ft)** Depression (2nd quartile) ⇔ Anxiety ⇔ Substance Use ⇔ **IDW well density/proximity (5 km, 16,404 ft)** Depression (2nd and 3rd quartile) ▲ Anxiety ⇔ Substance Use ⇔ **IDW well density/proximity (10 km, 32,808 ft)** Depression (2nd and 3rd quartile) △ Anxiety ⇔ Substance Use ⇔
Casey et al. (2018a)	OK Statewide	Oil & natural gas	NIEHS	Time-series analysis using Google queries	Monthly counts of injection-induced earthquakes ≥ magnitude 4	Prevalence of searches for anxiety estimated for 75 weekly samples of the Google API 2010–2017 Oklahoma Google anxiety search data	US-wide anxiety search episodes, Oklahoma-specific health-related queries	**Google search episodes related to anxiety**: For each additional injection-induced earthquake ≥magnitude 4 that exceeded the monthly average, the proportion of Google search episodes increased by 1.3% (95% CI: 0.1-2.4%) In months with two or more ≥magnitude 4 injection-induced earthquakes, Google searched episodes focused on anxiety increased by 5.8% (95% CI, 2.3-9.3%).

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Elser et al. (2023)	Oklahoma	Oil & natural gas	Stanford Research Computing Center	Retrospective cohort with repeated measures	County-level 6-month rolling average exposure to earthquakes ≥magnitude 4 at county level (USGC Advanced National Seismic System)	4,594 patients ≥ 18 years of age residing in OK during study period 2010-2019 Healthcare encounters for anxiety disorders, Optum Clinformatics Data Mart (commercia)l and Medicare Advantage Claims Databases	Age, sex, calendar year and month.	**For every additional five ≥magnitude 4 earthquakes in the preceding 6 months:** Healthcare visits for stress disorders ▲ Adjustment reaction ⇔ Anxiety-related disorders ⇔ Physical symptoms of anxiety ⇔
Casey et al. (2018b)	Marcellus Shale, PA	Natural gas	NIH, Degenstein Foundation	Case-control	UNGD activity metric – IDW^2 from participant residence, incorporating phase and duration of development (pad preparation, drilling, stimulation and production), total well depth and volume of natural gas produced	4,762 participants 2014–2015 Geisinger Health System electronic health records and questionnaire data	Race/ethnicity, sex, medical assistance, age, disordered sleep diagnosis or control date; smoking and alcohol use, BMI, antidepressant medication use in month prior to survey, community-based definition of place & socioeconomic deprivation, residential water source	**High UNGD exposure vs. very low** Mild depressive symptoms ▲ Moderate depression symptoms △ Moderately severe/severe depression symptoms △ Depression symptoms ▲ Disordered sleep ⇔
Casey et al. (2019)	Marcellus Shale, PA	Natural gas	NIEHS, National Institute on Drug Abuse, NIH Environmental Influences on Child Health Outcomes Program	Retrospective cohort	UNGD activity metric – IDW^2 between conception and the week prior to anxiety or depression (cases) based on well proximity to maternal residence, phase of development (pad development, drilling, hydraulic fracturing, production), total well depth, volume of natural gas produced	7,715 mothers and 8,371 births 2009–2013 Geisinger Health System	Maternal age at delivery, race/ethnicity, primary care provider status, smoking status during pregnancy, pre-pregnancy BMI, parity, receipt of antibiotic or Medical Assistance during pregnancy, income-based program surrogate for low family socioeconomic status, season/year of conception, gestational age, distance to nearest major road, community socioeconomic deprivation, mean residential greenness, residential well water use, decline in community-level housing value	**Highest UNGD exposure vs. lower UNGD exposure** Antenatal anxiety or depression ▲ Antenatal anxiety & depression (Both) ⇔ Adverse birth outcomes ⇔

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Mayer & Olson Hazboun (2019)	United States	Oil & natural gas	Not disclosed	Ecological	County-level oil and gas production	18,306 records related to alcohol consumption prevalence 2002–2012 Dwyer-Lindgren et al. (2015)	County median income, average earnings per job, labor force participation, USDA Rural-Urban Codes, lagged O&G productions, year fixed effects, state fixed effects	**County-level oil production across US (per 100,000 barrels)** Males, heavy or binge drinking △ Females, heavy or binge drinking ▽ **County-level gas production across US (per 100 million cubic feet)** Males, heavy or binge drinking ⇔ Females, heavy or binge drinking ⇔

[1] Associations from studies that tested for statistical significance are represented using the following symbols: ▲=significant increase, ▼= significant decrease, ▽= non-significant decrease, △= non-significant increase, ⇔ = null findings/no association. Studies that did not test for statistical significance are noted in the table and results are briefly summarized. Unless explicitly stated, the summary of outcomes represents results from comparing the highest tertile/quantile/quartile/highest exposure category to the lowest exposure category. In other words, the increase or decrease in a health outcome is the highest exposure group compared to the lowest (or reference category).

Abbreviations: body mass index (BMI); inverse distanced weighted (IDW); National Institute of Environmental Health Sciences (NIEHS); National Institutes of Health (NIH); unconventional natural gas development (UNGD), United States Department of Agriculture (USDA).

3.3.2.5 Cancer

Five studies examined oil and gas development and cancer outcomes between 1990 and 2017 (**Table 3.6**). Three studies were conducted in Pennsylvania (Clark et al. 2022; Finkel, 2016; Fryzek et al., 2013), one in Colorado (McKenzie et al., 2017), one in Texas (Hoang et al. 2023) and none in California. Four out of five studies found statistically significant associations between upstream OGD and cancer.

Fryzek et al. (2013) evaluated incidence of childhood cancer before and after drilling occurred in Pennsylvania counties among individuals <20 years old using a county-level ecological design. In counties where wells were drilled, standardized incidence ratios (SIRs) for all childhood cancers and leukemia did not increase after drilling; however, a slightly elevated SIR was reported for central nervous system tumors after drilling, particularly in counties with a fewer number of wells (1–500 wells). No trends were observed by the number of wells drilled per county. This study noted the increase in wells drilled between 2003 and 2008 in Pennsylvania, but examined cancer incidence between 1990 and 2009. Therefore, the time frame assessed in this study does not allow for the evaluation of exposure to upstream OGD and cancer, given the longer latency expected between exposure and cancer development.

Finkel (2016) investigated unconventional natural gas development and cancer incidence in southwest Pennsylvania between 2000 and 2012 using an ecological county-level design. Urinary bladder cases were higher than expected in counties with shale gas activity. Thyroid cancer cases increased over time, regardless of unconventional gas development activity, and patterns for leukemia incidence were mixed. Overall, observed cancer incidence was higher than expected prior to unconventional gas development in counties, regardless of unconventional gas development activity. Both the Finkel and Fryzek studies are limited by county-level (rather than individual-level) evaluations of exposure to upstream OGD and county-level measures of cancer incidence and do not control for other confounding variables, including other environmental exposures, that may influence cancer development.

McKenzie et al. (2017) focused on the incidence of childhood cancer cases and their association with upstream OGD in Colorado using a registry-based case-control design. A linear increase in risk of acute lymphocytic leukemia (ALL) was observed with increasing proximity and density exposure categories (McKenzie et al., 2017). Using inverse distance weighted well counts within 16.1 km (10 miles) to estimate exposure, young individuals (ages 5–24) with ALL were 4.3 times as likely to live in the highest well proximity and density category as compared to those not diagnosed with ALL (McKenzie et al., 2017). Patients 5 to 24 years of age were included in this study to account for the approximate 10-year latency period between exposures before the age of 15 and the onset of cancer (McKenzie et al., 2017). Exposure to oil and gas-related compounds, including polycyclic aromatic hydrocarbons, other hydrocarbons such as benzene, and diesel exhaust, have all been linked to non-Hodgkin's lymphoma and ALL (Adgate et al., 2014; Kassotis et al., 2018; McKenzie et al., 2017). While no association was observed between proximity/density for young children (ages 0–4) with ALL, this may be due to the fact that not enough time has passed for the onset of cancer to occur, due to the 10-year latency period discussed previously (Adgate et al., 2014; Kassotis et al., 2018; McKenzie et al., 2017). No association was found for non-Hodgkin's lymphoma, regardless of age.

Clark et al. (2022) examined associations between residential proximity to OGD activity and risk of acute lymphoblastic leukemia (ALBL), the most common form of childhood leukemia, using a cancer registry-based case-control study (2009–2017). Cases were matched with controls based on birth year. Birth address was used to assign exposures using distance to nearest well and a water-specific metric of ID_{ups} which captures the inverse distance to the nearest upgradient OGD well. Two exposure windows were considered: (1) three months prior to conception to one year prior to diagnosis, called the "primary window," and (2) three months prior to conception to birth, called the "perinatal window." Children with at least one unconventional oil and gas well within 2 km (6,561 ft) of their birth residence during the primary window had higher odds of developing ALBL compared to those with no OGD wells. Children with at least one versus no UOG wells within 2 km (6,561 ft) during the perinatal window also had even higher odds of developing ALBL. These relationships were slightly attenuated after adjusting for maternal race and socio-economic status.

Hoang et al. (2023) performed a spatial clustering analysis of 4,305 brain tumors diagnosed in Texas between 2000–2007 in children aged ≤ 19 years. They identified 20 spatial clusters where the incidence of brain tumors was higher than expected, compared to the state-wide incidence rate. The second most significant cluster was in North Texas, included the Dallas-Fort Worth Metropolitan Area, and overlapped the Barnett Shale. The authors identified factors such as unaccounted population growth, natural gas production in the Barnett Shale, and the Dallas-Fort Worth airport as hypotheses that could contribute to this cluster. The third and fourth clusters, which were not statistically significant, were near ports where petroleum and petroleum products are imported and exported or near oil and gas refineries. The remaining 17 clusters, including the most significant cluster, did not appear to overlap with oil and gas basins.

Table 3.6. Summary of epidemiological studies on the association between upstream oil and gas development and cancer in the United States and Canada. Studies are categorized by state and then chronologically by publication year.

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
McKenzie et al. (2017)	Rural areas in CO; towns with population <50,000	Oil & natural gas	University of Colorado Cancer Center	Case-control (registry-based)	IDW well count for active wells within 16.1 km (52,821 ft) radius of residence	87 ALL cases 50 NHL cases 528 controls 2001–2013 Colorado Central Cancer Registry	Patient's age, race, gender, income, elevation, year of diagnosis	**Highest tertile compared to reference (0 wells within 16.1 km [52,821 ft])** **All ages:** Childhood ALL △ Childhood NHL ▽ **0 to 4 Years:** Childhood ALL ▽ Childhood NHL ⇔ **5 to 24 Years:** Childhood ALL ▲ Childhood NHL ⇔
Fryzek et al. (2013)	PA Statewide	Natural gas	America's Natural Gas Alliance	Ecological	County-level well counts before and after oil and gas wells (vertical, horizontal, Marcellus) spudded	1,874 cancer cases pre-drilling 1,996 cancer cases post-drilling 1990–2009 Pennsylvania Department of Health and United States Census Bureau	Standardized incidence ratios calculated and indirectly standardized for age and sex	**Childhood cancer standardized incidence ratios for counties after drilling vs. before horizontal drilling** **Total wells for all counties with wells after drilling** All childhood cancer △ Leukemia △ Central nervous system tumors ▲ **Total wells for all counties, 1990–2009** All childhood cancer ⇔ Leukemia ⇔ Central nervous system tumors ⇔

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Finkel (2016)	Southwest PA	Natural gas	Not disclosed	Ecological	Categorized county-level well counts (high, moderate, minimal producing wells)	**All PA cancer cases** Urinary bladder - 57,177 Thyroid - 31,599 Leukemia - 27,670 2000–2012 Pennsylvania Department of Health Bureau of Health Statistics and Research's Pennsylvania Cancer Registry	Standardized incidence ratios calculated and indirectly standardized for age, sex, race	**% Difference 2008 - 2012 vs. 2000 - 2004, All PA, Males** Urinary bladder cancer – 10.00% Thyroid cancer – 91.20% Leukemia – 18.90% **SIR, Urinary bladder cancer, Males, All PA** 2000–2004 ▲ 2004–2008 ▲ 2008–2012 ▲ **SIR, Thyroid cancer, Males, All PA** 2000–2004 △ 2004–2008 ▲ 2008–2012 ▲ **SIR, Leukemia, Males, All PA** 2000–2004 ▽ 2004–2008 ▽ 2008–2012 ▼ **% Difference 2008–2012 vs. 2000–2004, All PA, Females** Urinary bladder cancer - 0.50% Thyroid cancer - 71.50% Leukemia - 18.30% **SIR, Urinary bladder cancer, Females, All PA** 2000–2004 ▲ 2004–2008 ▲ 2008–2012 ▲ **SIR, Thyroid cancer, Females, All PA** 2000–2004 ▲ 2004–2008 ▲ 2008–2012 ▲ **SIR, Leukemia, Females, All PA** 2000–2004 ▼ 2004–2008 ▼ 2008–2012 ▽

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Clark et al. (2022)	Pennsylvania	Unconventional oil & gas	NIH, EPA	case-control	IDW^2 index within 2 km, 5 km, and 10 km (6,561, 16,404, and 32,808 ft) for active UOG wells (used as binary); IDups: the inverse distance to the nearest upgradient active UOG well	2002–2017 Cases: 405, Controls: 2,080 Pennsylvania Department of Health	sex, mode of delivery, birth weight, race, ethnicity, maternal education, air pollution exposure, and pesticide exposure	**Risk of childhood acute lymphoblastic leukemia (parsimonious model)** **Primary exposure window:** 2 km (6,561 ft) △ 5 km (16,404 ft) △ 10 km (32,808 ft) ⇔ **Perinatal exposure window:** 2 km (6,561 ft) △ 5 km (16,404 ft) △ 10 km (32,808 ft) △
Hoang et al. 2023	Texas	Oil and natural gas	No external funding	Spatial cluster analysis of census tracts	None	4,305 brain tumors diagnosed in children ≤19 years old 2000–2017 Texas Cancer Registry	Age	Relative risk of childhood brain tumors for 20 clusters across Texas, two of which were found to significantly increase risk (significant clusters: Texas Medical Center; large portion of North Texas)

[1] Associations from studies that tested for statistical significance are represented using the following symbols: ▲=significant increase, ▼= significant decrease, ▽= non-significant decrease, △= non-significant increase, ⇔ = null findings/no association. Studies that did not test for statistical significance are noted in the table and results are briefly summarized. Unless explicitly stated, the summary of outcomes represents results from comparing the highest tertile/quantile/quartile/highest exposure category to the lowest exposure category. In other words, the increase or decrease in a health outcome is the highest exposure group compared to the lowest (or reference category).

Abbreviations: acute lymphocytic leukemia (ALL), inverse distance weighted (IDW), non-Hodgkin lymphoma (NHL), standardized incidence ratio (SIR).

3.3.2.6 Cardiovascular outcomes

Five studies evaluated associations between cardiovascular outcomes, including markers of cardiovascular disease, heart failure hospitalizations, acute myocardial infarction hospitalizations and mortality, and stroke mortality (Denham et al., 2021; Hu et al., 2022; McKenzie et al., 2019b; McAlexander et al., 2020; Trickey et al., 2023; **Table 3.7**) and upstream OGD. These studies examined upstream OGD exposures and outcomes between 2005 and 2018. None were conducted in California.

In a study focused in northeastern Colorado's Denver-Julesburg Basin, McKenzie et al. (2019b) found that well intensity per square kilometer was associated with indicators of cardiovascular disease, including increased indications of systemic inflammation, arterial stiffness, and systolic blood pressure among those not taking prescription medications. While specific mechanisms (e.g., air pollution, noise, stress) are not evaluated in this study, inhalation of hydrocarbons has been associated with increases in cardiovascular emergency visits (Ye et al., 2017) and cardiovascular morbidity and mortality (Bard et al., 2014; Harrison, 2016; Villeneuve et al., 2013; Xu et al., 2009).

Two recently published studies evaluated cardiovascular outcomes in Pennsylvania. McAlexander et al. (2020) examined heart failure among residents living near unconventional natural gas development, with exposure defined as residential proximity to wells, nearby well density, well depth, natural gas production, and phase of activity at the well pad 30 days prior to hospitalization. A statistically significant increase in heart failure hospitalization was observed among those in the highest exposure category compared to the lowest exposure category during pad preparation, stimulation and production. Associations were more pronounced among those with more severe heart failure at baseline, indicating that those with heart failure may be more vulnerable to adverse health impacts associated with unconventional natural gas development. Denham et al. (2021) also found significant associations between acute myocardial infarction hospitalization and mortality rates and county-level contemporaneous drilled wells, overall well count, and well density.

Trickey et al. (2023) used a difference-in-differences study design (that controls for time-invariant confounders by design since a place is compared to itself over time) to evaluate the impact of upstream OGD on cardiovascular and respiratory disease hospitalizations among Medicare enrollees from 2009–2015 in three Northern Pennsylvania counties. The study used daily hospitalization data from the 100% sample of Medicare fee-for-service beneficiaries in Northern Pennsylvania (n=36 zip codes) and Southern New York (n=128 zip codes). They defined exposure at the ZIP code annual level based on presence of OGD activity. No New York zip codes were exposed due to a drilling moratorium. In the primary analysis, they used 60 New York zip codes (not bordering Pennsylvania but nearby) as the unexposed group. Outcomes included: acute myocardial infarction, chronic obstructive pulmonary disease (COPD) and bronchiectasis, stroke, heart failure, and ischemic heart disease. Results showed that OGD was associated with more cardiovascular disease-related hospitalizations than expected in 2012–2015. For example, in 2015, exposed zip codes had 8.8 more heart failure hospitalizations per 1000 Medicare enrollees than expected associated with ODG activity.

Hu et al. (2022) used state-level data from the U.S. Centers for Disease Control and Prevention from 2010–2018 on stroke mortality (rate per 100,000) among adults aged 65+ years. They defined states as "fracking" and "non-fracking" states based on the presence of any hydraulically fractured wells. This resulted in 24 fracking states (n=19 active, n=5 not active) and 25 non-fracking states included in the analysis (Alaska was excluded). In geographical and temporal weighted regression adjusted for state-level behavioral, socioeconomic, and health risk factors, results revealed a correlation between fracking annualized loss expectancy and stroke mortality, with a potentially stronger correlation for men. This ecologic study is especially prone exposure misclassification that could lead to spurious associations.

Table 3.7. Summary of epidemiological studies that evaluate upstream oil and gas development and cardiovascular outcomes in the United States and Canada. Studies are categorized by state and then chronologically by publication year.

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
McKenzie et al. (2019b)	Northeast CO	Oil & natural gas	NIEHS, NSF	Cross-sectional	IA-IDW (well intensity/km^2) within 16 km (52,493 ft) of residence	97 adults 2015–2016 Clinic visits which included questionnaire, measurements, and blood sampling	Age, sex, race/ethnicity, BMI, education, income, employment status	Augmentation index ▲ Systolic blood pressure △ Diastolic blood pressure △ IL-1β/IL-6/IL-8 ⇔ TNF-α △ **No prescription medications:** Systolic blood pressure ▲ Diastolic blood pressure △
McAlexander et al. (2020)	PA Statewide	Natural gas	NIEHS	Case-control	UNGD activity metric – IDW^2 incorporating well depth, total daily volume of natural gas production, & phase (pad preparation, drilling, stimulation, and production) 30 days prior to hospitalization or matched control date	9,054 patients with heart failure 5,839 hospitalizations 3,215 controls 2008–2015 Geisinger Health System	Sex, race/ethnicity, age, smoking status, Charlson index of morbidity, receipt of medical assistance, comorbid conditions, duration of care, medication use, BMI, region, community socioeconomic deprivation, proximity to nearest major & minor roadway, normalized difference vegetation index	**Hospitalizations of heart failure patients (fully adjusted Model 5):** Pad preparation ▲ Drilling ⇔ Stimulation ▲ Production ▲

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Denham et al. (2021)	Marcellus (PA & NY)	Natural gas	NIH	Ecological	County-level variables - drilled wells (quarter-year); well county and well density (wells/mi^2)	2,840 county-year-quarters 2005–2014 Pennsylvania Health Care Cost Containment Council and New York's Statewide Planning and Research Cooperative System and United States' National Center for Health Statistics	Adjusted for age, sex, racial/ethnic composition of age-sex group, county-level unemployment rate, poverty rate, median household income, total number of hospitals, uninsured rates	**Cumulative well counts & acute myocardial infarction (AMI) hospitalizations per 10,000 residents** **Males** 45–54 years old ▲ 55–64 years old △ 65–74 years old ▲ 75+ years old △ **Females** 45–54 years old ⇔ 55–64 years old △ 65–74 years old ▲ 75+ years old ▲ **Well counts & AMI mortality/10,000 residents** **Males** 45–54 years old ▲ 55–64 years old △ 65–74 years old ▽ 75+ years old ⇔ **Females** 45–54 years old ▽ 55–64 years old ▽ 65–74 years old ⇔ 75+ years old △ **Well density & AMI hospitalizations/10,000 residents** **Males** 45–54 years old ▲ 55–64 years old △ 65–74 years old △ 75+ years old △ **Females** 45–54 years old ⇔ 55–64 years old ⇔ 65–74 years old △ 75+ years old ▲ **Well density & AMI mortality/10,000 residents** **Males** 45–54 years old ▲ 55–64 years old ⇔ 65–74 years old ▽ 75+ years old △ **Females** 45–54 years old ⇔ 55–64 years old ▽ 65–74 years old △ 75+ years old △

Author (Year)	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Hu et al. (2022)	49 US states (excludes Alaska)	Fracking wells	None	Ecological	Any fracking within a state	2010–2018 Stroke mortality in 65+ CDC	Prevalence of diabetes, cardiovascular, overdose, tobacco use, high cholesterol, physical activity, mean income, marital rate, employment rate, alcohol consumption, education, concentrations of hazardous air pollutants	Positive spatiotemporal correlation between fracking annualized loss expectancy and stroke mortality, with a potentially stronger correlation for men.
Trickey et al. (2023)	Three Northern Pennsylvania Counties and eight New York Counties	Unconventional oil & gas	University of Chicago and Argonne National Laboratories	Difference-in-differences	UOG activity in zip code (binary variable)	61,152 Medicare enrollees in 2015 2002–2015 Hospitalisation data (MedPAR) of 100% of Medicare fee-for-service beneficiaries	None. Modeling method controls for time-invariant confounders by design.	**Any diagnosis of COPD & bronchiectasis (hospitalizations):** 2010 ⇔ 2011 ⇔ 2012 ▲ 2013 ▲ 2014 ▲ 2015 ⇔ **Heart failure:** 2010 ⇔ 2011 ⇔ 2012 ▲ 2013 ▲ 2014 ▲ 2015 ▲ **AMI:** 2010 ⇔ 2011 ⇔ 2012 ▲ 2013 ▲ 2014 ▲ 2015 ▲ **Ischaemic heart disease (including AMI):** 2010 ⇔ 2011 ▲ 2012 ▲ 2013 ▲ 2014 ▲ 2015 ▲ **Stroke:** 2010 ⇔ 2011 ⇔ 2012 ⇔ 2013 ⇔ 2014 ⇔ 2015 ⇔

[1] Associations from studies that tested for statistical significance are represented using the following symbols: ▲=significant increase, ▼= significant decrease, ▽= non-significant decrease, △= non-significant increase, ⇔ = null findings/no association. Studies that did not test for statistical significance are noted in the table and results are briefly summarized. Unless explicitly stated, the summary of outcomes represents results from comparing the highest tertile/quantile/quartile/highest exposure category to the lowest exposure category. In other words, the increase or decrease in a health outcome is the highest exposure group compared to the lowest (or reference category).

Abbreviations: acute myocardial infarction (AMI); body mass index (BMI); intensity adjusted inverse distance weighted well intensity (IA-IDW); interleukin (IL); National Institute of Environmental Health Sciences (NIEHS); National Institutes of Health (NIH); National Science Foundation (NSF); tumor necrosis factor alpha (TNF-α); unconventional natural gas development (UNGD).

3.3.2.7 Other adverse health outcomes

Fifteen studies examined upstream OGD and other health outcomes, including all-cause mortality, non-outcome specific hospitalizations, antineutrophil cytoplasmic antibody (ANCA)-associated vasculitis, migraine headaches, and self-reported symptoms and outcomes.[10] These studies are summarized below by outcome and are shown in **Table 3.8**. A single study, on migraine headache, was conducted in California related to other adverse health outcomes.

Migraine headache

Elser et al. (2021) conducted a case-control study of migraineurs and those without migraine among Sutter Health patients across 27 counties in Northern California between 2014 and 2018. The authors also assessed the relationship of environmental factors with migraine severity in a case-only analysis. The authors evaluated exposure to four environmental stressors, including ambient annual average concentrations of $PM_{2.5}$ and NO_2 at the U.S. Census block group level and inverse-distance weighted metrics (considering proximity and nearby density) of methane super-emitters (including but not limited to oil and gas sources), as well as active oil and gas wells. Exposure to methane super-emitters and ambient NO_2 were associated with increased odds of being a migraine case. The authors did not observe an association between exposure to active oil and gas wells and migraine prevalence or severity.

All-cause mortality

Three studies evaluated the association between upstream OGD and all-cause mortality in the United States (Boslett & Hill, 2022; Li et al., 2022; Mayer et al., 2019). Using two methods — a Cox proportional hazards model and a difference-in-differences design — the Li et al. (2022) zip code level analysis found a statistically significant increased risk of mortality associated with Medicare beneficiaries living in proximity to and downwind of unconventional oil and gas wells. Similarly, another study using ecological study design found that for all counties in the United States, morality rates increase as the number of oil and gas wells increases (within-effect, active oil and gas wells) (Mayer et al., 2019). However, the authors also found that counties with active oil and gas production tend to have lower all-age, all-cause mortality rates (between-effect, average wells) compared to counties without oil and gas production. When evaluated at the regional level, these findings persist only for the southern United States, suggesting that regional differences in upstream OGD may influence all-cause, all-age mortality (Mayer et al., 2019).

Boslett and Hill (2022) applied an ecological retrospective study design using the National Vital Statistics System Multiple Cause of Death Data at the county level (1999–2016) to assess the relationship between boom-and-bust cycles associated with coal, oil, and natural gas extraction and mortality. Two-way fixed effects models controlling for state and year found no association between drilled horizontal wells and mortality.

[10] One study included in this count, Johnston et al. (2021), evaluates both measured respiratory outcomes and self-reported symptoms. This study is described in detail above under Section 3.3.2.3 "Respiratory outcomes" and also discussed within this section under "Self-reported symptoms."

Non-outcome specific hospitalizations

Two ecological studies examined the association between upstream OGD and a variety of non-outcome-specific, broad-disease categories of hospitalization rates in Pennsylvania between 2003 and 2014 (Denham et al., 2019; Jemielita et al., 2015). Denham et al. (2019) examined the relationship of 16 broad-disease categories of hospitalization rates[11] and total hospitalizations, with three county-specific exposure metrics at the county-year level: cumulative well count, cumulative well density (per square kilometer), and contemporaneous spudded wells. For all exposure metrics, the authors found significant positive associations with hospitalizations for genitourinary diseases. At a county level, an increase of 0.008 hospitalizations for genitourinary diseases per 10,000 residents was associated with the addition of one cumulative oil and gas well, and a 1.2% relative increase in the genitourinary hospitalization rate was associated with the addition of 100 cumulative oil and gas wells as compared with the baseline average rate. Twenty hospitalizations for genitourinary diseases per 10,000 residents were associated with an increase of one well per square kilometer (0.39 square miles). After removing large metropolitan counties, genitourinary hospitalizations were significantly positive associated with well count and well density remained. The authors also observed an increase of 0.004 skin-related hospitalizations per 10,000 residents with each additional well and well count and well density, and an increase of 12.2 hospitalizations for skin-related diseases per 10,000 residents was associated with each additional well per square kilometer (0.39 square miles), compared to the baseline rates. Finally, they found that cumulative well count and well density had significant positive associations with genitourinary and skin-related hospitalizations after controlling for multiple comparisons. Genitourinary hospitalization findings were driven by non-elderly adult females (ages 20–64) and included kidney infections, calculus of the ureter, and urinary tract infections, whereas the skin-related hospitalization findings were driven by non-elderly adult males. They found negative associations with infectious diseases and musculoskeletal diseases and no associations with other hospitalization categories or overall hospitalizations. No associations were found with any type of hospitalizations and contemporaneous wells.

Jemielita et al. (2015) examined ZIP code-specific inpatient prevalence rates per year per 100 people for the top 25 specific medical categories[12] and total inpatient rates, and their relationship to both the number of oil and gas wells (within a specific ZIP code for a specific year) and density of oil and gas wells (wells per square kilometer at the ZIP code level). With the strictest criteria to account for multiple comparisons, only cardiology inpatient rates were significantly associated

[11] Denham et al. (2019). The 16 broad-disease categories of hospitalization rates examined were infectious diseases, neoplasms, endocrine/nutritional & metabolic diseases/immunity disorders, diseases of the blood and blood-forming organs, mental disorders, diseases of the nervous system and sense organs, diseases of the circulatory system, diseases of the respiratory system, diseases of the digestive system, diseases of genitourinary system, complications of pregnancy and childbirth, diseases of the skin and subcutaneous tissues, diseases of the musculoskeletal system and connective tissue, congenital abnormalities, conditions originating in the perinatal period, injury and poisoning.

[12] Jemielita et al. (2015). The 25 specific medical categories of inpatient rates examined were cardiology, dermatology, endocrine, gastroenterology, general medicine, general surgery, gynecology, hematology, neonatology, nephrology, neurology, normal newborns, ob/delivery, oncology, ophthalmology, orthopedics, other/ob, otolaryngology, psych/drug abuse, pulmonary, rheumatology, thoracic surgery, trauma, urology, and vascular surgery.

with both number of wells and well density, and neurology inpatient rates were significantly associated with well density. However, the authors found the following inpatient prevalence rates were positively associated with ZIP code-level well counts and well density: dermatology, neonatology, neurology, oncology, and urology. Jemielita et al. (2015) also reported positive associations between well density and dermatology, endocrine, neurology, oncology, urology, and overall inpatient prevalence rates. The remaining inpatient prevalence rates had no associations with the two exposure measures. The authors also performed well density quantile analyses and found significant positive associations with inpatient prevalence rates for cardiology and neurology. Positive associations (though non-significant) were seen again with dermatology, neurology, oncology, and urology inpatient prevalence rates.

Antineutrophil cytoplasmic antibody (ANCA)-associated vasculitis

One ecological study evaluated the impacts of natural gas drilling in West Virginia on ANCA-associated vasculitis diagnoses and their subtypes (myeloperoxidase [MPO]-ANCA and persistent proteinase 3 [PR3]-ANCA) between 1990 and 2019 (Makati et al., 2022). The authors found the proportion of MPO-ANCA-diagnosed patients significantly increased after 2010, from 37.5% in 2010 to 61% after 2010. During this time, unconventional natural gas development rose more than tenfold after 2010. Similarly, the prevalence of ANCA-associated vasculitis diagnoses also increased significantly after 2010 — from 64.8 to 141.9 cases per one million individuals (Makati et al., 2022). This increase was largely driven by a rise in MPO-ANCA cases.

Self-reported symptoms

Ten studies focused on self-reported health symptoms related to exposure to upstream OGD, six of which were conducted in Pennsylvania (Blinn et al., 2020; Ferrar et al., 2013; Rabinowitz et al., 2015; Saberi et al., 2014; Steinzor et al., 2013; Tustin et al., 2016; Weinberger et al., 2017), one in Colorado (Weisner et al., 2023), one in Ohio (Elliot et al., 2018) and one in California (Johnston et al., 2021). Three of these studies relied on convenience sampling to recruit study participants, a well-known limitation of studies that rely on self-reported information to assess potential harmful exposures due to the small sample size (n=33–108) and potential for selection bias (Ferrar et al., 2013; Saberi et al., 2014; Steinzor et al., 2013). Of note, other studies evaluated health symptoms and outcomes using other methods, such as structured health assessments with physician review (Weinberger et al., 2017) or standardized and validated questionnaires (Tustin et al., 2016).

Self-report studies have consistently documented skin irritation and rash; respiratory symptoms including difficulty breathing; nose, throat, and sinus problems; gastrointestinal disturbances; headache; sleep disruption; and psychological symptoms including stress as symptoms related to oil and gas development (Ferrar et al., 2013; Rabinowitz et al., 2015; Saberi, 2013; Steinzor et al., 2013). Rabinowitz et al. (2015) found increased prevalence of dermal and respiratory symptoms was associated with increased proximity to gas wells.

Johnston et al. (2021) evaluated a variety of acute health symptoms in South Los Angeles and found that residents living near active oil wells self-reported higher odds of recent wheeze, sore throat, chest tightness, eye and nose irritation, dizziness, and ringing of the ears as compared to residents living near idle wells. Seven additional studies that rely on self-reported health symptom data between 2010 and 2017 have also reported the same acute health symptoms among residents living in areas of oil and gas development in Ohio and Pennsylvania (Blinn et al., 2020;

Elliott et al., 2018; Ferrar et al., 2013; Rabinowitz et al., 2015; Steinzor et al., 2013; Weinberger et al., 2017).

Blinn et al. (2020) found that exposure to unconventional OGD — estimated by proximity to and/or density of nearby wells — was associated with headache, difficulty sleeping, sore throat, stress, and itchy or burning eyes. Annual emissions concentrations (AEC) examined near unconventional OGD were also significantly associated with numerous health outcomes; the top five most reported symptoms being difficulty sleeping, anxiety/worry, cough, stress, and shortness of breath (difficulty breathing) (Blinn et al., 2020). Similarly, Rabinowitz et al. (2015) found that living within 1 km (3,281 ft) of active natural gas drilling is significantly associated with increased dermal symptoms. Gastrointestinal and neurological symptoms also increased among residents living within 1 km (3,281 ft) of active drilling, although these results were not significant (Blinn et al., 2020). Tustin et al. (2016) found the highest quartile of unconventional natural gas development activity, compared with the lowest, was associated with significantly increased odds of the following combinations of two or more outcomes: chronic rhinosinusitis and higher levels of fatigue (88% increased odds), migraine headache and higher levels of fatigue (95% increased odds), and all three outcomes (84% increased odds). Weinberger et al. (2017) found physician-reviewed symptoms reported within 1 km (3,281 ft) of active well drilling included sleep disruption, headache, throat irritation, stress or anxiety, cough, shortness of breath, sinus problems, fatigue, nausea, and wheezing; although, these findings were not statistically significant.

Elliott et al. (2018) sampled the drinking water of 66 Ohio homes located at varying distances from upstream OGD and found oil and gas-associated pollutants to be present in both the groundwater and surface water near oil and gas sites. The authors detected significantly elevated levels of toluene in groundwater and halogenated compounds in surface water. Furthermore, the authors found that as distance to the nearest well increased, the odds of detecting trihalomethanes, bromoform, and dibromochloromethane in surface water significantly decreased (odds ratios: 0.28–0.29 per km).[13] Similarly, the odds of detecting gasoline range organics, toluene, and organic compounds in groundwater also decrease as distance to the nearest oil and gas well increases. These findings were statistically significant, with the exception of organic compound detection. The authors accompanied the water sampling campaign with a self-report survey and found that "those with higher inverse-distance-squared-weighted unconventional oil and gas well counts within 5 km (16,404 ft) around the home were more likely to report experiencing general health symptoms (e.g., stress, fatigue)" (Elliott et al., 2018).

Weisner et al. (2023) undertook a cross-sectional survey study of 427 adults and 59 children to evaluate associations between self-reported health symptoms (Summed Likert scores for upper respiratory, lower respiratory, mental health, neurological, gastrointestinal, or acute symptoms) and residential distance from multi-well oil and gas sites in Broomfield, Colorado, in 2021. After adjustment for several covariates, respondents living within 1 mile (1.6 km) of a multi-well oil and gas site tended to report higher frequencies of upper respiratory, lower respiratory, gastrointestinal, and acute symptoms than respondents living more than 2 miles (3.2 km) from the sites, with the largest differences for upper respiratory and acute symptoms (nausea, vomiting, nosebleeds, lung irritation, shortness of breath, cough, and throat irritation).

[13] This incremental increase in odds ratios is applicable to bromoform, and dibromochloromethane in surface water.

Table 3.8. Summary of epidemiological studies that evaluate upstream oil and gas development and other adverse health outcomes in the United States and Canada. Studies are categorized by health outcome, by state and then chronologically by publication year.

Author (Year)	Health outcome category	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Mayer (2019)	All-cause mortality	Rural places, United States	Oil & natural gas	Not disclosed	Ecological	County-level number of active oil and gas wells and county-level averages for active oil and gas wells, aggregated nationally and regionally	47,937 deaths 2000–2016 Center for Disease Control	Labor force participation ratio, % poverty, median income, per capita income	*p-values of <0.05*, <0.01**, <0.001*** reported below; authors define statistical significance as p-value <0.01*** **All-cause mortality, All Ages** *Active oil and gas wells* All U.S. ▲ *** South △ * *Average oil and gas wells* All U.S. ▼ *** South ▼ ** Northeast △* **All-cause mortality, Females, 15–64** *Active oil and gas wells* South ▼ ** West △ * *Average oil and gas wells* Northeast △ * **All-cause mortality, Males, 15–64** *Active oil and gas wells* *South* ▽*
Li et al. (2022)	All-cause mortality	United States	Unconven-tional oil & gas	US EPA, NIH, Climate Change Solutions Fund - Harvard University	Retrospecti ve cohort & differences in differences	Zip code-level proximity exposure to unconventional oil and gas wells; sub-analysis of downwind vs. upwind exposure	15,198,496 Medicare beneficiaries 2001–2015 US Energy Information Administration, Center for Medicare & Medicaid Service	Sex, Medicaid availability, age, race/ethnicity, $PM_{2.5}$ ($\mu g/m^3$), development ratio, population density, income, educational attainment, BMI, smoking status, proximity-exposure to conventional oil and gas development	**Low proximity exposure vs. unexposed** All-cause mortality ▲ Mortality (upwind) ▲ Mortality (downwind) ⇔ **Medium & high proximity exposure vs. unexposed** All-cause mortality ▲ Mortality (upwind) ▲ Mortality (downwind) ▲

Author (Year)	Health outcome category	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Boslett & Hill (2022)	All-cause mortality	United States	Unconven-tional oil & gas	NIH	Ecological	Number of newly drilled horizontal oil & gas wells per county per year	1999–2016 CDC National Vital Statistics System (NVSS) Multiple Cause of Death Data	Year, shares of the county population who are white, Hispanic, and working-aged (25–64 years old); total population; and the total number of hospitals and pharmacies in the county	**# of horizontal O&G wells (in 100s), 0 < X ≤25 miles (40 km):** Non-drug mortality ⇔ Working age non-drug mortality △ Drug overdose mortality ⇔ Opioid overdose mortality ⇔ Non-drug overdose suicides ⇔ Alcohol overdoses ⇔ **# of horizontal O&G wells (in 100s), 25 <X ≤50 miles (40 km <X ≤80 km) :** Non-drug mortality ▼ Working age non-drug mortality ▽ Drug overdose mortality ▼ Opioid overdose mortality ▼ Non-drug overdose suicides ⇔ Alcohol overdoses ⇔ **# of horizontal O&G wells (in 100s):** Non-drug mortality ⇔ Working age non-drug mortality ⇔ Drug overdose mortality ⇔ Opioid overdose mortality ⇔ Non-drug overdose suicides ▲ Alcohol overdoses ⇔
Jemielita et al. (2015)	Non-outcome specific hospitalizations	Bradford, Susquehanna and Wayne County, PA	Oil & natural gas	NIEHS	Ecological	Wells per zip code per year (well analysis) and wells density per square kilometer per year (quantile analysis)	92,805 hospitalizations in 67 zip codes 2007–2011 Pennsylvania Health Care Cost Containment Council	Not considered	**Wells per zip code per year, inpatient prevalence rates:** Cardiology ▲ Dermatology, neonatology, neurology, oncology, urology △ **Well density per year, inpatient prevalence rates:** Cardiology ▲ Neurology ▲ Dermatology, endocrine, neurology, oncology, urology △

Author (Year)	Health outcome category	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Denham et al. (2019)	Non-outcome specific hospitalizations	54 rural counties that are not large metro areas, PA	Natural gas	NIH	Ecological	County-level wells for each year, cumulative well count and cumulative well density per square kilometer	1,452 records 2003–2014 Pennsylvania Health Care Cost Containment Council	Annual county-level data, including distributions of age, sex, race-ethnicity, poverty and median income, unemployment rates, hospital counts, uninsured rates	**Increased well density:** All-cause hospitalizations ⇔ Infectious diseases ▽ Neoplasms △ Endocrine/immune ⇔ Blood ⇔ Nervous system ⇔ Circulatory ⇔ Respiratory ⇔ Digestive ⇔ Genitourinary ▲ Pregnancy ⇔ Skin ▲ Musculoskeletal ⇔ CM ⇔ Perinatal ⇔
Makati et al. (2022)	ANCA-associated vasculitis	Northcentral, WV	Unconventional natural gas	None	Retrospective cohort	County-level unconventional natural gas production per year - pre-2010 vs. post-2010	212 patients diagnosed with ANCA-associated vasculitis 1990–2019 West Virginia University Health System-affiliated hospitals health records	Age, sex	**Natural gas production before 2010 vs. after 2010** ANCA-associated vasculitis ▲ PR3-ANCA (subtype) ⇔ MPO-ANCA (subtype) ▲
Elser et al. (2021)	Migraines	Northern CA	Oil & gas	CARB, NIEHS	Case-control (Case-case analysis for migraine severity)	Annual average concentrations of $PM_{2.5}$ and NO_2 at the block group level. Methane super-emitters (IDW sum kg/hour of all methane sources within 10 km (32,808 ft) of residence, weighted IDW[2]. IDW sum of active oil and gas wells within 10 km (32,808 ft) of each residence and presence of any active oil or gas well within 10 km (32,808 ft).	360,139 patients 89,575 cases 270,564 controls 2014–2018 Sutter Health Electronic Health Records	Age, sex, race/ethnicity, Medicaid use, number of primary care visits per year, block group-level population density, poverty	**IDW Active O&G well (per 1,000-unit increase)** Migraine case ⇔ MPA score ⇔ Urgent care visit ⇔ Neurology visit ⇔ Triptans ⇔ ED visit ⇔

Author (Year)	Health outcome category	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Weisner et al. (2023)	Self-reported symptoms	Colorado: City and County of Broomfield	UOGD	City and County of Broomfield	Cross-sectional	Residential proximity to UOGD (within 1 mile (1.6 km) versus >2 miles (3.2 km)	n=3393 2020–2021 survey	Age, sex, race, smoking, alcohol consumption, time spent in home, number of children <18 years in home, exercise, number of chronic health conditions, time of residence at current home, education level and occupation.	**Difference between >2 Mile (3.2 km) and 1–2 Mile (1.6–3.2 km) Means to multiwell O&G site:** Total symptoms ⇔ Upper respiratory ⇔ Lower respiratory ⇔ Mental Health ⇔ Neurological ⇔ Gastrointestinal ⇔ Acute ⇔ **Difference between >2 Mile (3.2 km) and <1 Mile (1.6 km) Means to multiwell O&G site:** Total symptoms ▲ Upper respiratory △ Lower respiratory ▲ Mental Health ⇔ Neurological ⇔ Gastrointestinal ▲ Acute ▲
Johnston et al. (2021)	Respir-atory & self-reported acute health symptoms	South Los Angeles, CA North University Park & Jefferson Park	Oil	NIEHS	Cross-sectional (self-reported survey with lung function measurements)	1 km (3,281 ft) buffer around two oil development sites, one with 28 active wells (Jefferson Park) and one with 21 idle wells (North University Park)	960 residents from 488 addresses 747 valid spirometry tests 2017–2019 Self-reported symptoms & spirometry measurements	Age, sex, height, age-height interaction, race/ethnicity, weight, recent flu/cold, proximity to freeway, asthma status smoking status, indoor exposure to environmental tobacco smoke, season, wind direction (downwind vs. upwind)	**Self-reported acute health symptoms** **Active vs. idle well site** Recent wheeze ▲ Recent cough every morning ▽ Sleep disturbed by wheeze △ Sore throat ▲ Chest tightness ▲ Sneezing/runny nose △ Eye irritation ▲ Nose irritation ▲ Dizziness ▲ Headache △ Fatigue △ Ringing of the ears ▲ Diarrhea ▽ Nausea/vomiting ▽ Nosebleeds △ Backache △ Rash ▽ *Lung function findings shown in* **Table 3.4**.

Author (Year)	Health outcome category	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Elliot et al. (2018)	Other / General health outcomes	Ohio, Appala-chian Basin, Belmont County	Unconvent ional oil & gas	Yale Institute of Biospheric Studies, Jan A. J. Stolwijk Fellowship	Self-reported survey & measureme nt of drinking water samples	IDW well count, IDW^2 count within 5 km of residence, and distance to nearest active O&G well (km)	66 residents of Belmont County June–August 2016 Self-reported survey and drinking water samples	Age, sex, body-mass index, smoking status, educational status, marital status, employment status	**Self-reported health symptoms:** ID^2W well count: Odds of reporting general symptoms ▲ respiratory ⇔ neurologic ⇔ dermal ⇔ gastro-intestinal ⇔
Blinn et al. (2020)	Other / General health outcomes	Southwest PA	Oil & natural gas	Heinz Endowments	Self-reported survey (health assessment reviewed by healthcare providers)	Cumulative well density (CWD), IDW of wells, and annual emission concentrations (AEC) from wells within 5 km (16,404 ft) of respondents' homes	104 health assessments 2012–2017 Self-selected survey conducted by Southwest Pennsylvania Environmental Health Project	Age, sex, smoker status	**Most commonly reported symptoms (CWD metric):** Headache ▲ Difficulty sleeping ▲ Sore throat ▲ Stress ▲ Itchy or burning eyes ▲ **Most commonly reported symptoms (IDW metric):** Headache ▲ Difficulty sleeping ▲ Sore throat ▲ Stress ▲ Itchy or burning eyes ▲
Rabinowi tz et al. (2015)	Other / General health outcomes	Washingt on County, PA	Natural gas	Heinz Endowments , 11th Hour Project, Claneil Foundation, Jan Stolwijk Fellowship fund and Yale University Clinical and Translational Science Award grant	Health symptom survey	DNDW (distance to nearest drilled well) - Proximity of residence with ground-fed water supply to nearest well, <1 km (3,281 ft) to >2km (6,562 ft)	492 persons (180 households) Summer 2012 Random-sample environmental health assessment of reported health symptoms and health status	Age, sex, household education, smoking, awareness of environmental risk, work type, animal in house	**DNDW (<1 km (3,281 ft) vs. >2 km (6,562 ft)):** Dermal ▲ Upper respiratory ▲ Lower respiratory △ Cardiac △ Gastrointestinal △ Neurological △ **DNDW (1–2 km, 3,281–6,562 ft):** Dermal △ Upper respiratory △ Lower respiratory △ Cardiac △ Gastrointestinal △ Neurological △

Author (Year)	Health outcome category	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Tustin et al. (2016)	Other / General health outcomes	Central and Northeast, PA	Natural gas	NIH, Robert Wood Johnson Foundation, Degenstein Foundation, NSF	Self-administered questionnaire	IDW[2] from patient residence, incorporating well phase, well depth, daily gas production; exposure averaged across three months prior to survey	7,785 surveyed patients April 2014 Survey of patients from Geisinger Health System	Socioeconomic status, race/ethnicity, age, medical assistance, smoking status	Current chronic rhinosinusitis △ Migraine headaches △ Higher levels of fatigue △ Chronic rhinosinusitis & migraine △ Chronic rhinosinusitis & higher fatigue ▲ Migraine & higher levels of fatigue ▲ Migraine, fatigue & chronic rhinosinusitis ▲
Wein-berger et al. (2017)	Other / General health outcomes	Marcellus Shale, PA	Natural gas	Heinz Endowments	Structured health assessments (physician-reviewed)	Residence within 1 km (3,281 ft) of an unconventional natural gas well	135 health records collected among people concerned about unconventional natural gas development 2012–2015 Structured health assessment	Not considered	Statistical significance not assessed. **Symptoms reported by >20% participants:** Sleep disruption Headache Throat irritation Stress/anxiety Cough Shortness of breath Sinus problems Fatigue Nausea Wheezing
Saberi et al. (2014)	Other / General health outcomes	Marcellus Shale, PA	Natural Gas	NIEHS, NIOSH, Health Resources and Services Administration Center of Excellence in Environmental Toxicology at University of Pennsylvania	Self-reported, health symptom survey	Shale region residents (not formally evaluated)	72 residents in the Shale region Summer 2012 Structured health symptom survey administered in primary care clinics	Not considered	Statistical significance not assessed. Nine patients thought natural gas activity was a cause for medical symptom One had both symptoms & environmental concern included in medical record 22% of patients in area with extensive UNGD activity expressed concern about health related to UNGD. 12.5% of patients believed symptoms due to UNGD, including anxiety or sleep disturbances.

Author (Year)	Health outcome category	Region	Primary hydro-carbon produced	Funder	Study design	Surrogate of exposure *(distance evaluated if specified)*	Sample size, study time frame, and outcome data source	Confounders and covariates considered	Main findings[1]
Steinzor et al. (2013)	Other / General health outcomes	Oil & gas regions, PA	Natural gas	Colcom Foundation	Self-reported health symptom survey & subset of environmental sampling	Residents in "gas patches;" questionnaire included proximity to three gas facilities (within 1,500 ft (457 m) & outside this radius): compressor and pipeline stations, gas-producing wells, and impoundment or waste pits	108 individuals (children and adults) from 55 households August 2011–July 2012 Self-administered, structured health symptom survey Environmental sampling from subset of 70 participants	Not considered	**Reported health symptoms from residents ≤1,500 ft (457 m) vs. >1,500 ft (457 m) of natural gas facility:** Throat Irritation ▲ Sinus problems ▲ Nasal irritation ▲ Eye burning ▲ Joint pain △ Severe headaches ▲ Sleep disturbances △ Skin rash▲ Shortness of breath △ Forgetfulness △
Ferrar et al. (2013)	Other / General health outcomes	Marcellus Shale, PA	Natural gas	University of Pittsburgh Graduate School of Public Health, Environmental & Occupational Health Department	Longitudinal health symptom & stressor interview	Not evaluated	Session 1: 33 individuals May–October 2010 Session 2: 20 individuals (same individuals as session 1) January–April 2012 Interviews administered by phone or in-person	Not considered; discussed participant characteristics	Statistical significance not assessed. A total of 59 health impacts were attributed to Marcellus Shale development, and 13 stressors, with most common symptom being stress. Perception of health impacts increased from session 1 to 2; Stressors remained the same across sessions.

[1] Associations from studies that tested for statistical significance are represented using the following symbols: ▲=significant increase, ▼= significant decrease, ▽= non-significant decrease, △= non-significant increase, ⇔ = null findings/no association. Studies that did not test for statistical significance are noted in the table and results are briefly summarized. Unless explicitly stated, the summary of outcomes represents results from comparing the highest tertile/quantile/quartile/highest exposure category to the lowest exposure category. In other words, the increase or decrease in a health outcome is the highest exposure group compared to the lowest (or reference category).

Abbreviations: annual emissions concentration (AEC); antineutrophil cytoplasmic antibody (ANCA); body mass index (BMI), California Air Resources Board (CARB); congenital malformations (CM); cumulative well density (CWD); distance to nearest drilled well (DNDW); emergency department (ED), inverse distance weighted (IDW); migraine probability algorithm (MPA); myeloperoxidase (MPO); micrograms per cubic meter (µg/m3); persistent proteinase 3 (PR3); National Institutes of Health (NIH); National Institute of Environmental Health Science (NIEHS); National Institutes of Occupational Safety and Health (NIOSH); nitrogen dioxide (NO_2), particulate matter less than or equal to 2.5 microns ($PM_{2.5}$); unconventional natural gas development (UNGD); United States Environmental Protection Agency (US EPA).

3.4. Discussion

This chapter presents the findings of epidemiological studies on the association between upstream OGD exposures and adverse health outcomes conducted in the United States and Canada, including California. Here, we discuss (1) the strengths and limitations of environmental epidemiological research evaluating health risks and impacts associated with oil and gas development; (2) the need for broad consideration of the peer-reviewed literature across time and space; (3) evidence of disproportionate exposure and health risks; and (4) measures to mitigate health risk and impacts associated with oil and gas development.

3.4.1 Strengths and limitations of environmental epidemiological research evaluating health risks and impacts associated with oil and gas development

The proliferation of upstream OGD in several regions of the United States has been followed by a rapid growth in the peer-reviewed epidemiologic literature assessing the human health risks associated with exposure to upstream OGD. Below we describe the strengths and limitations of environmental epidemiological research in evaluating health risk and impacts associated with upstream OGD, in the context of exposure assessment, overall study design, addressing confounding factors, and considering geographic differences and temporal changes in regulation, extraction methods, etc.

3.4.1.1. Exposure assessment

Epidemiological studies employ various approaches to evaluate the association between upstream OGD and various adverse health outcomes. Surrogates of exposure used in epidemiological studies often include proximity to oil and gas wells, density of oil and gas wells, phase of well development, and cumulative volume of oil and/or natural gas produced (see *Surrogates of exposure to upstream oil and gas development*; **Table 3.1**). These surrogates of exposures are aggregate measures of the chemical, physical, and social stressors associated with upstream OGD.

Recent reviews of the literature that examine upstream OGD acknowledge the need for more robust exposure assessment methods to more accurately evaluate specific risk factors, such as exposure to air and water pollution associated with upstream OGD (Bamber et al., 2019; Deziel et al., 2020, 2022a; Health Effects Institute-Energy Research Committee, 2019; Shonkoff et al., 2014).

However, given the complexity of and multiple potential hazards and exposure pathways associated with upstream OGD, relying on aggregate metrics of exposure (e.g., proximity to wells, well density, etc.) offers advantages over the examination of exposure to one pollutant or one hazard at a time (Deziel et al., 2022a). These approaches enable epidemiologists to identify human health burdens that may otherwise be missed (Buonocore et al., 2020). Therefore, the body of epidemiological literature is crucial to consider when aiming to mitigate exposures and

health burdens, as a narrow focus on one pollutant or pathway may be ineffective at reducing health burdens associated with multiple potential pathways.

Findings from previous studies have reinforced the need to consider stressors associated with upstream OGD from a broader perspective. For example, one study conducted in Pennsylvania found an asthma effect size that was much greater — almost an order of magnitude higher — than would be expected from exposure to criteria air pollutants alone (e.g., particulate matter [PM_{10}], nitrogen dioxide, ozone), suggesting that additional pollutants or other risk factors may be playing a role in the health effects observed (asthma exacerbation) (Rasmussen et al. 2016). Additionally, this body of epidemiological studies tend to place heavier focus on well sites as opposed to other oil and gas infrastructure (because of the public availability of geo-spatially explicit well data) though effects have still been observed in studies while adjusting for other upstream OGD sources (e.g., McKenzie et al., 2019a).

3.4.1.2. Addressing confounding factors

While residual confounders — unmeasured factors that might bias the observed associations — in epidemiological studies is always a possibility, such uncertainty has generally been well addressed in this body of peer-reviewed epidemiological studies. Over time, analytical epidemiological studies, such as cohort and case-control studies focused on upstream OGD in particular, have considered an increasing number of potential confounding variables and covariates in their study designs (see **Tables 3.2–3.7**), and epidemiologists have conducted sensitivity analyses among subsets of their study populations to further substantiate their findings. While the first studies examining adverse health outcomes reported inverse associations for certain outcomes (McKenzie et al., 2014), studies published since then have expanded upon the types of confounders considered and how exposure to upstream OGD is estimated. For example, recent studies looking at preterm birth include innovative exposure metrics that allow for a more detailed evaluation of exposure associated with upstream OGD (e.g., inclusion of phase of well pad, production volume, flaring activity) and indicate that adverse perinatal outcomes are still observed (Casey et al., 2016; Walker Whitworth et al., 2018; Cushing et al., 2020; Tran et al., 2020).

Additionally, certain causal inference study designs, such as difference-in-differences design, control for temporal changes in variables that might confound an observed association (Currie et al., 2017; Hill, 2018; Willis et al., 2018). Exposure misclassification is consistently a concern in environmental epidemiological studies. However, imprecision in exposure assessment or non-differential exposure misclassification is more likely to attenuate observed relationships (i.e., bias toward the null), thus leading to an underestimate of the true adverse impacts of upstream on perinatal outcomes (**Figure 3.10**) (Blanchard et al., 2018). In environmental epidemiologic studies, researchers often use surrogates to estimate exposures or assign individuals to exposure categories; these surrogates have some measurement error associated with them. When these errors in assigning or classifying participant exposures are similar between exposed and unexposed or those with or without the health outcome, this is referred to as non-differential exposure misclassification. This type of "noise" in the data tends to dilute or attenuate the true exposure-response relationship, as illustrated by the hypothetical dashed line in **Figure 3.10**,

which has a shallower slope compared to the hypothetical "true" solid line. In the context of the literature on OGD-related exposures summarized in this chapter, this suggests that positive associations are likely not attributable to exposure misclassification and that effect sizes may in fact have been underestimated (Deziel et al., 2020).

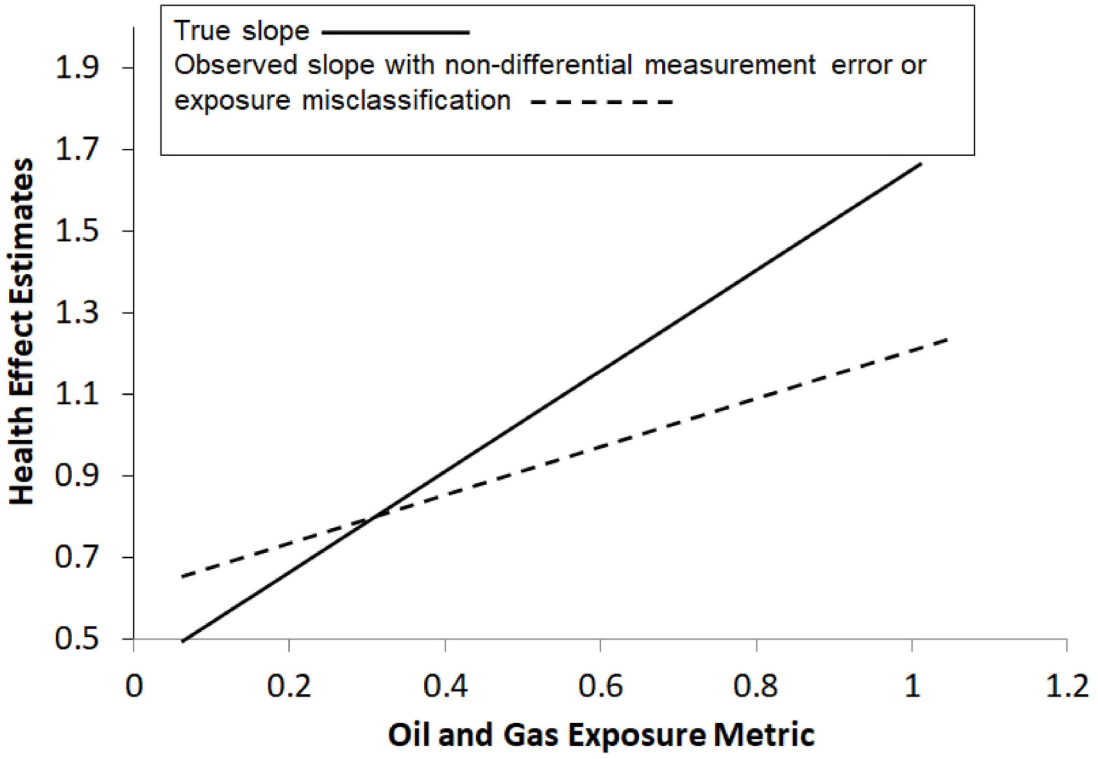


Figure 3.10. Potential effect of imprecise exposure estimates on a hypothetical exposure-response relationship. Source: Adapted from Seixas & Checkoway (1995).

3.4.1.3. Study design

Despite constraints inherent in environmental epidemiology — specifically, the reliance on observational study designs and surrogate measures of population-level exposure — retrospective study designs used in most of the published studies have accounted for both spatial and temporal aspects of past exposures, as well as complex exposure scenarios. Additionally, retrospective (longitudinal cohort and case-control) study designs are also able to establish temporality — that is that the exposure to OGD occurred prior to the health outcome. Registry-based studies, including those using birth certificate and cancer registry data, allow for inclusion of all adverse perinatal health outcomes, and therefore yield a low chance of selection bias.

Recent reviews of the literature that examine upstream OGD acknowledge the diversity of health outcomes, study design, geography of focus, and exposure assessment methodology among the peer reviewed literature introduce challenges to comparing adverse health outcomes across states, fields, and basins (Bamber et al., 2019; Deziel et al., 2020; Health Effects Institute-Energy Research Committee, 2019; Shonkoff et al., 2014). However, even when studies relying on hypothesis-generating designs (e.g., self-reported surveys, cross-sectional, ecological studies)

are removed, the directionality observed in the remaining body of analytical epidemiological studies indicating upstream oil and gas development is associated with adverse health outcomes is preserved.

3.4.2 Broad consideration of the epidemiological literature across time and space

The epidemiological literature to date has examined potential associations between upstream OGD and increased health risks and impacts across hydrocarbon types, technological approaches to extraction, and regions throughout the United States and Canada. The body of epidemiological literature examining exposure to upstream OGD and adverse health outcomes encompasses three decades, with the most recent year examined being 2019 in California (**Figure 3.3**). Because of this, assessment of epidemiological literature should include consideration of factors that may no longer be applicable in the immediate present, such as changes in emission control technologies, regulatory contexts, and shifting petroleum geological target zones and associated technological approaches to hydrocarbon development.

Though the majority of studies that examine health risks associated with upstream OGD have been conducted outside of California, these studies are relevant to the California context for multiple reasons. First, many health-damaging pollutants (e.g., benzene, toluene, ethylbenzene, xylene, and hexane) emitted from upstream OGD activities occur naturally in petroleum reservoirs, regardless of the region. While the magnitude of emissions of health-damaging petroleum-associated compounds across environmental media may vary across site-specific conditions, the presence of these health hazards is intrinsic to OGD and are therefore consistently present across different geographical and geological contexts.

Second, while petroleum reservoirs may differ by oil and gas region, certain regional petroleum reservoir characteristics and technological approaches to upstream OGD in other regions are similar to those of California. For example, similar to California, Colorado produces oil and gas from geological zones with migrated oil and gas with the use of relatively shallow hydraulic fracturing and the application of enhanced oil recovery (EOR), similar to California (Long et al., 2015). Furthermore, the regulatory environment may influence the types and levels risk of health-damaging exposure associated with upstream OGD. While the regulation of OGD has evolved over time and may differ by jurisdiction, there are examples of overlap between the California regulatory landscape and that of other oil and gas states. Like California, Colorado has methane and VOC-emission control rules which — if properly enforced — may significantly reduce emissions of methane, toxic air contaminants, and other potentially health damaging air pollutants from certain types of infrastructure during upstream oil and gas development (CARB, 2021; CDPHE AQCC, 2019a, 2019b). Similar to California's Public Health Rulemaking Process, the Colorado Oil and Gas Conservation Commission (COGCC) recently underwent a mission change rulemaking after the adoption of Senate Bill 19-181 (SB 19-181) (Colo. S.B. 19-181, 2019). SB 19-181 changed the mission of the COGCC "from 'fostering' to 'regulating' OGD in a manner that protects public health, safety, welfare, the environment and wildlife resources" (CO DNR, 2020). Four peer-reviewed epidemiological analytical studies evaluating upstream OGD have been conducted in Colorado and found associations between upstream OGD and congenital heart defects and neural tube defects, childhood cancer, and markers of cardiovascular disease

(McKenzie et al., 2014, 2017, 2019a, 2019b). These studies may be particularly relevant to California, given similar types of regional petroleum geology (e.g., migrated oil), methods of oil and gas development (e.g., enhanced oil recovery and hydraulic fracturing of migrated oil deposits), and similar regulatory environments.

Third, while the vast majority of studies published in recent years outside of California focus on unconventional OGD (e.g., high-volume hydraulic fracturing and development of hydrocarbons from source rock), we reiterate the relevance of considering epidemiological studies on both conventional and unconventional OGD, as many chemical stressors (e.g., toxic air contaminants, criteria pollutants) and physical stressors (e.g., noise) are intrinsic to both conventional and unconventional OGD (for more information see Chapter 2, Section 2.5.1).

Given the similarities in hydrocarbons under production, petroleum reservoir characteristics, technological approach to extraction, and regulatory context between California and other regions where epidemiological studies have been conducted, most notably for Colorado, the body of epidemiologic literature is relevant to consider in assessing health risks and health impacts of upstream OGD in the California context. Further, consistency in findings across studies given this heterogeneity provides additional confidence that such studies are relevant to consider when assessing the health risks and burdens attributable to upstream OGD on California and how best to minimize them. An important guiding principle here is the precedent in the United States and elsewhere of governing bodies making decisions to protect health based on scientific evidence of environmental hazards elsewhere, such as the promulgation of National Ambient Air Quality Standards for particulate matter, despite differences in chemical composition and physical characteristics of particulates across different geographic regions and the range of intrinsic and extrinsic vulnerabilities among study populations (US EPA National Center for Environmental Assessment, 2019).

3.4.3 Disproportionate exposures and health risks

Epidemiological studies in California and other oil and gas regions have observed stronger associations between exposure to upstream OGD and adverse health effects among vulnerable subpopulations. In California, Gonzalez et al. (2020) reported associations between exposure to upstream OGD and preterm birth at 28–31 weeks, that, in a stratified analysis by maternal race/ethnicity and educational attainment, were restricted to Hispanic mothers. The stratified analysis also revealed that exposure to new and active wells was associated with preterm birth at 20–27 weeks, 28–31 weeks, and 32–36 weeks among mothers with less than a high school education. Additionally, Johnston et al. (2021) noted that the majority of the study participants within 1,000 m (3,281 ft) of active oil and gas sites in South Los Angeles identify as Hispanic/Latinx and reported reduced lung function on average to be significant among adults, Hispanic/Latinx residents and participants over the age of 60 if living downwind and within 200 m (656 ft) of a well site. Of note, effect sizes in reductions in lung function by Johnston et al. (2021) are similar in magnitude to reductions in lung function associated with secondhand smoke exposure among women (Eisner, 2002) and reductions in lung function among adults living near busy roadways (Kan et al., 2007). In oil and gas regions outside of California, health inequities have also been observed among population subsets. For example, Casey et al. (2019) reported a stronger association between exposure to unconventional natural gas development and antenatal anxiety and depression during pregnancy among mothers receiving Medical Assistance (an indicator of low family income) in Pennsylvania. Additionally, in Texas, Cushing et al. (2020) found that exposure to nightly oil and gas-associated flare events was associated with increased odds of preterm birth and shorter gestation, and that in a stratified analysis, these findings were restricted to Hispanic women.

3.4.4 Strategies to reduce human health hazards, risks, and impacts from upstream OGD activities

The body of science reviewed by the Panel for this report strongly supports the need for additional protections (such as setbacks) for populations existing in close proximity to upstream OGD. Although additional research on the impacts of upstream OGD would be helpful, this should not be used as a reason to delay regulatory action to reduce exposure to OGD-related hazards.

Existing epidemiologic studies were not designed to test and establish a specific "safe" buffer distance between upstream OGD sites and sensitive receptors, such as homes and schools. Nevertheless, studies consistently demonstrate evidence of harm at distances less than 1 km (3,281 ft), and some studies also show evidence of harm linked to upstream OGD activity at distances greater than 1 km (3,281 ft). In addition, exposure pathway studies have demonstrated through measurements and modeling techniques, the potential for human exposure to numerous environmental stressors (e.g., air pollutants, water contaminants, noise) at distances less than 1 km (3,281 ft) (e.g., Allshouse et al., 2019; DiGiulio & Shonkoff, 2021; Holder et al., 2019; McKenzie et al., 2018; Soriano et al., 2020), and that the likelihood and magnitude of exposure decreases with increasing distance.

Figure 3.11 presents a hierarchy of strategies to reduce human health hazards, risks and impacts from upstream OGD activities. **Table 3.9** presents the advantages and disadvantages of each strategy from an environmental public health perspective.

At the top of **Figure 3.11** is the most health protective strategy: to stop drilling and developing new wells, phase out existing upstream OGD activities and associated infrastructure, and properly plug remediate legacy wells and ancillary infrastructure. This approach is being considered or adopted by various states and municipalities.

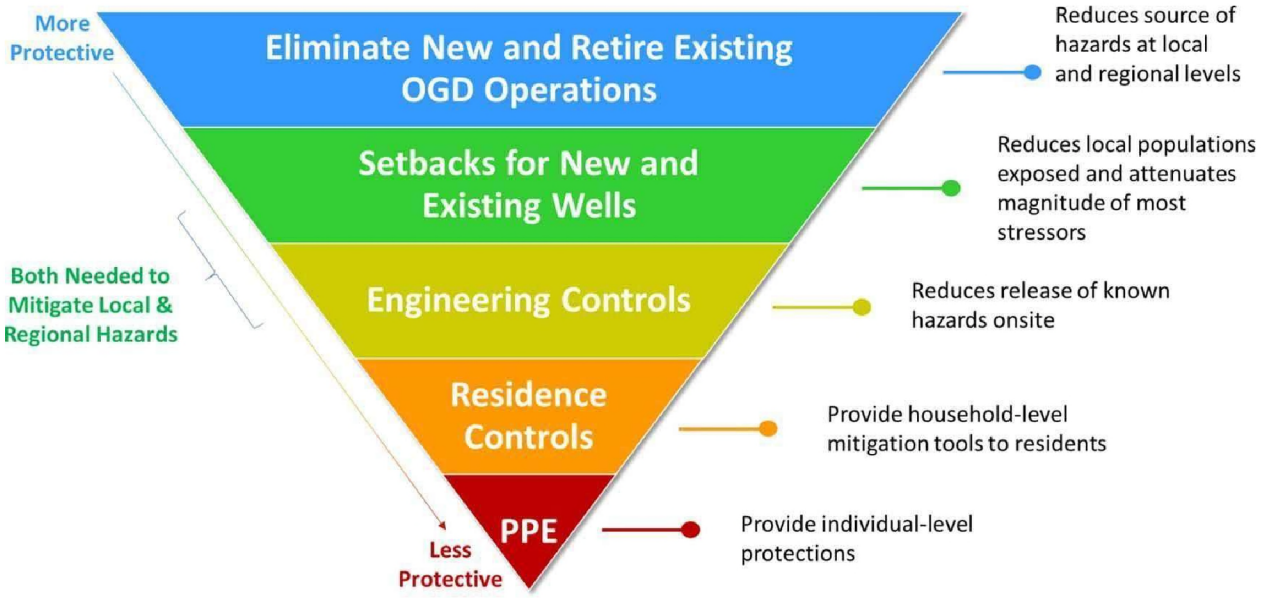


Figure 3.11. Hierarchy of controls to reduce public health harms from oil and gas development activities Source: Figure 1, Deziel et al. (2022b).

For example, unconventional OGD (i.e., hydraulic fracturing or 'fracking') has been eliminated in Vermont, Maryland, New York, and Washington, which vary in available reserves. The Delaware River Basin (DRB) Commission prohibited fracking in the DRB region, which covers parts of New York, Pennsylvania, New Jersey, and Delaware, in order to protect drinking water (DRBC, 2021). Because these bans are specific to fracking, they do not eliminate conventional wells or orphaned and abandoned wells. However, some municipalities are moving towards complete upstream OGD elimination, including Los Angeles, which has approved a ban of all new conventional and unconventional oil and gas wells and a phase-out of existing wells (LACBS, 2021).

If the development of oil and gas is to continue, the greatest health benefits would be gained from a strategy that includes the next two controls in the hierarchy depicted in **Figure 3.11**: the elimination of new and existing wells and ancillary infrastructure within scientifically informed setback distances, and the deployment of engineering emission controls and associated monitoring approaches that lead to rapid leak detection and repair for new and existing wells and ancillary infrastructure. Because air pollutant concentrations and noise levels decrease with increasing distance from a source, adequate setbacks can reduce harm to local populations by reducing exposures to air pollutants and noise directly emitted from the OGD activities. However, setbacks do not reduce harms from upstream OGD contributions to regional air pollutant levels,

such as secondary particulate matter and ozone, nor greenhouse gases such as methane, which are nearly always co-mingled with health-damaging air pollutants (Michanowicz et al., 2021). As compared to other pollutant-specific or pathway-specific policy measures (e.g., implementation of chemical additive restrictions or additional emission control requirements), the implementation of a minimum surface setback distance is a policy measure that considered the real-world scenarios of multiple stressors associated with upstream OGD but makes allowance for some continued oil and gas production. Setback distances between a source and a receptor are utilized in other federal, state, and local settings to mitigate harms associated with a given source. Engineering controls that reduce emissions at the well site are also necessary to reduce these harms.

Engineering controls include cradle-to-grave noise and air pollution emission mitigation controls on OGD infrastructure — including new, modified and existing infrastructure — and proper abandonment of legacy infrastructure, prioritizing those nearest to residential sites and schools and those associated with the highest emissions, leaks and other environmental hazards.

However, engineering controls can fail and engineering solutions may not be available for or economically feasible to handle all of the complex stressors generated by upstream OGD, including multiple sources and types of air pollution, noise pollution, light pollution, water pollution, and other stressors. Therefore, neither setbacks or engineering controls alone are sufficient to reduce the health hazards and risks from OGD activities — both approaches are needed in tandem.

Finally, we note that while outside of CalGEM's jurisdiction, setbacks for new construction of housing or schools at a certain distance from existing or permitted OGD sites (commonly referred to as reverse setbacks) should be considered.

Table 3.9. Advantages and disadvantages of oil and gas development (OGD) control strategies from an environmental public health perspective. Source: Table 1, Deziel et al. (2022b).

Control	Description	Advantage	Disadvantage
Elimination	Eliminate new wells, properly plug existing wells, and remediate ancillary infrastructure.	Eliminates the source of nearly all environmental stressors (e.g., air and water pollutants, noise); protects local and regional populations; largest reduction in carbon emissions.	May require a long-term approach due to economic, legal, political dynamics and energy reliability considerations, the need to address both conventional and unconventional wells, and the unknown location of many abandoned wells.
Setbacks	Establish a protective buffer zone between OGD hazards and sensitive receptors.	Reduces risk of exposures to populations living near OGD sites; environmental stressors are generally attenuated with increasing distance.	Setbacks alone without coupled engineered mitigation controls allow continued release of hazards. There is no universal setback that would adequately address regional air quality issues and emissions of climate-warming gases from OGD.
Engineering controls	Reduce or eliminate release of specific environmental hazards on site.	Reduces or eliminates certain hazards and therefore can have local and regional environmental public health benefits.	Tends to be disproportionately focused on air pollutant emissions and noise, and thus fails to address other pathways of exposure, including via water resources. Often not feasible to apply engineering solutions to multiple, complex hazards each requiring different control technologies (e.g., noise, air and water impacts, odors, light pollution) and lacks the important factor of safety provided by a setback when engineering controls fail.

Control	Description	Advantage	Disadvantage
Residence controls	Households deploy devices and strategies to reduce exposure to indoor environmental hazards at the household/school-level (e.g., water filter, light-blocking shades, air filters).	Reduces intensity of certain hazards to nearby communities at the household level.	Places burden on individuals and households to use and maintain devices properly to maximize effectiveness. Not feasible to apply devices to address numerous, complex stressors. Does not adequately address impacts of ambient air pollutant and greenhouse gas emissions from OGD on regional air quality and the climate.
Personal protective equipment	Individuals wear protective equipment to reduce exposure to environmental hazards (e.g., respiratory masks, ear plugs, eye masks).	Reduces intensity of exposure of certain hazards to nearby individuals.	Places burden on individuals to use PPE consistently and properly. May not be feasible for understudied stressors or certain environmental toxicants. Does not address impacts of air pollutant and greenhouse gas emissions from OGD on regional air quality and the climate.

3.5. Summary

Our review included 72 peer-reviewed epidemiological studies in the United States and Canada, six of which are from California, that evaluated the relationships between upstream oil and gas development and adverse health outcomes. Studies in California observed associations between upstream OGD and diagnosed asthma, reduced lung function, and reduced fetal growth at distances of up to 1 km (0.62 mi or 3,281 ft). Studies in California evaluating the relationship between upstream OGD development and risk of preterm birth reported inconsistent results. One California study did not observe an association between upstream oil and gas development and migraine headaches. The Panel concluded that the totality of the epidemiological evidence from 25 studies (three from California) provides a high level of certainty for a causal relationship between residential exposure to upstream OGD and poor perinatal outcomes. The Panel also concluded that the epidemiologic evidence (11 studies, two from California) provides a high level of certainty for a causal relationship between residential exposure to upstream OGD and adverse respiratory outcomes. These conclusions were reached because of the consistency of results across multiple studies that were conducted using different methodologies, in different locations, with diverse populations, and during different time periods. Numerous other health endpoints have been examined and are summarized herein. Most studies report statistically significant associations between oil and gas development and adverse health effects across different geological regions, in both urban and rural settings, and when examining different extraction methods (e.g., high-volume hydraulic fracturing and enhanced oil recovery approaches such as cyclic steam injection and water flooding). Epidemiological studies have observed consistent associations between upstream OGD and adverse health effects while considering different exposure assessment methods, including proximity of human receptors to oil and gas sites, nearby well density, well depth, production volume, and phase of well pad development (e.g., pad preparation, drilling, stimulation, production). In summary, the body of literature indicates upstream OGD is associated with adverse health impacts in nearby populations.

References

ACOG (The American College of Obstetricians and Gynecologists). (2015). *The Apgar Score*. https://www.acog.org/clinical/clinical-guidance/committee-opinion/articles/2015/10/the-apgar-score

Adgate, J. L., Goldstein, B. D., & McKenzie, L. M. (2014). Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development. *Environmental Science & Technology*, *48*(15), 8307–8320. https://doi.org/10.1021/es404621d

Alghannam M, Juanes R. (2020). Understanding rate effects in injection-induced earthquakes. *Nature Communications, 11*, 1–6. https://doi.org/10.1038/s41467-020-16860-y

Allshouse, W. B., McKenzie, L. M., Barton, K., Brindley, S., & Adgate, J. L. (2019). Community Noise and Air Pollution Exposure During the Development of a Multi-Well Oil and Gas Pad. *Environmental Science & Technology*, *53*(12), 7126–7135. https://doi.org/10.1021/acs.est.9b00052

Aker, A. M., Whitworth, K. W., Bosson-Rieutort, D., Wendling, G., Ibrahim, A., Verner, M.-A., Benoit, A. C., & Caron-Beaudoin, É. (2022). Proximity and density of unconventional natural gas wells and mental illness and substance use among pregnant individuals: An exploratory study in Canada. *International Journal of Hygiene and Environmental Health*, *242*, 113962. https://doi.org/10.1016/j.ijheh.2022.113962

Apergis, N., Hayat, T., & Saeed, T. (2019). Fracking and infant mortality: Fresh evidence from Oklahoma. *Environmental Science and Pollution Research*, *26*(31), 32360–32367. https://doi.org/10.1007/s11356-019-06478-z

Bamber, A. M., Hasanali, S. H., Nair, A. S., Watkins, S. M., Vigil, D. I., Van Dyke, M., McMullin, T. S., & Richardson, K. (2019). A Systematic Review of the Epidemiologic Literature Assessing Health Outcomes in Populations Living near Oil and Natural Gas Operations: Study Quality and Future Recommendations. *International Journal of Environmental Research and Public Health*, *16*(12), 2123. https://doi.org/10.3390/ijerph16122123

Bard, D., Kihal, W., Schillinger, C., Fermanian, C., Ségala, C., Glorion, S., Arveiler, D., & Weber, C. (2014). Traffic-Related Air Pollution and the Onset of Myocardial Infarction: Disclosing Benzene as a Trigger? A Small-Area Case-Crossover Study. *PLOS ONE*, *9*(6), e100307. https://doi.org/10.1371/journal.pone.0100307

Beleche, T., & Cintina, I. (2018). Fracking and risky behaviors: Evidence from Pennsylvania. *Economics & Human Biology*, *31*, 69–82. https://doi.org/10.1016/j.ehb.2018.08.001

Blanchard, O., Deguen, S., Kihal-Talantikite, W., François, R., & Zmirou-Navier, D. (2018). Does residential mobility during pregnancy induce exposure misclassification for air pollution? *Environmental Health*, *17*(1), 72. https://doi.org/10.1186/s12940-018-0416-8

Blinn, H. N., Utz, R. M., Greiner, L. H., & Brown, D. R. (2020). Exposure assessment of adults living near unconventional oil and natural gas development and reported health symptoms in southwest Pennsylvania, USA. *PLOS ONE*, *15*(8), e0237325. https://doi.org/10.1371/journal.pone.0237325

Boslett, A., & Hill, E. (2022). Mortality during resource booms and busts. *Journal of Environmental Economics and Management*, *115*, 102696. https://doi.org/10.1016/j.jeem.2022.102696

Bruckner, T. A., & Catalano, R. (2018). Selection in utero and population health: theory and typology of research. *SSM - Population Health, 5*, 101–113. https://doi.org/10.1016%2Fj.ssmph.2018.05.010

Buonocore, J. J., Casey, J. A., Croy, R., Spengler, J. D., & McKenzie, L. (2020). Air Monitoring Stations Far Removed from Drilling Activities do not Represent Residential Exposures to Marcellus Shale Air Pollutants. Response to the Paper by Hess et al. On Proximity-Based Unconventional Natural Gas Exposure Metrics. *International Journal of Environmental Research and Public Health*, *17*(2). https://doi.org/10.3390/ijerph17020504

Busby, C., & Mangano, J. J. (2017). There's a World Going on Underground—Infant Mortality and Fracking in Pennsylvania. *Journal of Environmental Protection*, *08*(04), 381. https://doi.org/10.4236/jep.2017.84028

Bushong, A., McKeon, T., Regina Boland, M., & Field, J. (2022). Publicly available data reveals association between asthma hospitalizations and unconventional natural gas development in Pennsylvania. *PLOS ONE*, *17*(3), e0265513. https://doi.org/10.1371/journal.pone.0265513

Cairncross, Z. F., Couloigner, I., Ryan, M. C., McMorris, C., Muehlenbachs, L., Nikolaou, N., Wong, R. C.-K., Hawkins, S. M., Bertazzon, S., Cabaj, J., & Metcalfe, A. (2022). Association Between Residential Proximity to Hydraulic Fracturing Sites and Adverse Birth Outcomes. *JAMA Pediatrics*. https://doi.org/10.1001/jamapediatrics.2022.0306

CalEPA OEHHA. (2021, March 19). The Proposition 65 List. OEHHA. https://oehha.ca.gov/proposition-65/proposition-65-list

CARB (California Air Resources Board). (2021). *Oil and Gas Methane Regulation*. https://ww2.arb.ca.gov/resources/fact-sheets/oil-and-gas-methane-regulation

Caron-Beaudoin, É., Whitworth, K. W., Bosson-Rieutort, D., Wendling, G., Liu, S., & Verner, M.-A. (2020). Density and proximity to hydraulic fracturing wells and birth outcomes in Northeastern British Columbia, Canada. *Journal of Exposure Science & Environmental Epidemiology*, 1–9. https://doi.org/10.1038/s41370-020-0245-z

Casey, J. A., Savitz, D. A., Rasmussen, S. G., Ogburn, E. L., Pollak, J., Mercer, D. G., & Schwartz, B. S. (2016). Unconventional natural gas development and birth outcomes in Pennsylvania, USA. *Epidemiology*, *27*(2), 163–172. https://doi.org/10.1097/EDE.0000000000000387

Casey, J. A., Goldman-Mellor, S., & Catalano, R. (2018a). Association between Oklahoma earthquakes and anxiety-related Google search episodes. *Environmental Epidemiology*, *2*(2), e016. https://doi.org/10.1097/EE9.0000000000000016

Casey, J. A., Wilcox, H. C., Hirsch, A. G., Pollak, J., & Schwartz, B. S. (2018b). Associations of unconventional natural gas development with depression symptoms and disordered sleep in Pennsylvania. *Scientific Reports*, *8*(1), 11375. https://doi.org/10.1038/s41598-018-29747-2

Casey, J. A., Goin, D. E., Rudolph, K. E., Schwartz, B. S., Mercer, D., Elser, H., Eisen, E. A., & Morello-Frosch, R. (2019). Unconventional natural gas development and adverse birth outcomes in Pennsylvania: The potential mediating role of antenatal anxiety and depression. *Environmental Research*, *177*, 108598. https://doi.org/10.1016/j.envres.2019.108598

CDPHE AQCC (Colorado Department of Public Health and Environment Air Quality Control Commission). (2019a). *5 CCR 1001-8—Standards of Performance for New Stationary Sources*. https://www.sos.state.co.us/CCR/GenerateRulePdf.do?ruleVersionId=8224&fileName=5%20CCR%201001-8

CDPHE AQCC. (2019b). *5 CCR 1001-26—Colorado Greenhouse Gas Reporting and Emission Reduction Requirements*. https://www.coloradosos.gov/CCR/GenerateRulePdf.do?ruleVersionId=8879&fileName=5%20CCR%201001-26

Clarivate. (2020, October 27). *Web of Science*. https://webofknowledge.com

Clark, C. J., Johnson, N. P., Soriano, M., Warren, J. L., Sorrentino, K. M., Kadan-Lottick, N. S., Saiers, J. E., Ma, X., & Deziel, N. C. (2022). Unconventional Oil and Gas Development Exposure and Risk of Childhood Acute Lymphoblastic Leukemia: A Case–Control Study in Pennsylvania, 2009–2017. *Environmental Health Perspectives*, *130*(8), 087001. https://doi.org/10.1289/EHP11092

CO DNR (Colorado Department of Natural Resources). (2020, November 23). *Colorado Oil & Gas Conservation Commission Unanimously Adopts SB 19-181 New Mission Change Rules, Alternative Location Analysis and Cumulative Impacts*. https://dnr.colorado.gov/press-release/colorado-oil-gas-conservation-commission-unanimously-adopts-sb-19-181-new-mission

Collier-Oxandale, A., Wong, N., Navarro, S., Johnston, J., & Hannigan, M. (2020). Using gas-phase air quality sensors to disentangle potential sources in a Los Angeles neighborhood. *Atmospheric Environment*, *233*, 117519. https://doi.org/10.1016/j.atmosenv.2020.117519

Cunningham, S., DeAngelo, G., & Smith, B. (2020). Fracking and risky sexual activity. *Journal of Health Economics*, *72*, 102322. https://doi.org/10.1016/j.jhealeco.2020.102322

Currie, J., Greenstone, M., & Meckel, K. (2017). Hydraulic fracturing and infant health: New evidence from Pennsylvania. *Science Advances*, *3*(12), e1603021. https://doi.org/10.1126/sciadv.1603021

Cushing, L. J., Vavra-Musser, K., Chau, K., Franklin, M., & Johnston, J. E. (2020). Flaring from Unconventional Oil and Gas Development and Birth Outcomes in the Eagle Ford Shale in South Texas. *Environmental Health Perspectives*, *128*(7), 077003. https://doi.org/10.1289/EHP6394

Dadvand, P., Parker, J., Bell, M. L., Bonzini, M., Brauer, M., Darrow, L. A., Gehring, U., Glinianaia, S. V., Gouveia, N., Ha, E., Leem, J. H., van, den H. E. H., Jalaludin, B., Jesdale, B. M., Lepeule, J., Morello, -Frosch Rachel, Morgan, G. G., Pesatori, A. C., Pierik, F. H., … Woodruff, T. J. (2013). Maternal Exposure to Particulate Air Pollution and Term Birth Weight: A Multi-Country Evaluation of Effect and Heterogeneity. *Environmental Health Perspectives*, *121*(3), 267–373. https://doi.org/10.1289/ehp.1205575

Delaware River Basin Commission. (2021). *2021 Resolution No. 2021-01*. https://www.nj.gov/drbc/library/documents/Res2021-01_HVHF.pdf

Denham, A., Willis, M., Zavez, A., & Hill, E. (2019). Unconventional natural gas development and hospitalizations: Evidence from Pennsylvania, United States, 2003–2014. *Public Health*, *168*, 17–25. https://doi.org/10.1016/j.puhe.2018.11.020

Denham, A., Willis, M. D., Croft, D., Liu, L., & Hill, E. L. (2021). Acute Myocardial Infarction Associated with Unconventional Natural Gas Development: A Natural Experiment. *Environmental Research*, 110872. https://doi.org/10.1016/j.envres.2021.110872

Deziel, N. C., Humeau, Z., Elliott, E. G., Warren, J. L., & Niccolai, L. M. (2018). Shale gas activity and increased rates of sexually transmitted infections in Ohio, 2000–2016. *PLOS ONE*, *13*(3), e0194203. https://doi.org/10.1371/journal.pone.0194203

Deziel, N. C., Brokovich, E., Grotto, I., Clark, C. J., Barnett-Itzhaki, Z., Broday, D., & Agay-Shay, K. (2020). Unconventional oil and gas development and health outcomes: A scoping review of the epidemiological research. *Environmental Research*, *182*, 109124. https://doi.org/10.1016/j.envres.2020.109124

Deziel, N. C., Clark, C. J., Casey, J. A., Bell, M. L., Plata, D. L., & Saiers, J. E. (2022a). Assessing Exposure to Unconventional Oil and Gas Development: Strengths, Challenges, and Implications for Epidemiologic Research. *Current Environmental Health Reports*. https://doi.org/10.1007/s40572-022-00358-4

Deziel, N. C., McKenzie, L. M., Casey, J. A., McKone, T. E., Johnston, J. E., Gonzalez, D. J. X., Shonkoff, S. B. C., & Morello-Frosch, R. (2022b). Applying the hierarchy of controls to oil and gas development. *Environmental Research Letters*, *17*(7), 071003. https://doi.org/10.1088/1748-9326/ac7967

DiGiulio, D. C., & Shonkoff, S. B. C. (2021). *Potential Impact to Groundwater Resources from Disposal of Produced Water into Unlined Produced Water Ponds in the San Joaquin Valley. In: Assessment of Oil and Gas Water Cycle Reporting in California. Evaluation of Data Collected Pursuant to California Senate Bill 1281, Phase II Report*. California Council on Science and Technology. https://ccst.us/wp-content/uploads/CCST-SB-1281-Phase-II-Full-Report-FINAL.pdf

Dwyer-Lindgren, L., Flaxman, A. D., Ng, M., Hansen, G. M., Murray, C. J. L., & Mokdad, A. H. (2015). Drinking Patterns in US Counties From 2002 to 2012. *American Journal of Public Health*, *105*(6), 1120–1127. https://doi.org/10.2105/AJPH.2014.302313

Eisner, M. D. (2002). Environmental tobacco smoke exposure and pulmonary function among adults in NHANES III: Impact on the general population and adults with current asthma. *Environmental Health Perspectives*, *110*(8), 765–770. https://doi.org/10.1289/ehp.02110765

Elliott, E. G., Ma, X., Leaderer, B. P., McKay, L. A., Pedersen, C. J., Wang, C., Gerber, C. J., Wright, T. J., Sumner, A. J., Brennan, M., Silva, G., Warren, J. L., Plata, D. L., & Deziel, N. C. (2018). A community-based evaluation of proximity to unconventional oil and gas wells, drinking water contaminants, and health symptoms in Ohio. *Environmental Research*. https://doi.org/10.1016/j.envres.2018.08.022

Elser, H., Morello-Frosch, R., Jacobson, A., Pressman, A., Kioumourtzoglou, M.-A., Reimer, R., & Casey, J. A. (2021). Air pollution, methane super-emitters, and oil and gas wells in Northern California: The relationship with migraine headache prevalence and exacerbation. *Environmental Health*, *20*(1), 45. https://doi.org/10.1186/s12940-021-00727-w

Elser, H., Kempinsky, A., Goldman-Mellor, S., Li, M., Catalano, R., Rehkopf, D. H., & Casey, J. A. (2023). Manmade earthquakes and healthcare visits for anxiety disorders in Oklahoma, 2010-2019. *Environmental Epidemiology*, *7*(1), e232. https://doi.org/10.1097/EE9.0000000000000232

Erickson, C. L., Barron, I. G., & Zapata, I. (2022). The Effects of Hydraulic Fracturing Activities on Birth Outcomes are Evident in a Non-Individualized County-Wide Aggregate Data Sample from Colorado. *Journal of Public Health Research*, *11*(1). https://doi.org/10.4081/jphr.2021.2551

Ferrar, K. J., Kriesky, J., Christen, C. L., Marshall, L. P., Malone, S. L., Sharma, R. K., Michanowicz, D. R., & Goldstein, B. D. (2013). Assessment and longitudinal analysis of health impacts and stressors perceived to result from unconventional shale gas development in the Marcellus Shale region. *International Journal of Occupational and Environmental Health*, *19*(2), 104–112. https://doi.org/10.1179/2049396713Y.0000000024

Finkel, M. L. (2016). Shale gas development and cancer incidence in southwest Pennsylvania. *Public Health*, *141*, 198–206. https://doi.org/10.1016/j.puhe.2016.09.008

Fryzek, J., Pastula, S., Jiang, X., & Garabrant, D. H. (2013). Childhood cancer incidence in pennsylvania counties in relation to living in counties with hydraulic fracturing sites. *Journal of Occupational and Environmental Medicine / American College of Occupational and Environmental Medicine*, *55*(7), 796–801. https://doi.org/10.1097/JOM.0b013e318289ee02

Garcia-Gonzales, D. A., Shamasunder, B., & Jerrett, M. (2019). Distance decay gradients in hazardous air pollution concentrations around oil and natural gas facilities in the city of Los Angeles: A pilot study. *Environmental Research*, *173*, 232–236. https://doi.org/10.1016/j.envres.2019.03.027

Gaughan, C., Sorrentino, K. M., Liew, Z., Johnson, N. P., Clark, C. J., Soriano, M., Plano, J., Plata, D. L., Saiers, J. E., & Deziel, N. C. (2023). Residential proximity to unconventional oil and gas development and birth defects in Ohio. *Environmental Research*, *229*, 115937. https://doi.org/10.1016/j.envres.2023.115937

General Assembly of the State of Colorado. (2019). *Senate Bill 19-181*. https://cogcc.state.co.us/documents/sb19181/Overview/SB_19_181_Final.pdf

Goin, D.E., Casey, J.A., Kioumourtzoglou, M.A., Cushing, L.J., & Morello-Frosch, R. (2021). Environmental hazards, social inequality, and fetal loss: implications of live-birth bias for estimation of disparities in birth outcomes. *Environmental Epidemiology*, *5*(2), e131. https://doi.org/10.1097%2FEE9.0000000000000131

Gonzalez, D. J. X., Sherris, A. R., Yang, W., Stevenson, D. K., Padula, A. M., Baiocchi, M., Burke, M., Cullen, M. R., & Shaw, G. M. (2020). Oil and gas production and spontaneous preterm birth in the San Joaquin Valley, CA: A case–control study. *Environmental Epidemiology*, *4*(4), e099. https://doi.org/10.1097/EE9.0000000000000099

Gonzalez, D. J. X., Francis, C. K., Shaw, G. M., Cullen, M. R., Baiocchi, M., & Burke, M. (2022). Upstream oil and gas production and ambient air pollution in California. *Science of The Total Environment*, *806*, 150298. https://doi.org/10.1016/j.scitotenv.2021.150298

Han, J., Zhang, B., Zhang, X., Huang, K., Fang, V., & Xu, X. (2023). Associations between occurrence of birth defects and hydraulic fracturing activities in Barnett shale region, Texas. *Heliyon*, *9*(4), e15213. https://doi.org/10.1016/j.heliyon.2023.e15213

Harrison, R. J. (2016). Sudden Deaths Among Oil and Gas Extraction Workers Resulting from Oxygen Deficiency and Inhalation of Hydrocarbon Gases and Vapors—United States, January 2010–March 2015. *MMWR. Morbidity and Mortality Weekly Report*, *65*. https://doi.org/10.15585/mmwr.mm6501a2

Health Effects Institute-Energy Research Committee. (2019). *Potential Human Health Effects Associated With Unconventional Oil and Gas Development: A Systematic Review of the Epidemiology Literature*. https://hei-energy.org/system/files/hei-energy-epi-lit-review.pdf

Hill, E. L. (2018). Shale gas development and infant health: Evidence from Pennsylvania. *Journal of Health Economics*, *61*, 134–150. https://doi.org/10.1016/j.jhealeco.2018.07.004

Hoang, T. T., Rosales, O., Burgess, E., Lupo, P. J., Scheurer, M. E., & Oluyomi, A. O. (2023). Clustering of Pediatric Brain Tumors in Texas, 2000–2017. *Toxics*, *11*(4), Article 4. https://doi.org/10.3390/toxics11040351

Holder, C., Hader, J., Avanasi, R., Hong, T., Carr, E., Mendez, B., Wignall, J., Glen, G., Guelden, B., Wei, Y., & CDPHE (Colorado Department of Public Health and Environment). (2019). Evaluating potential human health risks from modeled inhalation exposures to volatile organic compounds emitted from oil and gas operations. *Journal of the Air & Waste Management Association*, *69*(12), 1503–1524. https://doi.org/10.1080/10962247.2019.1680459

Hu, C., Liu, B., Wang, S., Zhu, Z., Adcock, A., Simpkins, J., & Li, X. (2022). Spatiotemporal Correlation Analysis of Hydraulic Fracturing and Stroke in the United States. *International Journal of Environmental Research and Public Health*, *19*(17), Article 17. https://doi.org/10.3390/ijerph191710817

Huseth-Zosel, A. L., Secor-Turner, M., Wen, Q., Liu, X., & Jansen, R. J. (2021). Associations between oil development and sexually transmitted infections: Public health nurse perspectives. *Public Health Nursing*, *38*(1), 4–12. https://doi.org/10.1111/phn.12836

Janitz, A. E., Dao, H. D., Campbell, J. E., Stoner, J. A., & Peck, J. D. (2019). The association between natural gas well activity and specific congenital anomalies in Oklahoma, 1997-2009. *Environment International*, *122*, 381–388. https://doi.org/10.1016/j.envint.2018.12.011

Jemielita, T., Gerton, G. L., Neidell, M., Chillrud, S., Yan, B., Stute, M., Howarth, M., Saberi, P., Fausti, N., Penning, T. M., Roy, J., Propert, K. J., & Panettieri, R. A. (2015). Unconventional Gas and Oil Drilling Is Associated with Increased Hospital Utilization Rates. *PLOS ONE*, *10*(7), e0131093. https://doi.org/10.1371/journal.pone.0131093

Johnson, N. P., Warren, J. L., Elliott, E. G., Niccolai, L. M., & Deziel, N. C. (2020). A Multi-Region Analysis of Shale Drilling Activity and Rates of Sexually Transmitted Infections in the United States. *Sexually Transmitted Diseases*, *(47)*4, 254–260. https://doi.org/10.1097/OLQ.0000000000001127

Johnston, J. E., Enebish, T., Eckel, S. P., Navarro, S., & Shamasunder, B. (2021). Respiratory Health, Pulmonary Function and Local Engagement in Urban Communities Near Oil Development. *Environmental Research*, 111088. https://doi.org/10.1016/j.envres.2021.111088

Kan, H., Heiss, G., Rose, K. M., Whitsel, E., Lurmann, F., & London, S. J. (2007). Traffic exposure and lung function in adults: The Atherosclerosis Risk in Communities study. *Thorax*, *62*(10), 873–879. https://doi.org/10.1136/thx.2006.073015

Kassotis, C. D., Vu, D. C., Vo, P. H., Lin, C.-H., Cornelius-Green, J. N., Patton, S., & Nagel, S. C. (2018). Endocrine-Disrupting Activities and Organic Contaminants Associated with Oil and Gas Operations in Wyoming Groundwater. *Archives of Environmental Contamination and Toxicology*, 1–12. https://doi.org/10.1007/s00244-018-0521-2

Keranen KM, Weingarten M, Abers GA, Bekins BA, Ge S. Sharp increase in central Oklahoma seismicity since 2008 induced by massive wastewater injection. *Science. 2014;345:448–451.* Koehler, K., Ellis, J. H., Casey, J. A., Manthos, D., Bandeen-Roche, K., Platt, R., & Schwartz, B. S. (2018a). Exposure Assessment Using Secondary Data Sources in Unconventional Natural Gas Development and Health Studies. *Environmental Science & Technology*, *52*(10), 6061–6069. https://doi.org/10.1021/acs.est.8b00507

Koehler, K., Ellis, J. H., Casey, J. A., Manthos, D., Bandeen-Roche, K., Platt, R., & Schwartz, B. S. (2018b). Exposure Assessment Using Secondary Data Sources in Unconventional Natural Gas Development and Health Studies. *Environmental Science & Technology*, *52*(10), 6061–6069. https://doi.org/10.1021/acs.est.8b00507

Komarek, T., & Cseh, A. (2017). Fracking and public health: Evidence from gonorrhea incidence in the Marcellus Shale region. *Journal of Public Health Policy*, 1–18. https://doi.org/10.1057/s41271-017-0089-5

LACBS (Los Angeles County Board of Supervisors. (2021). *Statement Of Proceedings for the Regular Meeting of the Board of Supervisors of the County of Los Angeles.* https://file.lacounty.gov/SDSInter/bos/sop/1112973_091521.pdf

Li, L., Dominici, F., Blomberg, A. J., Bargagli-Stoffi, F. J., Schwartz, J. D., Coull, B. A., Spengler, J. D., Wei, Y., Lawrence, J., & Koutrakis, P. (2022). Exposure to unconventional oil and gas development and all-cause mortality in Medicare beneficiaries. *Nature Energy*, *7*(2), 177–185. https://doi.org/10.1038/s41560-021-00970-y

Li, J., Jahan, J., & Newcomb, P. (2023). Environmental characteristics and disparities in adult asthma in north central Texas urban counties. *Public Health*, *217*, 164–172. https://doi.org/10.1016/j.puhe.2023.01.037

Long, J. C. S., Birkholzer, J. T., & Feinstein, L. C. (2015). *An Independent Scientific Assessment of Well Stimulation in California: Summary Report—An Examination of Hydraulic Fracturing and Acid Stimulations in the Oil and Gas Industry.* https://ccst.us/wp-content/uploads/2015SB4summary.pdf

Ma, Z.-Q. (2016). Time Series Evaluation of Birth Defects in Areas with and without Unconventional Natural Gas Development. *Journal of Epidemiology and Public Health Reviews*, *1*. https://doi.org/10.16966/2471-8211.107

Makati, D., Akers, J., Aljuhani, M., Pellegrino, B., Schmidt, R., Shawwa, K., & Kannabhiran, D. (2022). Prevalence of ANCA-associated vasculitis amid natural gas drilling sites in West Virginia. *Journal of Nephrology*, *35*(4), 1185–1192. https://doi.org/10.1007/s40620-021-01243-3

Mayer, A., Malin, S., McKenzie, L., Peel, J., & Adgate, J. (2019). Understanding Self-Rated Health and Unconventional Oil and Gas Development in Three Colorado Communities. *Society & Natural Resources*, 1–22. https://doi.org/10.1080/08941920.2020.1734702

Mayer, A., & Olson Hazboun, S. (2019). Does fracking drive you to drink? Unconventional oil and gas production and alcohol consumption in U.S. counties. *The Extractive Industries and Society*. https://doi.org/10.1016/j.exis.2019.04.002

McAlexander, T. P., Bandeen-Roche, K., Buckley, J. P., Pollak, J., Michos, E. D., McEvoy, J. W., & Schwartz, B. S. (2020). Unconventional Natural Gas Development and Hospitalization for Heart Failure in Pennsylvania. *Journal of the American College of Cardiology*, *76*(24), 2862–2874. https://doi.org/10.1016/j.jacc.2020.10.023

McKenzie, L. M., Guo, R., Witter, R. Z., Savitz, D. A., Newman, L. S., & Adgate, J. L. (2014). Birth outcomes and maternal residential proximity to natural gas development in rural Colorado. *Environmental Health Perspectives*, *122*(4), 412–417. https://doi.org/10.1289/ehp.1306722

McKenzie, L. M., Allshouse, W. B., Byers, T. E., Bedrick, E. J., Serdar, B., & Adgate, J. L. (2017). Childhood hematologic cancer and residential proximity to oil and gas development. *PLOS ONE*, *12*(2), e0170423. https://doi.org/10.1371/journal.pone.0170423

McKenzie, L. M., Blair, B., Hughes, J., Allshouse, W. B., Blake, N. J., Helmig, D., Milmoe, P., Halliday, H., Blake, D. R., & Adgate, J. L. (2018). Ambient Nonmethane Hydrocarbon Levels Along Colorado's Northern Front Range: Acute and Chronic Health Risks. *Environmental Science & Technology*, *52*(8), 4514–4525. https://doi.org/10.1021/acs.est.7b05983

McKenzie, L. M., Allshouse, W., & Daniels, S. (2019a). Congenital heart defects and intensity of oil and gas well site activities in early pregnancy. *Environment International*, *132*, 104949. https://doi.org/10.1016/j.envint.2019.104949

McKenzie, L. M., Crooks, J., Peel, J. L., Blair, B. D., Brindley, S., Allshouse, W. B., Malin, S., & Adgate, J. L. (2019b). Relationships between indicators of cardiovascular disease and intensity of oil and natural gas activity in Northeastern Colorado. *Environmental Research*, *170*, 56–64. https://doi.org/10.1016/j.envres.2018.12.004

Michanowicz, D. R., Lebel, E. D., Domen, J. K., Hill, L. L., Jaeger, J. M., Schiff, J. E., Krieger, E. M., Banan, Z., Nordgaard, C. L., & Shonkoff, S. B. C. (2021). *Methane and Health-damaging Air Pollutants From the Oil and Gas Sector: Bridging 10 Years of Scientific Understanding*. PSE Healthy Energy. https://www.psehealthyenergy.org/work/methane-and-health-damaging-air-pollutants-from-oil-and-gas/

Okorn, K., Jimenez, A., Collier-Oxandale, A., Johnston, J., & Hannigan, M. (2021). Characterizing methane and total non-methane hydrocarbon levels in Los Angeles communities with oil and gas facilities using air quality monitors. *Science of The Total Environment*, *777*,146194. https://doi.org/10.1016/j.scitotenv.2021.146194

Peng, L., Meyerhoefer, C., & Chou, S.-Y. (2018). The health implications of unconventional natural gas development in Pennsylvania. *Health Economics*, *27*(6), 956–983. https://doi.org/10.1002/hec.3649

PSE Healthy Energy. (2020, October 27). *Repository for Oil and Gas Energy Research (ROGER)*. https://www.psehealthyenergy.org/our-work/shale-gas-research-library/

Rabinowitz, P. M., Slizovskiy, I. B., Lamers, V., Trufan, S. J., Holford, T. R., Dziura, J. D., Peduzzi, P. N., Kane, M. J., Reif, J. S., Weiss, T. R., & Stowe, M. H. (2015). Proximity to Natural Gas Wells and Reported Health Status: Results of a Household Survey in Washington County, Pennsylvania. *Environmental Health Perspectives*, *123*(1), 21–26. https://doi.org/10.1289/ehp.1307732

Rasmussen, S. G., Ogburn, E. L., McCormack, M., Casey, J. A., Bandeen-Roche, K., Mercer, D. G., & Schwartz, B. S. (2016). Association Between Unconventional Natural Gas Development in the Marcellus Shale and Asthma Exacerbations. *JAMA Internal Medicine*, *176*(9), 1334. https://doi.org/10.1001/jamainternmed.2016.2436

Saberi, P., Propert, K. J., Powers, M., Emmett, E., & Green-McKenzie, J. (2014). Field Survey of Health Perception and Complaints of Pennsylvania Residents in the Marcellus Shale

Region. *International Journal of Environmental Research and Public Health*, *11*(6), 6517–6527. https://doi.org/10.3390/ijerph110606517

Sarkis-Onofre, R., Catalá-López, F., Aromataris, E., & Lockwood, C. (2021). How to properly use the PRISMA Statement. *Systematic Reviews*, *10*(1), 117. https://doi.org/10.1186/s13643-021-01671-z

Seixas, N. S., & Checkoway, H. (1995). Methodology Series: Exposure Assessment in Industry Specific Retrospective Occupational Epidemiology Studies. *Occupational and Environmental Medicine*, *52*(10), 625–633. https://www.jstor.org/stable/27730414

Shamasunder, B., Collier-Oxandale, A., Blickley, J., Sadd, J., Chan, M., Navarro, S., Hannigan, M., & Wong, N. (2018). Community-Based Health and Exposure Study around Urban Oil Developments in South Los Angeles. *International Journal of Environmental Research and Public Health*, *15*(1), 138. https://doi.org/10.3390/ijerph15010138

Shonkoff, S. B. C., Hays, J., & Finkel, M. L. (2014). Environmental Public Health Dimensions of Shale and Tight Gas Development. *Environmental Health Perspectives*, *122*(8), 787–795. https://doi.org/10.1289/ehp.1307866

Shonkoff, S. B. C., & Hill, L. A. L. (2019). *Human health and oil and gas development: A review of the peer-reviewed literature and assessment of applicability to the City of Los Angeles*. https://www.psehealthyenergy.org/wp-content/uploads/2022/08/Literature-Review.pdf

Soriano, M. A., Siegel, H. G., Gutchess, K. M., Clark, C. J., Li, Y., Xiong, B., Plata, D. L., Deziel, N. C., & Saiers, J. E. (2020). Evaluating Domestic Well Vulnerability to Contamination From Unconventional Oil and Gas Development Sites. *Water Resources Research*, *n/a*(n/a), e2020WR028005. https://doi.org/10.1029/2020WR028005

Stacy, S. L., Brink, L. L., Larkin, J. C., Sadovsky, Y., Goldstein, B. D., Pitt, B. R., & Talbott, E. O. (2015). Perinatal Outcomes and Unconventional Natural Gas Operations in Southwest Pennsylvania. *PLOS ONE*, *10*(6), e0126425. https://doi.org/10.1371/journal.pone.0126425

Steinzor, N., Subra, W., & Sumi, L. (2013). Investigating links between shale gas development and health impacts through a community survey project in Pennsylvania. *New Solutions: A Journal of Environmental and Occupational Health Policy: NS*, *23*(1), 55–83. https://doi.org/10.2190/NS.23.1.e

Tang, I. W., Langlois, P. H., & Vieira, V. M. (2021). Birth defects and unconventional natural gas developments in Texas, 1999–2011. *Environmental Research*, *194*, 110511. https://doi.org/10.1016/j.envres.2020.110511

Tran, K. V., Casey, J. A., Cushing, L. J., & Morello-Frosch, R. (2020). Residential Proximity to Oil and Gas Development and Birth Outcomes in California: A Retrospective Cohort Study of 2006–2015 Births. *Environmental Health Perspectives*, *128*(6), 067001. https://doi.org/10.1289/EHP5842

Tran, K. V., Casey, J.A., Cushing, L.J., Morello-Frosch, R. (2021). Residential proximity to hydraulically fractured oil and gas wells and adverse birth outcomes in urban and rural communities in California (2006-2015). *Environmental Epidemiology*. *5*(6), e172. https://doi.org/10.1097%2FEE9.0000000000000172

Trickey, K. S., Chen, Z., & Sanghavi, P. (2023). Hospitalisations for cardiovascular and respiratory disease among older adults living near unconventional natural gas

development: A difference-in-differences analysis. *The Lancet Planetary Health*, *7*(3), e187–e196. https://doi.org/10.1016/S2542-5196(23)00009-8

Tustin, A. W., Hirsch, A. G., Rasmussen, S. G., Casey, J. A., Bandeen-Roche, K., & Schwartz, B. S. (2016). Associations between Unconventional Natural Gas Development and Nasal and Sinus, Migraine Headache, and Fatigue Symptoms in Pennsylvania. *Environmental Health Perspectives,* (*125*)2, 189–197. https://doi.org/10.1289/EHP281

US DHHS (U.S. Department of Health and Human Services). (2012). *Principles of Epidemiology in Public Health Practice, Third Edition: An Introduction*. https://stacks.cdc.gov/view/cdc/6914

US EPA (U.S. Environmental Protection Agency) National Center for Environmental Assessment, R. T. P. N. (2019). *Integrated Science Assessment (ISA) for Particulate Matter (Final Report, Dec 2019)*. https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=347534

US EPA. (2020). Integrated Science Assessment (ISA) for Ozone and Related Photochemical Oxidants (Final Report, Apr 2020) [Reports & Assessments].

https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=348522Villeneuve, P. J., Jerrett, M., Su, J., Burnett, R. T., Chen, H., Brook, J., Wheeler, A. J., Cakmak, S., & Goldberg, M. S. (2013). A cohort study of intra-urban variations in volatile organic compounds and mortality, Toronto, Canada. *Environmental Pollution*, *183*, 30–39. https://doi.org/10.1016/j.envpol.2012.12.022

Walker Whitworth, K., Kaye Marshall, A., & Symanski, E. (2018). Drilling and Production Activity Related to Unconventional Gas Development and Severity of Preterm Birth. *Environmental Health Perspectives*, *126*(3), 037006. https://doi.org/10.1289/EHP2622

Weinberger, B., Greiner, L. H., Walleigh, L., & Brown, D. (2017). Health symptoms in residents living near shale gas activity: A retrospective record review from the Environmental Health Project. *Preventive Medicine Reports*, *8*, 112–115. https://doi.org/10.1016/j.pmedr.2017.09.002

Weingarten, M., Ge, S., Godt, J. W., Bekins, B. A., & Rubinstein, J. L. (2015). High-rate injection is associated with the increase in U.S. mid-continent seismicity. *Science*, *348*(6241), 1336–1340. https://doi.org/10.1126/science.aab1345

Weisner, M. L., Allshouse, W. B., Erjavac, B. W., Valdez, A. P., Vahling, J. L., & McKenzie, L. M. (2023). Health Symptoms and Proximity to Active Multi-Well Unconventional Oil and Gas Development Sites in the City and County of Broomfield, Colorado. *International Journal of Environmental Research and Public Health*, *20*(3), 2634. https://doi.org/10.3390/ijerph20032634

Whitworth, K. W., Marshall, A. K., & Symanski, E. (2017). Maternal residential proximity to unconventional gas development and perinatal outcomes among a diverse urban population in Texas. *PLOS ONE*, *12*(7), e0180966. https://doi.org/10.1371/journal.pone.0180966

Willis, M. D., Jusko, T. A., Halterman, J. S., & Hill, E. L. (2018). Unconventional natural gas development and pediatric asthma hospitalizations in Pennsylvania. *Environmental Research*, *166*, 402–408. https://doi.org/10.1016/j.envres.2018.06.022

Willis, M., Hystad, P., Denham, A., & Hill, E. (2020). Natural gas development, flaring practices and paediatric asthma hospitalizations in Texas. *International Journal of Epidemiology*. https://doi.org/10.1093/ije/dyaa115

Willis, M. D., Hill, E. L., Boslett, A., Kile, M. L., Carozza, S. E., & Hystad, P. (2021). Associations between Residential Proximity to Oil and Gas Drilling and Term Birth Weight and Small-for-Gestational-Age Infants in Texas: A Difference-in-Differences Analysis. *Environmental Health Perspectives*, *129*(7), 77002. https://doi.org/10.1289/EHP7678

Willis, M. D., Hill, E. L., Kile, M. L., Carozza, S., & Hystad, P. (2022). Associations between residential proximity to oil and gas extraction and hypertensive conditions during pregnancy: A difference-in-differences analysis in Texas, 1996–2009. *International Journal of Epidemiology*, *51*(2), 525–536. https://doi.org/10.1093/ije/dyab246

Willis, M. D., Carozza, S. E., & Hystad, P. (2023). Congenital anomalies associated with oil and gas development and resource extraction: A population-based retrospective cohort study in Texas. *Journal of Exposure Science & Environmental Epidemiology*, *33*(1), 84–93. https://doi.org/10.1038/s41370-022-00505-x

Xu, X., Freeman, N. C., Dailey, A. B., Ilacqua, V. A., Kearney, G. D., & Talbott, E. O. (2009). Association between Exposure to Alkylbenzenes and Cardiovascular Disease among National Health and Nutrition Examination Survey (NHANES) Participants. *International Journal of Occupational and Environmental Health*, *15*(4), 385–391. https://doi.org/10.1179/oeh.2009.15.4.385

Ye, D., Klein, M., Chang, H. H., Sarnat, J. A., Mulholland, J. A., Edgerton, E. S., Winquist, A., Tolbert, P. E., & Sarnat, S. E. (2017). Estimating Acute Cardiorespiratory Effects of Ambient Volatile Organic Compounds: *Epidemiology*, *28*(2), 197–206. https://doi.org/10.1097/EDE.0000000000000607

Appendix C.

C.1. List of Key Terms for Literature Search

List S1. Key Terms Used in Epidemiological Assessment Web of Science Boolean search conducted July 15, 2023.

TS=("oil and gas" OR shale OR petroleum OR "natural gas" OR "shale gas" OR "tight gas" OR "tight resource" OR "shale oil" OR "tight oil" OR "unconventional gas" OR "unconventional oil" OR "unconventional resource" OR "conventional gas" OR "conventional oil" OR "conventional resource" OR "natural gas liquids" OR drilling OR "well stimulation" OR "hydraulic fracturing" OR fracking OR flar* OR "coalbed methane" OR "well head" OR wellbore OR "casing head" OR "well pad" OR "abandoned well" OR pipeline* OR "oil well" OR "gas well") AND TS=("Health" OR "epidemiological" OR "symptom*" OR "health risk*" OR "occupational health" OR "physiological" OR "psychological" OR "hospitalization" OR "asthma" OR "injury" OR "mortality" OR "cancer" OR "morbidity" OR "adverse pregnancy outcomes" OR "birth" OR "congenital" OR "birth defects" OR "birth weight" OR "low birth weight" OR "preterm birth" OR "premature birth" OR "preterm delivery" OR "small for gestational age" OR "LBW" OR "PTB" OR "PTD" OR "SGA" OR "fetal death" OR "mental health" OR "cardiovascular" OR "exposure") NOT TS=(Europe OR Australia OR China OR India OR "Middle East" OR Africa) AND TS=("U.S." OR "United States" OR USA OR Canada OR "North* America" OR Alabama OR Alaska OR Arizona OR Arkansas OR California OR Colorado OR Connecticut OR Delaware OR Florida OR Georgia OR Idaho OR Hawaii OR Illinois OR Indiana OR Iowa OR Kansas OR Kentucky OR Louisiana OR Maine OR Maryland OR Massachusetts OR Michigan OR Minnesota OR Mississippi OR Missouri OR Montana OR Nebraska OR Nevada OR "New Hampshire" OR "New Jersey" OR "New Mexico" OR "New York" OR "North Carolina" OR "North Dakota" OR Ohio OR Oklahoma OR Oregon OR Pennsylvania OR "Rhode Island" OR "South Carolina" OR "South Dakota" OR Tennessee OR Texas OR Utah OR Vermont OR Virginia OR Washington OR "West Virginia" OR Wisconsin OR Wyoming OR "Washington DC" OR "Washington D.C." OR "D.C." OR "District of Columbia" OR "Canada" OR "British Columbia" OR Anadarko OR Ardmore OR Arkoma OR Appalachian OR Devonian OR Bakken OR Barnett OR Chattanooga OR Cherokee OR Delaware OR "Denver-Julesburg" OR "Eagle Ford" OR Fayetteville OR "Fort Worth" OR "Greater Green River Basin" OR "Front Range" OR Haynesville OR Inglewood OR Marcellus OR Monterey OR Niobrara OR Permian OR "Powder River" OR Piceance OR Rogersville OR Saskatchewan OR San Juan OR Uinta OR Utica OR Wattenberg OR Williston OR "Wind River Basin" OR Woodford OR Wolfcamp OR "Four Corners" OR "Canadian Oil Sands")

C.2. Summary of studies evaluating sexually transmitted infections

Six studies focused on the effects of oil and gas development on rates of sexually transmitted infections (STIs) (Beleche & Cintina, 2018; Cunningham et al., 2020; Deziel et al., 2018; Huseth-Zosel et al., 2021; Johnson et al., 2020; Komarek & Cseh, 2017). This is an area of concern, as the influx of non-local, specialized workers can result in changes to the local labor market when an area is flagged for new oil and gas development (Johnson et al., 2020). Studies conducted in Pennsylvania, Texas, North Dakota, and Ohio found counties with fracking activities to have

higher rates of gonorrhea and chlamydia infections compared to counties without oil and gas development (Beleche & Cintina, 2018; Deziel et al., 2018; Huseth-Zosel et al., 2021; Johnson et al., 2020). Similarly, in the Marcellus Shale region of Pennsylvania and in the general United States, oil and gas development was found to be associated with higher rates of gonorrhea compared to the comparison group (Cunningham et al., 2020; Komarek & Cseh, 2017).

The minority of studies found no association with rates of STIs. Two studies found no association between oil and gas development and rates of syphilis (Deziel et al., 2018; Johnson et al., 2020). Similarly, no association was found between oil and gas development and rates of STIs in Colorado and North Dakota counties (Johnson et al., 2020). Similarly, no association was found between oil and gas development and rates of STIs in Colorado and North Dakota counties (Johnson et al., 2020).

CHAPTER FOUR

Oil and Gas-Associated Air Pollution, Health Risks and Approaches to Emission Control

Table of Contents

4.0. Abstract **1**

4.1. Introduction **2**

4.2. Review of existing emissions data, air quality impacts, and related health risks **3**

4.2.1. Characterization of air pollutants from upstream oil and gas in California **3**

4.2.1.1 Composition of upstream oil and gas in California **5**

4.2.1.2 Emissions from upstream OGD in California **7**

4.2.1.3 Air quality and permitting in California's oil and gas basins **11**

4.2.2. Review of source, exposure, and health risk assessment studies **17**

4.2.2.1 Source assessment studies conducted in California **18**

4.2.2.2 Source assessment studies conducted outside California **29**

4.2.2.3 Exposure assessment studies conducted in the U.S. **32**

4.2.2.4 Health risk assessments conducted in the U.S. **35**

4.2.3. Summary of findings **38**

4.2.3.1 California studies **38**

4.2.3.2 Studies outside California **39**

4.3. Approaches to emissions control and best practices implemented in California **40**

4.3.1. Overview of federal controls & California emission requirements for oil & gas **40**

4.3.1.1 Federal rules & regulations relevant to reducing emissions from upstream OGD **40**

4.3.1.2 Federal emission control requirements: RACT, BACT, & LAER **44**

4.3.1.3 California rules & regulations relevant to reducing emissions from upstream OGD **46**

4.4. Gaps in existing emission control regulations with relevance to public health **48**

4.4.1. TACs and NMVOCs are co-emitted with emissions of methane **49**

4.4.2. Regulation of gas-driven pneumatic devices in Colorado: A comparison with current California requirements **54**

4.4.3. Separators and condensate tank systems: Exemptions from vapor recovery requirements for small producers **57**

4.4.4. LDAR requirements: Heavy liquid exemptions and consideration of vulnerable communities **60**

4.4.4.1 Heavy liquid exemptions from state LDAR requirements **60**

4.4.4.2 Consideration of proximity and disproportionately impacted communities **62**

4.4.5. Summary of findings **65**

4.5. Discussion **65**

References **68**

Appendix D **82**

D.1 Chemical usage in upstream OGD in California with respect to airborne exposure **82**

OECD P_{ov} & LRTP Screening Tool and Chemical Screening for Potential Airborne Hazard **84**

D.2 Interpreting cancer and non-cancer health risks **87**

Interpreting non-cancer health risk **87**

Interpreting cancer risk estimates **88**

Figures

Figure 4.1. Air Districts that intersect with oil and gas fields in California (22 total). Sources: CalGEM (2021b); CARB (2019a). 11

Figure 4.2. Air Districts that have a new or active oil and gas well within their jurisdiction. Sixteen districts have one or more new or active oil and gas wells as of March 1, 2021. Striped districts have zero new or active oil and gas wells. Sources: CalGEM (2021b); CARB (2019a). 12

Figure 4.3. Air basin designation of 2015 8-hour ozone standard. Source: US EPA (2016c). .. 14

Figure 4.4. Air basin designation of 2012 $PM_{2.5}$ standard. Source: US EPA (2016c). 15

Figure 4.5. CO_2 and non-methane hydrocarbon emissions at Sites E1 and E2, annotated with noise and odor complaints as well as observations by residents of heavy activity at the drill site. Source: Figure 14, Collier-Oxandale et al. (2020). 19

Figure 4.6. Methane and total non-methane hydrocarbon (TNMHC) concentrations at the control site, within 500 m (1,640 ft) of each facility, and outside the 500 m (1,640 ft) radius. Source: Figure 5, Okorn et al. (2021). 20

Figure 4.7. Point estimates (95% CIs) for the marginal effect of one additional preproduction well upwind (left column) and downwind (right column) of the monitor. The bar plots show the number of monitor-days with exposure to at least one preproduction well within each distance bin. Source: Figure 3, Gonzalez et al. (2022) 22

Figure 4.8. Point estimates (95% CIs) for the marginal effect of 100 additional barrels of oil equivalent (BOE) of daily production volume, for wells upwind (left column) and downwind (right column) of the monitor. The bar plots show the number of monitor-days with exposure at least 1 BOE of daily production volume within each distance bin. Note that more monitor-days had exposure to production volume than preproduction wells. Source: Figure 4, Gonzalez et al. (2022)..... 23

Figure 4.9. Contribution of total alkane emission fluxes from stationary sources by category. Source: Figure ES-1, Mellqvist et al. (2017). 24

Figure 4.10. Current list of federal regulations applicable to OGD in California, including well stimulation techniques as well as conventional methods. 41

Figure 4.11. Current list of statewide regulations applicable to emissions from OGD in California. (Regulations relevant to plugged, idle, or abandoned wells included in Chapter 6.). 47

Figure 4.12. Range of control levels that apply to new or modified stationary sources in California. Source: CARB (2021a). 48

Figure 4.13. Emission rates of key NMVOCs by unconventional oil and gas activity in the Piceance Basin and Denver-Julesburg Basin. Source: Figure 1, Hecobian et al. (2019)..... 51

Figure 4.14. California oil field API gravity in 2018. Source: Figure from CEC (2020) analysis. 61

Tables

Table 4.1. Major components of gas from oil and gas wells in the San Joaquin Valley. Source: Lillis et al. (2007); USGS (2014)..... 7

Table 4.2. Total California combustion, vented, and fugitive emissions by primary business type. Source: Table 3-2 and Table 3-3 in CARB (2013a)..... 9

Table 4.3. Emission rates of VOCs identified in upstream gas systems in California (n=81 samples). Sources of VOCs cannot be determined due to ambient air mixing during sample collection. Emission rates are provided for comparison purposes only. Source: SAGE Environmental Consulting (2019)..... 10

Table 4.4. Estimated total and selected state $PM_{2.5}$- and ozone-related premature deaths attributable to emissions from the oil and gas sector in 2025. Source: Fann et al. (2018). 17

Table 4.5. 2012 and 2018 emissions (lbs/day) by major relevant source category for the South Coast Air Basin. We did not compare 2018 estimates of TACs to 2012 concentrations, as 2018 estimates were not readily available. This is noted in cells with "NA". Source: Adapted from Appendix VIII, SCAQMD (2012), and Appendix I, SCAQMD (2021)..... 27

Table 4.6. Oil and gas industry sources covered under 2012 NSPS for VOCs and the 2016 NSPS for Methane and VOCs. Source: US EPA (2016b)..... 42

Table 4.7. High-level overview of major provisions relevant to upstream oil and gas made to the 2012 and 2016 NSPS. Source: US EPA (2023b)..... 43

Table 4.8. Comparison of California District Control Technology Definitions with Federal Definitions. Source: Table 9, CARB (2017b)..... 45

Table 4.9. Comparison of Rich et al. (2014) air sampling results with other studies. Source: Table 3, Rich et al. (2014). 53

Table 4.10. Required timeline for implementation of non-emitting devices on existing well production facilities. Source: Regulation Number 7, Table 1, CDPHE AQCC (2021). 55

Table 4.11. Estimate of vented emissions from pneumatic devices. Source: Tables 9-1 and 9-2, CARB (2013a). 56

Table 4.12. Impact of different annual methane standards on uncontrolled systems. Source: Table 7, CARB (2016b). 58

Table 4.13. Well production facility and gas compressor station component inspections. Source: Adapted from Table 4, Colorado Regulation Number 7, CDPHE AQCC (2021). 63

4.0. Abstract

Upstream activities related to oil and gas development (OGD) (e.g., production and processing) in California — and across the United States — emit numerous air pollutants. While OGD in California is declining overall, dense upstream oil and gas activities still occur in many regions of the state. The San Joaquin Valley and South Coast Air Basins are the largest oil and gas producing regions in California, both of which have some of the worst air quality in the state. Findings suggest that emissions from upstream oil and gas may significantly impact regional air quality within specific regions of California, such as the San Joaquin Valley. In regions where upstream oil and gas is only a small contributor to the region's ambient air quality levels, such as the South Coast Air Basin, emissions from upstream OGD sites still pose a risk to residents and other sensitive receptors located nearby. More than 3 million people live within 1 km (3,281 ft) of an oil and gas well in California. Therefore, the health hazards from upstream OGD still present a significant issue given that proximity to upstream OGD is a health risk factor.

A review of one California-specific health risk assessment identified 38 air pollutants near upstream oil and gas sites, including 22 compounds listed as known or suspected human carcinogens. Toxic air contaminants (TACs) associated with upstream OGD include diesel exhaust; benzene, toluene, ethylbenzene, and xylenes (BTEX); formaldehyde; n-hexane; styrene; hydrogen sulfide (H_2S); and 1,3-butadiene, among others. Cancer risk during specific upstream oil and gas processes (i.e., hydraulic fracturing activities, cleanout events) exceeded the U.S. Environmental Protection Agency *de minimis* threshold (one case in one million), the South Coast Air Quality Management District (SCAQMD) significance thresholds of 1, 10, and 25 in one million, and the San Joaquin Valley Air Pollution Control District (SJVAPCD) significance thresholds of 1 and 20 in one million excess cancers.

In California, regulatory exemptions from vapor recovery, leak detection and repair (LDAR), and equipment change-out requirements have been established based on methane and non-methane volatile organic compound (NMVOC) emissions from specific upstream oil and gas sources. These exemptions include, but are not limited to (1) a statewide zero-bleed/zero-emission standards exemption for existing low-bleed (<6 standard cubic feet per hour) natural-gas driven pneumatic devices installed prior to January 1, 2016; 2) an exemption from the statewide 95% vapor recovery requirement for low-throughput separators and condensate tank systems; and (3) an exemption from the statewide leak detection and repair (LDAR) requirement for upstream oil and gas infrastructure components associated with heavy oil (API gravity <20).

The closure of the exemptions from statewide zero-bleed/zero-emission standards for existing low-bleed pneumatic devices and vapor recovery requirements for low-throughput separates and condensate tank systems would reduce non-methane volatile organic compound (NMVOC) emissions, which include TACs, by an estimated 15 tons per year (tpy) from 50 existing natural gas powered pneumatic devices and 208 tpy from ~2,200 small throughput separator and tank systems. Additionally, the California Air Resources Board (CARB) states that heavy oil components (API gravity <20) exempt from LDAR account for less than 1% of hydrocarbon

emissions from leaking components. While these exemptions represent a small fraction of NMVOC emissions from the statewide upstream oil and gas development sector, these emissions may be meaningful to risk of TAC exposure in areas with concentrated exempt infrastructure or when this infrastructure exists in close proximity to human populations.

LDAR focused on monitoring for methane is useful when monitoring equipment with emissions that have high methane/non-methane hydrocarbon ratios. In this context, methane can be a reasonable indicator of the presence of TACs and other NMVOCs that are intermixed with methane. However, when monitoring emissions from infrastructure or processes containing gases with low methane/non-methane ratios (e.g., condensate tanks, produced water management and disposal, etc.) or little to no methane content (e.g., combustion from diesel engines, combustion emission from natural gas-powered equipment, etc.), methane is not a reliable indicator of TAC and other NMVOC emissions and there is likely no surrogate for these situations. LDAR approaches that focus on measurement of large suites of air pollutant species may be more comprehensive and appropriate for various applications when gas composition is uncertain.

Our findings suggest there are numerous additional emission control measures (including regulatory setback distances) that could be implemented in California to further reduce emissions from upstream OGD and protect the health of residents in proximity to activity. Agencies with jurisdiction should deploy measures to reduce exposure to air pollution associated with upstream OGD sites, including but not limited to LDAR requirements and increased emission control.

4.1. Introduction

Over the past 15 years, the United States has seen unprecedented growth in domestic upstream oil and gas development (OGD) and production (Bamber et al., 2019; Deziel et al., 2020; Shonkoff et al., 2014). Due to technological advancements in high-volume hydraulic fracturing, directional and horizontal drilling, and dense spatial clustering of wells, previously inaccessible petroleum resources, such as tight sand and source rock formations (e.g., shale, sandstone, coal seams), have become more accessible and economically viable (Bamber et al., 2019; Deziel et al., 2020; Shonkoff et al., 2014). Since 2005, these techniques, collectively referred to as unconventional OGD, have resulted in a boom of tight oil and gas production in the United States, especially in states with active shale plays such as Colorado, Louisiana, New Mexico, North Dakota, Ohio, Oklahoma, Pennsylvania, Texas, West Virginia, and Wyoming (US EIA, 2019, 2020). Both conventional and unconventional OGD continue to be a prominent industry in specific regions of California, including the San Joaquin Valley and South Coast Air Basins (CalGEM, 2021a; CCST, 2015).

This section summarizes the air quality and health risk impacts from upstream OGD in California and elsewhere.

Components of upstream OGD

Upstream components of the oil and gas industry supply chain are separated into two main categories: oil and gas production (including exploration efforts) and processing (Adgate et al., 2014; Johnston et al., 2019; NRC, 2014; Shonkoff et al., 2014). Primary components of production include the well pad, which encompasses wells and related casing head, tubing head, and Christmas tree piping. Additional components include any pumps, compressors (associated with production side), heater treaters, separators, storage vessels, pneumatic devices, and dehydrators used at oil and gas facilities for production and processing (Adgate et al., 2014; Johnston et al., 2019; NRC, 2014; Shonkoff et al., 2014). Some of the available studies in the peer-reviewed literature evaluate emissions from production facilities as a whole, which would measure emissions from all these components collectively, while other studies have measured emissions from individual components (Adgate et al., 2014; Johnston et al., 2019; NRC, 2014; Shonkoff et al., 2014).

Production also involves the use of combustion equipment, such as drill rigs and service trucks, which are often diesel or gas powered. In production emissions, we also count well development, which includes well drilling activities such as the completion and recompleting of the portable non-self-propelled apparatus of the well. Stand-alone sites where oil, condensate and produced water and gas from several wells are separated, stored and treated are also considered. Finally, we include low pressure, small diameter, gathering pipelines and related components that collect and transport oil, gas and other materials and wastes from the wells to the refineries or gas processing plants (Adgate et al., 2014; Johnston et al., 2019; NRC, 2014; Shonkoff et al., 2014).

Processing consists of separating certain hydrocarbons and fluids from the oil and gas to produce pipeline quality oil and dry gas (CARB, 2013a). Some processing can be accomplished in the production segment, but the majority is performed in post-production. For upstream emissions, we consider the former. The components of processing include oil and condensate separation, water removal, separation of gas liquids, sulfur and carbon dioxide removal, fractionation of gas liquids, carbon dioxide capture, and gas processing. Emissions from idle, and/or orphaned wells are also considered, the results of which are summarized in Chapter 6 of this report.

4.2. Review of existing emissions data, air quality impacts, and related health risks

Upstream activities related to OGD emit numerous chemical pollutants into air, water, and soil. People that live, work, or attend school near oil and gas wells are exposed to these pollutants through several exposure pathways, including inhalation via the nose and mouth, ingestion through the mouth, and dermal absorption through the skin.

4.2.1. Characterization of air pollutants from upstream oil and gas in California

The primary focus for this section is to review studies that evaluate air pollution from upstream OGD in California.

Air pollutant emissions associated with upstream OGD

Upstream activities include the transport of equipment and materials to and from the well pad; well drilling, mixing, handling, and injection of oil and gas chemicals (including during well stimulation and routine maintenance operations), and management of recovered fluids and other waste products (Adgate et al., 2014; Johnston et al., 2019; NRC, 2014; Shonkoff et al., 2014). Well stimulation treatments include methods such as hydraulic fracturing, matrix acidizing, and acid fracturing, which are used to access hydrocarbons from previously-inaccessible tight geological formations, such as shale (CCST, 2015). Sources of air pollutants include products of incomplete combustion from flares and diesel-powered equipment, which emit carbon monoxide (CO), hydrocarbons, black carbon, diesel particulate matter (DPM) (a known carcinogen), and carbonyls, as well as chemicals emitted from surface and subsurface equipment such as wells, pumps, generators, compressors, pneumatic devices, tanks, surface impoundments, and solid and liquid waste handling equipment. External combustion equipment used during upstream OGD include boilers, heaters/treaters, and vapor recovery systems such as flares, incinerators, and thermal oxidizers; internal combustion equipment includes generators, pumps, accumulators, and turbines (CARB, 2013a). In 2007, California had an estimated 1,630 external combustion "units" (the majority of which were 5–10 years old) and 3,290 internal combustion "units" in operation (the majority of which were 10 years old or less) (CARB, 2013a).

Air pollutant emissions from upstream OGD include toxic air contaminants (TACs) (e.g., benzene, H_2S, hexane), criteria air pollutants (CAPs), sulfur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (VOCs) and reactive organic gases (ROG). The latter three are associated with the formation of tropospheric ozone (i.e., smog). ROG, SO_x, and NO_x emissions are also known precursors for secondary $PM_{2.5}$ formation (SJVAPCD, 2018). $PM_{2.5}$ can be emitted directly or formed indirectly through a set of chemical reactions between pollutants such as NO_x (Brandt et al., 2015).

The method of hydrocarbon extraction is not important from a toxic air contaminant (TAC) exposure perspective. Many TACs are co-produced with upstream OGD because of their natural occurrence in oil and gas reservoirs, regardless of whether hydraulic fracturing and other forms of well stimulation are used, such as acid fracturing or matrix acidizing (Garcia-Gonzales et al., 2019a). TACs such as benzene may be emitted to the atmosphere during the relatively brief amount of time that well stimulation treatments take place. Any produced water or products extracted from wells that contain TACs are of concern, particularly those that can become airborne.

The environmental public health literature strongly implicates geographic proximity to active upstream OGD as an important risk factor for a variety of adverse health outcomes. The overwhelming majority of studies that have assessed associations between upstream OGD and

emissions of TACs have identified a number of regularly emitted pollutants, including: diesel exhaust; benzene, toluene, ethylbenzene, and xylenes (BTEX); n-hexane; styrene; and 1,3 butadiene, among others (Garcia-Gonzales et al., 2019a). Few studies found no association between proximity and TAC concentrations.

Intermittent peaks in air pollutant emissions from upstream oil and gas activities and equipment have also been observed (Allen, 2014; Brown et al., 2014). While these emissions may have a limited influence on regional air pollutant concentrations, they are likely to be associated with increased health-relevant exposures to local populations near emission sources. As such, studies that focus on regional concentrations of air pollutants associated with upstream OGD may arrive at estimates of low- to moderate-level chronic exposures experienced by regional populations, but in order to capture the full range of potential public health risks at the local level, it is important to consider the proximity of receptors to sources (Gonzalez et al., 2022; McKenzie et al., 2018; Pétron et al., 2014; Shonkoff et al., 2015a).

Methane and non-methane volatile organic compounds (NMVOCs) are emitted during upstream OGD (e.g., Koss et al., 2015; Rich et al., 2014; Marrero et al., 2016; see Section 4.4.1). Many of the NMVOCs and emitted are TACs or ground-level ozone precursors. Because both methane and some NMVOCs have a common source, certain infrastructure components, such as wellheads, gas pipelines, and gas processing plants, have emission profiles with high methane:non-methane hydrocarbon ratios. However, other components, such as condensate tanks, and produced water ponds, have emission profiles with far lower methane:non-methane hydrocarbon ratios, and methane is not a reliable indicator of NMVOCs that are not hydrocarbons. While diesel engines used for transport pumps and other purposes do not emit methane and have a zero methane:non-methane hydrocarbon ratio, they do emit criteria air pollutants (CAPs), TACs, and other air pollutants.

4.2.1.1 Composition of upstream oil and gas in California

Publicly available data concerning the composition of gas and the presence of NMVOCs and TACs in upstream oil and gas activities in California is limited. When gas composition data is available, analyses primarily focus on the characterization of light alkanes (C1–C6 hydrocarbons), nitrogen, oxygen, and other trace gases. Heavier hydrocarbons, including compounds of interest with regard to human health impacts (e.g., BTEX), are commonly reported as undifferentiated C6+ compounds (i.e., heavier alkanes) (USGS, 2014) or grouped together based on a range of carbon numbers (e.g., C5–C8). Analyses of gas in California for individual NMVOCs and TACs are not widely available.

The U.S. Geological Survey Energy Resources Program Geochemistry Laboratory Database (USGS EGDB) (USGS, 2014) is an important resource for analytical data for crude oil and gas samples from both California, and around the world. Analytical data is compiled from a variety of sources, including the USGS EGDB, other contracted laboratories, published literature, and unpublished public domain sources.

The USGS EGDB contains analytical data for gas sampled from 827 unique American Petroleum

Institute identifications (API)[1] in California; however, information regarding analytical methods, detection limits, non-detect and not measured parameter reporting, and sampling methods, dates, and locations is incomplete. Without additional context and documentation, it is unclear if constituents of interest (e.g., BTEX compounds) were measured and not detected, or if they were not measured at all. Thus, it is difficult to analyze and draw conclusions from these data with confidence.

A subset of gas samples in the USGS EGDB, originating from a 2007 USGS report on upstream OGD in the San Joaquin Basin (Lillis et al., 2007), was identified for further analysis based on the availability of background information regarding methodology, measured parameters, and sampling locations. In the report, 66 gas samples from oil and gas wells, tanks, and separators from six counties in the San Joaquin Basin were analyzed for gas composition, including select chemicals relevant to human health (i.e., benzene, n-hexane, H_2S) (Lillis et al. 2007). Statistical data from this report are summarized in **Table 4.1**. Of the 66 analyzed samples, benzene was detected six times, H_2S was detected three times, and n-hexane was reported 30 times. When reported, median concentrations of benzene, H_2S, and n-hexane were 0.04 mole percent (400 parts per million by volume, ppmv), 0.03 mole percent (300 ppmv), and 0.09 mole percent (900 ppmv), respectively. Detection limits for individual gas constituents were not explicitly stated in the study; non-detection does not mean a constituent was not present, and it possible the constituent is present below the detection limit.

It is important to note that these data represent a small fraction of oil and gas wells in California. Due to the limited data on upstream gas composition in California, it is difficult to ascertain how prevalent and at what concentrations pollutants are present in upstream sources. Additional testing and public disclosure of the composition of NMVOCs in upstream gas is needed to assess air pollution health risks and better inform policy makers.

[1] An API well number, or API number, is a unique numeric identifier assigned to each well permitted to drill in the United States. These API numbers are established by the American Petroleum Institute.

Table 4.1. Major components of gas from oil and gas wells in the San Joaquin Valley. Source: Lillis et al. (2007); USGS (2014).

Constituents	No. of detections[1]	Min (Mole%)	5th Percentile	Median (Mole%)	Mean (Mole%)	95th Percentile (Mole%)	Max (Mole%)
Nitrogen[2]	66	0.23	0.74	2.92	6.44	26.23	39.21
Oxygen and Argon[3]	66	0.07	0.16	0.77	1.14	3.13	8.13
Helium	1	0.11	0.11	0.11	0.11	0.11	0.11
Hydrogen	1	4.1	4.1	4.1	4.1	4.1	4.1
Carbon Dioxide	61	0.03	0.12	1.05	5.55	17.51	92.24[4]
Methane	66	1.722	56.3	81.2	77.02	95.44	97.53
Ethane	64	0.04	0.07	3.49	4.23	10.36	16.03
Propane	62	0.02	0.03	2.75	3.64	12.08	13.1
iso-Butane	57	0.02	0.02	0.52	0.8	2.36	3.74
n-Butane	46	0.04	0.1	1.4	2.1	6.11	8.4
iso-Pentane	45	0.02	0.02	0.16	0.31	0.9	1.97
neo-Pentane	7	0.02	0.02	0.02	0.03	0.07	0.09
n-Pentane	40	0.02	0.02	0.29	0.38	0.97	1.36
n-Hexane	30	0.02	0.02	0.09	0.14	0.34	0.42
n-Heptane	12	0.02	0.02	0.04	0.06	0.14	0.18
Benzene	6	0.02	0.02	0.04	0.04	0.06	0.06
Hydrogen Sulfide	3	0.02	0.02	0.03	0.03	0.04	0.04

[1] Detection limits for individual constituents were not provided in this study
[2] High nitrogen values are due to possible air contamination
[3] Measured oxygen and argon concentrations are assumed to be from air contamination
[4] High CO_2 and low methane in one sample possibly due to being taken from surface casing of producing well

4.2.1.2 Emissions from upstream OGD in California

In 2007, the California Air Resources Board (CARB) conducted a survey of the oil and gas industry in California, referred to herein as the "2007 Oil and Gas Survey" (CARB, 2013a). The 2007 Oil and Gas Survey gathered information on the various equipment and emissions associated with crude oil and gas production, processing, and storage in California.

The survey categorizes sources into three distinct categories: combustion, vented, and fugitive emissions. Combustion emissions are released from equipment that converts fuel to energy, whereas vented and fugitive emissions encompass the intentional (vented) and unintentional (fugitive) releases of vapors to the air (CARB, 2013a). As summarized in **Table 4.2**, 93% of carbon dioxide equivalents (CO_2e) emissions emitted during the production, processing, and storage of oil and gas in California come from combustion sources, with fugitive and vented emissions accounting for just 7% of total CO_2e emissions (CARB, 2013a). Similarly, facilities with the primary business types "onshore crude production" and "other" (i.e., compressed gas compression and marketing, cogeneration, combined heat and power, electricity generation, portable heating, water disposal, vapor recovery services) were responsible for 85% of the total CO_2e and ~48% of methane generated by California's oil and gas industry, even though they only account for 44% of total facilities surveyed. While oil and gas sources for these combustion, fugitive, and vented emissions likely co-emit TACs along with CO_2 and methane, TAC emissions were not quantified in this survey.

A study by SAGE Environmental Consulting (2019) measured fugitive methane and NMVOC (referred to as VOCs in the report) emissions from 39 upstream gas production facilities in California on a component level (e.g., valves, connectors, flanges, open-ended lines). The study's primary goal was to characterize fugitive emissions; composition of gas was not a priority. SAGE Environmental Consulting detected a total of 31 NMVOCs from 81 emission samples taken from various components in liquid and gas service at upstream gas facilities. Because the high flow rates of the sampling devices were higher than the fugitive emission rates from the components, it is likely that the samples contained a mixture of fugitive emissions and ambient air. Therefore, it is not possible to determine how much the fugitive emissions and ambient air contributed to the NMVOC concentrations in the samples. Detected NMVOCs are listed in **Table 4.3** and are provided for comparative purposes only.

An additional study by Lebel et al. (2020) measured methane emissions from abandoned oil and gas wells in California. Benzene was measured at a single unplugged well and was found to be below the detection limit of 6 micrograms per hour (µg/h). Additional testing and public disclosure of the composition of NMVOCs in emissions from upstream gas is needed to assess air pollution health risks and inform policy makers.

Table 4.2. Total California combustion, vented, and fugitive emissions by primary business type. Source: Table 3-2 and Table 3-3 in CARB (2013a).

Primary Business Type		Metric Tons			Metric Tons of CO_2e			Totals	
Type	No. of Facilities	CO_2	CH_4	N_2O	Combustion	Vented	Fugitive	CO_2e	% of Total
Onshore Crude Production	668	9,645,891	30,568	178	9,784,578	125,428	433,082	10,343,089	58%
Other	53	4,579,097	567	108	4,616,047	53	8,512	4,624,612	26%
Natural Gas Processing	17	913,595	6,090	6	879,601	24,102	139,698	1,043,400	6%
Onshore Natural Gas Production	703	205,336	16,247	4	218,910	117,835	210,879	547,624	3%
Crude Processing and Storage	42	370,666	1,719	2	346,952	15,940	44,347	407,239	2%
Natural Gas Storage	10	200,638	6,263	9	226,569	90,537	17,758	334,864	2%
PERP Equipment Owner	58	148,082	339	1	148,825	1,960	4,793	155,577	1%
Offshore Crude Production	16	101,807	1,772	4	104,272	16,708	19,138	140,118	1%
Crude Pipeline	65	71,625	829	3	72,515	0	17,306	89,821	1%
Totals:	**1,632**	**16,236,738**	**64,394**	**314**	**16,398,268**	**392,563**	**895,513**	**17,686,345**	**100%**

Other includes: Compressed natural gas (CNG) compression and marketing, cogeneration, combined heat and power, electricity generation, portable heating, water disposal, vapor recovery services.

Table 4.3. Emission rates of VOCs identified in upstream gas systems in California (n=81 samples). Sources of VOCs cannot be determined due to ambient air mixing during sample collection. Emission rates are provided for comparison purposes only. Source: SAGE Environmental Consulting (2019).

VOC Name	CASRN	No. of Detections	Min (µg/hr)	5th Percentile (µg/hr)	Mean (µg/hr)	Median (µg/hr)	95th Percentile (µg/hr)	Max (µg/hr)	From gas service	From liquid service
1,2,4-Trimethylbenzene	95-63-6	3	0.81	0.99	5.33	2.59	11.60	12.60	Yes	
1,2-Dibromoethane	106-93-4	29	58.00	195.00	3,740.00	585.00	15,800.00	21,100.00		Yes
1,3,5-Trimethylbenzene	108-67-8-	2	5.16	5.32	6.80	6.80	8.27	8.44	Yes	
2-Hexanone	591-78-6	1	124.00	124.00	124.00	124.00	124.00	124.00	Yes	
4-Ethyltoluene	622-96-8	3	2.71	2.71	8.20	6.77	14.70	15.60	Yes	
Acetone	67-64-1	4	0.78	0.78	2.94	1.07	7.72	8.88	Yes	
Benzene	71-43-2	16	0.37	0.37	6.63	1.14	25.80	80.60	Yes	
Carbon disulfide	75-15-0	2	0.32	0.32	0.32	0.32	0.33	0.33	Yes	
Chlorobenzene	108-90-7	1	45.60	45.60	45.60	45.60	45.60	45.60	Yes	
Chloroform	67-66-3	1	34.00	34.00	34.00	34.00	34.00	34.00		Yes
Cyclohexane	110-82-7	21	0.44	0.51	25.00	2.47	174.00	227.00	Yes	
Ethanol	64-17-5	13	0.83	0.90	2.27	1.48	6.31	8.98	Yes	
Ethyl Acetate	141-78-6	2	0.49	0.50	0.59	0.59	0.67	0.68	Yes	
Ethylbenzene	100-41-4	5	0.68	0.95	5.32	2.22	15.00	17.80	Yes	
Heptane	142-82-5	18	0.63	0.77	12.50	1.51	77.80	89.30	Yes	
Hexane	110-54-3	23	0.37	0.72	29.70	2.49	77.20	404.00	Yes	
Isopropyl alcohol	67-63-0	8	0.23	0.28	3.11	0.67	13.20	19.20	Yes	
Methyl Isobutyl Ketone	108-10-1	4	0.38	0.43	7.15	3.17	19.40	21.90	Yes	Yes
Methylene chloride	75-09-2	8	1.72	1.76	2.91	2.35	5.99	7.73		Yes
Methyl-t-butyl ether	1634-04-4	8	0.41	0.41	0.61	0.46	1.29	1.69		Yes
Propylene	115-07-1	8	0.51	0.53	0.90	0.62	2.17	2.98		Yes
t-Amyl Methyl Ether	994-05-8	25	0.35	0.39	885.00	20.90	3,730.00	3,780.00		Yes
Tetrahydrofuran	109-99-9	37	0.14	0.16	935.00	1.36	5,730.00	5,820.00		Yes
Toluene	108-88-3	32	0.34	0.40	7.90	2.31	46.60	64.80	Yes	Yes
TPH Gasoline (C4-C12)	N/A	12	154.00	167.00	3,120.00	542.00	15,100.00	16,200.00	Yes	
trans-1,2-Dichloroethene	156-60-5	10	0.71	0.74	2.64	2.11	7.51	11.80		Yes
trans-1,3-Dichloropropene	10061-02-6	20	0.82	0.98	596.00	111.00	1,910.00	1,940.00		Yes
Trichloroethene (TCE)	79-01-6	34	0.92	1.18	4,680.00	24.70	26,400.00	26,800.00	Yes	Yes
Trichlorofluoromethane	75-69-4	6	1.33	1.37	2.77	1.60	5.47	5.64		Yes
Vinyl chloride	75-01-4	31	0.26	0.28	76.00	0.95	375.00	380.00		Yes
Xylenes (total)	1330-20-7	25	0.46	0.51	7.65	3.59	29.90	57.30	Yes	Yes

4.2.1.3 Air quality and permitting in California's oil and gas basins

The state of California relies on 35 local air districts to control air pollution emissions from stationary sources, including upstream OGD (CalGEM, 2015). Referred to as Air Quality Management Districts (AQMD) or Air Pollution Control Districts (APCD), these governing authorities process and approve permits for stationary sources and regulate the cumulative air quality impact to the region through air quality management plans or clean air plans (CalGEM, 2015).

Of the 35 air districts in the state, 22 intersect with active oil and gas fields, and 16 districts have one or more active or new oil and gas wells within their jurisdiction (**Figure 4.1**; **Figure 4.2**) (CalGEM, 2021b; CARB, 2019a). The highest number of wells are located in SJVAPCD and SCAQMD regions (**Figure 4.1**) (CalGEM, 2021b; CARB, 2019a). When considering only active and new well permits, we found that only 16 air districts had at least one active or new well intersect with its boundaries (as of March 1, 2021) (**Figure 4.2**). Again, SJVAPCD and SCAQMD had the largest number of active and new oil and gas wells.

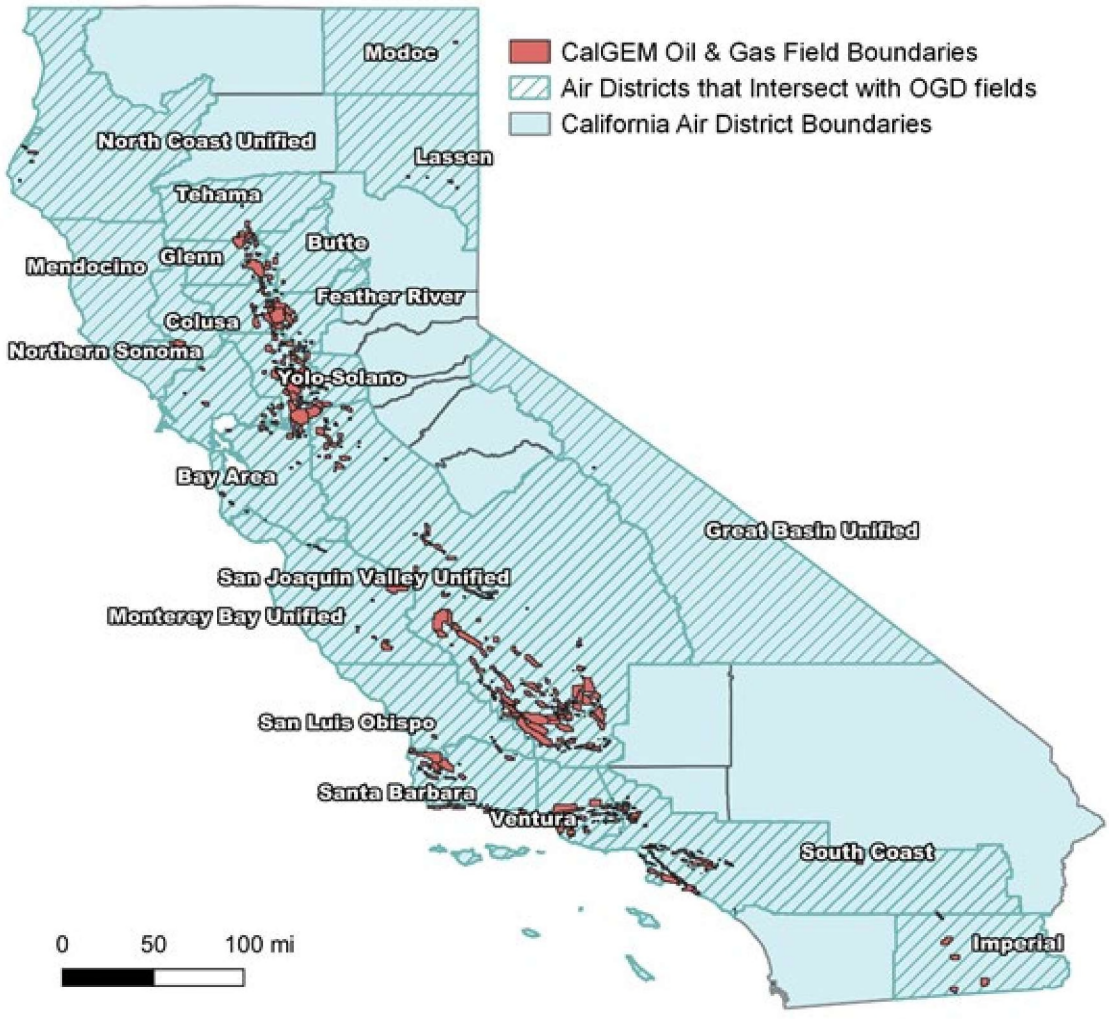


Figure 4.1. Air Districts that intersect with oil and gas fields in California (22 total). Sources: CalGEM (2021b); CARB (2019a).

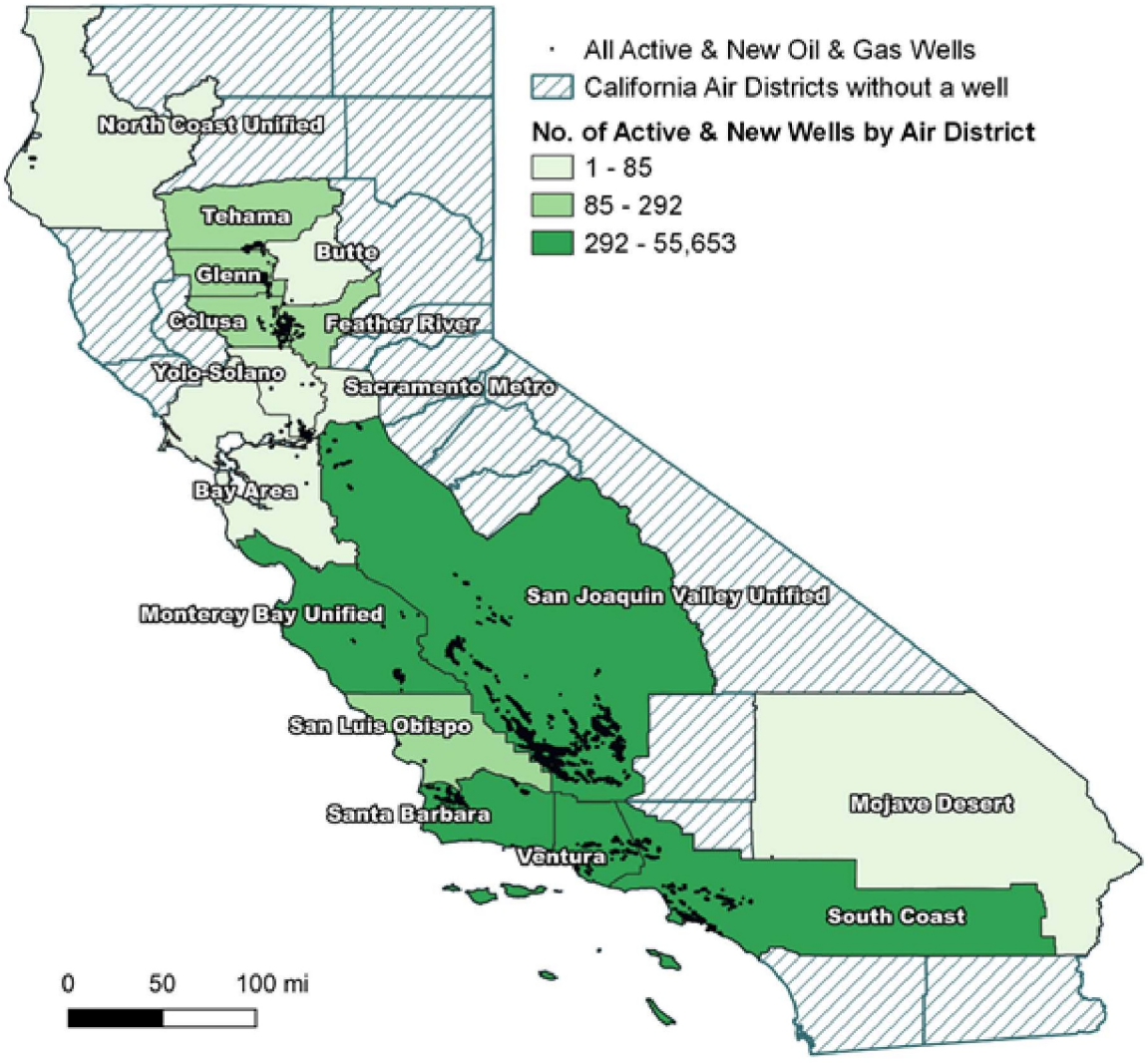


Figure 4.2. Air Districts that have a new or active oil and gas well within their jurisdiction. Sixteen districts have one or more new or active oil and gas wells as of March 1, 2021. Striped districts have zero new or active oil and gas wells. Sources: CalGEM (2021b); CARB (2019a).

Top upstream OGD regions in California

The San Joaquin Valley and South Coast Air Basins encompass the largest oil and gas producing regions in California. The majority of hydraulic fracturing operations in California occurs in the San Joaquin Valley Air Basin (EIA, 2021; Shonkoff & Gautier, 2015) . More generally, current oil production in both regions accounts for a significant portion of California's overall production volume, accounting for approximately 80% of all oil produced since 2015 (Brandt et al., 2015; CalGEM, 2021a). CalGEM annual production volumes indicate 88.1% of the total oil produced in the state from 2015 to the beginning of 2021 can be attributed to upstream oil and gas activity in just 20 fields (CalGEM, 2021a). Twelve of these 20 oil and gas fields (70% of oil produced since 2015) are located in the San Joaquin Valley and Kern County, four are located in the South Coast Air Basin (Wilmington, Huntington Beach, Long Beach & Inglewood) (10% of oil production), and the remaining three are located outside of these two regions (CalGEM, 2021a).

In 2015 and pursuant to Senate Bill 4, (2013, Pavley) the California Council on Science and Technology (CCST) published a multi-volume, multi-chapter assessment on well stimulation activities in California. The report found that, from 2012 to 2013, 96% of hydraulic fracturing activities in California were located in the San Joaquin Basin, with 85% of activity occurring in just four fields: South and North Belridge, Lost Hills, and Elk Hills (CCST, 2015). A smaller amount of hydraulic fracturing activities occur in the Los Angeles-South Coast Air Basin (CCST, 2015). Approximately 25% of all production in the Los Angeles Basin is associated with hydraulic fracturing techniques (CCST, 2015).

The South Coast and San Joaquin Valley Air Basins also have some of the worst air quality in California (Brandt et al., 2015; CARB, 2021a). As of March 1, 2021, both air basins are not in attainment for ozone and fine particulate matter ($PM_{2.5}$) when compared to the National Ambient Air Quality Standards (NAAQS) and California Ambient Air Quality Standards (CAAQS), and not in attainment for coarse particulate matter (PM_{10}) when compared to state CAAQS (SCAQMD, 2018a; SJVAPCD, 2012). Attainment with national standards for each region is determined by comparing the "design value" to the established NAAQS (US EPA, 2016a). For ozone pollution, the design value represents a three-year average of the fourth highest annual daily maximum 8-hour ozone concentration among the area's regional monitors (US EPA, 2016a, 2021). For $PM_{2.5}$ pollution, the design value is the annual mean $PM_{2.5}$ concentration averaged over three consecutive years, and represents the highest value among monitors with valid values (US EPA, 2016a). Depending on the magnitude to which the design value exceeds the established standard, areas of nonattainment are further broken down into six categories ranging from "marginal" to "extreme" (CARB, 2021a).

The designations by air basin for ozone and $PM_{2.5}$ attainment status are shown in **Figure 4.3** and **Figure 4.4**, respectively. Ozone pollution in the San Joaquin Valley and South Coast region are both in "extreme" nonattainment with national standards, meaning their design values are 0.163 ppm or greater — more than double the current 8-hour standard of 0.07 ppm (US EPA, 2016b). Similarly, $PM_{2.5}$ pollution is classified as "serious" in the Los Angeles-South Coast Air Basin and

"moderate" in the San Joaquin Valley, indicating large to moderate excesses above the national standard for $PM_{2.5}$ in both basins.

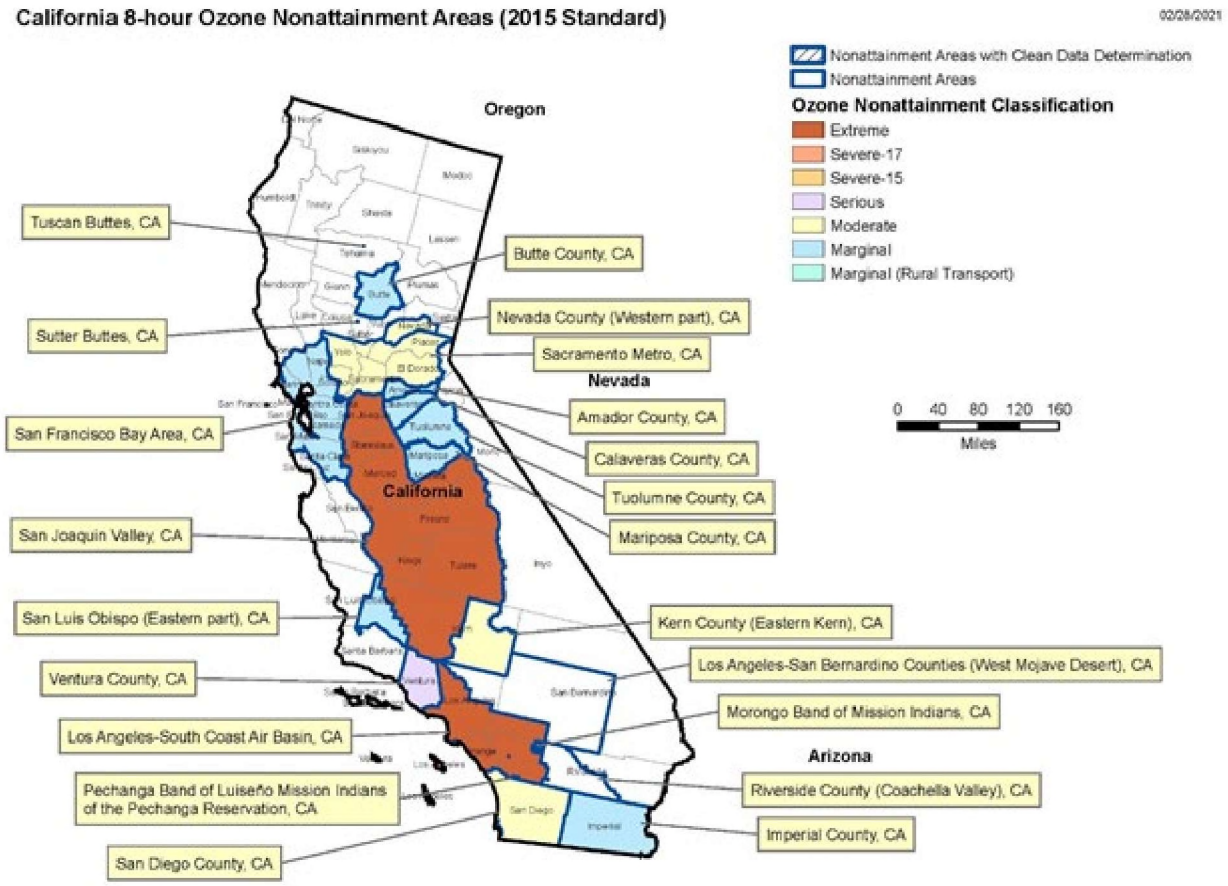


Figure 4.3. Air basin designation of 2015 8-hour ozone standard. Source: US EPA (2016c).

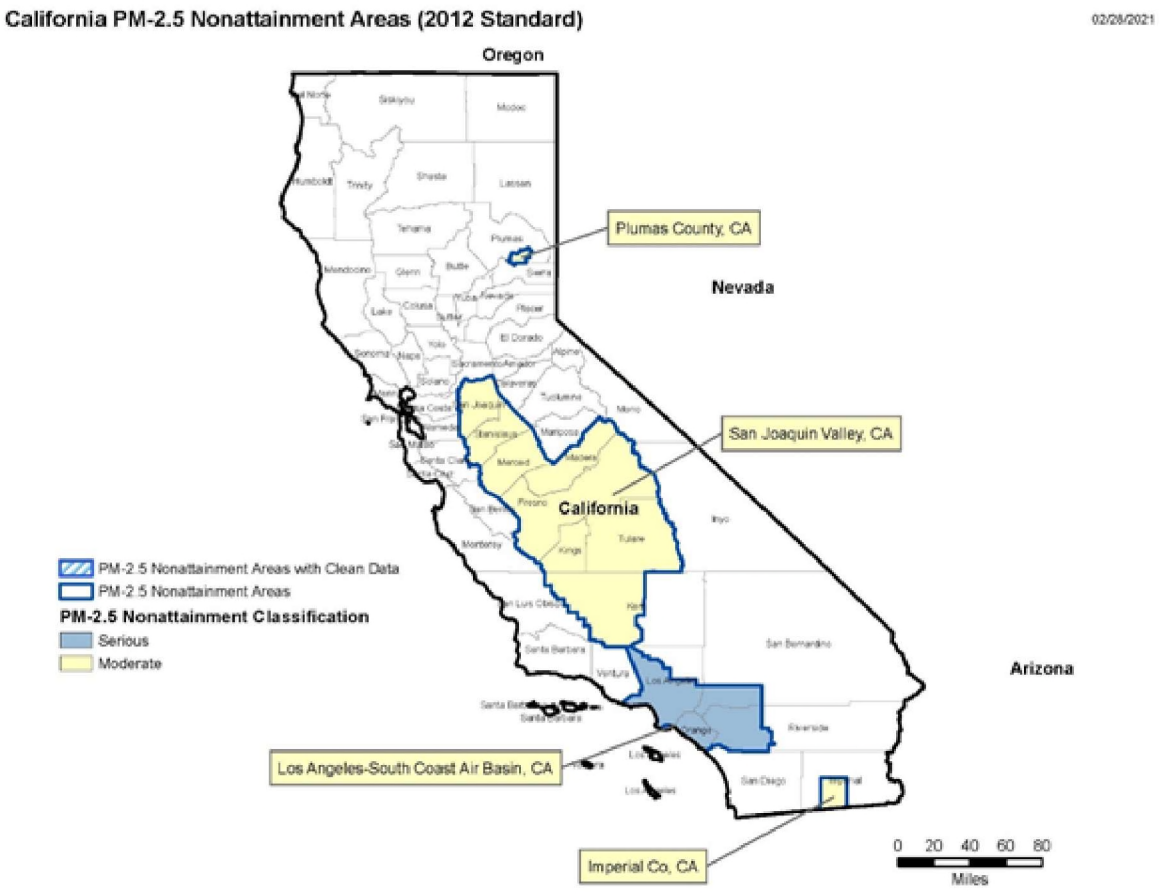


Figure 4.4. Air basin designation of 2012 $PM_{2.5}$ standard. Source: US EPA (2016c).

Chapter 3 of the CCST report identified the major contributors to air pollution in the Los Angeles-South Coast and San Joaquin Valley Air Basins (Brandt et al., 2015). This study found that many sources are responsible for the poor air quality seen in both the South Coast and San Joaquin Valley regions, including but not limited to emissions from upstream OGD, other industrial sources, agriculture, residences and businesses, and transportation (Brandt et al., 2015). Upstream OGD in the San Joaquin Valley contributes significantly more to the region's overall air pollutant burden as compared to the South Coast region (Brandt et al., 2015). In the Los Angeles-South Coast area, upstream OGD is only a small portion of the District's regional emissions, accounting for less than 1% of all pollutants (Brandt et al., 2015). In the San Joaquin Valley, however, upstream OGD accounts for a significant portion of H_2S emissions (70%) and SO_x emissions (31%), and is responsible for approximately 8% of the District's ROG emissions and 4% of emissions of NO_x (Brandt et al., 2015). This finding is significant, as photochemical oxidation reactions between ROGs and NO_x contribute to the formation of ground-level ozone (US EPA OAR, 2014). Additionally, upstream OGD in the San Joaquin Valley contributes to significant fractions of some TAC species, including BTEX ((Brandt et al., 2015, see Figure 3.3-10).

Upstream OGD plays a significant role in influencing the air quality of San Joaquin Valley. This finding is especially important when considering the large population located near upstream OGD in the San Joaquin Valley. Shonkoff et al. (2015b) found that approximately 500,000 people live within 1 mi (1,609 m) of a stimulated well, and this number significantly increases when considering any type of upstream OGD. Results from our proximity analysis (presented in Chapter 7) indicate that over 3 million people live within 1 kilometer (3,281 ft) of an oil and gas well in California. Similarly, while upstream OGD does not contribute to a large portion of emissions in the South Coast Air Basin, the region's population density is more than 10 times greater than in the San Joaquin Valley, with residents often located near upstream oil and gas activity (Brandt et al., 2015).

In Chapter 4 of the CCST report, Shonkoff & Gautier (2015) conducted a bottom-up inventory analysis of the various sources that contribute to the harmful air pollution levels seen in the South Coast Air Basin. Results from this assessment found stationary sources from upstream OGD to emit 2,361 kilograms per year (kg/yr) of benzene representing a significant portion (9.6%) of benzene emissions from stationary sources (Shonkoff & Gautier, 2015). Similarly, this analysis found upstream oil and gas facilities to emit 5,846 kg/yr of formaldehyde, accounting for 3.8% of formaldehyde emissions from stationary sources. However, when accounting for all sources of emissions (including mobile) within the South Coast Air Basin, the authors find that the upstream oil and gas sector is responsible for <1% of all source emissions of benzene and formaldehyde. These results suggest that while emissions from upstream OGD may not significantly impact regional air quality within the South Coast Air Basin, local emission peaks in close proximity to upstream OGD sites may pose a risk to those residents and other sensitive receptors located nearby.

Shonkoff & Gautier (2015) also performed a proximity analysis in the Los Angeles Basin. They considered production wells that were active in 2013 or 2014, and estimated populations within buffers of 100 to 2,000 m (328 to 6,562 ft) from these active wells. This assessment found that approximately 12% of the South Coast Air Basin population (~2.3 million people) live within 2,000 m (6,562 ft) of an active oil and gas well (Shonkoff & Gautier, 2015). Therefore, upstream OGD also presents a significant air pollution hazard for communities in the South Coast Air Basin given that proximity to these activities increases exposure to TACs (Brandt et al., 2015; Shonkoff & Gautier, 2015).

Fann et al. (2018) estimated the number of air pollution-related deaths and adverse health symptoms attributable to the oil and gas industry in the United States.[2] Annual attributable mean $PM_{2.5}$ concentrations from oil and gas activities ranged from 5.27 $\mu g/m^3$ to <0.001 $\mu g/m^3$, with Alabama, Colorado, Illinois, Louisiana, North Dakota, Ohio, Oklahoma, Pennsylvania, Texas, and Wyoming experiencing the largest $PM_{2.5}$ concentrations (Fann et al. (2018). Similarly, the authors found average 8-hour ozone concentrations to range from 8.12 parts per billion (ppb) to 0.003 ppb, with Alabama, Louisiana, Nebraska, Oklahoma, Texas, and West Virginia experiencing the

[2] This study included oil and gas sources associated with production and transportation of oil and natural gas and distribution of natural gas but excluded refineries and the distribution of refined products (Fann et al., 2018).

greatest summer-season ozone concentrations from the oil and gas sector. The $PM_{2.5}$- and ozone-related excess mortality burden was greatest in Texas, Pennsylvania, Ohio, Oklahoma, Illinois, California, Michigan, Colorado, Indiana, and Louisiana. In 2025 in California, an estimated 59 deaths will be attributable to $PM_{2.5}$ emissions from the oil and gas sector, as well as an additional 14 deaths attributable to ozone associated to upstream oil and gas production (**Table 4.4**) (Fann et al., 2018).

Table 4.4. Estimated total and selected state $PM_{2.5}$- and ozone-related premature deaths attributable to emissions from the oil and gas sector in 2025. Source: Fann et al. (2018).

	Estimated numbers of premature deaths (95% confidence interval)[b]			
State[a]	**Attributable to $PM_{2.5}$**	**Attributable to ozone**	**Total deaths attributable to $PM_{2.5}$ and ozone**	**Total deaths per 100,000 people**
Texas	130 (88–170)	130 (70–190)	260 (160–370)	1.4
Pennsylvania	85 (57–110)	55 (30–80)	140 (87–190)	1.6
Ohio	65 (44–86)	48 (26–70)	110 (69–160)	1.5
Oklahoma	48 (32–63)	55 (29–81)	100 (62–140)	4.1
Illinois	55 (37–73)	38 (20–55)	92 (57–130)	1.1
California	59 (40–77)	14 (7.4–20)	72 (47–97)	0.27
Michigan	39 (26–52)	32 (17–47)	71 (44–98)	1.1
Colorado	37 (25–49)	34 (18–49)	70 (43–98)	1.9
Indiana	38 (26–50)	29 (15–42)	66 (41–92)	1.6
Louisiana	34 (23–45)	28 (15–40)	61 (38–85)	2
National total	1,000 (670–1,300)	970 (520–1,400)	1,900 (1,100–2,700)	0.9

[a] These states comprise the largest health impacts for the sector. States listed by descending order of total $PM_{2.5}$ and ozone-attributable deaths.

[b] All values rounded to two significant figures.

4.2.2. Review of source, exposure, and health risk assessment studies

In this section, we review studies that assess upstream OGD as a source of air pollution, as well as studies that assess exposures to and health risks from air pollutants attributed to upstream OGD. Our review focuses on peer-reviewed journal publications, government reports, and white papers commissioned by government agencies. The studies include air monitoring or modeling approaches to measure or estimate methane and associated health-damaging air pollutant concentrations from upstream OGD. Additionally, some of these sources place findings in the context of human health, for example, by comparing observed pollutant concentrations to air quality standards (e.g., NAAQS) or by estimating cancer and/or non-cancer health risk. Studies

that rely on emissions inventories or are focused solely on methane emissions without quantification or estimation of TAC, CAP, and/or NMVOC concentrations were not included in this review.

Relevant sources were compiled using the PSE Repository for Oil and Gas Energy Research (ROGER) and California government agency websites (PSE Healthy Energy, 2020). In addition to California, we also summarize the results of peer-reviewed studies conducted outside the state, including assessments done in Colorado, Pennsylvania, Texas, Utah, and other states with upstream OGD. While these studies are not directly applicable to the California context, they provide useful insight into the air pollution and resultant health impacts associated with exposure to oil and gas at various distances.

4.2.2.1 Source assessment studies conducted in California

The primary focus of this section is to review studies that assess upstream OGD as a source of air pollutants (e.g., methane, CAPs, VOCs, TACs) using ambient air sampling, tracer, and modelling approaches. Studies that rely on emissions inventories or are focused solely on methane emissions were not included in this review.

Four peer-reviewed studies included air monitoring focused on upstream OGD in California (Collier-Oxandale et al., 2020; Gonzalez et al., 2022; Johnston et al., 2021; Okorn et al., 2021). Three studies were conducted in South Los Angeles at sites near oil and gas facilities. This region is of particular interest given its unique urban setting, high oil and gas activity, and high population density. In the Los Angeles Basin, about 1.7 million residents live within 1 mi (1,609 m) of an active oil and gas well (Collier-Oxandale et al., 2020; Okorn et al., 2021). Some 70% of active oil and gas wells are within 500 m (1,640 ft) of a residence, school, or hospital in Los Angeles, including over 500,000 residents (Okorn et al., 2021). Results from each study are summarized below in chronological order.

Collier-Oxandale et al. (2020) evaluated upstream OGD as a source of air pollutants in the Los Angeles region of California. The authors deployed low-cost device systems equipped with metal oxide VOC sensors to measure concentrations of methane and total non-methane hydrocarbons near upstream oil and gas activity. Methane and non-methane hydrocarbons are released during production and processing activities at oil and gas facilities, and are of highest concern at these sites (Allen et al., 2013).

Fifteen devices were deployed for an 8-week period at sites surrounding highways and oil and gas extraction activities occurring at a multi-well site within the West Adams and University Park communities in South Los Angeles.

The surrounding community was specifically interested in pollutant concentrations at two sampling sites (E1 and E2) <50 m (<164 ft), one east and one west of the oil and gas extraction site of interest. Results at these two sites suggest that the oil and gas extraction site is one plausible source of NMVOC (which include non-methane hydrocarbon) emissions. The authors incorporated CO_2 and CO concentration data over the same period, the results of which suggest that the short-term increases in methane and non-methane hydrocarbon observed over

background levels are likely the result of volatilized vented (intentional release) emissions from the extraction site of interest, and not from a combustion source such as vehicle emissions from the nearby highway and surrounding major roadways (Collier-Oxandale et al., 2020). NMHCs include a variety of odor causing aromatic compounds, including BTEX and polycyclic aromatic hydrocarbons (PAHs). Some of the increases in methane and non-methane hydrocarbon concentrations observed at the two sites <50 m east and west of the extraction site correspond with concerns from the community regarding odors and/or heavy activity occurring at the extraction facility. **Figure 4.5** highlights how emissions of CO_2 and non-methane hydrocarbons correspond to odor and noise complaints as well as reports of heavy activity at the oil and gas extraction site.

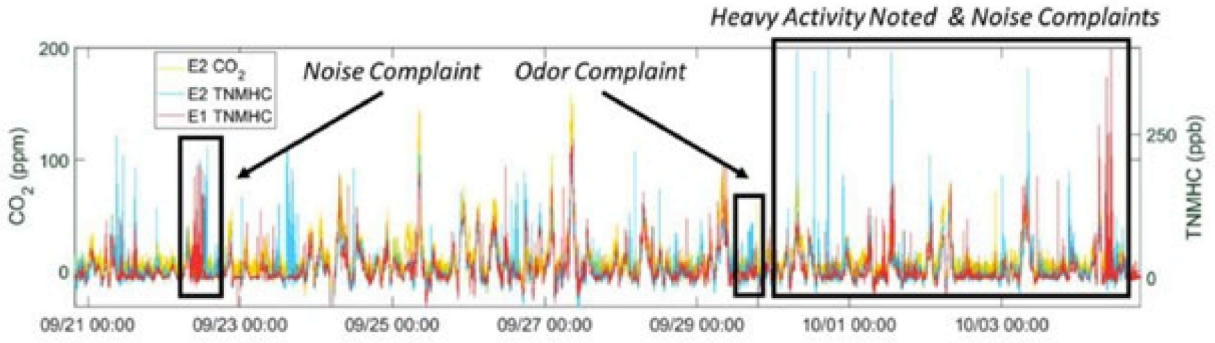


Figure 4.5. CO_2 and non-methane hydrocarbon emissions at Sites E1 and E2, annotated with noise and odor complaints as well as observations by residents of heavy activity at the drill site. Source: Figure 14, Collier-Oxandale et al. (2020).

While this study is limited in that it relies on low-cost monitoring tools, results suggest vehicle emissions are not the only source impacting the air quality of the West Adams and University Park communities. Results from Okorn et al. (2021) support these findings.

From 2016 to 2019, Okorn et al. (2021) deployed low-cost air sensors that measure methane, non-methane hydrocarbons, CO_2, and CO in three Los Angeles communities located near oil and gas facilities, with active operations occurring at sites 1 and 3 and no production occurring at site 2 (well activity ceased in 2013). All three facilities are located within 3 km (1.86 mi) of each other and draw from the Las Cienegas oil field (Okorn et al., 2021). At each site, anywhere from four to 11 devices were installed within 500 m (1,640 ft) of the facility. Two to 11 devices were deployed outside this 500 m radius: at a distance of 800 m to 8 km (2,624 ft to 26,247 ft) for Site 1; 4 km away (13,123 ft) for Site 2; and 800 m to 1 km (2,624 ft to 3,281 ft) for Site 3. The devices deployed outside the 500 m (1,640 ft) radius were used to estimate emissions from major roadways and to act as controls (Okorn et al., 2021, see Figure 2).

Results from this study demonstrate that methane levels varied based on proximity to an oil and gas facility (Okorn et al., 2021). Specifically, monitoring results show that methane levels are higher within 500 m (1,640 ft) of the three oil and gas facilities and near a gas pipeline, compared to concentrations farther away (**Figure 4.6**). The authors theorize this trend is likely a result of proximity to emission sources (Okorn et al., 2021). Significant methane concentrations were also

found at Site 2, where wells have been idle since 2013, indicating that fugitive emissions of methane may still be released by oil and gas well sites long after active operations have stopped.

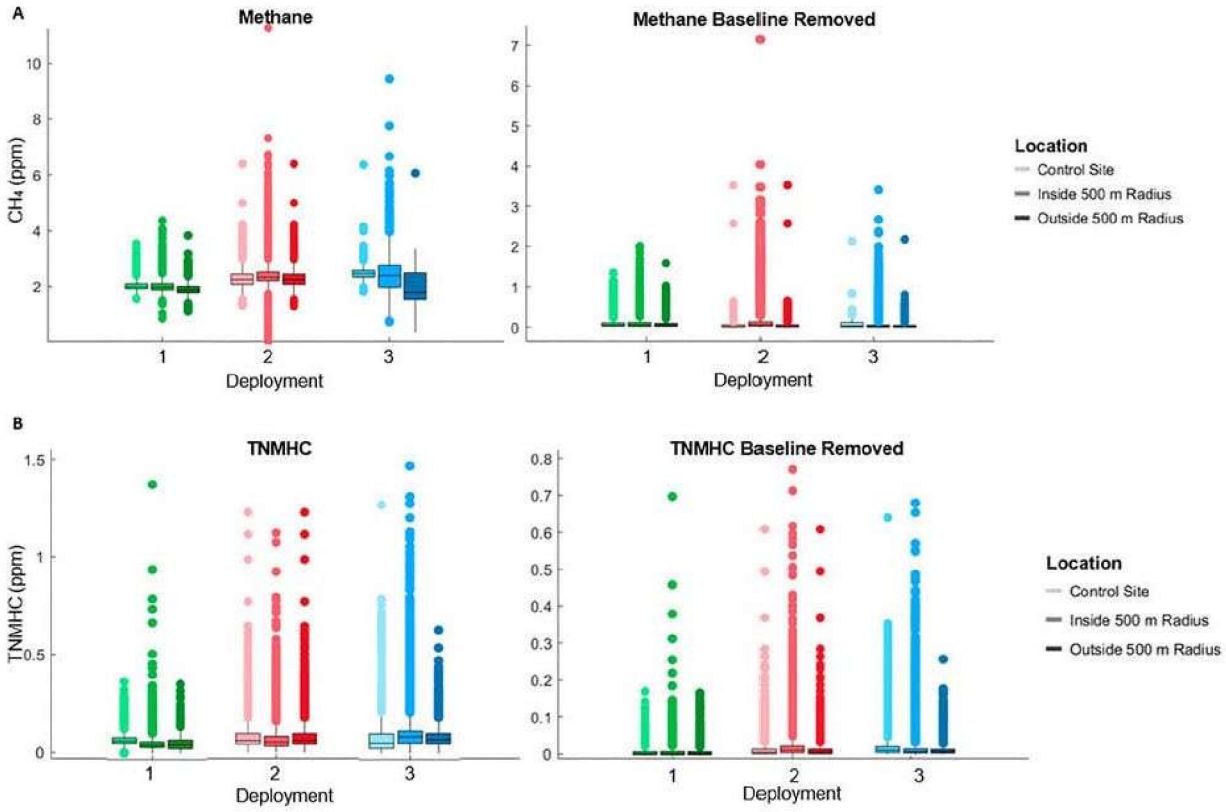


Figure 4.6. Methane and total non-methane hydrocarbon (TNMHC) concentrations at the control site, within 500 m (1,640 ft) of each facility, and outside the 500 m (1,640 ft) radius. Source: Figure 5, Okorn et al. (2021).

Unlike methane, which shows a clear and significant association with proximity to upstream oil and gas activity, total non-methane hydrocarbons results were less straightforward. Total non-methane hydrocarbon concentrations within the 500 m (1,640 ft) radius were similar to concentrations found outside this radius (control sites and near major freeways), with modest differences seen at Sites 1 and 2. Total non-methane hydrocarbons levels were found to be significantly associated with proximity to freeways for Sites 1 and 3, suggesting that traffic is a significant source of non-methane hydrocarbons in these communities. However, total non-methane hydrocarbons monitoring results show that short-term, episodic emissions spikes tended to be higher at locations near an oil and gas facility compared to variances seen outside of the 500 m (1,640 ft) radius, suggesting these events may be associated with specific oil and gas activities conducted on-site (Okorn et al., 2021).

Johnston et al. (2021) evaluated the methane, NMVOC, and TAC concentrations adjacent to an oil and gas production site in Los Angeles. Oil and gas production facilities, have periods of active production as well as idle periods, emissions of which greatly differ depending on the phase. Johnston et al. (2021) found average concentrations of methane, total NMVOC, BTEX, styrene, n-hexane, n-pentane, ethane, and propane to decrease once production activities idled.

Specifically, the authors observed a 28%, 32%, and 69% decrease in toluene, benzene, and n-hexane concentrations, respectively, after production at the site idled. Results from positive matrix factorization (PMF) modeling suggest that oil and gas drilling during the active phase contributed 23.7% of the total NMVOCs measured, while the idle period only contributes 0.6% (Johnston et al., 2021). While TAC concentrations at the fenceline were below state-designated acute Reference Exposure Levels (RELs), they were higher than background concentrations taken by CARB (2013b) and SCAQMD (Final Multiple Air Toxics Exposure Study (MATES) IV, 2015) for the area, suggesting a local emissions source. RELs are Health Guidance Values from California Office of Environmental Health Hazard Assessment that are used to determine the amount of a chemical in air that does not cause a noncancer health effect, such as asthma.

Gonzalez et al. (2022) investigated whether drilling new wells or increasing production volume at active wells in California resulted in emissions of $PM_{2.5}$, CO, nitrogen dioxide (NO_2), ozone, or NMVOCs (referred to as VOCs in the study). To isolate the effect of oil and gas activities on air pollutant concentrations, the authors used daily variation in wind direction as an instrumental variable and used fixed effects regression to control for unobserved time-trending factors and time-invariant geographic factors. This allowed the authors to control for geographic, meteorological, seasonal, and time trending factors and compare monitors to themselves, i.e., to compare concentrations of pollutants on days when the wind was blowing from nearby oil and gas operations to days when there were no oil and gas activities.

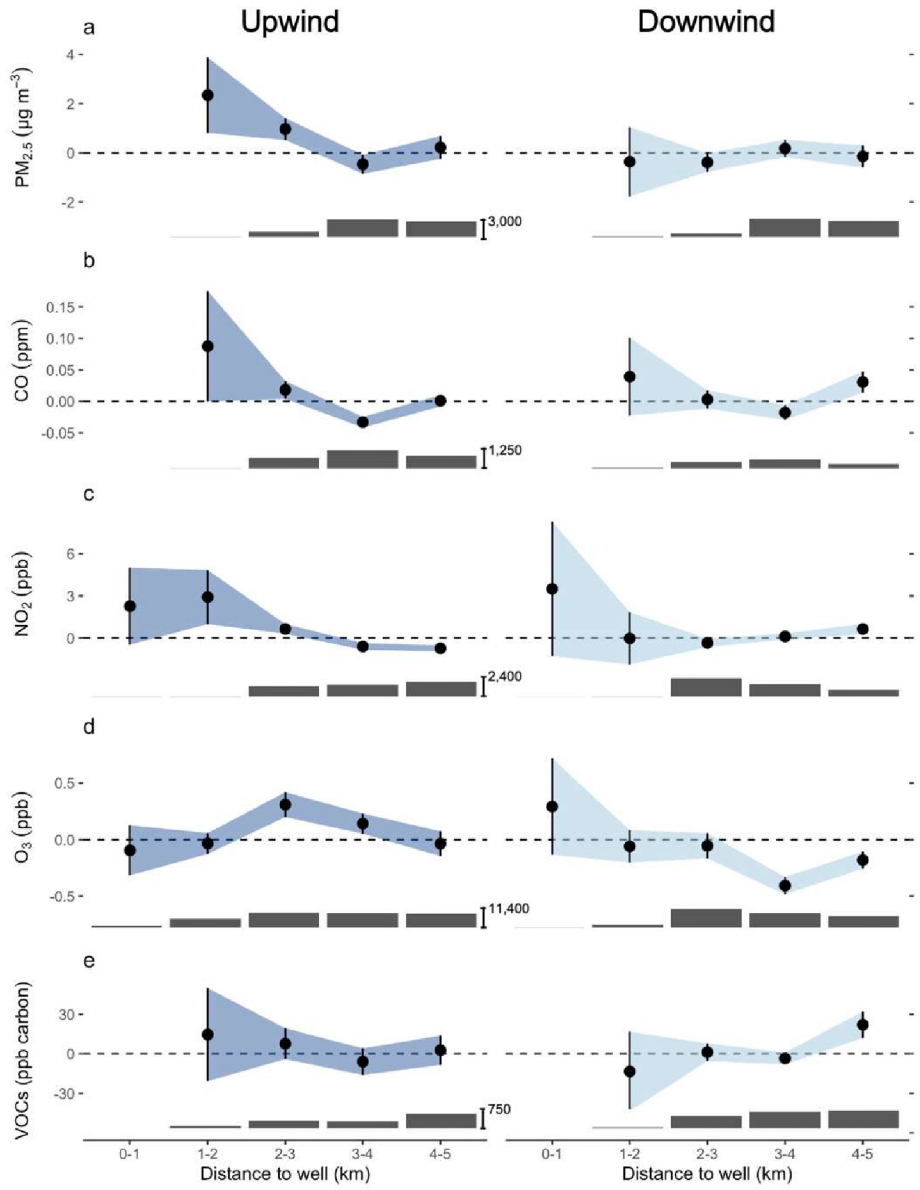


Figure 4.7. Point estimates (95% CIs) for the marginal effect of one additional preproduction well upwind (left column) and downwind (right column) of the monitor. The bar plots show the number of monitor-days with exposure to at least one preproduction well within each distance bin. Source: Figure 3, Gonzalez et al. (2022).

Results from the Gonzalez et al. (2022) study indicate that, on days when wells were being drilled upwind, there were significantly higher concentrations of $PM_{2.5}$, NO_2, NMVOCs, and ozone as far as 4 km (13,123 ft) from the wells (**Figure 4.7**). While there were higher concentrations up to 4 km (13,123 ft) from the wells, the amount to which concentrations were elevated do appear to decrease with increasing distance from the well. Daily concentrations of $PM_{2.5}$ increased by 2.35 µg/m^3 (95% confidence interval [CI]: 0.81, 3.89) for each additional well drilled upwind of a monitor ~2 km (~6,562 ft) away. Daily concentrations of ozone (O_3) increased by 0.31 (standard error [SE]: 0.06) parts per billion (ppb) for wells within 2–3 km (6,562–9,843 ft); and nitrogen dioxide (NO_2) increased by 2.27 (SE: 1.40) ppb for wells within 1 km (3,281 ft). For each additional active

well upwind of the monitor, these authors also found 1.93 (SE: 0.43) µg/m^3 of $PM_{2.5}$, 0.62 (SE: 0.12) ppb of NO_2, and 0.04 (SE: 0.02) ppb carbon (C) of NMVOCs. (**Figure 4.8**). The daily concentrations of $PM_{2.5}$ increased 1.93 µg/m^3 (95% CI: 1.08, 2.78) for each additional 100 barrels of oil equivalent (BOE) produced within 1 km (3,281 ft) of monitors; 100 BOE is approximately the median volume of oil and gas production at active wells in California. In placebo tests, the authors assessed exposure to wells *downwind* of the air monitors and observed no effect on air pollutant concentrations. Notably, the methods employed by Gonzalez et al. (2022) to estimate air pollutant concentrations in relation to distance from oil and gas wells are similar to methods employed in many epidemiological studies that measure exposure using residential proximity wells.

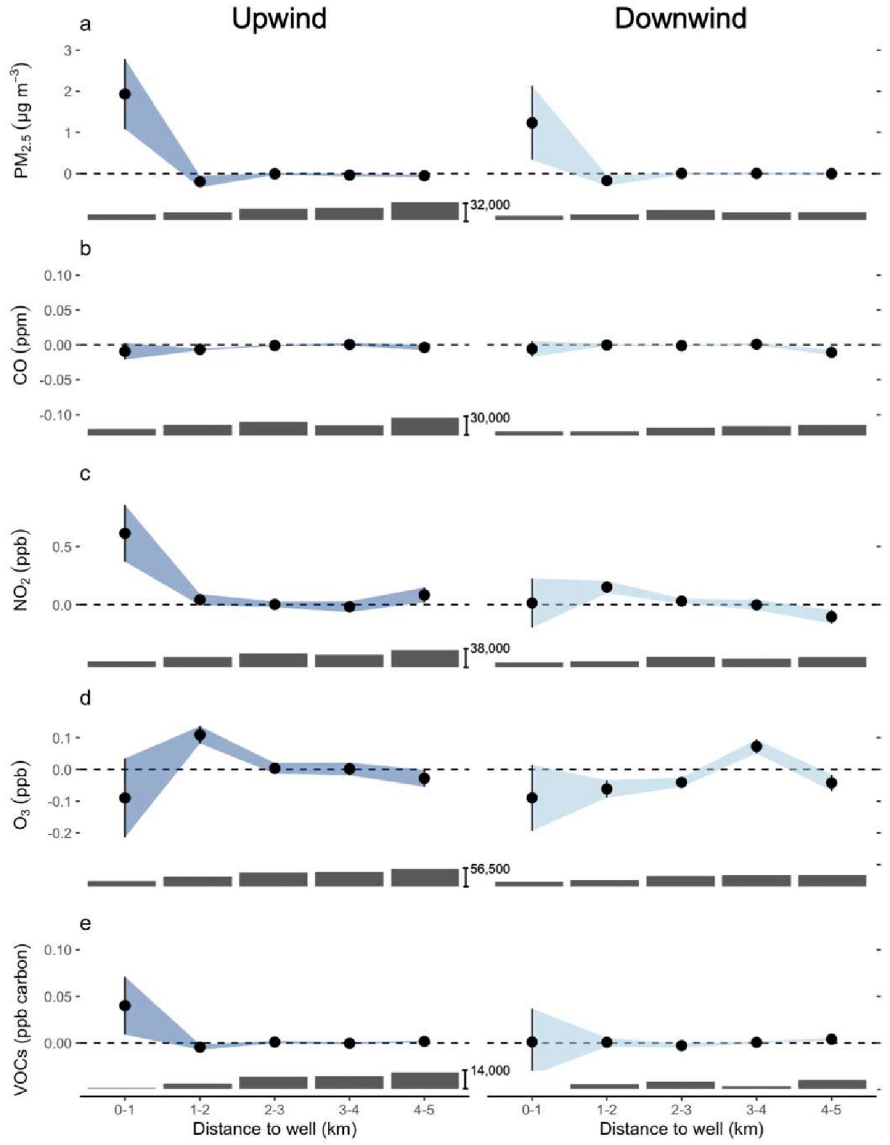


Figure 4.8. Point estimates (95% CIs) for the marginal effect of 100 additional barrels of oil equivalent (BOE) of daily production volume, for wells upwind (left column) and downwind (right column) of the monitor. The bar plots show the number of monitor-days with exposure at least 1 BOE of daily production volume within each distance bin. Note that more monitor-days had exposure to production volume than preproduction wells. Source: Figure 4, Gonzalez et al. (2022).

We also reviewed five government-sponsored reports that include air monitoring focused on upstream OGD in California (LACDPH, 2018; Mellqvist et al., 2017, 2019; SCAQMD, 2015a, 2015b). Four of the studies focused on emissions in the South Coast Air Basin (LACDPH, 2018; Mellqvist et al., 2017; SCAQMD, 2015a, 2015b), and one was conducted in the San Joaquin Valley (Mellqvist et al., 2019).

In 2015, Fluxsense Inc. conducted a five week sampling campaign to characterize emissions from oil wells, oil treatment facilities, and small tank farms (Mellqvist et al., 2017). This study took measurements from 900 surveys related to emissions from the oil and gas sector, completed between September–November 2015 (Mellqvist et al., 2017). Emission fluxes (kg/hr) of alkanes (a subset of non-methane hydrocarbons), BTEX, and methane were estimated by source type using a variety of methods and instruments. Results from all locations sampled were 1,318 kg/hr of alkanes, 68 kg/hr of BTEX (12 kg/hr for benzene) and 636 kg/hr of methane (Mellqvist et al., 2017). These totals are based on emissions measurements from various oil and gas facilities, including oil and gas well sites, and tank farms, terminals, and depots, among others. **Figure 4.9** shows the contribution of total alkane emission fluxes from stationary sources by source category.

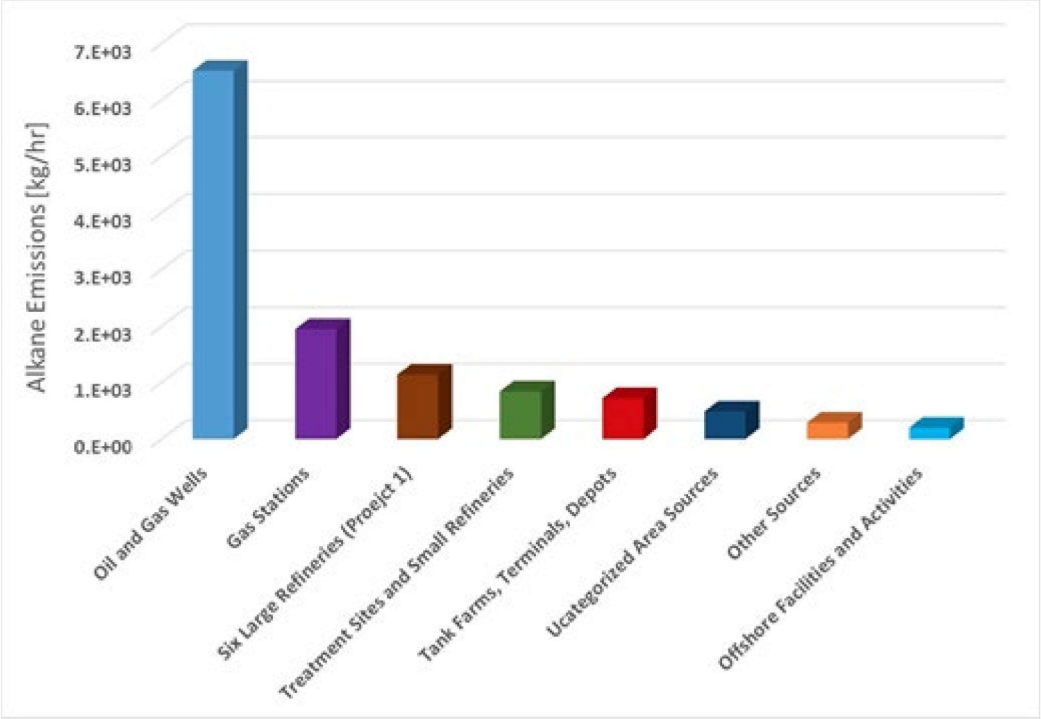


Figure 4.9. Contribution of total alkane emission fluxes from stationary sources by category. Source: Figure ES-1, Mellqvist et al. (2017).

As demonstrated in **Figure 4.9**, the study found 85% of total alkane emissions surveyed can be attributed to releases from oil and gas wells, gas stations, and treatment facilities and small refineries, with oil and gas wells contributing more than half of the estimated total (Mellqvist et al., 2017). The authors note that emissions from small point sources such as oil and gas wells are especially concerning when considering the large population residing in close proximity to these source types in the South Coast Air Basin and the potential adverse health impacts associated with such elevated exposures (Mellqvist et al., 2017).

Additionally, in 2022, FluxSense Inc. conducted another assessment, evaluating the emissions from upstream OGD in the San Joaquin Valley and South Coast (Mellqvist et al., 2022). Emissions of NMVOCs, methane and TACs from several of California's largest producing oil fields in Kern County were measured. A total of 6,100 kg/hr of alkanes and 10,300 kg/hr of methane were measured from 11 fields. NMVOC plumes were detected at all oil field fencelines; however, BTEX concentrations were measured above detection limit (low ppb) in only some of the fields. For field plumes with detectable BTEX concentrations, the ratio of BTEX mass fraction to alkane mass fraction was of the order of 5%. The ratio of benzene specifically was 1%. Some processing sites or facilities close to the fenceline had evident BTEX emissions reaching neighboring communities. Emissions of alkanes and methane from Inglewood Oil Field in Los Angeles County were 101 kg/hr alkanes and 121 kg/hr, respectively. BTEX emissions were 16 kg/hr, with benzene contributing 7.7 kg/hr. Plume dispersion measurements within the field campaigns showed that evening and nighttime plumes of TACs can be traced at measurable levels often kilometers away from an isolated source. Modeling of plume dispersion and contaminant concentrations were carried out for two sites in San Joaquin Valley and were validated with measurements. Although cross wind dispersion may be underestimated by the simulation, the results showed that plumes likely carry far into residential areas, and this was supported by measurements.

In addition to the 2017 and 2022 reports, Fluxsense Inc. also conducted a set of comparative measurements to characterize and quantify emissions of NMVOCs from a subset of small oil and gas sources in the South Coast region (SCAQMD, 2015a). Preliminary results found elevated levels of alkanes (~3,200 ppb) and benzene (21 ppb) downwind from a small oil treatment facility. Instantaneous elevated concentrations of benzene were detected near three oil well sites on multiple days, and follow-up inspections confirmed the presence of leaks as the source of these elevated benzene levels (SCAQMD, 2015a). Main findings from this study suggest (1) small sources like oil wells likely contribute substantially to total NMVOC emissions from stationary sources, and (2) oil wells may contribute to total NMVOC emissions more than previously thought (SCAQMD, 2015a).

The SCAQMD's Multiple Air Toxics Exposure Study IV (MATES IV), released in 2015, estimated the emissions contribution of various oil and gas processes, including upstream OGD activities such as oil production, in the South Coast Air Basin (SCAQMD, 2015b). A comparison of emissions estimates from major source categories found OGD (i.e., upstream activities) in the South Coast Air Basin to contribute significantly to total emissions of TACs and NMVOCs from oil and gas sources (e.g., midstream activities like refining) (SCAQMD, 2012). Emissions from upstream oil and gas activities (e.g., production) accounted for 17.4% (~57 lbs/day) of benzene emissions; 7.2% of formaldehyde (~70.6 lbs/day); 100% of diesel particulate matter (DPM) (~25 lbs/day); and 100% of fine DPM (~24 lbs/day) emitted by oil and gas upstream and midstream sources (e.g., petroleum production, refining, and marketing) (**Table 4.5**). Similarly, upstream oil and gas sources accounted for 77.5% of NO_x emissions (~1,380 lbs/day) and 7.7% of CO emissions (~1,200 lbs/day) emitted by midstream and upstream oil and gas sources in 2012. Both of these constituents are ozone precursors and contribute to the secondary formation of $PM_{2.5}$.

We compared these 2012 estimates to 2018 CAP emission estimates provided in Appendix I of South Coast's *Draft 2021 PM_{10} Maintenance Plan for the South Coast Air Basin* (SCAQMD, 2021). These estimates, included in **Table 4.5**, show that emissions from the oil and gas industry

decreased from 2012 to 2018 for all CAPs, with the exception of NO_x emissions (increased by ~140 lbs/day). While total emissions from oil and gas sources generally decreased over time, emissions from upstream oil and gas production sources, such as oil and gas well sites did not. Total organic gas emissions from upstream production sources increased by ~5,420 lbs/day from 2012 to 2018; NMVOCs by ~1,700 lbs/day; CO and NO_x by ~60 lbs/day; and SO_x emissions by ~120 lbs/day (SCAQMD, 2012, 2021).

This trend is more clearly defined when the contribution from upstream oil and gas activities in 2012 is compared to emissions in 2018. Oil and gas production contributed 3.5% of total oil- and gas-related NMVOC emissions in 2012, while in 2018, oil and gas production accounted for 10.2% of emissions. A similar trend can be seen when comparing SO_x estimates. In 2012, production accounted for 1.7% of emissions whereas in 2018, production was responsible for 21.9% of total SO_x emissions from oil and gas sources. The large reductions in midstream oil and gas processes that have been achieved (e.g., petroleum refining), suggest it is possible to reduce emissions from upstream oil and gas production sites. CAPs from oil and gas production that increased from 2012 to 2018 are highlighted in red in **Table 4.5**. Note that we converted all estimates to pounds per day (lbs/day) for ease of comparison.

Table 4.5. 2012 and 2018 emissions (lbs/day) by major relevant source category for the South Coast Air Basin. We did not compare 2018 estimates of TACs to 2012 concentrations, as 2018 estimates were not readily available. This is noted in cells with "NA". Source: Adapted from Appendix VIII, SCAQMD (2012), and Appendix I, SCAQMD (2021).

Code	Source Category	TOG	VOC	CO	NO_x	SO_x	TSP	PM_{10}	$PM_{2.5}$	Benzene	Formaldehyde	Toluene	Diesel PM	$DPM_{2.5}$	Elemental carbon	$EC_{2.5}$
		2012 Criteria Air Pollutants (lbs/day)								*2012 Constituents of Concern (lbs/day)*						
30	***Oil and Gas Production (Combustion)***	***1,760.0***	***200.0***	***1,080.0***	***1,220.0***	***20.0***	***200.0***	***200.0***	***200.0***	***25.4***	***60.7***	***12.6***	***25.0***	***24.2***	***51.2***	***50.8***
40	Petroleum Refining (Combustion)	8,840.0	2,560.0	10,120.0	0.0	0.0	3,240.0	3,120.0	3,080.0	12.8	284.4	6.3	0.0	0.0	453.6	441.4
310	***Oil and Gas Production***	***4,760.0***	***2,700.0***	***120.0***	***160.0***	***0.0***	***20.0***	***20.0***	***20.0***	***31.7***	***9.9***	***17.5***	***0.0***	***0.0***	***7.1***	***7.1***
320	Petroleum Refining	12,280.0	8,220.0	9,960.0	380.0	1,120.0	5,680.0	3,640.0	3,160.0	46.5	621.2	98.0	0.0	0.0	235.1	240.8
330	Petroleum Marketing	235,840.0	69,340.0	0.0	20.0	20.0	0.0	0.0	0.0	211.2	0.0	2,926.1	0.0	0.0	0.2	0.2
399	Other (Petroleum Production and Marketing)	40.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.7	0.0	0.0	0.5	0.5
Total emissions from O&G (2012)		**263,520**	**83,060**	**21,280**	**1,780**	**1,160**	**9,140**	**6,980**	**6,460**	**328**	**976**	**3,061**	**25**	**24**	**748**	**741**
% of emissions from upstream activities		***2.5%***	***3.5%***	***5.6%***	***77.5%***	***1.7%***	***2.4%***	***3.2%***	***3.4%***	***17.4%***	***7.2%***	***1.0%***	***100.0%***	***100.0%***	***7.8%***	***7.8%***
		2018 Criteria Air Pollutants (lbs/day)								*2018 Constituents of Concern (lbs/day)*						
30	***Oil and Gas Production (Combustion)***	***2,220.0***	***240.0***	***1,220.0***	***1,420.0***	***20.0***	***200.0***	***180.0***	***180.0***	***NA***	***NA***	***NA***	***NA***	***NA***	***NA***	***NA***
40	Petroleum Refining (Combustion)	12,960.0	2,660.0	9,740.0	0.0	20.0	3,560.0	3,540.0	3,540.0	NA	NA	NA	NA	NA	NA	NA
310	***Oil and Gas Production***	***9,720.0***	***4,360.0***	***40.0***	***20.0***	***120.0***	***80.0***	***60.0***	***40.0***	***NA***	***NA***	***NA***	***NA***	***NA***	***NA***	***NA***
320	Petroleum Refining	12,700.0	8,860.0	4,780.0	460.0	480.0	3,740.0	2,500.0	1,760.0	NA	NA	NA	NA	NA	NA	NA
330	Petroleum Marketing	109,580.0	27,600.0	460.0	0.0	0.0	20.0	0.0	0.0	NA	NA	NA	NA	NA	NA	NA
399	Other (Petroleum Production and Marketing)	1,200.0	1,160.0	20.0	20.0	0.0	0.0	0.0	0.0	NA	NA	NA	NA	NA	NA	NA
Total emissions from O&G (2018)		**148,380**	**44,880**	**16,260**	**1,920**	**640**	**7,600**	**6,280**	**5,520**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
% of emissions from upstream activities		***8.0%***	***10.2%***	***7.7%***	***75.0%***	***21.9%***	***3.7%***	***3.8%***	***4.0%***	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Oil and gas production emissions (2012)		**6,520**	**2,900**	**1,200**	**1,380**	**20**	**220**	**220**	**220**	**57**	**71**	**30**	**25**	**24**	**58**	**58**
Oil and gas production emissions (2018)		***11,940***	***4,600***	***1,260***	***1,440***	***140***	***280***	***240***	**220**	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

For many air pollutants, upstream OGD contributes relatively less emissions than other pollution sources at a regional scale. For example, benzene emissions from oil and gas production accounted for <1% of total emissions from all major sources in the South Coast (SCAQMD, 2012). This is consistent with previous emissions inventory studies conducted in the South Coast Air Basin (Brandt et al., 2015), which also found upstream oil and gas sources contribute <1% of total emissions from all major sources in the South Coast region. However, as noted above, emissions from upstream OGD contribute substantially to localized air pollution near wells.

Mellqvist et al. (2019) estimates emission fluxes (kg/hr) of ammonia, alkanes, SO_x, NO_2, BTEX, methane, and formaldehyde from oil and gas sources in the San Joaquin Valley using a mix of methods similar to those implemented in Mellqvist et al. (2017). Sites were surveyed over a three-week period in October 2019. The first two weeks were dedicated to surveying emissions from the Lost Hills oil and gas production area, while the last week was dedicated to sampling of different oil and gas sources in the San Joaquin Valley, specifically the Cymric, McKittrick, and Belridge oil fields, as well as emissions from produced ponds in the Cymric/McKittrick and Taft fields (Mellqvist et al., 2019).

Average emission fluxes from the Lost Hills oil and gas production area were estimated to be 522 kg/hr for alkanes, and 244 kg/hr for methane emissions over the sampling period (**Table 4.6**) (Mellqvist et al., 2019). Higher average emission fluxes were observed from the Cymric & McKittrick oil and gas production area, with estimated alkane and methane fluxes of 1,380 and 2,430 kg/h over the sampling period (Mellqvist et al., 2019, see Table S1). The highest average alkane flux of 2,970 kg/h was observed in the Cymric & McKittrick Belridge production area (Mellqvist et al., 2019, see Table S1). Larger sources of emissions were found to occur during workover activities and activities at other oil rigs, as well as from vacuum trucks accessing the oil and gas field, with the largest permanent source of emissions attributed to separators operating within the field.

Finally, a neighborhood health investigation conducted at the AllenCo Energy Facility, located in the University Park Community in Los Angeles, found the facility's operational emissions to adversely affect the health of nearby residents (LACDPH, 2018). The AllenCo facility consisted of seven oil production wells on-site, and an additional 14 production wells located at various locations nearby, with the closest resident located 60 feet (18 m) from an active well. Between 2010 to 2014, the SCAQMD received nearly 300 odor complaints, conducted 150 inspections, and issued 18 notices of violation (SCAQMD, 2018b). Complaints from University Park residents were recurrent and included reports of headaches, nausea, and irritation to the eyes, nose, throat and airway (LACDPH, 2018).

Sampling results in 2011 indicated very low levels of H_2S emissions; however, the U.S. Environmental Protection Agency (EPA) and county health investigators suspected that constant exposure to even low levels of pollutants such as H_2S were associated with the symptoms reported by community members (Sahagun, 2013a, 2013b). Additionally, one sample, taken from a wastewater tank discharge line, found hydrocarbon levels to be 10,000 times higher than ambient concentrations (Sahagun, 2013a). As stated by the Los Angeles County Department of Public Health (LACDPH), the petroleum-based compounds emitted at the AllenCo facility appeared to be "well below levels that would lead to long-term systemic health effects. However,

intermittent exposure to low level emissions can cause recurrent short-term health effects with symptoms consistent with those reported by neighboring residents" (LACDPH, 2018). The Director of Environmental Health for Los Angeles County agreed with this conclusion, stating that symptoms described by nearby residents "are not inconsistent with what we would expect to see after exposure to low levels of hydrocarbons. So, while the detectable concentrations of hazardous pollution may be below regulatory standards, they are nonetheless making people sick" (Los Angeles Times, 2013b).

4.2.2.2 Source assessment studies conducted outside California

A total of 20 peer-reviewed studies focused on air monitoring and modeling of air pollutant emissions from upstream OGD outside of California. Four were conducted in Pennsylvania (Goetz et al., 2015, 2017; Maskrey et al., 2016; Yuan et al., 2015), seven were conducted in Texas (Allen, 2016; Brantley et al., 2015; Marrero et al., 2016; Rich & Orimoloye, 2016; Roest & Schade, 2017; Zhou et al., 2021; Zielinska et al., 2014), three were conducted in Utah (Ahmadov et al., 2015; Helmig et al., 2014; Koss et al., 2015; Oltmans et al., 2016), two were conducted in Colorado (Hecobian et al., 2019; Milford, 2015), one was conducted in West Virginia (McCawley, 2015), and two were conducted across multiple states (Eisele et al., 2016; Johnson et al., 2018).

Texas

Studies in Texas found upstream OGD to have a significant impact on air quality. Rich & Orimoloye (2016) assessed air quality as a function of distance and found concentrations of various TACs, including benzene, to be higher in close proximity to active upstream OGD. Zielinska et al. (2014) found air quality impacts beyond a distance of approximately 100 m (328 ft) from gas wells and compressor stations in the Barnett Shale region to be indiscernible from background levels, suggesting that higher concentrations close to activity are observed. Source apportionment results from Zielinska et al. (2014) also demonstrate the significant contribution to regional NMVOCs from gas production sources in the Barnett Shale region, especially for alkanes with a low molecular weight. This corresponds with a study conducted in the Eagle Ford Shale, which estimated NMVOC emissions from the largest oil and gas facilities in the state (Zhou et al., 2021). Similarly, Eisele et al. (2016) measured NMVOC concentrations at an oil and gas site in the Texas Barnett Shale and found BTEX and styrene concentrations sampled within 60 m (197 ft) of the well site to be significantly higher than concentrations sampled 195 – 290 m (640 – 951 ft) from the site.

Marrero et al. (2016) collected whole air samples upwind and downwind from a number of upstream oil and gas sources in Texas. The authors found the highest hexane and m- & p-xylene mixing ratios to be observed downwind of well pads with compressors, where methane leak rates were highest; the highest toluene and benzene mixing ratios were found near oil-producing wells. Estimates of hexane, benzene, and toluene in Texas were consistent with estimates in Colorado and Utah, suggesting that there may be some consistency in emissions profiles from upstream OGD across geographic regions (Marrero et al., 2016). Findings from another Texas-based study suggests that a small number of upstream oil and gas sources are responsible for a significant portion of methane and NMVOC emissions ("super emitters") (Allen, 2016). While it is still

uncertain why specific sites become super emitters over other upstream sites, the evidence suggests that differences in operational practices at well sites, as well as operational failures of high-emitting oil and gas components like pneumatic controllers and compressors, are potential factors (Allen, 2016).

Findings from Roest & Schade (2017) in Texas confirmed methane and non-methane hydrocarbons are indeed co-emitted from liquid storage tanks, with alkane mixing ratios increasing in the Eagle Ford Shale region in tandem with increasing oil and gas production rates. The largest fraction of methane emissions identified in Brantley et al. (2015) were found in tank samples collected from a dehydrator (64.4%), which is a device used to remove excess water vapor from gas (Brantley et al., 2015).

Pennsylvania

In the Marcellus Shale region of Pennsylvania, Goetz et al. (2015) performed a tracer study 480–1,100 m (1,575–3,609 ft) downwind of several gas facilities (eight compressor stations, two transient well pads for drilling and completion, and four production well pads) to measure and compare methane, ethane, and combustion by-product emission rates. They observed compressors and transient sites, followed by production sites to be the largest emitters of methane, CO, NO_x, and CO_2. The greatest ethane emission rates were measured at well production sites, although ethane emission rates were not reported for transient sites. They did not detect benzene or toluene in any plumes downwind of the sites, and detected elevated levels of methanol in only one plume downwind of a compressor site.

This is consistent with findings from Goetz et al. (2017), which identified gas well pads as significant sources of methane, ethane, and CO, but not major contributors of toluene and benzene. This may be due to the presence of dry-gas wells in the northeast region, as opposed to wet gas, which is composed of methane and other light alkanes (Goetz et al., 2017). Ethane to methane enhancement ratios were found to be consistent with ratios similar to dry gas, consistent with this hypothesis. Another Pennsylvania study (Yuan et al., 2015) found methane to benzene enhancement ratios to be consistent with emissions signatures associated with upstream OGD. The authors note that ~10% of facilities (e.g., gas processing facilities, compressor stations) accounted for ~40% of methane emissions observed in the monitored regions, highlighting the potential presence of super-emitting facilities that require further mitigation. One study conducted in Pennsylvania found operations at the well pad did not significantly impact local air concentrations of $PM_{2.5}$ and NMVOCs (Maskrey et al., 2016).

Utah

In Utah's Uintah Basin, surface and vertical profile observations of NMVOCs identified highly elevated levels of atmospheric NMVOCs, including benzene and toluene, at 200−300 times above the regional and seasonal background during temperature inversion events in 2013 (Helmig et al., 2014). These observations suggest a causal link between oil and gas emissions and, accumulation of TACs in the atmospheric surface layer. Another study in Utah found methane emissions from a gas field to be significantly correlated with levels of ethane, propane, n-butane,

i-pentane, n-pentane, hexane, benzene, heptane, toluene, octane, and xylenes (Oltmans et al., 2016). Emissions were traced to several upstream sources, including numerous well sites, gathering pipelines, compressor stations and two large processing plants. Consistency in the distribution of these NMVOCs with methane distributions suggests they are co-emitted (Oltmans et al., 2016). A 2015 study in the Uintah Basin found pollutant emission ratios to be consistent with contributions of emissions from oil and gas producing wells (Koss et al., 2015). In addition, the methane emission rate, extrapolated from the emission rate for benzene, was consistent with an independent evaluation of methane emissions using aircraft measurements (top-down) from 2012. Another Utah-based study evaluated emissions from oil and gas operations using a top-down (i.e., aircraft measurements) and bottom-up (i.e., emissions inventory) approach (Ahmadov et al., 2015). They found high emissions of NMVOCs compared to emissions of NO_x, suggesting oil and gas operations are a significant source of ozone in the region.

Colorado

In Colorado, Hecobian et al. (2019) found variations in measured emission rates of TACs and NMVOCs at the various stages of production in the Denver-Julesburg and Piceance Basins in Colorado. Emission rates differed depending on the basin and phase of production, with flowback operations accounting for the highest levels of light and heavy alkane (e.g., n-hexane, n-heptane) emissions among all the sites sampled. Drilling and production activities produced elevated levels of light alkane emissions (e.g., ethane, propane, n-butane), but at much lower levels than during hydraulic fracturing and flowback operations. When the duration of operations is considered, however, drilling and production activities could still present a significant risk, as drilling and production activities (including conventional methods) are continuous (e.g., ≥8 hours per day) and generally fixed in one location (i.e., longer exposure duration), whereas stimulation treatments and flowback operations occur over shorter intervals (e.g., 5 hours of operation per day) and move from location to location (Hecobian et al., 2019). Similarly, Eisele et al. (2016) measured NMVOC emissions at oil and gas sites in Colorado and Texas and found benzene and toluene concentrations at the well pad to be significantly higher in the Denver-Julesburg Basin compared to downtown Denver.

These findings are consistent with findings from Milford (2015), which identified diesel-powered drill rigs and natural gas-powered compressor stations as the largest contributors to emissions of NO_x in Colorado. In addition to NO_x, large reciprocating natural-gas powered compressors are significant sources of NMVOCs, CO, PM, CO_2, and methane; diesel fuel-powered drill rigs are significant sources of PM, NMVOCs, and sulfur dioxide (SO_2) (Milford, 2015). The largest NMVOC emissions were attributed to "flashing losses from crude oil and condensate storage tanks, fugitive emissions from leaks in valves, fittings and other equipment, venting of hydrocarbons from completions and blowdowns, venting from glycol dehydration units and gas-driven pneumatic devices" (Milford, 2015).

The intensive use of service trucks, horizontal drilling rigs, and hydraulic fracturing pumps during unconventional OGD in the United States, all of which are typically diesel fuel-powered, are also sources of air pollution. Johnson et al. (2018) found engines used during hydraulic fracturing

activities to produce the largest amount of NO_x emissions, drilling rigs produced large amounts of CO emissions, and diesel-powered trucks produced the largest total hydrocarbon emissions of all phases evaluated. McCawley (2015) evaluated releases from drill sites in West Virginia using tapered element oscillating microbalance (TEOM) 24-hour dust samples and found $PM_{2.5}$ and PM_{10} concentrations to not exceed 24-hr NAAQS. Average concentrations of ammonia, NO_X, ozone, and SO_2 "did not indicate a concern for ambient or occupational exposures," though the author did not offer direct comparison to standards for these pollutants (McCawley, 2015).

4.2.2.3 Exposure assessment studies conducted in the U.S.

The majority of exposure assessments found in the peer-reviewed literature and in government-sponsored reports were conducted outside of California. We identified 12 exposure assessment studies: three in California (CARB, 2021b; Deschenes et al., 2021; Garcia-Gonzales et al., 2019b); one in Colorado (Esswein et al., 2014); five in Pennsylvania (Banan & Gernand, 2018, 2021; Brown et al., 2015; Long et al., 2019, 2021); and three across multiple states (Garcia-Gonzales et al., 2019a; Haley et al., 2016; Macey et al., 2014).[3]

Garcia-Gonzales et al. (2019b) evaluated the distance decay gradient of air pollutant exposures from upstream OGD, and the potential impacts to health for residents in Los Angeles. The authors selected a facility in the West Adams community of South Los Angeles. Referred to as the Jefferson drill site, this facility is one of the top producers of oil and gas in California, operating 20 active oil and gas wells at the time of sampling and producing a total 8,890 million cubic feet (Mcf) of gas and 8,553 barrels (bbls) of oil in February 2016 alone. Homes within the West Adams community are located as close as 60 ft (18 m) to an active wellhead, exposing residents to health-damaging air pollutants released during operation.

The authors placed passive samplers at 11 home sites, three at the fence line of the Jefferson drill site (approximately 804 ft [245 m] from an active wellhead), and one approximately 2,460 ft (750 m) from the Jefferson drill site to act as a control. Pollutants were sampled for a two-week period and included measurements of n-pentane, n-hexane, benzene, and 2-butoxyethanol, all of which are known to be associated with upstream OGD (Garcia-Gonzales et al., 2019b). N-pentane, n-hexane, and benzene were found to be above the limit of detection for all samples (including the control), with the two-week time weighted average concentration being 0.51, 0.43, and 1.07 ppb, respectively (Garcia-Gonzales et al., 2019b). Benzene and n-hexane concentrations exceeded those found in the SCAQMD's MATES IV report on air quality in central Los Angeles (SCAQMD, 2015b).

Results from the distance decay analysis show a clear trend of decline in pollutant concentrations as you move away from the Jefferson drill site (Garcia-Gonzales et al., 2019b). To the east of the drill site (downwind), benzene concentrations decayed to background levels at 427 ft (130 m) from the closest wellhead, n-hexane concentrations decayed to background at 640 ft (195 m), and n-pentane concentrations decayed to background at 542 ft (165 m). To the west of the site

[3] Radioactive materials can also spread through airborne transport. However, this section does not include exposure assessments focused on radioactivity from OGD. For more information related to OGD and radioactive materials, see Chapter 2.

(upwind), n-pentane concentrations were highest near the facility; benzene and n-hexane concentrations, however, exhibited the opposite trend, increasing as distance from the facility increased. This pattern likely indicates the presence of other sources of pollution upwind from the Jefferson drill site, such as combustion emissions from the four-lane arterial roadway just west of the site. Results from the distance decay analysis suggest that residences downwind (east) from the Jefferson drill site are exposed to a higher pollution burden, with benzene concentrations increasing by 9%, n-hexane by 22%, and n-pentane by 24% from activity.

The Study of Neighborhood Air near Petroleum Sources (SNAPS) is a program under CARB that evaluates short-term, intensive air quality monitoring results in relation to proximity to oil and gas production facilities and other pollution sources in California (CARB, 2021b). For each site and community of interest, CARB staff will deploy stationary trailers equipped with sensors to measure ambient concentrations of NMVOCs, PM, metals, and CAPs for approximately one year (CARB, 2021b). Communities selected for the first round of monitoring include (1) Lost Hills, Lost Hills Oil Field, Kern County; (2) McKittrick and Derby Acres, McKittrick Oil Field and Midway-Sunset Oil Field, Kern County; (3) Baldwin Hills, Inglewood Oil Field, Los Angeles County; and (4) South Los Angeles, Las Cienegas Oil Field, Los Angeles County (CARB, 2018a).

The first and only site to undergo monitoring efforts at the time this report was prepared was the Lost Hills community neighboring the Lost Hills Oil Field in Kern County (CARB, 2018a). Monitoring efforts occurred over the course of a year starting in June 2019 and ending on April 29, 2020. CARB published preliminary data and analysis in a mid-monitoring update from the Lost Hills sampling campaign (CARB, 2019b). Of the 135 organic chemicals sampled each week, 10 were detected near the Lost Hills oil field, including TACs commonly associated with upstream oil and gas facilities such as benzene and H_2S (CARB, 2019b). Twenty-four metals were also detected during the sampling campaign, with concentrations of silicon, aluminum, calcium, and iron found to be higher on windy days, suggesting the source is from fugitive emissions of crustal dust at the site. On-site measurements of ozone and $PM_{2.5}$ used to estimate the air quality index (AQI) at the site found the AQI to be at "good" levels 53.8% of the time, at "moderate" levels 46% of the time, and at unhealthy levels for sensitive groups 0.2% of the time (CARB, 2019b). Preliminary findings demonstrate that all concentrations of detected pollutants were below the acute reference exposure threshold for those pollutants with state designated RELs.

A 2021 study evaluated the potential air quality impacts from oil and gas production under two different policy levers aimed at reducing oil and gas-related pollutant emissions in California (Deschenes et al., 2021). The first policy lever includes the implementation of either (1) a statewide oil production quota (potentially implemented through auctioned extraction permits), or (2) an equivalent tax on extraction for all new and existing wells, first from fields with more costly extraction then from less costly extraction fields. Results from this assessment found that tighter statewide crude oil production quotas not only lowers local air pollution exposure across California, but it also has an equity co-benefit by minimizing the gap in pollution exposure for disadvantaged communities (Deschenes et al., 2021). Furthermore, if the production quota is implemented through auctioned extraction permits, the additional state funding could be directed towards decarbonization efforts.

The second policy lever implements setback distances that prohibit extraction from new and

existing oil wells within a certain distance of occupied areas at risk of exposure, including residences, schools, childcare and healthcare facilities, among others. Setback policies are more effective at mitigating harmful pollutant exposures than they are at achieving full decarbonization. However, setback policies would have a substantial impact on direct exposures to pollutant emissions from oil production for those living near oil well sites. Deschenes et al. (2021) found that a setback distance to wells of 2,500 ft (762 m) from residences, schools, playgrounds, childcare centers, elderly care and healthcare facilities would achieve a 49% reduction in greenhouse gas (GHG) emissions from 2019–2045. Finally, if the two policies were both implemented, the same improvements would be observed in aggregate with slightly fewer job losses.

Studies conducted in other states also found elevated levels of NMVOCs and TACs near oil and gas operations. An occupational exposure assessment conducted in Colorado by Esswein et al. (2014) found inhalation risks to oil and gas workers from benzene exposure to be associated with the amount of time spent working in close proximity to specific oil and gas operations (Esswein et al., 2014). Banan & Gernand (2018) measured $PM_{2.5}$ concentrations at varying locations around a typical well site (six wells per pad) in the Marcellus Shale in Pennsylvania in 2015 and concluded that the state's current setback distance policy of 152 m (500 ft) (58 PA. Cons. Stat. § 3215) is insufficient at protecting the public health of nearby residents. Results demonstrate that $PM_{2.5}$ concentrations 152 m (500 ft) away from a generic well site frequently exceeded the U.S. EPA's NAAQS health-protective (primary) standard annual average level of 12 $\mu g/m^3$ for $PM_{2.5}$ (Banan & Gernand, 2018). The authors recommend that Pennsylvania establish a minimum setback distance of 736 m (2,415 ft) to ensure compliance with health-protective (and other safety) thresholds for those individuals living within this radius of an active well site (Banan & Gernand, 2018).

Banan & Gernand (2021) also evaluated $PM_{2.5}$ concentrations in 2017 at varying locations around Pennsylvania well sites in relation to nearby populations. Consistent with findings from Banan & Gernand (2018), this study found that doubling the current setback distance to a distance of 305 m (1,000 ft) — from the current 152 m (500 ft) policy — would reduce the total number of $PM_{2.5}$ exceedances by 95% (Banan & Gernand, 2021). Brown et al. (2015) assessed air quality as a function of distance and found concentrations of various TACs in Pennsylvania, including benzene, to be higher in close proximity to active upstream OGD. Long et al. (2019) evaluated concentrations of 11 air pollutants[4] associated with upstream OGD in Pennsylvania and found a small fraction of measurements to exceed the acute and chronic "health-based air comparison values" in the Marcellus shale region ("peak" emissions), consistent with findings from Banan & Gernand (2018, 2021).

A minority of Pennsylvania studies found operations at the well pad to not significantly impact local air concentrations of $PM_{2.5}$ and NMVOCs (Long et al., 2021). Results summarized in Long et al. (2021) found all measurements of $PM_{2.5}$ and NMVOC monitoring at three locations approximately 1,000 ft to 2,800 ft (304 m to 853 m) away from a well pad to be "below health-

[4] $PM_{2.5}$, NO_2, SO_2, BTEX, acetaldehyde, formaldehyde, n-hexane, and H_2S.

based air comparison values, and thus do not provide evidence of either 24-hour or long-term air quality impacts of potential health concern at the school."

Consistent with findings in California, Colorado, and Pennsylvania, benzene is observed across the majority of studies investigating TACs associated with upstream OGD in the United States, regardless of the geographic focus of each study (Garcia-Gonzales et al., 2019a.). For example, Macey et al. (2014) assessed air emissions associated with upstream oil and gas activities in various locations within the United States and found significant concentrations of benzene and formaldehyde across Wyoming, Pennsylvania, and Arkansas (Macey et al., 2014). Upstream OGD operations in Wyoming and Pennsylvania were both found to have benzene concentrations in exceedance of acceptable risk levels (Macey et al., 2014). Macey et al. (2014) also found formaldehyde concentrations near compressor stations in Wyoming, Pennsylvania, and Arkansas that exceeded health-protective thresholds. Elevated levels of H_2S were found near sites in Colorado and Wyoming as well (Macey et al., 2014). Haley et al. (2016) evaluated setback policies in three oil and gas producing states (Colorado, Pennsylvania, and Texas) and found them all to be insufficient at protecting human health, allowing human exposure above the established limits for benzene and H_2S to occur.

4.2.2.4 Health risk assessments conducted in the U.S.

We identified six health risk assessment studies focused on upstream OGD exposure in the United States. These studies place findings in the context of human health by estimating potential cancer and/or non-cancer health risks from exposure to observed pollutant concentrations. The majority of studies were conducted in Colorado (Holder et al., 2019; McKenzie et al., 2012, 2018; McMullin et al., 2018), with only one study conducted in California (Shonkoff & Hill, 2020) and one study conducted in Texas (Bunch et al., 2014).

Shonkoff & Hill (2020) evaluated air monitoring data collected by independent consultants with guidance from CARB (CARB, 2018b). Air sampling occurred in five oil fields in the San Joaquin Valley and Kern County regions (North and South Belridge, Buena Vista Nose, Elk Hills, and Lost Hills) in California from December 2016 to December 2018. This study was conducted as a joint effort by CARB and the California Geologic Energy Management Division (CalGEM, formerly known as the Division of Oil, Gas and Geothermal Resources [DOGGR]). 8-hr continuous samples were taken at eight sites within 300 to 500 ft (91 m to 152 m) of an oil and gas well undergoing well stimulation activities; in addition, measurements were taken at the perimeter of the well during cleaning activities post-stimulation. Sampling efforts sought to collect air monitoring data at locations representative of the background (air quality of the general oil field) and ambient concentrations (regional air quality away from oil and gas activity) for the region, to act as a control for comparison to emissions from well stimulation activities, specifically (CARB, 2018b).

Shonkoff and Hill (2020) relied upon the Office of Environmental Health Hazard Assessment's (OEHHA) health risk assessment guidance to evaluate cancer and noncancer health risks from oil and gas exposure. Lifetime excess cancer risk was estimated by multiplying the average daily inhalation dose by the cancer potency factor, while noncancer health risks (chronic and acute

exposures) were estimated using OEHHA's RELs, the Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs), the U.S. EPA's reference concentrations, and the U.S. EPA's Provisional Peer-Reviewed Toxicity Value (Shonkoff & Hill, 2020).

Over the two-year sampling period (2016–2018), sixty-four individual compounds were detected in the 8-hr continuous samples. Of these detected compounds, 59% (38 compounds) were identified as health-relevant state- or federally-designated air pollutants[5], and 34% (22 compounds) of which are known or suspected human carcinogens (Shonkoff & Hill, 2020). Cumulative lifetime excess cancer risks were found to exceed the U.S. EPA *de minimis* threshold (1 case in one million) at each sampling location type (ambient, background, well stimulation and cleanout), with levels detected at ambient locations representing the highest lifetime cancer risks (Shonkoff & Hill, 2020). While the ambient monitoring locations were intended to act as a control, the authors note that "the proximity of off-field (ambient) locations to oil field activities and the similarities observed between off-field and on-field air quality suggest off-field (ambient) reference sites may be more reflective of oil field air quality than regional air quality" (Shonkoff & Hill, 2020). This statement is supported by evidence from a companion study, (Stringfellow & Camarillo, 2020), in which the authors concluded that the proximity of ambient sampling locations to oil and gas fields suggests that the chosen ambient sampling locations are not actually indicative of off-field air concentrations.

Excess cancer risks during both hydraulic fracturing activities and cleanout events were largely driven by concentrations of formaldehyde and benzene, with hydraulic fracturing activities resulting in a cumulative excess cancer risk of 62 in one million and cleanout events resulting in an excess cancer risk of 46 in one million, assuming continuous 8-hour exposures over a 70-year lifetime, per guidance for assessing cumulative lifetime cancer risk (Shonkoff & Hill, 2020). These findings are significant, as risks not only exceed the *de minimis* significance threshold, but they also exceed three SCAQMD significance thresholds of 1, 10, and 25 in one million, and both SJVAPCD significance thresholds of 1 and 20 in one million excess cancers (see Appendix D for more detail). Benzene was found to contribute 85% of the total cancer risk observed at these "ambient" sampling locations, a compound that is co-emitted during upstream oil and gas activities. Benzene was also the main driver for noncancer adverse health impacts associated with exposure, evidenced by the elevated acute and chronic hazard quotients (HQ, HQs>1) greater than 1, and by the elevated acute and chronic hazard indices (HI, HIs>1) at "ambient" sampling locations (Shonkoff & Hill, 2020).[6]

The authors note that these cancer risk estimates are conservative, as well stimulation treatment activities "are relatively short-lived and only represent a limited set of activities involved in OGD that warrant further investigations into potential air quality impacts" (Shonkoff & Hill, 2020). Even so, this study provides useful insight into the cumulative health risks that may be associated with oil and gas production in California. In addition, studies conducted outside of California clearly demonstrate that oil and gas production activities, when accounting for specific phases of production, emit continuous amounts of harmful air pollutants.

[5] "Health-relevant air pollutants" include state designated TACs and federally designated TACs.
[6] See Appendix D for description of HQs and HIs and how they are estimated.

Studies conducted in Colorado also suggest that significant health risks exist to residents as a function of proximity to upstream oil and gas activity. Holder et al. (2019) clearly demonstrates that cancer risks and noncancer health risks associated with acute, subchronic and chronic exposures are reduced as distance from oil and gas sites increases. Holder et al. (2019) also found potential for noncancer adverse health effects associated with acute exposures to 2-ethyltoluene, 3-ethyltoluene, toluene, and benzene, and for respiratory, nervous, and hematologic (i.e., blood) target organ systems. These results applied to the highest-exposed hypothetical individuals and were found to persist out to 2,000 ft (610 m) for benzene exposure, as well as for neurologic and hematologic effects.

McKenzie et al. (2012) also found noncancer health risks associated with subchronic exposures as well as cancer risks, to be greater for residents living within ½ mi (2,640 feet, 805 m) from oil and gas wells, as compared to those living beyond ½ mi (2,640 feet, 805 m). These findings are specific to respiratory, neurological and hematological target organ systems. Increased risk was driven primarily by exposure to trimethylbenzenes, xylenes, and aliphatic hydrocarbons; slightly elevated excess lifetime cancer risk estimates were also driven by benzene exposure (McKenzie et al., 2012).

McKenzie et al. (2018) found that lifetime excess cancer risks exceeded the U.S. EPA *de minimis* threshold (1 case in one million) at all locations, including background, and began to increase over background at 501 to 610 m (1,673 ft to 2,000 ft). While cancer risk associated with exposure to benzene exceeded the U.S. EPA *de minimis* threshold across all distances examined, McKenzie et al. (2018) observed that lifetime excess cancer risk clearly increases with proximity to upstream OGD. Considering air monitoring data collected within 350 to 3,700 ft (107 m to 1128 m) of oil and gas sites in Colorado, lifetime excess cancer risks were estimated at 4.3 cases per 100,000 individuals, also exceeding the U.S. EPA *de minimis* threshold by more than an order of magnitude (McMullin et al., 2018). The lifetime excess cancer risk estimate reported by McMullin et al. (2018) also fell within the range reported by McKenzie et al. (2018) within similar distances from oil and gas sites (5.7 cases per 100,000 compared to one case per 10,000).

It is important to note that Holder et al. (2019) only considered cancer risks associated with exposure to benzene and did not consider exposures to other possible or probable carcinogens, as did McKenzie et al. (2018) and McMullin et al. (2018). Holder et al. (2019) recognize that because they only considered benzene, total cancer risks were likely underestimated, although the degree of underestimation is unknown. Despite this limitation, they found that excess lifetime cancer risk below the U.S. EPA *de minimis* threshold was only achieved at a distance beyond 1,800 ft (549 m) from the well pad when considering various combinations of benzene exposure and risk estimate scenarios.

Numerous oil and gas-associated TACs have been detected at distances beyond 500 ft (152 m) from the well pad, out to distances of approximately 1,600 m (1 mi) (McKenzie et al., 2018). Consistent with findings in California, Colorado, and Pennsylvania, benzene is observed across the majority of studies investigating TACs associated with upstream OGD in the United States, regardless of the geographic focus of each study (Garcia-Gonzales et al., 2019a; Haley et al., 2016; Macey et al., 2014).

In addition to the acute and chronic health outcomes documented, many oil and gas pollutants also have endocrine-disrupting properties. Endocrine disruptors can cause harmful effects at low doses and the timing of exposure influences the risk of outcome (Bolden et al., 2018). Furthermore, risk assessment studies often do not account for the full suite of air contaminants near oil and gas sites and are likely underestimating cancer and non-cancer health risks, particularly for compounds that affect similar adverse pathways, and are likely to adversely impact vulnerable population groups.

One study in Texas, Bunch et al. (2014), did not find a positive correlation between proximity to oil and gas activity and air pollutant concentrations. This may be due to the fact that the study relied upon regional concentrations of pollutants in Texas rather than samples conducted at the community level; community level sampling often captures differences in local emissions concentrations and are therefore more relevant to human health exposure than regional sampling efforts (Shonkoff & Gautier, 2015).

4.2.3. Summary of findings

The body of literature focused on oil and gas-associated air pollution exposures provides sufficient evidence that upstream OGD may present risks to human health.

4.2.3.1 California studies

Source assessment studies conducted in California found upstream oil and gas activities to be a substantial source of air pollutant emissions. Studies were conducted in Los Angeles and/or the South Coast region (Collier-Oxandale et al., 2020; Johnston et al., 2021; LACDPH, 2018; Mellqvist et al., 2017; Okorn et al., 2021; SCAQMD, 2015a, 2015b); the San Joaquin Valley (Mellqvist et al., 2019); and across OGD regions in California (Gonzalez et al., 2022).

The majority of studies focused on NMVOC and TAC emissions from and near upstream oil and gas activities. Findings from Johnston et al. (2021) show concentrations of methane, NMVOCs, BTEX, styrene, n-hexane, n-pentane, ethane, and propane to decrease once production at the site idled, with n-hexane decreasing by 68%, benzene decreasing by 32%, and toluene decreasing by 28%. The authors found oil and gas drilling during the active phase to contribute 23.7% of the total NMVOCs measured (Johnston et al., 2021). Two studies found high rates of total alkanes (e.g., pentane, hexane) associated with upstream OGD (Mellqvist et al., 2017, 2019). Mellqvist et al. (2017) found releases from oil and gas wells to be responsible for more than 50% of total alkane emissions surveyed.

Collier-Oxandale et al. (2020) and Okorn et al. (2021) both found elevated levels of non-methane hydrocarbons near oil and gas wells (e.g., within 1,640 ft [500 m] of activity as stated by Okorn et al., 2021). Results suggest that sources of combusted and volatilized hydrocarbons were likely impacting air quality throughout the surrounding community as well as near the oil and gas site (Collier-Oxandale et al., 2020), and that large, short-term increases in non-methane hydrocarbon emissions tend to occur more frequently in close proximity to activity (Okorn et al., 2021). LACDPH (2018) found hydrocarbon levels at a large production facility to be 10,000 times higher than ambient levels.

The SCAQMD's MATES IV study found oil and gas production to contribute a significant portion of formaldehyde, DPM, fine DPM, NO_x and CO emissions of major upstream oil and gas sources (SCAQMD, 2015b). Controlling for geographic, seasonal, meteorological, and time-trending factors, Gonzalez et al. (2022) observed elevated concentrations of $PM_{2.5}$, CO, NO_2, ozone, and NMVOCs downwind of wells on days with oil and gas activities, as far as 4 km away (13,123 ft). The most commonly detected constituents of concern near oil and gas sites were benzene, a known human carcinogen, and methane.

We identified three exposure assessments (CARB, 2021b; Deschenes et al., 2021; Garcia-Gonzales et al., 2019b) and one health risk assessment (Shonkoff & Hill, 2020) conducted in California. In a preliminary analysis, using preliminary data from the first few months of monitoring, CARB (2021b) detected 10 chemicals near active oil fields, including benzene and H_2S; measurements of ozone and $PM_{2.5}$ found the AQI on-site to be at "good" levels 53.8% of the time, at "moderate" levels 46%, and at unhealthy levels for sensitive groups 0.2% of the time (CARB, 2021b). While chronic exposure risks are still being investigated and are expected in a later report, all detected chemicals thus far were below acute state designated RELs (CARB, 2019b). Garcia-Gonzales et al. (2019b) measured pollutant concentrations near upstream OGD and found n-pentane, n-hexane, and benzene to be above the limit of detection for all samples, with benzene and n-hexane concentrations exceeding those found in the SCAQMD's MATES IV report on air quality in central Los Angeles, suggesting a local emissions source.

Shonkoff & Hill (2020) identified 38 health-relevant state or federally designated air pollutants and 22 known or suspected human carcinogens near upstream oil and gas sites. Calculated excess cancer risks during both hydraulic fracturing activities and cleanout events were largely driven by concentrations of formaldehyde and benzene (contributed to 85% of total risk), with hydraulic fracturing activities and cleanout events resulting in cancer risks that exceed the U.S. EPA *de minimis* threshold (one case in one million), SCAQMD significance thresholds of 1-, 10-, and 25-in one million, and SJVAPCD significance thresholds of 1- and 20-in one million excess cancers.

4.2.3.2 Studies outside California

Regardless of location, the vast majority of peer-reviewed air monitoring and modeling studies, exposure assessments, and health risk assessments outside California found significant concentrations of various TACs, including benzene, to be higher in close proximity to active upstream OGD. Only three studies in Texas and Pennsylvania did not find significant exposures associated with oil and gas as a function of proximity (Bunch et al., 2014; Long et al., 2021; Maskrey et al., 2016).

The majority of Texas studies found pollutant concentrations to decline as a function of distance (Rich & Orimoloye, 2016; Zhou et al., 2021; Zielinska et al., 2014). Significant concentrations of benzene and formaldehyde at oil and gas sites were found across Wyoming, Pennsylvania, and Arkansas, with formaldehyde concentrations in all three states to be above health-protective thresholds, and benzene concentrations in Wyoming and Pennsylvania to be above acceptable risk levels (Macey et al., 2014). Haley et al. (2016) found setback policies in Colorado (500 ft [152 m] or 1,000 ft [305 m] for high-occupancy building), Pennsylvania (500 ft [152 m]), and Texas (200 ft [61 m]) to be insufficient, allowing human exposure above the established limits for

benzene and H_2S to occur.

In Colorado, the potential for noncancer adverse health effects from acute exposures have been estimated out to 2,000 ft (610 m) (Holder et al., 2019). Cancer risks and noncancer health risks associated with subchronic exposures were greater for those living within 2,640 ft (805 m) of OGD as compared to those living beyond 2,640 ft (805 m) from oil and gas wells (McKenzie et al., 2012). Additionally, cancer risk evaluations considering air monitoring data collected beyond 500 feet indicate elevated cancer risks above the U.S. EPA *de minimis* threshold for acceptable risk (1 in one million) out to 2,000 feet (610 m) from upstream OGD (McKenzie et al., 2018). Oil- and gas-associated compounds with evidence of endocrine activity have been detected beyond 500 feet (152 m), raising additional concerns about even low level exposures to these compounds at further distances, particularly during critical periods of fetal and early childhood development (Bolden et al., 2018).

Pennsylvania studies are consistent with studies in California, Colorado, and Texas (Banan & Gernand, 2018, 2021; Brown et al., 2015; Long et al., 2019). Banan & Gernand (2018) recommended that Pennsylvania establish a minimum setback distance of 736 m (2,415 ft). Banan & Gernand (2021) evaluated $PM_{2.5}$ concentrations at varying well sites and found that doubling the current setback distance to 305 m (1,000 ft) (from the current 152 m [500 ft] policy) would reduce the total number of $PM_{2.5}$ exceedances by 95%.

4.3. Approaches to emissions control and best practices implemented in California

4.3.1. Overview of federal controls & California emission requirements for oil & gas

The following section provides an overview of regulations and best practices intended to control air pollutant emissions from upstream OGD. This section is not intended to be an exhaustive list of every relevant regulation or rule, but rather acts as a summary of the current regulatory landscape in the state and elsewhere. In doing so, we hope to gain insight into potential gaps in emission control regulation at the federal, state, and local levels to inform our findings, conclusions, and recommendations.

4.3.1.1 Federal rules & regulations relevant to reducing emissions from upstream OGD

The Clean Air Act (CAA) [42 United States Code § 7401 et seq. (1970)], passed in 1970 and last amended in 1990, is a federal law that gives the U.S. EPA broad authority to regulate air emissions from stationary and mobile sources, and to implement air pollution prevention and control programs nationwide (US EPA, 2020a). The CAA requires the U.S. EPA's Office of Air Quality Planning and Standards (OAQPS) to set NAAQS and monitor and mitigate when areas are found to be in non-attainment (i.e., measured air pollutant concentration is greater than established safety threshold) (US EPA OAR, 2016a). Established NAAQS specify the allowable concentrations for six of the most common air pollutants in ambient air, otherwise known as CAPs, which include CO, lead, ground-level ozone, PM, NO_2, and SO_2 (US EPA, 2016d). In an effort to

comply with NAAQS, each state is required to prepare an air quality control plan (referred to as a State Implementation Plan (SIP)) that incorporates regulatory controls for reducing air pollutant emissions in non-attainment areas (US EPA, 2020a). The U.S. EPA is responsible for reviewing each SIP to ensure that implementation will effectively reduce emissions to below NAAQS levels (US EPA, 2020a).

Sources of TAC emissions are controlled through a separate set of standards, as outlined in CAA Section 112 National Emission Standards for TACs (NESTAC) (US EPA, 2020b). These emissions standards are intended to prevent adverse health risks (non-cancer and cancer) from specific source types (US EPA, 2020b). The CAA also gives the U.S. EPA and other specified air agencies the authority to issue permits and set minimum performance standards for select source types to prevent significant deterioration of air quality (CalGEM, 2015; US EPA OAR, 2016b). Referred to as New Source Performance Standards (NSPS), emissions from new stationary sources can be reduced (under CAA Section 111(b)), as well as emissions from existing stationary sources, retroactively (under CAA Section 111(d)) (CalGEM, 2015; US EPA OAR, 2016b). **Figure 4.10** lists the federal regulations applicable to OGD in California (including well stimulation).

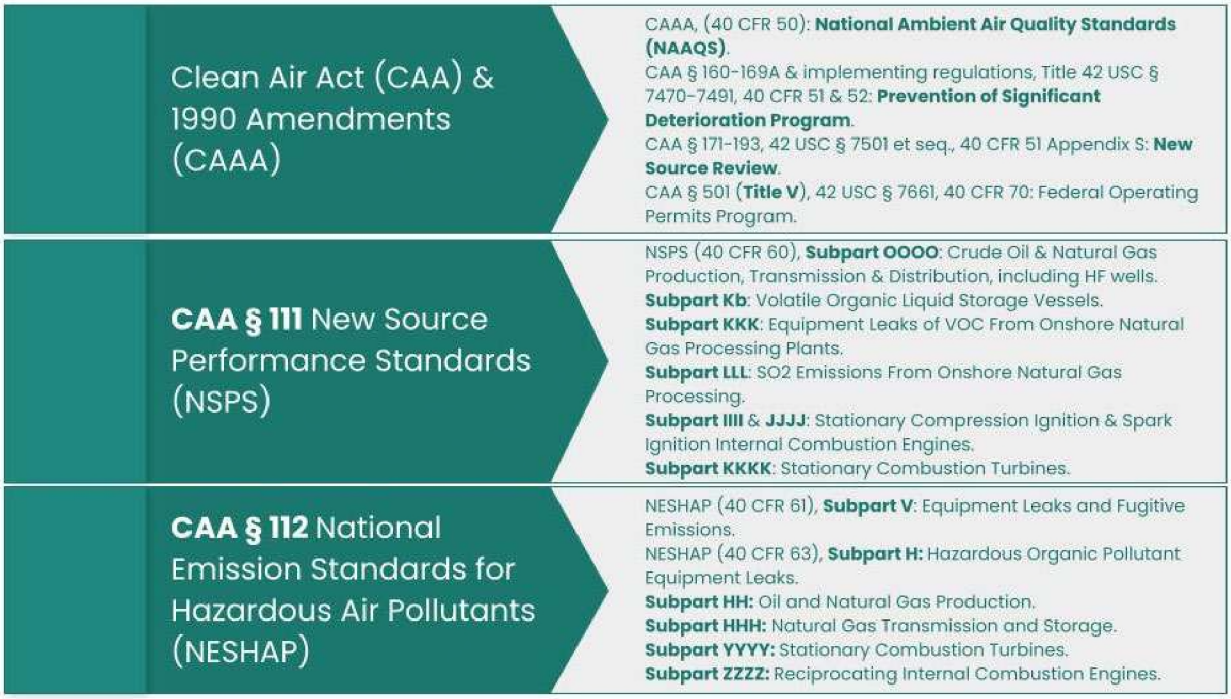


Figure 4.10. Current list of federal regulations applicable to OGD in California, including well stimulation techniques as well as conventional methods.

In 2016, the U.S. EPA updated the NSPS program to include specific permitting rules for upstream oil and gas sources constructed, reconstructed, or modified after September 15, 2015 (US EPA OAR, 2016b). As outlined in the CAA "2016 NSPS subpart OOOOa" and the *President's Climate Action Plan: Strategy to Reduce Methane Emissions*, the U.S. EPA issued three final rules within the NSPS program to reduce GHG (mainly methane) and NMVOC emissions from additional new,

modified, and reconstructed sources in the oil and gas industry (US EPA OAR, 2016b). **Table 4.6.** provides a summary of the oil and gas source types subject to additional emission reductions under this federal rule. For sites with gas wells, new requirements for leak detection and repair were added, as well as requirements to limit emissions from pneumatic pumps (US EPA OAR, 2016c). For sites with oil wells, emission limits for hydraulically fractured oil well completions and pneumatic pumps were established, as well as new leak detection and repair (LDAR) requirements (US EPA OAR, 2016c).

Table 4.6. Oil and gas industry sources covered under 2012 NSPS for VOCs and the 2016 NSPS for Methane and VOCs. Source: US EPA (2016b).

Sources covered by the 2012 New Source Performance Standards (NSPS) for VOCs and the 2016 NSPS for Methane and VOCs, by site				
Location and Equipment/Process Covered	Required to Reduce Emissions Under EPA Rules	Rules that Apply		
		2012 NSPS for VOCs*	2016 NSPS for methane	2016 NSPS for VOCs
Natural Gas Well Sites				
Completions of hydraulically fractured wells	✓	•	•	
Compressors				
Equipment leaks	✓		•	•
Pneumatic controllers	✓	•	•	
Pneumatic pumps	✓		•	•
Storage tanks	✓	•		
Oil Well Sites				
Completions of hydraulically fractured wells	✓		•	•
Compressors				
Equipment leaks	✓		•	•
Pneumatic controllers	✓	•	•	
Pneumatic pumps	✓		•	•
Storage tanks	✓	•		
Production Gathering and Boosting Stations				
Compressors	✓	•	•	
Equipment leaks	✓		•	•
Pneumatic controllers	✓	•	•	
Pneumatic pumps				
Storage tanks	✓	•		
Natural Gas Processing Plants*				
Compressors	✓	•	•	
Equipment leaks	✓	•	•	
Pneumatic controllers	✓	•	•	
Pneumatic pumps	✓		•	•
Storage tanks	✓	•		
Natural Gas Compressor Stations (Transmission & Storage)				
Compressors	✓		•	•
Equipment leaks	✓		•	•
Pneumatic controllers	✓		•	•
Pneumatic pumps				
Storage tanks	✓	•		
*Note: Types of sources already subject to the 2012 NSPS requirements for VOC reductions that also are covered by the 2016 methane requirements will not have to install additional controls, because the controls to reduce VOCs reduce both pollutants				

In 2021 and 2022, the U.S. EPA proposed additional measures to further reduce GHG and NMVOC emissions from upstream OGD equipment (US EPA, 2023a). In 2023, the U.S. EPA

issued a final ruling in which the following amendments to the NSPS and emissions guidelines were included, as outlined in **Table 4.7** (US EPA, 2023b).

Table 4.7. High-level overview of major provisions relevant to upstream oil and gas made to the 2012 and 2016 NSPS. Source: US EPA (2023b).

Description of Amendments from 2023 Ruling
"EPA is updating, strengthening, and expanding the current requirements under CAA section 111(b) for methane and VOC emissions from sources that commenced construction, modification, or reconstruction after December 6, 2022. These final standards of performance will be in a new subpart, 40 Code of Federal Regulations (C.F.R.) part 60, subpart OOOOb (NSPS OOOOb), and include standards for emission sources previously not regulated under the 2012 NSPS OOOO and 2016 NSPS OOOOa."
"New emissions guidelines (EG) will be added to a new subpart — 40 C.F.R. part 60, subpart OOOOc (EG OOOOc). The EG finalizes presumptive standards for GHG emissions (in the form of methane limitations) from designated facilities that commenced construction, reconstruction, or modification on or before December 6, 2022, and implementation requirements designed to inform states in the development, submittal, and implementation of state plans that are required to establish standards of performance for emissions of GHGs from their designated facilities in the Crude Oil and Natural Gas source category. The EPA is also finalizing regulatory language in NSPS OOOO, NSPS OOOOa, and NSPS KKK to provide clarity on when sources transition from being subject to these NSPS and become subject to a state or Federal plan implementing EG OOOOc."
"The EPA is taking several related actions stemming from the joint resolution of Congress, adopted on June 30, 2021, under the CRA [Congressional Review Act], disapproving the EPA's final rule titled, "Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources Review," 85 Federal Regulation (F.R.) 57018 (September 14, 2020) ("2020 Policy Rule"). The EPA is finalizing amendments to the 2016 NSPS OOOOa to address (1) certain inconsistencies between the VOC and methane standards resulting from the disapproval of the 2020 Policy Rule and (2) certain determinations made in the final rule titled, "Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources Reconsideration," 85 F.R. 57398 (September 15, 2020) ("2020 Technical Rule"), specifically with respect to fugitive emissions monitoring at low production well sites and gathering and boosting stations. With respect to the latter, as described below, the EPA is finalizing the rescission of provisions of the 2020 Technical Rule that were not supported by the record for that rule or by our subsequent information and analysis. Additionally, the EPA updates the NSPS OOOO and NSPS OOOOa provisions in the C.F.R. to reflect the CRA resolution's disapproval of the final 2020 Policy Rule, specifically, the reinstatement of the NSPS OOOO and NSPS OOOOa requirements that the 2020 Policy Rule repealed but that came back into effect immediately upon enactment of the CRA resolution. *It should be noted that these requirements have come back into effect already, even prior to these updates to CFR text to reflect them. The EPA waited to make these updates to the C.F.R. text until the final rule simply because it was more efficient and clearer to amend the C.F.R. once at the end of this rulemaking process to account for all changes to the 2012 NSPS OOOO (77 F.R. 49490, August 16, 2012) and 2016 NSPS OOOOa at the same time."*
"The EPA is finalizing a protocol for the use of OGI in leak detection being finalized as appendix K to 40 C.F.R. part 60 (referred to hereafter as appendix K). While this protocol is being finalized in this action, the applicability of the protocol is broader. The protocol is applicable to facilities when specified in a referencing subpart to help determine the presence and location of leaks; it is not currently

applicable for use in direct emission rate measurements from sources. The protocol does not on its own apply to any sources. For NSPS OOOOb and EG OOOOc, the EPA is finalizing the use of the protocol for application at natural gas processing plants and may be applied to other sources only when incorporated through rulemaking to a specific subpart."

4.3.1.2 Federal emission control requirements: RACT, BACT, & LAER

Federal emission control requirements, as authorized under Part C, Title I of the federal Clean Air Act, fall under three categories: best available control technology (BACT), lowest achievable emission rate (LAER), and reasonably available control technology (RACT) (CARB, 2017a, 2017b).

Federal LAER is defined as either: (1) the most stringent of any emission control included in a SIP control strategy; or (2) the most stringent emission limit "achieved in practice," the definition of which varies from district to district (CARB, 2017a, 2017b). Unlike BACT, federal LAER does not require the inclusion of economic, energy, or environmental considerations when assessing the applicability of the rule to a major emitting facility (CARB, 2017a, 2017b). § 169(3) of the federal CAA defines BACT as an emission limit (based on the maximum degree of reduction of each pollutant) applicable to any major emitting facility (major sources) (CARB, 2017a, 2017b). In regions of federal nonattainment, new stationary sources, sources that undergo modification, and relocated sources which result in an emissions increase are subject to these additional emission control requirements (CARB, 2017a, 2017b). While there are federal requirements, California air districts have the authority to establish more stringent requirements for oil and gas at the local level. As a result, stringency levels differ by air district, as shown in **Table 4.8**, which summarizes how federal BACT and LAER definitions compare to district-level definitions of BACT & LAER (**Table 4.8**) (CARB, 2017b).

The final category of emission control requirements is RACT, which applies to existing sources in regions that are not meeting NAAQS (non-attainment) (US EPA OAR, 2016d). In 2016, the US EPA published *Control Techniques Guidelines for the Oil and Gas Industry*, which provides guidance for California's local air districts on what should be included as RACT for specific oil and gas emission sources (US EPA, 2016d).

Table 4.8. Comparison of California District Control Technology Definitions with Federal Definitions. Source: Table 9, CARB (2017b).

District	District BACT Definition *most similar to* Federal LAER Definition	District BACT Definition *most similar to* Federal BACT Definition	District LAER Definition *most similar to* Federal LAER Definition
Bay Area AQMD	x		
Butte Co. AQMD	x		
Colusa Co. APCD	x		
El Dorado Co. APCD Portion	x		
Feather River AQMD	x		
Glenn County APCD	x		
Great Basin Unified APCD	x		
Kern Co. APCD	x		
Lake Co. AQMD	x		
Lassen Co. APCD	x		
Modoc Co. APCD	x		
Mojave Desert AQMD	x		
Monterey Bay Unified APCD	x		
Placer Co. APCD Portion	x		
Placer Co. APCD Portion	x		
Sacramento Metropolitan AQMD	x		
San Joaquin Unified APCD	**x**		
San Luis Obispo Co. APCD	x		
Santa Barbara Co. APCD (NSR LAER)	x		
Shasta Co. AQMD	x		
Siskiyou Co. APCD	x		
South Coast AQMD	**x**		
Tehama Co. APCD	x		
Ventura Co. APCD	x		
Yolo-Solano Co. AQMD	x		
Amador Co. APCD		x	x
Calaveras Co. APCD		x	x
Imperial Co. APCD		x	x
Mariposa Co. APCD		x	x
Northern Sierra AQMD		x	x
San Diego Co. APCD		x	x
Mendocino Co. AQMD		x	
North Coast AQMD		x	
Northern Sonoma Co. APCD		x	
Santa Barbara Co. APCD (PSD BACT)		x	

Federal LAER (NSR) Definition: LAER is considered the most stringent of any emission control used in a state implementation plan (SIP) control strategy or the most stringent emission limit achieved in practice.
Federal BACT (PSD) Definition: Section 169(3) of the federal Clean Air Act defines BACT an emission limitation based on the maximum degree of reduction of each pollutant subject to regulation under this Act emitted from or which results from any major emitting facility...New stationary sources, sources that undergo significant modification, and relocated sources which result in an emissions increase are subject to these additional emissions control requirements.

4.3.1.3 California rules & regulations relevant to reducing emissions from upstream OGD

In addition to federal controls, there are also California state-level requirements for emissions from upstream OGD. The regulation of air quality in California is different from other states, as the CAA gives California special authority to enact stricter air pollution standards than those established nationally (e.g., NAAQS). Implemented in 1988, the California CAA gives independent authority to the CARB to implement CAAQS, which represent more stringent, state-level thresholds for air quality attainment (CARB, 2017a). The responsibility of air quality management is shared between CARB and the 35 local air districts that make up the state's air basins (CalGEM, 2015). CARB is responsible for implementing the California CAA, and for the development and implementation of statewide air pollution control plans to achieve attainment with national standards (e.g., NAAQS) (CARB, 2017a). CARB also has authority to establish statewide strategies to control TAC emissions and set emissions standards for mobile sources (e.g., motor vehicles and off-road equipment) (CARB, 2017a). The local air districts are responsible for achieving and maintaining attainment with the CAAQS, which can be achieved through the development of an air quality management plan or clean air plan that assesses the feasibility of various emission control requirements to reduce emissions from major and minor sources in the region (CalGEM, 2015; CARB, 2017a).

Methane emissions from upstream OGD are controlled under C.C.R. Title 17, Subarticle 13: Greenhouse Gas Emission Standards for Crude Oil and Gas Facilities (CARB, 2017c). Adopted in March, 2017, this regulation includes standards for separator and tank systems, circulation tanks, LDAR, underground gas storage monitoring, gas compressors, pneumatic devices and pumps, and reporting requirements (CARB, 2017c, 2018c). Additionally, this regulation requires reductions in fugitive and vented emissions of methane from both new and existing oil and gas facilities (CARB, 2017c, 2018c). The following state regulations (currently codified) are applicable to air pollutant emissions from upstream OGD in California (including well stimulation) (**Figure 4.11**).



Figure 4.11. Current list of statewide regulations applicable to emissions from OGD in California. (Regulations relevant to plugged, idle, or abandoned wells included in Chapter 6.)

The stringency of local emission control requirements vary from district to district, and depends (largely) on the region's attainment status, severity of violation(s) with NAAQS, source size (major vs. minor sources), and how BACT rules and regulations are defined in each air district (CARB, 2017a, 2021c). In general, new and modified stationary sources and relocated sources that have an emissions increase are all subject to additional emissions control requirements (CARB, 2021a).

Operators must apply for a permit with the relevant air district prior to construction of any new, modified, or relocated source and New Source Review (NSR) may be triggered if emissions exceed established safety thresholds (CARB, 2021a). Not unlike the federal program, California's NSR permit program aims to protect air quality and public health by encouraging the use of the latest (and often lowest-emitting) technologies, as well as requiring the offset of any new emissions (while still accounting for economic impacts) (CARB, 2021a). In areas where pollutant levels are in attainment (or unclassifiable) with federal NAAQS, Prevention of Significant Deterioration (PSD) standards may be required. Applicable to any new major source or any major modifications to an existing source, the goal of PSD is to ensure that in regions of attainment, no new permitted source or combination of sources can result in a region's nonattainment for a particular pollutant. This is enforced through the use of PSD increments, defined as "the maximum allowable increase in concentration that is allowed to occur above a baseline concentration for a pollutant" (US EPA OAR, 2015a). If the amount of the new pollutant exceeds the applicable PSD increment, then significant deterioration is said to occur. Best available control technology for air

toxics (T-BACT) may also be triggered for relevant sources that release TAC emissions (CARB, 2017a, 2017b, 2021a).

Emission control requirements for new or modified sources (i.e., BACT/T-BACT) in California are categorized into three levels: (1) Federal BACT, the least stringent; (2) Federal/State LAER, the most stringent at the state and federal level; and (3) California BACT, the most stringent at the local level (**Figure 4.12**) (CARB, 2021a).



Figure 4.12. Range of control levels that apply to new or modified stationary sources in California. Source: CARB (2021a).

Under state law, Federal BACT is triggered for sources in areas in nonattainment of the state's NSR program; under federal law, Federal BACT is required in regions of attainment where PSD standards may be required (CARB, 2021a). California BACT is authorized by the state, which allows air districts to implement emission control requirements beyond LAER limits, assuming the measures are technically feasible and cost effective (CARB, 2021a). Under state and federal law, LAER (both California and Federal) applies to sources in nonattainment of the federal NSR program (CARB, 2021a).

Finally, districts having moderate, serious, severe, or extreme air pollution may be required to implement expedited best available retrofit control technology (BARCT), as defined by § 40921.5, Chapter 10, Part 1, Division 26 of the California Health and Safety Code (HSC), Assembly Bill (AB) 617, and discussed in greater detail in Section 4.2.1 (CARB, 2020a). Similar to BACT, BARCT is an emissions threshold, and unlike BACT, BARCT is meant for *existing* stationary sources, not new or modified sources (CARB, 2020a). A recent requirement, air districts in nonattainment of NAAQS thresholds for CAP emissions were charged with the task of creating an "expedited BARCT schedule" by January 1, 2019, with implementation planned for December 31, 2023 (CARB, 2020a). These schedules are intended to control emissions from industrial sources subject to the Cap and Trade program (as of January 1, 2017), with the goal of reducing air pollutant emissions and protecting the health and safety of residents living close by (CARB, 2020a).

4.4. Gaps in existing emission control regulations with relevance to public health

After review of the various federal, state, and local emission control regulations applicable to upstream OGD activity in California, we identified gaps in existing emission control regulations where specific source types could be better controlled. When available, we refer to oil and gas

regulations implemented elsewhere or at the local level to better inform the types of policy changes in which regulators may be interested. We also incorporate emissions estimates and equipment/component counts when available to determine (1) the impact that this change in policy would have on California's air quality and regional attainment status; and (2) the implications for those individuals being exposed to pollutants emitted during upstream OGD that are relevant to health.

4.4.1. TACs and NMVOCs are co-emitted with emissions of methane

In many cases reviewed in this section, emission estimates were not available for TACs and NMVOCs emitted by the various oil and gas components. Estimates of methane and other GHGs (e.g., CO_2, N_2O) were the most widely reported values provided by California-specific reports on upstream OGD. While methane does not contribute significantly to the formation of ground-level ozone or pose a health risk at the levels detected in ambient air near upstream oil and gas production sites, TACs, as well as precursor emissions to ground-level ozone (i.e., NMVOCs) are often co-emitted.

Rich et al. (2014) conducted a sampling campaign of residential sites located near unconventional shale gas extraction and production activity in the Dallas-Fort Worth region of Texas. Results confirmed the presence of methane (detected at 98% of sampling sites) and 101 other chemicals in the outdoor air of residences located within 200 ft (61 m), 2,000 ft (610 m), and 5,280 ft (1.6 km) of equipment used for unconventional OGD (Table 1, Rich et al., 2014). Approximately 20 of the detected chemicals were identified as TACs and included benzene (detected at 76% of sampling sites), 1,3-butadiene, carbon disulfide, carbonyl sulfide, chloromethane, tetrachloroethane, toluene, and xylene (Rich et al., 2014).

Concentrations of 15 detected chemicals were found to significantly correlate with methane levels, including pentane (C5), heptane (C7), and butane (C4) as well as TACs including hexachlorobutadiene, tetrachloroethene (PCE), 1,2,4-trichlorobenzene, and chloroform. The strongest correlation with methane was 3-methylhexane, a constituent of gas condensate (Rich et al., 2014). Significant correlations were also found among detected TACs, with the strongest relationships found between benzene and toluene, benzene, and m- & p-xylene, and toluene and m- & p-xylene.

Table 4.10 compares the results of Rich et al. (2014) to two studies conducted in Colorado (McKenzie et al., 2012; Pétron et al., 2012) and one study conducted in the U.K.[7] Levels of alkanes (e.g., ethane, propane, butane, pentane, and hexane) generally agreed across all three studies (McKenzie et al., 2012; Pétron et al., 2012; Rich et al., 2014). Concentrations of aromatic hydrocarbons (e.g., BTEX, trimethylbenzenes) from the Rich et al. (2014) study were generally higher than what was detected in the other studies. Similarly, methane concentrations were higher in Rich et al. (2014) compared to methane levels detected in Pétron et al. (2012).

[7] We disregard this last study, as it is out of the geographic scope of this report.

There are several additional studies that support the findings from Rich et al. (2014), McKenzie et al. (2012), and Pétron et al. (2012). For example, Koss et al. (2015) conducted a sampling campaign in the Uintah Basin, Utah, and found pollutant emission ratios to be consistent with contributions of emissions from both oil and gas producing wells. In addition, the methane emission rate, extrapolated from the emission rate for benzene, was consistent with an independent evaluation of methane emissions using aircraft measurements from 2012. Marrero et al. (2016) conducted a similar assessment in the Barnett Shale region of Texas and found the highest hexane and m- & p-xylene mixing ratios to be observed downwind of well pads with compressors, where methane leak rates were highest. Similarly, the authors found some of the highest toluene and benzene mixing ratios to be near oil-producing wells. The authors note that estimates of hexane, benzene, and toluene emissions in the Barnett Shale region were consistent with values witnessed in oil and gas producing regions of Colorado and Utah, suggesting that there may be some consistency in emissions profiles from oil and gas development across geographic regions (Marrero et al., 2016).

In Pennsylvania, the Goetz et al. (2015) sampling campaign of oil and gas sites in the Marcellus Shale region found elevated ethane and methane concentrations, with no other chemical significantly detected at sampling sites. With regards to emissions near oil and gas wells, results were somewhat variable — the smallest of the well pads (with seven wells) had the second largest methane concentrations of all well pad sites sampled (Goetz et al., 2015). This was likely because this well pad produces wet gas, which is high in methane and other hydrocarbons such as ethane (Goetz et al., 2015). Results at the remaining well sites found elevated levels of methane and ethane from combustion sources at all locations, in addition to elevated levels of CO and NO_x, an ozone precursor at one well location.

A study conducted by Hecobian et al. (2019) also found variations in measured emissions of TACs and NMVOCs at the various stages of production in the Denver-Julesburg and Piceance Basins in Colorado. As shown in **Figure 4.13**, emissions differed depending on the basin and phase of production, with flowback operations accounting for the highest levels of heavy alkane (e.g., n-hexane, n-heptane) emissions among all the sites sampled. Drilling and production activities produced elevated levels of light alkane emissions (e.g., ethane, propane, n-butane), but at much lower levels than during hydraulic fracturing and flowback operations. When the duration of operations is considered, however, drilling and production activities could still present a significant risk, as drilling and production activities (including conventional methods) are continuous (e.g., ≥8 hours of operation/day) and generally fixed in one location (i.e., longer exposure duration), whereas stimulation treatments and flowback operations occur over shorter intervals (e.g., 5 hours of operation/day) and move from location to location.

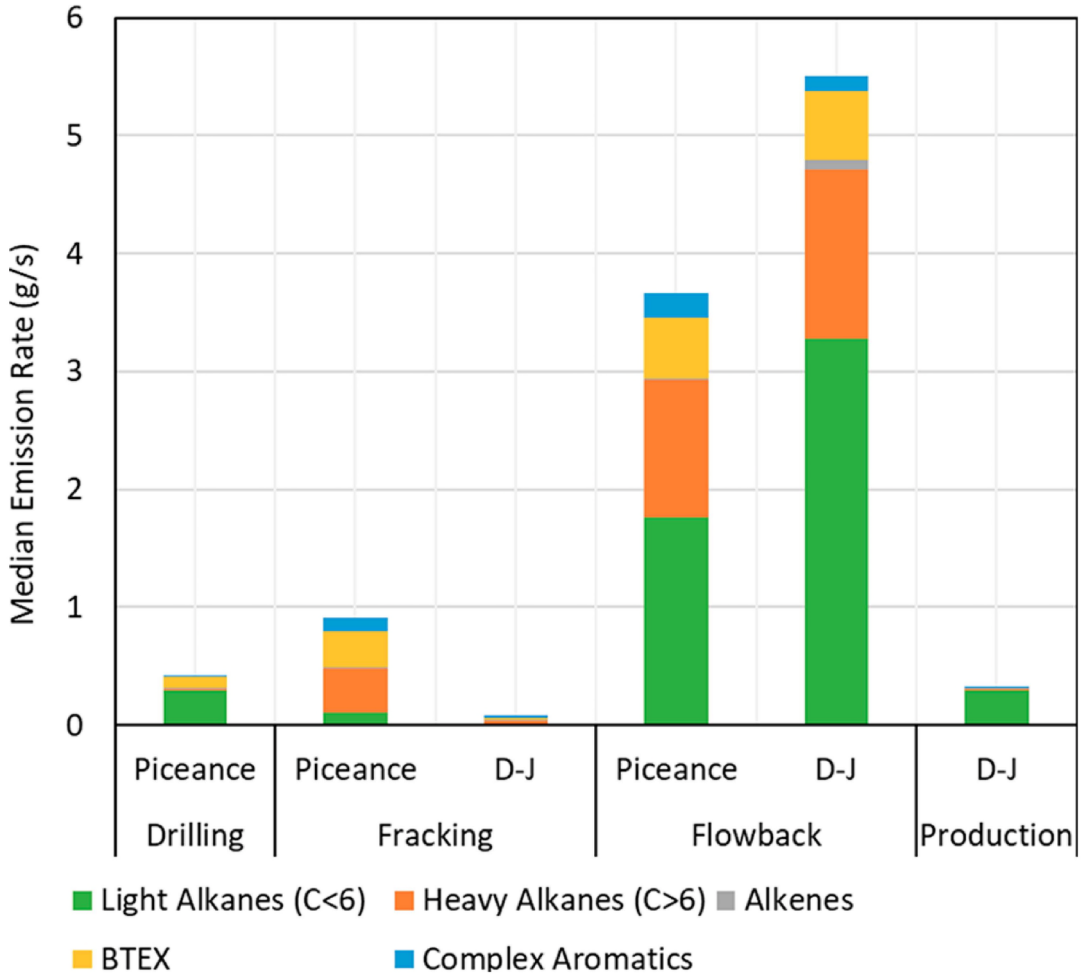


Figure 4.13. Emission rates of key NMVOCs by unconventional oil and gas activity in the Piceance Basin and Denver-Julesburg Basin. Source: Figure 1, Hecobian et al. (2019).[8]

There is substantial evidence that methane emissions from many upstream oil and gas sources are indeed co-emitted, and in some cases, significantly correlated with emissions of TACs and other NMVOCs. Methane and other pollutant emissions are released during many stages of upstream oil and gas production. Fugitive (unintentional) releases of methane, and associated NMVOCs can occur from component and equipment leaks, including from valves, screwed connections, flanges, open-ended lines, and pump seals (ExxonMobil, 2021; US EPA, 2016a). Direct venting of methane emissions can also occur during well stimulation treatments, specifically during flowback operations and manual liquids unloadings. In some cases, the intended function of a component results in the intentional release of methane emissions, such as is the case with gas-powered pneumatic devices, which directly release or "bleed" gas (ExxonMobil, 2021). NMVOCs and TACs are often co-emitted with methane releases from pneumatic controllers and

[8] Light Alkanes: ethane, propane, i-butane, n-butane, i-pentane, n-pentane; Heavy Alkanes: 2,3-dimethylpentane, 2,4-dimethylpentane, 2,2,4-trimethylpentane, 2,3,4-trimethylpentane, n-hexane, 2-methylhexane, 3-methylhexane, n-heptane, 2-methylheptane, 3-methylheptane, n-octane, n-nonane, n-decane; Alkenes: ethene, propene, t-2-butene, 1-butene, c-2-butene, t-2-pentene, 1-pentene, C-2-pentene; Complex Aromatics: styrene, i-propylbenzene, n-propylbenzene, 1,2,3-trimethylbenzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, 1,3-diethylbenzene, 1,4-diethylbenzene, 2-ethyltoluene, 3-ethyltoluene, 4-ethyltoluene; BTEX: BTEX benzene, toluene, ethylbenzene, o-xylene, m & p-xylenes.Source: Table S5, Hecobian et al. (2019).

pumps (US EPA, 2016a). Methane is the largest component of vapor releases from storage vessels, but these vapor releases may also include releases of n-hexane, alkanes (e.g., ethane, butane, propane) and TACs (e.g., BTEX) (US EPA, 2016a).

Additional sources of methane and associated NMVOCs from upstream OGD include releases from incomplete combustion (e.g., flaring), centrifugal and reciprocating compressors, and transmission pipeline blowdowns (ExxonMobil, 2021; US EPA, 2016a). Combustion and incomplete combustion (e.g., flaring) of organic pollutants also produces secondary pollutants including NO_x, CO, SO_x, and PM (US EPA, 2016a).

Many of the compounds detected at California oil and gas sites (e.g., benzene, alkanes) were identified as co-pollutants of methane in other oil and gas producing states. The most commonly detected constituents near oil and gas sites were benzene and methane, with estimated rates of benzene to be 12 kg/hr (Mellqvist et al., 2017) and ~57 lbs/day (SCAQMD, 2015b); concentrations of benzene to be 1.07 ppb ((Collier-Oxandale et al., 2020; Garcia-Gonzales et al., 2019b; Okorn et al., 2021); and rates of methane to be 244 kg/hr (Mellqvist et al., 2019) and 636 kg/hr (Mellqvist et al., 2017). The 1.07 ppb benzene concentration estimated in Garcia-Gonzales et al. (2019b) is greater than the median benzene concentrations (0.02 ppb–0.89 ppb) summarized in Table 3 of the Rich et al. (2014) study (**Table 4.9**). Therefore, in lieu of California-specific studies, these findings should be considered when determining risks to public health, especially in areas with high-intensity upstream OGD activities (e.g., production, hydraulic fracturing, acidizing) near residences and other sensitive receptors. The most important implication from this assessment is that significant reductions in methane could translate to potentially significant reductions in TACs, and ozone precursors emissions (e.g., NMVOCs), beyond what is currently being achieved in California.

Table 4.9. Comparison of Rich et al. (2014) air sampling results with other studies. Source: Table 3, Rich et al. (2014).

	This Study			Garfield County, Colorado[a]		Birmingham, UK[b]	Weld County, Colorado[c]	State of California[d]
Chemical	Max (ppb_v)	Median (ppb_v)	Mean (ppb_v)	Max (ppb_v)	Median (ppb_v)	Range of Means (ppb_v)	Range of Medians (ppb_v)	Ambient Average (ppb_v)
Methane (ppmv)	457	2.7	11.99				1.81—1.89	
Benzene	592	0.89	18.53	4.39	0.30	0.25-0.7	0.02-0.1	4.6
Chloroform	2.58	0.3	0.45					0.006-0.13
Dichloromethane/Methylene chloride	1	0.3	0.34					1.1—2.4
Ethylbenzene	113	0.53	4.42	1.87	0.04			
Styrene	43.4	0.37	1.91	0.80	0.035			10
Tetrachloroethene (PCE)	2.43	0.3	0.33					0.71
Toluene / Methylbenzene	276	2.55	19.45	21.0	0.48	0.7—1.9		
Trichloroethene (TCE)	60.9	0.3	1.58					0.22
1,3,5-Trimethylbenzene	9.95	0.59	1.43	0.25	0.024			
1,2,4-Trimethylbenzene	60.4	0.4	3.45	0.63	0.037			
m- and *p*-Xylene	221	1.68	15.69	2.28	0.20			
o-Xylene	39.4	0.85	3.19	0.83	0.05			
Propylbenzene	23.5	1.4	2.08	0.14	0.02			
Pentane	198	1.4	7.73	21.1	3.09	0.2—0.5	0.01—0.48	
Methyl cyclohexane	38	1.4	2.42	5.98	0.92			
Propane (ppmv)	62.9	1.4	2.97			0.8—2.8	0.1—3.0	
Butane (ppmv)	69	1.4	2.95			0.9—2.8	0.04—1.24	
Ethane (ppmv)	34.6	1.4	2.24			2.2—6.3		
Isobutane	34	1.4	3.95			0.8		
Methylpentane/Isohexane	199	1.4	6.1			0.15—1.1		
Hexane	35	1.4	2.46	7.11	1.14	0.1—0.2		

Notes: Values are reported by California Air Resources Board for California, except for benzene, which was reported for the South Coast Air Basin of California (Los Angeles metropolitan area). [a]McKenzie et al. (2023). [b]Hopkins et al. (2005). [c]Petron et al. (2012). [d]Seinfeld and Pandis (1998).

4.4.2. Regulation of gas-driven pneumatic devices in Colorado: A comparison with current California requirements

Like California, oil and gas regions in Colorado face similar challenges in achieving attainment with NAAQS thresholds for ozone (CDPHE AQCC, 2021). The Denver Metropolitan North Front Range was just recently recategorized by the U.S. EPA in April 2022 to be in "Severe" nonattainment of the 2008 8-hour ozone NAAQS, after 2020–2021 ozone concentrations exceeded the established safety limits (CDPHE, 2022). In California, 22 air districts are in nonattainment for the 2015 ozone NAAQS, 13 of which are classified as "moderate" to "extreme." Of these 13 air districts, six have oil and gas operations subject to emission control (CARB, 2018d). A more detailed discussion of California's nonattainment statuses can be found in Section 4.2.1.

Statewide, the oil and gas industry is the largest contributor of NMVOC emissions in Colorado (CDPHE AQCC, 2021). Natural gas-driven pneumatic controllers are collectively one of the largest sources of NMVOCs and the second largest source of methane emissions from oil and gas operations nationwide (CDPHE AQCC, 2021). These findings are significant, as ground-level ozone is formed when chemical reactions catalyzed by heat and sunlight occur between NO_x and NMVOCs (US EPA OAR, 2015b). Furthermore, depending on the level of exposure, ozone is associated with coughing, sore throat, difficulty breathing, inflammation of the airway and exacerbation of asthma, emphysema, and chronic bronchitis (US EPA OAR, 2015c).

Similarly, while methane does not pose a health risk at the levels detected in ambient air near upstream oil and gas production sites, TACs including benzene, toluene, and formaldehyde are often co-emitted. In the case of gas-powered pneumatic devices, the intended function of the component results in the release of methane emissions, which directly emit or "bleed" gas (ExxonMobil, 2021; US EPA, 2016a). Thus, significant reductions in methane emissions would also result in significant reductions of TACs and associated health risks.

Colorado's *Regulation Number 7 - Statements of Basis, Specific Statutory Authority and Purpose* (Regulation Number 7) defines pneumatic controllers as,

> "a device that monitors a process parameter such as liquid level, pressure, or temperature and uses pressurized gas (which may be released to the atmosphere during normal operation) to send a signal to a control valve in order to control the process parameter. Controllers that do not utilize pressurized gas are not pneumatic controllers" (CDPHE AQCC, 2021).

According to Part F of Regulation Number 7, NMVOC emissions from gas driven pneumatic controllers within ozone nonattainment areas were estimated to be responsible for 14% (24.8 tons per day (tpd) and 15.1% (31.1 tpd) of total NMVOC emissions from oil and gas sources in 2006 and 2011, respectively (CDPHE AQCC, 2021).

The Colorado Department of Public Health and the Environment's Air Quality Control Commission (CDPHE AQCC) updated Regulation Number 7 to include requirements for the use of zero-bleed and zero-emission pneumatic control devices at oil and gas well sites (CDPHE AQCC, 2021). Adopted on February 18, 2021, and effective on April 14, 2021, the following requirements are applicable to both new and existing natural-gas driven devices (CDPHE AQCC, 2021):

- All new and modified well production facilities and compressor stations that commence operations on or after May 1, 2021, are required to use non-emitting pneumatic control devices (i.e., those activated by compressed air or electricity as opposed to high-pressure gas); and
- All existing pneumatic control devices (defined as those in operation prior to May 1, 2021) must be retrofitted with zero-emission devices, through a phase in process, as outlined in Table 1 of Colorado's revised Regulation Number 7 (**Table 4.10**) (CDPHE AQCC, 2021).

Table 4.10. Required timeline for implementation of non-emitting devices on existing well production facilities. Source: Regulation Number 7, Table 1, CDPHE AQCC (2021).

Table 1*—Well Production Facilities					
Total Historic Non-Emitting Facility Percent Production	**May 1, 2022 Additional Required Non-Emitting Facility Percent Production**	**May 1, 2022 Maximum Required Non-Emitting Facility Percent Production**	**May 1, 2023 Additional Required Non-Emitting Facility Percent Production**	**May 1, 2023 Maximum Required Non-Emitting Facility Percent Production**	**Total Additional Required Non-Emitting Facility Percent Production By May 1 2023**
> 75%	+5%	90%	+10%	96.5%	+15%
> 60—75%	+5%	80%	+10%	90%	+15%
> 40—60%	+10%	65%	+15%	75%	+25%
> 20—40%	+15%	50%	+20%	65%	+35%
> 0—20%	+15%	35%	+25%	55%	+40%

*Table 1 establishes minimum increases in the percentage of liquids produced (based on historic non-emitting controller use) from non-emitting facilities. Owners or operators do not need to go beyond the maximum required percentages set forth in Table 1, although they may choose to do so.

In California, pneumatic control device and pump requirements are required by CARB's 2017 *C.C.R., Title 17, Division 3, Chapter 1, Subchapter 10 Climate Change, Article 4, Subarticle 13: Greenhouse Gas Emission Standards for Crude Oil and Gas Facilities* (Oil and Gas Methane Regulation) (CARB, 2018d). California's Oil and Gas Methane Regulation requires pneumatic controllers installed after January 1, 2016, to have a zero-bleed rate and those installed before this date to comply with the low-bleed rate of less than or equal to 6 standard cubic feet per hour (scfh) (CARB, 2018c). This differs, and is less stringent than, Colorado's Regulation Number 7, which requires all *existing* natural-gas driven pneumatic controllers to be retrofitted with zero-bleed technology via a phase-in process, in addition to new and modified sources.

Both regulations apply to the same or similar source types. California's Oil and Gas Methane Regulation covers pneumatic controllers at (1) gas processing plants, (2) between the wellhead and the gas processing plant, or (3) the point of custody transfer to an oil pipeline (CARB, 2018d). In Colorado, revisions to Regulation Number 7 apply to pneumatic controllers that are "actuated

by gas, and located at, or upstream of gas processing plants," with upstream activities encompassing: (1) oil and gas exploration and production operations; and (2) gas compressor stations (CDPHE AQCC, 2021). Therefore, the key difference between Colorado and California's regulation of pneumatic devices is the stringency placed on emissions from existing low- and high-bleed pneumatic controllers — Colorado requires zero-bleed (retroactively) whereas California allows low-bleed rate devices to operate if they are grandfathered in.

If implemented, it is unclear how this type of policy would impact NMVOCVOC or TAC emissions from upstream OGD in California, in particular due to the lower prevalence of low-bleed devices. In 2007, CARB conducted a survey of the oil and gas industry. Referred to as *Final Report (Revised): 2007 Oil and Gas Industry Survey Results, Final Report (Revised), October 2013 (posted November 1, 2013)*, this survey gathered information on various components and methane emissions associated with crude oil and gas production, processing, and storage facilities in the state (CARB, 2013a). The survey identified 1,151 continuous bleed devices (e.g., high bleed) and 50 low-bleed devices (<6 scfh) in operation in California, accounting for ~86% and 1% of vented methane emissions emitted by automated control devices, respectively (CARB, 2013a).

Using emission rates for low-bleed devices from Table 6-2 of the U.S. EPA's *Control Technique Guidelines for the Oil and Gas Industry*, we were able to estimate the proportion of VOCs associated with these annual methane emissions estimates (**Table 4.11**) (US EPA, 2016a). Requiring replacement of low-bleed devices to zero bleed devices would result in a 15 tpy reduction in VOCs, approximately 0.3% of total vented VOC emissions.

Table 4.11. Estimate of vented emissions from pneumatic devices. Source: Tables 9-1 and 9-2, CARB (2013a).

Automated Control Device Type	No. of Devices	CH_4 (MT/yr)	VOCs (tpy)
Continuous Bleed	1,151	4,915	1,502
Low Bleed	50	46	15
Intermittent Bleed	405	760	-
Non-Emitting (e.g. electric, no bleed, air)	15,440	-	-
Control Device Total	**17,046**	**5,721**	**1,517**
Vented Emissions Total	**-**	**16,026**	**4,445**

It should be noted that these estimates are most likely an underestimation of the true contribution in emissions from gas-driven pneumatic devices for several reasons. Because the estimates provided are from 2007, these statistics may no longer be representative of 2020 inventories, as they are more than a decade old. Since 2007, these pneumatic devices may have been replaced upon failure with newer versions such as no-bleed units. Additional NMVOC and methane emissions reductions from the oil and gas sector would be possible if the state implemented a policy that applied zero-bleed/zero-emission standards to existing pneumatic controllers, retroactively, similar to revisions made to Colorado's Regulation Number 7. However, these

emissions reductions represent a small fraction of overall vented emissions from control devices.

4.4.3. Separators and condensate tank systems: Exemptions from vapor recovery requirements for small producers

Methane is the largest component of vapor releases from storage vessels, but may also include releases of n-hexane, alkanes (e.g., ethane, butane, propane), and TACs (US EPA, 2016a). California's 2017 Oil and Gas Methane Regulation includes standards to control emissions from storage vessels, including separator and condensate tank systems, through the use of flash analysis testing and vapor collection systems (95% vapor control efficiency). § 95668(a) of the Oil and Gas Methane Regulation states:

- By January 1, 2018, owners and operators of existing separator and tank systems with uncontrolled emissions (i.e., no vapor collection system installed) are required to conduct flash analysis testing "of the crude oil, condensate, or produced water processed, stored, or held in the system."
- Starting January 1, 2018, new separator and tank systems are required to conduct flash analysis testing within 90 days (CARB, 2017c).

Results from the flash analysis testing are then used to determine which operators/owners are required to implement vapor collection systems. § 95668(a) of the Oil and Gas Methane Regulation states:

- Existing separator and tank systems with an annual emission rate of 10 metric tons (MT) or greater of methane per year (equivalent to ~1.8 MT/year VOCs) are required to control emissions via a vapor collection system by January 1, 2019 (as specified in § 95671).
- Starting January 1, 2018, new separator and tank systems with an emissions rate of 10 MT methane/year or greater (equivalent to ~1.8 MT/year VOCs) will be required to implement a vapor collection system within 180 days of flash analysis testing (CARB, 2017c, 2018d).

CARB outlines two key exemptions from the requirements. First, separators and tank systems that have a vapor collection system already installed and approved for use by the local air district by January 1, 2018, are exempt (CARB, 2017c). Air Districts that meet this exemption criteria include:

- Sacramento Metropolitan AQMD (Rule 446: Storage of Petroleum Products)
- San Joaquin Valley APCD (Rule 4623: Storage of Organic Liquids)
- South Coast AQMD (Rule 463: Organic Liquid Storage; Rule 1178: Further Reductions of VOC Emissions from Storage Tanks at Petroleum Facilities)
- Ventura County APCD (Rule 71.1: Crude Oil Production and Separation; Rule 71.2: Storage of Reactive Organic Compound Liquids)
- Yolo-Solano AQMD (Rule 2.21: Organic Liquid Storage and Transfer) (CARB, 2018d).

All of these district rules require the implementation of vapor collection systems to reduce emissions by at least 95%, consistent with state law; however, small producer definitions may vary from district to district.

Second, separators and condensate tank systems are exempt from vapor collection requirements if they "receive an average of less than 50 barrels of crude oil or condensate per day" or "receive an average of less than 200 barrels of produced water per day" for non-associated gas production systems (CARB, 2017c). Average daily production is estimated using the annual production volume, as reported to DOGGR (now CalGEM), divided by 365 days per year (CARB, 2017c). This "small tank producer" exemption was implemented by CARB, because systems that meet these specifications are not likely to produce a large enough volume of liquids to meet the methane emission standard of 10 MT methane/year and therefore do not require flash testing or a permanent vapor recovery system. CARB states,

> "Methane is emitted from the production of crude oil, condensate, and produced water when the fluids are produced from an underground reservoir and separated or stored on the surface. The emissions are primarily a result of depressurizing the liquids from reservoir pressure to a lower surface pressure and subjecting the liquids to changes in temperature. The analysis showed that separator and tank systems with a production level of than 50 barrels of crude oil per day and less than 200 barrels of produced water do not produce enough liquids to meet the proposed emissions standard and therefore do not warrant flash emissions testing, or a permanent vapor collection system" (CARB, 2016b).

However, according to CARB's *Initial Statement of Reasons* (ISOR) for oil and gas regulation, condensate tanks with a throughput of 50 barrels of crude oil or condensate per day have the potential to exceed the 10 MT of methane threshold. CARB found that "the throughput levels for systems at 10 MT of methane were 5.5 barrels of oil per day (BOPD)" (CARB, 2016a). Furthermore, when CARB conducted testing on storage vessels with a throughput of 50 BOPD, they found four of them to exceed the 10 MT of methane threshold, demonstrating that small throughput producers exempt from flash testing and emission control requirements have the potential to emit substantial amounts of methane and subsequent co-pollutants.

In an effort to determine what impact removing the small tanks producer exemptions from California's Oil and Gas Methane Regulation would have on the state's air quality, we evaluated the existing literature as it pertains to emissions from small throughput producers. According to a 2016 analysis, separator and tank systems exempt from control measures account for approximately 12% (1,088 MT) of total methane emissions reductions that could be achieved if a permanent vapor collection system were installed on all separator and tank systems under CARB jurisdiction (**Table 4.12**) (CARB, 2016b).

Table 4.12. Impact of different annual methane standards on uncontrolled systems. Source: Table 7, CARB (2016b).

Control Status	Category	# of Systems	# of Water Tanks	System Emission Reductions (MT/yr)		Water Tank Emission Reductions (MT/yr)		Total CH_4	Total CH_4
				CH_4	VOC	CH_4	VOC		
Exempt	0 MT	1,034	1,129	288	52	687	124	975	10.4%
	5 MT	9	9	58	10	21	4	79	0.8%
	10 MT	-	5	-	-	34	-	34	0.4%
Exempt Total		***1,043***	***1,143***	***346***	***62***	***742***	***127***	***1,088***	***11.6%***
Controlled	15 MT	3	8	50	-	46	-	96	1.0%
	20 MT	19	29	413	-	228	-	641	6.9%
	25 MT	2	28	58	-	372	-	430	4.6%
	30 MT	1	56	34	-	847	-	881	9.4%
	35 MT	-	69	-	-	1,266	-	1,266	13.5%
	40 MT	4	99	316	-	4,631	-	4,947	52.9%
Controlled Total		***29***	***289***	***871***	***-***	***7,390***	***-***	***8,261***	***88.4%***

Condensate and produced water tank systems are also known to be a significant source of NMVOC emissions. As stated by CARB, 10 MT of methane from a small throughput condensate or produced water tank is equivalent to ~1.8 MT/year (~2 tons/year) VOCs. Using this ratio, we found the potential NMVOC emission reductions that could be achieved if exempt sources were included in this regulation to be 189 MT of VOC annually (~208 tons/year) (**Table 4.12**). However, it is important to note that these reductions are a very small fraction of the State's total VOC inventory.

The emissions estimates do not include emissions from tanks and systems currently controlled or exempt under district rules, including those condensate tank systems regulated under SJVAPCD Rule 4623, and SCAQMD Rule 463 and Rule 1178, for example (CARB, 2016b). Each local district rule for storage vessels requires 95% vapor recovery from separator and tank systems but may have different definitions for exempt sources. Similar to state-level exemptions, *SJVAPCD Rule 4623 Storage of Organic Liquids* excludes small producers with tank throughputs of 50 barrels per day (BPD) or less from vapor collection system requirements (SJVAPCD, 2005). SCAQMD Rule 463 is more stringent, however, only exempting tanks with a monthly average throughput of less than 30 BPD of oil and only if construction occurred prior to June 1, 1984 (SCAQMD, 2011). Furthermore, these estimates were taken from a five-year-old report and may not reflect the number of exempt and non-exempt systems currently in operation in California. Therefore, the methane and subsequent NMVOC and TAC emission reductions are likely greater than what is summarized here.

The additional reduction in methane emissions and subsequent reductions in NMVOCs and TACs released from storage vessel vapor would be potentially significant if the small throughput exemption of <50 BPD of oil or condensate and <200 BPD of produced water were removed from California's statewide Oil and Gas Methane Regulation or updated to be as stringent as SCAQMD's rules. Furthermore, if local jurisdictions like the SJVAPCD also agree to

remove/reduce their small throughput exemptions, the emissions reductions achieved and co-benefits to local residents could be much greater.

4.4.4. LDAR requirements: Heavy liquid exemptions and consideration of vulnerable communities

California's Oil and Gas Methane Regulation (as summarized in § 95669) includes measures related to LDAR (CARB, 2017c). Specifically, CARB's LDAR regulation requires owners and operators of oil and gas facilities (as defined in § 95666) to conduct LDAR surveys on a quarterly basis (beginning January 1, 2018) in an effort to adequately monitor oil and gas components (including components found on tanks, separators, wells, pressure vessels) for potential leaks, and repair said leaks in a timely manner (CARB, 2020b). Operators are required to submit annual LDAR reports to CARB by July 1 of each year (CARB, 2017c, 2020b).

4.4.4.1 Heavy liquid exemptions from state LDAR requirements

Components used exclusively for crude oil with an average annual API gravity of less than 20 degrees are exempt from California's Oil and Gas Methane Regulation LDAR requirements (CARB, 2017c). The API gravity scale is intended to measure the density of produced oil in relation to water. Crude oil that is heavy is more viscous and denser than what is considered to be light or medium crude oil, which typically has an API gravity of 20 degrees or more (CEC, 2020). This exemption applies to crude oil and produced water components, as well as to tank components, including pressure relief valves and pressure vacuum valves (SJVAPCD, 2019). **Figure 4.14** below provides the percentage of oil produced in California by API gravity in 2018 (CEC, 2020). As you can see, a substantial portion of oil produced in California is defined as "heavy."

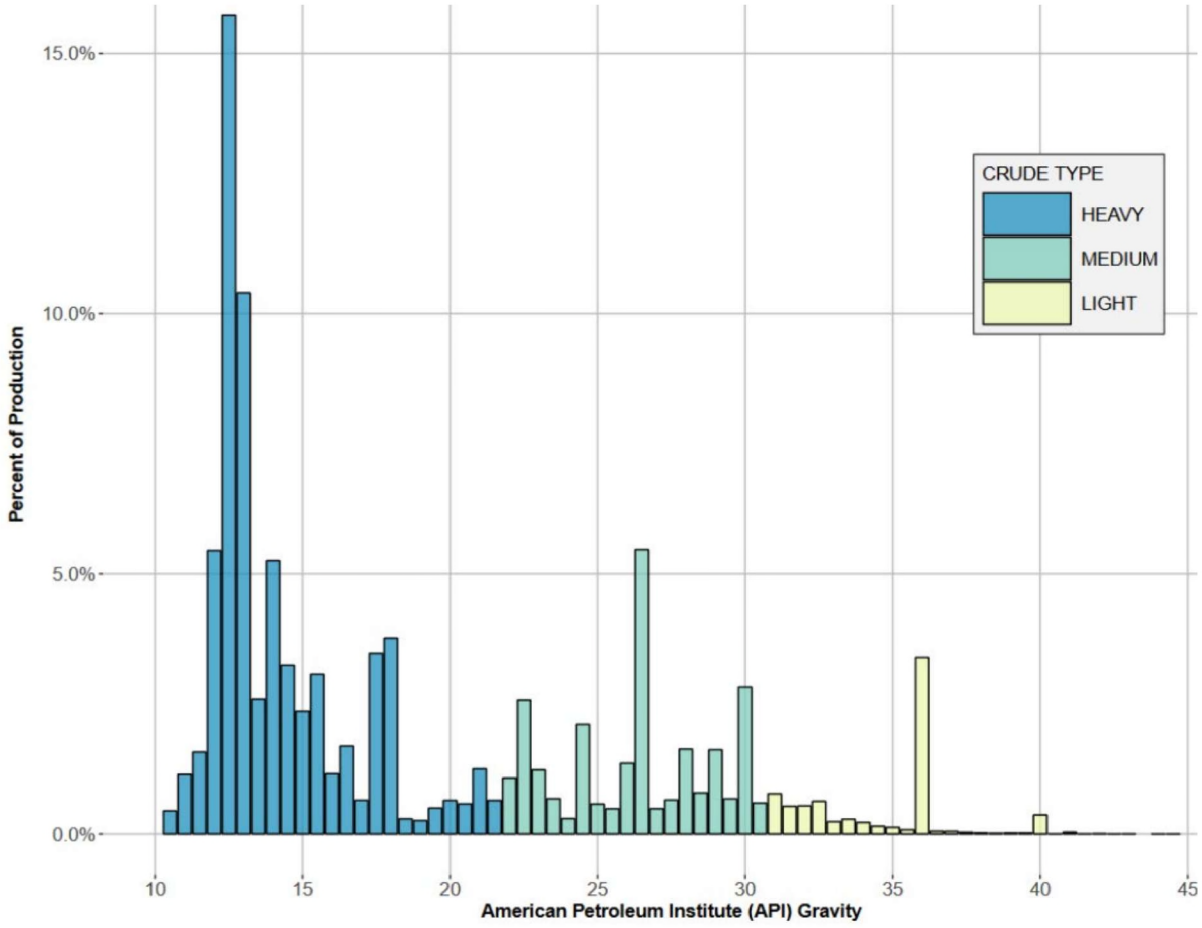


Figure 4.14. California oil field API gravity in 2018. Source: Figure from CEC (2020) analysis.

CARB states the LDAR exemption for heavy oil components is due to the fact that heavy oil (API gravity <20) emits lower levels of emissions when compared to all components subject to California's Oil and Gas Methane Regulation (CARB, 2020b). In CARB's ISOR for oil and gas, CARB states,

> "...analysis of published emission factors to date show that components associated with heavy oil emit less total hydrocarbons, and therefore less methane, than other components found in gas or other liquid service" (CARB, 2016b).

Heavy oil exemptions remain amid recent "Amendments to the Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities," which will go into effect on April 1, 2024 (CARB, 2024). CARB states that this exempt category makes up less than 1% of hydrocarbon emissions from leaking components (CARB, 2020b; 2022; CalGEM, 2023). While heavy crude oil production operations and associated components may represent a small fraction of total hydrocarbon emissions from the statewide upstream OGD sector, these emissions may be meaningful to risk of NMVOC exposure in areas with concentrated exempt infrastructure, or when this infrastructure exists in close proximity to human populations. Of note, CalGEM released a Request for Information on February 29, 2024, to seek feedback on "technologies and processes

that can be used to effectively ensure leaks associated with oil and gas operations are being detected." (CalGEM, 2024)

4.4.4.2 Consideration of proximity and disproportionately impacted communities

As previously discussed in Section 4.4.2, oil and gas regions in Colorado face similar challenges to California in achieving attainment with NAAQS thresholds for ozone (CDPHE AQCC, 2021). As the oil and gas industry is the largest contributor of NMVOCs and anthropogenic methane statewide, Colorado implemented rules, including LDAR requirements, to control and reduce contributions from the oil and gas industry (CDPHE AQCC, 2021). Colorado's LDAR program, as outlined in Regulation Number 7 and updated in 2021 (IEA, 2021), is more stringent when compared to California's existing LDAR requirements, indicating that there are additional measures that could be integrated into California's current regulations to further reduce methane and associated co-pollutant emissions from the oil and gas sector.

Under Section II.E of Colorado's Regulation Number 7, well site and compressor station owners and operators must inspect components, at varying frequencies, for leaks using an approved monitoring method, and must repair identified leaks within a timely manner (CDPHE AQCC, 2021). LDAR inspection frequencies for well production facilities and gas compressor stations are established based on the magnitude of NMVOC emissions. Recent updates to this rule also require consideration of the facility's proximity to occupied areas (a residence, school, large commercial establishment, or outdoor venue) in addition to the amount of NMVOCs emitted. **Table 4.13** below provides a summary of the inspection frequency schedules for each facility type.

Table 4.13. Well production facility and gas compressor station component inspections. Source: Adapted from Table 4, Colorado Regulation Number 7, CDPHE AQCC (2021).

Well Production Facilities				
Fugitive VOC Emissions (tpy)		**Inspection Frequency**		
Without Storage Tanks	**With Storage Tanks**	**Approved Instrument Monitoring**	**Audio, Visual, Olfactory**	**Phase-In Schedule**
> 0 to < 2		One time	Monthly	January 1, 2016
≥ 2 to ≤ 12		Semi-annual	Monthly	* begins in 2020
> 2 and < 12, located within 1,000 feet of an occupied area		Quarterly	Monthly	* begins in 2020
> 12 to ≤ 20	> 12 to ≤ 50	Quarterly	Monthly	January 1, 2015
> 12, located within 1,000 feet of an occupied area		Monthly	NA	* begins in 2020
> 20	> 50	Monthly	NA	January 1, 2015
Beginning January 1, 2023				
> 0 to < 2		Annual	Monthly	January 1, 2023
> 0 to < 2, located within 1,000 feet of an occupied area		Semi-annual	Monthly	
> 0 to < 2, located in the 8-hour ozone control area and within a disproportionately impacted community		Semi-annual	Monthly	
> 2 and < 50		Quarterly	Monthly	
> 2 to < 12, located within 1,000 feet of an occupied area or within a disproportionately impacted community		Bimonthly	Monthly	
> 12, located within 1,000 feet of an occupied area or within a disproportionately impacted community		Monthly	NA	
> 20	> 50	Monthly	NA	
Natural Gas Compressor Stations				
Fugitive VOC Emissions (tpy)		**Inspection Frequency**		
Without Storage Tanks	**With Storage Tanks**	**Approved Instrument Monitoring**	**Audio, Visual, Olfactory**	**Phase-In Schedule**
> 0 to ≤ 12		Semi-annual	NA	January 1, 2015
> 12 to ≤ 50		Quarterly	NA	
> 50		Monthly	NA	
Beginning January 1, 2023				
> 0 to < 12		Quarterly	NA	January 1, 2023
> 0 to < 50, located within a disproportionately impacted community or within 1,000 feet of an occupied area		Bimonthly	NA	
> 12 to < 50		Quarterly	NA	
>50		Monthly	NA	

The updated LDAR requirements under Colorado Regulation Number 7 require more frequent inspections to be conducted for compressor stations and well production facilities located within 1,000 ft (305 m) of an occupied area or located in disproportionally impacted communities

(CDPHE, 2021).[9] For example, beginning in 2020, well production facilities emitting greater than 2 tpy of NMVOCs but less than or equal to 12 tpy (≥2 and ≤12 tpy) are required to conduct inspections semi-annually using an approved instrument monitoring method;[10] however, facilities with emissions in this same range located within 1,000 feet of an occupied area are required to conduct inspections quarterly (**Table 4.13**). Gas compressor stations and well production facility component inspections on or after January 1, 2023 are required to adhere to an even faster inspection schedule, with more inspections required on a more frequent basis for facilities located within 1,000 ft (305 m) of a well production facility and for facilities located in disproportionately impacted communities (CDPHE, 2021).

Facilities located within 1,000 ft (305 m) of an occupied area are also subject to more stringent repair timelines (CDPHE AQCC, 2021). Beginning March 2021, leaks identified at well production facilities within 1,000 ft (305 m) of an occupied area are required to either (1) repair the leak within five working days from initial discovery; or (2) follow-up with additional monitoring using EPA Method 21 within five working days from initial discovery. For facilities with leaks located outside this distance of 1,000 ft, operators are required to either (1) repair the leak within five but no later than 30 working days from initial discovery; or (2) follow-up with additional monitoring using EPA Method 21 within five working days from initial discovery. As determined by the Commission, faster repair schedules and additional monitoring is required to protect public health and the environment within these vulnerable and disproportionately impacted communities (CDPHE AQCC, 2021).

California's current local and statewide LDAR programs do not consider disproportionately impacted communities or communities in close proximity to well production facilities and gas compressor stations (CARB, 2017c). Leaks from upstream gas infrastructure represents a significant source of methane and ozone precursor emissions and LDAR requirements have demonstrated their effectiveness at mitigating off-normal NMVOC releases from the oil and gas industry. While California's existing LDAR program does much to reduce emissions from this sector, examples of other state LDAR policies indicate that it is possible for California to do more to further reduce large off-normal releases of methane and NMVOCs, especially for those communities near upstream sites and who are disproportionately health burdened. As such, California LDAR policies could consider implementing more stringent inspection, monitoring, and repair requirements for upstream oil and gas production facilities located closed to populations or located within disproportionately burdened communities.

[9] Disproportionately impacted communities are defined by the Colorado Environmental Justice Act (HB21-1266) as census block groups where greater than 40% of households are (1) low income, (2) housing cost-burdened, or (3) include people of color.

[10] An alternative to the list of approved air monitoring methods includes non-quantitative monitoring, e.g., infrared cameras and/or audio, visual, olfactory (AVO) methods. However, for operators implementing these alternative monitoring methods are required to conduct monthly inspections, however, and are subject to more stringent repair requirements.

4.4.5. Summary of findings

Enforced vapor recovery and LDAR regulations provide tools to enhance detection and reductions of emissions of methane and NM VOCs, including TACs and ozone precursors to the atmosphere. In California, regulatory exemptions from vapor recovery, LDAR, and equipment change-out requirements have been established based on methane and NMVOC emissions from specific upstream oil and gas sources. These exemptions include, but are not limited to (1) a statewide zero-bleed/zero-emission standards exemption for existing low-bleed (<6 standard cubic feet per hour) natural gas-driven pneumatic devices installed prior to January 1, 2016; 2) an exemption from the statewide 95% vapor recovery requirement for low-throughput separators and condensate tank systems; and (3) an exemption from the statewide leak detection and repair (LDAR) requirement for upstream oil and gas infrastructure components associated with heavy oil (API gravity <20).

The closure of the exemptions from statewide zero-bleed/zero-emission standards for existing low-bleed pneumatic devices and vapor recovery requirements for low-throughput separators and condensate tank systems would reduce NMVOC emissions by an estimated 15 tpy from 50 existing natural gas powered pneumatic devices and 208 tpy from ~2,200 small throughput separator and tank systems. Additionally, the California Air Resources Board states that heavy oil components (API gravity <20) exempt from LDAR account for less than 1% of hydrocarbon emissions from leaking components. While these exemptions represent a small fraction of NMVOC emissions from the statewide upstream oil and gas development sector, these emissions may be meaningful to risk of NMVOC exposure in areas with concentrated exempt infrastructure or when this infrastructure exists in close proximity to human populations

4.5. Discussion

Findings suggest that emissions from upstream oil and gas may significantly impact regional air quality within specific regions of California, such as the San Joaquin Valley. In regions where upstream OGD is one of several sources of the regional ambient air pollution, such as the South Coast Air Basin, emissions from upstream OGD sites still pose a local risk to residents and other nearby sensitive populations (e.g., schools, playgrounds, community centers) due to local increases in pollutants associated with active oil and gas production. The cumulative burden of air pollution from oil and gas in addition to other pollution sources may exacerbate health risks.

The status of California's oil and gas producing regions under federal air quality regulations is relevant in thinking about the potential impacts from upstream OGD. The majority of the state's oil and gas producing regions are in nonattainment for ozone NAAQS, with upstream oil and gas contributing to these regions' nonattainment status. In the South Coast region, upstream OGD contributions are minimal when compared to all sources; in the San Joaquin Valley, emissions contributions are significant. Further, a 2018 federal rule on TAC emissions allows major industrial sources to reclassify as area sources and potentially increase their TAC emissions. Many such facilities lie within California's oil and gas producing regions. One study found that in the San Joaquin Valley, 13 major sources of TACs could potentially increase emissions by 300 tpy total

and in the Los Angeles area 15 facilities could potentially increase TACs by a total of 345 tpy (Declet-Barreto et al., 2020). These findings suggest more could be done to control emissions in these regions.

Methane and NMVOCs are emitted during upstream oil and gas development. Many of the NM VOCs emitted are TACs or ground-level ozone precursors. Because both methane and some NMVOCs have a common source, certain infrastructure components, such as wellheads, gas pipelines, and gas processing plants, have emission profiles with high methane:non-methane hydrocarbon ratios. However, other components, such as condensate tanks and produced water ponds, have emission profiles with far lower methane:non-methane hydrocarbon ratios, and methane is not a reliable indicator of NMVOCs that are not hydrocarbons. While diesel engines used for transport, pumps, and other purposes do not emit methane and have a zero methane:non-methane hydrocarbon ratio, they do emit criteria air pollutants (CAPs), TACs, and other air pollutants.

Results demonstrate a clear decline in methane (Collier-Oxandale et al., 2020; Okorn et al., 2021), benzene, and alkane emissions (Garcia-Gonzales et al., 2019b) as distance from oil and gas production increases. For example, in one study, benzene levels were highest 427 ft (130 m) from activity, and levels of n-hexane and n-pentane (alkanes) were highest 640 ft (195 m) and 542 ft (165 m) away, respectively (Garcia-Gonzales et al., 2019b). An important implication from this assessment is that significant reductions in methane could translate to potentially significant reductions in TACs and ozone precursors emissions (e.g., NMVOCs), beyond what is currently being achieved in California.

Studies conducted on oil and gas development outside of California identified several NMVOCs, including TACs such as n-hexane, benzene, ethylbenzene, toluene, and xylenes, as methane co-pollutants. Significant correlations were also found among emissions of benzene and toluene, benzene and m- & p-xylene, and toluene and m- & p-xylene. Many of the NMVOCs identified as methane co-pollutants in other oil and gas producing states have been detected in emissions from, and atmospheric concentrations near, upstream oil and gas development in California (e.g. benzene, toluene, ethylbenzene, xylenes, alkanes).

LDAR focused on monitoring for methane is useful when monitoring equipment with emissions that have high methane:non-methane hydrocarbon ratios. In this context, methane can be a reasonable indicator of the presence of TACs and other NMVOCs that are intermixed with methane. However, when monitoring emissions from infrastructure or processes containing gases with low methane:non-methane ratios (e.g., condensate tanks, produced water management and disposal, etc.) or little to no methane content (e.g., combustion from diesel engines, combustion emission from natural gas-powered equipment, etc.), methane is not a reliable indicator of TAC and other NMVOC emissions and there is likely no surrogate for these situations. LDAR approaches that focus on measurement of large suites of air pollutant species may be more comprehensive and appropriate for various applications when gas composition is uncertain.

In California, regulatory exemptions from vapor recovery, LDAR, and equipment change-out requirements have been established based on methane and NMVOC emissions from specific upstream oil and gas sources. These exemptions include, but are not limited to (1) a statewide zero-bleed/zero-emission standards exemption for existing low-bleed (<6 standard cubic feet per hour) natural-gas driven pneumatic devices installed prior to January 1, 2016; (2) an exemption from the statewide 95% vapor recovery requirement for low-throughput separators and condensate tank systems; and (3) an exemption from the statewide leak detection and repair (LDAR) requirement for upstream oil and gas infrastructure components associated with heavy oil (API gravity <20). While exemptions represent a small fraction of NMVOC emissions from the statewide upstream OGD sector (Section 4.4), these emissions may be meaningful to risk of NMVOC exposure in areas with concentrated exempt infrastructure or when this infrastructure exists in close proximity to human populations.

Studies conducted outside California identified ethane, hexane, pentane, heptane, butane, and benzene as methane co-pollutants. Significant correlations were also found among emissions of benzene and toluene, benzene and m- & p-xylene, and toluene and m- & p-xylene. While not specific to California, many of the compounds identified as co-pollutants of methane in other oil and gas producing states have also been detected in emissions from upstream OGD in California (e.g., BTEX, alkanes).

References

Adgate, J. L., Goldstein, B. D., & McKenzie, L. M. (2014). Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development. *Environmental Science & Technology*, *48*(15), 8307–8320. https://doi.org/10.1021/es404621d

Ahmadov, R., McKeen, S., Trainer, M., Banta, R., Brewer, A., Brown, S., Edwards, P. M., de Gouw, J. A., Frost, G. J., Gilman, J., Helmig, D., Johnson, B., Karion, A., Koss, A., Langford, A., Lerner, B., Olson, J., Oltmans, S., Peischl, J., … Zamora, R. (2015). Understanding high wintertime ozone pollution events in an oil- and natural gas-producing region of the western US. *Atmospheric Chemistry and Physics*, *15*(1), 411–429. https://doi.org/10.5194/acp-15-411-2015

Allen, D. T., Torres, V. M., Thomas, J., Sullivan, D. W., Harrison, M., Hendler, A., Herndon, S. C., Kolb, C. E., Fraser, M. P., Hill, A. D., Lamb, B. K., Miskimins, J., Sawyer, R. F., & Seinfeld, J. H. (2013). Measurements of methane emissions at natural gas production sites in the United States. *Proceedings of the National Academy of Sciences*, *110*(44), 17768–17773. https://doi.org/10.1073/pnas.1304880110

Allen, D. T. (2014). Atmospheric Emissions and Air Quality Impacts from Natural Gas Production and Use. *Annual Review of Chemical and Biomolecular Engineering*, *5*(1), 55–75. https://doi.org/10.1146/annurev-chembioeng-060713-035938

Allen, D. T. (2016). Emissions from oil and gas operations in the United States and their air quality implications. *Journal of the Air & Waste Management Association*, *66*(6), 549–575. https://doi.org/10.1080/10962247.2016.1171263

Aronson, D., Boethling, R., Howard, P., & Stiteler, W. (2006). Estimating biodegradation half-lives for use in chemical screening. *Chemosphere*, *63*(11), 1953–1960. https://doi.org/10.1016/j.chemosphere.2005.09.044

Bamber, A. M., Hasanali, S. H., Nair, A. S., Watkins, S. M., Vigil, D. I., Van Dyke, M., McMullin, T. S., & Richardson, K. (2019). A Systematic Review of the Epidemiologic Literature Assessing Health Outcomes in Populations Living near Oil and Natural Gas Operations: Study Quality and Future Recommendations. *International Journal of Environmental Research and Public Health*, *16*(12), 2123. https://doi.org/10.3390/ijerph16122123

Banan, Z., & Gernand, J. M. (2018). Evaluation of gas well setback policy in the Marcellus Shale region of Pennsylvania in relation to emissions of fine particulate matter. *Journal of the Air & Waste Management Association*, *68*(9), 988–1000. https://doi.org/10.1080/10962247.2018.1462866

Banan, Z., & Gernand, J. M. (2021). Emissions of particulate matter due to Marcellus Shale gas development in Pennsylvania: Mapping the implications. *Energy Policy*, *148*, 111979. https://doi.org/10.1016/j.enpol.2020.111979

Bolden, A. L., Schultz, K., Pelch, K. E., & Kwiatkowski, C. F. (2018). Exploring the endocrine activity of air pollutants associated with unconventional oil and gas extraction. *Environmental Health*, *17*. https://doi.org/10.1186/s12940-018-0368-z

Brandt, A., Millstein, D., Jin, L., & Englander, J. (2015). *Air Quality Impacts from Well Stimulation*. In An Independent Scientific Assessment of Well Stimulation in California. https://ccst.us/wp-content/uploads/160708-sb4-vol-II-3-1.pdf

Brantley, H. L., Thoma, E. D., & Eisele, A. P. (2015). Assessment of volatile organic compound and hazardous air pollutant emissions from oil and natural gas well pads using mobile remote and on-site direct measurements. *Journal of the Air & Waste Management Association*, *65*(9), 1072–1082. https://doi.org/10.1080/10962247.2015.1056888

Brown, D. R., Weinberger, B., Lewis, C., & Bonaparte, H. (2014). Understanding exposure from natural gas drilling puts current air standards to the test. *Reviews on Environmental Health*, *29*(4). https://doi.org/10.1515/reveh-2014-0002

Brown, D. R., Lewis, C., & Weinberger, B. I. (2015). Human exposure to unconventional natural gas development: A public health demonstration of periodic high exposure to chemical mixtures in ambient air. *Journal of Environmental Science and Health, Part A*, *50*(5), 460–472. https://doi.org/10.1080/10934529.2015.992663

Bunch, A. G., Perry, C. S., Abraham, L., Wikoff, D. S., Tachovsky, J. A., Hixon, J. G., Urban, J. D., Harris, M. A., & Haws, L. C. (2014). Evaluation of impact of shale gas operations in the Barnett Shale region on volatile organic compounds in air and potential human health risks. *Science of The Total Environment*, *468–469*, 832–842. https://doi.org/10.1016/j.scitotenv.2013.08.080

CalGEM (California Geologic Energy Management Division). (2015). *SB4 Well Stimulation Final Environmental Impact Report*. https://www.conservation.ca.gov/calgem/Pages/SB4_Final_EIR_TOC.aspx

CalGEM. (2021a). *Annual Production & Injection Volumes, 2010—2021*.

CalGEM. (2021b). *GIS Mapping—Oil & Gas Field Boundaries & All Well Locations*. https://www.conservation.ca.gov/calgem/maps/Pages/GISMapping2.aspx

CalGEM (2023). Methane Task Force — Frequently Asked Questions. https://www.conservation.ca.gov/calgem/Documents/MTF%20FAQs%20draft%2010-12-23.pdf.

CalGEM. (2024). Geologic Energy Management Laws and Rulemaking. https://www.conservation.ca.gov/calgem/laws-regulations.

Cal. Senate Bill No. 4 (2013) (Pavley, sponsor). Oil and Gas: Well Stimulation. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB4

CARB (California Air Resources Board). (2013a). *Final Report (Revised): 2007 Oil and Gas Industry Survey Results, Final Report (Revised), October 2013 (posted November 1, 2013)*. https://ww2.arb.ca.gov/resources/documents/oil-and-gas-industry-survey

CARB. (2013b). Annual Toxics Summaries by Monitoring Site. https://www.arb.ca.gov/adam/toxics/sitesubstance.html

CARB. (2016a). *INITIAL STATEMENT OF REASONS - Appendix D: Calculation of Emission Estimates and Reductions*. https://www.arb.ca.gov/regact/2016/oilandgas2016/oilgasappd.pdf

CARB. (2016b). *PUBLIC HEARING TO CONSIDER THE PROPOSED REGULATION FOR GREENHOUSE GAS EMISSION STANDARDS FOR CRUDE OIL AND NATURAL GAS FACILITIES STAFF REPORT: INITIAL STATEMENT OF REASONS.* https://ww3.arb.ca.gov/regact/2016/oilandgas2016/oilgasisor.pdf

CARB. (2017a, April 20). *CAPCOA BACT Clearinghouse Resource Manual: Stationary Source Regulation in California*. https://ww3.arb.ca.gov/bact/docs/ssrcalifornia.htm

CARB. (2017b, April 27). *BACT Definitions. https://ww2.arb.ca.gov/our-work/programs/stationary/stationary-source-permitting/bact-program/bact-definitions*

CARB. (2017c). *California Code of Regulations, Title 17, Division 3, Chapter 1, Subchapter 10 Climate Change, Article 4, Subarticle 13: Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities (Oil and Gas Methane Regulation)*. https://ww2.arb.ca.gov/sites/default/files/2020-03/2017%20Final%20Reg%20Orders%20GHG%20Emission%20Standards.pdf

CARB. (2018a). *SNAPS Communities Selected for First Round of Air Monitoring*. SNAPS First Round Communities. https://ww2.arb.ca.gov/resources/documents/snaps-first-round-communities

CARB. (2018b). *Air Sampling and Analysis Plan for Well Stimulation Treatment Operations for Wells API*. https://ww2.arb.ca.gov/sites/default/files/2021-03/PSE_Appendix_A.pdf

CARB. (2018c, August 13). *Oil and Gas Methane Regulation Factsheet*. https://ww2.arb.ca.gov/resources/fact-sheets/oil-and-gas-methane-regulation

CARB. (2018d). *STAFF REPORT: PROPOSED SUBMISSION OF CALIFORNIA'S GREENHOUSE GAS EMISSION STANDARDS FOR CRUDE OIL AND NATURAL GAS FACILITIES INTO THE CALIFORNIA STATE IMPLEMENTATION PLAN*. https://ww2.arb.ca.gov/sites/default/files/2020-04/O_G%20CTG%20-%20Staff%20Report.pdf

CARB. (2019a, November 12). *Geographical Information System (GIS) Library*. https://ww2.arb.ca.gov/geographical-information-system-gis-library

CARB. (2019b, October). *SNAPS Lost Hills Mid-Monitoring Update—October 2019*. https://ww2.arb.ca.gov/resources/documents/snaps-lost-hills-mid-monitoring-update-october-2019

CARB. (2020a). *Expedited BARCT*. https://ww2.arb.ca.gov/our-work/programs/technology-clearinghouse/expedited-barct

CARB. (2020b). *CARB's Oil and Gas Methane Regulation 2018 Annual LDAR Summary*. 13. https://ww2.arb.ca.gov/sites/default/files/2022-01/CARBOilandGasMethaneRegulation2018AnnualLDARSummary-Revised.pdf

CARB. (2021a). *BACT Program*. https://ww2.arb.ca.gov/BACT

CARB. (2021b). *Study of Neighborhood Air near Petroleum Sources: Resources*. https://ww2.arb.ca.gov/our-work/programs/study-neighborhood-air-near-petroleum-sources/resources

CARB. (2021c). *Current Air District Rules*. https://ww2.arb.ca.gov/current-air-district-rules

CARB. (2022). Public Workshop: Potential Changes to the Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities (Oil and Gas Methane Regulation). https://ww2.arb.ca.gov/sites/default/files/2022-09/Potential%20Changes%20to%20OG%20Methane%20Regulation%20-%20Workshop%209-20-22_0.pdf

CARB. (2024). Amendments to the Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities. https://ww2.arb.ca.gov/rulemaking/2023/oil-and-gas-2023

CCST (California Council on Science and Technology). (2015). *An Independent Scientific Assessment of Well Stimulation in California: Volume 1 Well Stimulation Technologies and their Past, Present, and Potential Future Use in California*. https://ccst.us/wp-content/uploads/160708-sb4-vol-I.pdf

CDPHE (Colorado Department of Public Health). (2021, November 1). *Data Viewer for Disproportionately Impacted Communities in Colorad*. https://cohealthviz.dphe.state.co.us/t/EnvironmentalEpidemiologyPublic/views/EJActDICommunities-Public/HB21-1266DICommunities?%3AshowAppBanner=false&%3Adisplay_count=n&%3AshowVizHome=n&%3Aorigin=viz_share_link&%3AisGuestRedirectFromVizportal=y&%3Aembed=y

CDPHE. (2022). *Severe Ozone Planning | Department of Public Health & Environment*. https://cdphe.colorado.gov/severe-ozone-planning

CDPHE AQCC (Air Quality Control Commission). (2021, February 18). *Regulation Number 7: Control of Ozone via Ozone Precursors and Control of Hydrocarbons via Oil and Gas Emissions (Emissions of Volatile Organic Compounds and Nitrogen Oxides)*.

CEC (California Energy Commission). (2020). *February 2020 Petroleum Watch*. https://www.energy.ca.gov/sites/default/files/2020-02/2020-02_Petroleum_Watch_ADA_0.pdf

Collier-Oxandale, A., Wong, N., Navarro, S., Johnston, J., & Hannigan, M. (2020). Using gas-phase air quality sensors to disentangle potential sources in a Los Angeles neighborhood. *Atmospheric Environment*, *233*, 117519. https://doi.org/10.1016/j.atmosenv.2020.117519

CVRWQCB (Central Valley Regional Water Quality Control Board), Mahoney, J. G., Asami, R. T., & Stringfellow, W. T. (2021). *Draft Food Safety Project White Paper On the Reuse of Oil Field Produced Water for Irrigation of Food Crops In Central Kern County, California*. https://www.waterboards.ca.gov/centralvalley/water_issues/oil_fields/food_safety/data/white_paper/foodsafety_whitepaper.pdf

Declet-Barreto, J., Goldman, G. T., Desikan, A., Berman, E., Goldman, J., Johnson, C., Montenegro, L., & Rosenberg, A. A. (2020). Hazardous air pollutant emissions implications under 2018 guidance on U.S. Clean Air Act requirements for major sources. *Journal of the Air & Waste Management Association*, *70*(5), 481–490. https://doi.org/10.1080/10962247.2020.1735575

Deschenes, O., Deshmukh, R., Lea, D., Meng, K., Weber, P., Cobian, T., Hernandez Cortes, D., Lee, R., Malloy, C., Mangin, T., Meng, M., Oliver, M., Sum, S., Thivierge, V., Uppal, A., Kordell, T., Clemence, M., O'Reilly, E., & Kelley, A. (2021). *Enhancing equity while eliminating emissions in California's supply of transportation fuels*. https://doi.org/10.5281/zenodo.4707966

Deziel, N. C., Brokovich, E., Grotto, I., Clark, C. J., Barnett-Itzhaki, Z., Broday, D., & Agay-Shay, K. (2020). Unconventional oil and gas development and health outcomes: A scoping review of the epidemiological research. *Environmental Research*, *182*, 109124. https://doi.org/10.1016/j.envres.2020.109124

Eisele, A. P., Mukerjee, S., Smith, L. A., Thoma, E. D., Whitaker, D. A., Oliver, K. D., Wu, T., Colon, M., Alston, L., Cousett, T. A., Miller, M. C., Smith, D. M., & Stallings, C. (2016). Volatile organic compounds at two oil and natural gas production well pads in Colorado and Texas using passive samplers. *Journal of the Air & Waste Management Association*, *66*(4), 412–419. https://doi.org/10.1080/10962247.2016.1141808

Esswein, E. J., Snawder, J., King, B., Breitenstein, M., Alexander-Scott, M., & Kiefer, M. (2014). Evaluation of Some Potential Chemical Exposure Risks During Flowback Operations in Unconventional Oil and Gas Extraction: Preliminary Results. *Journal of Occupational and Environmental Hygiene*, *11*(10), D174–D184. https://doi.org/10.1080/15459624.2014.933960

ExxonMobil. (2021). *Mitigating Methane Emissions from the Oil and Gas Industry*. https://corporate.exxonmobil.com/~/media/Global/Files/newsroom/publications-and-reports/Mitigating-Methane-Emissions-from-the-Oil-and-Gas-Industry-Model-Regulatory-Framework.pdf

Fann, N., Baker, K. R., Chan, E. A. W., Eyth, A., Macpherson, A., Miller, E., & Snyder, J. (2018). Assessing Human Health PM2.5 and Ozone Impacts from U.S. Oil and Natural Gas Sector Emissions in 2025. *Environmental Science & Technology*, *52*(15), 8095–8103. https://doi.org/10.1021/acs.est.8b02050

Garcia-Gonzales, D. A., Shonkoff, S. B. C., Hays, J., & Jerrett, M. (2019a). Hazardous Air Pollutants Associated with Upstream Oil and Natural Gas Development: A Critical Synthesis of Current Peer-Reviewed Literature. *Annual Review of Public Health*, *40*(1), 283–304. https://doi.org/10.1146/annurev-publhealth-040218-043715

Garcia-Gonzales, D. A., Shamasunder, B., & Jerrett, M. (2019b). Distance decay gradients in hazardous air pollution concentrations around oil and natural gas facilities in the city of Los Angeles: A pilot study. *Environmental Research*, *173*, 232–236. https://doi.org/10.1016/j.envres.2019.03.027

Goetz, J. D., Floerchinger, C., Fortner, E. C., Wormhoudt, J., Massoli, P., Knighton, W. B., Herndon, S. C., Kolb, C. E., Knipping, E., Shaw, S. L., & DeCarlo, P. F. (2015). Atmospheric Emission Characterization of Marcellus Shale Natural Gas Development Sites. *Environmental Science & Technology*, *49*(11), 7012–7020. https://doi.org/10.1021/acs.est.5b00452

Goetz, J. D., Avery, A., Werden, B., Floerchinger, C., Fortner, E. C., Wormhoudt, J., Massoli, P., Herndon, S. C., Kolb, C. E., Knighton, W. B., Peischl, J., Warneke, C., Gouw, J. A. de, Shaw, S. L., & DeCarlo, P. F. (2017). Analysis of local-scale background concentrations of methane and other gas-phase species in the Marcellus Shale. *Elementa: Science of the Anthropocene*, *5*(0). https://doi.org/10.1525/elementa.182

Gonzalez, D. J. X., Francis, C. K., Shaw, G. M., Cullen, M. R., Baiocchi, M., & Burke, M. (2022). Upstream oil and gas production and ambient air pollution in California. *Science of The Total Environment*, *806*, 150298. https://doi.org/10.1016/j.scitotenv.2021.150298

Gouin, T., & Harner, T. (2003). Modelling the environmental fate of the polybrominated diphenyl ethers. *Environmental International*, *29*(6), 717–724. https://doi.org/10.1016/S0160-4120(03)00116-8

Haley, M., McCawley, M., Epstein, A. C., Arrington, B., & Bjerke, E. F. (2016). Adequacy of Current State Setbacks for Directional High-Volume Hydraulic Fracturing in the Marcellus, Barnett, and Niobrara Shale Plays. *Environmental Health Perspectives*, *124*(9), 1323–1333. https://doi.org/10.1289/ehp.1510547

Hecobian, A., Clements, A. L., Shonkwiler, K. B., Zhou, Y., MacDonald, L. P., Hilliard, N., Wells, B. L., Bibeau, B., Ham, J. M., Pierce, J. R., & Collett, J. L. (2019). Air Toxics and Other Volatile Organic Compound Emissions from Unconventional Oil and Gas Development. *Environmental Science & Technology Letters*, *6*(12), 720–726. https://doi.org/10.1021/acs.estlett.9b00591

Helmig, D., Thompson, C. R., Evans, J., Boylan, P., Hueber, J., & Park, J.-H. (2014). Highly Elevated Atmospheric Levels of Volatile Organic Compounds in the Uintah Basin, Utah. *Environmental Science & Technology*, *48*(9), 4707–4715. https://doi.org/10.1021/es405046r

Holder, C., Hader, J., Avanasi, R., Hong, T., Carr, E., Mendez, B., Wignall, J., Glen, G., Guelden, B., Wei, Y., & CDPHE (Colorado Department of Public Health and Environment). (2019). Evaluating potential human health risks from modeled inhalation exposures to volatile organic compounds emitted from oil and gas operations. *Journal of the Air & Waste Management Association*, *69*(12), 1503–1524. https://doi.org/10.1080/10962247.2019.1680459

IEA (International Energy Agency). (2021, May 17). *(Colorado) Regulation No. 7: Control of ozone precursors and control of hydrocarbons via oil and gas emissions (as amended in February 2021)*. IEA. https://www.iea.org/policies/8857-colorado-regulation-no-7-control-of-ozone-precursors-and-control-of-hydrocarbons-via-oil-and-gas-emissions-as-amended-in-february-2021

Johnson, D., Heltzel, R., Nix, A., Darzi, M., & Oliver, D. (2018). Estimated Emissions from the Prime-Movers of Unconventional Natural Gas Well Development Using Recently Collected In-Use Data in the United States. *Environmental Science & Technology*. https://doi.org/10.1021/acs.est.7b06694

Johnston, J. E., Lim, E., & Roh, H. (2019). Impact of upstream oil extraction and environmental public health: A review of the evidence. *Science of The Total Environment*, *657*, 187–199. https://doi.org/10.1016/j.scitotenv.2018.11.483

Johnston, J. E., Okorn, K., Van Horne, Y. O., & Jimenez, A. (2021). Changes in neighborhood air quality after idling of an urban oil production site. *Environmental Science: Processes & Impacts*, *23*(7), 967–980. https://doi.org/10.1039/D1EM00048A

Koss, A. R., de Gouw, J., Warneke, C., Gilman, J. B., Lerner, B. M., Graus, M., Yuan, B., Edwards, P., Brown, S. S., Wild, R., Roberts, J. M., Bates, T. S., & Quinn, P. K. (2015). Photochemical aging of volatile organic compounds associated with oil and natural gas extraction in the Uintah Basin, UT, during a wintertime ozone formation event. *Atmospheric Chemistry and Physics*, *15*(10), 5727–5741. https://doi.org/10.5194/acp-15-5727-2015

LACDPH (Los Angeles County Department of Public Health). (2018, February). *Public Health and Safety Risks of Oil and Gas Facilities in Los Angeles County*. http://publichealth.lacounty.gov/eh/docs/ph_oilgasfacilitiesphsafetyrisks.pdf

Lebel, E. D., Lu, H. S., Vielstädte, L., Kang, M., Banner, P., Fischer, M. L., & Jackson, R. B. (2020). Methane Emissions from Abandoned Oil and Gas Wells in California. *Environmental Science & Technology*, *54*(22), 14617–14626. https://doi.org/10.1021/acs.est.0c05279

Lillis, P., Warden, A., Claypool, G., & Magoon, L. (2007). *Chapter 10: Petroleum Systems of the San Joaquin Basin Province—Geochemical Characteristics of Gas Types* (USGS Professional Paper 1713; Petroleum Systems and Geologic Assessment of Oil and Gas in the San Joaquin Basin Province, California). USGS. https://pubs.usgs.gov/pp/pp1713/10/pp1713_ch10.pdf

Long, C. M., Briggs, N. L., & Bamgbose, I. A. (2019). Synthesis and health-based evaluation of ambient air monitoring data for the Marcellus Shale region. *Journal of the Air & Waste Management Association*, *69*(5), 527–547. https://doi.org/10.1080/10962247.2019.1572551

Long, C. M., Briggs, N. L., Cochran, B. A., & Mims, D. M. (2021). Health-based evaluation of ambient air measurements of PM 2.5 and volatile organic compounds near a Marcellus Shale unconventional natural gas well pad site and a school campus. *Journal of Exposure Science & Environmental Epidemiology*, 1–14. https://doi.org/10.1038/s41370-021-00298-5

Macey, G. P., Breech, R., Chernaik, M., Cox, C., Larson, D., Thomas, D., & Carpenter, D. O. (2014). Air concentrations of volatile compounds near oil and gas production: A community-based exploratory study. *Environmental Health*, *13*(1), 82. https://doi.org/10.1186/1476-069X-13-82

Marrero, J. E., Townsend-Small, A., Lyon, D. R., Tsai, T. R., Meinardi, S., & Blake, D. R. (2016). Estimating Emissions of Toxic Hydrocarbons from Natural Gas Production Sites in the Barnett Shale Region of Northern Texas. *Environmental Science & Technology*, *50*(19), 10756–10764. https://doi.org/10.1021/acs.est.6b02827

Maskrey, J. R., Insley, A. L., Hynds, E. S., & Panko, J. M. (2016). Air monitoring of volatile organic compounds at relevant receptors during hydraulic fracturing operations in Washington County, Pennsylvania. *Environmental Monitoring and Assessment*, *188*(7), 1–12. https://doi.org/10.1007/s10661-016-5410-4

McCawley, M. (2015). Air Contaminants Associated with Potential Respiratory Effects from Unconventional Resource Development Activities. *Seminars in Respiratory and Critical Care Medicine*, *36*(3), 379–387. https://doi.org/10.1055/s-0035-1549453

McKenzie, L. M., Witter, R. Z., Newman, L. S., & Adgate, J. L. (2012). Human health risk assessment of air emissions from development of unconventional natural gas resources. *Science of The Total Environment*, *424*, 79–87. https://doi.org/10.1016/j.scitotenv.2012.02.018

McKenzie, L., Blair, B., Hughes, J., Allshouse, W. B., Blake, N. J., Helmig, D., Milmoe, P., Halliday, H., Blake, D. R., & Adgate, J. L. (2018). Ambient Nonmethane Hydrocarbon Levels Along Colorado's Northern Front Range: Acute and Chronic Health Risks. *Environmental Science & Technology*, *52*(8), 4514–4525. https://doi.org/10.1021/acs.est.7b05983

McMullin, T., Bamber, A., Bon, D., Vigil, D., & Van Dyke, M. (2018). Exposures and Health Risks from Volatile Organic Compounds in Communities Located near Oil and Gas Exploration and Production Activities in Colorado (U.S.A.). *International Journal of Environmental Research and Public Health*, *15*(7), 1500. https://doi.org/10.3390/ijerph15071500

Mellqvist, J., Samuelsson, J., Andersson, P., Brohede, S., Isoz, O., & Marianne, E. (2017). *Using Solar Occultation Flux and other Optical Remote Sensing Methods to measure VOC emissions from a variety of stationary sources in the South Coast Air Basin*. http://www.aqmd.gov/docs/default-source/fenceline_monitroing/project_2/fluxsense_project2_2015_final_report.pdf

Mellqvist, J., Samuelsson, J., Offerle, B., Lysvret, T., & Ericsson, M. (2019). *VOC Emissions Monitoring in the Lost Hills Vicinity, San Joaquin Valley*. 44. https://ww2.arb.ca.gov/resources/documents/voc-emissions-monitoring-lost-hills-vicinity-san-joaquin-valley

Mellqvist, J., Samuelsson, J., Offerle, B., Johansson, J., Brohede, S., Andersson, P., babore, A., Ruiz, D., & Ericsson, M. (2022) Toxic Air Contaminant and Greenhouse Gas Measurements near Oil and Gas Operations and Proximate Communities. https://ww2.arb.ca.gov/sites/default/files/2022-09/CARB_contract_18ISD023_FinalReport_ADA.pdf

Milford, J. (2015). Out in Front: State and Federal Regulation of Air Pollution Emissions from Oil and Gas Production Activities in the Western United States. *Natural Resources*, *55*(1). https://digitalrepository.unm.edu/nrj/vol55/iss1/3

NRC (National Research Council). (2009). *Science and Decisions: Advancing Risk Assessment* (p. 12209). National Academies Press. https://doi.org/10.17226/12209

NRC. (2014). *Risks and Risk Governance in Shale Gas Development: Summary of Two Workshops. P.C. Stern, Rapporteur. Board on Environmental Change and Society, Division of Behavioral and Social Sciences and Education.* National Academies Press.

OECD (Organisation for Economic Co-operation and Development). (2009). *The OECD POV and LRTP Screening Tool* (2.2). https://www.oecd.org/chemicalsafety/risk-assessment/oecdpovandlrtpscreeningtool.htm

OEHHA. (2015a). *Air Toxics Hot Spots Program Risk Assessment Guidelines: Guidance Manual for Preparation of Health Risk Assessments*. 231. https://oehha.ca.gov/media/downloads/crnr/2015guidancemanual.pdf

OEHHA (Office of Environmental Health Hazard Assessment). (2015b, December 15). *Notice of Adoption of Air Toxics Hot Spots Program Guidance Manual for the Preparation of Health Risk Assessments 2015* [Text]. OEHHA. https://oehha.ca.gov/air/crnr/notice-adoption-air-toxics-hot-spots-program-guidance-manual-preparation-health-risk-0

Okorn, K., Jimenez, A., Collier-Oxandale, A., Johnston, J., & Hannigan, M. (2021). Characterizing methane and total non-methane hydrocarbon levels in Los Angeles communities with oil and gas facilities using air quality monitors. *Science of The Total Environment*, 146194. https://doi.org/10.1016/j.scitotenv.2021.146194

Oltmans, S. J., Karion, A., Schnell, R. C., Pétron, G., Helmig, D., Montzka, S. A., Wolter, S., Neff, D., Miller, B. R., Hueber, J., Conley, S., Johnson, B. J., & Sweeney, C. (2016). O3, CH4, CO2, CO, NO2 and NMHC aircraft measurements in the Uinta Basin oil and gas region under low and high ozone conditions in winter 2012 and 2013. *Elementa: Science of the Anthropocene*, *4*, 000132. https://doi.org/10.12952/journal.elementa.000132

Pétron, G., Frost, G., Miller, B. R., Hirsch, A. I., Montzka, S. A., Karion, A., Trainer, M., Sweeney, C., Andrews, A. E., Miller, L., Kofler, J., Bar-Ilan, A., Dlugokencky, E. J., Patrick, L., Moore, C. T., Ryerson, T. B., Siso, C., Kolodzey, W., Lang, P. M., … Tans, P. (2012). Hydrocarbon emissions characterization in the Colorado Front Range: A pilot study. *Journal of Geophysical Research: Atmospheres*, *117*(D4). https://doi.org/10.1029/2011JD016360

Pétron, G., Karion, A., Sweeney, C., Miller, B. R., Montzka, S. A., Frost, G. J., Trainer, M., Tans, P., Andrews, A., Kofler, J., Helmig, D., Guenther, D., Dlugokencky, E., Lang, P., Newberger, T., Wolter, S., Hall, B., Novelli, P., Brewer, A., … Schnell, R. (2014). A new look at methane and nonmethane hydrocarbon emissions from oil and natural gas operations in the Colorado Denver-Julesburg Basin: Hydrocarbon emissions in oil & gas basin. *Journal of Geophysical Research: Atmospheres*, *119*(11), 6836–6852. https://doi.org/10.1002/2013JD021272

PSE Healthy Energy. (2020, October 27). *Repository for Oil and Gas Energy Research (ROGER)*. PSE | Physicians, Scientists, and Engineers for Healthy Energy. https://www.psehealthyenergy.org/our-work/shale-gas-research-library/

Rich, A. L., Grover, J. P., & Sattler, M. L. (2014). An exploratory study of air emissions associated with shale gas development and production in the Barnett Shale. *Journal of the Air & Waste Management Association*, *64*(1), 61–72. https://doi.org/10.1080/10962247.2013.832713

Rich, A. L., & Orimoloye, H. T. (2016). Elevated Atmospheric Levels of Benzene and Benzene-Related Compounds from Unconventional Shale Extraction and Processing: Human Health Concern for Residential Communities. *Environmental Health Insights*, *10*, EHI.S33314. https://doi.org/10.4137/EHI.S33314

Roest, G., & Schade, G. (2017). Quantifying alkane emissions in the Eagle Ford Shale using boundary layer enhancement. *Atmospheric Chemistry and Physics*, *17*(18), 11163–11176. https://doi.org/10.5194/acp-17-11163-2017

Rogers, J. D., Burke, T. L., Osborn, S. G., & Ryan, J. N. (2015). A framework for identifying organic compounds of concern in hydraulic fracturing fluids based on their mobility and persistence in groundwater. *Environmental Science & Technology Letters*, *2*(6), 158–164. https://doi.org/10.1021/acs.estlett.5b00090

Rücker, C., & Kümmerer, K. (2012). Modeling and predicting aquatic aerobic biodegradation – a review from a user's perspective. *Green Chemistry*, *14*, 875–887. https://doi.org/DOI: 10.1039/c2gc16267a

SAGE Environmental Consulting. (2019). *Air Resources Board IFB No. 13-414: Enhanced Inspection & Maintenance for GHG & VOCs at Upstream Facilities –(Revised)*. https://ww2.arb.ca.gov/sites/default/files/2020-04/2019-11-21%20CARB%2013-414%20Revised%20Final%20Report_0.pdf

SCAQMD (South Coast Air Quality Management District). (2009). *RULE 1173 CONTROL OF VOLATILE ORGANIC COMPOUND LEAKS AND RELEASES FROM COMPONENTS AT PETROLEUM FACILITIES AND CHEMICAL PLANTS*. http://www.aqmd.gov/docs/default-source/rule-book/reg-xi/rule-1173.pdf?sfvrsn=4

SCAQMD. (2011). *RULE 463. ORGANIC LIQUID STORAGE*. http://www.aqmd.gov/docs/default-source/rule-book/rule-iv/rule-463.pdf

SCAQMD. (2012). *The Multiple Air Toxics Exposure Study IV (MATES IV): Appendix VIII - 2012 Emissions by Major Source Category*. https://www.aqmd.gov/docs/default-source/air-quality/air-toxic-studies/mates-iv/h-appendix.pdf?sfvrsn=7

SCAQMD. (2015a). *Project #2 Quantification of Gaseous Emissions from Gas Stations, Oil Wells, and Other Small Point Sources*. http://www.aqmd.gov/ors-study/project-2

SCAQMD. (2015b, May 1). *Multiple Air Toxics Exposure Study (MATES IV)*. https://www.aqmd.gov/home/air-quality/air-quality-studies/health-studies/mates-iv

SCAQMD. (2015c, June 5). *RISK ASSESSMENT PROCEDURES for Rules 1401, 1401.1 and 212*. http://www.aqmd.gov/docs/default-source/planning/risk-assessment/riskassprocjune15.pdf?sfvrsn=2

SCAQMD. (2018a, September). *AAQS/CAAQS and Attainment Status for South Coast Air Basin*. Clean Air Plans. http://www.aqmd.gov/home/air-quality/clean-air-plans

SCAQMD. (2018b, August). *Community Recommendations for AB 617 Implementation: Final Submittal from South Coast AQMD*. https://ww2.arb.ca.gov/sites/default/files/2018-08/Final%20SCAQMD%20AB%20617%20Submittal%20to%20CARB_LowRes_w_coverletter.pdf

SCAQMD. (2020, October). *Risk Reduction—Rule 1402*. https://www.aqmd.gov/home/rules-compliance/compliance/toxic-hot-spots-ab-2588/risk-reduction

SCAQMD. (2021, April). *Draft 2021 PM10 Maintenance Plan for the South Coast Air Basin*. http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2022-air-quality-management-plan/draft-pm10-maintenance-plan-for-the-south-coast-air-basin.pdf?sfvrsn=8

Scheringer, M., MacLeod, M., & Wegmann, F. (2006). *Analysis of Four Current POP Candidates with the OECD Pov and LRTP Screening Tool*. ETH Zürich, Institute for Chemical and Bioengineering. https://ethz.ch/content/dam/ethz/special-interest/chab/icb/set-dam/documents/downloads/POP-Candidates-OECD-Tool.pdf

Scheringer, M. (2010). *Procedure for estimating chemical properties and chemical concentrations in different media of an environmental fate model*. ETH Zürich, Institute for Chemical and Bioengineering. http://www.ipcp.ethz.ch/Armenia/Using_EpiSuite_and_Box_Models.pdf

Sahagun, L. (2013a, September 21). Chemical odor, kids' nosebleeds, few answers in South L.A. neighborhood. *Los Angeles Times*. https://www.latimes.com/local/la-me-0922-oil-20130922-story.html

Sahagun, L. (2013b, November 9). EPA officers sickened by fumes at South L.A. oil field. *Los Angeles Times*. https://www.latimes.com/local/la-me-1109-fumes-20131109-story.html

Shonkoff, S. B. C., Hays, J., & Finkel, M. L. (2014). Environmental Public Health Dimensions of Shale and Tight Gas Development. *Environmental Health Perspectives*, *122*(8). https://doi.org/10.1289/ehp.1307866

Shonkoff, S. B. C., & Gautier, D. (2015). *A Case Study of the Petroleum Geological Potential and Potential Public Health Risks Associated with Hydraulic Fracturing and Oil and Gas Development in The Los Angeles Basin. In: An Independent Scientific Assessment of Well Stimulation in California.* (p. 68). California Council on Science and Technology. https://ccst.us/wp-content/uploads/160708-sb4-vol-III-4.pdf

Shonkoff, S. B. C., Maddalena, R., Hays, J., Stringfellow, W., Wettstein, Z., Harrison, R., & McKone, T. (2015). Public Health Risks Associated with Current Oil and Gas Development in The Los Angeles Basin. In *An Independent Scientific Assessment of Well Stimulation in California*. https://ccst.us/wp-content/uploads/160708-sb4-vol-III-4.pdf

Shonkoff, S. B. C., Maddalena, R. L., Hays, J., Stringfellow, W., Wettstein, S., Harrison, R., Sandelin, W., & McKone, T. E. (2015). *Potential Impacts of Well Stimulation on Human Health in California*. 74.

Shonkoff, S. B. C., & Hill, L. A. L. (2020). *Analysis of Air Monitoring Data Collected During Oil Field Well Stimulation Treatments in California: Implications for Human Health. Prepared for the California Air Resources Board and the California Environmental Protection Agency (Agreement Number 18ISD029)*, 58. https://ww2.arb.ca.gov/sites/default/files/2021-05/PSE_Final_Report.pdf

SJVAPCD (San Joaquin Valley Air Pollution Control District). (2005). *RULE 4623 STORAGE OF ORGANIC LIQUIDS (Adopted April 11, 1991; Amended September 19, 1991; Amended December 17, 1992; Amended December 20, 2001; Amended May 19, 2005).* https://www.valleyair.org/rules/currntrules/r4623.pdf

SJVAPCD. (2012). *Ambient Air Quality Standards & Valley Attainment Status*. https://www.valleyair.org/aqinfo/attainment.htm

SJVAPCD. (2018). *SJVAPCD State Implementation Plan. Appendix G: Precursor Demonstration.* http://www.valleyair.org/PMplans/documents/2018/pm-plan/G.pdf

SJVAPCD. (2019, November 13). *Frequently Asked Questions Regarding Rule 2260, Registration Requirements for Equipment Subject to California's Oil and Gas Regulation.* https://www.valleyair.org/busind/pto/ptoforms/faq-r2260.pdf

SJVAPCD. (2021). *Registration for State Regulation to Reduce Methane Emissions from Oil and Gas Operations*. https://www.valleyair.org/busind/pto/ptoforms/oil-and-gas-registration.htm

Stringfellow, W. T., & Camarillo, M. K. (2020). *Comparative Analysis of Air Monitoring Data Collected During Oil Field Well Stimulation Treatments*. 42. https://ww2.arb.ca.gov/sites/default/files/2021-03/Will_final_report.pdf

Sühring, R., Scheringer, M., Rodgers, T., Jantunen, L., & Diamond, M. (2020). Evaluation of the OECD POV and LRTP screening tool for estimating the long-range transport of organophosphate esters. *Environmental Science Processes & Impacts*, *20*, 207. https://doi.org/10.1039/C9EM00410F

US EIA (U.S. Energy Information Administration). (2019). *Natural Gas Gross Withdrawals and Production from Shale Gas Wells (Volumes in Million Cubic Feet)*. https://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_FGS_mmcf_a.htm

US EIA. (2020, August). *U.S. Tight Oil Production—Selected Plays (millions barrels per day)*. U.S. Energy Information Administration. https://www.eia.gov/energyexplained/oil-and-petroleum-products/images/u.s.tight_oil_production.jpg

US EIA. (2021, February 18). *California—State Energy Profile Analysis—U.S.* https://www.eia.gov/state/analysis.php?sid=CA#81

US EPA (U.S. Environmental Protection Agency). (2012). *Sustainable Futures / P2 Framework Manual* (EPA-748-B12-001). U.S. Environmental Protection Agency. https://www.epa.gov/sustainable-futures/sustainable-futures-p2-framework-manual

US EPA. (2016a). *Control Techniques Guidelines for the Oil and Natural Gas Industry 2016*. https://www.epa.gov/sites/production/files/2016-10/documents/2016-ctg-oil-and-gas.pdf

US EPA. (2016b). *Sources covered by the 2012 New Source Performance Standards (NSPS) for VOCs and the 2016 NSPS for Methane and VOCs, by site*. 2. https://www.epa.gov/stationary-sources-air-pollution/oil-and-natural-gas-industry-sources-covered-2012-new-source

US EPA. (2016c, June 21). *Ozone Designation and Classification Information* [Data and Tools]. US EPA. https://www.epa.gov/green-book/ozone-designation-and-classification-information

US EPA. (2016d, December 20). *NAAQS Table* [Other Policies and Guidance]. US EPA. https://www.epa.gov/criteria-air-pollutants/naaqs-table

US EPA. (2020a, August 6). *Summary of the Clean Air Act (42 U.S.C. §7401 et seq. (1970))* [Overviews and Factsheets]. US EPA. https://www.epa.gov/laws-regulations/summary-clean-air-act

US EPA. (2020b, June 5). *National Emission Standards for Hazardous Air Pollutants (NESHAP)*. Stationary Sources of Air Pollution. https://www.epa.gov/stationary-sources-air-pollution/national-emission-standards-hazardous-air-pollutants-neshap-9

US EPA. (2020c). *Interim Guidance for Using Ready and Inherent Biodegradability Tests to Derive Input Data for Multimedia Models and Wastewater Treatment Plant (WWT) Models*. https://www.epa.gov/tsca-screening-tools/interim-guidance-using-ready-and-inherent-biodegradability-tests-derive-input

US EPA. (2021, February 19). *Title 40: Protection of Environment PART 50—NATIONAL PRIMARY AND SECONDARY AMBIENT AIR QUALITY STANDARDS. § 50.10 National 8-hour primary and secondary ambient air quality standards for ozone*. Electronic Code of Federal Regulations. https://www.ecfr.gov/

US EPA (2023a). Actions and Notices about Oil and Natural Gas Air Pollution Standards. https://www.epa.gov/controlling-air-pollution-oil-and-natural-gas-operations/actions-and-notices-about-oil-and-0#nsps

US EPA (2023b). Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review. https://www.epa.gov/system/files/documents/2023-12/eo12866_oil-and-gas-nsps-eg-climate-review-2060-av16-final-rule-20231130.pdf

US EPA OAR (U.S. EPA Office of Air and Radiation). (2014, August 18). *Technical Overview of Volatile Organic Compounds* [Overviews and Factsheets]. US EPA. https://www.epa.gov/indoor-air-quality-iaq/technical-overview-volatile-organic-compounds

US EPA OAR. (2015a, August 31). *Prevention of Significant Deterioration Basic Information* [Collections and Lists]. US EPA. https://www.epa.gov/nsr/prevention-significant-deterioration-basic-information

US EPA OAR. (2015b, May 29). *Ground-level Ozone Basics* [Overviews and Factsheets]. US EPA. https://www.epa.gov/ground-level-ozone-pollution/ground-level-ozone-basics

US EPA OAR. (2015c, June 5). *Health Effects of Ozone Pollution* [Overviews and Factsheets]. US EPA. https://www.epa.gov/ground-level-ozone-pollution/health-effects-ozone-pollution

US EPA OAR. (2016a, June 8). *Air Quality Planning and Standards* [Overviews & Factsheets]. https://www3.epa.gov/airquality/cleanair.html

US EPA OAR. (2016b, September 27). *New Source Performance Standards and Permitting Requirements* [Overviews and Factsheets]. US EPA. https://www.epa.gov/controlling-air-pollution-oil-and-natural-gas-industry/new-source-performance-standards-and

US EPA OAR. (2016c, September 22). *EPA's Actions to Reduce Methane and Volatile Organic Compound (VOC) Emissions from the Oil and Natural Gas Industry: Final Rules and Draft Information Collection Request Fact Sheet and Presentation* [Overviews and Factsheets]. US EPA. https://www.epa.gov/stationary-sources-air-pollution/epas-actions-reduce-methane-and-volatile-organic-compound-voc

US EPA OAR. (2016d, February 26). *Explaining the RACT/BACT/LAER Clearinghouse*. https://www3.epa.gov/ttn/catc/rblc/htm/rbxplain_eg.html

USGS (U.S. Geological Survey). (2014). *USGS Energy Resources Program Geochemistry Laboratory Database (EGDB)*. https://certmapper.cr.usgs.gov/data/apps/geochem-db/

Ventura County APCD (Air Pollution Control District). (1998). *RULE 74.10—COMPONENTS AT CRUDE OIL AND NATURAL GAS PRODUCTION AND PROCESSING FACILITIES*. http://www.vcapcd.org/Rulebook/Reg4/RULE%2074.10.pdf

Wania, F., & Dugani, C. (2003). Assessing the long-range transport potential of polybrominated diphenyl ethers: A comparison of four multimedia models. *Environmental Toxicology and Chemistry*, *22*(6), 1252–1261. https://doi.org/10.1002/etc.5620220610

Wegmann, F., Cavin, L., MacLeod, M., Scheringer, M., & Hungerbühler, K. (2009). The OECD software tool for screening chemicals for persistence and long-range transport potential. *Environmental Modelling & Software*, *24*(2), 228–237. https://doi.org/10.1016/j.envsoft.2008.06.014

WHO (World Health Organization). (1989). *Indoor air quality: Organic pollutants* (EURO Reports and Studies 111; Report on a WHO Meeting, Berlin, 23-27 August 1987). World Health Organization Regional Office for Europe. https://pubmed.ncbi.nlm.nih.gov/2599116/

WSPA (Western States Petroleum Association). (2015). *Recirculation Tank Emissions Testing*. https://ww2.arb.ca.gov/sites/default/files/2020-04/WSPA_Recirculation_Tank_Testing_Report_Oct2015_1.pdf

Yost, E. E., Stanek, J., & Burgoon, L. D. (2017). A decision analysis framework for estimating the potential hazards for drinking water resources of chemicals used in hydraulic fracturing fluids. *Science of the Total Environment*, *574*, 1544–1558. http://dx.doi.org/10.1016/j.scitotenv.2016.08.167

Yuan, B., Kaser, L., Karl, T., Graus, M., Peischl, J., Campos, T. L., Shertz, S., Apel, E. C., Hornbrook, R. S., Hills, A., Gilman, J. B., Lerner, B. M., Warneke, C., Flocke, F. M., Ryerson, T. B., Guenther, A. B., & de Gouw, J. A. (2015). Airborne flux measurements of methane and volatile organic compounds over the Haynesville and Marcellus shale gas production regions. *Journal of Geophysical Research: Atmospheres*, *120*(12), 6271–6289. https://doi.org/10.1002/2015JD023242

Zhou, X., Peng, X., Montazeri, A., McHale, L. E., Gaßner, S., Lyon, D. R., Yalin, A. P., & Albertson, J. D. (2021). Mobile Measurement System for the Rapid and Cost-Effective Surveillance of Methane and Volatile Organic Compound Emissions from Oil and Gas Production Sites. *Environmental Science & Technology*. https://doi.org/10.1021/acs.est.0c06545

Zielinska, B., Campbell, D., & Samburova, V. (2014). Impact of emissions from natural gas production facilities on ambient air quality in the Barnett Shale area: A pilot study. *Journal of the Air & Waste Management Association*, *64*(12), 1369–1383. https://doi.org/10.1080/10962247.2014.954735

Appendix D

D.1 Chemical usage in upstream OGD in California with respect to airborne exposure

Chemical additives used in upstream OGD can volatilize and have the potential to increase airborne exposure of surrounding communities to potentially hazardous chemicals depending on the location and distribution of upstream oil and gas operations. Characterizing chemical additives using physical and chemical properties such as boiling point, Henry's law constant, and atmospheric oxidation half-life can be useful for comparing the potential for exposure via airborne pathways.

Chemical volatility describes the likelihood that a chemical will vaporize from a solid or liquid state and is useful for screening chemicals regarding their mobility and potential for airborne exposure. Organic chemical additives were classified as either very volatile, volatile, or semi-volatile according to boiling point categorizations for VOCs (aka NMVOCs) adapted from the U.S. EPA and the World Health Organization (WHO) (see Table D.2) (US EPA OAR, 2014; WHO, 1989). Organic chemicals with boiling points greater than 400°C were considered non-volatile for categorization purposes.

Henry's law constant provides an indication of chemical volatility from water sources, such as drilling or hydraulic fracturing fluids, produced water ponds, and storage tanks. Organic chemical additives were classified as either very volatile, volatile, moderately volatile, slightly volatile, or non-volatile from water according to generalized categorizations for Henry's law constant provided in Table D.2. To provide a conservative estimate, if a chemical was classified as semi-volatile, volatile, or very volatile based on boiling point or classified as slightly volatile, moderately volatile, volatile, or very volatile based on Henry's law constant, the chemical is considered volatile for the sake of this analysis.

In addition to volatility, atmospheric oxidation half-life can be used as a metric for determining the persistence of chemicals in the atmosphere and the potential for long-range transport and airborne exposure. Atmospheric oxidation half-life due to hydroxyl radicals (OH) was calculated using OH rate constants according to the following equation:

$$\text{Atmospheric oxidation half-life} = \ln(2)/(\text{OH rate constant} * \text{concentration of OH radicals})$$

using a standard OH concentration of 1.5×10^6 OH radicals cm^{-1} and converted to hours. Data regarding hydroxyl radical rate constants were generally more available than ozone and nitrate rate constants. When data for both OH and ozone rate constants were available, atmospheric oxidation half-lives due to OH were generally shorter, indicating OH radicals are likely the primary method of atmospheric oxidation for the investigated chemical additives. Atmospheric half-life due to OH radicals were categorized according to Table D.2 using a 12-hour day due to the formation of OH radicals during daylight hours and negligible oxidation during the night.

When experimental boiling point data, Henry's law constant, or OH rate constant values were not available, estimates from EPI Suite™ MPBPWIN™, HENRYWIN™, and AOPWIN™ modules were used, respectively. Classification of organic chemicals according to volatility and

atmospheric half-life is provided in Table D.1.

Table D.1. Categorization of organic chemicals used in upstream OGD in California by volatility, based on boiling point and Henry's law constant, and atmospheric half-life.

Volatility Category	Number of Chemicals	Atmospheric Oxidation Half-Life (OH)	
		Time frame*	Number of Chemicals
Very Volatile	63	≤ 2 h	4
		2 h–1 d	33
		>1 d	24
		No data	2
Volatile	115	≤ 2 h	18
		2 h–1 d	53
		>1 d	33
		No data	11
Semi-volatile, moderately volatile, or slightly volatile	54	≤ 2 h	15
		2 h–1 d	17
		>1 d	16
		No data	6
Non-volatile	112	≤ 2 h	63
		2 h–1 d	38
		>1 d	12
		No data	0
No data	134	≤ 2 h	1
		2 h–1 d	1
		>1 d	0
		No data	132

*Atmospheric half-life timeframes are grouped according to categories in Table D.2.

A total of 232 chemical additives (out of 630) are considered very volatile, volatile, semi-volatile, moderately volatile, or slightly volatile based on boiling point or Henry's law constant

categorization. A total of 176 out of the 232 chemicals have slow to moderate atmospheric oxidation rates (>2 hours, see Tables D.2), indicating increased potential for atmospheric transport and subsequent airborne exposure. A total of 152 chemicals were inorganic and were not assessed in this analysis.

OECD P_{ov} & LRTP Screening Tool and Chemical Screening for Potential Airborne Hazard

Chemical additives were characterized for long-range transport potential (LRTP) and overall persistence (P_{ov}) using the Organization for Economic Co-operation and Development (OECD) P_{ov} & LRTP Screening Tool (The Tool). The Tool and the accompanying manual can be downloaded from the OECD's website (OECD, 2009). More information about The Tool can be found in Wegmann et al. (2009).

Briefly, the Tool is a fugacity-based steady-state multimedia mass balance model that was developed to estimate overall environmental persistence and long-range transport potential of organic chemicals at a screening level to support decision-making for chemical management (OECD, 2009; Wegmann et al., 2009). The Tool utilizes a unit-world model and takes into account chemical partitioning between air, soil, and sea compartments. For our purposes, the characteristic travel distance (CTD) is the LRTP metric used to compare chemical additive mobility, and is defined as the distance from a point release to where the concentration is 1/e or 37% of the initial value (Wegmann et al., 2009). P_{ov} is a measure of the degradation time scale for a given chemical in the whole environment (Wegmann et al., 2009). In addition to calculating combined whole environment scores, individual CTD and P_{ov} are also calculated for air, soil, and seawater emission scenarios separately.

The Tool requires five physicochemical inputs: log K_{aw}, log K_{ow}, and estimated half-lives in air, water, and soil (OECD, 2009). Log K_{aw} was calculated using Henry's law constant values. When experimental values for Henry's Law constant and log K_{ow} were not available, estimates from EPI Suite™ HENRYWIN™ and KOWWIN™ modules were used, respectively. Half-life in air was calculated using atmospheric oxidation half-life due to hydroxyl radicals as previously described. Half-life in water and soil were estimated using the EPI Suite™ BIOWIN™ module. Results from the BIOWIN3 model for ultimate biodegradation in aerobic aqueous environments were assigned half-lives based on conversions utilized in other studies and frameworks (Aronson et al., 2006; Scheringer et al., 2006; Scheringer, 2010; US EPA, 2012). Some studies use the EPI Suite™ BIOWIN4 model for primary biodegradation to estimate the half-life in water (Rogers et al., 2015); we used ultimate biodegradation because it represents a more conservative approach. Half-life in soil is assumed to be the same as the half-life in water based on U.S. EPA guidance (US EPA, 2020c). Estimations from EPI Suite™ models, such as BIOWIN™, AOPWIN™, KOWWIN™, KOAWIN™, and HENRYWIN™ are generally accepted by US regulatory authorities when experimental data are unavailable (Rücker & Kümmerer, 2012) and are widely used by the scientific community as inputs for modeling the environmental fate of chemicals when experimental data is unavailable (Aronson et al., 2006; Gouin & Harner, 2003; Rücker & Kümmerer, 2012; Scheringer, 2010; Scheringer et al., 2006; Sühring et al., 2020; Wania & Dugani, 2003). The Tool is inappropriate for the characterization of acids, bases, metals, inorganic, and ionizing compounds (Wegmann et al., 2009).

Using the outputs from The Tool, chemical additives were ranked according to potential hazard for airborne exposure based on the chemical screening methodology adapted from Yost et al. (2017). Briefly, chemicals were assigned three scores based on inhalation toxicity, occurrence, and physicochemical properties. For our purposes, the cancer inhalation toxicity score is based on inhalation unit risk factors, while the non-cancer inhalation toxicity score was based on chronic inhalation reference concentrations (RfC) and minimal risk levels (MRLs). The occurrence score is determined by the frequency of use of a chemical in available chemical disclosure databases. Mass data was not used due lack of availability and uncertainty in the underlying data; chemical concentrations would often add up to >100% in the FracFocus dataset. Chemicals only reported in the AB 1328 dataset did not have any frequency of use data available and could not be given an occurrence score (CVRWQCB, 2021). The physicochemical properties score was determined by summing three separate scores for volatility (based on boiling point), persistence (based on P_{ov} for air emission), and mobility (based on CTD for air emissions). Each individual score was rated from 1 to 4 based on either quartiles (e.g., toxicity) or threshold values (see Table D.3) and summed together to determine the physicochemical properties score. The scores for toxicity, occurrence, and physicochemical properties were standardized within each subset of chemicals from a scale of 0 to 1, and all three scores were summed together to determine relative total hazard potential score. Because each score is relative to other compounds, only chemicals with data available to calculate all three scores were evaluated.

As shown in Table D.4, chemicals that were frequently reported in oil and gas chemical additive disclosures were consistently ranked high for potential hazards compared to other additives. Highly toxic chemicals that were rarely reported in oil and gas operations, such as benzyl chloride and acrylonitrile, were still ranked high due to their environmental persistence and mobility. Other chemicals with relatively low toxicity but which were the most frequently reported, such as methanol and isopropanol, and were also ranked high due to environmental persistence and mobility. BTEX compounds were not grouped together due to relative differences in frequency of use and non-cancer toxicity. Cancer based hazard rankings generally favored chemicals with higher inhalation unit risk values, even if they were infrequently reported (Table D.5). The BTEX compounds benzene and ethylbenzene ranked surprisingly low due to their relatively low inhalation unit risk values compared to other chemical additives.

The major limitation of this approach is the availability of physicochemical and toxicity data required to evaluate chemicals. In total, only 23 chemical additives had all the required data for evaluation. Toxicity data was the biggest limiting factor, with only 43 and 18 chemicals having non-cancer and cancer inhalation toxicity information, respectively, out of 630 chemical additives. Because the vast majority of chemical additives were missing data and could not be evaluated, it is difficult to draw conclusions about the relative hazards of upstream chemical usage. Additional data on chronic inhalation toxicity and cancer unit risks would aid in the evaluation of potential hazards associated with airborne exposure to chemicals used in upstream oil and gas activities.

Table D.2. General interpretation of various chemical properties in the context of mobility and hazard assessment. Sources: US EPA (2012); US EPA OAR (2014).

Chemical property	Value	Generalized Classification
Henry's Law Constant (atm-m^3/mole)	$>10^{-1}$	Very volatile from water
	10^{-1}–10^{-3}	Volatile from water
	10^{-3}–10^{-5}	Moderately volatile from water
	10^{-5}–10^{-7}	Slightly volatile from water
	$<10^{-7}$	Non-volatile
Log K_{ow}	<1	Highly soluble in water (hydrophilic)
	>4	Not very soluble in water (hydrophobic)
	>8	Not readily bioavailable
	>10	Not bioavailable - difficult to measure experimentally
	2–4	Liquids tend to absorb well through the skin
	>4	Chemical tends to not absorb well through skin
	5–6	Chemical tends to bioconcentrate in the lipid portion of the membrane
Atmospheric oxidation half-life	<2 hours	Rapid oxidation
	2 hrs–< 1 day	Moderate oxidation
	1–10 days	Slow oxidation
	>10 days	Negligible oxidation
	>2 days	Potential for long range transport in air
Boiling Point	<0 to 50–100°C	Very volatile
	50–100 to 240–260°C	Volatile
	240–260 to 380–400°C	Semi-volatile

Table D.3. Threshold values used to rank physicochemical properties for screening potential airborne exposure of chemicals

Chemical Property	Value	Ranking value
P_{OV} for air emissions (days)	>100	4
	10–100	3
	1–10	2
	<1	1
CTD for air emissions (km)	>100	4
	10–100	3
	1-10	2
	<1	1
Boiling point (°C)	<0 to 50–100	4
	50–100 to 240–260	3
	240–260 to 380–400	2
	>400	1
Non-cancer inhalation reference concentration (mg/m^3)	≤1st quartile	4
	>1st quartile to ≤2nd quartile	3
	>2nd quartile to ≤3rd quartile	2
	>3rd quartile	1
Cancer inhalation unit risk $(ug/m3)^{-1}$	≥3rd quartile	4
	≥2nd quartile to <3rd quartile	3
	≥1st quartile to <2nd quartile	2
	<1st quartile	1
Number of disclosures	≥3rd quartile	4
	≥2nd quartile to <3rd quartile	3
	≥1st quartile to <2nd quartile	2
	<1st quartile	1

Table D.4. Chemical additives ranked according to relative potential hazard via airborne exposure using relative non-cancer toxicity, occurrence, and physicochemical scores.

Chemical Name	CASRN	Physico-chemical Score	Occurrence Score	Non-Cancer Toxicity Score	Overall Score
Formaldehyde	50-00-0	0.75	1	0.66	2.41
Naphthalene	91-20-3	0.25	1	1	2.25
Isopropanol	67-63-0	0.75	1	0.33	2.08
Ethylbenzene	100-41-4	0.5	1	0.33	1.83
Methanol	67-56-1	0.75	1	0	1.75
Acrylonitrile	107-13-1	0.75	0	1	1.75
Benzyl chloride	100-44-7	0.75	0	1	1.75
Benzene	71-43-2	0.75	0.33	0.66	1.75
Xylenes	1330-20-7	0.25	1	0.33	1.58
Acrylamide	79-06-1	0.5	0	1	1.5
Cumene	98-82-8	0.5	0.66	0.33	1.5
Acetone	67-64-1	1	0.33	0	1.33
1,2,4-Trimethylbenzene	95-63-6	0	0.66	0.66	1.33
Diethylene glycol mono-n-butyl ether	112-34-5	0.25	0	1	1.25
2-Butoxyethanol	111-76-2	0.25	0.66	0.33	1.25
1-Methoxy-2-propanol	107-98-2	0.5	0.66	0	1.16
Toluene	108-88-3	0.5	0.66	0	1.16
Diethanolamine	111-42-2	0	0	1	1
1,2,3-Trimethylbenzene	526-73-8	0	0.33	0.66	1
1,3,5-Trimethylbenzene	108-67-8	0	0.33	0.66	1
Isobutylmethylcarbinol	108-11-2	0.25	0.33	0	0.58
Methyl isobutyl ketone	108-10-1	0.25	0	0	0.25

Table D.5. Chemical additives ranked according to relative potential hazard via airborne exposure using relative cancer toxicity, occurrence, and physicochemical scores

Chemical Name	CASRN	Physicochemical Score	Occurrence Score	Cancer Toxicity Score	Overall Score
Ethylene oxide	75-21-8	1	0.33	1	2.33
Formaldehyde	50-00-0	0.66	1	0.33	2
Acrylamide	79-06-1	0.33	0.33	1	1.66
Acrylonitrile	107-13-1	0.66	0	0.66	1.33
Benzyl chloride	100-44-7	0.66	0	0.66	1.33
Naphthalene	91-20-3	0	1	0.33	1.33
Benzene	71-43-2	0.66	0.66	0	1.33
Ethylbenzene	100-41-4	0.33	0.66	0	1

D.2 Interpreting cancer and non-cancer health risks

Interpreting non-cancer health risk

Hazard quotients and hazard indices are used to estimate noncancer health risks associated with acute and chronic exposures. A hazard quotient (HQ) is the ratio between the estimated or observed exposure concentration and a health guidance value for a given chemical. It is often assumed in risk assessment that exposures at or below the health guidance value (i.e., HQs of 1 or less) are of less concern for adverse non-cancer health effects. Additionally, exposures at or

below the health guidance value (i.e., HQs of 1 or less) are not likely to be associated with adverse health effects. It must be noted, however, that in reality, non-cancer endpoints (e.g., infertility, pregnancy complications, birth defects, neurodevelopmental delays, metabolic disorders, and cardiovascular disease) may also have non-threshold dose response relationships due to population variability in response (NRC, 2009). However, as exposures increase above the health guidance value (i.e., HQs are greater than 1), the potential for adverse effects increases. To consider exposure from multiple air pollutants, acute and chronic hazard indices (HI) are calculated by summing HQs for individual compounds that are anticipated to affect the same target organ system based on acute or chronic exposure duration. Target organ systems can include the respiratory system, hematologic system, alimentary system, endocrine system, growth and development, reproductive system, nervous system, cardiovascular system, skin, eyes, and general toxicity (OEHHA, 2015a).

Interpreting cancer risk estimates

In California and per requirements of Assembly Bill 2588 (the Air Toxics "Hot Spots" Information and Assessment Act), the Office of Environmental Health Hazard Assessment (OEHHA) and CARB are responsible for providing local air districts guidance on the preparation of health risk assessments for stationary sources with the potential to emit TACs (TACs) (OEHHA, 2015b). AB 2588, enacted in 1987, requires stationary sources to report the types and quantities of TACs emitted routinely from a given facility in an effort to reduce significant risks to "acceptable" levels (OEHHA, 2015a).

SJVAPCD utilizes the following action thresholds with respect to stationary source permitting:

- For each permitted unit that exceeds the 1 in one million excess cancer risk threshold, installation of toxic best available control technology (T-BACT) is required.
- If the cumulative cancer risk for the facility exceeds 20 in a million excess cancers, the permit for the project will be denied (SJVAPCD, 2015).

Similarly, the SCAQMD establishes requirements that must be met before a permit can be issued. Risk assessment guidance for equipment subject to Rules 1401, 1401.1, and 212 states:

"The cumulative increase from all TACs emitted from a single piece of equipment in MICR shall not exceed:

- 1 in one million (1.0 x 10-6 or 1E-06) if toxic best available control technology(T-BACT) is not used; or,
- 10 in one million (10 x 10-6 or 10E-06) if T-BACT is used (SCAQMD, 2015c).

Additionally, SCAQMD Rule 1402 defines the "Action Risk Level" as greater than or equal to 25 in one million excess cancer risks and the "Significant Risk Level" as greater than or equal to 100 in one million excess cancer risks (SCAQMD, 2020). In both cases, Risk Reduction Plans are required to be submitted to the District within a certain time frame, and must be implemented within 2–2 ½ years. Excess cancer risk levels for the two top oil and gas producing air districts in California are described in more detail in Table D.6.

Table D.6. Excess cancer risk levels and interpretation for two top oil and gas producing air districts in California.

Air District	Significant Cancer Risk Threshold	Interpretation	Source
SCAQMD *Rules 1401, 1401.1 & 212*	**>1 in one million**	T-BACT is required.	SCAQMD (2015c)
	>10 in one million	Tier 3 or 4 more detailed analysis required before permit can be issued.	
SCAQMD *Rule 1402*	**≥25 in one million**	120 days to submit a Risk Reduction Plan; three months for the District to approve the Plan; No later than 2.5 years to implement the Plan.	SCAQMD (2020)
	≥100 in one million	90 days to submit an Early Action Reduction Plan; 180 days to submit a Health Risk Assessment and/or Risk Reduction Plan; No later than two years to implement the Plan.	
SJVAPCD *APR 1905*	**>1 in one million**	T-BACT is required.	SJVAPCD (2015)
	>20 in one million *significance threshold*	Not approvable. Additional controls or alternative design needs to be applied.	

CHAPTER FIVE

Potential Impact to Public Health from the Management and Disposal of Produced Water

Table of Contents

5.0 Abstract **1**

5.1. Overview **1**

5.2. Produced Water Volumes and Disposition **3**

5.3. Chemical Characterization of Produced Water **5**

5.3.1. Compiled Produced Water Quality Dataset **8**

5.3.2. Compiled Produced Water Quality Dataset Summary **9**

5.3.3. Chemical Additives and Transformation Products in Produced Water **12**

5.3.3.1 Organohalide Compounds **15**

5.3.3.2 Polyacrylamide **15**

5.3.3.3 Glutaraldehyde **17**

5.3.3.4 Per- and Polyfluoroalkyl Substances (PFAS) **17**

5.3.3.5 Modeling **18**

5.4. Contamination Pathways and Regulations for Underground Injection Control Wells **18**

5.5. Contamination Pathways and Regulations for Produced Water Ponds **21**

5.5.1. Background **21**

5.5.2. Regulatory Actions Relevant to Produced Water Ponds in California **24**

5.5.3. Chemical Characterization of Produced Water Disposed in Produced Water Ponds **26**

5.5.3.1 Emissions of Organic Compounds Produced Water Ponds **31**

5.5.4. Number, Status, and Locations of Produced Water Ponds in the Tulare Basin **32**

5.5.5. Exceedance of Effluent Limits in the Tulare Basin and Assessment of Potential Impact to Groundwater 33
5.5.5.1 Counts of Unlined Ponds and Exceedances of Tulare Basin Effluent Limits in Basin Sub Areas 34
5.5.5.2 Documented Impacts to Groundwater in the Tulare Basin 35
5.5.5.3 Potential Impacts to Groundwater in the Tulare Basin 38
5.5.6. Populations Living Near Produced Water Infrastructure 39
5.5.7. Available Information on Setbacks from Produced Water Management Facilities at Other States. 40
5.6. Exposure Pathways from the Discharge of Produced Water to Surface Water 40
5.7. Exposure Pathway Analysis from Spills of Produced Water 42
5.7.1. Environmental Impacts 42
5.7.2. A Summary of Spill Incidents in California 43
5.7.2.1 Reported Spills in California from 2006–2020 43
5.7.2.2 Comparisons to Other States 44
5.7.2.3 Impacts of Spill Events on Drinking Water 45
5.7.2.4 Inconsistencies in Spill Volume Reporting 46
5.7.2.5 Spill Occurrence by Volume of Material Released 48
5.7.2.6 Summary of Shortcomings of the Spill Database 49
5.8. Exposure Pathways from Use of Produced Water for Irrigation 49
5.9. Summary 51
References 54
Appendix E 68
E.1. Produced Water Dataset Compilation 68
E.2. Locations of Water Disposal Wells 72
E.3. Characterization of the Chemistry of Produced Water Ponds 73
E.4. Counts of Produced Water Ponds by Location and Status 79
E.5. Populations Living in Proximity to Produced Water Ponds 81
E.6. County Level Spill Counts 82

Figures

Figure 5.1. Conceptual model of the potential contamination and exposure pathways from the generation and use of produced water in California. Inset boxes indicate the sections where detailed conceptual models and discussion of specific activities are located. 3

Figure 5.2. Plot of oil production in millions of barrels (MMbbl), gas production in billions of cubic feet (BCF), produced water generation (MMbbl), and water to oil ratio from 1977 to 2017 as reported to CalGEM. Source: Figure S2 from DiGiulio et al. (2021)..... 4

Figure 5.3. Stacked area plot of produced water disposition from 1977 to 2017 as reported to CalGEM. Data from CalGEM Well Production and Injection Summary Reports. Source: Figure S3 from DiGiulio et al. (2021)..... 4

Figure 5.4. Conceptual contamination and exposure pathways of underground injection control wells..... 19

Figure 5.5. Total populations living within buffer distances of water disposal wells. 21

Figure 5.6. Percent produced water disposal to the surface (evaporation-percolation ponds, lined produced water ponds, sewage, and surface water) from 1977 to 2017 as reported to CalGEM. Inset provided in logarithmic scale to better illustrate disposition of lined sumps after 1998. Source: Figure S2 from DiGiulio et al. (2021). 22

Figure 5.7. Conceptual contamination and exposure pathways associated with produced water disposal ponds..... 23

Figure 5.8. Cumulative volumes of produced water discharged into unlined produced water ponds, lined produced water ponds, surface water, and sewer systems from 1977 to 2017. Source: Figure S5 from DiGiulio et al. (2021). 24

Figure 5.9. Boxplot of pH, conductivity, and other selected constituents and their relation to California regulatory limits for produced water disposal ponds, and drinking water (22 C.C.R. § 64431, 2021; 22 C.C.R. § 64442, 2021; 22 C.C.R. § 64444, 2021; CVRWQCB, 2018). Total xylenes are the maximum detected concentration of p-&m-xylenes, o-xylene, or total xylenes. Source: Figure 3 from DiGiulio et al. (2021)..... 30

Figure 5.10. Summary and status of produced water ponds in the Tulare Basin. Source: Figure 2 modified from DiGiulio et al. (2021). 33

Figure 5.11. Interpolated levels (contour lines) of total dissolved solids (TDS) in groundwater from water well samples and the location of active, inactive, and closed unlined produced water pond facilities in subbasins within the Tulare Basin in the southern portion of the San Joaquin Valley. Source: Figure 1 from DiGiulio et al. (2021)..... 34

Figure 5.12. Locations of produced water pond facilities where groundwater monitoring indicates impact. Source: Figure 4 modified from DiGiulio et al. (2021)..... 36

Figure 5.13. Concentrations of electrical conductivity (EC), total dissolved solids (TDS), chloride (Cl), and boron (B) (inset) in groundwater monitoring wells at facilities with an impact to groundwater. Downgradient and unimpacted monitoring wells are located more distant from a facility in the direction of groundwater flow. Source: Figure 5 from DiGiulio et al. (2021)..... 37

Figure 5.14. Total populations living within buffer distances of both active, and any status produced water disposal ponds. 39

Figure 5.15. Conceptual pathways of surface discharges of produced water. 41

Figure 5.16. Conceptual pathways of spills. 43

Figure 5.17. Reported number of incidents involving crude oil, produced water, or a mixture of both in the CalOES HazMat Spill Release Reporting Database (CalOES, 2021). Source: Figure 3 from Rossi et al. (2022). 44

Figure 5.18. Comparison of the total reported volumes of crude oil and produced water in the initial (grey) and updated (black) CalOES spill incident reports per year. Annotations provide the percent increases of the total. Source: Figure 5 from Rossi et al. (2022) 47

Figure 5.19. Percent of incidents in 2018–2020 involving crude oil, produced water, and mixtures of the two substances for any given volume with solid vertical annotation lines indicating proposed reporting thresholds for spilled materials (CalGEM, 2021c), and dashed vertical annotation lines indicating the volume that 75% of spill incidents are less than. Data used to generate these cumulative distributions were taken from the updated spill reports. Source: Figure 6 from Rossi et al. (2022). 48

Figure 5.20. Conceptual contamination and exposure pathways of the use of produced water for irrigation. 50

Tables

Table 5.1. Chemical constituents required to be analyzed in produced waters as required by CalGEM Well Stimulation Regulations (14 C.C.R. § 1788, 2015), CalGEM UIC Regulations (14 C.C.R. § 1724.7.2, 2019), CVRWQCB Lost Hills, South Belridge, and North Belridge Section 13267 Order (CVRWQCB, 2020), and CVRWQCB Waste Discharge Requirements General Order for Oil Field Discharges to Land Order R5-2017-0034 (CVRWQCB, 2017a) 6

Table 5.2. Overview of California produced water quality datasets. 11

Table 5.3. Select constituents from the compiled produced water quality database for OGD in California. 13

Table 5.4. Summary of studies investigating chemical transformations of specific chemical additives related to hydraulic fracturing. 16

Table 5.5. Characterization of water quality data from sampled produced water ponds in the Tulare Basin contained in the SWRCB Geotracker website (SWRCB, 2021b). Constituents include general water quality parameters, major and minor ions, trace elements, radionuclides, isotopes, nutrients, and organics. California maximum contaminant levels (MCLs) for regulated drinking water contaminants provided for reference (SWRCB, 2023) 28

Table 5.6. Summary of selected constituents of produced water pond aqueous samples. Source: Schmidt and Card (2020) 31

Table 5.7. Summary of selected constituents of produced water pond gases and vapors. Source: Schmidt and Card (2020) 32

Table 5.8. Maximum concentrations of benzene, toluene, ethylbenzene, total xylenes, and the distance downgradient of facilities at which groundwater monitoring wells indicate an impact to groundwater..... 37

Table 5.9. Breakdown of spills of crude oil, produced water, and a mixture of both by county. Source: Table 1 from Rossi et al. (2022). 45

Table 5.10. Comparison of total and average crude oil and produced water spills per year for the period of 2006–2014. Spill data for Colorado, New Mexico, North Dakota, and Pennsylvania were taken from Maloney et al. (2017). Source: Table from Rossi et al. (2022). 45

Table 5.11. Counts of crude oil, produced water, and mixture spills, and documented impacts to waterways or drinking water. Source: Table 3 from Rossi et al. (2022). 46

5.0 Abstract

In this chapter, the disposition, chemistry, and potential contamination and/or exposure pathways of produced water from oil and gas industry operations in the state of California are examined. Both the production volumes and disposal methods of produced water during the period of 1977–2017 were examined. In general, produced water generation in California has been increasing since the mid-1990s, and the majority is disposed of via subsurface injection. However, the multiple reporting systems of produced water disposal introduce uncertainty in quantifying exact volumes of disposed water.

This chapter also characterizes the chemistry of produced waters in California, providing a relatively comprehensive assessment of constituents found in produced waters. However, there is considerable heterogeneity in the analysis requirements across both regulatory programs and geographic areas. Thus, despite being well known to contain potentially harmful compounds (e.g., benzene, toluene, arsenic), the exact composition of produced water, and organic compounds in particular, is not explicitly regulated. For example, in the southern San Joaquin Valley, produced water was commonly disposed of in unlined earthen ponds from the early 20th century until 2014. Comprehensive chemical analyses of these waters were relatively rare prior to 2015, and few studies have examined airborne emissions of organic compounds from these ponds. An analysis of chemical data contained in the State Water Resources Control Board Geotracker system indicates that waters contained in disposal ponds exceed Tulare Basin effluent limits in at least 75% of samples, and often contain contaminants (e.g., benzene, radium) at concentrations that exceed California Maximum Contaminant Levels. Despite sparse groundwater monitoring near these facilities, recent work has demonstrated that the disposal of produced water via this method has impacted groundwaters over 4 km (2.5 mi) from disposal facilities, and most commonly more than 1 km (3,281 ft). Approximately 545,000 (~1 in 75) Californians live within 1 km (3,281 ft) of an active, inactive, or historical produced water pond.

An extensive review of onshore oil and produced water spills in California was also conducted, indicating that there were 1,029 incidents involving a spill of produced water. However, despite the potential threat to environmental and human receptors, significant knowledge gaps surrounding these incidents appear to exist. Specifically, only approximately 6% of incidents involving a spill of crude oil or produced water contained geographic coordinates, greatly hindering assessing the potential impacts of these events to public health. Moreover, updated spill volumes are not rapidly retrievable from the database maintained by the California Office of Emergency Services, and during the years 2018–2020 volumes of produced water spilled were underreported ranging from 35–2,750%. It is unclear if groundwater monitoring is performed following spill events.

5.1. Overview

Wastewater from oil and gas development (OGD) is commonly referred to as produced water. Produced water is generated during several oil and gas exploration and production activities, including drilling through saline groundwater that overlies target oil and gas reservoirs; stimulation

of oil or gas reservoirs by hydraulic fracturing; workover (i.e., well maintenance) operations; and day-to-day production and operations (GWPC, 2019). In the state of California, about 20% of all produced waters come from stimulated (hydraulic fracturing, matrix acidizing) reservoirs (Stringfellow et al., 2015).

Produced water is considered waste from oil and gas exploration and production and is thus excluded from hazardous waste classification under Subtitle C of the Resource Conservation and Recovery Act (RCRA) (US EPA, 2002). Operators employ numerous methods to dispose of this waste, and in Section 5.2 the volumes of produced water disposed of via various methods are discussed.

The chemical characteristics of produced water depend on the geographic location of the field, the geological formation in which groundwater resides, and the hydrocarbon being extracted (GWPC, 2019). For example, produced waters vary greatly in salinity (GWPC, 2019). In addition, produced water commonly contains many toxic organic and inorganic compounds. Some of these are naturally occurring dissolved or emulsified hydrocarbons, while others are related to chemicals added for well control or reservoir stimulation purposes. While produced waters from shale reservoirs (e.g., the Marcellus Shale) are relatively enriched in radionuclides, radionuclide levels in Californian produced waters are significantly lower (McMahon et al., 2019).

A number of factors can influence the chemistry of produced water including but not limited to: hydrocarbon field setting and petroleum geology; geologic history; flushing of meteoric water; confining geologic layers; history of oil and gas activities and water injection; current and historical downhole chemical use; and field temperature and pressure (Clark & Veil, 2009; Kahrilas et al., 2015; McMahon et al., 2018). Chemical constituents that are or may be in produced water include residual petroleum hydrocarbons, chemical additives, geogenic compounds, and degradation byproducts of chemical transformations. Operators have few, if any, restrictions on the chemicals used for conventional and unconventional OGD in California. Section 5.3 contains a detailed discussion of the chemistry of produced water, and Section 5.5.3 describes the chemical composition of produced waters contained in disposal ponds in the California.

Multiple strategies are used to dispose of produced water. This chapter provides a discussion of California's produced water generation, disposal, and chemistry, along with possible environmental contamination pathways due to produced water disposal methods (**Figure 5.1**).

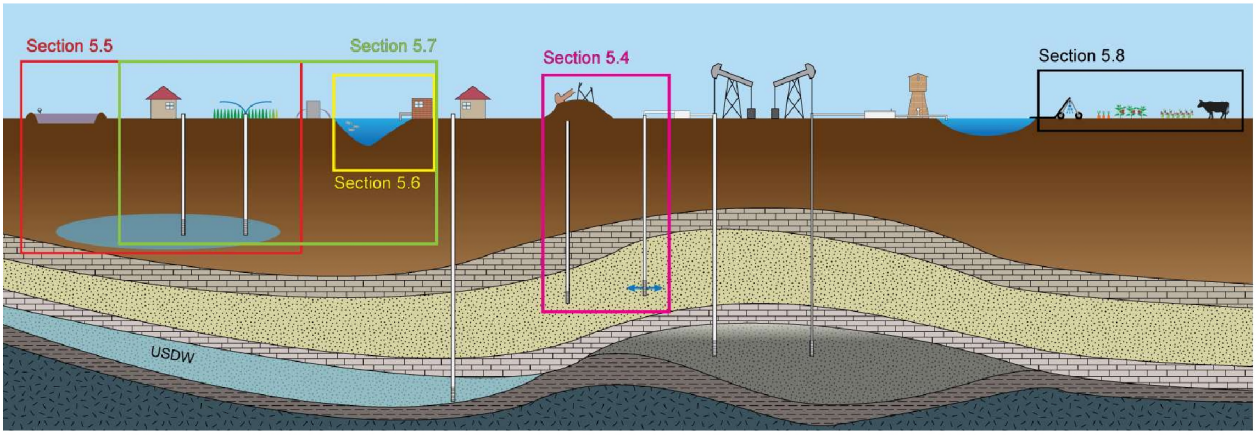


Figure 5.1. Conceptual model of the potential contamination and exposure pathways from the generation and use of produced water in California. Inset boxes indicate the sections where detailed conceptual models and discussion of specific activities are located.

5.2. Produced Water Volumes and Disposition

The long-term trends of produced water generation and disposal in California are tied to the amount and type of oil and gas activities. In 2017, California ranked second only to Texas in produced water generation, was tied with New Mexico for fourth place in oil production (behind Texas, North Dakota, and Alaska), and was 15th in natural gas production (Veil, 2020). Remaining oil reserves in California are mostly heavy crude, which largely requires energy-intensive enhanced oil recovery (water flooding and steam injection) for removal and generates large quantities of produced water (Alvarado & Manrique, 2010).[1]

To determine long-term trends of produced water disposal in California, data files from the California Geologic Energy Management Division's (CalGEM) Well Production and Injection Summary Reports were downloaded for the years 1977 (year of earliest electronic availability) to 2017. The reports indicate the generation of produced water in California has been increasing since 1994, while oil and gas production has been decreasing since 1985, thus resulting in an increasing ratio of produced water to oil volumes (**Figure 5.2**).

In California, subsurface injection is the most common method of produced water management (**Figure 5.3**), accounting for a low of 40.3% and a high of 84.5% of produced water in 1981 and 2017, respectively. In both CalGEM's Well Production and Injection Summary Reports and reporting pursuant to Senate Bill (SB) 1281 (Pavley, 2014), injection for enhanced oil recovery is not distinguished from injection into wells for disposal. However, Veil (2020) estimates that most (~73%) injected water in California is used for enhanced oil recovery. CalGEM does not provide a definition of "Not Applicable" in Well Production and Injection Summary Reports.

---

[1] Enhanced oil recovery wells are used to prolong the productive life of wells within a specific oil field. Secondary recovery is an enhanced oil recovery process commonly referred to as water flooding.

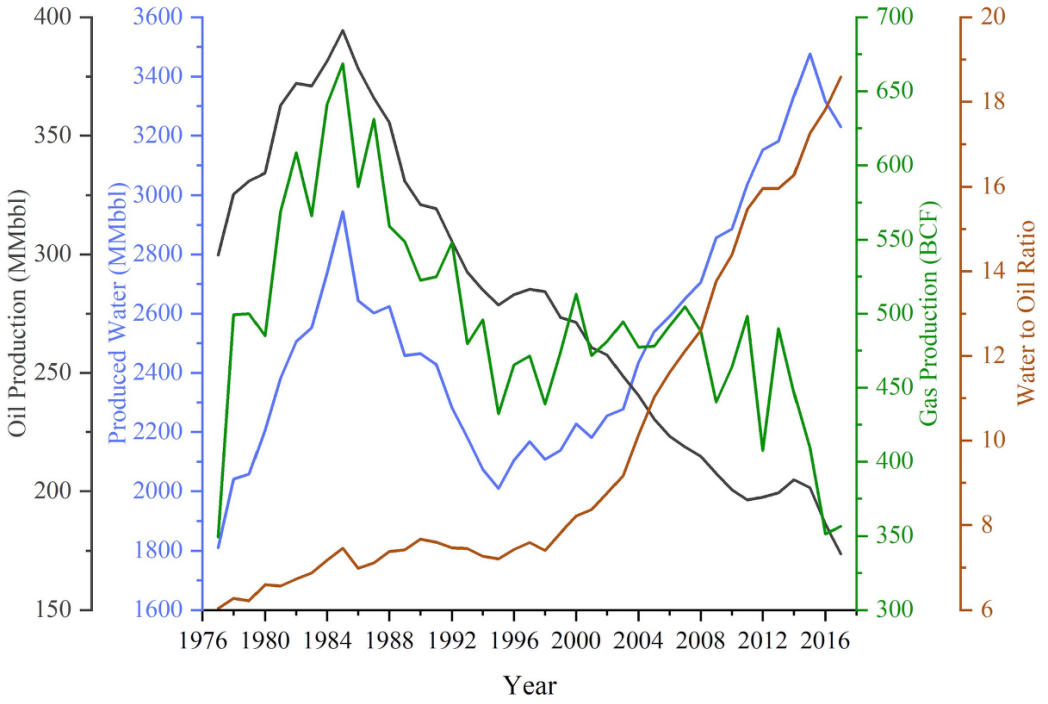


Figure 5.2. Plot of oil production in millions of barrels (MMbbl), gas production in billions of cubic feet (BCF), produced water generation (MMbbl), and water to oil ratio from 1977 to 2017 as reported to CalGEM. Source: Figure S2 from DiGiulio et al. (2021).

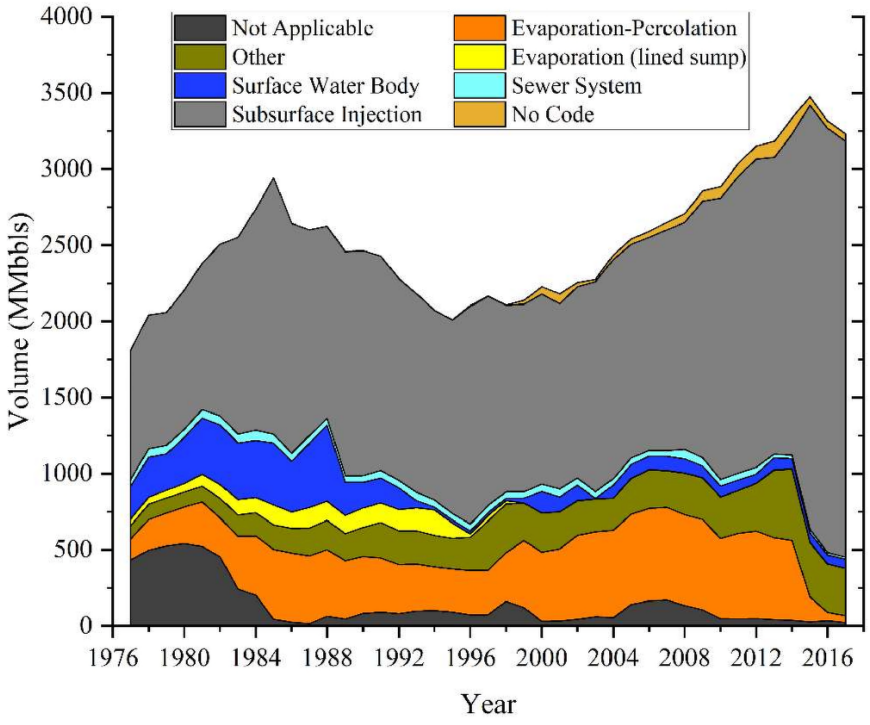


Figure 5.3. Stacked area plot of produced water disposition from 1977 to 2017 as reported to CalGEM. Data from CalGEM Well Production and Injection Summary Reports. Source: Figure S3 from DiGiulio et al. (2021).

The multiple reporting systems of produced water disposal in California appear to create uncertainty regarding the volumes of produced water disposed via specific methods. As such, it is possible that actual volumes of produced water disposed via a particular method exceed reported volumes for said method. For example, both the "Other" disposition category in the CalGEM Well Production and Injection Summary Reports and reporting pursuant to SB 1281 contain an "Other" category which includes commercial disposal. However, because commercial water disposal companies also dispose of produced water into unlined ponds, the "Other" category in both reporting systems could also include disposal to unlined produced water ponds. Hence, actual disposal volumes into unlined produced water ponds could be greater than represented under both reporting systems and further assessment is needed to confirm this one way or another. It should also be noted that for those ponds that are under orders from the Central Valley Regional Water Quality Control Board (CVRWQCB), operators are required to submit volume information to the CVRWQCB.

5.3. Chemical Characterization of Produced Water

Requirements for analysis of produced water in California largely depend on the regulatory program and geographic area where storage or disposal of produced water occurs. Some requirements for chemical characterization are statewide, whereas others are regional. Logically, the stringency and scope of requirements for chemical characterization of produced water should be dependent on potential exposure pathways to human or ecological receptors.

Following the enactment of SB 4, an analysis of produced water during the first three well volumes of flow and after 30 days of operation at stimulated production wells is required (**Table 5.1**) (14 C.C.R. § 1788, 2015). While many commonly reported water chemical constituents are included, stable water isotopes, ammonia/ammonium, radium-228, and uranium are notably absent from this analytical list. A similar requirement was instituted for produced water disposed in Class II disposal wells when CalGEM's Underground Injection Control (UIC) regulations were updated in April 2019 (**Table 5.1**) (14 C.C.R. § 1724.7.2, 2019), although stable water isotopes and radionuclides are also absent from this list. These regulations do allow for expansions of the required suite of analyzed chemical constituents in locations where migration is suspected outside an injection zone. For instance, in August 2020, the list of required constituents was expanded by the CVRWQCB for Class II disposal wells near the Lost Hills, Belridge South, and Belridge North fields, due to concern of suspected migration outside injection zones (CVRWQCB, 2020).

Like the required analyses of produced water from stimulated wells and produced water disposed of by injection wells, chemical analyses of produced water disposed of in unlined ponds have been required since 2015, with further updates to analytical requirements in 2017 (**Table 5.1**) (CVRWQCB, 2015, 2017a, 2017b, 2017c). This analysis also includes ponds used to blend produced water with surface water and groundwater for irrigation.

Table 5.1. Chemical constituents required to be analyzed in produced waters as required by CalGEM Well Stimulation Regulations (14 C.C.R. § 1788, 2015), CalGEM UIC Regulations (14 C.C.R. § 1724.7.2, 2019), CVRWQCB Lost Hills, South Belridge, and North Belridge Section 13267 Order (CVRWQCB, 2020), and CVRWQCB Waste Discharge Requirements General Order for Oil Field Discharges to Land Order R5-2017-0034 (CVRWQCB, 2017a).

Constituent	CalGEM Well Stimulation Regulations	CalGEM UIC Regulations	CVRWQCB Lost Hills, South Belridge, and North Belridge Section 13267 Order	CVRWQCB Waste Discharge Requirements General Order for Oil Field Discharges to Land Order R5-2017-0034
General Water Quality				
Alkalinity	X	X	X	X
Electrical Conductivity		X	X[2]	X
Total Dissolved Solids	X	X	X	X
pH	X	X	X[2]	X
Temperature		X	X[2]	X
Major Ions				
Chloride	X	X	X	X
Sulfate	X	X	X	X
Bicarbonate		X	X[2]	X
Carbonate		X	X[2]	X
Hydroxide		X	X[2]	X
Calcium	X	X	X	X
Magnesium	X	X	X	X
Potassium	X	X	X	X
Sodium	X	X	X	X
Inorganics				
Boron	X	X	X	X
Bromide	X	X	X[2]	
Iodine		X	X[2]	
Iron	X	X	X	X
Lithium	X		X	X
Manganese	X	X	X	X
Nitrate	X		X	X
Nitrite	X			
Strontium	X	X	X	X
Title 22 metals[1]	X		X	X
Radionuclides/Isotopes				
Deuterium			X	X
Oxygen-18			X	X
Gross alpha	X		X	X
Gross beta	X			
Radium-226	X		X	X
Radium-228			X	X
Radon-222	X			
Uranium			X	X
Organics				
Total petroleum hydrocarbons as Crude oil		X	X	X
Benzene	X		X	X
Toluene	X		X	X
Ethylbenzene	X		X	X
Xylenes	X		X	X
Polynuclear Aromatic Hydrocarbons			X	X
Gases				
Hydrogen Sulfide	X			
Methane	X		X	

[1]Title 22 metals include: antimony, arsenic, barium, beryllium, cadmium, chromium (total & VI), cobalt, copper, fluoride, lead, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc (22 C.C.R. § 66261.24, 1994).

[2]It was unclear from the § 13267 order whether these constituents would be measured. However, given this order is an expansion of monitoring requirements, it was assumed that constituents mandated to be measured by UIC regulations would also be measured.

Efforts to improve the chemical characterization of produced water ponds appears limited to the CVRWQCB. That is, other regional water quality control boards do not require comprehensive analysis of produced water stored in lined ponds or disposed in unlined produced water ponds. There also does not appear to be any analytical requirements for testing produced water associated with spills. In the event of a large spill, important insights could be provided by comprehensive chemical analysis on the remaining produced water in a vessel.

At present, it does not appear that non-targeted and/or bioanalytical testing has been used to supplement chemical characterization of produced water. These approaches could be beneficial when produced water is used for agriculture or discharge to surface water. A significant fraction of unidentified compounds in produced water are likely degradation products of petroleum hydrocarbons. However, some unidentified compounds may be additives or transformation products of additives. Bioanalytical testing could enable assessment of toxicity, mutagenicity, teratogenicity, and other toxicological endpoints of concern. These tests are poised to be deployed for municipal wastewater recycling by the California State Water Resources Control Board (SWRCB), thus their use could be adapted for produced water (SWRCB, 2018).

In its report on well stimulation in California, the California Council on Science and Technology (CCST) recommended evaluation of "impacts of production for all OGD, rather than just the portion of production enabled by well stimulation" (Long et al., 2016). The CCST report found oil and gas production operators voluntarily reported the use of more than 300 chemical additives in California. However, knowledge of the hazards and risks associated with these chemicals was incomplete for almost two-thirds of the reported chemicals, and the toxicity and biodegradability of more than half the chemicals was uninvestigated, unmeasured, and unknown (Stringfellow et al., 2015).

Where feasible, green chemistry principles could be used to maintain an equivalent function while using less toxic chemicals and smaller amounts of toxic chemicals (Long et al., 2016). Long et al. (2016) suggested that California regulators could also disallow certain chemicals, or limit chemicals to those on an approved list, where approval depends on the chemical having an acceptable environmental profile. The latter approach reverses the usual practice, whereby an industry is permitted to use a chemical until a regulatory body proves that the chemical is harmful. Oil and gas production in the environmentally sensitive North Sea uses this pre-approval approach and might provide a model for limiting chemical risk in California (Stringfellow et al., 2015). Any of these approaches requires that operators report the unique Chemical Abstracts Service (CAS) number for all chemicals. The CCST recommended:

> "Relevant state agencies, including DOGGR [now CalGEM], should as soon as practical engage in discussion of technical issues involved in restricting chemical use with a group representing environmental and health scientists and industry practitioners, either through existing roundtable discussions or independently" (Long et al., 2016).

5.3.1. Compiled Produced Water Quality Dataset

To better understand the nature of produced water, information from available databases and reports on the chemical composition of produced water in California were compiled. Major sources of produced water quality in California include the U.S. Geological Survey (USGS) National Produced Waters Geochemical Database, the CalGEM Well Stimulation Disclosure Database, and various smaller scale USGS data releases. Detailed descriptions of produced water quality data sources are provided in **Table 5.2**.

California-specific data were extracted from the USGS National Produced Waters Geochemical Database, which includes 40 individual sources of produced water quality data from across the country, and contains measurements for major and trace elements, dissolved gases, and isotopes (both stable and radioactive). Data regarding analytical methods and detection limits are not available for the USGS National Produced Waters Geochemical Database. Water quality parameters were converted from parts per million (ppm) to milligrams per liter (mg/L) using specific gravity to allow for easier integration with other data sources.

Produced water quality data were extracted from the recovered fluids analytical table in the CalGEM Well Stimulation Disclosure Database. The CalGEM database maintains data regarding the chemical analysis of recovered fluids (after three well volumes and 30 days of operation following stimulation) and is publicly available for download (CalGEM, 2021a). Although recovered fluids from well stimulation may ultimately differ from well stimulation produced water, they are handled in the same manner in California, aligning with the methodology of previous studies (e.g., Shonkoff et al., 2021), and thus were included in the analysis of produced water quality. Data for volatile organic compounds (VOCs) and other organic compounds are limited to the CalGEM database, which includes produced water from matrix acidizing, acid fracturing, and hydraulic fracturing activities. On a statewide basis, chemical additives used in upstream OGD and degradation byproducts are generally not monitored in produced water, with notable exceptions for guar gum and silica in the CalGEM database. However, CVRWQCB General Orders and waste discharge requirements (WDRs) for produced water reuse projects require that the operator list the chemicals and additives used, and then test for those ones that have approved analytical methods. Data for organic compounds in produced water from conventional OGD is generally unavailable.

Other data sources that were incorporated include individual USGS data releases containing both historical and current produced water quality data from various oil fields throughout California. Due to their inclusion of historical produced water quality data, these data releases varied in data quality, background information regarding analytical methods, detection limits, geographic coverage, and the types of water quality parameters measured. Three USGS data releases (Everett et al., 2019; Gillespie et al., 2019; Metzger et al., 2018) contained only total dissolved solids (TDS) data and were excluded from our compiled dataset. Other sources of produced water quality, such as monitoring data from produced water ponds, were excluded from the compiled dataset to focus on produced water quality prior to any treatment, blending, evapoconcentration, or volatilization that could impact produced water quality in ponds. Chemical characterization of produced water ponds is discussed in Section 5.5.3.

Due to the individual nature of each database, our compiled produced water quality dataset has a number of limitations, including:

- USGS datasets could not be independently verified and did not always specify protocols, methods, or detection limits, limiting interpretation and integration.

- For all datasets, results that were reported as zero, a non-detection qualifier (e.g., "ND"), below a detection/reporting limit (e.g., <0.05), or negative were not considered in compiled summary statistics. Results reported as a range (e.g., >100 mg/L) were removed to allow for consolidation. If no measurement value was provided for a given analysis or if the value was "NA," it was assumed that the analysis was not performed. Charge balance values were included in some databases; however, data points were not removed because large charge imbalances were often due to missing major ion analytes.

- Information on the source of produced water (e.g., water body, well identifiers, latitude, and longitude) beyond the oil field was not always available. Geospatial information is necessary to identify human health risks associated with produced water handling and reuse.

5.3.2. Compiled Produced Water Quality Dataset Summary

A total of 4,242 unique produced water samples were analyzed for subsets of 287 different water quality parameters and chemical compounds. Water quality parameters included standard water quality indicators, naturally occurring radioactive materials (NORM) and other radioactivity indicators, major and minor ions, trace elements, dissolved gasses, organic compounds, select compounds relating to hydraulic fracturing additives, and isotopes. Summary statistics were calculated for select parameters (**Table 5.3**), and additional water quality parameters (Table E.1, Appendix E.1) contained within the compiled produced water quality dataset.

Standard water quality parameters (e.g., alkalinity, pH) and ions (e.g., calcium, magnesium, sodium, chloride, alkalinity, and TDS) were the most often reported constituents. TDS concentrations in the vast majority (95%) of samples in the dataset are 3,250 mg/L or more (**Table 5.3**), well above the upper limit of 2,000 mg/L TDS used as a general rule of thumb for acceptable irrigation water (Ayers & Westcot, 1985), although some crops can handle higher TDS irrigation water. Consequently, most produced waters included in this database would require treatment or dilution before reuse for agricultural purposes (which would also dilute potential constituents of concern).

The CalGEM Well Stimulation Disclosure Database is the only synthesized database that contains monitoring data for organic compounds often co-produced with oil and gas. Benzene, toluene, ethylbenzene, and xylenes (BTEX) compounds were detected in most samples in the CalGEM database, with median concentrations of 0.71, 1.9, 0.25, and 1.2 mg/L, respectively. These levels are orders of magnitude higher than those reported in produced water ponds that supply produced water for irrigation and for discharge to land (Mahoney et al., 2021). BTEX compounds are expected to volatilize from produced water and pose additional hazards to human

health if emissions are uncontrolled. For example, benzene is a known human carcinogen, with a California Maximum Contaminant Level of 1 µg/L. Additional discussion on emissions from produced water ponds is provided in Section 5.5. Other notable organic compounds detected to a lesser extent include 2,2-dibromo-3-nitrilopropionamide (DBNPA, CASRN: 10222-01-2), and naphthalene. In instances where a large fraction of analyses for compounds resulted in non-detection, there may be an upper bias estimation in quartile and median concentrations.

Table 5.2. Overview of California produced water quality datasets.

Organization	Source	Data period	Region	Number of parameters	Number of samples	Description
USGS	USGS National Produced Waters Chemical Database (Blondes et al., 2018)	Feb 1937–Nov 1996	Los Angeles, Sacramento, San Joaquin, Santa Barbara-Ventura, Santa Maria basins	45	856	Produced water quality data including major and minor ions, trace elements, isotopes, dissolved gases, and naturally occurring radioactive materials.
CalGEM	Well Stimulation Disclosure Database (CalGEM, 2021a)	Jul 2015–Jun 2021	California	167	2,346	Composition of recovered fluids within 30 days following the end of well stimulation treatment. Data includes major and major ions, trace elements, isotopes, radioactive isotopes, and various VOCs.
USGS	Davis et al. (2016)	Nov 2014	North Belridge, South Belridge, Lost Hills oil fields	38	4	Produced water from four petroleum wells analyzed for dissolved hydrocarbon gases and their isotopic composition, salinity, major ions, nutrients, dissolved organic carbon, and stable isotopes of water and strontium dissolved in water.
USGS	Gannon et al. (2018)	Jul 2016–Oct 2017	Fruitvale, Lost Hills, North Belridge, and South Belridge oil fields	75	23	Produced water data including dissolved noble and hydrocarbon gases and their isotopic composition, salinity, major ions, nutrients, dissolved organic constituents and carbon, and stable isotopes of water and solutes dissolved in water.
USGS	Gans et al. (2018)	Jan 1933–Dec 2013	Fruitvale oil field	40	203	Historical produced water quality data including major ions, some minor ions, TDS, pH, specific gravity, resistivity, electrical conductivity, and charge balance.
USGS	Gans et al. (2019)	Nov 1930–May 1999	Lost Hills, North Belridge, and South Belridge oil fields	31	260	Historical produced water quality data including major ions, some minor ions, TDS, pH, specific gravity, resistivity, electrical conductivity, and charge balance.
USGS	Metzger et al. (2020)	Dec 1933–Nov 2016	Los Angeles and Orange County	59	200	Historical produced water quality data including major ions, some minor ions, TDS, pH, specific gravity, resistivity, electrical conductivity, and charge balance.
USGS	Metzger & Herrera (2020)	Nov 1958–Jan 2014	Orcutt and Oxnard oil fields	58	58	Historical produced water quality data including major ions, some minor ions, TDS, pH, specific gravity, resistivity, electrical conductivity, and charge balance.
USGS	Metzger (2021)	Jan 1948–Mar 2016	San Ardo	73	271	Historical produced water quality data including major ions, some minor ions, TDS, pH, specific gravity, resistivity, electrical conductivity, and charge balance.
USGS	Gans et al. (2021)	Jan 1957–Jan 1990	North Coles Levee oil field	45	40	Historical produced water quality data including major ions, some minor ions, TDS, pH, specific gravity, resistivity, electrical conductivity, and charge balance.

The CalGEM database was also the main source of data for radioactive indicators and NORM. Median values for gross alpha, gross beta, and radium-226 + radium-228 in produced water are 66, 144, and 38 picocuries per liter (pCi/L), respectively, well above screening levels of 15, 50, and 5 pCi/L, respectively (**Table 5.3**).

Overall, currently available produced water quality data sources are not adequate to evaluate produced water composition on a statewide level with respect to potential impacts to human health. The CalGEM "Well Stimulation Disclosure Database" is the most comprehensive but is limited in scope to stimulated wells. Stimulated wells represent a small fraction of the total number of producing oil and gas wells in California. Formation of a comprehensive produced water dataset would better inform assessment of exposure pathways associated with disposition of produced water.

5.3.3. Chemical Additives and Transformation Products in Produced Water

Chemical additives used in oil and gas production operations have the potential to undergo subsurface chemical transformations and return to the surface via flowback and produced water. Although degradation pathways and products have been established for some chemical additives under standard state conditions (i.e., standard temperature and pressure), downhole conditions including high temperatures and pressures can result in altered biodegradation potentials and unexpected chemical reactions and degradation productions (Kahrilas et al., 2015). The formation of degradation byproducts from downhole chemical transformations are poorly understood, yet can have significant implications for produced water quality, treatment, and disposal, and for human health due to environmental releases (Abdullah et al., 2017).

Current studies of degradation byproducts from transformations of chemicals used in OGD are limited to hydraulic fracturing, of which most are focused on regions outside of California (Hoelzer et al., 2016; Xiong et al., 2018, 2020). The characterization of flowback and produced water in these studies have detected compounds that cannot be attributed to geologic sources or chemical additive sources (Hoelzer et al., 2016; Maguire-Boyle & Barron, 2014; Sumner & Plata, 2018). Although these studies are not specific to California, some of the hydraulic fracturing chemical additives investigated in these studies are also used in California. Additionally, there is significant overlap in chemical usage between different upstream OGD operations as discussed in Chapter 2, Appendix B.

Table 5.3. Select constituents from the compiled produced water quality database for OGD in California.

					Percentile			
Constituents (units)	**Detections (%)**	**Min**	**Med**	**Max**	**5th**	**25th**	**75th**	**95th**
General Water Quality								
Alkalinity as $CaCO_3$ (mg/L)	1,490 (100)	0.34	2,800	5,800	250	2,000	3,300	4,100
Hardness (mg/L)	307 (99.4)	0.2	150	8,820	2.1	5.8	506	2,970
Specific Conductance (mS/cm)	356 (100)	29	35,000	190,476	3,790	16,150	42,000	60,210
Total Dissolved Solids (mg/L)	4,070 (100)	28	26,000	890,000	3,250	18,000	31,000	47,000
Total Organic Carbon (mg/L)	22 (95.7)	18	225	2,054	25.7	110	798	1,167
pH (pH units)	3,967 (100)	1.0	7.6	11.8	6.7	7.3	7.8	8.3
Major Ions								
Bicarbonate (mg/L)	1,702 (99.2)	2.0	1,154	12,809	163	582	2,270	4,550
Carbonate (mg/L)	329 (27.5)	1	51.6	2,250	3.76	20.4	138	447
Bromide (mg/L)	2,606 (97.6)	0.19	100	16,000	28	73	130	166
Chloride (mg/L)	4,211 (99.9)	1.0	14,000	360,000	408	8,670	17,000	24,980
Sulfate (mg/L)	3,023 (73.8)	0.1	38	15,250	3.77	24	87.2	475
Calcium (mg/L)	4,333 (99.9)	0.1	190	190,000	22	128	350	2,110
Magnesium (mg/L)	4,306 (99.5)	0.08	120	10,000	6.8	67	166	457
Potassium (mg/L)	3,082 (99.8)	1.2	190	52,000	33	140	300	1,400
Sodium (mg/L)	4,102 (100)	4.48	8,700	120,000	870	6,200	10,400	13,000
Inorganics								
Boron (mg/L)	3,289 (99.3)	0.02	92	158,000	4.2	62	105	150
Antimony (µg/L)	253 (9.8)	10	160	17,000	30	70	260	478
Arsenic (µg/L)	194 (7.6)	10	190	4,600	40	90	298	996
Barium (mg/L)	3,316 (96.6)	0.01	7.7	26,300	1.0	5.1	11	55
Beryllium (µg/L)	76 (2.9)	10	10	4,130	10	10	20	170
Cadmium (µg/L)	52 (2.0)	10	30	420	10	10	40	143
Chromium (µg/L)	643 (25.1)	10	40	9,400	10	30	70	200
Chromium VI (µg/L)	68 (3.1)	10	10	610	10	10	20	93
Cobalt (µg/L)	102 (3.9)	10	30	8,510	10	10	50	344
Copper (µg/L)	884 (33.6)	10	40	184,000	10	30	80	619
Iron (mg/L)	2,693 (91.8)	0.01	12	48,100	0.4	3.5	37	130
Lead (µg/L)	240 (9.3)	10	80	30,000	10	20	170	1,200
Lithium (mg/L)	2,759 (98.9)	0.004	5.8	17,500	0.99	4.15	8.3	18.1
Manganese (µg/L)	2,579 (95.0)	10	480	85,7000	110	250	920	2,800
Mercury (µg/L)	7 (0.3)	10	30	980	10	10	160	755
Molybdenum (µg/L)	343 (13.2)	10	40	48,500	10	20	70	270
Nickel (µg/L)	550 (21.5)	10	50	22,000	10	22.5	100	396

					Percentile			
Constituents (units)	**Detections (%)**	**Min**	**Med**	**Max**	**5th**	**25th**	**75th**	**95th**
Selenium (µg/L)	429 (16.7)	10	280	15,000	54	130	530	1,900
Silver (µg/L)	33 (1.3)	10	50	260	10	30	60	162
Strontium (mg/L)	2,886 (99.8)	0.01	11.2	190,000	2.80	7.2	16	126
Thallium (µg/L)	27 (1.0)	10	90	6,400	13	25	365	3,010
Vanadium (µg/L)	91 (3.6)	10	70	24,000	10	45	135	1,350
Zinc (µg/L)	1,017 (38.8)	10	110	243,000	30	70	250	1,920
Silica (mg/L)	744 (98.5)	0.18	60	2,200	14	36	90.2	177
Radionuclides/Isotopes								
Gross alpha (pCi/L)	1,916 (81.8)	0.05	66.1	2,589	7.33	32.9	109	238
Gross beta (pCi/L)	2,283 (97.6)	0.14	144	41,000	29.2	88.2	227	1,379
Radium 226 (pCi/L)	2,326 (98.6)	0.03	24.7	917	5.21	15.7	33.2	65.5
Radium 228 (pCi/L)	258 (94.8)	0.08	13	515	1.48	5.59	28.6	60.8
Radon 222 (pCi/L)	1,148 (71.5)	0.52	106.3	250,690	10.2	49	213	1,557
Uranium (µg/L)	8 (22.2)	0.28	1.84	7.03	0.44	1.25	4.37	6.84
Nutrients								
Ammonia (mg/L)	158 (99.3)	1.28	27.5	2,300	7.08	17	41.0	75.5
Ammonium (mg/L)	272 (92.8)	3	139	2,560	12.2	73.8	201	377
Nitrate (mg/L)	214 (8.90)	0.1	12	800	0.6	1.59	24.8	170
Nitrite (mg/L)	646 (28.0)	0.04	0.09	10	0.04	0.05	0.27	0.97
Organics								
Total carbohydrates (mg/L)	2,041 (97.4)	1.2	97	11,000	21	53	190	560
Benzene (µg/L)	2,293 (98.0)	10	710	25,000	80	300	1,400	3,600
Toluene (µg/L)	2,307 (98.5)	10	1,900	61,000	170	885	3,000	4,970
Ethylbenzene (µg/L)	2,277 (97.2)	10	250	5,300	40	140	360	670
m-Xylenes (µg/L)	68 (100)	210	770	6,000	300	488	1,200	2,030
o-Xylene (µg/L)	2,129 (98.3)	10	420	5,700	70	230	640	1,200
Total Xylenes (µg/L)	2,307 (98.5)	10	1,200	19,000	140	570	2,000	3,800
Naphthalene (µg/L)	9 (75)	10	30	3,900	14	30	250	2,980
2,2-Dibromo-3-nitrilopropionamide (mg/L)	52 (32.7)	5	15	20	5	10	20	20

Abbreviations: mg/L - milligrams per liter; mS/cm - milliSiemens per centimeter; pCi/L - picocuries per liter; ug/L - micrograms per liter

5.3.3.1 Organohalide Compounds

Halogenated organic compounds are an area of growing concern. They have been detected in multiple studies of hydraulic fracturing flowback and produced waters where they were not reported in chemical disclosures (Evans et al., 2019; Hoelzer et al., 2016; Sumner & Plata, 2018). Halogenated benzenes, pyrans, alkanes, methanes, and acetones have been detected in hydraulic fracturing wastewaters from the Fayetteville Shale (Hoelzer et al., 2016) and chlorocarbons and organobromides have been detected in produced water from the Barnett, Marcellus, and Eagle Ford formations (Maguire-Boyle & Barron, 2014). Evans et al. (2019) detected 20 organohalide compounds in Marcellus Shale produced water (e.g., haloalkanes, haloamides, haloamines, halobenzenes, and haloesters), and determined microbial organohalide transformation may play a direct role in the formation of these organohalides.

A study conducted by Sumner and Plata (2018) found that epichlorohydrin, cinnamaldehyde (CASRN: 104-55-2), and 2,2-dibromo-3-nitrilopropionamide (DBNPA) showed evidence of halogenation when subjected to simulated downhole hydraulic fracturing conditions. They concluded that halogenation reactions are facilitated by the following conditions:

1) Presence of oxidants (i.e., breakers) that can react with halides to form reactive intermediates, which then react with organic species.
2) High concentrations of chloride, bromide, or iodide in formation waters increase the likelihood of halogenated product formation. Other factors, including pH and temperature, can also affect halogenated species formation rates and distribution.
3) Reaction kinetics are highly dependent on well temperature, increasing by an order of magnitude with a 40°C (~104°F) increase.

DBNPA is widely used in hydraulic fracturing operations in California. Cinnamaldehyde has been reported in a limited number of hydraulic fracturing and maintenance acidizing operations, and in operations in the southern San Joaquin Valley that provide produced water for irrigation. Epichlorohydrin has not been reported in any upstream oil and gas operations in California.

Halogenated transformation products may also form through the downhole reaction of guar gum-based fracturing fluids using borate or zirconium crosslinkers with oxidative breakers (Sumner & Plata, 2019). Under simulated conditions, Sumner and Plata (2019) found oxidative breakers — such as persulfates, chlorites, and hypochlorites — can react with other additives (e.g., cinnamaldehyde, citric acid) to form various halogenated transformation products. Hydraulic fracturing operations in California predominantly use guar-based fracturing fluids and all the major reactants in this study (i.e., borate and zirconium crosslinkers, citric acid, persulfates, chlorites, hypochlorites, and cinnamaldehyde) have been reported in well stimulation operations in California.

5.3.3.2 Polyacrylamide

The chemical and mechanical degradation of polyacrylamide in high-volume hydraulic fracturing was investigated by Xiong et al. (2018, 2020). They found significant degradation in polyacrylamide due to both mechanical shearing and free radical chain scission mechanisms,

resulting in a wide distribution in polyacrylamide molecular weights. The abundance of degraded polyacrylamide may complicate produced water treatment and increase the likelihood of environmental releases of acrylamide, a toxicant and probable human carcinogen (IARC, 1994). Polyacrylamide is a common friction reducer used in hydraulic fracturing fluids in shale plays across the United States (Stringfellow et al., 2014). Although polyacrylamide has not been reported in hydraulic fracturing operations in California, primarily due to the predominant use of gel-based fracturing fluids in the state, polyacrylamide has been used as a viscosity modifier in a limited number of horizontal and vertical well drilling operations reported to the South Coast Air Quality Management District (SCAQMD) and the CVRWQCB (Stringfellow et al., 2015, 2017). It is unclear if the described degradation mechanisms also apply to polyacrylamide use in conventional well drilling operations.

Table 5.4. Summary of studies investigating chemical transformations of specific chemical additives related to hydraulic fracturing.

Study	Precursor chemicals	Halides	Halogenated categories	Detected products	Conditions
Kahrilas et al. (2016)	Glutaraldehyde	Bromide Chloride Iodide	-	Glutaraldehyde dimers trimers; possibly unchanged depending on conditions	Influenced by pH, temperature, and salinity. May readily degrade under hot, alkaline conditions. Likely to return to surface with transformation products in cooler, acidic, saline conditions.
Sumner and Plata (2018)	Epichlorohydrin Cinnamaldehyde DBNPA	Bromide Chloride Iodine	Methanes Acetonitriles Alcohols Others	Chloroacetonitrile dichloroacetonitrile bromoacetonitrile dibromoacetonitrile tribromomethane chloroiodomethane boromodichloromethane dibromochloromethane iodoacetonitrile α-iodocinnamaldehyde α-chlorocinnamaldehyde α-bromocinnamaldehyde 2,3-dichloro-1-propanol 1,3-dichloro-2-propanol 3-chloro-1,2-propanediol	Presence of oxidants (i.e., breakers) that can react with halides to form reactive intermediates, which then react with organic species. pH and temperature affect halogenated species formation rates and distribution.
Sumner and Plata (2019)	Guar gum Borate and zirconium crosslinkers Oxidant breakers Citric acid	Bromide Chloride Iodine	Methanes	Bromochloromethane Chloroiodomethane Bromodichloromethane Dibromochloromethane Chlorodiiodomethane Bromodiiodomethane Tribromomethane Trichloromethane Triiodomethane	Halogenation requires high concentrations of oxidants. Citric acid more prone to trihalomethane formation than guar gum. Zirconium crosslinkers more prone to trihalomethane formation than borate-based crosslinkers.
Xiong et al. (2018, 2020)	Polyacrylamide	-	-	Degraded short chain polyacrylamides Possibility of acrylamide monomer formation	Degradation caused by both physical shearing and chemical decomposition.

5.3.3.3 Glutaraldehyde

A study of glutaraldehyde under simulated hydraulic fracturing conditions found that degradation of glutaraldehyde is influenced by pH, temperature, and salinity (Kahrilas et al., 2016). Under downhole conditions, glutaraldehyde is suspected of undergoing autopolymerization, reactions with thiols and sulfides, or reactions with NH_3 or amines. These transformation products could precipitate out of solution at high temperatures or under alkaline conditions but would likely return to the surface with unreacted glutaraldehyde products in cooler, more acidic, and saline conditions. Glutaraldehyde is a commonly used biocide in upstream OGD in California and has been reported in all of the chemical disclosure datasets (Shonkoff et al., 2021; Stringfellow et al., 2017). Glutaraldehyde is a skin, eye, and nose irritant that has a U.S. Environmental Protection Agency (US EPA) risk based screening level for chronic ingestion exposure of 2 mg/L based on the Agency for Toxic Substances and Disease Registry (ATSDR) minimum risk level of 0.1 mg/kg/day (ATSDR, 2017), and an California Office of Environmental Health Hazard Assessment (OEHHA) chronic inhalation reference exposure level of 0.02 ppb (OEHHA, 2020). The toxicity of the investigated glutaraldehyde transformation products are largely unknown (Kahrilas et al., 2016) and it is important to note that the absence of toxicological information does not mean the absence of health risk.

5.3.3.4 Per- and Polyfluoroalkyl Substances (PFAS)

Recent reports have linked the use of per- and polyfluoroalkyl substances (PFAS) — sometimes referred to as "forever chemicals" — with hydraulic fracturing fluids in the U.S. (Horwitt & Gottlieb, 2021, 2022). Based on the list of PFAS maintained in the U.S. EPA CompTox Chemicals Dashboard (US EPA, 2022a; 2022b), the only PFAS chemical reported in hydraulic fracturing chemical disclosures in California is polytetrafluoroethylene (PTFE) (Stringfellow et al., 2015; Shonkoff et al., 2021). PTFE — commonly known as Teflon — is not included in chemical analyses of produced water and subsequently has not been documented in any produced water samples from California.

The risk posed by the inclusion of PTFE in hydraulic fracturing fluids is unknown. It has been argued that PTFE should be considered a polymer of low concern and distinctly different from other PFAS for hazard assessment due to its thermal, chemical, and biological stability and toxicological studies (Henry et al., 2018); however, others suggest that the complete life cycle of fluoropolymers (including PTFE) should be taken into account (Lohmann et al., 2020). While PTFE is known to produce fluorinated degradation products when heated to temperatures greater than 250 °C (482 °F) (Lohmann et al., 2020), no studies of PTFE degradation under hydraulic fracturing conditions appear to have been conducted, and thus transformation products generated by PTFE in downhole conditions are relatively unknown. However, given that guar-based fracturing fluids — the dominant type used in California — are generally unstable above 149 °C (300 °F) but may be used under conditions as high as 204 °C (400 °F) with appropriate stabilizers (Almubarak et al., 2021), it is possible that proper conditions for the generation of fluorinated degradation products are not reached.

5.3.3.5 Modeling

There remains a need to better characterize the potential transformation products and conditions that contribute to their formation (Kahrilas et al., 2016). There are no studies that look specifically at transformation products from hydraulic fracturing (or conventional OGD) in California to our knowledge; however, the chemical transformations documented elsewhere are possible if similar downhole conditions and fluid chemistry are present in California.

Limited studies of widely used hydraulic fracturing chemical additives have shown there is a potential for multiple types of halogenated organic compounds to form and return to the surface with flowback and produced water. Other studies have detected similar compounds in produced water that do not match disclosed chemical additives or geogenic compounds. These halogenated organic compounds are generally environmentally persistent with varying degrees of human toxicity and are regulated in drinking water as disinfection byproducts.

Standard water quality monitoring methods and approaches overlook a variety of potential constituents found in produced water, including chemical additives and their transformation products. Non-targeted analytical methods to monitor produced water quality, such as high-resolution mass spectrometry with liquid chromatography, are an emerging approach that could detect the presence of unknown or problematic transformation products, such as halogenated organic compounds (Shonkoff et al., 2021).

In an effort to facilitate future studies of subsurface chemical transformations and develop predictive modeling tools, Sumner and Plata (2020) developed a geospatial database that combines FracFocus chemical disclosure information, subsurface conditions, and produced water compositions to identify regions where chemical transformation conditions are likely to occur. Predictive tools such as these can inform future produced water monitoring programs, and help operators make informed decisions on the usage of chemical additives in order to mitigate potential problematic chemical transformations (Sumner & Plata, 2020).

5.4. Contamination Pathways and Regulations for Underground Injection Control Wells

The U.S. EPA recognizes six pathways through which injected fluids could potentially migrate into underground sources of drinking water (USDW), causing groundwater contamination and impact to domestic or municipal water wells:

1) migration of fluids through a faulty injection well casing;
2) migration of fluids through the annulus located between the casing and wellbore;
3) migration of fluids from an injection zone through the confining strata;
4) vertical migration of fluids through improperly abandoned and improperly completed wells that penetrate the injection zone;
5) lateral migration of fluids from within an injection zone into a protected portion of that stratum;
6) direct injection of fluids into or above an USDW (Osbourne, 2002).

If injection wells are located near a surface water body, contaminants may enter surface water and downstream drinking water intakes through migration at the borehole or through preferential flow paths in subsurface media (**Figure 5.4**). If idle production wells are located near surface water, over pressurization could cause a production well to flow at the surface, with subsequent entry into surface water.

According to the U.S. EPA's Underground Injection Control (UIC) well inventory, as of 2019, there were 1,698 produced water disposal wells (Class IID) and 34,990 enhanced recovery (Class IIR) wells in California (US EPA, 2018). California is second only to Texas in the number of UIC Class II wells in the state.

The California Class II UIC program is managed by CalGEM under California Public Resources Code § 3106, which provides the State Oil and Gas Supervisor broad authority to protect public health and safety. The existing regulations include specific data requirements that an applicant must satisfy before CalGEM can approve an injection project. Project data requirements include engineering studies (including area of review determination and casing diagrams); geologic studies (including structural contour and isopach maps and reservoir characteristics); and injection plans (including identification of the proposed maximum anticipated surface injection pressure and proposed monitoring system or methods to ensure no damage is occurring).

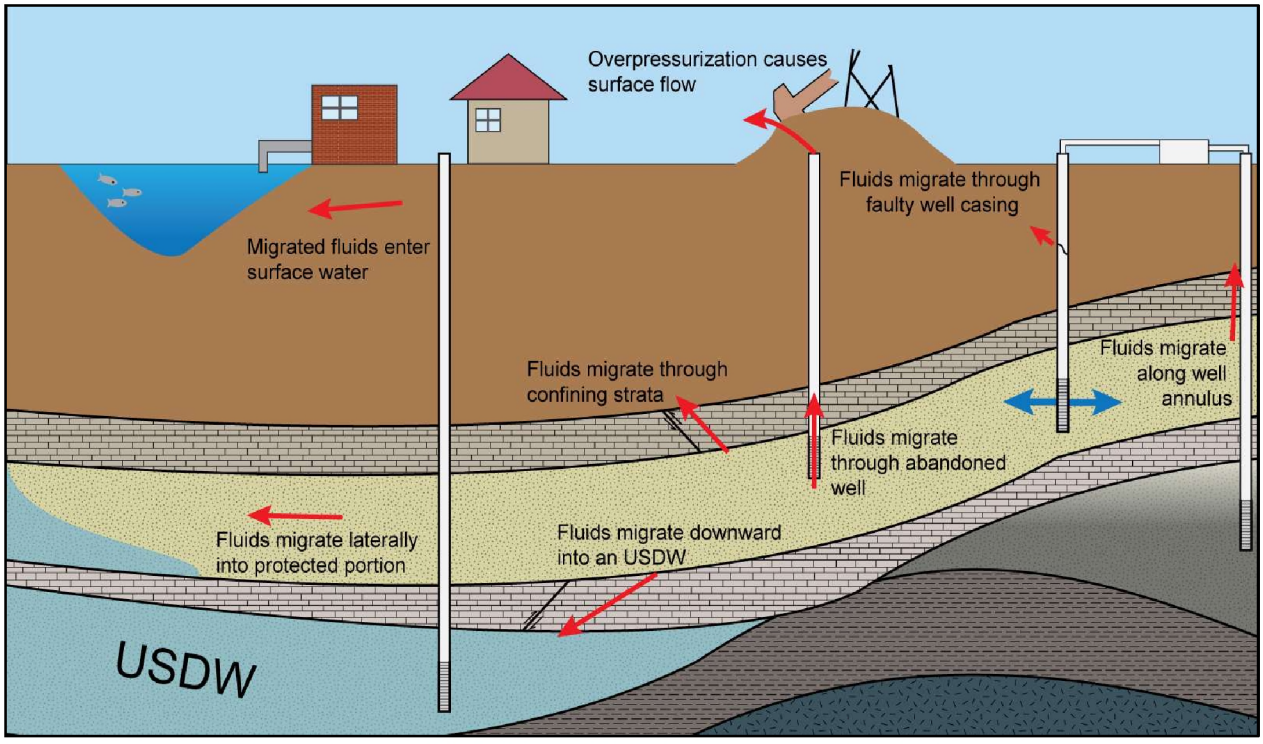


Figure 5.4. Conceptual contamination and exposure pathways of underground injection control wells.

In 2011, the U.S. EPA hired an independent consultant group to conduct an audit of California's UIC Program (Walker, 2011). The consultant group found inconsistencies in the definition of protected water. CalGEM reported protecting "freshwater" containing less than or equal to 3,000 mg/L TDS, while federal regulations (the Safe Drinking Water Act) require protection of an USDW at less than or equal to 10,000 mg/L TDS. The audit also found the Division lacking in the implementation of a number of requirements, including consistent area of review analyses, accurate determination of fracture gradients for injection projects, and enforcement of appropriate maximum allowable surface injection pressures (Walker, 2011). Also in 2011, an oil industry employee died when the ground beneath them gave way and they fell into a pool of heated fluid. The pool, known as a "surface expression," was in part the result of nearby cyclic steam injection operations. The existence of a surface expression is indicative of injection being performed at rates and pressures above safe levels and that injection is not confined to the approved injection zone (CalGEM, 2019). In 2019, UIC regulations were revised to prohibit surface expressions and enact monitoring and prevention requirements (14 C.C.R. § 1724.11).

In 2014, CalGEM ordered the immediate closure of 11 disposal wells in Kern County that potentially presented health or environmental risks. The SWRCB identified 108 water supply wells located within a one-mile radius of these wells. However, sampling of the wells did not indicate impact (Bishop, 2014).

Following the discovery of permitting injection of produced water into nonexempt aquifers, the California Legislature enacted Senate Bill 83 (SB 83) in 2015 (California Senate Bill No. 83, 2015) in part to mandate review of proposed aquifer exemptions by the State and regional water quality control boards. The SWRCB and nine regional water quality control boards (RWQCB) now play a role in both project review and approval in ensuring that injection will not adversely degrade USDWs, which could lead to an exposure pathway for current and future groundwater users. CalGEM and the SWRCB now coordinate approval of aquifer exemptions (CalGEM, 2019).

Pursuant to SB 83 (2015), the California Natural Resources Agency and the California Environmental Protection Agency appointed a panel comprised of a diverse group of individuals with expertise and scientific backgrounds in geology, toxicology, oil and gas industry, public health, and the environment, as well as representatives from the agricultural and environmental justice communities. The purpose of the panel is to evaluate the regulatory performance and administration of the UIC Program and make recommendations on how to improve its effectiveness by evaluating resource needs, statutory or regulatory changes, and program organization (CalGEM, 2021b). The first public meeting was held on May 29, 2018 (Cal-Span, 2018). Results from the panel are forthcoming at the time of writing this report. A performance audit conducted by California Department of Finance and completed in 2020 evaluated CalGEM's UIC project approval process and highlighted the need to (1) improve UIC program controls, (2) strengthen project review documentation and transparency, (3) ensure project modifications or expansions are not approved through infill well reviews, (4) discontinue use of placeholder projects and issuance of associated well permits, (5) improve well permit detail and review documentation, and (6) strengthen Axial Dimensional Stimulation Area (ADSA) review documentation (California Department of Finance, 2020).

It is not clear exactly how many Californians relying on water wells for domestic use could be potentially impacted by underground disposal wells. As a result of a proximity analysis conducted as part of Chapter 7 of this report, about 261,000 Californians were found to live within 1 km (3,281 ft) of a water disposal well (**Figure 5.5**). However, distances of these wells to domestic water wells were not considered due to the limited spatial resolution of these data. A detailed discussion of this issue is included in Section 5.5.7. Locations of all wells with a type of "Water Disposal" in the CalGEM "All Wells" dataset are provided in Figure E.1, Appendix E.2.

5.5. Contamination Pathways and Regulations for Produced Water Ponds

5.5.1. Background

The SWRCB defines a produced water pond as an earthen structure that is used to store, dispose, treat, and/or separate liquids; and of which produced water comprises a significant amount of liquid (SWRCB, 2019). Produced water ponds can be lined, typically with a type of sprayed concrete called gunite, or more commonly, unlined. The SWRCB classifies produced water ponds as one of three statuses: (1) active —ponds that currently receive produced water; (2) inactive— ponds that have a physical connection to a produced water source but currently do not receive produced water; or (3) historical/closed —ponds that have no physical connection to a produced water source and have been out of service for an extended period of time (SWRCB, 2019).

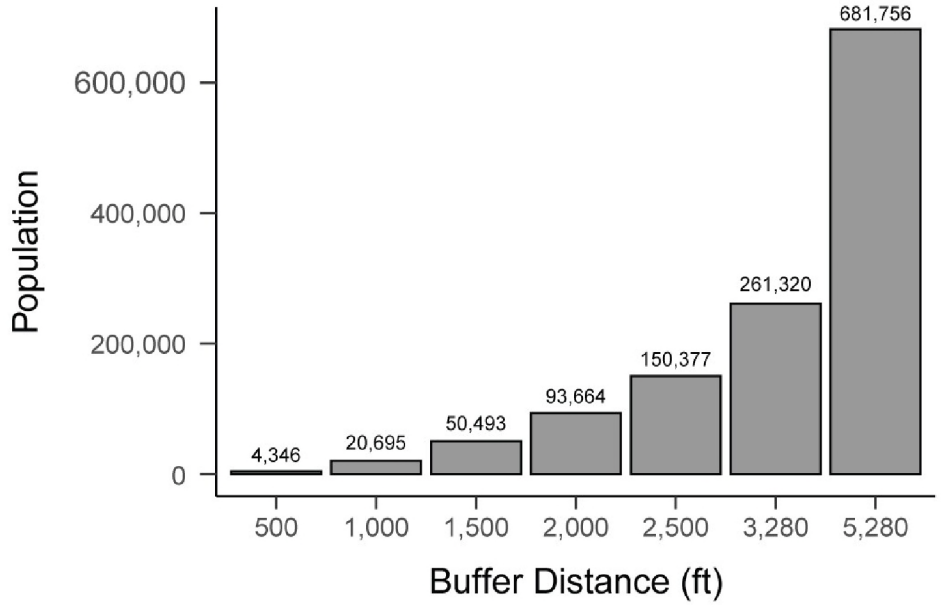


Figure 5.5. Total populations living within buffer distances of water disposal wells.

Historically, the primary method of surface-based (non-injection) produced water disposal in California has been discharge to unlined produced water ponds (**Figure 5.6**), which has been ongoing in California since the early 1900s. For instance, Bean & Logan (1983) state that 570,000

acre-feet of produced water, containing 15 million tons of salt, was disposed of in sumps or shallow injection wells from 1900 to 1980 in southwestern Kern County alone.

Recently, DiGiulio & Shonkoff (2021) conducted an examination of produced water disposal trends in the SB1281 dataset. They found the volume of produced water disposed in unlined ponds peaked in 2007 at 609 million barrels (MMbbls) (23.0% of produced water disposition), and the proportion of produced water disposed in unlined produced water ponds peaked in 2003 (24.5% produced water disposition). Disposal of produced water to unlined produced water ponds decreased significantly after 2014, with a low of 45.1 MMbbls in 2017 (corresponding to 1.4% of total produced water disposition). Discharge to lined produced water ponds (evaporation ponds) tapered off after 1998 after reaching a peak in 1992 (8.2% of produced water) and a low in 2001 (0.01% of produced water).

Prior to discharge to unlined ponds, treatment of produced water typically consists of gravity separation of oil and water using wash or storage tanks. Emulsion breakers, surfactants, clarifiers, and other additives may be used in wash tanks to facilitate oil/water separation (WZI Inc., 2020). At small facilities consisting of one to three unlined ponds, produced water is subsequently discharged to unlined ponds where remaining oil is skimmed during evaporation and percolation. At larger facilities, produced water enters a series of unlined ponds for skimming of oil prior to discharge to larger unlined ponds for evaporation and percolation (Jordan et al., 2015).

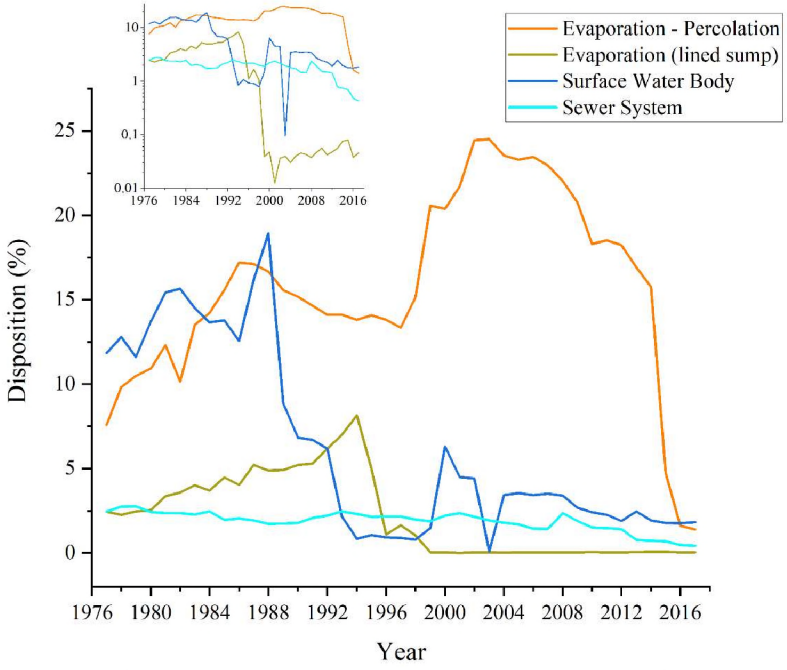


Figure 5.6. Percent produced water disposal to the surface (evaporation-percolation ponds, lined produced water ponds, sewage, and surface water) from 1977 to 2017 as reported to CalGEM. Inset provided in logarithmic scale to better illustrate disposition of lined sumps after 1998. Source: Figure S2 from DiGiulio et al. (2021).

One area of growing concern in California is the impact to groundwater used for public water supply from ongoing and past disposal of wastewater from OGD (i.e., produced water) into unlined

produced water ponds (Grinberg, 2014, 2016; Heberger & Donnelly, 2015; Jordan et al., 2015; Stringfellow et al., 2015). The primary intent of percolation pits is to percolate produced water into subsurface media. This practice provides a direct pathway to transport produced water constituents into groundwater (Jordan et al., 2015; Stringfellow et al., 2015). Contaminated groundwater could then impact municipal, domestic, and irrigation wells (**Figure 5.7**). In addition, contaminated groundwater could also intercept rivers, streams, and surface water resources. Finally, contaminated water used by plants (including food crops), fish, and wildlife can introduce contaminants into the food chain. Other pathways of human exposure include skin contact via accidental exposure (e.g., falling into a pond) and inhalation of volatile compounds present in produced water from ponds.

Approximately 89% of produced water ponds and 99% of unlined produced water ponds in California are in the Tulare Basin, in the San Joaquin Valley (SJV) (DiGiulio & Shonkoff, 2019, 2021). Facilities containing unlined produced water ponds vary from single ponds to large complexes consisting of numerous ponds. Between 1977 and 2017, 16,129 MMbbls of produced water were disposed in unlined produced water ponds (**Figure 5.8**) representing a potential wide-scale legacy groundwater contamination issue in the Tulare Basin, where most unlined ponds are located (DiGiulio et al., 2021; DiGiulio & Shonkoff, 2019).

The SJV is arid-to-semiarid hot, with total annual precipitation from 12 to 45 cm (5 to 18 in) falling mostly in winter months (Faunt et al., 2010). While evaporation exceeds precipitation throughout most of the year, in practice, the year-round flow of water to unlined ponds results in most water percolating to subsurface media (Jordan et al., 2015). For instance, an analysis of evaporation/percolation in three unlined ponds in the Edison Field in the southeastern portion of the Tulare Basin indicated that 92% of disposed water percolated to subsurface media in 2006 (WZI Inc., 2020). Consequently, this disposal practice may introduce a potential contamination pathway for nearby USDWs.

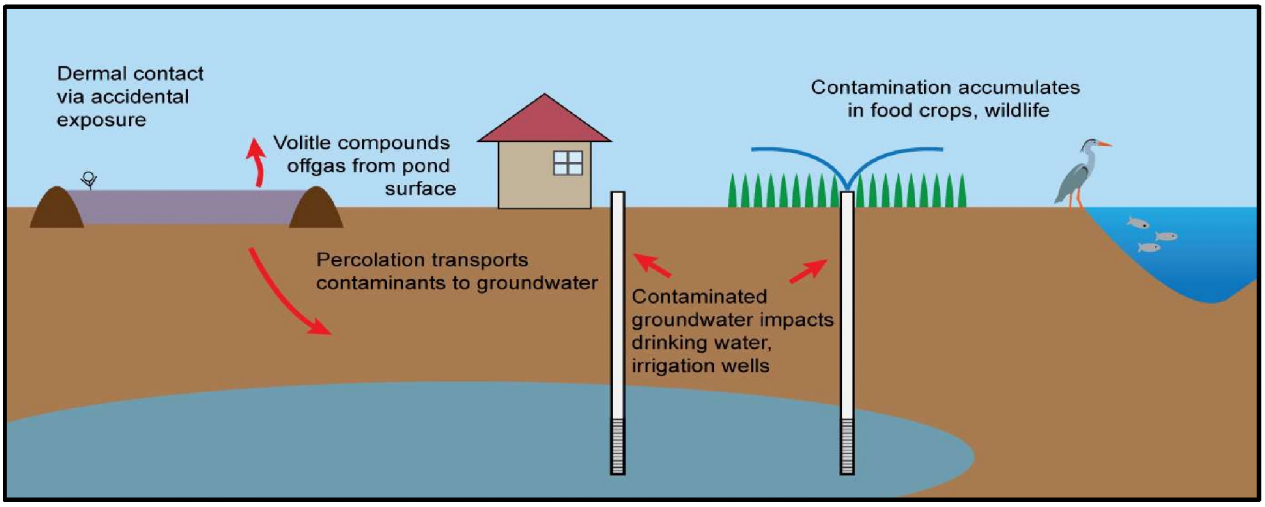


Figure 5.7. Conceptual contamination and exposure pathways associated with produced water disposal ponds.

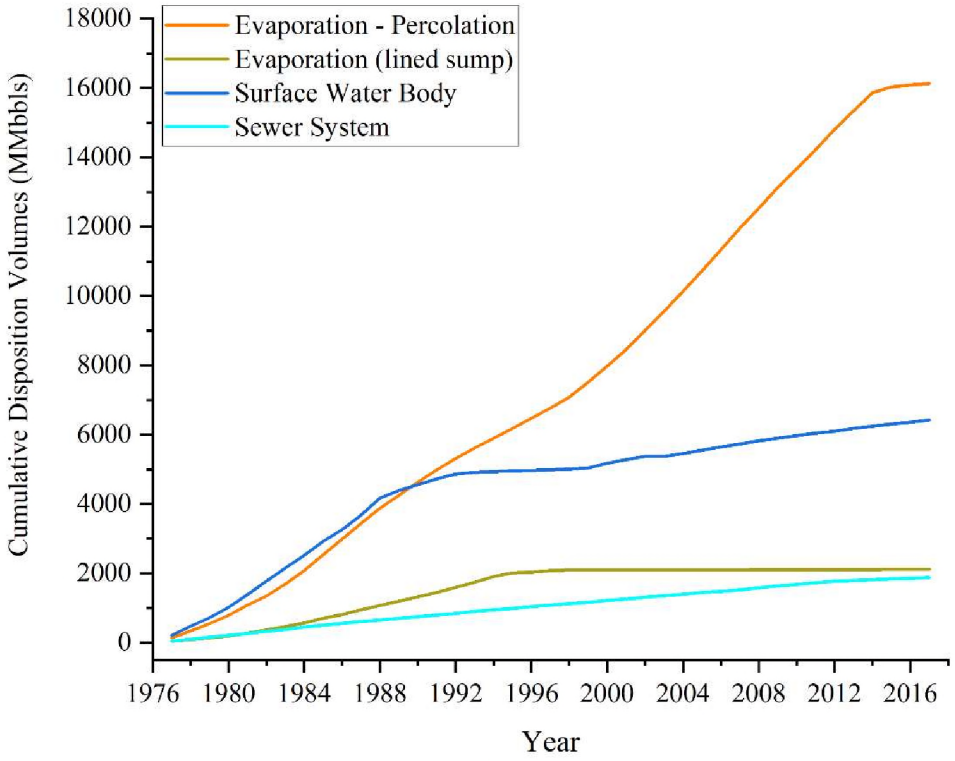


Figure 5.8. Cumulative volumes of produced water discharged into unlined produced water ponds, lined produced water ponds, surface water, and sewer systems from 1977 to 2017. Source: Figure S5 from DiGiulio et al. (2021).

5.5.2. Regulatory Actions Relevant to Produced Water Ponds in California

The California Legislature and the CVRWQCB, the regulatory jurisdiction where most unlined produced water ponds are located, have undertaken numerous regulatory actions to better control and understand the risks posed to groundwater resources and public health from the disposal of produced water into unlined produced water ponds.

In September 2013, the California Legislature passed Senate Bill 4 (SB 4), setting the framework for regulation of well stimulation technologies in California, including hydraulic fracturing (California Senate Bill No. 4, 2013). SB 4 required full disclosure of the composition of well stimulation fluids which could be present to some degree in produced water from stimulated wells. SB 4 also required the SWRCB to implement Regional Groundwater Monitoring Programs (RMPs) prioritizing monitoring of groundwater that has the potential to be a source of drinking water including from impact by well stimulation, UIC wells, and produced water ponds. The USGS, through funding from the SWRCB, is the technical lead on implementing RMPs (SWRCB, 2021a).

In May 2014, the CVRWQCB began an effort to better regulate the disposal of produced water into unlined produced water ponds (CVRWQCB, 2014). The CVRWQCB located 326 facilities with 1,100 produced water ponds that receive or had received produced water in the Tulare Basin (CVRWQCB, 2017). At 241 of these 326 (~74%) facilities, produced water was being discharged to produced water ponds without Waste Discharge Requirements (WDRs) required for operation.

At the remaining 85 facilities (~26%), wastewater was being discharged to produced water ponds under WDRs that were 20 years old or older. The CVRWQCB subsequently issued Notices of Violation to numerous facility operators not having WDRs (CVRWQCB, 2017, 2017a, 2017b).

In September 2014, the California Legislature passed Senate Bill 1281 (SB 1281) requiring improved reporting on the volume, characteristics, treatment, and disposition of produced fluids from any well to the California Department of Oil, Gas, and Geothermal Resources (DOGGR, now CalGEM) starting with the first quarter of 2015 (California Senate Bill No. 1281, 2014). CalGEM had previously used six category codes (including discharge to lined and unlined sumps) to track the disposition of produced water in California. Subsequently, this number increased to 12 category codes, including discharge to land surface and "domestic use" which includes irrigation (CalGEM, 2018).

SB 1281 does not mandate the tracking of waste products associated with the handling and management of produced water (e.g., filter socks, sludge from settling tanks, scale from pipes). It is unclear how these waste products are tracked in California, which agencies having jurisdiction for waste management, and the degree of fragmentation of waste management. For instance, while CalGEM may have jurisdiction for sludge management in oil-water separators, a regional water board may have jurisdiction for sludge management in produced water ponds. SB 1281 also does not mandate tracking the destination of produced water. Hence, produced water from a particular well or field cannot be traced to a produced water pond facility discharge point. Pursuant to SB 1281, CalGEM is required to provide the SWRCB with an "inventory of all unlined oil and gas field sumps" (California Senate Bill No. 1281, 2014).

Characterization of produced water under SB 1281 is limited to a determination of whether concentrations of TDS are greater or less than 10,000 mg/L (binary yes or no response). Prior to 2014, the CVRWQCB required determination of electrical conductivity, boron, and chloride concentrations in produced water discharged to produced water ponds. These constituents were monitored in order to evaluate compliance with the Tulare Basin Water Quality Control Plan effluent limitations (1,000 microSiemens per centimeter (µS/cm), 200 mg/L, and 1 mg/L, respectively) (CVRWQCB, 2018). Limits do not exist for other constituents present in produced water, such as heavy metals, radionuclides, and volatile organic compounds such as benzene, toluene, ethylbenzene, and xylenes (BTEX).

In May 2015, the CVRWQCB issued a directive pursuant to the California Water Code Section 13267 to 77 facility operators expanding chemical analysis of produced water discharged into ponds to major ions (e.g., sodium, potassium, calcium, magnesium, sulfate, chloride, bicarbonate, carbonate, hydroxide); target metals (e.g. chromium, nickel); trace metals (e.g., lithium, strontium); arsenic; petroleum hydrocarbons; polyaromatic hydrocarbons (PAHs); target VOCs (e.g., benzene, toluene, ethylbenzene, xylenes); and radionuclides (radium-226, radium-228, gross alpha) (CVRWQCB, 2015).

In June 2015, the California Legislature passed SB 83, which in part required that the SWRCB issue a status report ("Produced Water Pond Status Report") on the regulation of oil field produced

water ponds within each region by January 30, 2016, and every six months thereafter (California Senate Bill No. 83, 2015).

In April 2017, the CVRWQCB developed three general orders to facilitate the permitting of unlined produced water ponds. In areas where groundwater with beneficial use exists, General Order Number One applies to discharge facilities where wastewater effluent can meet the discharge requirements of the Tulare Lake Basin Plan (CVRWQCB, 2017), whereas General Order Number Two applies to discharge facilities where wastewater effluent cannot meet Tulare Lake Basin Plan discharge requirements (CVRWQCB, 2017a). Both general orders require quarterly chemical monitoring of produced water discharged into produced water ponds, and the installation of at least three monitoring wells in the vicinity of produced water ponds (CVRWQCB, 2017, 2017a). General Order Number Three applies to facilities where wastewater effluent exceeds the Tulare Lake Basin Plan effluent requirements, and where first encountered groundwater is associated with commercial oil and gas production or where natural background groundwater quality does not have beneficial use (CVRWQCB, 2017b).

In October 2017, the California Legislature passed Assembly Bill (AB) 1328 authorizing RWQCBs to require and make public information about chemicals added to produced water if discharged to surface or land (California Assembly Bill No. 1328, 2017). AB 1328 addressed the concern that there are numerous additives such as surfactants, solvents, and biocides used during oil and gas extraction that are not subject to target analyses at commercial laboratories routinely used to test produced water. Quarterly or semiannual reports on discharge of produced water to produced water ponds must now contain this information.

In July 2018, CalGEM commissioned a study to better understand reporting pursuant to SB 1281. DiGiulio and Shonkoff (2021) found that treatment of produced water prior to discharge in the Tulare Basin was limited to de-oiling (94.86%); de-oiling with other treatment (0.25%); no method specified (2.06%); and no treatment (2.83%). DiGiulio and Shonkoff (2021) also found that reporting pursuant to SB 1281 indicated that ~96% of produced water disposed in unlined produced water ponds in the Tulare Basin between 2015 and 2017 exceeded 10,000 mg/L TDS.

Finally, to better understand emissions of VOCs from produced water ponds, in May 2020, the California Air Resources Board (CARB) released a report on VOC emissions from produced water ponds in California (Schmidt & Card, 2020).

5.5.3. Chemical Characterization of Produced Water Disposed in Produced Water Ponds

USGS reports have summarized produced water composition from several oil and gas fields in California (**Table 5.1**). However, there is no counterpart which describes the disposition of waters contained in produced water ponds. Few peer-reviewed studies have characterized the chemical constituents of produced water contained within individual ponds in California (e.g., McMahon et al., 2018, 2019). This is a crucial knowledge gap, as both produced water treatment methods, along with shifts in geochemical setting (i.e., changes in redox status, evapoconcentration) during storage within percolation ponds, make it relatively likely that the chemistry of produced waters do not reflect the chemistry of pondwaters. To address this knowledge gap, publicly available data contained within the SWRCB Geotracker system (SWRCB, 2021b) were extracted and summarized.

The Geotracker website contains chemical data of samples collected from produced water ponds at a variety of timescales (e.g., quarterly, annually). For some facilities, and in relatively recent years, chemical data is provided electronically and can be downloaded directly in a digitized format (e.g., a comma separated value file). However, the vast majority of the data is contained within undigitized PDF format documents, necessitating manual retrieval from analytical reports. Data sets from the Tulare Basin were extracted from analytical reports dated prior to December 31, 2019.

In general, large produced water pond facilities had more sample data than small facilities. Hence, summary statistics presented here (**Table 5.5**) are biased toward large facilities. However, most produced water disposed in unlined produced water ponds is associated with large facilities. Thus, the summaries presented here are generally representative of the chemistry of produced water ponds on a statewide basis.

To assess the accuracy of the measured major cations and anions, a charge balance error was calculated for each sample. However, data points were not removed because large (>7%) charge imbalances were often due to a missing major ion analyte. All results that were reported as zero, a non-detection qualifier (e.g., "ND"), below a detection/reporting limit (e.g., "<0.05"), or negative were not considered in summary statistics. Detection limits for organic compounds were highly variable, complicating calculation of median and quartile values. In instances where a substantial fraction of analyses resulted in non-detection, there may be an upper bias estimation in quartile and median concentrations for organic compounds.

There is considerable spatial variability in the composition of produced water disposed in produced water ponds throughout the Tulare Basin. High concentrations of salts and BTEX components in produced water disposed in unlined produced water ponds generally occurs in the western and southwestern portion of the Tulare Basin (DiGiulio et al., 2021).

Chloride and boron are the most commonly measured (n>1,400) constituents across the database. The frequent measurement of chloride and boron is unsurprising, as measurement of these constituents is required by the Tulare Basin Water Quality Control Plan (CVRWQCB, 2018). Specific conductance or electrical conductivity was measured less frequently despite also being required under the basin plan. Major ions (calcium, magnesium, potassium, sodium, bicarbonate, and sulfate) and pH are the next most measured constituents (n>900). Most detections of analytes beyond electrical conductivity, TDS, chloride, and boron are from measurements made after the CVRWQCB expanded the list of required analytes in 2015 (CVRWQCB, 2015).

Several constituents of concern in the database exceed regulatory limits. Both median and maximum levels of electrical conductivity, chloride, and boron in produced water disposed in unlined ponds exceed allowable effluent limitations in the Tulare Basin Plan (**Figure 5.9**). Concentrations of other major ions (e.g., sodium), are also high. Elevated levels of salts in produced water can salinize groundwater resources having potential domestic, municipal, and agricultural use. High levels of total organic carbon reflect the presence of dissolved hydrocarbons remaining in produced water after water-oil separation. Arsenic is the primary inorganic constituent of concern, with median and maximum concentrations of 26 and 380 µg/L, respectively. The majority (74%) of detected arsenic concentrations exceed the California Maximum Contaminant Level (CA MCL) of 10 µg/L (**Table 5.5**).

Table 5.5. Characterization of water quality data from sampled produced water ponds in the Tulare Basin contained in the SWRCB Geotracker website (SWRCB, 2021b). Constituents include general water quality parameters, major and minor ions, trace elements, radionuclides, isotopes, nutrients, and organics. California maximum contaminant levels (MCLs) for regulated drinking water contaminants provided for reference (SWRCB, 2023).

					Percentile				
Constituents (units)	**Detections (%)**	**Min**	**Med**	**Max**	**5th**	**25th**	**75th**	**95th**	**CA MCLs**
General Water Quality									
Alkalinity as $CaCO_3$ (mg/L)	938 (99.8)	45	1,000	6,700	160	690	1760	3,120	
Hardness as $CaCO_3$ (mg/L)	calculation	4.87	345	21,000	46	180	650	2,070	
Specific Conductance (µS/cm)	1,101 (100)	220	15,000	216,000	545	6,100	30,000	52,200	
Total Dissolved Solids (mg/L)	1,187 (100)	150	9,530	95,000	390	4,580	17,000	31,200	
Total Organic Carbon (mg/L)	290 (100)	0.9	58	750	4.7	32.2	98	297	
Total Suspended Solids (mg/L)	243 (87.7)	1.2	26	3,500	3.01	12	58	199	
pH (pH units)	1,123 (100)	5.04	7.63	11.7	6.38	7.22	8	8.45	
Major Ions									
Bicarbonate (mg/L)	1,331 (99.8)	54.9	1,460	8,430	190	854	2,480	4,700	
Carbonate (mg/L)	165 (17.1)	0.9	77	1,870	5.12	30.1	175	502	
Bromide (mg/L)	135 (94.4)	0.11	11	370	0.234	4.9	37.5	110	
Chloride (mg/L)	1,597 (99.8)	11	2,050	59,600	55	266	7,200	15,800	
Sulfate (mg/L)	1,190 (88.6)	0.46	110	6,410	5.14	34.6	450	1,560	
Calcium (mg/L)	1,345 (99.9)	0.8	64	2,700	8.62	33.2	130	437	
Magnesium (mg/L)	1,330 (99.3)	0.032	39	4,980	1.65	17.6	84	229	
Potassium (mg/L)	969 (100)	0.38	72.6	1,010	2.2	35	103	230	
Sodium (mg/L)	1,352 (100)	15	2,500	31,100	140	1,230	4,900	10,000	
Inorganics									
Boron (mg/L)	1,429 (99.8)	0.048	40	360	0.65	7.72	65	111	
Antimony (µg/L)	58 (7.8)	0.21	3	2,200	0.853	1.3	97	223	6
Arsenic (µg/L)	360 (49.7)	0.47	26	380	3.48	9.85	53.5	153	10
Barium (mg/L)	734 (96.1)	0.001	1.44	130	0.067	0.512	4	13	1
Beryllium (µg/L)	14 (1.9)	0.5	10.9	120	0.591	1.05	13	68	4
Cadmium (µg/L)	7 (1)	0.23	1	10	0.239	0.415	2	7.72	5
Chromium (µg/L)	112 (15.1)	0.014	4.85	580	0.623	2.6	12.2	60.4	50[1]
Chromium VI (µg/L)	39 (12.1)	0.07	6.7	480	0.413	2.75	19.5	103	
Cobalt (µg/L)	102 (13.7)	0.06	0.975	150	0.5	0.653	1.58	12.9	
Copper (µg/L)	234 (31.5)	0.37	4.05	1,600	1.3	2.5	13	337	1,300[2]
Iron (mg/L)	500 (74.6)	0.011	1.44	77.4	0.071	0.328	3.7	14.3	
Lead (µg/L)	53 (7.1)	0.15	15	1,700	0.564	2.4	41	384	15[2]

					Percentile				
Constituents (units)	**Detections (%)**	**Min**	**Med**	**Max**	**5th**	**25th**	**75th**	**95th**	**CA MCLs**
Lithium (mg/L)	377 (92.6)	0.015	0.93	33	0.12	0.63	2.5	6.9	
Manganese (µg/L)	397 (90.8)	2.6	120	1,900	19.2	77	230	671	
Mercury (µg/L)	213 (28.9)	0.018	0.12	65	0.032	0.06	0.34	7.02	2
Molybdenum (µg/L)	266 (35.9)	0.28	12	600	1.3	4.32	28.8	118	
Nickel (µg/L)	324 (43.7)	0.3	7.4	1,700	1.66	3.5	17.2	64.8	100
Selenium (µg/L)	337 (46.3)	0.28	32	950	4.32	19	87	290	50
Silver (µg/L)	34 (4.6)	0.3	13.5	300	0.694	7.82	20.8	124	
Strontium (mg/L)	580 (96)	0.041	3.38	120	0.15	1.5	7.91	17	
Thallium (µg/L)	4 (0.6)	0.2	279	580	34.7	173	391	542	2
Vanadium (µg/L)	81 (10.9)	1	9.9	640	1.6	6	36	200	
Zinc (µg/L)	343 (45.9)	1.8	39	3,900	5.72	15	75	199	
Silica (mg/L)	140 (96.6)	10	70.5	270	18	40.5	140	210	
Radionuclides/Isotopes									
Deuterium (per mil)	417 (100)	-98.7	-54.1	26	-68.5	-59.6	-47.1	-29.5	
Oxygen-18 (per mil)	416 (100)	-44.3	-4.89	11.4	-8.39	-6.06	-3.37	-0.83	
Gross alpha (pCi /L)	280 (95.2)	0.015	12.6	310	0.418	5.2	28.4	101	15
Gross beta (pCi /L)	142 (100)	0.033	61.6	440	1.8	31.1	110	242	4[3]
Radium-226 (pCi /L)	362 (95.8)	0.065	2.6	55.3	0.238	1.1	7.79	24.1	5[4]
Radium-228 (pCi /L)	312 (91.5)	0.001	3.92	67.6	0.109	1.1	8.13	22.7	5[4]
Uranium (µg/L)	87 (30.1)	0.102	1.3	39	0.143	0.57	2.99	18.8	20[5]
Nutrients									
Ammonia (mg/L)	233 (98.3)	0.13	49.9	194	1.33	24.7	93.9	152	
Ammonium (mg/L)	43 (100)	0.21	64.3	170	0.593	35.4	100	159	
Nitrate (mg/L)	126 (14.3)	0.03	2.58	85.8	0.077	0.29	13.4	55.2	10[6]
Total Kjeldahl Nitrogen (mg/L)	47 (100)	0.25	72	220	0.656	1.65	110	168	
Organics									
Oil & Grease (mg/L)	292 (94.2)	1.3	19	1,800	3.96	8.65	46.2	160	
Benzene (µg/L)	540 (57)	0.09	22	5,700	0.78	5.8	182	1,500	1
Toluene (µg/L)	570 (62)	0.1	38	5,990	0.375	7.65	240	1,950	150
Ethylbenzene (µg/L)	496 (52.4)	0.12	14.5	4,000	0.688	4.9	53	240	300
p- & m-Xylenes (µg/L)	483 (67.4)	0.27	20	14,000	0.606	6.55	120	710	
o-Xylene (µg/L)	483 (67.2)	0.1	15	6,700	0.412	4.3	69	389	
Total Xylenes (µg/L)	638 (68.5)	0.14	24.3	20,700	0.83	6.6	131	960	1,750
Naphthalene (µg/L)	289 (51)	0.061	6.1	340	0.26	1.4	19	145	

1. Total chromium
2. Regulatory action level
3. millirem per year (mrem/yr)
4. Radium 226 + 228
5. pCi/L
6. As nitrogen (N)

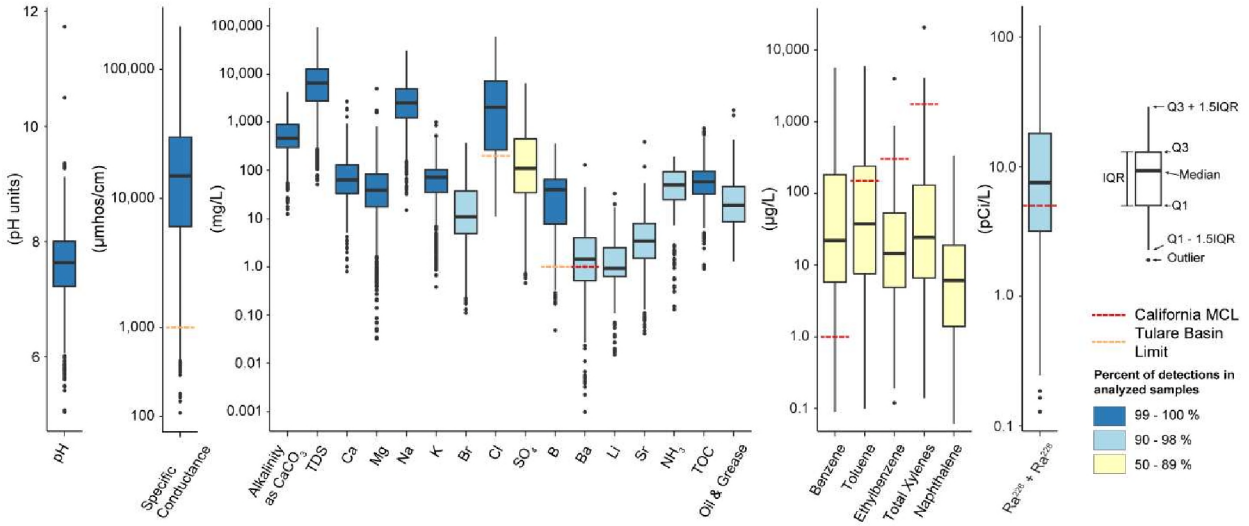


Figure 5.9. Boxplot of pH, conductivity, and other selected constituents and their relation to California regulatory limits for produced water disposal ponds, and drinking water (22 C.C.R. § 64431, 2021; 22 C.C.R. § 64442, 2021; 22 C.C.R. § 64444, 2021; CVRWQCB, 2018). Total xylenes are the maximum detected concentration of p-&m-xylenes, o-xylene, or total xylenes. Source: Figure 3 from DiGiulio et al. (2021).

Ammonium levels in produced water discharged to unlined produced water ponds are also quite high, with median and maximum levels of 64.3 and 170 mg/L, respectively. Both ammonia (which includes free ammonia and ammonium) and ammonium were often reported. Because the pH of water in most produced water ponds was near neutral, most ammonia was present as ammonium. A primary concern with high ammonium levels in produced water discharged in unlined ponds is nitrification. Unlike produced water coming directly from an oil and gas well, produced water in unlined ponds is oxic and can facilitate nitrification in subsurface media. The CA MCL for nitrate is 45 mg/L as nitrate or 10 mg/L as nitrogen. The CA MCL for nitrite is 1 mg/L. Because the toxicity of nitrate and nitrite are additive, the CA MCL for the sum of nitrate and nitrite as nitrogen is 10 mg/L, and only one of the detected sums of these constituents exceeds that level.

In comparison with produced water from shale formations (e.g., Marcellus, Utica), gross alpha, gross beta, radium-226, and radium-228 activities are relatively low in California's produced water ponds. However, despite being relatively low, the detected activities of these radionuclides are still concerning from a regulatory standpoint. Specifically, 58% of detected radium-226 + radium-228 activities meet or exceed the associated CA MCL (5 pCi/L) and 44% of detected gross alpha meets or exceeds the CA MCL (15 pCi/L). Radium mobilization from sediments near unlined produced water ponds has been observed in groundwaters associated with the Fruitvale, Lost Hills, and South Belridge oil fields (McMahon et al., 2019).

The median concentration of benzene in produced water discharged to produced water ponds (24 µg/L) is an order of magnitude higher than the CA MCL of 1 µg/L, while the median concentration of detected toluene, ethylbenzene, and total xylene concentrations are less than the associated CA MCLs (150, 300, and 1,750 µg/L, respectively) (**Figure 5.9**). However, the maximum detected levels of these constituents are well above the associated CA MCLs.

5.5.3.1 Emissions of Organic Compounds Produced Water Ponds

Relatively few studies have measured emissions of organic compounds from produced water disposal ponds, and thus there is a large knowledge gap surrounding this aspect of produced water disposal. Of the few studies that have measured emissions of these compounds (e.g., Lyman et al., 2018; Mansfield et al., 2018; Schmidt & Card, 2020; Thoma, 2009; Tran et al., 2018), only one has sampled produced water ponds in the California (Schmidt & Card, 2020). None of these studies measured transport distances of these compounds, and thus distances of impact are unknown.

Schmidt & Card (2020) analyzed a total of 95 samples from 25 disposal facilities. Of the sampled facilities only 19 utilized produced water disposal ponds, and thus a total of 89 samples were collected from produced water ponds. The aqueous sampling (**Table 5.6**) and vapor concentrations in flux chambers (**Table 5.7**) above produced water ponds provide additional information on concentrations of VOCs, especially BTEX components, and are another source of data for these constituents. In general, the lower bounds of the aqueous samples collected by Schmidt and Card (2020) (**Table 5.6**) agree with those in the Geotracker database (**Table 5.5**). However, the maximum detected values of BTEX compounds in the Geotracker data (**Table 5.5**) are generally 1–1.5 times those measured by Schmidt and Card (2020) **(Table 5.6**). Complete data for the aqueous and vapor samples collected by Schmidt and Card (2020) are provided in Appendix E.3.

Table 5.6. Summary of selected constituents of produced water pond aqueous samples. Source: Schmidt and Card (2020).

Constituents (units)	No. of Detections				Percentile			
		Min	Med	Max	5th	25th	75th	95th
Oil & Grease (mg/L)	94	1.4	13.5	660,000	2.95	7.13	28	537
Benzene (µg/L)	86	0.1	6	1,650	0.18	0.5	70.3	838
Ethylbenzene (µg/L)	84	0.11	6.45	1,600	0.22	0.95	34.3	688
Toluene (µg/L)	86	0.1	3.35	1,900	0.14	0.6	25.3	550
Total Xylenes (µg/L)	86	0.39	9.9	2,200	0.51	2.2	60.3	979
p- & m-Xylenes (µg/L)	85	0.29	5.7	1,400	0.4	1.3	40	629
o-Xylene (µg/L)	90	0.09	3.6	790	0.12	0.9	20.8	349

Table 5.7. Summary of selected constituents of produced water pond gases and vapors. Source: Schmidt and Card (2020).

Constituents (units)	No. of Detections				Percentile			
		Min	Med	Max	5th	25th	75th	95th
Total Non-Methane Hydrocarbons (C6 µg/m^3)	90	65.6	5,770	47,300,000	178	1,530	37,800	288,000
Total Non-Methane Hydrocarbons (C1 µg/m^3)	90	73	6,420	52,700,000	198	1,700	42,100	321,000
Benzene (µg/m^3)	88	1.47	56.7	125,000	2.94	10.1	342	11,800
Ethylbenzene (µg/m^3)	57	1.5	39.2	303,000	4.27	11.1	318	2,510
Toluene (µg/m^3)	75	0.92	55.7	574,000	2.93	9.94	571	19,800
m,p-Xylenes (µg/m^3)	62	1.1	84.2	579,000	2.98	16.4	602	9,120
o-Xylene (µg/m^3)	55	1.21	86.4	286,000	3.84	15.3	398	4,960
Total Xylene (µg/m^3)	71	0	86.3	865,000	0	10.3	739	13,200
Total BTEX (µg/m^3)	95	0	104	1,870,000	1.85	17.1	1,150	42,500
Carbon Dioxide (%)	40	0.01	0.05	0.41	0.02	0.02	0.13	0.32
Methane (ppmv)	88	0.47	11	1,350	1.18	2.67	117	487

Abbreviations: ppmv – parts per million by volume; µg/m^3 – micrograms per cubic meter

5.5.4. Number, Status, and Locations of Produced Water Ponds in the Tulare Basin

No individual publicly available State database accurately accounts for all produced water ponds in the Tulare Basin. DiGiulio et al. (2021) found major discrepancies between data sources in locating produced water ponds in the Tulare Basin. The authors catalogued a total of 1,784 produced water ponds in the Tulare Basin, of which 29 were used for mixing produced water with surface water and groundwater for agricultural irrigation. There were 1,317 ponds listed on the SWRCB Produced Water Ponds List, of which 511 were unique to this list; 311 ponds were listed in WellSTAR, of which 60 were unique to WellSTAR; and 1,213 ponds located on Geotracker, of which 407 were unique to Geotracker.

The discrepancy between identification of ponds on the SWRCB produced water pond list and Geotracker is due in part to a lack of identification of many closed produced water ponds on the SWRCB list. Other reasons for discrepancies between WellSTAR, Geotracker, and the SWRCB produced water pond list are unclear (DiGiulio et al., 2021). Precise information on location (latitude and longitude) was available for most (92.9%) ponds that were located. In Geotracker, there were 110 ponds that had only Public Land Survey System (PLSS) descriptions and 21 ponds that only had an oil and gas field identifier.

DiGiulio et al. (2021) also found that an unknown number of closed facilities remain unidentified. For example, while viewing produced water ponds on the Google Earth application of Geotracker, they noted the presence of three large inactive unlined produced water facilities west of the Belridge North field and one large inactive unlined produced water facility in the Midway-Sunset Field, cumulatively consisting of at least 95 unlined ponds not identified in any

database. As such, we have included 95 unlined ponds as unidentified, although locations should be field verified as used for produced water disposal.

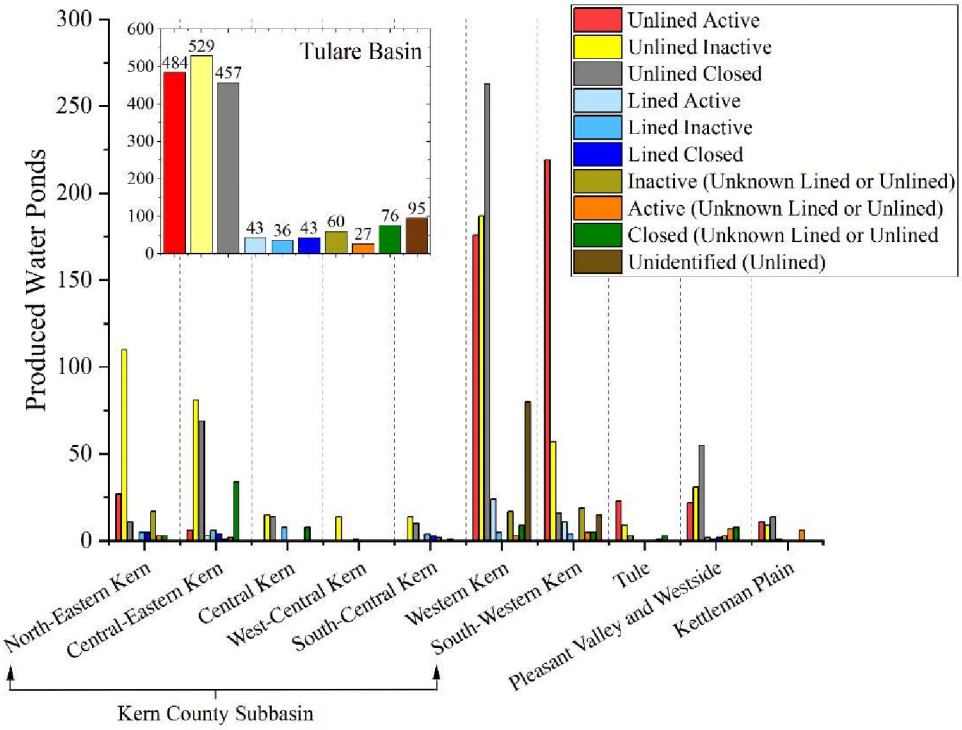


Figure 5.10. Summary and status of produced water ponds in the Tulare Basin. Source: Figure 2 modified from DiGiulio et al. (2021).

In summary, there appears to be at least 1,850 active, inactive, and closed ponds that were used exclusively to store or dispose produced water in the Tulare Basin (**Figure 5.10**). The status of ponds in WellSTAR were listed as active, idle, and removed. The latter two categories were assumed to refer to inactive and closed ponds. At least 85% (1,565) of ponds in the Tulare Basin are unlined, of which 31% (484) are still active. This is an underestimate of the number of unlined ponds, as the 60 unique WellSTAR entries contain no description of whether ponds are lined or unlined.

5.5.5. Exceedance of Effluent Limits in the Tulare Basin and Assessment of Potential Impact to Groundwater

The California Department of Water Resources (CDWR) created groundwater subbasins in California by dividing groundwater basins into smaller units using geologic and hydrologic barriers or, more commonly, institutional boundaries for the purpose of collecting and analyzing data and managing water resources (CDWR, 2021). Subbasins in the Tulare Basin are used here to describe locations where unlined produced water ponds overlie groundwater with municipal or agricultural beneficial use, and where impact to groundwater has been documented. A list of oil and gas fields associated with each subbasin is provided in Appendix E.4.

The disposal of produced water having high levels of electrical conductivity, chloride, and boron

into unlined produced water ponds exceeding the Tulare Basin effluent limits has occurred and continues to occur in many areas of the Tulare Basin overlying groundwater resources. Groundwater monitoring at unlined produced water pond facilities is relatively sparse, but where monitoring has occurred, impact to groundwater has been observed and has proven too expensive to actively remediate. Hence, the practice of disposing produced water into unlined ponds can cause permanent damage to groundwater resources. Also, impact to groundwater has occurred at distances greater than 4 km (2.5 mi) from unlined ponds. Given demonstrated cases of impact to groundwater, unlined produced water ponds should not be located hydraulically upgradient of domestic, municipal, and agricultural water supply wells.

5.5.5.1 Counts of Unlined Ponds and Exceedances of Tulare Basin Effluent Limits in Basin Sub Areas

DiGiulio et al. (2021) found most unlined produced water ponds in California were located in the Kern County Subbasin (**Figure 5.11**). As such, this area, and counts of unlined ponds in particular, are the focus of discussion here. Complete counts of all types of produced water disposal ponds within each geographic area of the SJV are provided in Table E.4.

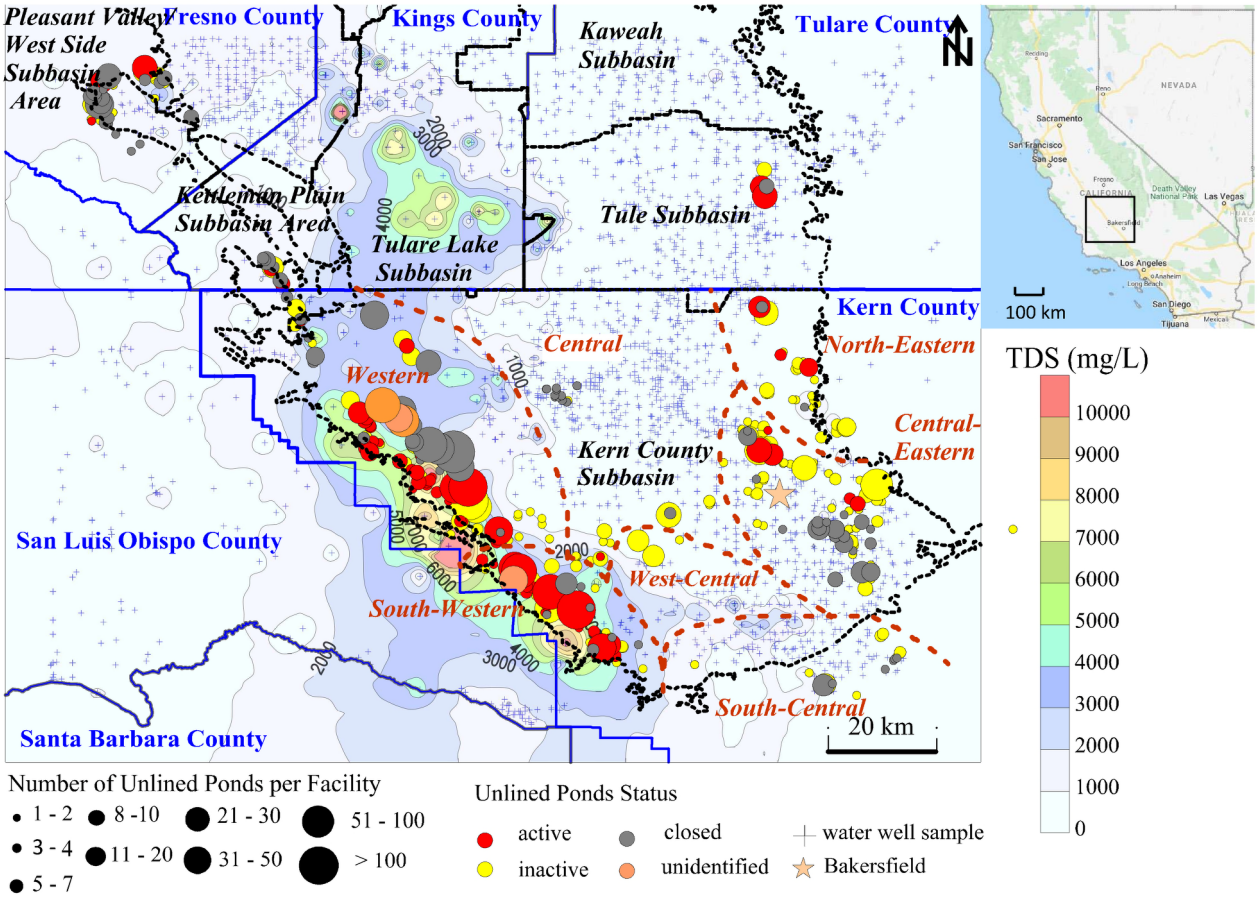


Figure 5.11. Interpolated levels (contour lines) of total dissolved solids (TDS) in groundwater from water well samples and the location of active, inactive, and closed unlined produced water pond facilities in subbasins within the Tulare Basin in the southern portion of the San Joaquin Valley. Source: Figure 1 from DiGiulio et al. (2021).

In the northeastern area of the Kern County Subbasin (148 unlined ponds, of which 27 are active) (Table E.4), levels of TDS in groundwater are generally <1,000 mg/L (**Figure 5.11**). While median levels of electrical conductivity, chloride, and boron of produced water discharged to ponds at facilities in this area were generally within the Tulare Basin effluent limitations, maximum levels of electrical conductivity, chloride, and boron indicate periodic exceedance of these standards (DiGiulio et al., 2021). Additionally BTEX compounds other than benzene were detected in produced water discharged to ponds (DiGiulio et al., 2021).

In the central-eastern area of the Kern Subbasin (156 unlined ponds, of which six are active) (Table E.4), TDS levels in water wells are generally <1,000 mg/L (**Figure 5.11**). Median levels of electrical conductivity, chloride, and boron of produced water discharged to ponds in this area were generally above the Tulare Basin effluent limitations, with maximum levels of electrical conductivity, chloride, and boron indicating significant exceedances of these standards (DiGiulio et al., 2021). Benzene was detected in produced water discharged to ponds at a maximum concentration of 2,410 µg/L (DiGiulio et al., 2021).

Relatively few produced water ponds are in the south-central (24 unlined ponds), central (29 unlined ponds), and west-central (14 unlined ponds) portions of the Kern Subbasin, and no unlined ponds are active in this area (Table E.4). In all of these areas, groundwater having TDS levels <3,000 mg/L is present (**Figure 5.11**). DiGiulio et al. (2021) did not find any pond effluent data in this area. Given the lack of active unlined disposal ponds in these areas, the primary concern is potential groundwater contamination from legacy ponds.

The western portion of the Kern Subbasin has the largest number of produced water ponds (626 unlined ponds, of which 176 are active) in the Tulare Basin (**Figure 5.11**, Table E.4). Most produced water ponds in this area lie directly east of oil and gas fields where there is a transition from brackish groundwater (TDS 3,000–10,000 mg/L) to fresher (TDS <3,000 mg/L) groundwater from west to east (**Figure 5.11**), toward the synclinal axis of the San Joaquin Valley (DiGiulio et al., 2021). Produced water disposed in unlined ponds in this area far exceeds the Tulare Basin effluent limits. BTEX compounds were consistently detected in produced water disposed in ponds in this area with a maximum concentration of benzene at 5,700 µg/L (DiGiulio et al., 2021).

Most active unlined ponds (292 ponds, of which 219 are active) are within the southwestern portion of the Kern Subbasin (**Figure 5.11**, Table E.4). Like the western portion of the Kern Subbasin, produced water disposed in unlined ponds in this area far exceeds the Tulare Basin effluent limits, and BTEX compounds were consistently detected in produced water disposed in ponds in this area, with a maximum concentration of benzene at 3,600 µg/L (DiGiulio et al., 2021).

5.5.5.2 Documented Impacts to Groundwater in the Tulare Basin

DiGiulio et al. (2021) primarily documented impacts to groundwater in the western portion of the Kern Subbasin (**Figure 5.12**), where the authors mainly found groundwater monitoring was occurring. However, impacts to groundwater near the Race Track Hill facility in the Edison Field (the only field in the eastern SJV where DiGiulio et al. (2021) found groundwater monitoring was occurring) near Bakersfield were also observed (**Figure 5.12**). Thus, impacts to groundwater via unlined disposal ponds appear to be possible anywhere that this practice has happened, or is

currently happening, and any geographic heterogeneity is likely more a function of the location of monitoring infrastructure rather than other drivers (e.g., hydrogeologic setting, geochemical).

DiGiulio et al. (2021) found levels of electrical conductivity, TDS, chloride, and boron in impacted wells to range anywhere from two times to as much as ~46 times those in unimpacted wells (**Figure 5.13**). The only disagreement to this trend were boron levels in monitoring wells downgradient of the S.E. Taft Old and New facilities, which were two times higher in the unimpacted wells. However, after discounting outliers (i.e., values falling outside of the third quartile plus or -1.5 times the interquartile range), levels of these constituents in impacted wells range from two times to 19 times higher, and on average are ~6.5 times higher than those in the unimpacted wells. Using the elevated levels of electrical conductivity, TDS, chloride, and boron, DiGiulio et al. (2021) documented the distances at which produced water disposal facilities impacted groundwater. The distances of impacts range from anywhere to as little as less than 0.5 km (0.3 mi) to as much as greater than 4 km (2.5 mi) (**Table 5.8**). With the exception of the Race Track Hill facility (**Table 5.8**), groundwater was impacted at distances more than 1 km (3,281 ft) from produced water disposal pond facilities.

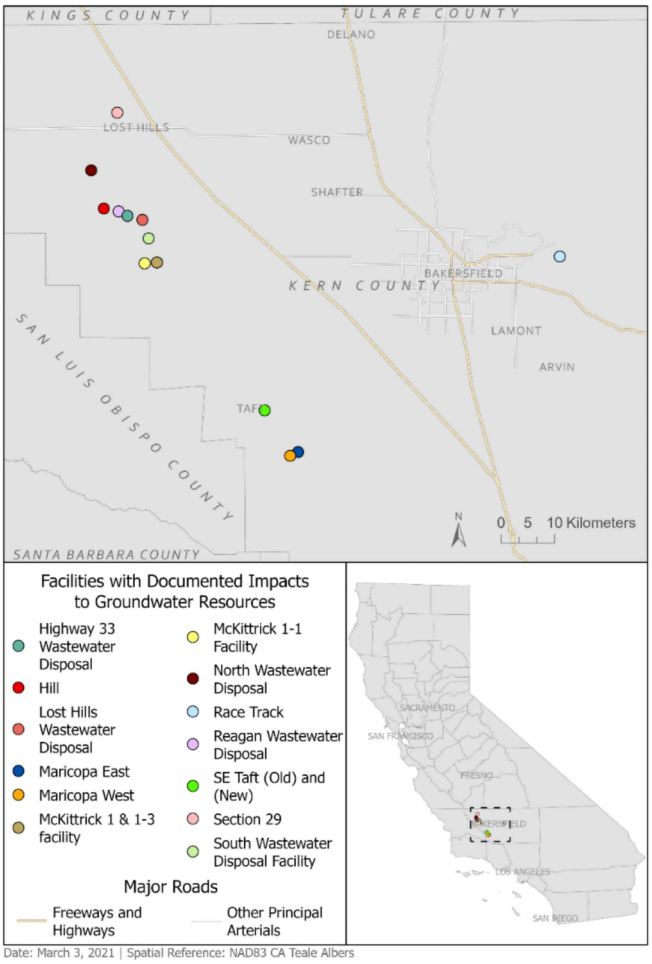


Figure 5.12. Locations of produced water pond facilities where groundwater monitoring indicates impact. Source: Figure 4 modified from DiGiulio et al. (2021).

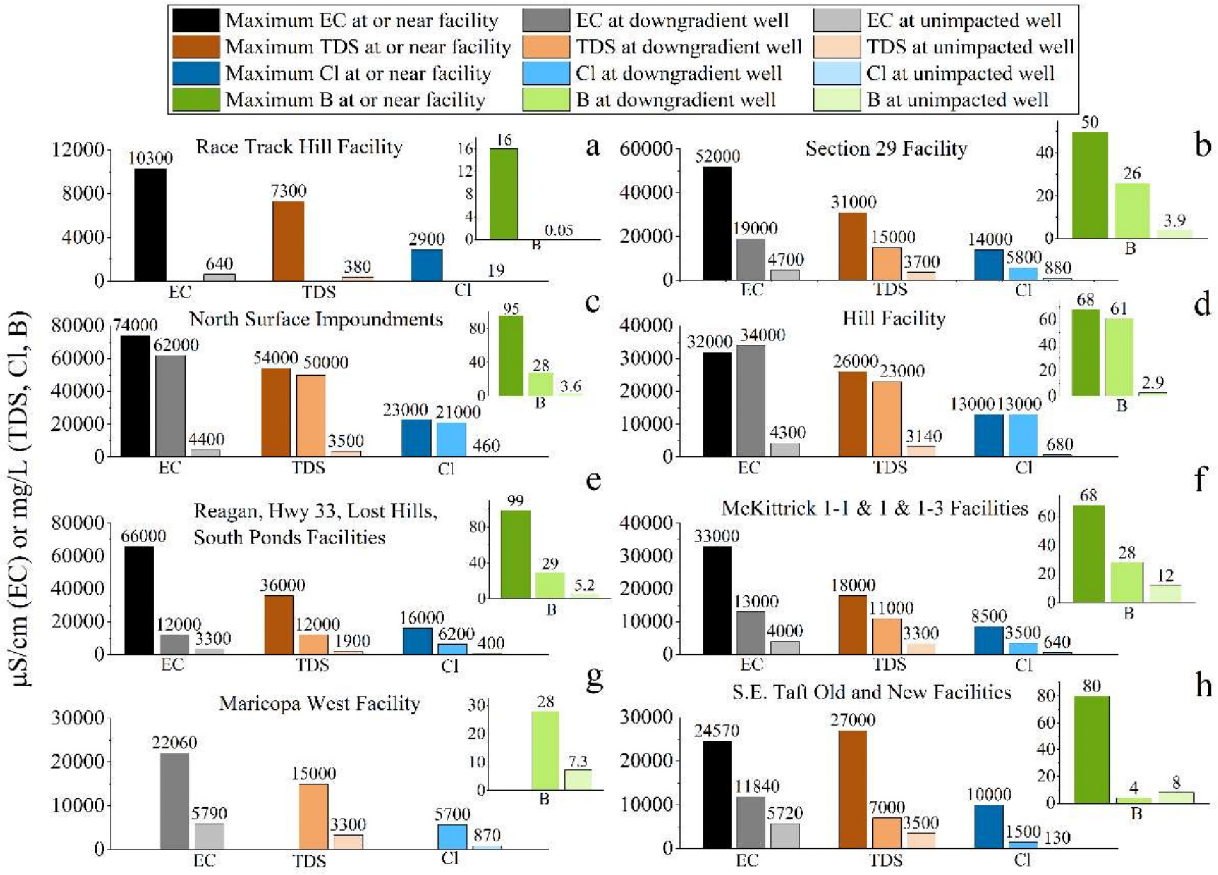


Figure 5.13. Concentrations of electrical conductivity (EC), total dissolved solids (TDS), chloride (Cl), and boron (B) (inset) in groundwater monitoring wells at facilities with an impact to groundwater. Downgradient and unimpacted monitoring wells are located more distant from a facility in the direction of groundwater flow. Source: Figure 5 from DiGiulio et al. (2021).

Table 5.8. Maximum concentrations of benzene, toluene, ethylbenzene, total xylenes, and the distance downgradient of facilities at which groundwater monitoring wells indicate an impact to groundwater.

Facility Name	Associated Field	Max Benzene (µg/L)	Max Toluene (µg/L)	Max Ethylbenzene (µg/L)	Max Xylenes (µg/L)	Distance of impact
Race Track Hill	Edison	<0.50	67	<0.50	<0.50	<0.5 km (0.3 mi)
Section 29	Lost Hills	47	5.7	0.26	3.1	>1.7 km (1.1 mi)
North Surface Impoundments	Belridge North	360	<2.0	<2.0	15	>1.5 km (0.9 mi)
Hill	Belridge South	84	140	28	140	>1.4 km (0.9 mi)
Reagan, Hwy 33, Lost Hills, South Ponds	Belridge South	3.7	43	13	NA	>4 km (2.5 mi)
McKittrick 1-1 and McKittrick 1 & 1-3	Cymric	1.6	7.0	<0.25	<0.25	>2 km (1.2 mi)
Maricopa West	Midway Sunset	<2.0	<2.0	<2.0	<2.0	>1.2 km (0.75 mi)
S.E. Taft Old and New	Midway Sunset	<2.0	<2.0	<2.0	<2.0	>1.2 km (0.75 mi)

In addition to elevated levels of electrical conductivity (EC), TDS, chloride, and boron, DiGiulio et al. (2021) also observed BTEX compounds and other hydrocarbons in monitoring wells near disposal facilities (**Table 5.8**). For example, BTEX compounds and other hydrocarbons (e.g., naphthalene, methyl naphthalenes, trimethylbenzenes) were detected in monitoring well samples near the closed Section 29 Facility (**Figure 5.12, Table 5.8**). At the nearby Lost Hills facility (**Figure 5.12**) Karolytė et al. (2021) demonstrated the presence of surface disposed produced water in groundwater using noble gas isotope ratios, although benzene concentrations (0.87 µg/L) were less than both the CA MCL and the U.S. EPA MCL (1 and 5 µg/L, respectively). Both Karolytė et al. (2021) and DiGiulio et al. (2021) detected benzene (15.1 µg/L) in a monitoring well east of the McKittrick 1-1 and McKittrick 1 & 1-3 Facilities (**Figure 5.12**). Karolytė et al. (2021) utilized noble gas isotope mixing ratios to demonstrate the nearby McKittrick disposal ponds were the likely surface source of produced water. The highest benzene concentrations (360 µg/L) observed in monitoring wells by DiGiulio et al. (2021) (**Table 5.8**) were located near the North Surface Impoundments Facility (**Figure 5.12**). While most organic compounds were below detection near the Race Track Hill facility, DiGiulio et al. (2021) observed a maximum detectable concentration of toluene at 67 µg/L, which they attributed to the disposal of produced water into unlined ponds and spray irrigation (**Table 5.8**).

5.5.5.3 Potential Impacts to Groundwater in the Tulare Basin

In January 2015, an independent scientific study on well stimulation in California commissioned by the California Natural Resources Agency concluded that the disposal of produced water in unlined produced water ponds posed a risk to groundwater resources. The report recommended that produced water discharged to these ponds should contain non-hazardous concentrations of chemicals or their use should be phased out in the future (Jordan et al., 2015; Stringfellow et al., 2015). The report stated further that groundwater investigations should be conducted to determine if historical disposal activities have impacted groundwater resources in the vicinity of these produced water ponds (Jordan et al., 2015).

The recent comprehensive assessment of unlined produced water ponds in the SJV by DiGiulio et al. (2021) bolsters this recommendation. Their investigation also supports a recommendation that the definition of protected groundwater during disposal of produced water into produced water ponds should be consistent with the definition of protected groundwater used in California's UIC program and for hydraulic fracturing. This inconsistency appears to be a major driver for this disposal practice, especially in the western and southwestern portion of the Kern Subbasin or Tulare Basin.

Further research would help determine whether individual groundwater plumes from large, closely spaced, historical, and active facilities in the western portion of the Kern Subbasin are in the process of forming "mega" plumes moving eastward toward the synclinal axis of the SJV and toward numerous irrigation and public water supply wells.

5.5.6. Populations Living Near Produced Water Infrastructure

As previously discussed, produced water potentially poses numerous health hazards (e.g., exposure to carcinogens) to human beings, and these hazards may occur via multiple exposure pathways (groundwater, air, etc.). A proximity analysis was conducted to quantify the number of people potentially at risk from produced water ponds (detailed in Chapter 7). To better constrain populations that may be impacted by legacy water disposal activities, the total number of individuals near a pond of any status (active, idle, or closed) and water disposal wells were also calculated (**Figure 5.14**; Table E.5, Appendix E.5). In general, roughly 545,000 Californians live within 1 km (3,281 ft) of an active, inactive, or historical produced water pond. About 168,000 Californians live within 1 km (3,281 ft) of an active pond, slightly less than the ~261,000 Californians that live within 1 km (3,281 ft) of a water disposal well (**Figure 5.5**). While these counts provide an approximation of populations that could be impacted by surficial processes (i.e., suspension of legacy contaminated sediments or air emissions from active infrastructure), this estimate does not fully capture populations that may be impacted by subsurface processes.

Fully constraining the risk of exposure to populations via subsurface pathways relies on two factors: (1) having knowledge of the spatial distribution of drinking water wells; and (2) understanding the subsurface geochemistry and hydrogeology. Locations of wells in California are relatively poorly constrained using publicly available data. Due to privacy concerns, coordinates of drinking water wells are logged as the centroid of the PLSS sections, and as such the spatial accuracy of these coordinates range from ± 142 m (467 ft) to ± ~1,140 m (3,729 ft) (Johnson & Belitz, 2015). As this range spans nearly all of the considered buffer distances, counts using these distances would be highly speculative and likely miss a substantial amount of residents relying on groundwater. Furthermore, while there is a large volume of literature supporting the inclusion of the buffer distances used to consider air emissions (see Chapter 7), their selection is likely more arbitrary for considering subsurface impacts.

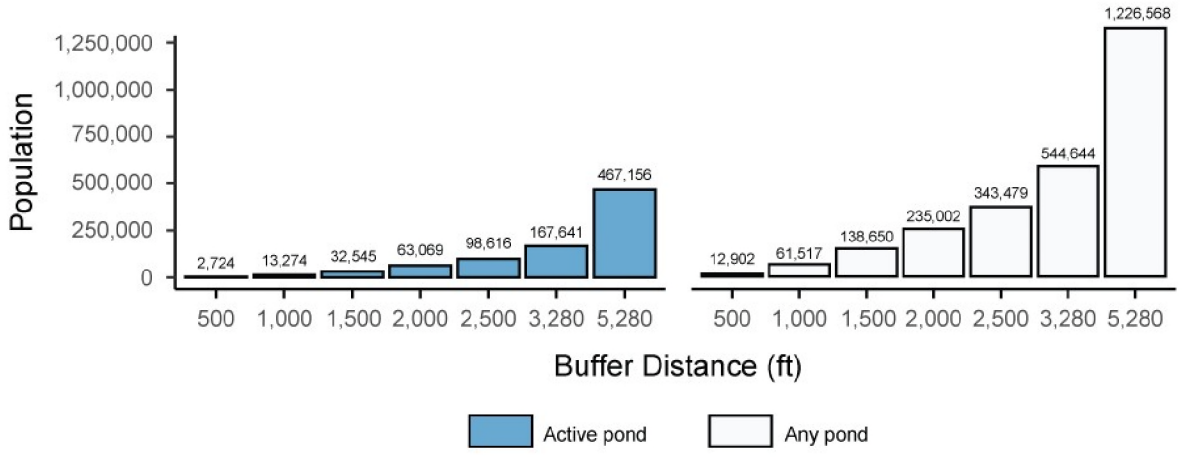


Figure 5.14. Total populations living within buffer distances of both active, and any status produced water disposal ponds.

As previously discussed, subsurface transport of contaminants has been observed anywhere from 0.5 km (1,640 ft) to greater than 4 km (2.5 mi) from pond facilities, thus the buffer distances

that are appropriate for airborne contaminants would likely not completely identify groundwater receptors. Additionally, subsurface contaminant transport is mediated by both geochemical and hydrological conditions, both of which can be highly heterogeneous over relatively small spatial areas. Furthermore, current land use practices, which are also quite diverse, can enhance or retard subsurface contaminant transport. Consequently, transport distances are likely equally disparate. Thus, drinking water wells were not considered in this analysis, and future research efforts could be devoted to this topic to fully constrain the risk produced water ponds pose to communities relying on groundwater resources.

5.5.7. Available Information on Setbacks from Produced Water Management Facilities at Other States.

In Colorado, after January 15, 2021, operators must design, construct, and operate pits that are within 2,000 ft (610 m) of an existing building unit or designated outside activity area to emit less than 2 tons per year (tpy) VOCs (COGCC Rule 903.d(6)A.i, 2021). In highly populated counties (Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, Jefferson, Larimer, and Weld), pits must emit less than 2 tpy VOCs regardless of distance to existing buildings (COGCC Rule 903.d(6)A.ii, 2021). Otherwise, pits must emit less than 5 tpy VOCs. Operators cannot construct new Centralized Waste Management Facilities (large pit facilities) within 2,000 ft (610 m) of the nearest Building Unit or High Occupancy Building Unit, unless all Building Unit owners and tenants within 2,000 ft (610 m) consent to a closer location (COGCC Rule 907.b(5)G, 2021).

In Utah, a disposal facility must be located a minimum of 1 mi (1.6 km) from residences or occupied buildings not associated with the facility unless a waiver has been signed by the owners of the residences and buildings within one mile (Utah Admin. Code R649-9-3.3.2, 2013) or within 500 ft (152 m) of a wetland, water-course or lakebed (Utah Admin. Code R649-9-3.4.1, 2013).

5.6. Exposure Pathways from the Discharge of Produced Water to Surface Water

Humans may contact radionuclides, metals, organic compounds, or degradation products of organic compounds associated with the discharge of produced water through multiple exposure pathways. These include: dermal contact during swimming; ingestion via drinking water intake; incidental ingestion during swimming; inhalation and dermal contact during bathing and showering; consumption of fish, crops, or livestock that have bioaccumulated produced water contaminants; inhalation of volatile compounds from surface water; and inhalation of dust from ephemeral stream beds (**Figure 5.15**).

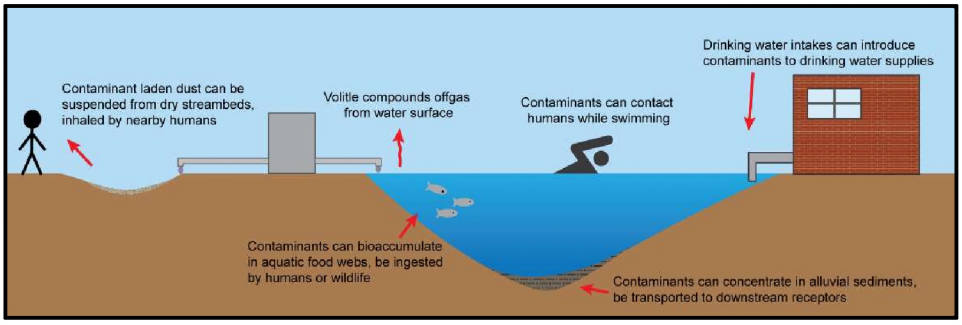


Figure 5.15. Conceptual pathways of surface discharges of produced water.

Produced water can be directly discharged to surface water or indirectly discharged to surface water through publicly owned treatment works (POTW). Any discharge of pollutants to surface waters must obtain authorization to discharge (i.e., a National Pollutant Discharge Elimination System permit) (US EPA, 2020). Under 40 Code of Federal Regulations (C.F.R.) 435 Subpart C, the direct onshore discharge of produced water to surface water must meet an Effluent Limitation Guideline (ELG) of "zero discharge" of pollutants (US EPA, 2020), essentially resulting in a prohibition of direct discharges of produced water to surface water. However, 40 C.F.R. § 435 Subpart C allows indirect discharges of produced water to surface water through POTWs, and does not specify pretreatment standards (US EPA, 2020). In 2016, the US EPA prohibited the indirect discharge of produced water from unconventional wells to POTWs (81 Fed. Reg., 2016). Disposal of produced water into sanitary sewer systems had occurred in fields where production wells have been stimulated (e.g., Wilmington Oil Field in Los Angeles County and a small amount from the Lost Hills Oil Field and Midway-Sunset Oil Field in Kern County) (Stringfellow et al., 2015).

Produced water can be directly or indirectly discharged to surface water under 40 C.F.R. § 435 in Subparts E, F, and H (US EPA, 2020). Under 40 C.F.R. § 435 Subpart E, produced water can be discharged directly to surface water if production wells are located west of the 98th meridian and produced water "is of good enough quality to be used for wildlife or livestock watering or other agricultural uses and that the produced water is actually put to such use during periods of discharge" (US EPA, 2020). The ELG for discharge under 40 C.F.R. § 435 Subpart E is limited to an oil and grease concentration ≤35 mg/L (US EPA, 2020). Under 40 C.F.R. § 435 Subpart F, produced water can be discharged directly to surface water if production wells produce ≤10 barrels of crude oil per day (i.e., stripper wells) (US EPA, 2020).

The direct discharge of produced water to surface water in California reached a peak in 1988 with discharge of 497.2 MMbbls (18.9% of produced water disposition) and a low in 2002 with a discharge of 2.2 MMbbls (0.1% of produced water disposition). In 2017, 58.9 MMbbls of produced water was discharged directly to surface water (1.8% of produced water disposition) (**Figure 5.3**). Cumulative direct disposal to surface water from 1977 to 2017 was 6,424 MMbbls, second only to disposal in unlined produced ponds for surface disposal methods (**Figure 5.3**). Hence, disposal to surface water continues to be an important disposal method for surface disposal methods (non-injection). However, it is unclear what proportions of discharge are occurring under 40 C.F.R. § 435 Subpart E and F. Discharge to a POTW (sewage) with subsequent discharge to surface water

reached a peak in 1984 at 67.2 MMbbls (2.5% produced water disposition) and a low in 2017 at 13.8 MMbbls (0.43% of produced water).

For discharge of produced water from conventional oil and gas wells, operators in California are required by the sanitation districts to obtain pretreatment permits. However, pretreatment of produced water is typically minimal, consisting primarily of oil and water separators, followed by clarification and sometimes air stripping or flotation, and does not remove most chemicals associated with well stimulation operations or associated with oil and gas production. Additionally, sewage treatment plants are not typically equipped to handle produced water, potentially disrupting the treatment process and discharging salt and other contaminants into the environment (Stringfellow et al., 2015).

A search was conducted on U.S. EPA's National Pollutant Discharge Elimination System (NPDES) General Permit Web Inventory under the term "oil and gas extraction" between January 1, 1976, to February 1, 2021. This search revealed only one offshore permit issued in 2013. A search was then conducted for NPDES permits for oil and gas wastewater discharge in the California Integrated Water Quality System (CIWQS) (SWRCB, 2021c). Two permits were located for offshore discharge, one permit for stormwater discharge, and one permit for discharge of treatment groundwater from a condensate spill.

While CalGEM disposal records and reporting pursuant to SB 1281 indicate that direct discharge of produced water to surface water is ongoing, NPDES permits in CIWQS indicate little or no discharge of produced water traceable to NPDES permits. It does not appear that past and present locations of discharge of onshore produced water to surface water can be determined through CIWQS. Given these limitations it is not possible to evaluate potential impact to public health from disposal of produced water to surface water in California.

5.7. Exposure Pathway Analysis from Spills of Produced Water

Surface spills and leaks can occur at any time in the production process. Releases can result from tank ruptures, piping failures, blowouts, other equipment failures and defects, overfills, fires, vandalism, accidents, or improper operations (NYSDEC, 2011). Additionally, natural disasters (e.g., floods or earthquakes) may damage storage and disposal sites or cause them to overflow. Once released, these materials can run off into surface water bodies and/or seep into groundwater that serve as drinking water sources.

5.7.1. Environmental Impacts

Spills pose a wide variety of environmental concerns (**Figure 5.16**). For example, spills on the land surface can greatly enrich topsoil sodium and chloride content, and increase mortality rates in vegetative communities (Adams, 2011). Furthermore, chemical constituents of produced water including trace metals (Chen et al., 2017; Oetjen et al., 2018), salts, BTEX compounds (Gross et al., 2013; Shores et al., 2017), and other organic compounds (Cozzarelli et al., 2017; Drollette et al., 2015), can percolate into groundwater, providing a subsequent exposure route to co-located

drinking water wells. In agricultural areas, the percolation of sodium is especially troublesome, as sodium can deplete soil nutrients (calcium, magnesium, potassium) via exchange reactions (Bäckström et al., 2004; Cates et al., 1996; Norrström & Bergstedt, 2001; Rossi, Bain, Elliott, et al., 2017; Shanley, 1994), negatively affect soil structure (Amrhein et al., 1994), reduce soil hydraulic conductivity, and salinize groundwater sources (Schoups et al., 2005; Suarez, 1989), rendering them unsuitable for irrigation (Maas, 1986).

Spills can also introduce contaminants to surface water, with a subsequent exposure route to humans through a drinking water intake or bioaccumulation in fish. For example, spills have been found to cause endocrine-disrupting activity in aquatic communities (Cozzarelli et al., 2017; Kassotis et al., 2014, 2016, 2020). Spills of produced water into surface water could also result in an accumulation of NORM (Lauer et al., 2016; Lauer & Vengosh, 2016) or trace metals (Lauer et al., 2016) in alluvial sediments, which can be mobilized by flood events or anthropogenic activities (Pizzuto, 2014; Rossi, Bain, Hillman, et al., 2017; Steding et al., 2000; Tao et al., 2005).

5.7.2. A Summary of Spill Incidents in California

Any significant or threatened release of produced water and hazardous substances must be reported to the California Office of Emergency Services (CalOES) (19 C.C.R. § 2631, 2016). The reporting threshold varies by chemical but there is no reporting threshold for produced water. Similarly, there are locational differences in reporting thresholds, with spills of oil greater than 1 barrel being the mandated threshold outside of the SJV, and 5 or 10 barrel thresholds (depending on the oil field) mandated within the SJV (San Joaquin Valley Field Rule, 1996). The CalOES maintains a database, known as the HazMat Spill Release Reporting Database, with information on the location, size, and composition of the spill; whether the spill impacted a waterway; and the cause of the spill (CalOES, 2021).

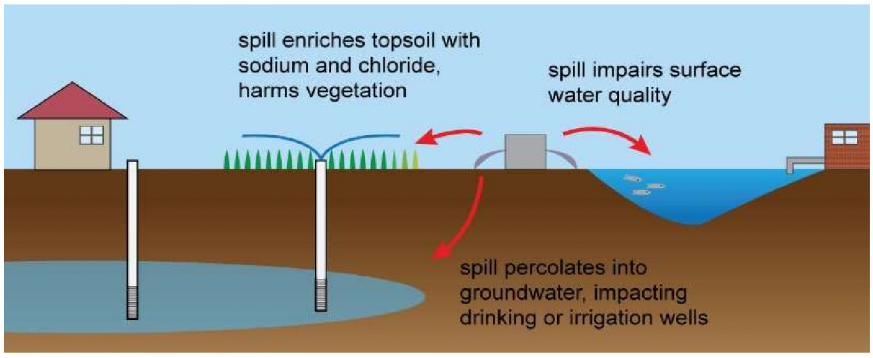


Figure 5.16. Conceptual pathways of spills.

5.7.2.1 Reported Spills in California from 2006–2020

Rossi et al. (2022) recently quantified the volume and frequency of onshore spills of crude oil and produced water in the California between 2006 and January 1, 2021. The authors retrieved every spill incident in the HazMat database containing the key words "produced water" or "crude oil," and observed a total of 2,299 incidents involving a spill of crude oil, 1,029 incidents involving a spill of produced water, and 288 incidents which involved a mixture of these two substances

whose proportion was undifferentiated. During the period of 2006–2020, they noted the number of reported spill incidents involving crude oil or produced water appeared to be decreasing, with the frequency of incidents involving produced water declining relatively slower (**Figure 5.17**).

Rossi et al. (2022) observed the majority of produced water spills (65%) occurred in Kern County (**Table 5.9**), and the breakdown of crude oil spills on a per county basis follow similar trends as those observed in the produced water spills (**Table 5.9**). Only the top six counties (which represent 95% or more of spill incidents), ranked by incident counts are presented in **Table 5.9**; a complete listing of incidents by county is provided in the Appendix (Table E.6).

5.7.2.2 Comparisons to Other States

Rossi et al. (2022) also compared spill events in California to other peer-reviewed studies that examined spill incidents in other states. In general, they found trends in California crude oil and produced water spill volumes during the period of 2006–2014 were similar to those observed in North Dakota by Maloney et al. (2017), with spill events in both states marked by both chronic and catastrophic spill incidents (although the magnitude of events were more extreme in California) (**Table 5.10**).

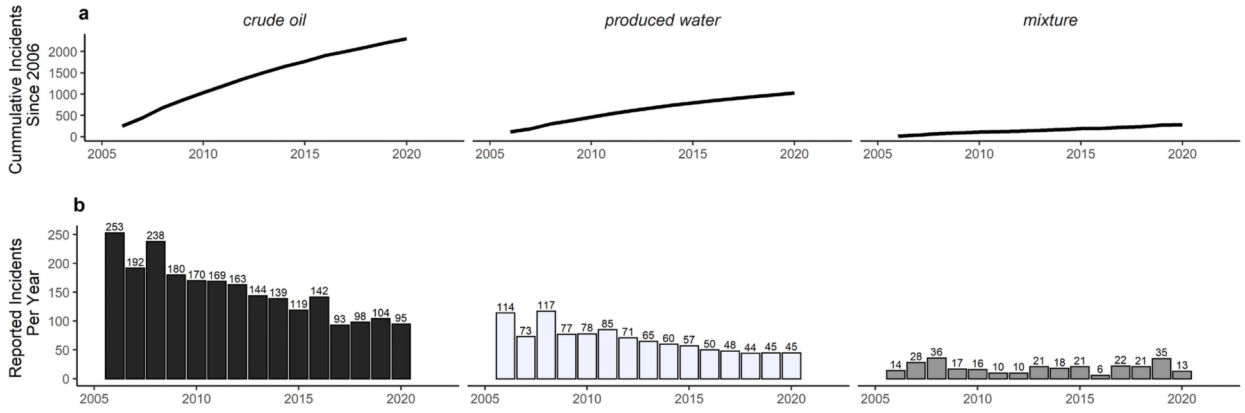


Figure 5.17. Reported number of incidents involving crude oil, produced water, or a mixture of both in the CalOES HazMat Spill Release Reporting Database (CalOES, 2021). Source: Figure 3 from Rossi et al. (2022).

Table 5.9. Breakdown of spills of crude oil, produced water, and a mixture of both by county. Source: Table 1 from Rossi et al. (2022).

Crude oil spills				Produced water spills				Mixture spills			
County	Count	%	Cum. %	County	Count	%	Cum. %	County	Count	%	Cum. %
Kern	1,165	51%	51%	Kern	665	65%	65%	Kern	126	44%	44%
Los Angeles	383	17%	67%	Los Angeles	117	11%	76%	Los Angeles	77	27%	70%
Santa Barbara	271	12%	79%	Santa Barbara	108	10%	86%	Santa Barbara	32	11%	82%
Ventura	204	9%	88%	Ventura	44	4%	91%	Ventura	18	6%	88%
Orange	63	3%	91%	Orange	28	3%	93%	Monterey	11	4%	92%
Fresno	54	2%	93%	Monterey	27	3%	96%	Fresno	10	3%	95%
San Bernardino	39	2%	95%	Fresno	22	2%	98%	Orange	8	3%	98%
Total	2299			Total	1029			Total	288		

Table 5.10. Comparison of total and average crude oil and produced water spills per year for the period of 2006–2014. Spill data for Colorado, New Mexico, North Dakota, and Pennsylvania were taken from Maloney et al. (2017). Source: Table from Rossi et al. (2022).

State	Period of analysis	Crude oil		Produced water	
		Total spills	Average yearly spills	Total spills	Average yearly spills
California	2006–2014	1,648	183	740	82
Colorado	2006–2013	48	6	29	4
New Mexico	2006–2014	121	14	138	15
North Dakota	2005–2014	2,624	263	1,538	154
Pennsylvania	2006–2014	18	2	215	24

5.7.2.3 Impacts of Spill Events on Drinking Water

Rossi et al. (2022) found that relatively few onshore incidents impacted California state waters. Specifically, they observed that 12% of crude oil, 16% of produced water, and 18% of mixture spills, respectively, have affected waterways (**Table 5.11**). These proportions were relatively higher than those reported by the U.S. EPA in an analysis of hydraulic fracturing-related spills in nine states (Arkansas, Colorado, Louisiana, New Mexico, Oklahoma, Pennsylvania, Texas, Utah, Wyoming) from 2006 to 2012 (12% and 4%, respectively) (US EPA, 2015). Rossi et al. (2022) noted that this discrepancy may have resulted due to the U.S. EPA study only considering spills associated with unconventional OGD.

Table 5.11. Counts of crude oil, produced water, and mixture spills, and documented impacts to waterways or drinking water. Source: Table 3 from Rossi et al. (2022).

	Spills Impacting Water count (%)	Spills Impacting Drinking Water count (%)
Crude oil		
Yes	273 (11.8)	0 (0)
No	2,002 (86.6)	106 (19.5)
Unknown	24 (1.0)	426 (78.3)
Produced water		
Yes	159 (15.3)	0 (0)
No	861 (83.0)	189 (78.8)
Unknown	9 (0.9)	43 (17.9)
Mixture		
Yes	52 (17.8)	0 (0)
No	229 (78.4)	38 (37.6)
Unknown	7 (2.4)	59 (58.4)

Impacts to drinking water were included in California spill reporting beginning in 2016, and Rossi et al. (2022) observed no crude oil or produced water spills were reported to have impacted drinking water (**Table 5.11**). They did note a discrepancy between crude oil and produced water spills, with 80% of reported crude oil spills indicating unknown impacts to drinking water, whereas 80% of produced water spills were reported to have not impacted drinking water (**Table 5.11**), but were unable to identify the cause.

From the data contained within spill incident reports, Rossi et al. (2022) were not able to determine what is included in the definition of "drinking water" and how impacts are determined. They postulated the requirement comes from 42 United States Code § 11004 (42 USC § 11004, 2010), but after a search of 5,000 incident reports in the HazMat database, only 28 (0.56%) were found to report impacts to drinking water, two of these incidents mentioned a well, and only one incident contained a mention of a state agency field verifying the impact to drinking water. Thus, Rossi et al. (2022) concluded impacts to drinking water were likely self-reported by the party responsible for the spill, and postulated (from the documents available on public facing websites) that there may not be a protocol for a third party (i.e., an agency with regulatory authority) to verify impact to drinking water resources following a spill event.

5.7.2.4 Inconsistencies in Spill Volume Reporting

To examine the accuracy of spill volumes in the HazMat database, Rossi et al. (2022) conducted a detailed examination of updated incident reports of produced water spills during the period of 2018–2020. They found the total volume of produced water spilled per year in 2018, 2019, and 2020 are 35%, 1,286%, and 2,750% higher, respectively, than the initially reported volumes (**Figure 5.18**). A discrepancy occurred during 2019 in Kern County (CalOES Control #19-6568), where the final volume of spilled produced water was ~1,930 times higher (~11,600 bbls) than the amount (~6 bbls) in the initial spill report (Rossi et al., 2022). Rossi et al. (2022) found no mention of a groundwater monitoring plan in the associated Notice of Violation (V19-0017), and

the nearest well in the Groundwater Ambient Monitoring and Assessment (GAMA) system (Well ID L10007494132-CYM-24R2D, ~2.4 km [1.5 mi] north of the expression), was installed independently of the spill event (Kennedy Jenks, 2019).

A previous study, Stringfellow et al. (2015), noted that this reporting inconsistency increases uncertainty in understanding exposure pathways and environmental impacts from accidental releases. Additionally, linking spill incidents to well stimulation activities is difficult, as operators are not required to report whether a spill was associated with well stimulation, and incident reports do not contain an American Petroleum Institute (API) number (Stringfellow et al., 2015). A subsequent study, Caryotakis et al. (2015), attempted to link spill incidents to well activities, but was unable to due to the lack of these pieces of information.

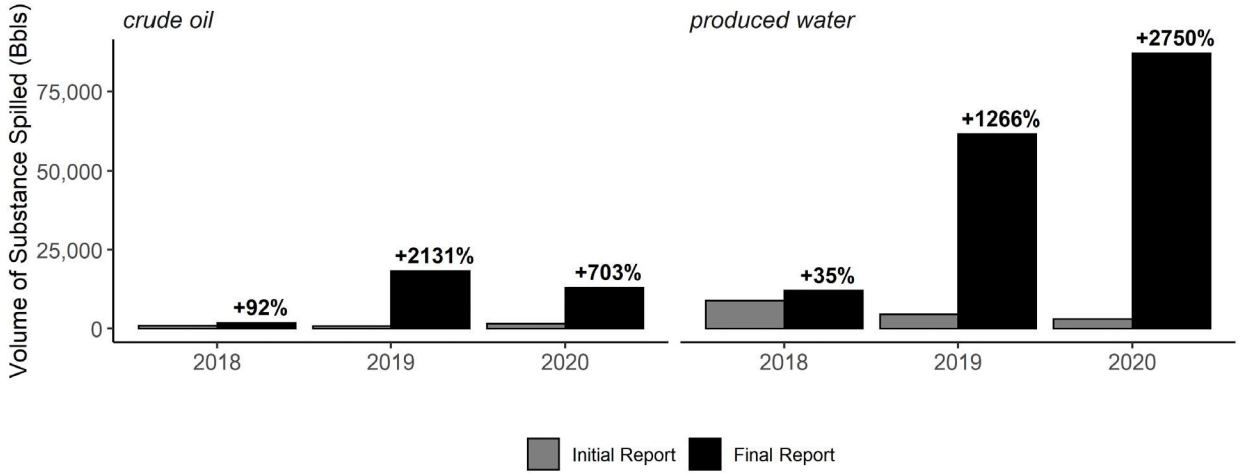


Figure 5.18. Comparison of the total reported volumes of crude oil and produced water in the initial (grey) and updated (black) CalOES spill incident reports per year. Annotations provide the percent increases of the total. Source: Figure 5 from Rossi et al. (2022).

5.7.2.5 Spill Occurrence by Volume of Material Released

Rossi et al. (2022) used the final volumes from the spill reports to generate cumulative distribution functions for each substance. They noted that while produced water spills are relatively less frequent than crude oil spills (**Figure 5.17**), typical volumes of produced water spill incidents greatly overshadow typical volumes of crude oil spill incidents (**Figure 5.19**). In particular, they observed that 50% of crude oil spills involve roughly four or less barrels of material, whereas 50% of produced water spills involve 20 or less barrels of material. This discrepancy becomes even more pronounced when considering a higher percentage of incidents, as 75% of crude oil spills are ~10 barrels or less, and 75% of produced water spills are ~100 barrels or less. Trends in the frequency of produced water spills on a per volume basis generally followed trends noted by the U.S. EPA in an multi-state analysis of hydraulic fracturing related spills during the period of 2006–2015 (US EPA, 2015).

Rossi et al. (2022) used the cumulative distribution functions for each substance to assess the adequacy of the volumetric thresholds recently released by CalGEM. Specifically, the Discussion Draft Rule that CalGEM released in October 2021 proposes instituting statewide volume thresholds for crude oil and produced water spills (0.5 and 10 barrels, respectively) occurring within 976 m (3,200 ft) of a sensitive receptor (e.g., residences, education resources, health care facilities) (CalGEM, 2021c). Rossi et al. (2022) considered crude oil spill volumes during the period 2018–2020 and noted that approximately 13% of these spills would not be reported using the proposed threshold. Likewise, approximately 38% of produced water spills were less than the proposed 10-barrel threshold. Thus, the selected thresholds appeared to introduce an inconsistency in spill reporting, which could be corrected by instituting a two-barrel reporting threshold for produced water spills (Rossi et al., 2022). Rossi et al. (2022) noted that these thresholds would only exist for areas containing sensitive receptors, which is not true for the western margins of the SJV, a relatively sparsely populated area that contains a substantial amount of oil and gas infrastructure (Rossi et al., 2022).

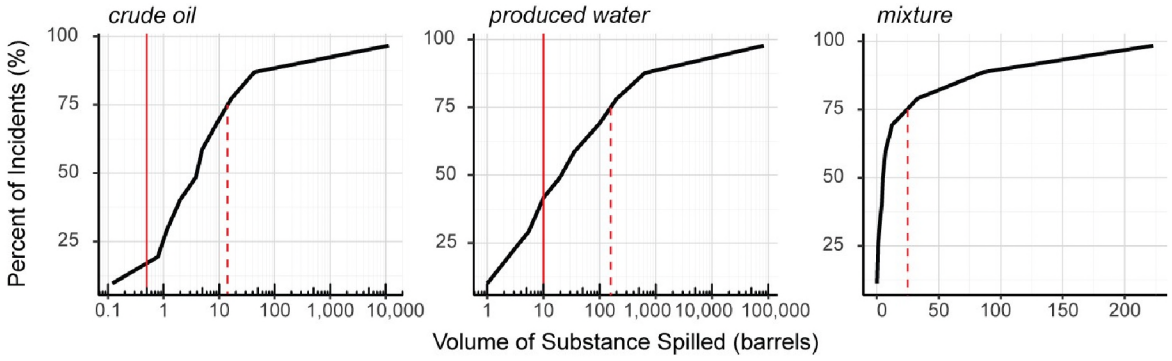


Figure 5.19. Percent of incidents in 2018–2020 involving crude oil, produced water, and mixtures of the two substances for any given volume with solid vertical annotation lines indicating proposed reporting thresholds for spilled materials (CalGEM, 2021c), and dashed vertical annotation lines indicating the volume that 75% of spill incidents are less than. Data used to generate these cumulative distributions were taken from the updated spill reports. Source: Figure 6 from Rossi et al. (2022).

5.7.2.6 Summary of Shortcomings of the Spill Database

In summary, Rossi et al. (2022) found it difficult to thoroughly analyze spill incidents in California using the current publicly facing database. Their findings were in line with a previous analysis, Caryotakis et al. (2015), who described the HazMat spill database as "incomplete, disorganized, and difficult to analyze effectively." Extra sources (e.g., CalGEM notice of violations) must be located to link extra information such as the type (conventional or unconventional) of operations (Caryotakis et al., 2015; Stringfellow et al., 2015). Furthermore, accurate release volumes of spill incidents must be manually retrieved from updated incident reports on a case-by-case nature, and comprehensive geospatial analyses of spill incidents are impossible due to the lack of exact location data reporting in spill reports (Rossi et al., 2022). Likewise, currently it is nearly impossible for outside parties to determine the environmental impacts associated with a particular spill event; Rossi et al. (2022) found incident reports to contain no mention of monitoring activities following releases. Due to these limitations, it is not possible to evaluate the potential impact of crude oil and produced water spills on public health.

5.8. Exposure Pathways from Use of Produced Water for Irrigation

In the United States, the practice of reusing untreated (from a water quality point of view) oil field produced water for irrigation is limited to select oil fields in the Central Valley region of California (Mahoney et al., 2021). This practice is currently expanding; the Kern-Tulare Water District has constructed an additional reservoir — the Guzman Reservoir completed in early 2021 (Google Earth Pro, 2021) — to increase capacity to receive produced water from oil field operators. Although the use of produced water for irrigation represents an additional exposure pathway, a Finding of No Significant Impact (FONSI) report by the U.S. Bureau of Reclamation determined that the new Kern-Tulare Water District reservoir project would have a beneficial impact on air quality from the reduction of sulfur dioxide and nitrogen oxides released to the air due to reduced emissions from existing activities such as produced water injection and the pumping and distribution of water for irrigation (USBR, 2017).

The SJV occupies the southern two-thirds of the Central Valley in California and is separated into the San Joaquin Basin to the north and the Tulare Basin to the south. The SJV is one of the most explored hydrocarbon-containing basins in the United States, with over 100,000 oil and gas wells (Hosford Scheirer, 2013) and one of the most agriculturally productive regions in the world (Hanak et al., 2017) — supplying over one-third of vegetables and two-thirds of the fruits and nuts consumed in the United States (CDFA, 2021; Xiao et al., 2017). Agriculture in the SJV is dependent on surface water from winter/spring snowpack melt, with excess demand met by groundwater withdrawal (Famiglietti et al., 2011), especially during drought years (CDWR, 2021; Faunt et al., 2009; Hanak et al., 2017).

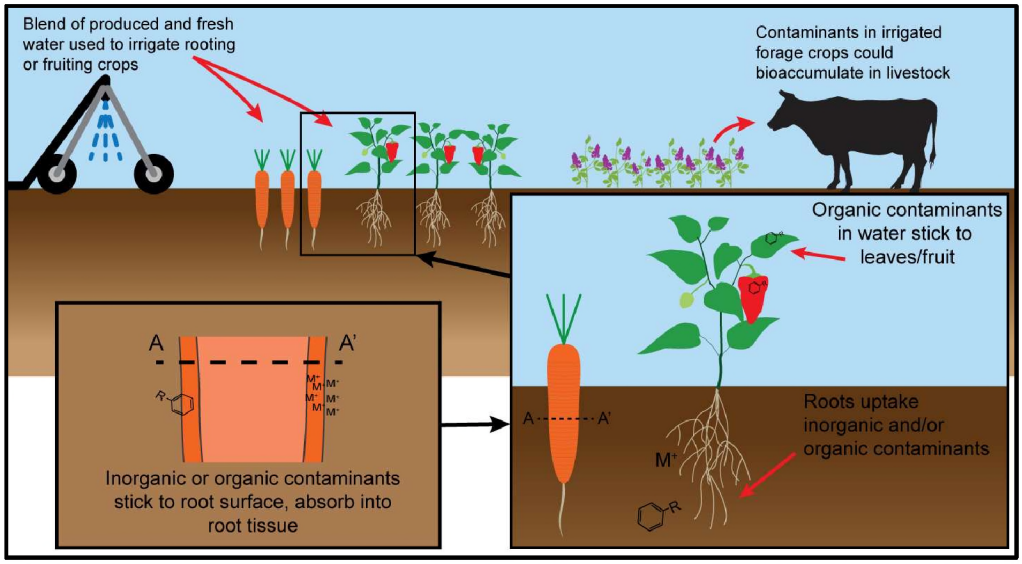


Figure 5.20. Conceptual contamination and exposure pathways of the use of produced water for irrigation.

If produced water is used for irrigation, exposure pathways include bioaccumulation of compounds in food for direct or indirect (via livestock) human consumption or via drinking water from groundwater contamination (**Figure 5.20**). A portion of the produced water in the SJV is combined with surface and groundwater and used for the irrigation of crops for human consumption. However, the use of produced water from stimulated wells for irrigation has been met with more concern, as a technical review of well stimulation in California concluded that produced water from stimulated wells could contain hazardous chemicals and chemical byproducts (CCST, 2015). The report included recommendations that agencies of jurisdiction should clarify that produced water from hydraulically fractured wells cannot be reused for purposes such as irrigation, which could negatively impact the environment, human health, wildlife, and vegetation (CCST, 2015).. This ban should continue until or unless testing for hydraulic fracturing chemicals and breakdown products shows non-hazardous concentrations, or required water treatment reduces concentrations to non-hazardous levels (CCST, 2015).. At present. produced water used for irrigation does not come from wells that have been hydraulically fractured.

In January 2016, the CVRWQCB convened a food safety expert panel to examine the safety of using produced water for irrigation of food crops for direct or indirect human consumption. The water board released a White Paper summarizing findings and recommendations of the panel in January 2021 (Mahoney et al., 2021). The panel recommended that the water board (1) discontinue crop sampling given other anthropogenic sources of chemicals and numerous uncertainties and limitations of analytical methods; (2) continue and periodically update water quality monitoring requirements as new analytical methods for regulatory use emerge; (3) evaluate the spatial and temporal variability of produced water used for irrigation; (4) consider the use of non-targeted analytical methods and bioanalytical assays to better characterize produced water used for irrigation; (5) continue disclosure of chemical additives currently used for oil and gas production; (6) continue evaluation of new additives; (7) consider requiring the disclosure of mass data for additives; (8) develop a list of additives considered as low hazard for potential use

by oil and gas field operators; (9) continue compiling chemical and toxicological information on additives as new information emerges; (10) consider findings of the panel when approving Waste Discharge Requirements for use of produced water for irrigation; (11) sponsor laboratory and controlled field studies to better understand the fate and transport of chemicals in produced water during irrigation; and (12) sponsor soil studies to better understand the impact of produced water on soil properties, fertility, microbiology, and accumulation of heavy metals and persistent organic compounds. The published White Paper from the panel was divided into three main tasks: (1) characterize the chemicals (either added or naturally occurring) in produced water, and assess their hazards; (2) perform a literature review to see the hazards from ingesting these chemicals, examine plant uptake of these chemicals, and determine the persistence of these chemicals in agricultural ecosystems; and (3) perform an experimental manipulation of irrigation of crops with and without produced water. In general, the panel concluded that no immediate threat to either human health or crop safety resulted from reusing produced water for irrigation. The panel issued general recommendations that the current produced water reuse program should continue with the sole modification of discontinuing crop sampling, potential hazards from chemical additives should be further constrained, and data gaps should be closed by conducting environmental studies and employing emerging water quality methods.

5.9. Summary

The generation of produced water (a by-product of many oil and gas related activities) has been increasing in California since 1994. Produced water can contain a wide range of chemical constituents including residual petroleum hydrocarbons, chemical additives, geogenic compounds, and degradation byproducts of chemical transformations. Although some of these inorganic (e.g., arsenic, radium) and organic (e.g., benzene, toluene) compounds are known toxicants, produced waters are not classified as hazardous waste under the Resource Conservation and Recovery Act, and analysis requirements for produced waters discharged to percolation ponds in the CVRWQCB jurisdiction have only relatively recently been strengthened. For example, starting in 2015 the CVRWQCB required a relatively comprehensive analysis of produced waters disposed in unlined percolation ponds, but other regional water quality control boards do not appear to have adopted similarly stringent regulatory programs.

Produced water is most often disposed of via subsurface injection, which is commonly used for enhanced oil recovery. Produced waters disposed of in this manner can potentially impact domestic or municipal water wells via a variety of pathways, leading to groundwater contamination (**Figure 5.4**). From publicly accessible documents, it is not clear if any of these impacts have occurred as a result of subsurface injection in California. A U.S. EPA-funded audit, completed in 2011, identified deficiencies (e.g., an inconsistent definition of protected water, lax enforcement of appropriate maximum allowable surface injection pressures) in California's UIC program. The audit, in conjunction with the passage of Senate Bill 83 in 2015, led to a strengthened oversight of the UIC program. Currently a panel comprised of a diverse group of experts is evaluating the regulatory performance and administration of the UIC Program and will make recommendations of improvements. At present, approximately 261,000 Californians live within 1 km (3,281 ft) of a water disposal well (**Figure 5.5**).

Another common disposal method of produced water is discharge into lined or unlined earthen structures known as produced water ponds. Like other disposal methods, the disposal of water in these ponds could potentially impact humans via a number of exposure pathways (**Figure 5.7**). Disposal ponds are primarily located in the southern SJV; however, ponds are also located in Southern California. Currently no state agency maintains a comprehensive list of all ponds in California (DiGiulio et al., 2021). Disposal of produced water into unlined produced water ponds has been ongoing in California since the early 20th century, but this practice has drastically decreased since 2014. Likewise, disposal of produced water into lined ponds has decreased since the early 1990s. An analysis of chemical data collected from produced water ponds in the SWRCB's Geotracker database highlights that detected concentrations of constituents of concern in produced water ponds commonly exceed CA MCLs (**Figure 5.9**). Likewise, detected concentrations of electrical conductivity, chloride, and boron in 75% or more samples exceed the Tulare Basin effluent limits, often in areas that overlie groundwater resources. Despite this clear threat to groundwater resources, groundwater monitoring at unlined produced water pond facilities is relatively sparse. Airborne emissions of organic compounds from ponds also likely pose another public health concern, but these emissions are relatively under-characterized in the peer reviewed literature. Roughly 545,000 (~1 in 75) Californians live within 1 km (3,281 ft) of an active, inactive, or historical produced water pond, with about 168,000 of those residents located within 1 km (3,281 ft) of an active pond. The lack of spatially explicit domestic well locations, coupled with a lack of knowledge pertaining to the transport distances of airborne contaminants, precludes determining what proportion of these populations are at risk.

The discharge of produced water to surface water poses the potential for humans to come into contact with a variety of chemical constituents (e.g., radionuclides, trace metals, organic compounds) via multiple exposure pathways (**Figure 5.15**). Conceptually, produced water discharges to surface waters can occur directly or indirectly via POTWs. While indirect discharges via POTWs are allowed (with the exception of produced waters from unconventional wells), pretreatment standards do not exist for waters discharged in this way. In California, produced water undergoes minimal pretreatment prior to discharge to POTWs; consequently, most chemicals associated with well stimulation operations remain. In California, this practice peaked in 1984 (67.2 MMbbls or 2.5% produced water disposition) and decreased until 2017 (13.8 MMbbls or 0.43% of produced water disposition). In general, regulatory limitations (i.e., 40 C.F.R. §§ 435.30-435.34, 2021) have effectively prohibited direct discharges to surface waters except for certain uses. For example, one such use applicable to California is discharging produced water (provided it meets Effluent Limitation Guidelines) for wildlife, livestock watering, or other agricultural purposes. Direct discharges to surface water in California peaked in 1988 (497.2 MMbbls or 18.9% produced water disposition) and have generally declined until 2017 (58.9 MMbbls or 1.8% of produced water disposition). While surface discharges of produced water appear to continue to be an important surface disposal method in California (second only to discharges into unlined ponds), it is unclear exactly what use these discharges fall under. Furthermore, searches of both the NPDES General Permit Web Inventory and CIWQS returned scant information relating to contemporary or historical produced water discharges. Thus, potential impacts to public health from disposal of produced water to surface water in California were not evaluated.

Spills of produced water pose multiple concerns for human, vegetative, and biotic receptors through both surface and subsurface pathways (**Figure 5.16**). Significant releases of produced water must be reported to CalOES; however, there is no reporting threshold for produced water. Between January 1, 2006, and January 1, 2021, a total of 1,029 spill incidents involving produced water have been reported to CalOES, with the majority (51%) of these events occurring in Kern County. None of these incidents have been reported to impact drinking water, but from publicly available data it is not clear how impacts to drinking water are determined. Furthermore, it is unclear if groundwater monitoring is conducted following large spill events. While the frequency of spills of produced water appears to be decreasing since 2006, comparisons to studies examining the frequency of produced water spills in other states suggest produced water spills may occur relatively more frequently in California. Although CalOES maintains a publicly available database of spill events, retrieving data pertaining to spill incidents is time intensive, and generally lacks precise location data. Moreover, updated spill volumes are not rapidly retrievable, and during the years 2018–2020, volumes of produced water spilled were underreported anywhere from 35% to 2,750%. These data limitations make it nearly impossible to evaluate potential impacts of produced water spills on public health in California.

The SJV has the unique distinction of being both one of the most agriculturally productive regions in the world, and one of the most explored hydrocarbon-containing basins in the United States. Significant water demand, projected to be exacerbated by both population growth and climatic shifts, has led to the blending of produced water with surface and groundwater to be used for agricultural irrigation in select areas of the Tulare Basin. This practice is currently expanding, with a new reservoir currently (at the time of writing this report) being constructed within the Kern-Tulare Water District to expand the storage capacity of blended water (i.e., blends of fresh and produced water). The possible existence of hazardous chemicals in produced water used for irrigation has garnered concerns from an expert panel reviewing well stimulation in California, and led to the recommendation that produced waters from hydraulically fractured wells be disallowed for irrigation purposes. To determine the safety of this practice, the CVRWQCB convened a separate food safety expert panel, who released a White Paper in January 2021. This white paper contains a list of 12 findings and recommendations and concludes no immediate threat to either human health or crop safety resulted from reusing produced water for irrigation. In general, the panel recommended that the current produced water reuse program should continue with the sole modification of discontinuing crop sampling, that potential hazards from chemical additives should be further constrained, and data gaps should be closed by conducting environmental studies and employing emerging water quality methods. Similarly, after reviewing the Kern-Tulare Water District reservoir project, the U.S. Bureau of Reclamation issued a FONSI. As such, although the reuse of produced water for crop irrigation does pose a potential contaminant pathway, the likelihood of this occurring seems relatively small compared to other pathways such as accidental releases of produced water, or the discharge of produced water into unlined pits.

References

14 Cal. Code Reg. § 1724.7.2 (2019). Liquid Analysis. https://casetext.com/regulation/california-code-of-regulations/title-14-natural-resources/division-2-department-of-conservation/chapter-4-development-regulation-and-conservation-of-oil-and-gas-resources/subchapter-1-onshore-well-regulations/article-4-underground-injection-control/section-172472-liquid-analysis

14 Cal. Code Reg. § 1724.11 (2019). https://govt.westlaw.com/calregs/Document/I4FBB58185B4D11EC976B000D3A7C4BC3?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default)

14 Cal. Code Reg. § 1788 (2015). Required Public Disclosures. https://casetext.com/regulation/california-code-of-regulations/title-14-natural-resources/division-2-department-of-conservation/chapter-4-development-regulation-and-conservation-of-oil-and-gas-resources/subchapter-2-environmental-protection/article-4-well-stimulation-treatments/section-1788-required-public-disclosures?

19 Cal. Code Reg. § 2631, 19 CCR § 2631 (2016). https://govt.westlaw.com/calregs/Browse/Home/California/CaliforniaCodeofRegulations?guid=I9658E1CDA82D469BB092C74D64D18C7E&originationContext=documenttoc&transitionType=Default&contextData=(sc.Default)

22 Cal. Code Reg. § 64431 (2021). Maximum Contaminant Levels. https://www.law.cornell.edu/regulations/california/22-CCR-64431#:~:text=22%2C%20§%2064431%20%2D%20Maximum%20Contaminant%20Levels%2DInorganic%20Chemicals,-State%20Regulations&text=Public%20water%20systems%20shall%20comply,as%20specified%20in%20this%20article

22 Cal. Code Reg. § 64442 (2021). https://www.law.cornell.edu/regulations/california/Cal-Code-Regs-Tit-22-SS-64442

22 Cal. Code Reg. § 64444 (2021). https://www.law.cornell.edu/regulations/california/Cal-Code-Regs-Tit-22-SS-64444

22 Cal. Code Reg. § 66261.24 (1994). Characteristic of Toxicity. https://www.law.cornell.edu/regulations/california/22-CCR-66261.24

40 Code of Federal Regulations §§ 435.30-435.34 (2021). https://www.ecfr.gov/current/title-40/chapter-I/subchapter-N/part-435

42 United States Code § 11004 (2010). Emergency Notification. https://www.law.cornell.edu/uscode/text/42/11004

81 Fed. Reg. 88126 (2016). Effluent Limitations Guidelines and Standards for the Oil and Gas Extraction Point Source Category - Implementation Date Extension. https://www.govinfo.gov/content/pkg/FR-2016-12-07/pdf/2016-29338.pdf

Abdullah, K., Malloy, T., Stenstrom, M. K., & Suffet, I. H. (2017). Toxicity of acidization fluids used in California oil exploration. *Toxicological and Environmental Chemistry*, *99*(1), 78–94. https://doi.org/10.1080/02772248.2016.1160285

Adams, M. B. (2011). Land Application of Hydrofracturing Fluids Damages a Deciduous Forest Stand in West Virginia. *Journal of Environmental Quality*, *40*(4), 1340–1344. https://doi.org/10.2134/jeq2010.0504

ATSDR (Agency for Toxic Substances and Disease Registry). (2017). *Toxicological Profile for Glutaraldehyde*. U.S. Department of Health and Human Services. https://www.atsdr.cdc.gov/toxprofiles/tp208.pdf

Almubarak, T., Li, L., Ng, J. H., Nasr-El-Din, H., & AlKhaldi, M. (2021). New insights into hydraulic fracturing fluids used for high-temperature wells. *Petroleum*, *7*(1), 70–79. https://doi.org/10.1016/j.petlm.2020.05.002

Alvarado, V., & Manrique, E. (2010). Enhanced oil recovery: An update review. *Energies*, *3*(9), 1529–1575. https://doi.org/10.3390/en3091529

Amrhein, C., Mosher, P. A., Strong, J. E., & Pacheco, P. G. (1994). Trace metal solubility in soils and waters receiving deicing salts. *Journal of Environmental Quality*, *23*(2), 219–227. https://doi.org/10.2134/jeq1994.00472425002300020001x

Ayers, R. S., & Westcot, D. W. (1985). *Water quality for agriculture*. Food and Agriculture Organization of the United Nations.

Bäckström, M., Karlsson, S., Bäckman, L., Folkeson, L., & Lind, B. (2004). Mobilisation of heavy metals by deicing salts in a roadside environment. *Water Research*, *38*(3), 720–732. https://doi.org/10.1016/j.watres.2003.11.006

Bean, R. T., & Logan, J. (1983). *Lower Westside Water Quality Investigation, Kern County* (Contract No. 2-096-158-0). California State Water Resources Control Board.

Bishop, J. (2014). *Underground Injection Control Drinking Water Source Evaluation*. https://www.biologicaldiversity.org/campaigns/california_fracking/pdfs/20140915_Bishop_letter_to_Blumenfeld_Responding_to_July_17_2014_UIC_Letter.pdf

Blondes, M. S., Gans, K. D., Engle, M. A., Kharaka, Y. K., Reidy, M. E., Saraswathula, V., Thordsen, J. J., Rowan, E. L., & Morrissey, E. A. (2018). *U.S. Geological Survey National Produced Waters Geochemical Database (ver. 2.3, January 2018)*. U.S. Geological Survey data release. https://doi.org/10.5066/F7J964W8

California Department of Finance. (2020). Final Report — California Department of Conservation, Underground Injection Control and Well Stimulation Treatment Programs, Performance Audit. https://esd.dof.ca.gov/reports/reportPdf/5631D3F7-882E-EB11-9121-00505685B5D1/California%20Department%20of%20Conservation%20Underground%20Injection%20Control%20and%20Well%20Stimulation%20Treatment%20Programs%20Performance%20Audit%20November%202020

CalGEM (California Geologic Energy Management Division). (2018). *Data Dictionary for Water Report Form. Water Produced From, or Used in, Oil and Gas Fields*. https://www.conservation.ca.gov/calgem/SB%201281/Documents/SB1281_DataDictionary-2018.pdf

CalGEM. (2019). *Updated Underground Injection Control Regulations-Final Text of Regulations*. https://www.conservation.ca.gov/calgem/general_information/Documents/UIC_regs_workshop/Final%20Text%20of%20the%20UIC%20Regulations%20(Marked).pdf

CalGEM. (2021a). *Well Stimulation Disclosure Database*. CalGEM. https://wellstar-public.conservation.ca.gov/General/PublicDownloads/Index

CalGEM. (2021b). *SB 83 Independent Review Panel for the Department of Conservation's Underground Injection Control Program*.

CalGEM. (2021c). Draft Rule for Protection of Communities and Workers From Health and Safety Impacts from Oil and Gas Production Operations Pre-Rulemaking Release for Public Review and Consultation. https://www.conservation.ca.gov/calgem/Documents/public-health/PHRM%20Draft%20Rule.pdf

CalGEM. (2021d). *Oil and Gas Wells GIS, California*. https://gis.conservation.ca.gov/portal/home/item.html?id=335e036c6a4f4cc39148ca2a9e0389c7

California Assembly Bill No. 1328 (AB-1328) Oil and Gas: Water Quality. (2017). https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB1328

California Senate Bill No. 1281 (SB-1281) Oil and Gas Production: Water Use: Reporting. (2013-2014) (2014, Pavley). http://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201320140SB1281

California Senate Bill No. 4 (SB-4) Oil and Gas: Well Stimulation (2013). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB4

California Senate Bill No. 83 (SB-83) Public Resources (2015). https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB83

CalOES (California Office of Emergency Services). (2021). *HazMat Spill Release Reporting Database*. https://w3.calema.ca.gov/operational/malhaz.nsf/$defaultview

Cal-Span. (2018). *First Meeting of the Underground Injection Control Advisory Panel*. https://cal-span.org/unipage/index.php?site=cal-span&owner=ICAP&date=2018-05-29

Caryotakis, A., Davies, I., Hafiz, S., Niketen, J., Noakes, D., Wang, R., & Wu, X. (2015). *An Analysis of Hazardous Materials Spills in California with a Focus on Oil and Gas*. (2015 Undergraduate Practicum Project for the UCLA Institute of the Environment and

Sustainability). UCLA Institute of the Environment and Sustainability. https://www.ioes.ucla.edu/project/an-analysis-of-hazardous-materials-spills-in-california-with-a-focus-on-oil-and-gas/

Cates, D. A., Knox, R. C., & Sabatini, D. A. (1996). The impact of ion exchange processes on subsurface brine transport as observed on piper diagrams. *Groundwater*, *34*(3), 532–544. https://doi.org/10.1111/j.1745-6584.1996.tb02035.x

CCST (California Council on Science and Technology). (2015). An Independent Scientific Assessment of Well Stimulation in California. Executive Summary. https://ccst.us/wp-content/uploads/2015SB4-v2ES.pdf

CDFA (California Department of Food and Agriculture). (2021). *California Agricultural Production Statistics.* https://www.cdfa.ca.gov/statistics/

CDWR (California Department of Water Resources). (2020, November 18). *CA Bulletin 118 Groundwater Basins*. https://data.ca.gov/dataset/californias-groundwater-bulletin-118

CDWR. (2021). *California's Groundwater Update 2020 Bulletin 118*. https://water.ca.gov/Programs/Groundwater-Management/Bulletin-118

Chen, S. S., Sun, Y., Tsang, D. C. W., Graham, N. J. D., Ok, Y. S., Feng, Y., & Li, X.-D. (2017). Insights into the subsurface transport of As(V) and Se(VI) in produced water from hydraulic fracturing using soil samples from Qingshankou Formation, Songliao Basin, China. *Environmental Pollution*, *223*, 449–456. https://doi.org/10.1016/j.envpol.2017.01.044

Clark, C. E., & Veil, J. A. (2009). *Produced water volumes and management practices in the United States.* (ANL/EVS/R-09-1, 1007397; p. ANL/EVS/R-09-1, 1007397). https://doi.org/10.2172/1007397

COGCC (Colorado Oil and Gas Conservation Commission). (2021). Rules and Regulations, Environmental Impact Prevention 900 Series. https://cogcc.state.co.us/documents/reg/Rules/LATEST/900%20Series%20-%20Environmental%20Impact%20Prevention.pdf

Cozzarelli, I. M., Skalak, K. J., Kent, D. B., Engle, M. A., Benthem, A., Mumford, A. C., Haase, K., Farag, A., Harper, D., Nagel, S. C., Iwanowicz, L. R., Orem, W. H., Akob, D. M., Jaeschke, J. B., Galloway, J., Kohler, M., Stoliker, D. L., & Jolly, G. D. (2017). Environmental signatures and effects of an oil and gas wastewater spill in the Williston Basin, North Dakota. *Science of The Total Environment*, *579*, 1781–1793. https://doi.org/10.1016/j.scitotenv.2016.11.157

CVRWQCB (Central Valley Regional Water Quality Control Board). (2014). *Oilfield Produced Water Sumps Central Valley Water Board Workplan*. https://www.waterboards.ca.gov/centralvalley/water_issues/oil_fields/information/disposal_ponds/#producedwp

CVRWQCB. (2015). *California Water Code Directive Pursuant to Section 13267. Attachment B.* https://www.waterboards.ca.gov/centralvalley/water_issues/oil_fields/information/disposal_ponds/#producedwp

CVRWQCB. (2017a). *Order R5-2017-0034 Waste discharge Requirements General Order for Oil Field Discharges to Land General Order Number One.* https://www.waterboards.ca.gov/centralvalley/water_issues/oil_fields/information/disposal_ponds/#producedwp

CVRWQCB. (2017b). *Order R5-2017-0035 Waste discharge Requirements General Order for Oil Field Discharges to Land General Order Number Two.* https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/general_orders/r5-2017-0035.pdf

CVRWQCB. (2017c). *Order R5-2017-0036 Waste discharge Requirements General Order for Oil Field Discharges to Land General Order Number Three.* https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/general_orders/r5-2017-0036.pdf

CVRWQCB. (2018). *Water Quality Control Plan for the Tulare Lake Basin. Third Edition.* https://www.waterboards.ca.gov/rwqcb5/water_issues/basin_plans/tularelakebp_201805.pdf

CVRWQCB. (2020). *Order Pursuant to California Water Code Section 13267, Aera Energy.* https://documents.geotracker.waterboards.ca.gov/regulators/deliverable_documents/9327466666/2020-08-28-Sec%2013267%20Order,%20Aera%20Injection%20Wells.pdf

Davis, T. A., Kulongoski, J. T., & McMahon, P. B. (2016). *Produced water chemistry data for samples from four petroleum wells, Southern San Joaquin Valley, California, 2014.* USGS. https://doi.org/10.5066/F7XG9P83

DiGiulio, D. C., & Shonkoff, S. B. C. (2019). Risk Posed to Groundwater Resources by the Disposal of Produced Water into Unlined Produced Water Ponds in California. *Groundwater Protection Council Annual Forum*.

DiGiulio, D. C., Rossi, R. J., Jaeger, J. M., Shonkoff, S. B. C., & Ryan, J. N. (2021). Vulnerability of Groundwater Resources Underlying Unlined Produced Water Ponds in the Tulare Basin of the San Joaquin Valley, California. *Environmental Science & Technology*, *55*(21), 14782–14794. https://doi.org/10.1021/acs.est.1c02056

DiGiulio, D. C., & Shonkoff, S. B. C. (2021). Potential Impact to Groundwater Resources from Disposal of Produced Water into Unlined Produced Water Ponds in the San Joaquin Valley. In *Assessment of Oil and Gas Water Cycle Reporting in California. Evaluation of Data Collected Pursuant to California Senate Bill 1281, Phase II Report.* California Council on Science and Technology. https://ccst.us/wp-content/uploads/CCST-SB-1281-Phase-II-Full-Report-FINAL.pdf

Drollette, B. D., Hoelzer, K., Warner, N. R., Darrah, T. H., Karatum, O., O'Connor, M. P., Nelson, R. K., Fernandez, L. A., Reddy, C. M., & Vengosh, A. (2015). Elevated levels of diesel range organic compounds in groundwater near Marcellus gas operations are

derived from surface activities. *Proceedings of the National Academy of Sciences*, *112*(43), 13184–13189. https://doi.org/10.1073/pnas.1511474112

Evans, M. V., Sumner, A. J., Daly, R. A., Luek, J. L., Plata, D. L., Wrighton, K. C., & Mouser, P. J. (2019). Hydraulically fractured natural-gas well microbial communities contain genomic halogenation and dehalogenation potential. *Environmental Science & Technology Letters*, *6*(10), 585–591. https://doi.org/10.1021/acs.estlett.9b00473

Everett, R. E., Fenton, N. C., Hill, J. M., Stephens, M. J., Martinez Francisco, D., Metzger, L. F., Gans, K. D., & Qi, S. L. (2019). *Geochemical and geophysical data for selected wells in and surrounding the South Cuyama oil and gas field*. USGS. https://doi.org/10.5066/P9KTYCNC

Famiglietti, J. S., Lo, M., Ho, S. L., Bethune, J., Anderson, K. J., Syed, T. H., Swenson, S. C., de Linage, C. R., & Rodell, M. (2011). Satellites measure recent rates of groundwater depletion in California's Central Valley. *Geophysical Research Letters*, *38*(3), 2010GL046442. https://doi.org/10.1029/2010GL046442

Faunt, C. C., Belitz, K., & Hanson, R. T. (2009). *Chapter B. Groundwater Availability in California's Central Valley.* U.S. Geological Survey Professional Paper 1766. https://pubs.usgs.gov/pp/1766/PP_1766.pdf

Faunt, C. C., Belitz, K., & Hanson, R. T. (2010). Development of a three-dimensional model of sedimentary texture in valley-fill deposits of Central Valley, California, USA. *Hydrogeology Journal*, *18*, 625–649. https://doi.org/10.1007/s10040-009-0539-7

Gannon, R. S., Saraceno, J. F., Kulongoski, J. T., Teunis, J. A., Barry, P. H., Tyne, R. L., Kraus, T. E. C., Hansen, A. M., & Qi, S. L. (2018). *Produced water chemistry data for the Lost Hills, Fruitvale, and North and South Belridge study areas, Southern San Joaquin Valley, California (version 1.1, September 2020).* USGS. https://doi.org/10.5066/F7X929H9

Gans, K. D., Metzger, L. F., Gillespie, J. M., & Qi, S. L. (2018). *Historical produced water chemistry data compiled for the Fruitvale Oilfield, Kern County, California.* U.S. Geological Survey data release. https://doi.org/10.5066/F72B8X8G

Gans, K. D., Metzger, L. F., Gillespie, J. M., & Qi, S. L. (2019). *Historical produced water chemistry data compiled for the lost hills and North and South Belridge Oilfields, Kern County, California*. U.S. Geological Survey data release. https://doi.org/10.5066/F7F18Z12

Gans, K. D., Metzger, L. F., Gillespie, J. M., & Qi, S. L. (2021). *Historical Produced Water Chemistry Data Compiled for the North Coles Levee Oilfield, Kern County, California*. USGS. https://doi.org/10.5066/P9GD7W9L

Gillespie, J. M., Davis, T., Ball, L., Herrera, P., Wolpe, Z., Medrano, V., Bobbitt, M., & Stephens, M. (2019). *Geological, geochemical, and geophysical data from the Lost Hills and Belridge oil fields (ver. 2.0, September 2019)*. U.S. Geological Survey data release. https://doi.org/10.5066/P90QH6CI

Google Earth Pro (7.3.4.8248). (2021). [Computer software].

Grinberg, A. (2014). *In the Pits. Oil and Gas Wastewater Disposal into Open Unlined Pits and the Threat to California's Water and Air.* Clean Water Action, Clean Water Fund. http://www.cleanwateraction.org/sites/default/files/docs/publications/In%20the%20Pits.pdf

Grinberg, A. (2016). *Still in the Pits. California is Still Failing to Protect Groundwater and Air Quality from Oil and Gas Wastewater and Air Quality from Oil and Gas Wastewater Disposal in Unlined and Open Air Pits.* Clean Water Action, Clean Water Fund. http://www.cleanwateraction.org/sites/default/files/docs/publications/Still%20In%20the%20Pits%20-%20March%202016.pdf

Gross, S. A., Avens, H. J., Banducci, A. M., Sahmel, J., Panko, J. M., & Tvermoes, B. E. (2013). Analysis of BTEX groundwater concentrations from surface spills associated with hydraulic fracturing operations. *Journal of the Air & Waste Management Association*, *63*(4), 424–432. https://doi.org/10.1080/10962247.2012.759166

GWPC (Ground Water Protection Council). (2019). *Produced Water Report: Regulations, Current Practices, and Research Needs.* https://www.gwpc.org/wp-content/uploads/2019/06/Produced_Water_Full_Report___Digital_Use.pdf

Hanak, E., Lund, J., Arnold, B., Escriva-Bou, A., Gray, B., Green, S., Harter, T., Howitt, R., MacEwan, D., Medellín-Azuara, J., Moyle, P., & Seavy, N. (2017). *Water Stress and a Changing San Joaquin Valley*. Public Policy Institute of California. https://www.ppic.org/publication/water-stress-and-a-changing-san-joaquin-valley/

Heberger, M., & Donnelly, K. (2015). *Oil, Food, and Water: Challenges and Opportunities for California Agriculture*. The Pacific Institute. https://pacinst.org/publication/oil-food-and-water-challenges-and-opportunities-for-california-agriculture/

Henry, B. J., Carlin, J. P., Hammerschmidt, J. A., Buck, R. C., Buxton, L. W., Fiedler, H., Seed, J., & Hernandez, O. (2018). A critical review of the application of polymer of low concern and regulatory criteria to fluoropolymers. *Integrated Environmental Assessment and Management*, *14*(3), 316–334. https://doi.org/10.1002/ieam.4035

Hoelzer, K., Sumner, A. J., Karatum, O., Nelson, R. K., Drollette, B. D., O'Connor, M. P., D'Ambro, E. L., Getzinger, G. J., Ferguson, P. L., Reddy, C. M., & others. (2016). Indications of transformation products from hydraulic fracturing additives in shale-gas wastewater. *Environmental Science & Technology*, *50*(15), 8036–8048. https://doi.org/10.1021/acs.est.6b00430

Horwitt, D., & Gottlieb, B. (2021). *Fracking with "Forever Chemicals."* Physicians for Social Responsibility. https://www.psr.org/wp-content/uploads/2021/07/fracking-with-forever-chemicals.pdf

Horwitt, D., & Gottlieb, B. (2022). *Fracking with "Forever Chemicals" in Colorado*. Physicians for Social Responsibility. https://www.psr.org/wp-content/uploads/2022/01/fracking-with-forever-chemicals-in-colorado.pdf

Hosford Scheirer, A. (2013). *The Three-Dimensional Geologic Model Used for the 2003 National Oil and Gas Assessment of the San Joaquin Basin Province, California:*

Chapter 7 in Petroleum Systems and Geologic Assessment of Oil and Gas in the San Joaquin Basin Province, California. U.S. Geological Survey Professional Paper 1713–7. https://pubs.usgs.gov/pp/pp1713/07/pp1713_ch07.pdf

IARC (International Agency for Research on Cancer). (1994). *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Volume 60 Some Industrial Chemicals*. World Health Organization. https://monographs.iarc.who.int/wp-content/uploads/2018/06/mono60.pdf

Johnson, T. D., & Belitz, K. (2015). Identifying the location and population served by domestic wells in California. *Journal of Hydrology: Regional Studies*, *3*, 31–86. https://doi.org/10.1016/j.ejrh.2014.09.002

Jordan, P., Brandt, A., Ferrar, K., Feinstein, L., & Phillips, S. (2015). *A Case Study of the Potential Risks Associated with Hydraulic Fracturing in Existing Oil Fields in the San Joaquin Basin.* In *An Independent Scientific Assessment of Well Stimulation in California.* The California Council on Science and Technology. http://ccst.us/publications/2015/vol-III-chapter-5.pdf

Kahrilas, G. A., Blotevogel, J., Stewart, P. S., & Borch, T. (2015). Biocides in Hydraulic Fracturing Fluids: A Critical Review of Their Usage, Mobility, Degradation, and Toxicity. *Environmental Science & Technology*, *49*(1), 16–32. https://doi.org/10.1021/es503724k

Kahrilas, G. A., Blotevogel, J., Corrin, E. R., & Borch, T. (2016). Downhole Transformation of the Hydraulic Fracturing Fluid Biocide Glutaraldehyde: Implications for Flowback and Produced Water Quality. *Environmental Science & Technology*, *50*(20), 11414–11423. https://doi.org/10.1021/acs.est.6b02881

Karolytė, R., Barry, P. H., Hunt, A. G., Kulongoski, J. T., Tyne, R. L., Davis, T. A., Wright, M. T., McMahon, P. B., & Ballentine, C. J. (2021). Noble gas signatures constrain oil-field water as the carrier phase of hydrocarbons occurring in shallow aquifers in the San Joaquin Basin, USA. *Chemical Geology*, *584*, 120491. https://doi.org/10.1016/j.chemgeo.2021.120491

Kassotis, C. D., Tillitt, D. E., Davis, J. W., Hormann, A. M., & Nagel, S. C. (2014). Estrogen and Androgen Receptor Activities of Hydraulic Fracturing Chemicals and Surface and Ground Water in a Drilling-Dense Region. *Endocrinology*, *155*(3), 897–907. https://doi.org/10.1210/en.2013-1697

Kassotis, C. D., Iwanowicz, L. R., Akob, D. M., Cozzarelli, I. M., Mumford, A. C., Orem, W. H., & Nagel, S. C. (2016). Endocrine disrupting activities of surface water associated with a West Virginia oil and gas industry wastewater disposal site. *Science of The Total Environment*, *557–558*, 901–910. https://doi.org/10.1016/j.scitotenv.2016.03.113

Kassotis, C. D., Harkness, J. S., Vo, P. H., Vu, D. C., Hoffman, K., Cinnamon, K. M., Cornelius-Green, J. N., Vengosh, A., Lin, C.-H., Tillitt, D. E., Kruse, R. L., McElroy, J. A., & Nagel, S. C. (2020). Endocrine disrupting activities and geochemistry of water resources associated with unconventional oil and gas activity. *Science of The Total Environment*, *748*, 142236. https://doi.org/10.1016/j.scitotenv.2020.142236

Kennedy Jenks. (2019). Monitoring Well Installation and Sampling Plan for the Valley Water Management Company, McKittrick 1-1 Ponds Facility.

Lauer, N. E., Harkness, J. S., & Vengosh, A. (2016). Brine Spills Associated with Unconventional Oil Development in North Dakota. *Environmental Science & Technology*, *50*(10), 5389–5397. https://doi.org/10.1021/acs.est.5b06349

Lauer, N. E., & Vengosh, A. (2016). Age Dating Oil and Gas Wastewater Spills Using Radium Isotopes and Their Decay Products in Impacted Soil and Sediment. *Environmental Science & Technology Letters*, *3*(5), 205–209. https://doi.org/10.1021/acs.estlett.6b00118

Lohmann, R., Cousins, I. T., DeWitt, J. C., Gluge, J., Goldenman, G., Herzke, D., Lindstrom, A. B., Miller, M. F., Ng, C. A., Patton, S., & others. (2020). Are fluoropolymers really of low concern for human and environmental health and separate from other PFAS? *Environmental Science & Technology*, *54*(20), 12820–12828. https://doi.org/10.1021/acs.est.0c03244

Long, J. C. S., Feinstein, L. C., Dirkholzer, J., Jordan, P., Houseworth, J., Dobson, P. F., Heberger, M., & Gautier, D. L. (2016). *An Independent Scientific Assessment of Well Stimulation in California: Volume I Well Stimulation Technologies and their Past, Present, and Potential Future Use in California* (p. 411). California Council on Science and Technology. https://ccst.us/reports/an-independent-scientific-assessment-of-well-stimulation-in-california-volume-1/

Lyman, S. N., Mansfield, M. L., Tran, H. N. Q., Evans, J. D., Jones, C., O'Neil, T., Bowers, R., Smith, A., & Keslar, C. (2018). Emissions of organic compounds from produced water ponds I: Characteristics and speciation. *Science of the Total Environment*, *619–620*, 896–905. https://doi.org/10.1016/j.scitotenv.2017.11.161

Maas, E. V. (1986). Salt tolerance of plants. *Applied Agricultural Research*, *1*(1), 12–25.

Maguire-Boyle, S. J., & Barron, A. R. (2014). Organic compounds in produced waters from shale gas wells. *Environmental Science: Processes & Impacts*, *16*(10), 2237–2248. https://doi.org/10.1039/C4EM00376D

Mahoney, J. G., Asami, R. T., & Stringfellow, W. T. (2021). *Food Safety Project White Paper: On the Reuse of Oil Field Produced Water for Irrigation of Food Crops In Central Kern County, California*. Central Valley Regional Water Quality Control Board. https://www.waterboards.ca.gov/centralvalley/water_issues/oil_fields/food_safety/data/white_paper/foodsafety_whitepaper.pdf

Maloney, K. O., Baruch-Mordo, S., Patterson, L. A., Nicot, J.-P., Entrekin, S. A., Fargione, J. E., Kiesecker, J. M., Konschnik, K. E., Ryan, J. N., Trainor, A. M., Saiers, J. E., & Wiseman, H. J. (2017). Unconventional oil and gas spills: Materials, volumes, and risks to surface waters in four states of the U.S. *Science of The Total Environment*, *581–582*, 369–377. https://doi.org/10.1016/j.scitotenv.2016.12.142

Mansfield, M. L., Tran, H. N. Q., Lyman, S. N., Bowers, R. L., Smith, A. P., & Keslar, C. (2018). Emissions of organic compounds from produced water ponds III: Mass-transfer

coefficients, composition-emission correlations, and contributions to regional emissions. *Science of The Total Environment*, *627*, 860–868. https://doi.org/10.1016/j.scitotenv.2018.01.242

McMahon, P. B., Kulongoski, J. T., Vengosh, A., Cozzarelli, I. M., Landon, M. K., Kharaka, Y. K., Gillespie, J. M., & Davis, T. A. (2018). Regional patterns in the geochemistry of oil-field water, southern San Joaquin Valley, California, USA. *Applied Geochemistry*, *98*, 127–140. https://doi.org/10.1016/j.apgeochem.2018.09.015

McMahon, P. B., Vengosh, A., Davis, T. A., Landon, M. K., Tyne, R. L., Wright, M. T., Kulongoski, J. T., Hunt, A. G., Barry, P. H., Kondash, A. J., Wang, Z., & Ballentine, C. J. (2019). Occurrence and Sources of Radium in Groundwater Associated with Oil Fields in the Southern San Joaquin Valley, California. *Environmental Science & Technology*, *53*(16), 9398–9406. https://doi.org/10.1021/acs.est.9b02395

Metzger, L. F., Davis, T. A., Peterson, M. F., Brilmyer, C. A., & Johnson, J. C. (2018). *Water and petroleum well data used for preliminary regional groundwater salinity mapping near selected oil fields in central and southern California.* U.S. Geological Survey data release. https://doi.org/10.5066/F7RN373C

Metzger, L. F., & Herrera, P. J. (2020). *Historical produced water chemistry data compiled for the Orcutt and Oxnard oil fields, Santa Barbara and Ventura Counties, southern California*. U.S. Geological Survey data release. https://doi.org/10.5066/P9AYRXBD

Metzger, L. F., Morris, D., & Watson, E. (2020). *Historical produced water chemistry data compiled for selected oil fields in Los Angeles and Orange Counties, southern California.* U.S. Geological Survey data release. https://doi.org/10.5066/P9JXQ3SD

Metzger, L. F. (2021). *Historical groundwater and produced water chemistry data compiled for the San Ardo Oil Field and vicinity, Monterey County, central California*. U.S. Geological Survey data release. https://doi.org/10.5066/P9W6KHK2

Norrström, A.-C., & Bergstedt, E. (2001). The impact of road de-icing salts (NaCl) on colloid dispersion and base cation pools in roadside soils. *Water, Air, and Soil Pollution*, *127*(1), 281–299. https://doi.org/10.1023/A:1005221314856

NYSDEC (New York State Department of Environmental Conservation). (2011). *Revised Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program—Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs*. Division of Mineral Resources. http://www.dec.ny.gov/data/dmn/rdsgeisfull0911.pdf

OEHHA (California Office of Environmental Health Hazard Assessment). (2020, August 20). *Acute, 8-hour and Chronic Reference Exposure Level (REL) Summary*. https://oehha.ca.gov/air/general-info/oehha-acute-8-hour-and-chronic-reference-exposure-level-rel-summary

Oetjen, K., Blotevogel, J., Borch, T., Ranville, J. F., & Higgins, C. P. (2018). Simulation of a hydraulic fracturing wastewater surface spill on agricultural soil. *Science of the Total Environment*, *645*, 229–234. https://doi.org/10.1016/j.scitotenv.2018.07.043

Osbourne, P. (2002). *Technical Program Overview: Underground Injection Control Regulations*. https://nepis.epa.gov/Exe/ZyNET.exe/2000E99H.TXT?ZyActionD=ZyDocument&Client=EPA&Index=2000+Thru+2005&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C00thru05%5CTxt%5C00000006%5C2000E99H.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL

Pizzuto, J. E. (2014). Long-term storage and transport length scale of fine sediment: Analysis of a mercury release into a river. *Geophysical Research Letters*, *41*(16), 5875–5882. https://doi.org/10.1002/2014GL060722

Rossi, R. J., Bain, D. J., Elliott, E. M., Divers, M., & O'Neill, B. (2017). Hillslope soil water flowpaths and the dynamics of roadside soil cation pools influenced by road deicers: Soil Water Flowpaths and Interactions of Roadside Soils and Road Salt. *Hydrological Processes*, *31*(1), 177–190. https://doi.org/10.1002/hyp.10989

Rossi, R. J., Bain, D. J., Hillman, A. L., Pompeani, D. P., Finkenbinder, M. S., & Abbott, M. B. (2017). Reconstructing Early Industrial Contributions to Legacy Trace Metal Contamination in Southwestern Pennsylvania. *Environmental Science & Technology*, *51*(8), 4173–4181. https://doi.org/10.1021/acs.est.6b03372

Rossi, R. J., DiGiulio, D. C., & Shonkoff, S. B. C. (2022). An Examination of Onshore Produced Water Spills in the State of California: Incident Frequency, Spatial Distribution, and Shortcomings in Available Data. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-022-23391-0

San Joaquin Valley Field Rule, Cal. Pub. Res. Code § 3233 (1996).

Schmidt, C., & Card, T. R. (2020). *Measurement of Produced Water Air Emissions from Crude Oil and Natural Gas Operations* (RFP No. 16ISD005). California Air Resources Board. https://ww2.arb.ca.gov/sites/default/files/2020-07/CARB%20Oil%20Wastewater%20Emissions%20Final%20Report_05.11.2020_ADA.pdf

Schoups, G., Hopmans, J. W., Young, C. A., Vrugt, J. A., Wallender, W. W., Tanji, K. K., & Panday, S. (2005). Sustainability of irrigated agriculture in the San Joaquin Valley, California. *Proceedings of the National Academy of Sciences*, *102*(43), 15352–15356. https://doi.org/10.1073/pnas.0507723102

Shanley, J. B. (1994). Effects of Ion Exchange on Stream Solute Fluxes in a Basin Receiving Highway Deicing Salts. *Journal of Environmental Quality*, *23*(5), 977–986. https://doi.org/10.2134/jeq1994.00472425002300050019x

Shonkoff, S. B. C., Hill, L. A. L., & Domen, J. K. (2021). California Produced Water Quality: Implications for Human Health and the Environment. In *Assessment of Oil and Gas Water Cycle Reporting in California. Evaluation of Data Collected Pursuant to California*

Senate Bill 1281, Phase II Report. California Council on Science and Technology. https://ccst.us/wp-content/uploads/CCST-SB-1281-Phase-II-Full-Report-FINAL.pdf

Shores, A., Laituri, M., & Butters, G. (2017). Produced Water Surface Spills and the Risk for BTEX and Naphthalene Groundwater Contamination. *Water, Air, & Soil Pollution*, *228*(11), 435. https://doi.org/10.1007/s11270-017-3618-8

Steding, D. J., Dunlap, C. E., & Flegal, A. R. (2000). New isotopic evidence for chronic lead contamination in the San Francisco Bay estuary system: Implications for the persistence of past industrial lead emissions in the biosphere. *Proceedings of the National Academy of Sciences*, *97*(21), 11181–11186. https://doi.org/10.1073/pnas.180125697

Stringfellow, W. T., Domen, J. K., Camarillo, M. K., Sandelin, W. L., & Borglin, S. (2014). Physical, chemical, and biological characteristics of compounds used in hydraulic fracturing. *Journal of Hazardous Materials*, *275*, 37–54. https://doi.org/10.1016/j.jhazmat.2014.04.040

Stringfellow, W. T., Cooley, H., Varadharajan, C., Heberger, M., Reagan, M. T., Domen, J. K., Sandelin, W., Camarillo, M. K., Jordan, P., Donnelly, K., Nicklisch, S. C. T., Hamdoun, A., & Houseworth, J. E. (2015). Impacts of Well Stimulation on Water Resources. In *An Independent Scientific Assessment of Well Stimulation in California.* California Council on Science and Technology. https://ccst.us/wp-content/uploads/160708-sb4-vol-II-2-1.pdf

Stringfellow, W. T., Camarillo, M. K., Domen, J. K., & Shonkoff, S. B. (2017). Comparison of chemical-use between hydraulic fracturing, acidizing, and routine oil and gas development. *PloS One*, *12*(4), e0175344. https://doi.org/10.1371%2Fjournal.pone.0175344

Suarez, D. L. (1989). Impact of Agricultural Practices on Groundwater Salinity. *Agriculture, Ecosystems and Environment*, *26*, 215–227. https://doi.org/10.1016/0167-8809(89)90014-5

Sumner, A. J., & Plata, D. L. (2018). Halogenation chemistry of hydraulic fracturing additives under highly saline simulated subsurface conditions. *Environmental Science & Technology*, *52*(16), 9097–9107. https://doi.org/10.1021/acs.est.8b01591

Sumner, A. J., & Plata, D. L. (2019). Oxidative breakers can stimulate halogenation and competitive oxidation in guar-gelled hydraulic fracturing fluids. *Environmental Science & Technology*, *53*(14), 8216–8226. https://doi.org/10.1021/acs.est.9b01896

Sumner, A. J., & Plata, D. L. (2020). A geospatially resolved database of hydraulic fracturing wells for chemical transformation assessment. *Environmental Science: Processes & Impacts*, *22*(4), 945–955. https://doi.org/10.1039/C9EM00505F

SWRCB (California State Water Resources Control Board). (2018). Monitoring Strategies for Constituents of Emerging Concern (CECs). In *Recycled Water Recommendations of a Science Advisory Panel Convened by the State Water Resources Control Board.* https://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/1032_CECMonitoringInRecycledWater.pdf

SWRCB. (2019). *Produced Water Ponds Status Report: January 31, 2019*. https://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/docs/pwpondsreport_january2019.pdf

SWRCB. (2021a). *Regional Groundwater Monitoring*. Regional Groundwater Monitoring. https://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/regional_monitoring/

SWRCB. (2021b). *Geotracker*. https://geotracker.waterboards.ca.gov/

SWRCB. (2021c). *California Integrated Water Quality System*. https://ciwqs.waterboards.ca.gov/ciwqs/readOnly/CiwqsReportServlet?inCommand=reset&reportName=RegulatedFacility

SWRCB. (2023). *MCLs, DLRs, PHGs, for Regulated Drinking Water Contaminants*. https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/mclreview/mcls_dlrs_phgs.pdf

Tao, F., Jiantong, L., Bangding, X., Xiaoguo, C., & Xiaoqing, X. (2005). Mobilization potential of heavy metals: A comparison between river and lake sediments. *Water, Air, and Soil Pollution, 161*(1), 209–225. https://doi.org/10.1007/s11270-005-4284-9

Thoma, E. (2009). *Measurement of Emissions from Produced Water Ponds: Upstream Oil and Gas Study #1 Final Report* (EPA/600/R-09/132). Air Pollution Prevention and Control Division, National Risk Management Research Laboratory. https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NRMRL&dirEntryId=213869

Tran, H. N. Q., Lyman, S. N., Mansfield, M. L., O'Neil, T., Bowers, R. L., Smith, A. P., & Keslar, C. (2018). Emissions of organic compounds from produced water ponds II: Evaluation of flux chamber measurements with inverse-modeling techniques. *Journal of the Air & Waste Management Association*, *68*(7), 713–724. https://doi.org/10.1080/10962247.2018.1426654

USBR (U.S. Bureau of Reclamation). (2017). *Finding of No Significant Impact: Kern-Tulare Water District Oil Field Water Reuse Project* (FONSI-15-006). https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=27516

US EPA (U.S. Environmental Protection Agency). (2002). *Exemption of Oil and Gas Exploration and Production Wastes from Federal Hazardous Waste Regulations* (EPA530-K-01–004). https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=10000M84.PDF

US EPA. (2018, May 9). *UIC Injection Well Inventory*. https://www.epa.gov/uic/uic-injection-well-inventory

US EPA. (2020). *Summary of Input on Oil and Gas Extraction Wastewater Management Practices Under the Clean Water Act* (EPA-821-S19-001). Engineering and Analysis Division, Office of Water. https://www.epa.gov/sites/default/files/2020-05/documents/oil-gas-final-report-2020.pdf

US EPA. (2022a). *CompTox Chemicals Dashboard—PFAS|EPA: PFAS structures in DSSTox (update August 2022)*. https://comptox.epa.gov/dashboard/chemical-lists/PFASSTRUCTV5

US EPA (U.S. Environmental Protection Agency). (2022b). *EPA CompTox Chemicals Dashboard—PFAS|EPA: Cross-Agency Research List*. https://comptox.epa.gov/dashboard/chemical-lists/EPAPFASRL

Utah Admin. Code R649-9-3 (2013). https://rules.utah.gov/publicat/code/r649/r649-009.htm

Veil, J. (2020). *U.S. Produced Water Volumes and Management Practices in 2017*. Ground Water Protection Council. https://www.gwpc.org/wp-content/uploads/2020/02/pw_report_2017___final.pdf

Walker, J. D. (2011). *California Class II Underground Injection Control Program Review: Final Report.* Horsley Witten Group. https://www.conservation.ca.gov/index/Documents/DOGGR%20USEPA%20consultant's%20report%20on%20CA%20underground%20injection%20program.pdf

WZI Inc. (2020). *Technical Report for NOI Lehr Lease Edison Oil Field Section 33, T29S, R29E MDB&M Kern County, California*. https://documents.geotracker.waterboards.ca.gov/esi/uploads/geo_report/2357210636/T10000008008.PDF

Xiao, M., Koppa, A., Mekonnen, Z., Pagán, B. R., Zhan, S., Cao, Q., Aierken, A., Lee, H., & Lettenmaier, D. P. (2017). How Much Groundwater Did California's Central Valley Lose During the 2012–2016 Drought? *Geophysical Research Letters*, *44*(10), 4872–4879. https://doi.org/10.1002/2017GL073333

Xiong, B., Miller, Z., Roman-White, S., Tasker, T., Farina, B., Piechowicz, B., Burgos, W. D., Joshi, P., Zhu, L., Gorski, C. A., & others. (2018). Chemical degradation of polyacrylamide during hydraulic fracturing. *Environmental Science & Technology*, *52*(1), 327–336. https://doi.org/10.1021/acs.est.7b00792

Xiong, B., Purswani, P., Pawlik, T., Samineni, L., Karpyn, Z. T., Zydney, A. L., & Kumar, M. (2020). Mechanical degradation of polyacrylamide at ultra high deformation rates during hydraulic fracturing. *Environmental Science: Water Research & Technology*, *6*(1), 166–172. https://doi.org/10.1039/C9EW00530G

Appendix E

E.1. Produced Water Dataset Compilation

Produced water datasets were cleaned and standardized for compilation. All results that were reported as zero, a non-detection qualifier (e.g., "ND"), below a detection/reporting limit (e.g., <0.05), or negative were not considered in compiled summary statistics. Results reported as a range (e.g., >100 mg/L) were removed to allow for consolidation. If no measurement value was provided for a given analysis or if the value was "NA", it was assumed that the analysis was not done. Charge balance values were included in some databases; however, data points were not removed because large charge imbalances were often due to a missing major ion analyte(s). Duplicate samples across USGS datasets were removed when both API and sample date information were available. Summary statistics, including minimum, maximum, and percentiles, for common water quality parameters and other measured constituents were then calculated. Due to inconsistent data reporting and limited availability of detection/reporting limits, well API, and sample date information across all datasets, aggregation of produced water data by well API was not possible. As such, samples taken from the same well, but on different dates were treated as separate samples for compiled summary statistics.

Table E.1. Compiled Produced Water Quality for OGD in California. Only constituents with at least one detection are listed here.

Constituents	Detections (%)	Min	Med	Max	Percentile				Units
					5th	25th	75th	95th	
General Water Quality									
Alkalinity	877 (100)	73	2,900	5,600	916	2,500	3,600	4,400	mg/L
Alkalinity as $CaCO_3$	1,490 (100)	0.34	2,800	5,800	255	2,000	3,300	4,100	mg/L
Alkalinity, total	143 (100)	100	855	6,680	256	524	1,800	2,870	mg/L
Hardness	307 (99.4)	0.2	150	8,820	2.1	5.8	506	2,970	mg/L
Specific conductance	356 (100)	29	35,000	190,476	3,790	16,150	42,000	60,210	mMhos/cm
Electrical conductivity	186 (100)	0.29	55.7	52,200	5.44	27.1	2250	8350	mMhos/cm
Total dissolved solids	4,070 (100)	28	26,000	890,000	3,250	18,000	31,000	47,000	mg/L
Salinity	279 (100)	9	3,690	97,200	50	129	20,450	30,110	mg/L
Total organic carbon	22 (95.7)	18	225	2,054	25.7	110	798	1,167	mg/L
Dissolved organic carbon	63 (100)	6.2	130	5,000	9.04	42.5	214	2,010	mg/L
Oxidation reduction potential	244 (100)	-219	192	424	-61.1	130	353	402	mV
Resistivity	862 (100)	0.08	0.37	32.4	0.19	0.25	1.02	4.09	ohm-m
Turbidity	160 (100)	0.7	100	1,000	15.8	78.9	333	973	NTU
Specific Gravity	1,317 (100)	0.99	1.02	1.22	1.002	1.01	1.024	1.04	unitless
pH	3,967 (100)	1.0	7.6	11.8	6.7	7.3	7.8	8.3	pH units

Constituents	Detections (%)	Min	Med	Max	Percentile				Units
					5th	25th	75th	95th	
Major Ions									
Bicarbonate	1,702 (99.2)	2.0	1,154	12,809	163	582	2,270	4,550	mg/L
Carbonate	329 (27.5)	1	51.6	2,250	3.76	20.4	138	447	mg/L
Bromide	2,606 (97.6)	0.19	100	16,000	28	73	130	166	mg/L
Chloride	4,211 (99.9)	1.0	14,000	360,000	408	8,670	17,000	24,980	mg/L
Sulfate	3,023 (73.8)	0.1	38	15,250	3.77	24	87.2	475	mg/L
Calcium	4,333 (99.9)	0.1	190	190,000	22	128	350	2,110	mg/L
Magnesium	4,306 (99.5)	0.08	120	10,000	6.8	67	166	457	mg/L
Potassium	3,082 (99.8)	1.2	190	52,000	33	140	300	1,400	mg/L
Sodium	4,102 (100)	4.48	8,700	120,000	870	6,200	10,400	13,000	mg/L
Inorganics									
Aluminum	55 (44.3)	0.01	0.63	2,530	0.025	0.2	2.5	518	mg/L
Antimony	253 (9.8)	10	160	17,000	30	70	260	478	µg/L
Arsenic	194 (7.6)	10	190	4,600	40	90	298	996	µg/L
Barium	3,316 (96.6)	0.01	7.7	26,300	1.0	5.1	11	55	mg/L
Beryllium	76 (2.9)	10	10	4,130	10	10	20	170	µg/L
Boron	3,289 (99.3)	0.02	92	158,000	4.2	62	105	150	mg/L
Cadmium	52 (2.0)	10	30	420	10	10	40	143	µg/L
Cesium	42 (82.3)	20	195	900	20.5	60	400	567	µg/L
Chromium	643 (25.1)	10	40	9,400	10	30	70	200	µg/L
Chromium VI	68 (3.1)	10	10	610	10	10	20	93	µg/L
Cobalt	102 (3.9)	10	30	8,510	10	10	50	344	µg/L
Copper	884 (33.6)	10	40	184,000	10	30	80	619	µg/L
Fluoride	337 (12.8)	0.03	1.4	53	0.17	0.5	3.8	23.2	mg/L
Iodine	451 (95.5)	0.1	35	294	2.2	15.6	61	136	mg/L
Iron	2,693 (91.8)	0.01	12	48,100	0.4	3.5	37	130	mg/L
Lead	240 (9.3)	10	80	30,000	10	20	170	1,200	µg/L
Lithium	2,759 (98.9)	0.004	5.8	17,500	0.99	4.15	8.3	18.1	mg/L
Manganese	2,579 (95.0)	10	480	85,7000	110	250	920	2,800	µg/L
Mercury	7 (0.3)	10	30	980	10	10	160	755	µg/L
Molybdenum	343 (13.2)	10	40	48,500	10	20	70	270	µg/L
Nickel	550 (21.5)	10	50	22,000	10	22.5	100	396	µg/L
Selenium	429 (16.7)	10	280	15,000	54	130	530	1,900	µg/L
Silver	33 (1.3)	10	50	260	10	30	60	162	µg/L
Strontium	2,886 (99.8)	0.01	11.2	190,000	2.80	7.2	16	126	mg/L

Constituents	Detections (%)	Min	Med	Max	Percentile				Units
					5th	25th	75th	95th	
Thallium	27 (1.0)	10	90	6,400	13	25	365	3,010	µg/L
Vanadium	91 (3.6)	10	70	24,000	10	45	135	1,350	µg/L
Zinc	1,017 (38.8)	10	110	243,000	30	70	250	1,920	µg/L
Silica	744 (98.5)	0.18	60	2,200	14	36	90.2	177	mg/L
Hydrogen sulfide	444 (17.1)	0.01	0.22	1,111	0.06	0.1	1	6.19	mg/L
Radionuclides/Isotopes									
Gross alpha	1,916 (81.8)	0.05	66.1	2,589	7.33	32.9	109	238	pCi/L
Gross beta	2,283 (97.6)	0.14	144	41,000	29.2	88.2	227	1,380	pCi/L
Radium-224	21 (100)	2.3	12	130	4	8	25	47.7	pCi/L
Radium-226	2,326 (98.6)	0.03	24.7	917	5.21	15.7	33.2	65.5	pCi/L
Radium-228	258 (94.8)	0.08	13	515	1.48	5.59	28.6	60.8	pCi/L
Radon	513 (71.2)	0.3	98	3,917	6	40.2	193	556	pCi/L
Radon-222	1,148 (71.5)	0.52	106.3	250,690	10.2	49	213	1,560	pCi/L
Uranium	8 (22.2)	0.28	1.84	7.03	0.44	1.25	4.37	6.84	µg/L
Nutrients									
Ammonia	158 (99.3)	1.28	27.5	2,300	7.08	17	41.0	75.5	mg/L
Ammonia (as N)	30 (100)	1.4	106	460	5.38	10.9	161	428	mg/L
Ammonium	272 (92.8)	3	138	2,560	12.2	73.8	201	377	mg/L
Nitrate	214 (8.9)	0.1	12	800	0.6	1.59	24.8	170	mg/L
Nitrate (as N)	14 (13.0)	0.1	0.89	14.4	0.1	0.17	6.05	11.5	mg/L
Nitrite	646 (28.0)	0.04	0.09	10	0.04	0.05	0.27	0.97	mg/L
Nitrite (as N)	4 (5.4)	1.99	3.78	5.8	2.01	2.11	5.49	5.74	mg/L
Nitrite, nitrate	1 (0.6)	220	220	220	220	220	220	220	mg/L
Nitrite, nitrate (as N)	37 (22.8)	0.02	0.07	8.02	0.02	0.03	0.11	2.53	mg/L
Phosphate	6 (54.5)	0.2	1.15	20.5	0.2	0.23	2.04	15.9	mg/L
Phosphate, Ortho	3 (6.8)	0.31	2.4	16.8	0.52	1.36	9.6	15.4	mg/L
Organics									
Total carbohydrates	2,041 (97.4)	1.2	97	11,000	21	53	190	560	mg/L
Guar gum	155 (89.5)	30	150	3500	36.7	79	255	1,490	mg/L
Benzene	2,293 (98.0)	10	710	25,000	80	300	1,400	3,600	µg/L
Toluene	2,307 (98.5)	10	1,900	61,000	170	885	3,000	4,970	µg/L
Ethylbenzene	2,277 (97.2)	10	250	5,300	40	140	360	670	µg/L
m-Xylenes	68 (100)	210	770	6,000	300	488	1,200	2,030	µg/L
o-Xylene	2,129 (98.3)	10	420	5,700	70	230	640	1,200	µg/L
Total Xylenes	2,307 (98.5)	10	1,200	19,000	140	570	2,000	3,800	µg/L

Constituents	Detections (%)	Min	Med	Max	Percentile				Units
					5th	25th	75th	95th	
Naphthalene	9 (75)	10	30	3,900	14	30	250	2,980	µg/L
1,2,4-Trimethylbenzene	4 (80)	250	300	3,400	255	273	1,090	2,940	µg/L
1,3,5-Trimethylbenzene	2 (40)	90	535	980	135	313	758	936	µg/L
Acetate	54 (98.1)	0.8	34	4,865	3.13	11.5	414	1,730	mg/L
Acetic acid	9 (60)	2.2	37	910	2.28	2.7	340	850	mg/L
Fuel oil No.2	6 (100)	12	28	46	14.3	21.3	40.8	45.3	mg/L
Gasoline	6 (100)	4.4	5.85	16	4.6	5.2	10.5	15	mg/L
Hydrotreated light petroleum distillate	6 (100)	4.8	34.5	150	8.6	22.8	52.3	127	mg/L
Total petroleum hydrocarbons	2 (100)	79	1,290	2,500	200	680	1,890	2,380	mg/L
Methane	2,336 (98.5)	0.006	0.74	280	0.04	0.27	1.40	3.5	mg/L
Propane	31 (93.9)	0.2	372	7,080	0.25	42.4	1,070	4,820	µg/L
p-Bromofluorobenzene	1 (100)	10	10	10	10	10	10	10	µg/L
p-Cymene	2 (40)	30	205	380	47.5	118	293	363	µg/L
n-Butylbenzene	2 (40)	20	165	310	34.5	92.5	238	296	µg/L
n-Propylbenzene	2 (40)	60	485	910	103	273	698	868	µg/L
2,2-Dibromo-3-nitrilopropionamide	52 (32.7)	5	15	20	5	10	20	20	mg/L
Gases									
Argon	21 (100)	0.012	0.029	1.92	0.012	0.015	0.153	1.89	mol %
C6+ Hydrocarbons	20 (95.2)	0.002	0.64	3.08	0.0019	0.059	1.16	1.9	mol %
Hexane, normal	3 (75)	0.03	0.25	0.29	0.052	0.14	0.27	0.29	mol %
Isobutane	18 (85.7)	0.0021	0.23	3.12	0.018	0.104	0.35	2.51	mol %
Isopentane	18 (85.7)	0.0003	0.061	1.96	0.002	0.028	0.56	1.93	mol %
n-Butane	32 (84.2)	0.0007	0.162	6.31	0.0011	0.029	0.85	4.32	mol %
Carbon dioxide	127 (96.9)	0.29	28.4	700	3.86	21.9	35.2	86.9	mg/L
Carbon monoxide	1 (4.76)	0.18	0.18	0.18	0.18	0.18	0.18	0.18	mol %
Helium	9 (69.2)	0.0058	0.0077	0.013	0.0058	0.0065	0.0095	0.012	mol %
Nitrogen	21 (100)	0.31	1.04	94.6	0.32	0.53	8.43	93.3	mol %
Oxygen	4 (100)	0.097	0.255	2.49	0.11	0.16	0.87	2.17	mol %

Abbreviations: mg/L - millgrams per liter; mMhos/cm - millimhos per centimeter; mol % - mole percent; mV – millivoit; NTU - nephelometric turbidity unit; ohm-m - ohm-metre; pCi/L - picocuries per liter; µg/L - micrograms per liter

E.2. Locations of Water Disposal Wells

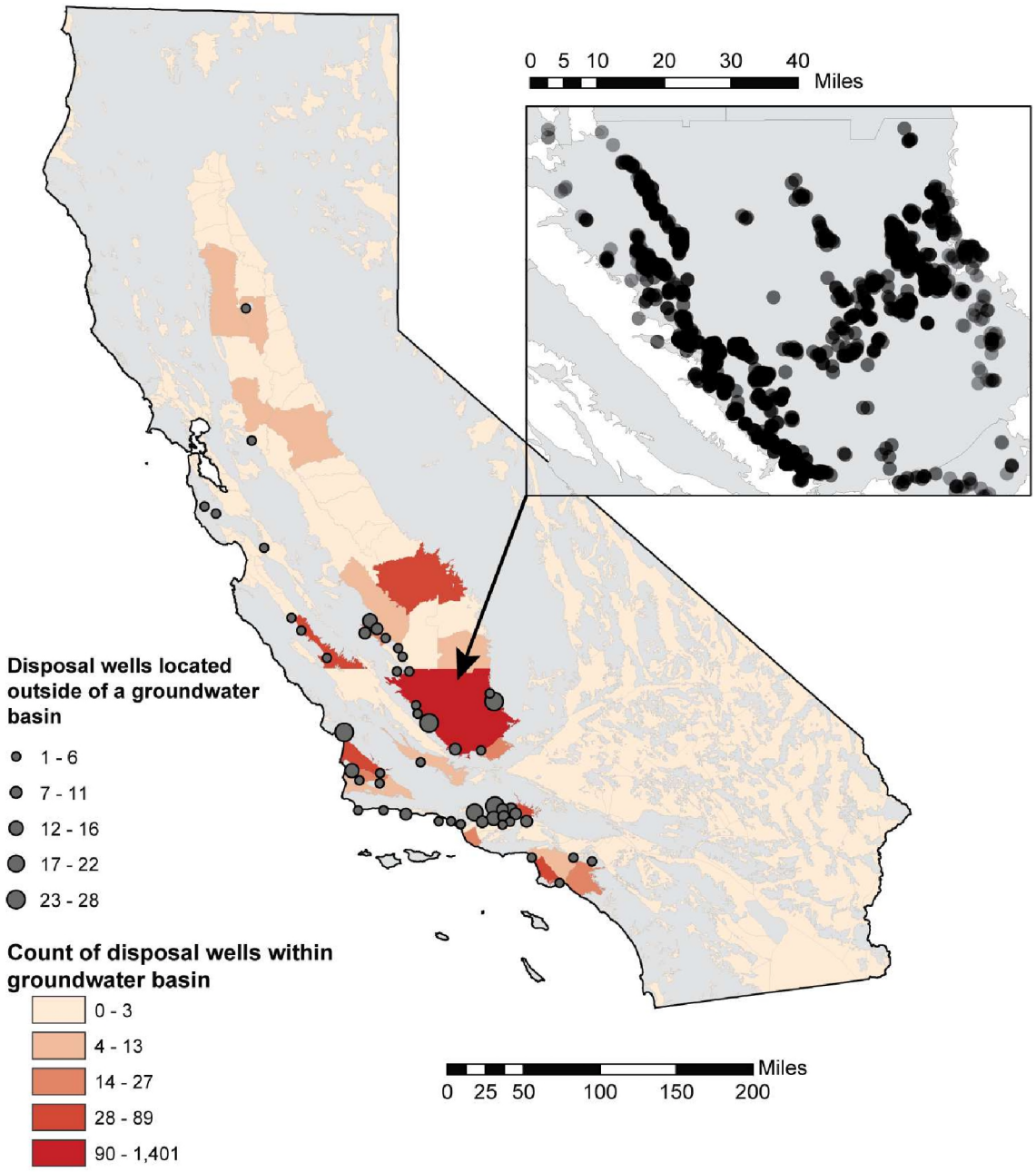


Figure E.1. Locations of all water disposal wells contained within the CalGEM "All Oil and Gas Wells" dataset (CalGEM, 2021d). Source: Groundwater basins from CADWR (2020).

E.3. Characterization of the Chemistry of Produced Water Ponds

Table E.2. Summary of produced water ponds aqueous data as measured by the California Air Resources Board. Source: Schmidt and Card (2020).

					Percentile				
Constituents	**No. of Detections**	**Min**	**Med**	**Max**	**5th**	**25th**	**75th**	**95th**	**Units**
Oil & Grease	94	1.4	13.5	660,000	2.95	7.13	28	537	mg/L
BTEX									
Benzene	86	0.1	6	1,650	0.18	0.5	70.3	838	µg/L
Ethylbenzene	84	0.11	6.45	1,600	0.22	0.95	34.3	688	µg/L
Toluene	86	0.1	3.35	1,900	0.14	0.6	25.3	550	µg/L
Total Xylenes	86	0.39	9.9	2,200	0.51	2.2	60.3	979	µg/L
p- & m-Xylenes	85	0.29	5.7	1,400	0.4	1.3	40	629	µg/L
o-Xylene	90	0.09	3.6	790	0.12	0.9	20.8	349	µg/L
Other Species									
Bromobenzene	0	--	--	--	--	--	--	--	µg/L
Bromochloromethane	0	--	--	--	--	--	--	--	µg/L
Bromodichloromethane	0	--	--	--	--	--	--	--	µg/L
Bromoform	0	--	--	--	--	--	--	--	µg/L
Bromomethane	0	--	--	--	--	--	--	--	µg/L
n-Butylbenzene	25	0.11	0.63	250	0.14	0.44	2.8	54.7	µg/L
sec-Butylbenzene	37	0.16	0.53	190	0.17	0.23	1.7	18.6	µg/L
tert-Butylbenzene	3	0.24	0.25	3.6	0.24	0.25	1.93	3.27	µg/L
Carbon tetrachloride	0	--	--	--	--	--	--	--	µg/L
Chlorobenzene	2	0.19	0.22	0.24	0.19	0.2	0.23	0.24	µg/L
Chloroethane	0	--	--	--	--	--	--	--	µg/L
Chloroform	0	--	--	--	--	--	--	--	µg/L
Chloromethane	0	--	--	--	--	--	--	--	µg/L
2-Chlorotoluene	0	--	--	--	--	--	--	--	µg/L
4-Chlorotoluene	0	--	--	--	--	--	--	--	µg/L
Dibromochloromethane	0	--	--	--	--	--	--	--	µg/L
1,2-Dibromo-3-chloropropane	0	--	--	--	--	--	--	--	µg/L
1,2-Dibromoethane	0	--	--	--	--	--	--	--	µg/L
Dibromomethane	0	--	--	--	--	--	--	--	µg/L
1,2-Dichlorobenzene	0	--	--	--	--	--	--	--	µg/L
1,3-Dichlorobenzene	0	--	--	--	--	--	--	--	µg/L
Dichlorodifluoromethane	0	--	--	--	--	--	--	--	µg/L
1,1-Dichloroethane	0	--	--	--	--	--	--	--	µg/L
1,2-Dichloroethane	0	--	--	--	--	--	--	--	µg/L
1,1-Dichloroethene	0	--	--	--	--	--	--	--	µg/L
cis-1,2-Dichloroethene	0	--	--	--	--	--	--	--	µg/L
trans-1,2-Dichloroethene	0	--	--	--	--	--	--	--	µg/L
1,2-Dichloropropane	0	--	--	--	--	--	--	--	µg/L

Constituents	No. of Detections	Min	Med	Max	Percentile 5th	25th	75th	95th	Units
1,3-Dichloropropane	0	--	--	--	--	--	--	--	µg/L
2,2-Dichloropropane	0	--	--	--	--	--	--	--	µg/L
1,1-Dichloropropene	0	--	--	--	--	--	--	--	µg/L
cis-1,3-Dichloropropene	0	--	--	--	--	--	--	--	µg/L
trans-1,3-Dichloropropene	0	--	--	--	--	--	--	--	µg/L
Hexachlorobutadiene	0	--	--	--	--	--	--	--	µg/L
Isopropylbenzene	60	0.14	1.33	240	0.15	0.46	2.71	14.2	µg/L
p-Isopropyltoluene	45	0.15	0.81	200	0.16	0.33	3.6	50.1	µg/L
Methylene chloride	0	--	--	--	--	--	--	--	µg/L
Methyl t-butyl ether	1	95.5	95.5	95.5	95.5	95.5	95.5	95.5	µg/L
Naphthalene	64	0.46	8.35	280	0.92	1.95	18	73.6	µg/L
n-Propylbenzene	62	0.11	1.15	500	0.14	0.34	2.68	16	µg/L
Styrene	0	--	--	--	--	--	--	--	µg/L
1,1,1,2-Tetrachloroethane	0	--	--	--	--	--	--	--	µg/L
1,1,2,2-Tetrachloroethane	0	--	--	--	--	--	--	--	µg/L
Tetrachloroethene	3	0.13	0.17	0.2	0.13	0.15	0.19	0.2	µg/L
1,2,3-Trichlorobenzene	0	--	--	--	--	--	--	--	µg/L
1,2,4-Trichlorobenzene	0	--	--	--	--	--	--	--	µg/L
1,1,1-Trichloroethane	0	--	--	--	--	--	--	--	µg/L
1,1,2-Trichloroethane	0	--	--	--	--	--	--	--	µg/L
Trichloroethene	1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	µg/L
Trichlorofluoromethane	0	--	--	--	--	--	--	--	µg/L
1,2,3-Trichloropropane	1	51	51	51	51	51	51	51	µg/L
1,1,2-Trichloro-1,2,2-trifluoroethane	0	--	--	--	--	--	--	--	µg/L
1,2,4-Trimethylbenzene	82	0.13	3.65	1,200	0.18	0.88	13.8	91	µg/L
1,3,5-Trimethylbenzene	69	0.12	1.1	300	0.15	0.39	3.35	19	µg/L
Vinyl chloride	0	--	--	--	--	--	--	--	µg/L

Table E.3. Summary of produced water ponds air emissions data as measured by the California Air Resources Board. Source: Schmidt and Card (2020).

					Percentile				
Constituents	**No. of Detections**	**Min**	**Med**	**Max**	**5th**	**25th**	**75th**	**95th**	**Units**
Total Non-Methane Hydrocarbons	90	65.6	5,770	47,300,000	178	1,530	37,800	288,000	C6 µg/m^3
Total Non-Methane Hydrocarbons	90	73	6,420	52,700,000	198	1,700	42,100	321,000	C1 µg/m^3
TO-14 BTEX									
Benzene	86	1.4	47.3	158,000	2.38	6.77	514	14,600	µg/m^3
Ethylbenzene	78	1.75	49.2	666,000	2.45	10.3	245	3,960	µg/m^3
Toluene	83	1.39	46.8	587,000	2.79	11.5	736	27,300	µg/m^3
m,p-Xylene	81	1.32	69.6	1,130,000	2.64	15.2	553	8,570	µg/m^3
o-Xylene	76	1.89	63.3	205,000	3.87	14.1	476	5,420	µg/m^3
TO-15 BTEX									
Benzene	88	1.47	56.7	125,000	2.94	10.1	342	11,800	µg/m^3
Ethylbenzene	57	1.5	39.2	303,000	4.27	11.1	318	2,510	µg/m^3
Toluene	75	0.92	55.7	574,000	2.93	9.94	571	19,800	µg/m^3
m,p-Xylenes	62	1.1	84.2	579,000	2.98	16.4	602	9,120	µg/m^3
o-Xylene	55	1.21	86.4	286,000	3.84	15.3	398	4,960	µg/m^3
Total Xylene	71	0	86.3	865,000	0	10.3	739	13,200	µg/m^3
Total BTEX	95	0	104	1,870,000	1.85	17.1	1,150	42,500	µg/m^3
Carbon Dioxide	40	0.01	0.05	0.41	0.02	0.02	0.13	0.32	%
Methane	88	0.47	11	1,350	1.18	2.67	117	487	ppmv
TO-14									
1,2,3-Trimethylbenzene	51	1.87	43.9	203,000	5.34	13.6	177	4,050	µg/m^3
1,2,4-Trimethylbenzene	80	2.17	38.4	164,000	2.86	9.92	249	4,830	µg/m^3
1,3,5-Trimethylbenzene	77	2.23	32.6	239,000	3.18	8.69	202	3,000	µg/m^3
1,3-Diethylbenzene	57	2.79	43.9	590,000	5.79	15.9	276	8,690	µg/m^3
1,4-Diethylbenzene	58	2.31	59.5	88,100	3.91	21.4	235	6,150	µg/m^3
1-Butene	3	2.18	9.27	32.7	2.89	5.73	21	30.4	µg/m^3
1-Pentene	4	8.94	11.2	1320	9.16	10	339	1,120	µg/m^3
2,2,4-Trimethylpentane	48	1.99	52.4	1,460,000	2.46	6.84	229	3,230	µg/m^3
2,2-Dimethylbutane	2	23.9	27.8	31.8	24.3	25.8	29.8	31.4	µg/m^3
2,3,4-Trimethylpentane	47	1.79	32.3	883,000	2.06	6.89	255	2,580	µg/m^3
2,3-Dimethylbutane	2	2.15	2.97	3.79	2.23	2.56	3.38	3.71	µg/m^3
2,3-Dimethylhexane	30	2.19	81.5	132,000	4.21	18.1	410	3,170	µg/m^3
2,3-Dimethylpentane	35	2.23	42	393,000	3.03	8.99	212	15,200	µg/m^3
2,4-Dimethylhexane	45	1.77	19.9	576,000	3.39	7.62	147	1,600	µg/m^3
2,4-Dimethylpentane	54	1.54	53.2	1,586,188	2.43	8.19	463	3,940	µg/m^3
2,5-Dimethylhexane	39	2.92	62.1	468,000	4.1	14.5	198	9,640	µg/m^3
2-Ethyltoluene	47	1.66	52.1	531,000	4.36	20.8	195	18,500	µg/m^3

					Percentile				
Constituents	No. of Detections	Min	Med	Max	5th	25th	75th	95th	Units
2-Methylheptane	41	5.37	82.1	1,520,000	13.3	34.6	259	1,990	µg/m^3
2-Methylpentane	50	2.36	65.6	1,040,000	2.85	13.1	447	2,900	µg/m^3
3-Ethyltoluene	46	3.36	31.3	297,000	4.7	16.4	173	1,840	µg/m^3
3-Methylheptane	40	5.57	67.4	614,000	7.08	34.1	135	17,600	µg/m^3
3-Methylhexane	66	1.4	42.2	1,100,000	3.53	11	319	1,050	µg/m^3
3-Methylpentane	49	1.99	23.9	816,000	2.71	7.17	190	6,410	µg/m^3
4-Ethyltoluene	64	1.49	40.9	427,000	2.7	13.7	359	3,400	µg/m^3
Acetylene	5	12.1	34.6	57.3	13.2	17.3	41.4	54.1	µg/m^3
a-Pinene	10	3.24	26.6	10,900	4.73	9.07	75.8	6,120	µg/m^3
b-Pinene	12	3.14	40.6	11,700	12.1	31.5	195	5,480	µg/m^3
c-2-Butene	0	--	--	--	--	--	--	--	µg/m^3
c-2-Pentene	5	2.13	11.6	81.7	2.13	2.13	22.9	70	µg/m^3
Cyclohexane	31	2	39.6	79,000	2.08	4.53	346	10,000	µg/m^3
Cyclopentane	1	114	114	114	114	114	114	114	µg/m^3
d-Limonene	13	2.43	22.8	14,300	3.73	12.4	168	6,920	µg/m^3
Dodecane	77	1.9	37.5	78,500	3.24	9.15	162	2,220	µg/m^3
Ethane	92	1.82	44.5	25,100	4.18	11.6	552	4,900	µg/m^3
Ethene	40	1.89	17.7	647	2.26	4.47	31.7	317	µg/m^3
i-Butane	50	2.14	19.4	31,000	2.83	7.46	155	2,450	µg/m^3
i-Pentane	63	1.54	43	405,000	2.06	6.7	237	5,150	µg/m^3
i-Propylbenzene	56	1.37	35.4	233,000	2.77	8.39	245	1,070	µg/m^3
Isoprene	1	123	123	123	123	123	123	123	µg/m^3
Methylcyclohexane	49	4.16	76.7	1,930,000	4.7	9.63	720	4,330	µg/m^3
Methylcyclopentane	15	1.46	8.07	1,590	2.17	6.04	25.3	511	µg/m^3
n-Butane	75	1.62	14.4	159,000	2.28	6.31	74.6	3,110	µg/m^3
n-Butylbenzene	27	6.43	79.2	15,200	8.11	32.5	370	2,530	µg/m^3
n-Decane	74	1.88	52.5	826,000	4.2	14.1	221	4,280	µg/m^3
n-Heptane	63	1.39	28.7	2,260,000	2.22	5.9	118	2,060	µg/m^3
n-Hexane	79	1.46	38.9	1,920,000	1.85	4.97	134	7,990	µg/m^3
n-Nonane	75	1.76	31.4	1,600,000	3.14	11.7	164	3,390	µg/m^3
n-Octane	79	1.98	30.1	1,910,000	2.64	7.16	130	1,410	µg/m^3
n-Pentane	85	1.81	21.1	790,000	2.75	6.17	157	11,300	µg/m^3
n-propylbenzene	54	2.16	28.5	188,000	3.51	12.6	278	1,340	µg/m^3
Propane	84	3.02	42.4	10,500	3.55	9.86	299	4,640	µg/m^3
Propene	6	3.9	29.1	37.1	9.7	27.5	34	36.7	µg/m^3
Styrene	34	3.63	26	1140	4.17	11.1	113	1,010	µg/m^3
t-2-Butene	1	17.2	17.2	17.2	17.2	17.2	17.2	17.2	µg/m^3
t-2-Pentene	7	3.84	21.5	198	5.91	11	39.1	154	µg/m^3
Undecane	78	1.58	46.1	374,000	2.41	9.38	201	5,900	µg/m^3

Constituents	No. of Detections	Min	Med	Max	Percentile 5th	25th	75th	95th	Units
TO-15									
1,1,1-Trichloroethane	0	--	--	--	--	--	--	--	µg/m^3
1,1,2,2-Tetrachloroethane	1	2.56	2.56	2.56	2.56	2.56	2.56	2.56	µg/m^3
1,1,2-Trichloroethane	2	870	4340	7,820	1,220	2,610	6,080	7470	µg/m^3
1,1-Dichloroethane	0	--	--	--	--	--	--	--	µg/m^3
1,1-Dichloroethene	4	6.14	16.9	53.5	6.14	6.15	34.2	49.7	µg/m^3
1,2,4-Trichlorobenzene	0	--	--	--	--	--	--	--	µg/m^3
1,2,4-Trimethylbenzene	50	1.22	28.1	210,000	3.71	12.9	327	9,800	µg/m^3
1,2-Dibromoethane	2	5	14.9	24.9	5.99	9.96	19.9	23.9	µg/m^3
1,2-Dichlorobenzene	4	1.44	4.81	9.84	1.78	3.16	6.87	9.25	µg/m^3
1,2-Dichloroethane	0	--	--	--	--	--	--	--	µg/m^3
1,2-Dichloropropane	0	--	--	--	--	--	--	--	µg/m^3
1,3,5-Trimethylbenzene	31	1.46	23.3	55,800	2.56	7.03	178	7,090	µg/m^3
1,3-Butadiene	0	--	--	--	--	--	--	--	µg/m^3
1,3-Dichlorobenzene	0	--	--	--	--	--	--	--	µg/m^3
1,4 Dioxane	1	38.4	38.4	38.4	38.4	38.4	38.4	38.4	µg/m^3
1,4-Dichlorobenzene	0	--	--	--	--	--	--	--	µg/m^3
2-Butanone	53	2.69	367	34,200	6.56	49.6	3230	10,800	µg/m^3
2-Hexanone	18	2.56	39.7	743	6.44	13.5	143	359	µg/m^3
2-propanol	25	7.38	96	1,900	8.92	32.8	346	1,140	µg/m^3
4-Ethyltoluene	33	2.33	22	214,000	4.42	8.45	428	23,700	µg/m^3
4-Methyl-2-pentanone	16	6.45	25.4	500	7.08	10.7	38.7	357	µg/m^3
Acetone	77	4.74	435	49,100	10.9	90.4	2,960	15,800	µg/m^3
Benzyl chloride	2	2.25	7.88	13.5	2.81	5.07	10.7	12.9	µg/m^3
Bromochloromethane	0	--	--	--	--	--	--	--	µg/m^3
Bromodichloromethane	0	--	--	--	--	--	--	--	µg/m^3
Bromoform	0	--	--	--	--	--	--	--	µg/m^3
Bromomethane	6	3	20.9	26.9	4.89	12.2	25.8	26.7	µg/m^3
Carbon disulfide	29	4.91	58.5	1,000	10.3	22.7	190	523	µg/m^3
Carbon tetrachloride	0	--	--	--	--	--	--	--	µg/m^3
Chlorobenzene	1	71.3	71.3	71.3	71.3	71.3	71.3	71.3	µg/m^3
Chloroethane	0	--	--	--	--	--	--	--	µg/m^3
Chloroform	0	--	--	--	--	--	--	--	µg/m^3
Chloromethane	7	0.83	18.9	77.3	1.24	8.01	35.9	69.9	µg/m^3
cis-1,2-Dichloroethene	0	--	--	--	--	--	--	--	µg/m^3
cis-1,3-Dichloropropene	0	--	--	--	--	--	--	--	µg/m^3
Cyclohexane	6	1.33	841	124,000	111	449	1,700	93,300	µg/m^3
Dibromochloromethane	0	--	--	--	--	--	--	--	µg/m^3
Dichlorodifluoromethane	0	--	--	--	--	--	--	--	µg/m^3
Dichloromethane	0	--	--	--	--	--	--	--	µg/m^3
Ethanol	8	3.76	30.9	986	4.94	8.34	90.6	717	µg/m^3

Constituents	No. of Detections	Min	Med	Max	Percentile 5th	25th	75th	95th	Units
Ethyl acetate	0	--	--	--	--	--	--	--	µg/m^3
Freon 113	0	--	--	--	--	--	--	--	µg/m^3
Freon 114	0	--	--	--	--	--	--	--	µg/m^3
Hexachlorobutadiene	0	--	--	--	--	--	--	--	µg/m^3
Methyl methacrylate	2	4.12	4.16	4.19	4.12	4.14	4.17	4.19	µg/m^3
Methyl tert butyl ether	0	--	--	--	--	--	--	--	µg/m^3
Naphthalene	36	0.83	11	2,410	1.02	3.62	26.2	836	µg/m^3
n-Heptane	16	23.6	221	2,040,000	31.7	53.2	871	1,030,000	µg/m^3
Styrene	4	5.74	68.1	3,120	5.79	5.99	877	2,670	µg/m^3
Tetrachloroethene	3	3.74	64.9	234	9.85	34.3	149	217	µg/m^3
Tetrahydrofuran	0	--	--	--	--	--	--	--	µg/m^3
trans-1,2-Dichloroethene	0	--	--	--	--	--	--	--	µg/m^3
trans-1,3-Dichloropropene	2	9.31	78.9	148	16.3	44.1	114	142	µg/m^3
Trichloroethene	0	--	--	--	--	--	--	--	µg/m^3
Trichlorofluoromethane	0	--	--	--	--	--	--	--	µg/m^3
Vinyl acetate	3	18.7	394	2,640	56.2	206	1,510	2,410	µg/m^3
Vinyl chloride	0	--	--	--	--	--	--	--	µg/m^3

E.4. Counts of Produced Water Ponds by Location and Status

Table E.4. Oil and gas fields having produced water ponds from DiGiulio et al. (2021).

Field Name	Field Code	County	Irrigation Pond	Unlined Active Pond	Unlined Inactive Pond	Unlined Closed Pond	Lined Active Pond	Lined Inactive Pond	Lined Closed Pond	Lined or Unlined Inactive Pond	Lined or Unlined Active Pond	Lined or Unlined Closed	Unidentified	Total Ponds	GW Subbasin
Northeastern Area of Kern Subbasin															
Jasmin	328	Kern	0	7	10	2	0	0	3	0	0	0	0	22	Kern
Kern Bluff	336	Kern	0	0	3	0	0	0	0	3	0	0	0	6	Kern
Kern Front	338	Kern	1	14	35	0	0	0	0	6	1	0	0	57	Kern
Kern River	340	Kern	0	0	13	2	0	0	0	0	0	2	0	17	Kern
Mount Poso	488	Kern	9	6	15	1	0	0	0	4	2	0	0	37	Kern
Poso Creek	566	Kern	19	0	17	6	0	2	2	3	0	1	0	50	Kern
Round Mountain	628	Kern	0	0	17	0	0	3	0	1	0	0	0	21	Kern
Area Summary			**29**	**27**	**110**	**11**	**0**	**5**	**5**	**17**	**3**	**3**	**0**	**210**	
Central Eastern Area of Kern Subbasin															
Ant Hills	018	Kern	0	0	1	0	0	3	0	0	0	0	0	4	Kern
Edison	222	Kern	0	6	43	7	3	1	0	0	1	30	0	91	Kern
Edison, Northeast	224	Kern	0	0	0	0	0	0	0	0	1	0	0	1	Kern
Fruitvale	256	Kern	0	0	11	2	0	0	0	1	0	0	0	14	Kern
Mountain View	490	Kern	0	0	25	60	0	2	4	0	0	4	0	95	Kern
Rosedale Ranch	626	Kern	0	0	1	0	0	0	0	0	0	0	0	1	Kern
Area Summary			**0**	**6**	**81**	**69**	**3**	**6**	**4**	**1**	**2**	**34**	**0**	**206**	
Central Area of the Kern Subbasin															
Bellevue	044	Kern	0	0	4	0	0	0	0	0	0	0	0	4	Kern
Canal	104	Kern	0	0	0	0	0	4	0	0	0	0	0	4	Kern
Canfield Ranch	106	Kern	0	0	0	0	0	1	0	0	0	5	0	6	Kern
Greeley		Kern	0	0	0	0	0	0	0	0	0	0	0	0	Kern
Rio Bravo	602	Kern	0	0	0	0	0	3	0	0	0	0	0	3	Kern
Semitropic	690	Kern	0	0	1	11	0	0	0	0	0	1	0	13	Kern
Strand	787	Kern	0	0	8	2	0	0	0	0	0	0	0	10	Kern
Stockdale	786	Kern	0	0	2	0	0	0	0	0	0	0	0	2	Kern
Ten Section	766	Kern	0	0	0	0	0	0	0	0	0	2	0	2	Kern
Wasco	822	Kern	0	0	0	1	0	0	0	0	0	0	0	1	Kern
Area Summary		**Kern**	**0**	**0**	**15**	**14**	**0**	**8**	**0**	**0**	**0**	**8**	**0**	**45**	
West Central Area of the Kern Subbasin															
Coles Levee North	156	Kern	0	0	7	0	0	0	0	0	0	0	0	7	Kern
Coles Levee South	158	Kern	0	0	7	0	0	1	0	0	0	0	0	8	Kern
Area Summary			**0**	**0**	**14**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**15**	
South Central Area of the Kern Subbasin															
Comanche Point	160	Kern	0	0	4	0	0	0	0	0	0	0	0	4	Kern
Landslide	375	Kern	0	0	1	0	0	0	0	0	0	0	0	1	
San Emido Nose		Kern	0	0	0	0	0	0	0	0	0	0	0	0	Kern

Field Name	Field Code	County	Irrigation Pond	Unlined Active Pond	Unlined Inactive Pond	Unlined Closed Pond	Lined Active Pond	Lined Inactive Pond	Lined Closed Pond	Lined or Unlined Inactive Pond	Lined or Unlined Active Pond	Lined or Unlined Closed	Unidentified	Total Ponds	GW Subbasin
Tejon	752	Kern	0	0	5	6	0	4	3	0	0	0	0	18	Kern
Tejon Hills	756	Kern	0	0	3	4	0	0	0	0	0	0	0	7	Kern
Tejon North	758	Kern	0	0	1	0	0	0	0	0	0	0	0	1	Kern
Wheeler Ridge	832	Kern	0	0	0	0	0	0	0	0	0	1	0	1	Kern
Valpredo	808	Kern	0	0	0	0	0	0	0	2	0	0	0	2	Kern
Yowlumne		Kern	0	0	0	0	0	0	0	0	0	0	0	0	Kern
Area Summary			**0**	**0**	**14**	**10**	**0**	**4**	**3**	**2**	**0**	**1**	**0**	**34**	
Western Area of the Kern Subbasin															
Antelope Hills	020	Kern	0	18	4	0	0	0	0	0	0	0	0	22	Kern
Antelope Hills North	022	Kern	0	0	4	0	0	0	0	0	0	0	0	4	Kern
Asphalto	032	Kern	0	19	6	1	0	0	0	1	1	0	0	28	Kern
Belgian Anticline	042	Kern	0	85	1	0	0	0	0	1	0	0	0	87	Kern
Blackwells Corner	060	Kern	0	0	0	6	0	0	0	0	0	1	0	7	Kern
Carneros Creek	117	Kern	0	8	2	0	0	0	0	0	0	0	0	10	Kern
Chico-Martinez	140	Kern	0	3	2	0	0	0	0	0	0	0	0	5	Kern
Cymric	190	Kern	0	22	92	0	0	0	0	4	2	3	0	123	Kern
Devils Den	204	Kern	0	4	8	5	0	1	0	0	0	0	0	18	Kern
Elk Hills	228	Kern	0	1	30	0	0	0	0	0	0	0	0	31	Kern
Lost Hills	432	Kern	0	4	9	8	3	0	0	3	0	0	0	27	Kern
Lost Hills Northwest	434	Kern	0	0	0	0	0	0	0	3	0	0	0	3	Kern
McDonald Anticline	450	Kern	0	3	3	19	0	2	0	0	0	0	0	27	Kern
McKittrick	454	Kern	0	4	6	0	0	0	0	2	0	0	0	12	Kern
Belridge North	050	Kern	0	3	5	25	4	0	0	1	0	0	80	118	Kern
Belridge South	052	Kern	0	2	14	198	17	2	0	0	0	5	0	238	Kern
Temblor Ranch	762	Kern	0	0	0	0	0	0	0	2	0	0	0	2	Kern
Welcome Valley	826	Kern	0	0	1	1	0	0	0	0	0	0	0	2	Kern
Area Summary			**0**	**176**	**187**	**263**	**24**	**5**	**0**	**17**	**3**	**9**	**80**	**764**	
Southwestern Area of the Kern Subbasin															
Buena Vista	080	Kern	0	0	4	9	0	0	0	0	0	0	0	13	Kern
Midway-Sunset	102	Kern	0	219	53	7	11	4	0	19	5	5	15	338	Kern
Area Summary			**0**	**219**	**57**	**16**	**11**	**4**	**0**	**19**	**5**	**5**	**15**	**351**	
Tule Subbasin															
Deer Creek	194	Tulare	0	23	6	3	0	0	0	0	1	3	0	36	Tule
Deer Creek North	196	Tulare	0	0	3	0	0	0	0	0	0	0	0	3	Tule
Area Summary			**0**	**23**	**9**	**3**	**0**	**0**	**0**	**0**	**1**	**3**	**0**	**39**	
Pleasant Valley and Westside Subbasins															
Coalinga	150	Fresno	0	22	22	44	2	1	2	2	7	4	0	106	Pleasant Valley/ Westside

Field Name	Field Code	County	Irrigation Pond	Unlined Active Pond	Unlined Inactive Pond	Unlined Closed Pond	Lined Active Pond	Lined Inactive Pond	Lined Closed Pond	Lined or Unlined Inactive Pond	Lined or Unlined Active Pond	Lined or Unlined Closed	Unidentified	Total Ponds	GW Subbasin
Coalinga, East Extension	152	Fresno	0	0	7	5	0	0	0	0	0	4	0	16	Westside
Guijarral Hills	288	Fresno	0	0	2	3	0	0	0	1	0	0	0	6	Pleasant Valley
Jacalitos	326	Fresno	0	0	0	3	0	0	0	0	0	0	0	3	Pleasant Valley
Area Summary			**0**	**22**	**31**	**55**	**2**	**1**	**2**	**3**	**7**	**8**	**0**	**131**	
Kettleman Plain Subbasin															
Pyramid Hills	578	Kings	0	11	9	14	1	0	0	0	6	0	0	41	Kettleman Plain
Helm	300	Fresno	0	0	1	1	0	1	2	0	0	0	0	5	Kings
Raisin City	584	Fresno	0	0	1	0	2	1	26	1	0	5	0	36	Kings
Riverdale	613	Fresno	0	0	0	1	0	0	1	0	0	0	0	2	Kings
Area Summary			0	11	11	16	3	2	29	1	6	5	0	84	
Total Pond Summary			**29**	**484**	**529**	**457**	**43**	**36**	**43**	**60**	**27**	**76**	**95**	**1879**	

E.5. Populations Living in Proximity to Produced Water Ponds

Table E.5. Total populations living within buffer distance of produced water disposal features.

Buffer Distance	Population Living Within Distance of a Pond	Population Living Within Distance of an Active Pond	Population Living Within Distance of a Disposal Well	Population Living Within Distance of Water Infrastructure
500 ft (152 m)	12,902	2,724	4,346	7,058
1,000 ft (305 m)	61,517	13,274	20,695	33,253
1,500 ft (457 m)	138,650	32,545	50,493	80,099
2,000 ft (610 m)	235,002	63,069	93,664	149,654
2,500 ft (762 m)	343,479	98,616	150,377	236,921
3,281 ft (1 km)	544,644	167,641	261,320	402,463
5,280 ft (1.61 km)	1,226,568	467,156	681,756	1,023,614

E.6. County Level Spill Counts

Table E.6. Breakdown of spills of crude oil, produced water, and a mixture of both by county. Source: Table S1 from Rossi et al. (2022).

County	Crude oil spills		Produced water spills		Mixture spills	
	Count	%	Count	%	Count	%
Alameda	1	0.04	1	0.1		
Colusa					1	0.3
Contra Costa	21	0.9			3	1.0
Fresno	54	2.3	22	2.1	10	3.5
Kern	1,165	50.7	665	64.6	126	43.8
Kings	12	0.5	3	0.3	2	0.7
Los Angeles	383	16.7	117	11.4	77	26.7
Madera	1	0.04				
Merced	1	0.04				
Monterey	34	1.5	27	2.6	11	3.8
Orange	63	2.7	28	2.7	8	2.8
Placer	10	0.4				
Riverside	1	0.04	1	0.10		
San Benito	1	0.04				
San Bernardino	39	1.7				
San Diego	1	0.04				
San Francisco	1	0.04				
San Joaquin	8	0.3	1	0.1		
San Luis Obispo	18	0.8	4	0.4		
Santa Barbara	271	11.8	108	10.5	32	11.1
Shasta	1	0.04				
Solano	5	0.2	2	0.2		
Stanislaus	1	0.04				
Sutter			5	0.5		
Tulare	3	0.1	1	0.1		
Ventura	204	8.9	44	4.3	18	6.3
Total	2,299		1,029		2,88	

CHAPTER SIX

Legacy Oil and Gas Infrastructure: Implications for Public Health

Table of Contents

6.0. Abstract **1**

6.1. Introduction **1**

6.2. Idle, Idle-deserted, and Abandoned Wells and Associated Infrastructure in California **2**

6.2.1. Clarification of terminology for these well types **2**

6.2.2. Number and Location of Abandoned Wells in California **3**

6.2.3. Number and Location of Idle and Idle-deserted Wells in California **4**

6.2.4. Number and Location of Legacy Pipelines and Associated Infrastructure **8**

6.3. Health and Safety Hazards, Risks and Impacts Associated with Idle, Idle-deserted and Abandoned Wells **9**

6.3.1. Air Pathways **11**

6.3.1.1 Volatile Organic Compounds and Toxic Air Contaminants **13**

6.3.2. Water Pathways **14**

6.3.3. Idle, Idle-deserted, or Abandoned Wells Examined in the Epidemiological Literature **16**

6.3.3.1 Epidemiological studies conducted in California **16**

6.3.3.2 Epidemiological studies conducted outside of California **17**

6.3.4. Regulations **17**

6.4. Health and Safety Hazards, Risks and Impacts Associated with Legacy Infrastructure **19**

6.4.1. Hazards Associated with Legacy Abandoned Pipelines and Infrastructure **20**

Abandoned Pipelines and Infrastructure: TENORM/NORM **22**

6.4.1.1 Abandoned Pipelines and Infrastructure: PCBs **26**

6.4.1.2 Abandoned Pipelines and Infrastructure: Asbestos **27**

6.4.1.3 Incidents from Abandoned Pipelines **28**

6.4.2. Pipeline Abandonment Regulations **28**

Pipeline Abandonment Regulations in Other Regions **30**

6.4.2.1 Framework for Pipeline and Infrastructure Abandonment **30**

6.5. Discussion **31**

6.5.1. Lack of Data Collection Relevant to Assessing Health and Safety Risks **31**

6.5.2. Locations of Idle and Abandoned Wells and Safety Concerns in Densely Populated Areas **32**

6.5.3. Economic Issues Associated with Idle, Idle-deserted, and Legacy Abandoned Wells **33**

6.6. Summary **33**

References **35**

Figures

Figure 6.1. Total number of abandoned wells (millions) in the United States. Source: US EPA (2022a). 3

Figure 6.2. Location of active, idle, and plugged wells in California. Source: Adapted from Lebel et al. (2020). 6

Figure 6.3. Location of likely idle-deserted wells (referred to in this report as "orphaned") and wells at high risk of becoming idle-deserted in California. Source: CCST (2018). 7

Figure 6.4. Net change in the number of oil and gas wells producing each month compared to the same month from the prior year. Positive values indicate a net increase in the number of wells producing, and negative values indicate that fewer wells were producing over the same month in the previous year. Source: Production data reported by CalGEM from 2018–2021 (CalGEM, 2022b). 8

Figure 6.5. Potential leakage pathways for plugged and abandoned wells. (1) Between cement and surrounding formation; (2) between casing and cement; (3) between cement plug and casing/production tubing; (4) through cement plug; (5) through cement; (6) across cement and then between cement and casing; and (7) along a sheared wellbore. Source: Alboiu and Walker, (2019). 11

Tables

Table 6.1. Number of wells in California according to well status from the CalGEM "All Wells" Dataset as of September 8, 2022. In addition to the well types already discussed, "New" means a well has been recently permitted and is in the process of being drilled and "Canceled" means that the well permit was canceled and no well was drilled. 4

Table 6.2. Mean methane emissions from various well types in California when emissions were detected. Source: Lebel et al. (2020) 12

Table 6.3. Possible contaminants that may be released into the environment by abandoned oil and gas pipelines. Source: Adapted from Thorne et al. (1996). 21

Table 6.4. Summary of regulations concerning NORM or TENORM thresholds for waste management and disposal. Source: Adapted from Thompson et al. (2015)..... 24

Table 6.5. Summary of provisions for in-place abandonment of gas pipeline systems containing PCBs ≥50 ppm under EPA TSCA (40 C.F.R. § 761.60(b)(5)). 29

6.0. Abstract

In this chapter, the potential hazards, exposure pathways, impacts to human health, and data gaps related to abandoned and idled wells and other associated legacy oil and gas infrastructure in the state of California are examined. Data from the California Geologic Energy Management Division (CalGEM) provided the basis to examine the current number of indexed idle and abandoned wells and overall trends in the number of producing wells from the period of 2019–2021. According to CalGEM's records, there are approximately 41,100 idle wells and 128,900 abandoned wells in the state; however, multiple studies suggest that the number of abandoned wells may be significantly greater than those indexed by CalGEM. Current trends in the number of producing wells indicates a year-over-year decrease in the number of producing wells from 2018–2021. The number of idle and abandoned wells is expected to increase as more wells reach their end of life or become no longer economically viable.

Few studies have examined emissions of hazardous air pollutants from idle or abandoned wells; however, it is likely that anytime there exists a pathway for gas to escape to the atmosphere, there is also the potential for co-occurring volatile organic compounds (VOCs) and other toxic air contaminants (TACs) to be released. A review of the epidemiological literature revealed insufficient information to draw conclusions about the potential health risks associated with proximity to inactive wells, abandoned wells, and other legacy oil and gas infrastructure.

Hazards associated with the in-place abandonment of pipelines include the release of residual oil and gas compounds, treatment chemicals, naturally occurring radioactive materials (NORM), technologically enhanced naturally occurring radioactive materials (TENORM), polychlorinated biphenyls (PCBs), and asbestos. A number of states have developed or are developing regulations on the disposal of TENORM associated with oil and gas development — California is not one of them. Despite existing regulations for pipeline abandonment, leaks from improperly abandoned pipelines in California have resulted in occupational exposures and threats to nearby communities.

Significant knowledge gaps surrounding the number and location of idle-deserted and abandoned wells and abandoned legacy pipelines remain. Studies of emissions from idle, inactive, and abandoned wells in the state remain limited. The extent of PCB contamination, TENORM/NORM buildup, and presence of asbestos in pipeline coatings in legacy infrastructure in California is unknown.

6.1. Introduction

California has a long history of drilling for oil and gas. The first commercial oil well in California was drilled in 1876, just 17 years after the discovery of oil in Pennsylvania. This well was located in Pico Canyon near Santa Clarita, and initially produced 25 barrels of oil per day, increasing to 150 barrels per day after drilling deeper (AOGHS, 2020). However, as is typical for most wells, this well's production slowed with time, and then the well ceased its production and eventually

required abandonment.

In 2022, more than 146 years later, 58,000 wells are actively producing across California. An additional 41,100 wells are currently idle, often because they do not produce enough oil or gas to be economically viable, and 128,900 wells have gone through their lifecycle and have been plugged and abandoned **(Table 6.1)**. This chapter addresses the potential hazards, impacts to human health, research findings, and data gaps related to these abandoned and idle wells and other associated legacy oil and gas infrastructure.

6.2. Idle, Idle-deserted, and Abandoned Wells and Associated Infrastructure in California

6.2.1. Clarification of terminology for these well types

States and countries use different nomenclature systems to refer to oil and gas wells at various stages of their lifecycles. Here, we briefly explain the terms used in California and in this report as defined in the California Public Resource Codes and by the California Geologic Energy Management Division (CalGEM) to provide clarity in the subsequent sections of this report.

An active well is a well that has been drilled and completed and has been used for oil or gas production, enhanced oil recovery, reservoir pressure management, or injection of waste or other fluids within the past 24 months. "Idle well" means any well that for a period of 24 consecutive months has not either produced oil or natural gas, produced water to be used in production stimulation, or been used for enhanced oil recovery, reservoir pressure management, or injection (Cal. Pub. Res. Code § 3008, 2018). Unlike abandoned wells, idle wells can be returned to production and injection. An idle well continues to be an idle well until it has been properly abandoned in accordance with California Public Resources Code (P.R.C.) § 3208 (2017) or it has been shown to the Division's satisfaction that, since the well became an idle well, the well has for a continuous six-month period either maintained production of oil or natural gas, maintained production of water used in production stimulation, or been used for enhanced oil recovery, reservoir pressure management, or injection (P.R.C. § 3008, 2018). An "idle-deserted well" is defined as "an oil and gas well determined by the supervisor to be deserted under [Public Resources Code] [s]ection 3237 and for which there is no operator responsible for its plugging and abandonment under [Public Resources Code] [s]ection 3237" (P.R.C. § 3251, subd. (e).

There are factors such as loss of economic viability that will result in an operator's decision to plug and abandon a well at its own cost according to California's plugging and abandonment standards. The state is responsible for the cost of plugging idle-deserted wells because there is no operator responsible for their plugging and abandonment under P.R.C. § 3237 Abandonment of a well is permanent; wells which are abandoned do not start producing again. Current plugging and abandonment procedures focus on preventing pollutants from reaching the surface or entering subsurface groundwater. The current abandonment standards have remained relatively unchanged since 1978 and are further described in Section 6.3.4 (CCST, 2018). Wells plugged

prior to these modern plugging requirements were regulated under much less stringent standards. Prior to regulations from the Department of Conservation, some legacy abandoned wells were not plugged at all. Because many of these wells could be undocumented by CalGEM in their current system, there is a concern that they are not included in total wells counts.

The total number of abandoned wells in the United States is estimated at more than 3 million and increasing (US EPA, 2022a). In the United States, more than three-quarters of the abandoned wells are oil wells with the remaining wells gas wells. As can be seen in **Figure 6.1**, most of the abandoned wells are unplugged but not necessarily leaking.

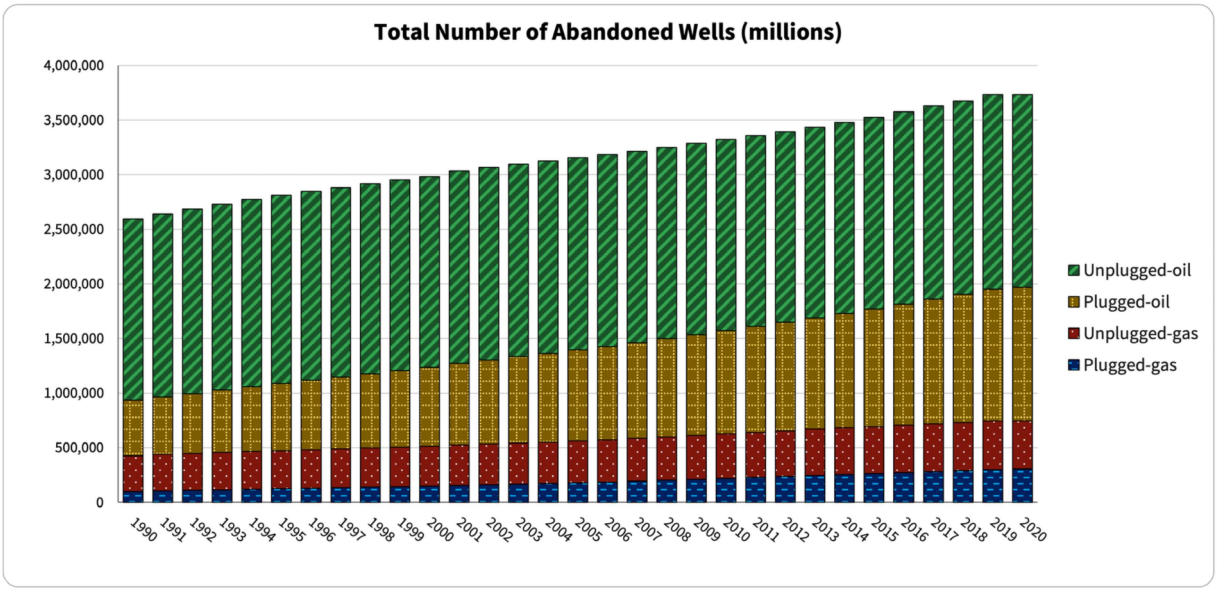


Figure 6.1. Total number of abandoned wells (millions) in the United States. Source: US EPA (2022a).

6.2.2. Number and Location of Abandoned Wells in California

Well status and location data were obtained from the CalGEM "All Wells" dataset (CalGEM, 2022a); numbers of wells of each category are shown in **Table 6.1**. As of September 2022, there were approximately 129,000 plugged and abandoned wells in California. Abandoned wells are located throughout the state but are at greatest density in the Central Valley, Los Angeles Basin, and the Sacramento regions (**Figure 6.2**). In California, nonassociated gas (gas produced without oil) is typically produced in the northern part of the state, while associated gas (gas produced as byproduct of oil production) is most common in Southern California.

The California Council on Science and Technology (CCST) estimated that approximately 41,000 abandoned wells were plugged before modern requirements went into effect in 1978, increasing the risk that some abandoned wells may need to be "re-abandoned" in the future (CCST, 2018). Inadequate abandonment practices in the early 20th century included using trash, telephone poles, logs, and rocks to block up wells (California State Lands Commission, 2017). Ongoing projects are working to identify and properly plug these legacy abandoned wells throughout the

state (e.g., the Coastal Hazards and Legacy Oil and Gas Well Removal and Remediation Program).

The actual number of abandoned wells in California may be significantly higher than reported in the CalGEM dataset. There is a long history of drilling for oil in California, going back to the late 1800s; contemporaneous records of drilling and abandoning are not available for many of these legacy wells (California State Lands Commission, 2020). A study by Lebel et al. (2020) suggested that the number of abandoned wells in California may be underreported by 17% based on a comparison of CalGEM data with historical U.S. Geological Survey (USGS) maps from the 1940s. Another study by Williams et al. (2021) suggested that abandoned oil and gas wells in California total approximately 200,000.

Table 6.1. Number of wells in California according to well status from the CalGEM "All Wells" Dataset as of September 8, 2022. In addition to the well types already discussed, "New" means a well has been recently permitted and is in the process of being drilled and "Canceled" means that the well permit was canceled and no well was drilled.

Well Status	Count
Plugged and Abandoned	128,864
Idle	41,069
Active	58,011
Canceled	9,286
New	3,722
Plugged Only	186
Unknown*	37

*Well status not known; mostly older wells dated pre-1976.

6.2.3. Number and Location of Idle and Idle-deserted Wells in California

Approximately 41,100 wells are listed as idle in the CalGEM database. Long-term idle wells were not differentiated from other idle wells in the database; however, according to the most recent Idle Well Program report, 17,560 idle wells met the definition of long-term idle at some point in 2019 (CalGEM, 2021). The locations of active, idle, and plugged wells are shown in **Figure 6.2**. Idle wells are generally located in the same regions as active wells. Because idle production wells must be non-producing for a 24-month period, there is an inherent lag between when production stops and a well is categorized as idle. There is also a period between when an idle well starts producing and when it is considered an active well, however, this is only a six-month period. Active wells are not all producing wells and can be injectors, underground gas storage, or observation wells as well. Given the issues noted in this paragraph, the true number of wells that are not actively producing at any given time may not be reliably estimated in CalGEM's "All Wells" dataset.

An idle-deserted well refers to an oil and gas well determined by the supervisor to be deserted under P.R.C. § 3237 and for which there is no operator responsible for its plugging and abandonment under P.R.C. § 3237. Although CalGEM maintains a list of idle wells, they have not historically monitored operator solvency (CCST, 2018). CalGEM is currently in the process of identifying idle-deserted wells under its Well Abandonment Program. In order to consider a well idle-deserted, CalGEM must (1) determine if a well is deserted by the operator, and (2) perform a financial solvency test to determine if any there are any solvent entities responsible for plugging the well (CalGEM, 2021). In the Idle Well Program report covering the reporting period of January 1, 2019, to December 31, 2019, CalGEM identified 24 idle-deserted wells and an additional 3,265 wells that are deserted or potentially deserted (CalGEM, 2021). The process of determining if a well (or group of wells) is idle-deserted, or if there is a solvent responsible entity, takes approximately four to six months (CalGEM, 2021).

A study by CCST (2018) identified idle-deserted (referred by CCST as orphaned) and likely idle-deserted wells using the following criteria:

- **Likely idle-deserted wells**: wells with no production or injection in past five years and belong to operators with no California production in past five years.
- **Wells at high risk of becoming idle-deserted wells**: wells with no production or injection in past five years and the operator is small and operates primarily idle and marginal wells.
- **Other idle and economically marginal wells**: wells producing <5 barrels of oil equivalent per day

CCST estimated 2,565 wells in California are likely idle-deserted wells and another 2,975 are at high risk of becoming idle-deserted wells in the near future. A further 69,425 economically marginal or idle wells are at risk of becoming idle-deserted wells in the future due to declining production or if acquired by financially weak operators. The locations of these wells are shown in **Figure 6.3**.

Based on 2019 data provided to the Interstate Oil and Gas Compact Commission, there are an estimated 4,844 idle-deserted wells in California (Interstate Oil and Gas Compact Commission, 2020). For comparison, another study by Nelson and Fisk (2021) estimated that there were approximately 1,400 idle-deserted wells in California in 2006. **Figure 6.4** shows the net change of number of oil and gas wells producing each month compared to the same month from the prior year.

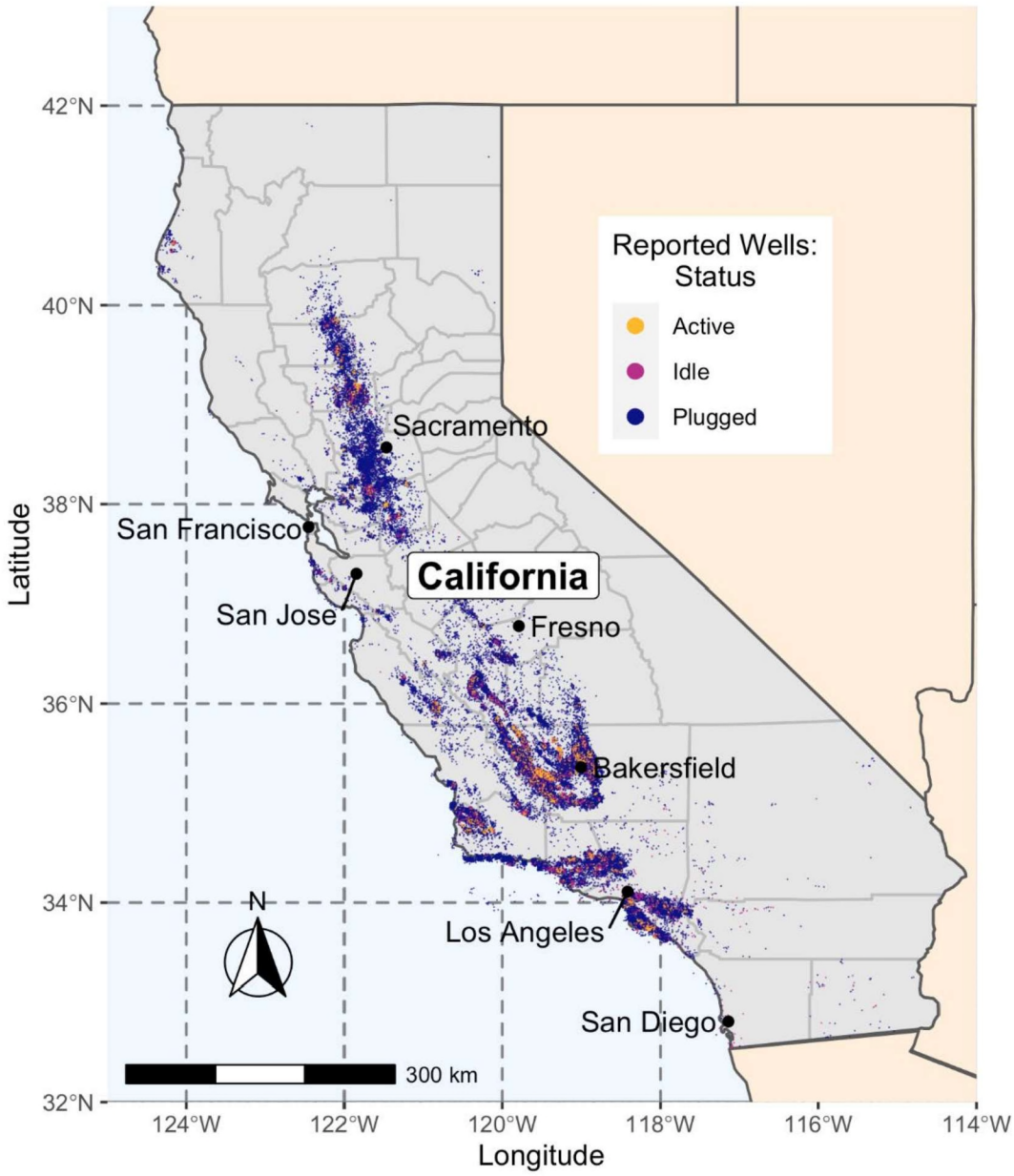


Figure 6.2. Location of active, idle, and plugged wells in California. Source: Adapted from Lebel et al. (2020).

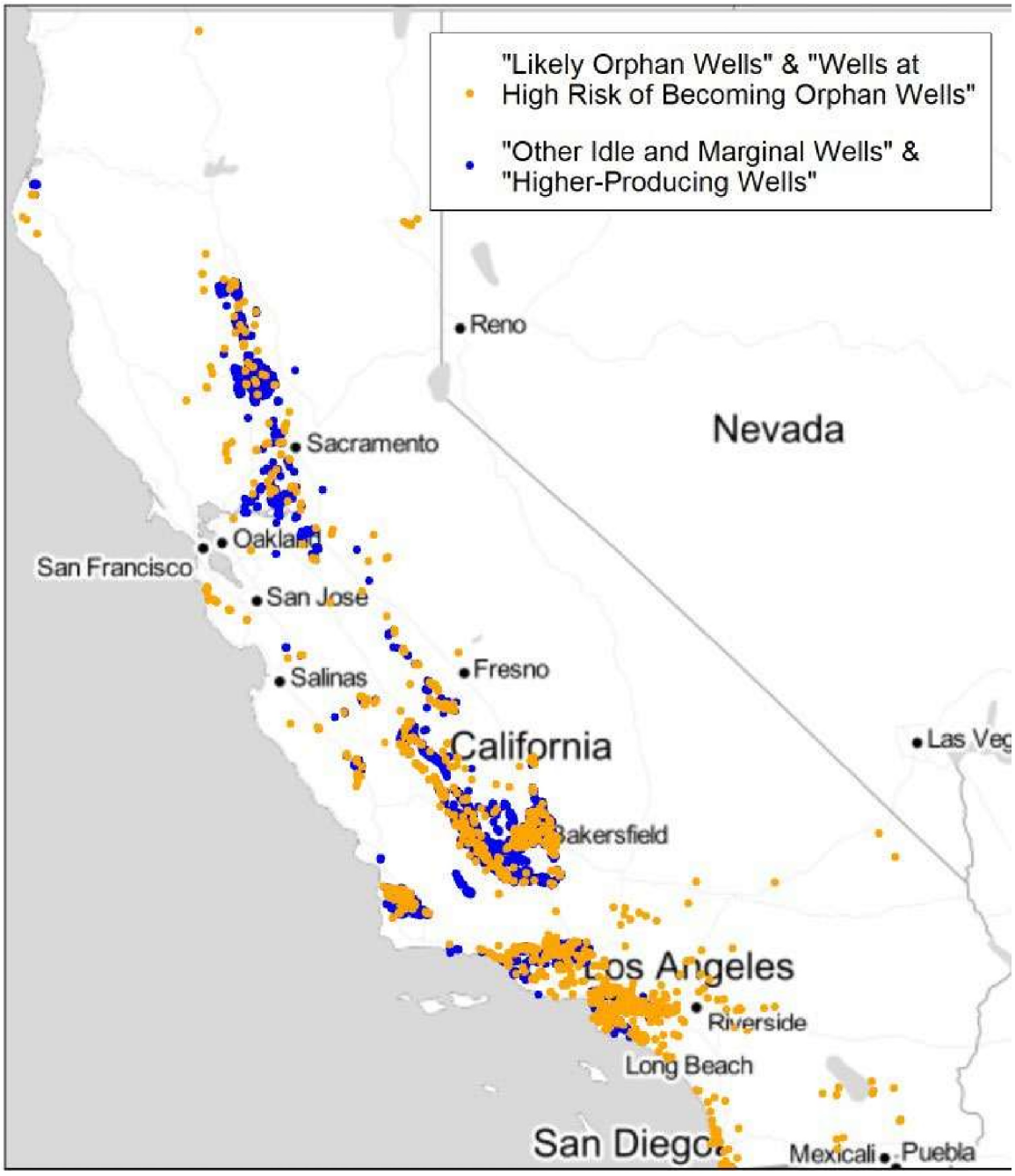


Figure 6.3. Location of likely idle-deserted wells (referred to in this report as “orphaned”) and wells at high risk of becoming idle-deserted in California. Source: CCST (2018).

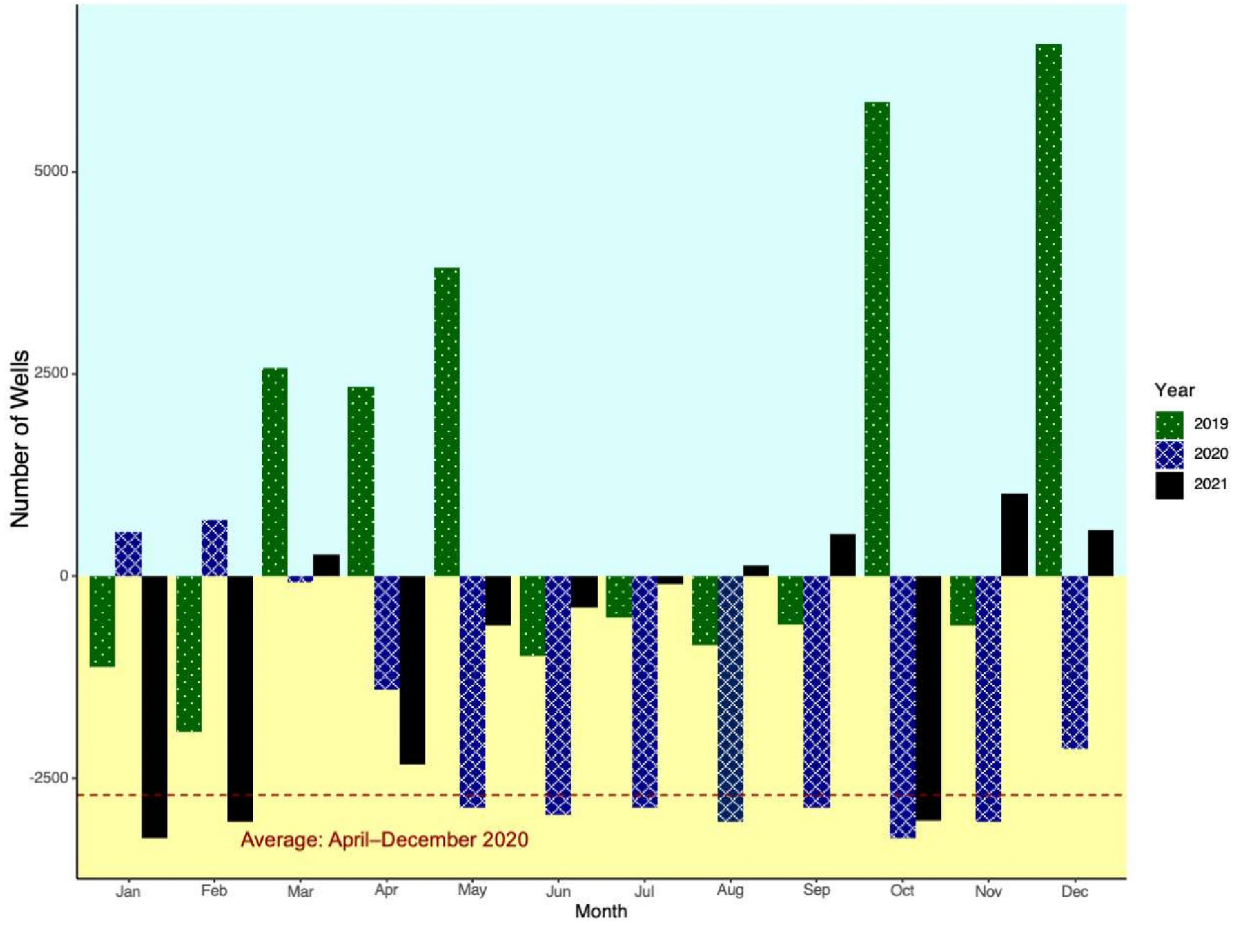


Figure 6.4. Net change in the number of oil and gas wells producing each month compared to the same month from the prior year. Positive values indicate a net increase in the number of wells producing, and negative values indicate that fewer wells were producing over the same month in the previous year. Source: Production data reported by CalGEM from 2018–2021 (CalGEM, 2022b).

6.2.4. Number and Location of Legacy Pipelines and Associated Infrastructure

CalGEM is currently in the process of mapping the locations of active pipelines, tanks, vessels, and other associated oil and gas infrastructure. Under 14 California Code of Regulations (C.C.R.) § 1774.2, operators must provide lists and maps of any active pipelines that pass through sensitive areas, environmentally sensitive areas, urban areas, and designated waterways as part of their pipeline management plans (14 C.C.R. § 1774.2, 2018). Similarly, under 49 Code of Federal Regulations (C.F.R.) 192.727 and 195.59, operators of pipelines that pass under, over, or through a commercially navigable waterway are required to submit data on pipeline abandonment to the National Pipeline Mapping System (49 C.F.R. § 195.59, 2019; 49 C.F.R. § 192.727, 2010; Research and Special Programs Administration, 2000). This data will provide a record of active pipelines in areas with the highest potential to impact human health, however, it does not address the current state of abandoned pipelines and infrastructure, nor take into account future land use scenarios. Idle, abandoned, removed, idle-deserted, and deserted

pipelines are not active and not reported by any operators in their pipeline management plans (CalGEM, personal communication, 2021).

We are not aware of any publicly available database of abandoned pipelines, flowlines, gathering lines, or other associated abandoned oil and gas infrastructure that falls under CalGEM's jurisdiction. An assumption could be made that there are at least one or two pipelines for every active or idle well in California, and that the average length and number of pipelines associated with idle and idle-deserted wells is the same as those associated with active wells (CalGEM, personal communication, 2021). The same assumptions cannot be made for abandoned wells. Under 14 C.C.R. § 1776, well site and lease restoration requires operators to remove all tanks, aboveground pipelines, debris, and other facilities and equipment within one year of plugging and abandonment of the last well (14 C.C.R. § 1776, 2006). Underground pipelines can be abandoned in-place after they are purged of oil and filled with an inert fluid. It is estimated that underground pipelines associated with wells are buried between 3–6 ft (91–189 cm) deep, with an average depth of 4 ft (122 cm) (CalGEM, personal communication, 2021). Gathering lines and flowlines in rural areas are likely to be routed above ground (and likely to be removed during lease restoration), while those in sensitive areas or urban areas are more likely to be routed underground (CalGEM, personal communication, 2021). Less is known about pipeline removal practices for legacy abandoned wells, which were abandoned before modern well abandonment requirements were put into effect in 1978. In some areas, cleanup and removal of abandoned pipelines from legacy oil and gas wells is an ongoing operation, as erosion continually exposes legacy infrastructure (California State Lands Commission, 2020).

6.3. Health and Safety Hazards, Risks and Impacts Associated with Idle, Idle-deserted and Abandoned Wells

Idle, idle-deserted, and abandoned wells can pose a risk to human health in several ways. Oil, gas, and other naturally occurring chemicals and radioactive materials can migrate through a variety of leakage pathways associated with these well types, resulting in gas emissions to the atmosphere or the contamination of groundwater or surface water resources. Abandoned and idle wells may also act as conduits for well stimulation fluids or pressurized steam from nearby operations to reach the surface or leak into surrounding groundwater resources. This could directly impact human health, depending on the proximity of these wells to human populations and the nature and extent of the leakage.

UIC project reviews include an evaluation of plugged and abandoned as well as idle wells that could potentially act as conduits. If they are found to be conduits they must be monitored, remediated, or plugged and abandoned. Conduit analysis (including analysis and potential remediation of abandoned wells) is also done as part of the aquifer exemptions mentioned in Chapter 5. Nevertheless, there are leaks that may remain undetected for extended periods of time (Kang et al., 2019). As abandoned wells age, they may become more prone to failure from a combination of catastrophic events (such as earthquakes) and/or the accumulation of small-scale and large-scale failures (Kang et al., 2019). Failures in wellbore integrity can result in leaks and may be due to a wide variety of chemical, mechanical, and physical factors, such as thermal

stress, pressure changes, poor cementing and abandoning operations, thread leaks, and the corrosion and dissolution of cement in acidic environments (Kang et al., 2019). Potential leakage pathways for abandoned wells are illustrated in **Figure 6.5**, and include leakage through cement plugs or casing cement, between the casing, cement, and/or surrounding reservoir rock, and along any shear zones that pass through the wellbore. Current standards require that wells have multiple layers of casing and cement to mitigate potential leakage pathways; however, wells can still be susceptible to leakage, particularly due to the corrosive effects of hydrogen sulfide on steel casings and cement, or poor well completion and abandonment procedures (Chilingar & Endres, 2005). Legacy abandoned wells may not have been constructed (or abandoned) to current standards and may have an increased potential for well leakage.

The process of abandoning (or re-abandoning) wells also carries the risk of loss of well control, which has the potential to impact public health through the release of crude oil to the environment or the release of gas and toxic air contaminants (TACs), causing fires, explosions, or impacting air quality (California State Lands Commission, 2017). For example, on January 11, 2019, a contractor was re-plugging a 1930s era gas well in Marina del Rey that was abandoned in the late 1950s (Department of Conservation, 2019). The well was located within 30 ft (9 m) of a sidewalk, 50 ft (15 m) of a road, and 100 ft (30 m) of residences. In the process of pulling tubing out of the well, pressure built up and blew a column of gas, water, and mud 100 ft (30 m) into the air (Department of Conservation, 2019). To minimize this risk, CalGEM may require the use of blowout preventer equipment during abandonment operations (14 C.C.R. § 1723 (e), 2006); however, in this case an estimated 100,000 ft^3 (2830 m^3) of gas was released before the blowout preventer was used to seal the well. Failure of blowout preventer equipment, while rare, does happen, but it should be noted that the blow out preventer itself is not the only means of well control. Additionally, blowout preventers are connected to the top of the well casing and are not intended to protect from leakage from the outside of the casing (California State Lands Commission, 2017). Loss of well control, while generally uncommon, may be more problematic when re-abandoning legacy abandoned wells, as reservoirs may re-pressurize over time and records of well construction and abandonment may not always be available (California State Lands Commission, 2017).

Idle and abandoned wells may also contribute to the formation of surface expressions in oilfields undergoing cyclic steam stimulation. Surface expressions are the release of steam, water, oil, or soil from the subsurface to the surface and may take the form of steam outlets, puddles or streams of oil, or sinkholes filled with steam and other noxious gases (Pollack et al., 2020). Surface expressions are a hazard to oilfield workers and were responsible for the death of one oilfield employee in California. There are many possible causes for surface expressions in California, including active and abandoned wells acting as conduits, natural faults or induced fractures, and fluid flow in porous media along structural features (Pollack et al., 2020). A study of surface expressions in the Midway-Sunset oilfield in Kern County found that surface expressions are significantly associated with the density of plugged wells (Pollack et al., 2020). High densities of poorly plugged abandoned wells could act as a conduit for steam and oil migration, or might be indicative of other underlying geologic factors that contribute to both surface expressions and well abandonment (Pollack et al., 2020).

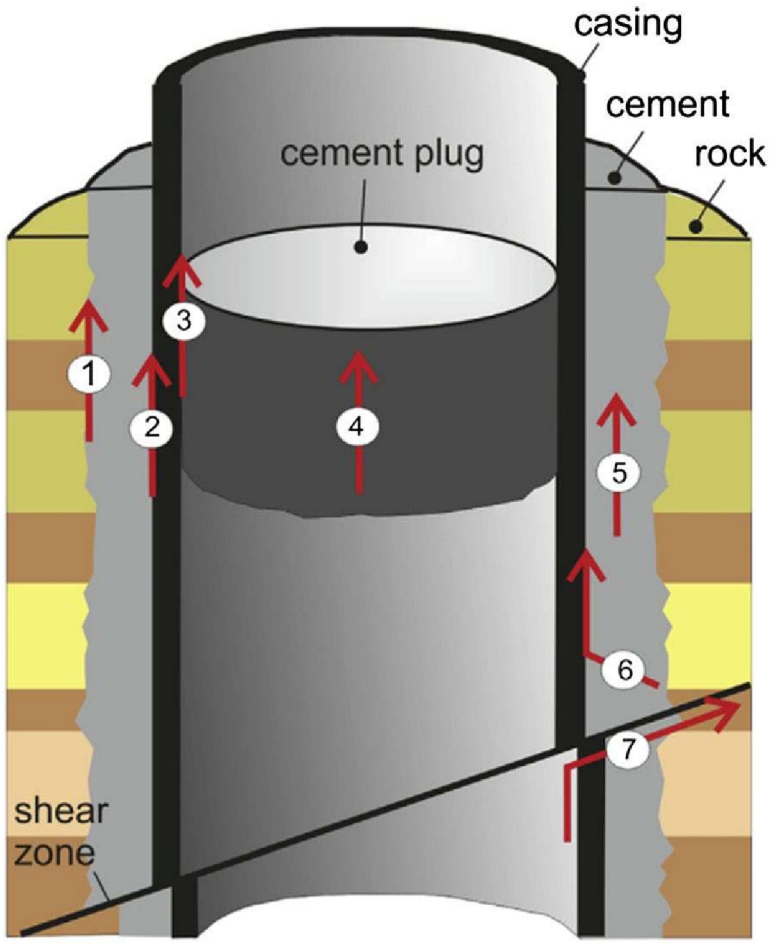


Figure 6.5. Potential leakage pathways for plugged and abandoned wells. (1) Between cement and surrounding formation; (2) between casing and cement; (3) between cement plug and casing/production tubing; (4) through cement plug; (5) through cement; (6) across cement and then between cement and casing; and (7) along a sheared wellbore. Source: Alboiu and Walker, (2019).

6.3.1. Air Pathways

Idle, idle-deserted, and abandoned wells present many of the same public health and safety risk factors as active wells. Wells can serve as a conduit for fluid migration from reservoir cavities deep within the Earth, creating the potential for crude oil, gas, formation water, and volatile organic compounds (VOCs) to reach the surface and be released into the atmosphere (CCST, 2018; CCST et al., 2015; Townsend-Small & Hoschouer, 2021). Emissions of volatile components from idle, idle-deserted, and abandoned wells can include methane, VOCs and other TACs, criteria pollutants, gaseous NORM, and reactive organic gases, which are associated with the formation of tropospheric ozone (i.e., smog). In addition, when idle, idle-deserted, and abandoned wells have inadequate well casing and cement plugging practices, legacy abandoned wells, in particular, are susceptible to acting as conduits for gas to seep to the surface from reservoir cavities (Chilingar & Endres, 2005). However, the lack of production and associated pumps, generators, compressors, pneumatic devices, storage tanks, and surface impoundments mean that the overall combined emissions footprint from idle, idle-deserted, and abandoned wells is smaller than active wells. There is no documentation that emissions from chemical mixing and

spills are major concerns, since these chemical additives are only used during well development and rework. But emissions from idle, idle-deserted, and abandoned wells may still result in regional air quality impacts and increased exposure to populations in close proximity.

In California, most studies of emissions from idle, idle-deserted, and abandoned wells have focused on methane. Although methane is not a TAC, it is a potent greenhouse gas, as well as an asphyxiant and an explosive hazard with a lower explosive limit of approximately 5% by volume (Chilingar & Endres, 2005). Methane buildup from leaking abandoned wells has been responsible for explosions that destroyed houses in Trinidad, Colorado, in 2007 (COGCC, 2008). Methane buildup also was possibly responsible for the Ross Dress for Less explosion in Los Angeles in 1985, which was linked to subsurface gas accumulation associated with a nearby oil well, but the source is still debated (LACDPH, 2018). Other instances of legacy abandoned wells acting as conduits for gas to seep to the surface in residential and commercial areas from underground gas storage facilities have been documented in the Los Angeles area (Chilingar & Endres, 2005).

Methane emissions from abandoned wells in California were most recently measured by Lebel et al. (2020). They measured methane emissions from 97 plugged and abandoned wells, 17 idle wells, six active wells, and one unplugged and abandoned well; the results are summarized in **Table 6.2**. They found that while emissions from plugged and abandoned wells are generally low, emissions from idle wells were more than two orders of magnitude greater. These idle wells were idle for an average of 13.9 years, with a range of 6–39 years. Similar to studies in other regions, emissions from both abandoned and idle wells followed a "long-tailed distribution," with a few wells responsible for the majority of emissions. The top three plugged and abandoned wells emitted 99.6% of emissions from all plugged and abandoned wells; the top two idle wells emitted 74.1% of emissions from all idle wells. Active wells had the highest emissions and values were generally consistent with previous studies by Jeong et al. (2014) and Zhou et al. (2021), which estimated active wells in California emit 0.168 teragrams per year of methane (Tg/yr CH_4) (1.1 million tons per year), and wells in Northern California emit 7.6 kilograms per day of methane (kg/day CH_4) (17 pounds per day), respectively.

Table 6.2. Mean methane emissions from various well types in California when emissions were detected. Source: Lebel et al. (2020)

Well Status	Number of detects/ Number of wells sampled	CH_4 Emissions (g/hr)
Plugged and Abandoned	34/97	0.286
Idle	11/17	35.4
Unplugged and Abandoned	1/1	10.9
Active	4/6	189.7

Most recently, in May 2022, residents of Bakersfield reported symptoms of dizziness, fatigue, and headaches, and noticed a hissing sound coming from a nearby oil well (Secaira, 2022). CalGEM investigated this well — classified as idle — and determined it was leaking. After further investigation, at least 44 additional idle wells in Bakersfield were found to be leaking methane. Evidence from other groups demonstrated that some of these wells were found to be leaking methane at rates that produced dangerously explosive levels of methane gas near the wellhead (Solis, 2022). Two months later, the Department of Conservation noted that 44 of the 45 wells had been completely repaired and one well was still found to be leaking methane, despite having undergone repairs. In August 2022, an additional 9 idle wells — three in Kern County and six in Los Angeles County — were found to be leaking methane. Eight of these wells were repaired within a week (California Department of Conservation, 2022). Situations like these, where private citizens find leaking wells in close proximity to their homes, further emphasizes the potential hazards of oil and gas wells — even idle wells — on the health and safety of the public.

6.3.1.1 Volatile Organic Compounds and Toxic Air Contaminants

Current studies of VOC and TAC emissions, such as benzene, toluene, ethylbenzene, and xylenes (BTEX) and n-hexane, from idle and abandoned wells in California are limited in scope and geographic coverage. Lebel et al. (2020) measured benzene emissions at a single unplugged well in California, but the levels were below the detection limit of 4.2 parts per billion by volume (ppbv). In 2016, the South Coast Air Quality Management District (SCAQMD) measured VOCs, methane, and hydrogen sulfide from two idle-deserted wells in a residential area of Echo Park prior to abandonment (SCAQMD, 2016). Concentration of hydrogen sulfide inside one of the wells was above the acute reference exposure level (REL) of 30 parts per billion (ppb) and methane levels were above the lower explosive limit (LEL) of 5%. VOCs were below acute RELs, with the exception of acrolein. It should be noted that acrolein is known to be difficult to measure with current U.S. EPA TO-15 methods (SCAQMD, 2016), and concentrations measured inside wells are not representative of concentrations in the surrounding ambient air. To our knowledge, no major studies have systematically measured statewide VOC and TAC emissions from idle or abandoned wells in California.

As discussed in Chapter 4, Section 4.2.1, VOC and TACs are not typically measured when determining gas composition in California. However, benzene and hydrogen sulfide were measured and detected in gas from select wells in the San Joaquin Valley (Lillis et al., 2007). VOCs have also been measured downstream of wells in the process of determining emissions inventories, but it is difficult to elucidate how representative those values are of emissions from wells in California.

Without additional data, it is challenging to determine how prevalent — and at what concentrations — TACs and other VOCs are present in emissions from idle, idle-deserted, and abandoned wells in California. However, as discussed in Chapter 4, Section 4.2.1, VOCs and TACs have been observed in gas from active wells in other parts of the country (Brantley et al., 2015; El Hachem & Kang, 2022; LACDPH, 2018; Lillis et al., 2007; Tran et al., 2020) and we can generally assume that anytime there exists a pathway for gas to escape to the atmosphere, there is the potential for

VOCs and TACs to be released as well. Additional testing and public disclosure of the composition of VOCs and TACs from idle, idle-deserted, and abandoned wells are needed to assess air pollution health risks and better inform policy makers.

In 2019, California passed Assembly Bill 1328, which calls for a study of fugitive emissions from idle, idle-deserted, and abandoned wells in California (Assembly Bill No. 1328, 2019). The results of this study have not been released to date. In 2018, the California Air Resources Board (CARB) started their Study of Neighborhood Air near Petroleum Sources (SNAPS) program. The SNAPS program does not specifically target emissions from abandoned or idle wells, but will provide data on upstream emissions of VOCs, hazardous air pollutants (HAPs), and other criteria pollutants from oil and gas operations in California (CARB, 2018, 2021).

6.3.2. Water Pathways

Abandoned wells, some of which were constructed prior to the implementation of current well construction standards, may be particularly prone to leakage along the wellbore (USGS, 2014). As wells age, failures in wellbore integrity can result in subsurface pathways whereby oil, gas, and formation water can contaminate groundwater resources through subsurface migration. Due to the large number of abandoned wells in California, failure of even a small percentage could result in a large number of potential subsurface migration pathways (USGS, 2019). A review of groundwater contamination from oil and gas development by the Ground Water Protection Council (2011) found that abandoned wells accounted for 14% and 22% of groundwater contamination events in Texas and Ohio, respectively. No similar studies have taken place in California. However, the USGS California Water Science Center is currently working together with state and federal agencies on the California Oil, Gas, and Groundwater Program to monitor potential contamination of groundwater resources near oil fields.

While developing the Underground Injection Control (UIC) Program regulatory framework, the U.S. EPA recognized that injected fluids could potentially migrate into Underground Sources of Drinking Water (USDW) (Osbourne, 2002). The vertical migration of injected fluids through improperly abandoned and improperly completed wells that penetrate the injection zone may cause groundwater contamination and impacts to domestic or municipal water wells (Osbourne, 2002). Although this report focuses on drinking water wells, any abandoned oil or gas well that passes through USDW has the potential to act as a conduit.

Similarly, abandoned and idle wells can act as a potential migration pathway for oil and gas, formation water, chemical additives, and cleanout fluids during well stimulation and well cleanout activities (CCST et al., 2015). Fractures created during well stimulation can hydraulically connect a stimulated well to nearby abandoned or idle wells; this is of particular concern in high-density fields and those with a long history of oil and gas operations (CCST et al., 2015). These nearby abandoned or idle wells must also fail in order for a pathway to the surface or surrounding groundwater resources to be present. Under 14 C.C.R. § 1784, operators must identify any existing wells that could be impacted from well stimulation operations (14 C.C.R. § 1784, 2015); however, 14 C.C.R. § 1784 does not require testing the integrity of idle wells (CCST et al., 2015).

But idle well regulations call for these wells to be tested. Additionally, current well stimulation risk assessments — conducted according to well stimulation treatment (WST) regulations — require accounting for and addressing any potential fluid migration pathways before a WST permit is issued. But abandoned wells continue to pose a risk of acting as a migration pathway due to the lack of monitoring requirements post abandonment.

Abandoned wells may be particularly susceptible to subsurface failure due to land deformation from seismic activity or subsidence (USGS, 2019). A geospatial analysis of well locations and earthquakes in California was done by Kang et al. (2019). They found two hotspots in California where seismic activity and oil and gas wells overlap: the southern Central Valley and Los Angeles County. There are no studies that investigate the relationship between seismic activity and wellbore integrity (Kang et al., 2019). However, abandoned wells may present an increased risk of subsurface leakage from seismic activities (compared to active wells) due to their age; lack of monitoring and management requirements; and incomplete records regarding location and wellbore integrity. Similarly, land deformation due to the injection of wastewater, steam and water flooding, or the withdrawal of petroleum or groundwater resources, can also cause wells to fail (USGS, 2019).

Box 1. Direct exposure to crude oil and VOCs from leaking legacy abandoned intertidal wells

Improperly abandoned legacy oil and gas wells near waterways and other surface waters can leak oil directly into coastal and aquatic environments. Oil leaking directly on the beach or into shallow nearshore waters can create oil sheens on beaches and in waters that can come in direct contact with surfers, swimmers, and others engaged in recreational activities. Additionally, the volatile fraction of crude oil is expected to rapidly volatilize and become air pollutants, resulting in odor complaints, unhealthy air quality, and negative health impacts. This is a particular problem along areas of the California coast with a long history of oil and gas development that are also widely used for recreation. For example, in Summerland Beach near Santa Barbara, multiple improperly abandoned legacy onshore and offshore wells from the early 1900s have been observed seeping oil directly onto the beach and into the ocean (California State Lands Commission, 2017, 2020). Nearby residents and visitors have complained of oil sheens, strong petroleum odors, headaches, and nausea, and the Santa Barbara County Public Health Department has closed the beach on occasion to protect public health (California State Lands Commission, 2017). Onshore clean-up and well re-abandoning efforts have been occurring along the Summerland coast since the 1960s; however, only recently have efforts been made to address oil leakage from improperly abandoned legacy wells in intertidal zones and shallow offshore wells (California State Lands Commission, 2017, 2020). In 2018, the Becker well became one of the first legacy abandoned wells in the intertidal zone to be successfully re-abandoned. Prior to re-abandonment, leakage from the Becker well was a known issue — a U.S. Coast Guard evaluation from 1994 estimated that approximately 0.5 barrels (80 liters) of crude oil a day were leaking onto the beach and into the ocean from the

legacy well (California State Lands Commission, 2017). Although offshore wells are outside the scope of this report, legacy abandoned wells located in intertidal zones that are above water part of the time and submerged at other times, can have direct impacts on the health of nearby residents and visitors engaging in recreational activities on the beach or in the ocean. The re-abandonment of intertidal wells presents unique challenges that increase overall costs and delay their timely completion, resulting in extended periods of leakage and potential human health impacts.

6.3.3. Idle, Idle-deserted, or Abandoned Wells Examined in the Epidemiological Literature

6.3.3.1 Epidemiological studies conducted in California

The environmental public health literature strongly supports geographic proximity to active oil and gas development as an important risk factor for a variety of adverse health outcomes. However, very few of these studies take into account idle (or inactive) wells and, to the best of our knowledge, no epidemiological studies in the United States have taken into account abandoned wells or associated legacy infrastructure. Five peer-reviewed epidemiological studies with a focus oil and gas development have been conducted in California, three of which include idle or inactive wells in their analysis (Johnston et al., 2021; Tran et al., 2020). A brief summary of these study results with regard to idle or inactive wells is provided below; a more in-depth summary of these studies is provided in Chapter 3.

Tran et al. (2020) and Tran et al. (2021)

Tran et al. (2020) evaluated adverse birth outcomes among infants born between 2006 and 2015 to mothers living near active and inactive wells in the San Joaquin Valley and South Central Coast and South Coast Air Basins. Exposure to inactive wells, defined as any well not producing at least one unit of oil/gas in a given month, was characterized by well counts within 1 km (3,281 ft) of maternal residence at time of delivery. Tran et al. (2020) found no association between inactive well counts and adverse birth outcomes among both urban and rural populations. This may have been because well count alone was not sufficient to capture nuanced exposure pathways associated with idle wells, leading to potential exposure misclassification (Tran et al., 2020). This study controlled for potential confounding variables, including community-level factors and individual-level factors for infants (sex, month/year of birth) and mothers (age in years, race/ethnicity, education level, Kotelchuk index of prenatal care, child parity).

In a similar study, Tran et al. (2021) evaluated the association between proximity to hydraulically fractured wells with the same health outcomes, population, and time frame as Tran et al. (2020). Exposure to hydraulically fractured wells was associated with increased odds of low birth weight, preterm birth, lower term birth weight, and small for gestational age, particularly among rural mothers. The exposed group included exposure to active and/or inactive wells; however,

inactive wells were not isolated from active wells and no conclusions were drawn specific to inactive wells.

Johnston et al., 2021

Johnston et al. (2021) evaluated lung function and self-reported acute health symptoms among residents living near the Las Cienegas oil fields in South Los Angeles. Patterns in reduced lung function were seen among participants living near active and idle wells, although it was more pronounced in communities near active wells. Even after adjusting for age, sex, height, proximity to freeway, asthma status, and smoking status, Johnston et al. (2021) found that living nearby and downwind of oil and gas development sites, active or idle, was associated with reduced lung function among residents.

6.3.3.2 Epidemiological studies conducted outside of California

Our review of 43 epidemiological studies related to oil and gas development in other states found only one study that was distantly related to inactive wells. Currie et al. (2017) examined birth weights for women living in Pennsylvania from 2004 to 2013 with respect to proximity of hydraulically fractured wells. They found negative impacts to mean term birth weight and increased incidents of low birth rate in babies whose mothers lived within 3 km (1.86 mi) of hydraulically fractured wells. When the study was adjusted to take into account inactive wells that may have been active during the study period (2004–2013), rather than just in 2014, they found no differences in the results.

The environmental public health literature that takes into account idle and abandoned wells is limited. There is evidence that geographic proximity to idle wells may be a risk factor for reduced lung function; however, this is the result of a single study. There is insufficient data to draw conclusions about abandoned wells as a risk factor for adverse health outcomes. Additional epidemiological studies that take into account idle and abandoned wells would increase the understanding of underlying exposure sources and pathways as well as elucidate which types of wells may be of the greatest concern with regard to human health outcomes (Tran et al., 2020). This data could then be used to inform future regulatory decisions to reduce community exposure from various types of wells.

6.3.4. Regulations

This section discusses many of the regulations in place for abandoned and idle wells. These descriptions are not meant to be exhaustive; rather, they are meant to provide descriptions of the current regulations and insight for future regulations.

In 2019, CalGEM (formerly the Division of Oil, Gas, and Geothermal Resources [DOGGR]) updated idle well regulations to require testing of idle wells in order to further protect public safety and to increase incentives for operators to plug and abandon idle wells (CalGEM, 2019). Operators are required to test idle well fluid levels for wells that penetrate a USDW within 24 months of a well becoming idle and every 24 months thereafter (14 C.C.R. § 1772.1(a)(1), 2019). If idle well fluid levels are above the base of a USDW, operators must perform a casing pressure

test to a depth 100 ft (30 m) above the uppermost perforation, top of the landed liner, or above the casing shoe of the deepest cemented casing. Pressure tests must be repeated every 48, 72, or 96 months depending on the pressure tested. Operators are also required to demonstrate the ability to reach an approved depth of the well within eight years of a well becoming idle, and every 48 months thereafter. Idle wells that fail testing must be either brought into compliance, partially or fully plugged and abandoned, or be scheduled for plugging and abandonment under an Idle Well Management Plan within 12 months.

Operators are required to pressure test all idle wells within 24 months of a well becoming idle. After April 1, 2025, if the fluid level in an idle well is above a USDW, then the well must be pressure tested on an expedited, 90-day timeframe (14 C.C.R. § 1772.1(a)(2), 2019). The engineering analysis includes pressure testing and clean out tag in addition to information on geologic units, producing zones, USDW and freshwater aquifers, faults, and containment features. If it is determined that a long-term idle well is not viable to return to operation, the operator must plug and abandon the well within 12 months or schedule it for plugging and abandonment under an Idle Well Management Plan or an approved Testing Waiver Plan.

California's requirements for plugging and abandoning wells are similar to those in Texas and Colorado. Plugging and abandoning oil and gas wells is regulated under 14 C.C.R. § 1723 and P.R.C. § 3208 (14 C.C.R. § 1723, 2016; P.R.C. § 3208, 2017). Briefly, cement plugs must be placed at specified intervals to protect and isolate oil and gas zones, usable freshwater resources, and to protect surface conditions and public health and safety. Mud fluid must be poured into intervals not plugged with cement and into all open annuli to prevent movement of other fluids into the wellbore. At the surface, the hole and annuli must be plugged, well casing should be cut off 5 to 10 ft (1.5 to 3 m) below the surface of the ground, and a steel plate must be welded to the top of the casing. Casings should be recovered when possible.

Operators may partially plug and abandon a well to reduce idle well testing requirements (14 C.C.R. § 1752, 2019). Partially plugged onshore wells must meet all the same requirements as fully plugged and abandoned wells with the exception of requirements for surface plugging, casing recovery, and post-plugging environmental inspections. Partially plugged wells must be pressure tested when they become a long-term idle well, or by April 1, 2024, and every 60 months thereafter. Partially plugged wells are not required to undergo engineering analysis. A partially plugged and abandoned well provides similar isolation of oil and gas producing zones and protection for groundwater as a fully plugged and abandoned well.

The plugging and abandonment of idle-deserted wells is based on protocols described in the CalGEM report *Orphan Well Screening and Prioritization Methodology* (CalGEM, 2023). Idle wells are prioritized for testing or plugging and abandonment based on the age of the well, if the fluid level of the wells is above the base of a USDW or freshwater, any downhole issues that would prevent reactivation or plugging, economic or operational efficiencies, if the well is a critical well or located near geologic hazards, urban areas, or environmentally sensitive areas, or if the well poses a threat to life, health, property, or natural resources. Critical wells are defined as wells within 300 ft (91 m) of a building intended for human occupancy or airport runway, or 100 ft (30

m) of a public recreational facility or area of periodic high-density population, navigable body of water, public street, highway, or railway, or a wildlife preserve (14 C.C.R. § 1720, 2006).

In 2019, California passed Assembly Bill 1328 (2019), which requires CalGEM and CARB to conduct a study of fugitive emissions, including TACs and VOCs, from a representative sample of idle, idle-deserted, and abandoned wells. The results of this study have not been published. To the best of our knowledge, there are no long-term monitoring requirements for plugged and abandoned wells in California or in other states, though some California municipalities require leak testing and visual inspection of abandoned wells prior to the development of an area (City of Carson, 2021; City of Signal Hill, 2020).

There is no agency that currently regulates emissions from abandoned and plugged wells, although CalGEM recently implemented a regulation for idle wells — 14 C.C.R. § 1772.1 — as described above. In 17 C.C.R. § 95665-95677 (2017), CARB has laid out regulations for emissions from oil and gas infrastructure, including Leak Detection and Repair (LDAR). CARB explicitly exempts abandoned wells from these requirements, defining a well in § 95667 as:

> "Well" means a boring in the earth for the purpose of the following:
> (A) Exploring for or producing oil or gas.
> (B) Injecting fluids or gas for stimulating oil or gas recovery.
> (C) Re-pressuring or pressure maintenance of oil or gas reservoirs.
> (D) Disposing of oil field waste gas or liquids.
> (E) Injection or withdraw of gas from an underground storage facility.

For the purpose of § 95667, wells do not include active observation wells as defined in P.R.C. § 3008 subdivision (c), or wells that have been properly abandoned in accordance with P.R.C. § 3208.

According to California definitions above, a well must have no production for 24 consecutive months to become classified as an idle well, so until then the well would remain subject to the regulations noted above.

There is currently no regulation of groundwater contamination from poorly or improperly abandoned wells. Current regulations specify that a properly abandoned well should have a cement plug above and below the aquifer layer in the plugged well. But as noted earlier in this section, many wells have not been properly abandoned, are unrecorded, or the plugging materials may fail over time, all leading to a possibility of increased groundwater contamination.

6.4. Health and Safety Hazards, Risks and Impacts Associated with Legacy Infrastructure

Oil and gas pipelines and associated infrastructure that are abandoned in-place will inevitably corrode and lose structural integrity (Crosby et al., 2015). Any persistent residual contaminants within the pipeline or associated components that outlive the rate of deterioration are at risk of

release into the surrounding environment. Other potential hazards associated with the in-place abandonment of pipelines include the drainage and subsequent contamination of surface water or groundwater through pipelines, ground subsidence due to failing structural integrity, and physical exposure and damage to pipelines from erosion, geohazards, or hydrotechnical hazards (Arcadis Canada, 2019). It is predicted that, for the United States at large, problems associated with legacy oil and gas infrastructure will increase in the future due to hydraulic fracturing and the expansion of production from shale in the past decade (Federal Facilities Research Center Radiation Focus Group, 2014). It is also the case that pipeline abandonment regulations have been in place for some time, with the potential result that pipelines on the surface in rural or undeveloped areas are likely removed and underground pipelines that are generally found in developed urban areas have been abandoned in place after flushing and "inerting." When this is the case, only very old abandoned and, in some cases, insulated pipelines are likely to have residual contaminants. We expect pipelines in the oil fields of California to be above ground when it is more economical to run them on the surface, unless the pipelines run thorough public or private property.

6.4.1. Hazards Associated with Legacy Abandoned Pipelines and Infrastructure

As abandoned oil and gas pipelines and infrastructure corrode over time, contaminants that may be released into the environment include components of the oil and gas transfer stream deposited scales, naturally occurring radioactive materials (NORM) and technologically enhanced naturally occurring radioactive materials (TENORM), treatment chemicals, pipe coatings, and metals due to corrosion (Thorne et al., 1996). A list of possible contaminants is provided in **Table 6.3**. Contaminants released into the environment may leach into underlying groundwater resources, seep up to the surface where they may volatilize or impact water resources, or become airborne as particulates from excavation or exposure due to erosion. Human health impacts associated with the release of treatment chemicals, components of oil and gas, NORM, and TENORM to the environment are discussed previously in Chapters 2, 4, and 5.

NORM, TENORM, PCBs, and asbestos are of particular concern due to their documented accumulation or use in legacy pipelines and infrastructure, environmental persistence, and well-documented human health impacts. TENORM/NORM, PCBs, and asbestos are discussed in further detail in the following sections.

As abandoned pipelines corrode and perforations form, they may act as water conduits, channeling surface water, groundwater, and other infiltrated materials to another location (Amec Foster Wheeler Environment & Infrastructure, 2017; Pipeline Abandonment Steering Committee, 1996; Swanson et al., 2010). Water that travels through abandoned pipelines may mobilize any residual contaminants within the pipeline and contaminate soil and water resources down gradient (Amec Foster Wheeler Environment & Infrastructure, 2017; Pipeline Abandonment Steering Committee, 1996; Swanson et al., 2010). Changes in natural drainage patterns could also negatively affect wetland and marsh ecosystems while simultaneously flooding other areas. A literature review conducted on behalf of the Pipeline Abandonment Steering Committee found that although abandoned pipelines becoming water conduits is a commonly cited hazard, there

were no documented cases of this actually occurring (Amec Foster Wheeler Environment & Infrastructure, 2017).

Abandoned pipelines that cross or pass alongside waterways and other bodies of water may become exposed due to hydrotechnical hazards including scouring, bank erosion, and flooding or failure of buoyancy control mechanisms (Pipeline Abandonment Steering Committee, 1996; PHMSA, 2019). These abandoned pipelines will be more susceptible to structural failure due to lateral water forces, impacts from debris or watercraft, and erosion of supporting soils. Subsequent releases of contaminants into waterways have the potential to impact large geographical areas and contaminate drinking water resources for downstream communities (PHMSA, 2019). In addition to potential contamination of surface water from pipeline corrosion and failure, these pipelines could pose a physical hazard for recreational and/or commercial activities (Swanson et al., 2010).

Ground subsidence can occur when abandoned pipelines corrode and collapse. Subsidence is primarily a concern for large transmission pipelines (Pipeline Abandonment Steering Committee, 1996). Gathering lines and flowlines, used to transport raw gas, crude oil, and/or produced water from wells to larger connection points and processing facilities, are generally smaller in diameter than transmission lines, and their potential for ground subsidence is expected to be minimal. However, gathering lines and flowlines represent a larger challenge with respect to integrity due to the variety of fluids transported, their more dispersed nature, and difficulties in inspection and monitoring (Godin, 2014).

Table 6.3. Possible contaminants that may be released into the environment by abandoned oil and gas pipelines. Source: Adapted from Thorne et al. (1996).

Category	Subcategory	Examples
Components in oil and gas stream	Hydrocarbons	Cycloalkanes; monoaromatic hydrocarbons; polyaromatic hydrocarbons; polyaromatic sulfonated hydrocarbons, n-hexane, BTEX
	Sulfur compounds	Hydrogen sulfide; carbon disulfide; carbonyl sulfide; mercaptans, including ethylated and methylated forms
	NORM/TENORM	Barium, strontium, radium, uranium, radon decay products: lead-210, bismuth-210, polonium-210
	Metals	Mercury, nickel, vanadium, chromium, arsenic
Deposited scales	Corrosion scale	Iron(II) sulfide, iron oxides, iron(II) carbonate
	Hardness scale	Calcium carbonate, calcium sulfate, barium sulfate
	Other	Asphaltenes, waxes, gums, resins, paraffins, naphthalenes, bitumens
Treatment chemicals	Scale control	Hydrochloric acid, with phosphate-type inhibitor and sodium or ammonium hydroxide neutralizer, xylene, toluene
	Corrosion inhibitors	Kerosene, sodium dichromate, hexametaphosphate, silicates, quaternized amines
	Biocides	Cocodiamine, glutaraldehyde, sodium hypochlorite
	Coolants	PCBs, triaryl phosphates, terphenyls, glycols (propylene; mono, di, and tri ethylene), brine and alcohol-based coolants

Category	Subcategory	Examples
Pipe body and metal wear	Pipe body	Iron (97 to 99% by weight), manganese (0.5 to 2.0% by weight), copper, nickel, molybdenum, chromium, carbon (0.5 to 1.0%), sulfur, phosphorus, tin, lead, bismuth, arsenic, zinc, cadmium, tungsten, magnesium, aluminum, calcium, cerium, silicon, boron (trace)
	Metal wear	Niobium (toughening agent); vanadium, titanium (strength at low temperatures); copper, zinc, chromium, cadmium (compressor wear); aluminum
	Welding rod	Carbon steel, stainless steel, cast iron, copper, brazing copper silicon with phosphor-bronze, brazing naval bronze with manganese-bronze, silver solder, soft solder (primarily lead), and wrought iron
	Sacrificial anodes	Lead, chromium, iron, magnesium, tungsten, aluminum, zinc
Pipe coatings and degradation products	Coal tar	Toluene, xylene, anthracene, and other polycyclic aromatic hydrocarbons
	Wraps	Coal tar enamel, glass or asbestos outer wrap, blown bitumen (asphalt), fiberglass wrap, asbestos felt
	"yellow jacket"	Rubberized asphalt mastic, high density polyethylene, carbon black
	Fusion bonded epoxy	Bisphenol, epichlorohydrin resin, amine or anhydride based hardener, chalk, silica
	"blue jacket"	Chromate pretreatment, epoxy resin, adhesive, high density polyethylene

Abandoned Pipelines and Infrastructure: TENORM/NORM

As discussed in Chapter 2, Section 2.3.3, NORM from the subsurface are typically transported to the surface during oil and gas production with produced water and precipitate out as scale or scale-bearing sludge within piping and upstream infrastructure such as gas dehydrators, oil and water separators, and associated water lines (Department of Health Services Radiologic Health Branch & DOGGR, 1996; The Cadmus Group, 1995; US EPA, 2022b). NORM that becomes concentrated due to oil and gas extraction and processing are generally classified as TENORM. The two radionuclides that are typically present in oil and gas produced water and scale are radium-226 (half-life=1,600 years) and radium-228 (half-life=5.8 years) (USGS, 1999). Scale and incorporated TENORM are usually found in the greatest concentrations in piping in close proximity to the wellhead and other infrastructure that has extended contact with produced water (US EPA, 1991; USGS, 1999). Accumulation is time-dependent, with pipelines in longer service more likely to have greater concentrations.

Building over oil and gas infrastructure creates a range of human exposure scenarios. As discussed in Chapter 2, Section 2.3.3, the immediate concern with TENORM from buried pipelines is gamma radiation exposure, while the major and long-term concern is future land use management redevelopment in areas of buried pipelines (Pipeline Abandonment Steering Committee, 1996). The half-life of radium-226 is 1,600 years, so the use of long-term institutional restrictions is not feasible. Oil and gas fields that do not appear habitable today could contain houses or buildings within 100 years or more. If excavation occurs during construction, in addition to gamma radiation exposure, there is concern of exposure to beta and alpha particles by

inhalation of dust during excavation. Furthermore, exposure of buried abandoned pipelines may occur naturally from erosion, geohazards (e.g., earthquakes, landslides), or hydrotechnical hazards (e.g., floods, bank erosion, scouring), increasing potential exposure to TENORM. Since there are likely a large number of pipelines buried in fields in California, this is likely to be a major legacy issue associated with legacy oil and gas development in California.

In the absence of excavation, there is also concern about intrusion of radon-222 gas (half-life=3.8 days) — a decay product of radium-226 — into buildings with subsequent inhalation by inhabitants. The U.S. EPA CERCLA standard for remediation of radium contaminated soils below 15 cm (6 in) is 15 picocuries per gram (pCi/g) above background (40 C.F.R § 192.12, 1995). Since pipelines are expected to corrode and eventually breakdown into the surrounding soil, this standard appears applicable to pipe scale and the long-term, near surface disposal of pipes. In areas of production where gas is retained inside of pipes and other components, lead-210 (half-life=22 years) — a decay product of the gas radon-222 and a beta and gamma emitter — may also accumulate over time; a TENORM issue that can differ from areas associated with scale accumulation (Faria & Moreira, 2016).

TENORM that is less than 0.05% uranium or thorium by weight falls outside of the control of the U.S. Nuclear Regulatory Commission (Ann Glass Geltman & LeClair, 2018). Although the U.S. EPA has provided guidance on the issue of TENROM (US EPA, 2003), they do not currently regulate it (Thompson et al., 2015). A number of states have developed or are developing regulations on the disposal of TENORM associated with oil and gas development — California is not one of them. Existing state regulations for the classification of oil and gas NORM/TENORM for waste management and disposal purposes are provided in **Table 6.4**. It is important to note that many states do not draw a regulatory distinction between TENORM and NORM (Thompson et al., 2015). In an effort to promote uniform regulation of TENORM, the Conference of Radiation Control Program Directors has developed suggested state regulations for TENORM concentrations and dose thresholds in the oil and gas industry (Conference of Radiation Control Program Directors, 2004; Thompson et al., 2015) (see **Table 6.4**).

The International Commission on Radiological Protection (ICRP) has set dose limits for both public and worker exposures to NORM from oil and gas operations (ICRP, 2019). The ICRP reference dose level for protection of the public "should be selected of the order of a few mSv [millisievert] per year, or below" (ICRP, 2019). The ICRP reference dose for protection of workers is "of the order of a few mSv per year, or below, for most cases; and above a few mSv, but very rarely exceeding 10 mSv year^{-1}." Most of the dose thresholds in **Table 6.4** are hourly rates. Four states (Illinois, Maine, New Jersey, Virginia) have annual dose thresholds, and these are compliant with ICRP recommendations. For states that have hourly thresholds, it would be necessary to restrict exposure time to be ICRP compliant. For example, at 0.5 uSv/hr (microsieverts per hour), an annual dose of 1 mSv would accrue in 2,000 hours of exposure and at 0.02 mSv/hr, an annual dose of 1 mSv would accrue in 50 hours.

Dose limits for NORM and TENORM have been recommended by the ICRP and standards have also been established by several states as noted in **Table 6.4**, California currently has no

mandatory monitoring program to confirm compliance with ICRP or California radiation protection standards and/or to confirm that California populations are not exposed to unacceptable risk from NORM and TENORM.

Table 6.4. Summary of regulations concerning NORM or TENORM thresholds for waste management and disposal. Source: Adapted from Thompson et al. (2015).

State or Organization	Concentration threshold for NORM/TENORM below which waste is exempt	Dose threshold for NORM/TENORM below which waste is exempt
Conference of Radiation Control Program Directors	0.185 Bq/g (5 pCi/g) of Ra-226 and/or Ra-228	0.5 μSv/hr (50 μR/hr) at any accessible point, including background
Alabama	0.185 Bq/g (5 pCi/g) of combined Ra-226 and Ra-228	0.5 μSv/hr (50 μR/hr) at contact with the NORM or NORM-contaminated article, including background
Arkansas	0.185 Bq/g (5 pCi/g) of Ra-226 and/or Ra-228, 0.05% by weight of uranium or thorium, or 5.55 Bq/g (150 pCi/g) of any other NORM radionuclide, provided that these concentrations are not exceeded at any time	0.5 μSv/hr (50 μR/hr) above background for equipment exposure level at any accessible point
Georgia	0.185 Bq/g (5 pCi/g) of technologically enhanced Ra-226 or Ra-228 in soil or other media, averaged over any 100 square meters (1,076 square feet) and averaged over the first 15 cm (6 in) of soil below the surface, in which the radon emanation rate is equal to or greater than 0.74 Bq (20 pCi) per square meter per second	0.02 mSv/hr (2 mrem/hr) 18 inches from the NORM contaminated material
Illinois	7.4 Bq/g (200 pCi/g) (dry weight basis) for sludges and water treatment residuals from the treatment of groundwater provided disposal is effected through one of two regulated pathways. Sludges beneath 0.111 Bq/g (3 pCi/g) (dry weight basis) are unregulated/not subject to exempt restrictions/requirements	0.10 mSv (10 mrem) per year above background exposure due to TENORM
Louisiana	0.185 Bq/g (5 pCi/g) of Ra-226 or Ra-228 above background or 5.55 Bq/g (150 pCi/g) of another NORM radionuclide	0.5 μSv/hr (50 μR/hr) above background for equipment exposure level
Maine	0.185 Bq/g (5 pCi/g) above background	1 mSv/yr (0.1 rem/yr) total effective dose for maximally exposed individual

State or Organization	Concentration threshold for NORM/TENORM below which waste is exempt	Dose threshold for NORM/TENORM below which waste is exempt
Mississippi	0.185 Bq/g (5 pCi/g) of Ra-226 or Ra-228 above background; or concentrations less than 1.11kBq/kg (30 pCi/g) of technologically enhanced Ra-226 or Ra-228, averaged over any 100 square meters (1,076 square feet), provided the radon emanation rate does not exceed 740 mBq (20 pCi) per square meter per second, or 5.55 kBq/kg (150 piCi/g) of any other NORM radionuclide, provided that these concentrations are not exceed at any time	0.25 µSv/hr (25 µR/hr) above background for equipment exposure level at any accessible point
Nevada[1]	0.555 Bq/g (15 pCi/g) Ra-226	-
New Jersey	37 kBq (0.1 microcurie)	0.15 mSv/yr (15 mrem/yr) total effective dose equivalent
New Mexico	1.11 Bq/g (30 pCi/g) or less of Ra226, above background, or 5.55Bq/g (150 pCi/g) or less of any other NORM radionuclide above background, in soil, in 15 cm (6 in) layers, averaged over 100 square meters (1,076 square feet).	0.5 µSv/hr (50 µR/hr) at any accessible point, including background
New York	Any NORM that is processed and concentrated is subject to regulation. TENORM from oil and gas production is not allowed for landfill disposal. (See 6NYCRR Part 380-1.2 (e) and 380-4.2.)	Note: High volume hydraulic fracturing for gas has been banned in the state of New York.
North Dakota[1]	0.185 Bq/g (5 pCi/g) total radium	-
Ohio	185 Bq/kg (5 pCi/g) above background	0.5 µSv/hr (50 µrem/hr) including background
Oregon	185 Bq/kg (5 pCi/g) of radium, 0.05% by weight of uranium or thorium or 5.55 kBq/kg (150 pCi/g) of any other NORM radionuclide provided that these concentrations are not exceeded at any time	Material that may be released to the general environment in groundwater, surface water, air, soil, plants, and animals shall not result in an annual dose above background exceeding an equivalent of 0.25 mSv (25 mrem) to the whole body or 0.75 mSv (75 mrem) to the critical organ of any member of the public

State or Organization	Concentration threshold for NORM/TENORM below which waste is exempt	Dose threshold for NORM/TENORM below which waste is exempt
Pennsylvania	No pre-approval required for TENORM waste disposal in RCRA D facilities if the combined radium activity is less than 0.185 Bq/g (5.0 pCi/g), and below 1 cubic meter in volume	-
South Carolina	1.11 Bq/g (30 pCi/g) or less of technologically enhanced natural radiation due to Ra-226 or Ra-228 in soil, averaged over any 100 square meters (1,076 square feet) and averaged over the first 15 cm (6 in) of soil below the surface, provided the radon emanation rate is less than 0.74 Bq (20 pCi) per square meter per second, OR 0.185 Bq/g (5 pCi/g) or less of technologically enhanced natural radiation due to Ra-226 or Ra-228 in soil, averaged over any 100 square meters (1,76 square feet) and averaged over the first 15 cm (6 in) of soil below the surface, in which the radon emanation rate is equal to or greater than 0.74 Bq/g (20 pCi) per square meter per second	0.5 µSv/hr (50 µR/hr) at any accessible point, including background
Tennessee[1]	1.11 Bq/g (30 pCi/g)	Contact dose rate 0.5 µSv/hr (50 µR/hr)
Texas[2]	1.11 Bq/g (30 pCi/g) or less of Ra-226 or Ra-228 and also contains 5.55 Bq/g (150 pCi) or less per gram of any other NORM radionuclide in soil, averaged over any 100 square meters (1,076 square feet) and averaged over the first 15 centimeters (6 in) of soil below the surface	0.02 mSv/hr (2 mrem/hr) at 18 inches from the NORM contaminated material
Utah[1]	0.555 Bq/g (15 pCi/g) Ra-226	-
Virginia	0.185 Bq/g, 185 Bq/kg (5 pCi/g) above background	1 mSv/y (100 mrem/y) total effective dose from TENORM for maximally exposed individual, excluding natural background

1. TENORM regulated as "Other Radioactive Material."
2. Only applies to oil and gas TENORM.

Abbreviations: Bg - becquerel; mBg - megabecquerel; kBg - kilobecquerel; mSv - millisievert; mrem - millrem; NORM - naturally occurring radioactive materials; pCi - picocurie; TENORM - technologically enhanced naturally occurring radioactive material; µR - microroentgen; µrem - microrem; µSv - microsievert

6.4.1.1 Abandoned Pipelines and Infrastructure: PCBs

The presence of PCBs in pipelines is primarily a legacy issue. PCBs were used from the 1950s to the 1970s as components of working fluids in compressors, pipeline lubricants, fogging agents, and valve grease, and migrated throughout gas systems (American Gas Association, 2010; US EPA, 2004). PCBs were also used in certain gas pipeline coatings (e.g., coal tar) (American Gas Association, 2010; Con Edison, 2012). PCBs are environmentally persistent, known human carcinogens, and can adversely alter the immune system, nervous system, thyroid, and hormonal

system, increasing the risk of infertility, heart disease, hypertension, diabetes, liver disease, and asthma (Carpenter, 2006; IARC, 2016). PCB contamination is a well-known hazard and action should be taken to remediate and/or manage PCBs during pipeline abatement. Priority for PCB management on pipeline abatement should be granted to those sections of pipe/areas with the highest potential for introducing PCBs along exposure pathways to humans (e.g., through soil, water) and sections where PCBs may accumulate.

Gas pipelines with PCB concentrations ≥50 parts per million (ppm) are regulated under 40 C.F.R. § 761.60 (b)(5) of the Toxic Substances Control Act (TSCA), and can be abandoned in place if certain provisions are met (40 C.F.R. § 761.60, 1979). An overview of TSCA regulations regarding in place abandonment of PCB contaminated pipelines is provided in **Table 6.5**.

In the absence of excavation and disposal, an assumption should be made that pipelines will corrode and PCBs will be incorporated into soil. PCBs would be expected to be present in scale and sludge in pipelines. The U.S. EPA has developed methods for determining remediation criteria for contaminated soils, which are applicable to California. CalGEM has an opportunity to use the U.S. EPA remediation criteria to estimate concentrations of PCB in scale or the lining of pipes that could result in a soil contaminated at an unacceptable level.

6.4.1.2 Abandoned Pipelines and Infrastructure: Asbestos

Prior to 1980, asbestos was used in oil and gas infrastructure as a component of gaskets, sealants, and in pipeline coatings (e.g., coal tar enamel or asphaltic enamel pipe wrap) to protect from corrosion and the elements (Con Edison, 2012; Howell, 2011; US EPA, 2019). Exposure to asbestos from buried pipelines may occur due to overlying development and excavation, or from erosion and other hazards that expose friable pipeline coatings to the environment. Inhalation of asbestos can negatively impact lung function, increase the risk of lung cancer and mesothelioma, and is a documented health concern in oil refinery workers (ATSDR, 2016; Gennaro et al., 2000).

Pipeline wrap that contains more than 1% asbestos and that can be crumbled, pulverized, or reduced to powder by hand pressure when dry is considered friable and is a regulated asbestos-containing material (RACM) that requires specific training and procedures for safe excavation and disposal (40 C.F.R. § 61.141, 1995). Asbestos-containing materials that may become friable during sanding, grinding, cutting, or abrading, or during demolition or renovation are also RACM (40 C.F.R. § 61.141, 1995). Intact pipeline wrap that is in good condition and nonfriable generally retains asbestos fibers within the coal tar or asphaltic matrix and is not considered a RACM (American Gas Association, 2006; BP U.S. Pipelines and Logistics, 2019). These materials can be manually removed with hand tools that shear or slice with minimal protective measures (BP U.S. Pipelines and Logistics, 2019).

To the best of our knowledge, there is no public database of pipelines, flowlines, gathering lines, or other oil and gas infrastructure that may contain asbestos. Thus, the extent of asbestos use in legacy oil and gas pipelines and infrastructure in California is unknown. However, Southern California Gas and San Diego Gas & Electric, two major gas utilities in California, have compiled historical construction records and estimate that they operate a combined 1,850 km (1,150 miles)

of transmission pipelines that use coal tar pipeline wrap and may contain asbestos (Southern California Gas Company & San Diego Gas & Electric, 2016). Although there is significant uncertainty about the presence of asbestos in California pipelines, the pipeline records of these two utilities suggest that asbestos-containing pipeline wraps are a potential concern that should be considered in pipeline excavation and disposal.

6.4.1.3 Incidents from Abandoned Pipelines

Regulations regarding pipeline abandonment require pipelines to be purged of oil or combustibles prior to abandonment. Despite existing regulations, improperly abandoned pipelines have negatively impacted surrounding communities. Two incidents of oil leaking from improperly abandoned underground pipelines in California were documented by the DOT Pipeline and Hazardous Materials Safety Administration (PHMSA) (PHMSA, 2016). On March 17, 2014, a leaking abandoned pipeline in Wilmington released between 36 to 71 barrels (bbl) (5,670 to 11,360 L; 1,498 to 3,001 gallons) of crude oil into a residential community, leading to numerous complaints of foul odors. The leak originated from internal pinhole corrosion on a weld. On October 28, 2015, an abandoned pipeline leaked approximately 28 bbl (4,450 L; 1,176 gallons) of oil-water mixture onto a busy intersection in Cypress. In both cases, the owners of the pipelines at the time were under the impression that the pipelines were properly purged and abandoned by the previous owners at the time of purchase (PHMSA, 2016).

In 2017 in Firestone, Colorado, improperly abandoned gas pipelines were responsible for leaking gas into a home, causing an explosion which killed two and injured two others (National Transportation Safety Board, 2019). Colorado regulations at the time required abandoned pipelines to be disconnected from hydrocarbon sources, purged, depleted to atmospheric pressure, and sealed.

6.4.2. Pipeline Abandonment Regulations

Although interstate pipelines for distribution of oil, gas, and petroleum products are downstream from oil and gas production, the regulation of abandoned downstream pipelines offers insight on the regulation of abandoned upstream pipelines. To gain insight for abandoned pipelines in California oil and gas production we provide in this section a review of U.S. federal regulations that apply to abandoned interstate pipelines, as well as abandoned pipeline regulations in Colorado and Canada.

Interstate pipelines are regulated at the federal level by PHMSA. Under 49 C.F.R. Part 195.402(c) and 192.727(b), pipelines abandoned in-place must be disconnected from operating pipeline systems, purged of combustibles, and sealed prior to abandonment. PHMSA does not recognize an idle, inactive, or decommissioned status for pipelines; pipelines are considered either active and subject to all safety regulations, or abandoned (PHMSA, 2016).

Abandonment of pipelines and flowlines on Bureau of Land Management-managed land requires flushing and disposal of any fluids and removal of any surface lines or shallow lines that may be

exposed due to wind or water erosion (US Department of the Interior & US Department of Agriculture, 2007). Deeply buried pipelines and flowlines can be abandoned in-place.

In California, CalGEM regulates oil and gas production equipment, including pipelines, from the wellhead to the sales meter. Downstream, the Office of the State Fire Marshal Pipeline Safety Division has authority to enforce federal and state regulations for intrastate hazardous liquid pipelines; intrastate gas and liquid petroleum gas pipelines are regulated by the California Public Utilities Commission. Under 14 C.C.R. § 1776, well site and lease restoration requires operators to submit a lease restoration plan prior to the plugging and abandonment of the last well on a lease (14 C.C.R. § 1776, 2006). Lease restoration requires the removal of all tanks, above-ground pipelines, debris, and other facilities and equipment. Remaining buried pipelines must be purged of oil and filled with an inert fluid. Lease restoration must be completed within one year of plugging and abandonment of the last well.

The handling and disposal of gas pipelines with PCB concentrations ≥50 ppm are regulated under U.S. EPA TSCA (40 C.F.R. § 761.60, 1979). These pipelines can be removed with subsequent disposal to a licensed facility, or they can be abandoned in-place under the provisions summarized in **Table 6.5.**

Table 6.5. Summary of provisions for in-place abandonment of gas pipeline systems containing PCBs ≥50 ppm under EPA TSCA (40 C.F.R. § 761.60(b)(5)).

Inside diameter requirement	Free-flowing liquids	PCBs requirement	Sealing requirement	Other requirements
≤4 inches	No free-flowing liquids	PCBs of any concentration	Each end is sealed closed	• Include pipeline in public service notification program. • Pipe filled to 50% volume or more with grout or polyurethane foam.
Any	No free-flowing liquids	PCB concentration determined after last transmission or at time of abandonment	Each end is sealed closed	-
Any	No free-flowing liquids	PCBs of any concentration	Each end is sealed closed	• Interior surface decontaminated using solvent washes. Must recover 95% of solvent volume. Recovered solvent PCB concentration must be <50 ppm. • Pipe filled to 50% volume or more with grout or polyurethane foam.

Inside diameter requirement	Free-flowing liquids	PCBs requirement	Sealing requirement	Other requirements
Any	-	PCBs of any concentration	-	• Drain and dispose of free-flowing liquids. • Decontamination of surfaces using either kerosene, diesel fuel, terpene hydrocarbons, or terpene hydrocarbon/terpene alcohol mix. • Multiple decontamination treatments required if PCB concentration in free-flowing liquid is >10,000 ppm.
				• Submit an alternate decontamination plan to EPA regional administrator.

Pipeline Abandonment Regulations in Other Regions

In Colorado, flowlines (defined as any pipe segment that transfers oil, gas, condensate, or produced water between a wellhead and processing equipment) and crude oil transfer lines can be abandoned in place by physically separating them from sources of fluids or pressure, purging any liquids, depressurizing, sealing the ends below grade, cutting risers to the depth of the flowline, and removing above ground cathodic protection and equipment (2 Colo. Code Reg. § 404-1-1105, 2020).

Canadian regulations surrounding pipeline abandonment vary according to province, but generally require pipelines to be purged with water or an inert gas, cleaned, and plugged or capped (Crosby et al., 2015). Cleaning techniques typically consist of some combination of pigging and chemical cleaning operations; however, questions remain regarding how clean is considered clean (Crosby et al., 2015).

6.4.2.1 Framework for Pipeline and Infrastructure Abandonment

The Petroleum Technology Alliance of Canada, the Canadian Energy Pipeline Association, Canada's National Energy Board, the Canadian Association of Petroleum Producers, and other stakeholders have collaborated on the Pipeline Abandonment Research Program to develop guidelines for pipeline cleaning prior to abandonment (Crosby et al., 2015) and a risk-based decision-making framework for pipeline abandonment (Arcadis Canada, 2019). This decision-making framework evaluates six categories of physical and technical hazards related to pipeline abandonment (Arcadis Canada, 2019):

1. Chemical impacts to soil or groundwater from former operations (i.e., existing contamination at the site).
2. Environmental impacts from pipeline materials abandoned in place.
    a. Residual products, lubricants, treatment chemicals (including NORM and PCBs).
    b. Leaching of construction materials and coatings.

    c. Presence and exposure of asbestos.
3. Drainage of surface water or groundwater through pipeline.
4. Ground subsidence.
5. Exposure of pipeline due to erosion and geohazards.
6. Exposure of pipeline due to hydrotechnical hazards.

This framework may act as a basis for developing a similar scientifically defensible risk-based decision-making pipeline abandonment framework in California.

6.5. Discussion

6.5.1. Lack of Data Collection Relevant to Assessing Health and Safety Risks

Several studies suggest that CalGEM undercounts the number of abandoned wells, particularly legacy abandoned wells with incomplete or undigitized historical records. These unrecorded wells tend to be old, unplugged wells or improperly plugged abandoned wells. Similarly, records are not always maintained for abandoned and legacy pipelines and operators are not required to report abandoned, removed, idle-deserted, or deserted pipelines in pipeline management plans.

Because idle production wells must be non-producing for a 24-month period, there is an inherent lag between when production stops and a well is categorized as idle. Thus, the true number of wells that not producing at any given time are likely under-represented in CalGEM's "All Wells" dataset. Long-term idle wells were not differentiated from other idle wells in the "All Wells" dataset. Other means of determining the number of long-term idle wells, or wells that may become idle in the future, require analyzing production data on an individual-well basis over periods of years. This information is available and included in required legislative reporting, but collecting and organizing it is labor intensive. Although CalGEM has made progress identifying and disclosing idle-deserted wells, there remains a large backlog of deserted wells that may potentially be idle-deserted and need to be evaluated. At a minimum, accurate location and count data for abandoned, idle-deserted, and idle wells and associated infrastructure are required for proper epidemiological studies and risk assessments.

Studies of emissions from idle and abandoned wells in California primarily focus on methane, and even these studies are sparse in California. Additional measurements of methane emissions from abandoned (plugged and unplugged) wells are needed with a large sample set and a random sample selection, designing the study to determine whether parameters such as well status, geography, geology, or age of well explain some of the variability in the emission rates. Studies of VOC and TAC emissions from idle and abandoned wells in California are limited in scope and geographic coverage and are insufficient to characterize emission trends on a broader level. However, studies in other states have found that VOCs and TACs are co-emitted with methane from upstream oil and gas wells. Additional emissions monitoring, such as that required under AB 1328, and public disclosure of the composition of VOCs and TACs from idle and abandoned wells in California are needed to assess air pollution health risks and better inform policy makers.

6.5.2. Locations of Idle and Abandoned Wells and Safety Concerns in Densely Populated Areas

Idle wells are generally located in many of the same areas as active wells and are capable of returning to active status after production or injection for a period of six months. Likewise, active wells may become idle after no production or injection for a period of 24 months. There is strong evidence that proximity to active wells is linked to a variety of adverse health outcomes (see Chapter 3); however, only two studies in California examined proximity to idle wells, one of which observed a positive relationship between lung function and distance from both active and idle wells out to 1 km (3,281 ft). According to the proximity analysis in Chapter 7, approximately 3 million people live within 1 km (3,281 ft) of an "active-producing" well in California. Abandoned wells are generally more dispersed throughout the state compared to active and idle wells, and it is unclear how many people in California live within a given proximity of an abandoned well. At some point in the future, all current active and idle wells will become abandoned wells, at which point the number of people living within 1 km (3,281 ft) of an abandoned well could easily exceed 3 million. The available environmental public health literature is insufficient to draw conclusions about proximity to abandoned wells and legacy oil and gas infrastructure as a risk factor for adverse health outcomes. Additional epidemiological studies that take into account idle and abandoned wells would increase the understanding of underlying exposure sources and pathways as well as elucidate which types of wells may be of the greatest concern with regard to human health outcomes (Tran et al., 2020). This data could then be used to inform future regulatory decisions regarding the prioritization of monitoring, inspection, and plugging and abandoning to reduce community exposure from various types of wells.

Building on or near abandoned wells, particularly legacy abandoned wells, or improperly abandoned pipelines may present serious explosive hazards and health risks to residents in densely populated areas (Chilingar & Endres, 2005). Studies of emissions from upstream oil and gas development in California have documented methane emissions from abandoned wells (Lebel et al., 2020). In urban and residential areas, methane from nearby or underlying sources can migrate and accumulate in confined spaces, becoming an explosion and fire hazard. Multiple instances of gas seepage from both natural faults and abandoned wells have been documented in the Los Angeles area, where residential and commercial development have occurred directly over oil fields and old legacy abandoned wells (Chilingar & Endres, 2005). Since the Ross Dress for Less explosion in 1985, which was possibly linked to leaking gas accumulation, none of the documented cases have resulted in explosions. However, they have resulted in homes being torn down to access and re-abandon leaking wells, or commercial businesses installing gas detection and ventilation systems to mitigate the risk of explosions (Chilingar & Endres, 2005). Potential health impacts from contaminants associated with abandoned pipelines and other legacy infrastructure, including TENORM, PCBs, and asbestos, also need to be considered for future land use and development. As commercial and residential development expands into areas that may have previously been used for oil and gas development, there is a clear need to mitigate the risk of explosions and exposure to VOCs, TACs, TENORM, PCBs, and other potential contaminants through better record keeping, disclosure of locations, and studies of potential health impacts associated with legacy abandoned wells, as well as long-term monitoring of emissions and integrity of abandoned wells.

6.5.3. Economic Issues Associated with Idle, Idle-deserted, and Legacy Abandoned Wells

Economic issues and limited funding availability often result in idle-deserted and improperly abandoned legacy wells remaining unplugged for extended periods of time, during which nearby communities have been negatively impacted through leaking oil and the emission of VOCs and noxious odors (California State Lands Commission, 2017; CalGEM, 2016; SCAQMD, 2016).

If oil prices fall, operators are at increased risk of bankruptcy and wells becoming idle-deserted (CCST, 2018; Kang et al., 2021; Williams-Derry, 2020). For smaller operators that are more vulnerable to bankruptcy (and more likely to desert wells), and for wells that change ownership numerous times during their operational lifetimes, determining financial liability and recovering costs for plugging and abandoning may not always be straightforward or feasible (CCST, 2018; Western Organization of Resource Councils, 2021). When wells become idle-deserted, the state becomes liable for any costs associated with plugging and abandonment. Costs of plugging wells in some areas can exceed $1 million per well (California State Lands Commission, 2020; Grilley & Welch, 2020), and studies have estimated California's total liability for plugging and abandoning idle-deserted wells to range from tens to hundreds of millions of dollars after bonding requirements were taken into account (CCST, 2018; Nelson & Fisk, 2021). Current funding appropriations for plugging and abandoning idle-deserted wells is $3 million per year until fiscal year 2022–2023, when it will decrease to $1 million (Department of Conservation, 2020). Based on estimated costs and appropriations, CalGEM estimates that seven to 33 idle-deserted wells will be plugged and abandoned annually, starting in fiscal year 2022-2023. Recent updates to idle well regulations have increased both testing requirements and incentives for operators to plug and abandon idle wells. As more idle wells are plugged and abandoned, the potential liability to the State is reduced. As of 2019, CalGEM identified 24 idle-deserted wells and another 3,265 deserted or potentially deserted wells that need to be evaluated.

The large number of potentially idle-deserted and improperly abandoned wells, their potential impacts to surrounding communities, the costs associated with proper plugging and abandonment, and limited funding availability could increase concerns about the existence of these wells.

6.6. Summary

California has a long history of oil and gas production and there are numerous abandoned wells and associated legacy infrastructure located in oil and gas basins throughout the state. CalGEM reports approximately 126,000 plugged and abandoned oil and gas wells in California, although recent studies suggest that the number of abandoned wells may be underreported by 17% or more. There are also an estimated 2,500–5,000 idle-deserted wells in which responsibility to plug and abandon falls to the state. The number of abandoned oil and gas wells is only expected to increase as individual well production eventually decreases to the point where operation is no longer economically viable. At some point in the future, all current active and idle wells will become abandoned wells, at which point the number of people living within 1 km (3,281 ft) of an

abandoned well could easily exceed 3 million. Less is known about the abundance of abandoned pipelines and other legacy infrastructure due to inadequate documentation. Idle, abandoned, removed, idle-deserted, and deserted pipelines are not considered active and thus are not required to be reported by operators in pipeline management plans submitted to CalGEM. Information on abandoned legacy infrastructure will depend on requirements from other regulatory agencies or datasets.

Abandoned oil and gas wells, pipelines, and other legacy infrastructure pose multiple concerns for public health through both surface and subsurface pathways, including the release of oil, gas, produced water, radioactive scale (i.e., TENORM), and legacy pipeline treatment chemicals (PCBs, etc). Corrosion and weathering may also release heavy metals from pipeline bodies and welds, and hazardous materials used in pipeline coatings such as asbestos.

Current non-methane hydrocarbons (NMHC) and TAC emissions data from abandoned, inactive, and idle wells are inadequate to reliably assess the potential impacts on human health. The majority of studies of emissions from idle and abandoned wells in California focus on methane and studies that have measured NMHC and TAC emissions are limited in scope and geographic coverage. Studies of methane emissions from abandoned and idle wells in California have found that most emissions come from a small number of wells that are "super-emitters." Additionally, failures in abandoned well integrity that result in emissions or contamination of water resources may go undetected for extended periods. Despite this, there are no long-term monitoring requirements for abandoned wells. Assembly Bill 1328 (2019) calls for CalGEM and CARB to initiate a study of greenhouse gas, TAC, and VOC emissions from idle and abandoned wells with cooperation from oil and gas operators; however, the results from this study are yet to be released at the time of writing this report.

Available epidemiological literature related to idle, inactive, and abandoned wells is limited. A single study found that living nearby and downwind of oil and gas development sites, active or idle, was associated with reduced lung function among residents. However, others did not find any association with proximity to idle wells and adverse health outcomes. Overall, the available environmental public health literature is insufficient to draw conclusions about proximity to inactive wells, abandoned wells, and other legacy oil and gas infrastructure as a risk factor for adverse health outcomes.

Key information regarding the number and location of abandoned pipeline and other legacy infrastructure, and the characterization of the extent of potential hazards such as PCB and TENORM contamination, is needed before health risks can be assessed. Current regulations for the handling and management of oil and gas related NORM/TENORM in California are lacking. In recent years, improperly abandoned legacy pipelines in California have resulted in events that released crude oil and oil-water mixtures to the surface, potentially exposing nearby communities to hazards. A risk-based decision-making framework for in-place pipeline abandonment, similar to the one developed by Canada, would help mitigate potential issues with groundwater resource contamination, future land use, and potential hazards such as PCBs, TENORM, and asbestos.

References

2 Colo. Code Regs. § 404-1-1105 (2020). Abandonment. https://casetext.com/regulation/colorado-administrative-code/department-400-department-of-natural-resources/division-404-oil-and-gas-conservation-commission/rule-2-ccr-404-1-practice-and-procedure/section-2-ccr-404-1-1105-abandonment#:~:text=Section%202%20CCR%20404%2D1%2D1105%20%2D%20ABANDONMENT%201105.&text=A%20flowline%20or%20crude%20oil,abandonment%20requirements%20set%20forth%20below

14 Cal. Code Regs. § 1720 (2006). Definitions. https://casetext.com/regulation/california-code-of-regulations/title-14-natural-resources/division-2-department-of-conservation/chapter-4-development-regulation-and-conservation-of-oil-and-gas-resources/subchapter-1-onshore-well-regulations/article-2-definitions/section-1720-definitions

14 Cal. Code Regs. § 1723 (2006). Plugging and Abandonment – General Requirements. https://casetext.com/regulation/california-code-of-regulations/title-14-natural-resources/division-2-department-of-conservation/chapter-4-development-regulation-and-conservation-of-oil-and-gas-resources/subchapter-1-onshore-well-regulations/article-3-requirements/section-1723-plugging-and-abandonment-general-requirements

14 Cal. Code Regs. § 1776 (2006). Well Site and Lease Restoration https://www.law.cornell.edu/regulations/california/14-CCR-1776

14 Cal. Code Regs. § 1774.2 (2018). Pipeline Management Plans. https://casetext.com/regulation/california-code-of-regulations/title-14-natural-resources/division-2-department-of-conservation/chapter-4-development-regulation-and-conservation-of-oil-and-gas-resources/subchapter-2-environmental-protection/article-3-requirements/section-17742-pipeline-management-plans

14 Cal. Code Regs. § 1752 (2019). https://casetext.com/regulation/california-code-of-regulations/title-14-natural-resources/division-2-department-of-conservation/chapter-4-development-regulation-and-conservation-of-oil-and-gas-resources/subchapter-2-environmental-protection/article-3-requirements/section-17722-idle-well-testing-waiver-plan

14 Cal. Code Regs. § 1772.1(a)(1) (2019). Pressure Testing Parameters. https://casetext.com/regulation/california-code-of-regulations/title-14-natural-resources/division-2-department-of-conservation/chapter-4-development-regulation-and-conservation-of-oil-and-gas-resources/subchapter-2-environmental-protection/article-3-requirements/section-177211-pressure-testing-parameters

14 Cal. Code Regs. § 1772.1.(a)(2) (2019). Pressure Testing Parameters. https://casetext.com/regulation/california-code-of-regulations/title-14-natural-resources/division-2-department-of-conservation/chapter-4-development-regulation-and-conservation-of-oil-and-gas-resources/subchapter-2-environmental-protection/article-3-requirements/section-177211-pressure-testing-parameters

14 Cal. Code Regs. § 1784 (2015). Well Stimulation Treatment Area Analysis and Design. https://casetext.com/regulation/california-code-of-regulations/title-14-natural-

resources/division-2-department-of-conservation/chapter-4-development-regulation-and-conservation-of-oil-and-gas-resources/subchapter-2-environmental-protection/article-4-well-stimulation-treatments/section-1784-well-stimulation-treatment-area-analysis-and-design

14 Cal. Public Res. Code § 3208 (2017). Well Properly Abandoned. https://casetext.com/statute/california-codes/california-public-resources-code/division-3-oil-and-gas/chapter-1-oil-and-gas-conservation/article-4-regulation-of-operations/section-3208-well-properly-abandoned

14 Cal. Public Res. Code § 3008 (2018). Well, prospect well, active observation well, idle well, long-term idle well. https://casetext.com/statute/california-codes/california-public-resources-code/division-3-oil-and-gas/chapter-1-oil-and-gas-conservation/article-1-definitions-and-general-provisions/section-3008-well-prospect-well-active-observation-well-idle-well-long-term-idle-well

14 Cal. Public Res. Code § 3237 (2023). https://codes.findlaw.com/ca/public-resources-code/prc-sect-3237/

14 Cal. Public Res. Code § 3251 (2023). https://codes.findlaw.com/ca/public-resources-code/prc-sect-3251/

17 Cal. Code Regs. § 95665-95677 (2017).

40 Code of Federal Regulations § 761.60 (1979). Disposal Requirements. https://www.law.cornell.edu/cfr/text/40/761.60

40 Code of Federal Regulations § 192.12 (1995). Standards. https://www.law.cornell.edu/cfr/text/40/192.12#:~:text=§%20192.12%20Standards.,-Remedial%20actions%20shall&text=(2)%2015%20pCi%2Fg,15%20cm%20below%20the%20surface.&text=(2)%20The%20level%20of%20gamma,than%2020%20microroentgens%20per%20hour

40 Code of Federal Regulations § 61.141 (1995). Definitions. https://www.law.cornell.edu/cfr/text/40/61.141

40 Code of Federal Regulations § 192.727 (2010). Abandonment or Deactivation of Facilities. https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-D/part-192/subpart-M/section-192.727

40 Code of Federal Regulations § 195.59 (2019). Abandonment or Deactivation of Facilities. https://www.law.cornell.edu/cfr/text/49/195.59

Alboiu, V., & Walker, T. R. (2019). Pollution, management, and mitigation of idle and orphaned oil and gas wells in Alberta, Canada. *Environmental Monitoring and Assessment*, *191*(10), 1–16. https://doi.org/10.1007/s10661-019-7780-x

Amec Foster Wheeler Environment & Infrastructure. (2017). *Water Conduit Effect in Abandoned Pipelines: Pipeline Abandonment Research Steering Committee PARSC 012* (No.

EE26423). Petroleum Technology Alliance Canada. https://ptac.org/wp-content/uploads/2023/12/Water-Conduit-Effect-on-Abandoned-Pipelines.pdf

American Gas Association. (2006). *AGA Voluntary Guideline for Handling Coal Tar or Asphaltic Enamel Wrapped Pipe*.

American Gas Association. (2010). *RE: EPA Advance Notice of Proposed Rulemaking, Polychlorinated Biphenyls (PCBs) Reassessment of Use Authorizations, 75 Fed. Reg. 17,645*.

Ann Glass Geltman, E., & LeClair, N. (2018). Variance in state protection from exposure to NORM and TENORM wastes generated during unconventional oil and gas operations: Where we are and where we need to go. *NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy*, *28*(2), 240–261. https://doi.org/10.1177/1048291118755387

AOGHS (American Oil & Gas Historical Society). (2020). *First California Oil Wells*. https://aoghs.org/petroleum-pioneers/first-california-oil-well

Arcadis Canada. (2019). *Risk-Based Decision-Making Framework for Pipeline Abandonment—Final: A Guide for Evaluating Risks Associated with Physical and Technical Hazards Related to Abandonment-In-Place*. Petroleum Technology Alliance of Canada (PTAC) on behalf of Pipeline Abandonment Research Steering Committee (PARSC). https://ptac.org/wp-content/uploads/2023/12/Risk-Based-Decision-Framework-for-Pipeline-Abandonment.pdf

ATSDR (Agency for Toxic Substances and Disease Registry). (2016). *Health Effects of Asbestos*. https://www.atsdr.cdc.gov/asbestos/health_effects_asbestos.html

BP U.S. Pipelines and Logistics. (2019). *Asbestos*. https://www.bp.com/content/dam/bp/country-sites/en_us/united-states/home/documents/products-and-services/pipelines/contractor-information/policy/asbestos-policy.pdf

Brantley, H. L., Thoma, E. D., & Eisele, A. P. (2015). Assessment of volatile organic compound and hazardous air pollutant emissions from oil and natural gas well pads using mobile remote and on-site direct measurements. *Journal of the Air & Waste Management Association*, *65*(9), 1072–1082. https://doi.org/10.1080/10962247.2015.1056888

CalGEM (California Department of Conservation Geologic Energy Management Division). (2016). *June 2016 Los Angeles Orphan Well Plugging Project*. https://www.conservation.ca.gov/index/Documents/LA%20orphan%20well%20plugging%20media%20fact%20sheet.pdf

CalGEM. (2019). *Requirements for Idle Well Testing and Management: Initial Statement of Reasons*. https://www.conservation.ca.gov/index/Documents/Initial%20Statement%20of%20Reasons.pdf

CalGEM. (2021). Personal Communication - March 8, 2021.

CalGEM. (2021). *Idle Well Program Report: Idle & Long-term Idle Wells in California Reporting Period: January 1, 2019 to December 31, 2019*. https://www.conservation.ca.gov/calgem/idle_well/Documents/AB%202729%20Idle%20Well%20Program%20Report%202019.pdf

CalGEM. (2022a). *Oil and Gas Wells Table, California*. https://gis.conservation.ca.gov/portal/home/item.html?id=0d30c4d9ac8f4f84a53a145e7d68eb6b

CalGEM. (2022b). *WellSTAR - Production/Injection Database*. https://wellstar-public.conservation.ca.gov/General/PublicDownloads/Index

CalGEM. (2023). Final Orphan Well Screening and Prioritization Methodology. https://www.conservation.ca.gov/calgem/Documents/Final%20Orphan%20Well%20Prioritization%20Methodology.pdf

California Department of Conservation. (2022). *Well Inspections & Repair Updates*. https://www.conservation.ca.gov/index/Pages/News/State-Oil-and-Gas-Supervisor-Issues-Statement-on-Two-Bakersfield-Long-Term-Idle-Wells.aspx

California State Assembly. (2019). *Assembly Bill No. 1328: Oil and gas: Notice of intention to abandon well: Study of fugitive emissions from idle, idle-deserted, and abandoned wells.* https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200AB1328

California State Lands Commission. (2017). *Final Environmental Impact Report for the Becker and Legacy Wells Abandonment and Remediation Project* (EIR Number: 792; W30214). https://slcprdappazappwordpress.azurewebsites.net/wp-content/uploads/2017/07/FEIR.pdf

California State Lands Commission. (2020). *Coastal Hazards and Legacy Oil and Gas Well Removal and Remediation Program: Progress Report 2020*. https://slcprdwordpressstorage.blob.core.windows.net/wordpressdata/2020/12/SB44_2020.pdf

CARB (California Air Resources Board). (2018). *SNAPS Communities Selected for First Round of Air Monitoring*. https://ww2.arb.ca.gov/resources/documents/snaps-first-round-communities

CARB. (2021). *Study of Neighborhood Air near Petroleum Sources: Resources*. https://ww2.arb.ca.gov/our-work/programs/study-neighborhood-air-near-petroleum-sources/resources

Carpenter, D. O. (2006). Polychlorinated biphenyls (PCBs): Routes of exposure and effects on human health. *Reviews on Environmental Health*, *21*(1), 1–24. https://doi.org/10.1515/reveh.2006.21.1.1

CCST (California Council on Science and Technology). (2018). *Orphan Wells in California: An Initial Assessment of the State's Potential Liabilities to Plug and Decommission Orphan*

Oil and Gas Wells. https://ccst.us/wp-content/uploads/CCST-Orphan-Wells-in-California-An-Initial-Assessment.pdf

CCST, Lawrence Berkeley National Laboratory, & Pacific Institute. (2015). *An Independent Scientific Assessment of Well Stimulation in California, Volume 2*. http://ccst.us/projects/hydraulic_fracturing_public/SB4.php

Chilingar, G. V., & Endres, B. (2005). Environmental hazards posed by the Los Angeles Basin urban oilfields: An historical perspective of lessons learned. *Environmental Geology*, *47*(2), 302–317. https://doi.org/10.1007/s00254-004-1159-0

City of Carson. (2021). *Carson Municipal Code: Part 3. Development Standards for Site Abandonment and Redevelopment*. https://www.codepublishing.com/CA/Carson/#!/Carson09/Carson09050300.html

City of Signal Hill. (2020). *Signal Hill Municipal Code: Chapter 16.24 Abandonment of Wells and Idle Wells*. https://codelibrary.amlegal.com/codes/signalhill/latest/signalhill_ca/0-0-0-58296

COGCC (Colorado Oil and Gas Conservation Commission). (2008). *In The Matter Of Alleged Violations Of The Rules And Regulations Of The Colorado Oil And Gas Conservation Commission By The City Of Trinidad, Gustavson Associates, Inc., Halliburton Services, And Pioneer Natural Resources USA, Inc., Las Animas County, Colorado.* https://cogcc.state.co.us/Hearings/Notices/2008/Feb08/0802-OV-03.pdf

Con Edison. (2012). *Field Coating of Steel Pipe and Fittings Installed Underground and in Subsurface Structures* (G-8209-4). https://www.coned.com/-/media/files/coned/documents/es/specs/electric/section-viii---g-8209.pdf

Conference of Radiation Control Program Directors. (2004). *Part N: Regulation and Licensing of Technologically Enhanced Naturally Occurring Radioactive Material (TENORM). 1*, Sec N.1–N.3. https://cdn.ymaws.com/www.crcpd.org/resource/resmgr/docs/SSRCRs/N_04-04-print.pdf

Crosby, T., Joe, D., Prefontaine, A., & Tsaprailis, H. (2015). *Cleaning of Pipelines for Abandonment*. Petroleum Technology Alliance of Canada. https://ptac.org/wp-content/uploads/2023/12/Cleaning-Pipelines-for-Abandonment-Final-Report-EN.pdf

Currie, J., Greenstone, M., & Meckel, K. (2017). Hydraulic fracturing and infant health: New evidence from Pennsylvania. *Science Advances*, *3*(12), e1603021. https://doi.org/10.1126/sciadv.1603021

Department of Conservation. (2019). *Fact Sheet: Marina del Rey Well Remediation*. State of California Natural Resources Agency. https://www.conservation.ca.gov/calgem/Documents/DOW%20RGC%2010%20Well%20Incident/DOC%20Marina%20del%20Rey%20gas%20leak%20fact%20sheet%20final-1.28.19.pdf

Department of Conservation. (2020). *Budget Change Proposal—Cover Sheet*. https://esd.dof.ca.gov/Documents/bcp/2021/FY2021_ORG3480_BCP3276.pdf

Department of Health Services Radiologic Health Branch, & DOGGR (Department of Conservation Division of Oil, Gas, and Geothermal Resources). (1996). *A Study of NORM Associated with Oil and Gas Production Operations in California*.

El Hachem, K., & Kang, M. (2022). Methane and hydrogen sulfide emissions from abandoned, active, and marginally producing oil and gas wells in Ontario, Canada. *Science of The Total Environment*, *823*, 153491. https://doi.org/10.1016/j.scitotenv.2022.153491

Faria, L. S., & Moreira, R. M. (2016, October 18). Lead-210 in NORM from the oil and gas industry. *Proceedings of an International Symposium*. Naturally Occurring Radioactive Material (NORM VIII), Rio de Janeiro, Brazil. https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1832_web.pdf

Federal Facilities Research Center Radiation Focus Group. (2014). *State Regulations and Policies for Control of Naturally-Occurring and Accelerator Produced Radioactive Materials (NARM) and Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM)*. Association of State and Territorial Solid Waste Management Officials. http://astswmo.org/files/policies/Materials_Management/State_Statutes_and_Regulations_TENORM_Final_Dec2014.pdf

Gennaro, V., Finkelstein, M. M., Ceppi, M., Fontana, V., Montanaro, F., Perrotta, A., Puntoni, R., & Silvano, S. (2000). Mesothelioma and lung tumors attributable to asbestos among petroleum workers. *American Journal of Industrial Medicine*, *37*(3), 275–282. https://doi.org/10.1002/(sici)1097-0274(200003)37:3%3C275::aid-ajim5%3E3.0.co;2-i

Godin, M. (2014). *Innovation Roadmap for Transmission Pipeline Transportation of Petroleum Products*. Alberta Innovates – Energy and Environment Solutions and the Canadian Energy Pipeline Association. https://ptac.org/wp-content/uploads/2023/12/Transmission-Pipeline-Roadmap-Final-Report.pdf

Grilley, D., & Welch, R. (2020). *Agenda Report: A Continuation of the Declaration that the Public Interest and Necessity Requires Certain Work to be Performed Without Competitive Bidding Pursuant to Public Contract Code Sections 22035 and 22050*. https://beverlyhills.granicus.com/MetaViewer.php?view_id=49&clip_id=7228&meta_id=438350

Ground Water Protection Council. (2011). *State Oil and Gas Agency Groundwater Investigations And Their Role in Advancing Regulatory Reforms A Two-State Review: Ohio and Texas*.

Howell, D. (2011). Considering Asbestos And Old Pipelines. *Pipeline & Gas Journal*, *238*(10), 76–78. https://pgjonline.com/magazine/2011/october-2011-vol-238-no-10/features/considering-asbestos-and-old-pipelines

IARC (International Agency for Research on Cancer). (2016). *Polychlorinated Biphenyls and Polybrominated Biphenyls.* IARC Monographs, *107*. World Health Organization. https://publications.iarc.fr/_publications/media/download/5979/c395f7fad077e8a5774c72c089a212d67cc18de1.pdf

ICRP (International Commission on Radiological Protection). (2019). Radiological protection from naturally occurring radioactive material (NORM) in industrial processes. ICRP Publication *142*, 48(4). https://www.icrp.org/publication.asp?id=ICRP%20Publication%20142

Interstate Oil and Gas Compact Commission. (2020). *Idle and Orphan Oil and Gas Wells: State and Provincial Regulatory Strategies Supplemental Information*. https://iogcc.ok.gov/sites/g/files/gmc836/f/supplemental_information_orphan_wells_5-28-2020.pdf

Jeong, S., Millstein, D., & Fischer, M. L. (2014). Spatially explicit methane emissions from petroleum production and the natural gas system in California. *Environmental Science & Technology*, *48*(10), 5982–5990. https://doi.org/10.1021/es4046692

Johnston, J. E., Enebish, T., Eckel, S. P., Navarro, S., & Shamasunder, B. (2021). Respiratory Health, Pulmonary Function and Local Engagement in Urban Communities Near Oil Development. *Environmental Research*, *197,* 111088. https://doi.org/10.1016/j.envres.2021.111088

Kang, M., Dong, Y., Liu, Y., Williams, J. P., Douglas, P. M. J., & McKenzie, J. M. (2019). Potential increase in oil and gas well leakage due to earthquakes. *Environmental Research Communications*, *1*(12), 121004. https://doi.org/10.1088/2515-7620/ab576e

Kang, M., Brandt, A. R., Zheng, Z., Boutot, J., Yung, C., Peltz, A. S., & Jackson, R. B. (2021). Orphaned oil and gas well stimulus—Maximizing economic and environmental benefits. *Elementa: Science of the Anthropocene*, *9*(1), 00161. https://doi.org/10.1525/elementa.2020.20.00161

LACDPH (Los Angeles County Department of Public Health). (2018). *Public Health and Safety Risks of Oil and Gas Facilities in Los Angeles County*. http://publichealth.lacounty.gov/eh/docs/ph_oilgasfacilitiesphsafetyrisks.pdf

Lebel, E. D., Lu, H. S., Vielstädte, L., Kang, M., Banner, P., Fischer, M. L., & Jackson, R. B. (2020). Methane Emissions from Abandoned Oil and Gas Wells in California. *Environmental Science & Technology*, *54*(22), 14617–14626. https://doi.org/10.1021/acs.est.0c05279

Lillis, P., Warden, A., Claypool, G., & Magoon, L. (2007). Chapter 10: Petroleum Systems of the San Joaquin Basin Province—Geochemical Characteristics of Gas Types. In *USGS Professional Paper 1713; Petroleum Systems and Geologic Assessment of Oil and Gas in the San Joaquin Basin Province, California*. https://pubs.usgs.gov/pp/pp1713/10/pp1713_ch10.pdf

Secaira, M. (2022, June 21). *How idle oil wells leaked explosive levels of methane in Bakersfield*. CapRadio. https://www.capradio.org/articles/2022/06/21/how-idle-oil-wells-leaked-explosive-levels-of-methane-in-bakersfield/

Solis, N. (2022, May 22). *California oil regulator confirms methane leak at idle oil wells in Bakersfield*. Los Angeles Times. https://www.latimes.com/california/story/2022-05-22/california-oil-regulator-reports-methane-leak-at-idle-oil-well-in-bakersfield

National Transportation Safety Board. (2019). *Pipeline Accident Brief: Natural Gas Explosion at Family Residence Firestone, Colorado April 17, 2017* (NTSB/PAB-19/02). https://www.ntsb.gov/investigations/AccidentReports/Reports/PAB1902.pdf

Nelson, S., & Fisk, J. M. (2021). End of the (Pipe) Line? Understanding how States Manage the Risks of Oil and Gas Wells. *Review of Policy Research*. https://doi.org/10.1111/ropr.12411

Osbourne, P. (2002). *Technical Program Overview: Underground Injection Control Regulations*.

Pipeline Abandonment Steering Committee. (1996). *Pipeline Abandonment—A Discussion Paper on Technical and Environmental Issues*. Pipeline Abandonment Steering Committee. https://www.cer-rec.gc.ca/en/applications-hearings/pipeline-abandonment/pipeline-abandonment-discussion-paper-technical-environmental-issues.html#a1

PHMSA (Pipeline and Hazardous Materials Safety Administration). (2016). *Pipeline Safety: Clarification of Terms Relating to Pipeline Operational Status*. 81 FR 54512; Docket No. PHMSA-2016-0075), 54512–54514. https://www.federalregister.gov/documents/2016/08/16/2016-19494/pipeline-safety-clarification-of-terms-relating-to-pipeline-operational-status

PHMSA. (2019). *Pipeline Safety: Potential for Damage to Pipeline Facilities Caused by Flooding, River Scour, and River Channel Migration.* 84 FR 14715; Docket No. PHMSA-2019-0047, 14715–14717. https://www.federalregister.gov/documents/2019/04/11/2019-07132/pipeline-safety-potential-for-damage-to-pipeline-facilities-caused-by-flooding-river-scour-and-river

Pollack, A., Mukerji, T., Fu, P., Nelson, D., Bartling, B., Toland, M., Lopez, A., & Guice, R. (2020). A spatial-statistical investigation of surface expressions associated with cyclic steaming in the Midway-Sunset Oil Field, California. *Geomechanics and Geophysics for Geo-Energy and Geo-Resources*, *6*(1), 1–23. http://dx.doi.org/10.2118/194027-STU

Research and Special Programs Administration. (2000). *Pipeline Safety: Underwater Abandoned Pipeline Facilities*. 5 FR 54440; RSPA-97-2094 Amdt. Nos. 192-89 195-69, 54440–54444. https://www.federalregister.gov/documents/2000/09/08/00-22986/pipeline-safety-underwater-abandoned-pipeline-facilities

SCAQMD (South Coast Air Quality Management District). (2016). *Firmin Street Orphan Wells Project*. http://www.aqmd.gov/home/news-events/community-investigations/firmin-street-orphan-wells

Southern California Gas Company, & San Diego Gas & Electric Company. (2016). *Application to Recover Costs Recorded in the Pipeline Safety and Reliability Memorandum Accounts, The Safety Enhancement Expense Balancing Accounts, and The Safety Enhancement Capital Cost Balancing Accounts (A.16-09-005)*. https://www.sdge.com/sites/default/files/ORA%2520DR-04.pdf

Swanson, J. M., Kunicky, T., & Poohkay, P. (2010). Environmental Considerations for Pipeline Abandonment: A Case Study From Abandonment of a Southern Alberta Pipeline. *IPC2010*, 179–185. https://doi.org/10.1115/IPC2010-31669

The Cadmus Group. (1995). *Assessment of Potential Technical and Regulatory Issues Relating to Naturally Occurring Radioactive Materials (NORM) in Class II Wells*. U.S. Environmental Protection Agency. https://www.epa.gov/sites/production/files/2015-08/documents/cadmus-norm-report.pdf

Thompson, J., Costello, F., Fahd, Z., Forsee, G., Gavitt, S., Goretzki, B., & Patrick, D. (2015). *E-42 Task Force Report: Review of TENORM in the Oil & Gas Industry* (CRCPD E-15-2). Conference of Radiation Control Program Directors, Inc. https://cdn.ymaws.com/www.crcpd.org/resource/collection/89CD4979-9A4C-41AF-8832-2F1EA116A8C0/E-42_Report_Review_of_TENORM.pdf

Thorne, W. E., Basso, A. C., & Dhol, S. K. (1996). Identification and Assessment of Trace Contaminants Associated With Oil and Gas Pipeline Abandoned in Place. *International Pipeline Conference*, *40214*, 1263–1270. https://doi.org/10.1115/IPC1996-1940

Townsend-Small, A., & Hoschouer, J. (2021). Direct measurements from shut-in and other abandoned wells in the Permian Basin of Texas indicate some wells are a major source of methane emissions and produced water. *Environmental Research Letters*, *16*(5), 054081. https://iopscience.iop.org/article/10.1088/1748-9326/abf06f

Tran, K. V., Casey, J. A., Cushing, L. J., & Morello-Frosch, R. (2020). Residential Proximity to Oil and Gas Development and Birth Outcomes in California: A Retrospective Cohort Study of 2006–2015 Births. *Environmental Health Perspectives*, *128*(6), 067001. https://doi.org/10.1289/EHP5842

Tran, K. V., Casey, J.A., Cushing, L.J., Morello-Frosch, R. (2021). Residential proximity to hydraulically fractured oil and gas wells and adverse birth outcomes in urban and rural communities in California (2006-2015). *Environmental Epidemiology*. *5*(6), e172. https://doi.org/10.1097%2FEE9.0000000000000172

US Department of the Interior, & US Department of Agriculture. (2007). *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development: The Gold Book* (BLM/WO/ST-06/021+3071/REV 07; p. 54). Bureau of Land Management. https://eplanning.blm.gov/public_projects/nepa/75541/102290/125058/Gold_Book_2007_Revised.pdf

US EPA (U.S. Environmental Protection Agency). (1991). *Diffuse NORM Wastes: Waste Characterization and Preliminary Risk Assessment Draft* (ANR-459).

US EPA. (2003). *Guidance—Potential for Radiation Contamination Associated with Mineral and Resource Extraction Industries*. https://www.epa.gov/sites/default/files/2015-04/documents/mineguide.pdf

US EPA. (2004). *PCB Inspection Manual*. https://www.epa.gov/sites/production/files/2013-09/documents/pcbinspectmanual.pdf

US EPA. (2019). *List of Uses Covered under April 2019 Final Rule; Restrictions on Discontinued Uses of Asbestos*. https://www.epa.gov/asbestos/list-uses-covered-under-april-2019-final-rule-restrictions-discontinued-uses-asbestos

US EPA. (2022a). *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020* (Reports and Assessments No. 430-R-22–003). https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2020

US EPA. (2022b). *TENORM: Oil and Gas Production Wastes*. https://www.epa.gov/radiation/tenorm-oil-and-gas-production-wastes

USGS (U.S. Geological Survey). (1999). *Naturally Occurring Radioactive Materials (NORM) in Produced Water and Oil-Field Equipment—An Issue for the Energy Industry* (USGS Fact Sheet FS-142-99). https://pubs.usgs.gov/fs/fs-0142-99/fs-0142-99.pdf

USGS. (2014). *Oil, Gas, and Groundwater Quality in California—A Discussion of Issues Relevant to Monitoring the Effects of Well Stimulation at Regional Scales*. USGS. https://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/docs/usgs_discussion_paper.pdf

USGS. (2019). *California Oil, Gas, and Groundwater Program: Potential Pathways between Oil & Gas Activities and Protected Groundwater*. https://webapps.usgs.gov/cogg/overview/potential-pathways-between-oil-gas-activities-and-protected-groundwater

Western Organization of Resource Councils. (2021). *Reclaiming Oil and Gas Wells and Addressing Climate Impacts: State Policy Recommendations*. http://www.worc.org/media/2021.3-WORC-Reclaiming-Wells-Addressing-Climate-Impacts-v2.pdf

Williams, J. P., Regehr, A., & Kang, M. (2021). Methane Emissions from Abandoned Oil and Gas Wells in Canada and the United States. *Environmental Science & Technology*, *55*(1), 563–570. https://doi.org/10.1021/acs.est.0c04265

Williams-Derry, C. (2020). *California Schemin' California Resources Corporation's Financial Distress Raises Questions About Cleanup—And What Occidental Petroleum Knew Before the CRC Spin-Off*. Institute for Energy Economics and Financial Analysis. https://ieefa.org/wp-content/uploads/2020/02/California-Schemin_February-2020.pdf

Zhou, X., Yoon, S., Mara, S., Falk, M., Kuwayama, T., Tran, T., Cheadle, L., Nyarady, J., Croes, B., Scheehle, E., Herner, J. D., & Vijayan, A. (2021). Mobile sampling of methane emissions from natural gas well pads in California. *Atmospheric Environment*, *244*, 117930. https://doi.org/10.1016/j.atmosenv.2020.117930

CHAPTER SEVEN

Proximity Analysis of Oil and Gas Development and Human Populations in California

Table of Contents

7.0. Abstract **1**

7.1. Purpose **2**

7.1.1. Proximity analysis and public health **3**

7.2. Background and Justification **4**

7.2.1. Review of surface setback regulations in the U.S. **4**

7.2.2. Existing well location restrictions and surface setback regulations in California **5**

7.2.3. California's well siting regulations and relevance to public health **11**

7.2.4. Summary of oil and gas sources and receptors considered in setback policies in California and beyond **11**

7.2.4.1 Sources targeted by setback policies **11**

7.2.4.2 Setback receptors targeted by setback policies **12**

7.2.5. Exemptions and exceptions considered in setback policies **13**

7.2.6. Summary of findings from previous California proximity analyses **15**

7.2.7. Implications of setbacks for decarbonization, production, air quality, and health **16**

7.3. Updated California Proximity Analysis: Approach & Methods **17**

7.3.1. Methods **18**

7.4. Results **19**

7.4.1. Socioeconomic disparities and total populations in proximity to oil and gas development **19**

7.4.2. Socioeconomic disparities and total populations in proximity to wastewater **23**

7.4.3. Sensitive receptors in proximity to oil and gas development **25**

7.4.3.1 Healthcare facilities **27**

7.4.3.2 Schools **27**

7.4.3.3 Total buildings and homes **29**
7.4.4. Density of oil and gas development **36**
7.4.5. Hyperlocal proximity: Within 500 feet of oil and gas development **42**
7.5. Discussion **44**
7.6. Summary **48**
References **52**
Appendix F **60**
F.1. Proximity Analysis Study Area and Data Sources **60**
F.1.1. Study area **60**
F.1.2. Oil and gas data **60**
F.1.3. Population data **63**
F.1.4. Sensitive receptors data **64**
F.2. Methods to Determine Populations and Sensitive Receptors in Proximity to Oil and Gas Activity **66**
F.2.1. Search-area buffer distances **66**
F.2.2. Downscaling Census population data **66**
F.2.3. Area-weighted metrics to determine proportions of populated areas and populations in proximity to oil and gas activity **68**
F.2.4. Calculating demographic group risk ratios **70**
F.2.5. Counts of sensitive land uses **70**
F.3. Community Vulnerability Metrics and Justification for Inclusion **70**
F.3.1. CalEnviroScreen 3.0 (CES 3.0) **70**
F.3.2. Racial Composition **71**
F.3.3. Healthcare and senior care facilities **71**
F.3.4. Parks **71**
F.3.5. Correctional Facilities **71**
F.3.6. Schools and Daycares **72**
F.4. Comparison of Buffer Areas **72**
F.5. Population and Demographic Counts Within Between-Buffer Areas **74**
F.6. Residential Parcels **76**
F.7. Previous California Proximity Analyses **78**

Figures

Figure 7.1. Approach to inform the California proximity analysis. 18

Figure 7.2. Active-producing oil and gas wells within each California Air Basin..... 20

Figure 7.3. Distributional inequities of demographic groups living within 1 km (3,281 ft) of active-producing oil and gas wells as compared to state population totals derived from the 2013–2017 American Community Survey (ACS) at the census block scale. Orange markers indicate a population weighted mean greater than one indicating a level of subgroup overrepresentation in areas that contain OGD within 1 km (3,281 ft). Blue markers indicate a level of subgroup underrepresentation in areas that contain OGD within 1 km (3,281 ft). 21

Figure 7.4. Distributional inequities of demographic groups living within 1 km (3,281 ft) of active produced water disposal ponds and water disposal wells as compared to total population. Orange markers indicate a population weighted mean greater than one indicating a level of subgroup overrepresentation in areas that contain OGD within 1 km (3,281 ft). Blue markers indicate a level of subgroup underrepresentation in areas that contain OGD within 1 km (3,281 ft)..... 23

Figure 7.5. Frequency histogram of the 207 healthcare facilities in 2021 that contain at least one active-producing well within 1 km (3,281 ft). The number above each bar indicates the number of healthcare facilities within that bar. Note: the first bar of 127 healthcare facilities may contain between 1–20 wells within 1 km (3,281 ft). 27

Figure 7.6. Frequency histogram of the 1,749 schools that contain at least one active-producing well within 1 km (3,281 ft). The number above each bar indicates the number of schools within that bar. Note the first bin of 1,306 schools may contain between 1–20 wells within 1 km (3,281 ft). An estimated 67 schools have at least 200 wells within 1 km (3,281 ft)..... 29

Figure 7.7. Well density near Los Angeles, Baldwin Hills, and Beverly Hills using the coincident wells within census tract method. Outlined census tract areas (black color) indicate areas that exceed 10 wells/km^2. Yellow areas represent the 1,000 ft (305 m) buffer areas around census tracts used to count wells beyond census tract boundaries to reduce the impact of edge effects. Note: Singular name is shown as representing select areas to simplify this visualization; however, these areas are broadly described and include various communities. 39

Figure 7.8. Well density near Long Beach (including Harbor City), Signal Hill, and Seal Beach using the coincident wells within census tract method. Outlined census tract areas (black color) indicate areas that exceed 10 wells/km^2. Yellow areas represent the 1,000 ft (305 m) buffer areas around census tracts used to count wells beyond census tract boundaries to reduce the impact of edge effects. Note: Singular name is shown as representing select areas to simplify this visualization; however, these areas are broadly described and include various communities... 40

Figure 7.9. Well density near Taft and Bakersfield using the coincident wells within census tracts method. Note the difference in scale compared to **Figure 7.7** and **Figure 7.8**. Also, the Bakersfield location included census tracts that were not directly adjacent. Outlined census tract areas (black color) indicate areas that exceed 10 wells/km^2. Yellow areas represent the 1,000 ft (305 m) buffer areas around census tracts used to count wells beyond census tract boundaries to reduce the impact of edge effects. Note: Singular name is shown as representing select areas to simplify this visualization; however, these areas are broadly described and include various communities... 41

Figure 7.10. Active-producing well (yellow marker) near Bakersfield depicting the hyperlocal proximity to nearby homes (tan color). Radial distances from the well are depicted in red

approximately 50 ft and 100 ft from the wellhead. Distances between buildings and their nearest well as shown here were used to create the frequency histogram as shown in **Figure 7.11**..... 43

Figure 7.11. Frequency histogram of cumulative counts (a) and binned counts (b) of residential buildings binned by distance to their nearest active-producing oil and gas well from 0–500 ft (0–152 m). The blue dashed line indicates the 300 ft (91 m) distances that demarcates California's "critical well" status. Note: residential buildings are represented once though they may have multiple wells within 500 ft (152 m)..... 44

Tables

Table 7.1. Summary of minimum surface setback distances from oil and gas development in the United States..... 6

Table 7.2. California and sub-state level well location restrictions and minimum surface setback regulations..... 8

Table 7.3. Total counts and associated age, racial, and socioeconomic demographic metrics of populations living in proximity to active-producing oil and gas wells in 2021. Percentages are based on state totals..... 22

Table 7.4. Total counts and associated age, racial, and socioeconomic demographic metrics of populations living in proximity to active produced water disposal ponds and any water disposal wells in 2021. Percentages are based on state totals..... 24

Table 7.5. Sensitive receptors in proximity to at least one of the 83,834 active-producing hydrocarbon wells in California. Percentage (%) represents the percent of total receptors within the respective buffer distance..... 30

Table 7.6. Counts of unique active-producing wells associated with the sensitive receptors in **Table 7.7**..... 31

Table 7.7. Sensitive receptors in proximity to at least one hydrocarbon extraction-related wastewater location in California. Percentage (%) represents the percent of total receptors within the respective buffer distance..... 32

Table 7.8. Schools and higher education facilities near at least one of the 83,834 active-producing wells in California. The number of wells driving the land use co-locations are shown in parentheses next to receptor counts where available. Percentage (%) represents the percent of total receptors within the respective buffer distance..... 33

Table 7.9. Counts of unique active-producing wells associated with the sensitive receptor in **Table 7.10**..... 34

Table 7.10. Schools and higher education facilities in proximity to at least one hydrocarbon extraction-related wastewater location in California. Percentage (%) represent percent of total receptors within the respective buffer distance..... 35

Table 7.11. Analysis of locations with the highest oil and gas well densities within California. . 38

Table 7.12. Residents and sensitive receptors in proximity to at least one of the 83,000 active-producing oil and gas wells in California, January 2021..... 49

7.0. Abstract

The peer-reviewed literature is sufficiently clear that oil and gas development (OGD) immediately adjacent to places where people live, work, play, and learn poses hazards and risks to public health. California has maintained one of the least stringent land zoning regulations (i.e., setbacks) in the United States. Consequently, a significant proportion of California residents currently live in proximity to OGD, with distinct racial and socioeconomic inequities whereby disadvantaged communities are much more likely to be located near OGD.

Specifically, an estimated 3 million, or approximately 1 in 12 (~8%) California residents live within 1 km (3,281 ft) of active oil and gas development (OGD). Within these populations, non-Hispanic Black Californians disproportionately live near active OGD, and are nearly 50% more likely to have at least one active well within 1 km (3,281 ft) of their residence as compared to the average Californian. Furthermore, non-Hispanic Black Californians are 87% more likely to have at least one active well within 1 km (3,281 ft) of their residence when compared to non-Hispanic White populations alone. Distance-based disparities also exist for low income, linguistically isolated households, renters, and low educational attainment. Although active-producing wells and locations of wastewater disposal infrastructure (e.g., disposal ponds and injection wells) share about 70% of observed land-uses, demographic analyses indicate that wastewater facilities do not completely mimic population-level inequities observed for active OGD. This discrepancy suggests that different populations across California may be disproportionately burdened by various sub-sectors of the oil and gas supply chain. Overall, populations living near OGD stand to benefit the most from any proximity-based legislation that addresses the public health and safety burdens faced by these communities.

The weight of the scientific evidence indicates that the risk of numerous adverse health outcomes (e.g., adverse birth outcomes, respiratory outcomes) increases with higher oil and gas well density and hydrocarbon production volume. Given typical spatial clustering of oil and gas wells, many Californians that live in proximity to one well likely live in proximity to many wells. Overall, we found that 157 census tracts in 16 areas have a well density of at least 10 wells/km^2 encompassing more than 628,000 Californians. Sixty-four of these 157 census tracts (~40%) have CalEnviroScreen 3.0 (OEHHA, 2018), scores designating them as disadvantaged communities, with disproportionate socioeconomic, health, and environmental burdens, in addition to the burdens associated with upstream oil and gas development. Because a quarter of all California census tracts are designated as disadvantaged communities based on CalEnviroScreen scores, this finding indicates that disadvantaged communities are overrepresented (1.6 times more likely) in census tracts that contain 10 or more wells per square kilometer. The highest mean well density was observed in the Los Angeles cluster location, where an area just over 5 mi^2 (13 km^2) contains 866 active-producing wells.

An estimated 1,749 (~8%) pre-K through 12th grade schools are within 1 km (3,281 ft) of at least one active-producing well, and 1,014 of these schools (58%) are within 1 km (3,281 ft) of multiple wells. Specifically, 107 schools are within 1 km (3,281 ft) of at least 100 wells and 33 schools have over 300 wells within a 1 km (3,281 ft) radius. Notably, a relatively small proportion of total OGD wells in California (2-7% depending on receptor) have a school, childcare facility, healthcare

facility, senior care facility, correctional facility, or park within 1 km (3,281 ft) (with the exception of residential buildings). For example, 2,377 out of 83,834 (roughly 1 in 35) wells are within 1 km (3,281 ft) of a healthcare facility. This represents just 3% of the total well inventory, with nearly 97% of wells beyond 1 km (3,281 ft) of any California healthcare facility. These findings suggest that nearly all co-locations between OGD and schools, childcare facilities, healthcare facilities, senior-care facilities, correctional facilities, and parks could be eliminated by shutting in less than 7% of California's total active-producing well inventory. However, over 30,000 (36%) of active-producing wells are located within 1 km (3,281 ft) of residential buildings indicating a more distributed overlap between OGD and Californian residents.

To mitigate health risks associated with upstream oil and gas development, California should implement a health-protective, minimum surface setback distance between upstream oil and gas development and human populations. Decision-making regarding the appropriate health-protective minimum surface setback distance should (1) consider multiple stressors associated with upstream oil and gas activities, (2) include an additional margin of safety to account for the vulnerabilities of population subgroups, and (3) take into account existing environmental and socioeconomic burdens experienced by communities that may enhance vulnerability to the adverse health effects of oil and gas development activities. Because exemptions and conditional exceptions for minimum surface setback requirements will likely diminish health protections for communities and other sensitive receptors, such exemptions and exceptions should be avoided. Finally, given the significant proportion of California residents currently living in proximity to OGD, the state of California should deploy measures to reduce impacts associated with existing upstream oil and gas development.

7.1. Purpose

The purpose of this analysis is to characterize human populations in proximity to existing oil and gas activities throughout the state of California. This analysis is framed within a public health context that considers the potential human health risks associated with upstream, oil and gas development (OGD) in California in tandem with population-level susceptibilities and socio-economic inequities. Here we use the term "land use co-location" to describe any occurrences where OGD is located within close proximity to human populations.

Given the findings and conclusions presented in earlier chapters and the importance of proximity and public health therein, this California proximity analysis includes multiple sections that address various aspects of setback regulations and related well location restriction policies. We first report on the state of setback policies in other major oil and gas producing states. We then discuss California's well location restrictions and setback policies that exist for certain jurisdictions within California. To inform future rulemaking recommendations, we compare these policies to other states, and discuss the precedence that has been set by these policies in terms of risk management. We also provide context related to general setback rulemaking and definitions and discuss the emerging understanding related to exemptions and exceptions and their potential to attenuate the effectiveness of setback policies in practice. Finally, we examine whether specific

racially or socioeconomically marginalized people in California are more likely to reside near active oil and gas wells.

7.1.1. Proximity analysis and public health

A proximity analysis is a type of analysis that anchors data to distinct locations or land areas to better understand the spatial relationship(s) between those entities of interest. Within an environmental public health context, a spatial proximity analysis is typically designed to characterize the spatial relationship(s) between a known or suspected set of source-hazards and a set of receptors, such as human populations that may be at risk to exposure from those hazards. This type of source-receptor study design is commonly used in environmental public health research to examine population-level health risks from hazards that are known to adversely impact health given certain exposure conditions. Identifying affected populations that may be exposed to a known risk factor can be considered a type of health impact analysis, which is often used to evaluate public health consequences of proposed decisions, interventions, or policy changes. A proximity analysis also facilitates an environmental justice assessment by assessing relative burdens to population sub-groups. "Identifying populations" is one of the five steps outlined in the SB 1000 (the Planning for Healthy Communities Act) Implementation Toolkit developed by the California Environmental Justice Alliance when performing a vulnerability assessment towards reducing unique or compounding health risks in disadvantaged communities (CEJA and PlaceWorks, 2017).

This proximity analysis provides:

1. Tangible metrics that contextualize the associated public health and safety burdens faced by communities living in proximity to OGD.
2. A comparison of spatial relationships to inform minimum surface setback regulations, and identify the associated populations benefitted by various setback distances.
3. An inequity assessment to determine if disadvantaged communities are more likely to be located in proximity to OGD in California.
4. Information regarding how close some homes and residents are to OGD.

Results of these analyses are discussed in terms of public-health-protective policies. Narrative discussions focus on both instances where health impacts may be greatest (e.g., population counts at the shortest distances) and where policy and mitigation efforts may be most protective (e.g., population counts at the greatest distances).

To characterize human populations in proximity to existing OGD throughout California, we used population and sociodemographic data resolved at the sub-census block level — representing the most spatially precise estimates to date. We present OGD in proximity to key sensitive receptors, such as schools and health care facilities, resolved at the building footprint and area extent resolutions. Finally, by using both the discrete locations of oil and gas wells and more than 10 million individual building footprints, we also show just how close some California residents live near active oil and gas wells. Overall, this proximity analysis employs a high degree of spatial

resolution to accurately characterize OGD and the immediately adjacent places where people live, work, play, and learn.

7.2. Background and Justification

As detailed in Chapters 2, 3, and 4, proximity to upstream OGD is a well-established public health risk factor in the peer-reviewed literature. From Chapter 3, public health risks and impacts increase with close proximity to oil and gas development. Chapter 4 further elucidates the importance of distance to explain differences in findings related to physical hazards, air monitoring/modeling studies, exposure assessments, and risks assessments. In sum, the public health risk factors associated with upstream OGD identified in the peer-reviewed literature include, but are not limited to, residential proximity to upstream oil and gas well sites, well density, and production volumes.

The identification of these multiple risk factors and adverse health effect findings observed in the peer-reviewed literature further support mitigation policies, such as minimum surface setback distances, to reduce public health risks and impacts. Setbacks are intended to reduce proximal population exposures to localized stressors such as toxic air contaminants, noise, and physical hazards associated with OGD by attenuating the exposure pathways that may be responsible for the observed human health risks and reported impacts in the peer-reviewed literature.

7.2.1. Review of surface setback regulations in the U.S.

Setbacks are land-zoning regulations intended to delineate a development-free or exclusion zone of land. Setbacks in some of the top producing states are summarized in **Table 7.1.** An estimated 20 of the 31 states with oil and gas development have some form of well setback restrictions from buildings (NCSL, 2021; Richardson et al., 2013). Many states, municipalities, and local governments have recently sought greater setback distances following rapid development in unconventional shale plays, particularly in increasingly urbanized areas. For example, following substantial growth in unconventional natural gas development in Pennsylvania, in 2012 the Pennsylvania General Assembly enacted the Pennsylvania Oil and Gas Act (58 Pa. Cons. Stat. § 3215, 2016) requiring (among other things) a more stringent setback from buildings, increasing from 200 to 500 ft (61 to 152 m) for unconventional wells. Similarly, in 2016, Maryland adopted a 1,000 ft (305 m) setback from any "school, church, drinking water supply, wellhead protection area, or an occupied dwelling" (Md. Code Regs. § 26.19.01.09, 2020). And despite a broad statewide setback preemption law in Texas, municipalities in Texas have been able to independently impose "commercially reasonable" setbacks (Tex. H.B. No. 40, 2015). Most recently, in 2020 the state of Colorado passed a 2,000 ft (610 m) setback from the "working pad surface" for residential buildings, high occupancy buildings, schools, and childcare centers. The exemption language for each building type includes additional informed consent, which requires consent from both building owners and tenants, as well as providing information in the languages used by populations living within the setback distances (COGCC Rules 600 Series, 2021). See **Table 7.1** for a fuller list of state and substate well location restriction regulations across the United States.

7.2.2. Existing well location restrictions and surface setback regulations in California

The state of California maintains regulations related to both well location restrictions and conditional performance standards based upon well location and nearby entities (14 Cal. Code Regs. § 1720; 24 Cal. Code Regs. § 5706.3). However, at the time of writing this report, as per Article 6, Preemption (Cal. Pub. Res. Code § 3690, 1971), California does not preempt any related land use zoning or well siting regulations and defers to political subdivisions. Thus, some political subdivisions have setbacks within their respective jurisdictions. At the time of writing this report, three cities and three counties within California have enacted setback regulations related to oil and gas activity, as shown in **Table 7.2**. Setback distances range from 50 to 2,500 ft (15 to 762 m), with distances based on the nature of the receptor. For example, places where more susceptible populations are likely present, such as schools and hospitals, have more stringent setback requirements.

Table 7.1. Summary of minimum surface setback distances from oil and gas development in the United States.

State	Jurisdiction	Year Adopted/ Amended	Setback Distance (ft)	Setback Target	Source
CO	State	2020	2,000 (610 m) (working pad surface boundary)	School facility or childcare center; residential building units and high occupancy building units	COGCC Rules 600 Series (2021)
IL	State	2013	500 (152 m) (UNGD[a])	Residence, school, hospital, nursing home, water well	Ill. Senate Bill No. 1715 (2013)
			1500 (457 m) (UNGD)	Ground water intake of a public water supply	
MD	State	2016	1,000 (305 m)	Housing, schools, faith institutions	LACDPH (2018)
			2,000 (610 m)	Private drinking water wells	
ND	State	2013	500 (152 m)	Occupied dwelling/structure	N.D. Cent. Code § 38-08-05
NM	Santa Fe County	2008	750 (229 m)	Housing, schools	LACDPH (2018)
			1,000 (305 m)	Groundwater and surface water resources	
OK	Oklahoma City	2015	300 (91 m)	Housing, fresh water well	LACDPH (2018)
			600 (183 m)	Faith institutions	
PA	State	2012	500 (152 m) (UNGD)	Housing and commercial buildings	58 Pa. Cons. Stat. § 3215 (2016), Haley et al. (2016)
	State	2012	200 (61 m) (CNGD[b])	Housing and commercial buildings	58 Pa. Cons. Stat. § 3215 (2016)

State	Jurisdiction	Year Adopted/ Amended	Setback Distance (ft)	Setback Target	Source
	State	2012	1,000 (305 m) (UNGD)	Water well; drinking water intake	58 Pa. Cons. Stat. § 3215 (2016)
	State	2012	750 (229 m) (Chemical storage)	Body of water	58 Pa. Cons. Stat. § 3215 (2016)
TX	City of Arlington	2011	200 (61 m)	Fresh water well	LACDPH (2018)
			600 (189 m)	Housing, schools, faith institutions, hospitals	
	City of Dallas	2013	1,500 (457 m)	Housing, schools, faith institutions	LACDPH (2018)
	City of Flower Mound	2011	1,500 (457 m)	Housing, schools, faith institutions, hospitals, existing water wells	LACDPH (2018)
	City of Fort Worth	2010	200 (61 m)	Fresh water well	LACDPH (2018)
			600 (189 m)	Housing, schools, faith institutions, hospitals	
WV	State	2012	200 (61 m) (CNGD)	Existing water well or dwelling	W. Va. Code § 22-6-21
			625 (191 m) (UNGD, center of well pad)	Occupied dwelling structure; building 2,500 sq. ft. or larger used to house or shelter dairy cattle or poultry husbandry	W. Va. Code § 22-6A-12
			250 (76 m) (UNGD)	Existing water well or developed spring	
			100 (30 m) (UNGD)	Perennial stream, natural or artificial lake, pond or reservoir, wetland	
			300 (91 m) (UNGD)	Naturally reproducing trout stream	
			1000 (305 m) (UNGD)	Surface or groundwater intake of a public water supply	

Table 7.2. California and sub-state level well location restrictions and minimum surface setback regulations.

Jurisdiction	Year Adopted	Setback Distance (ft)	Setback Receptors	Source
State of California	1975	100 (30 m)	Well deemed a "critical well" as one within 100 ft of a dedicated public street, highway, or operating railway; any navigable body of water; any public recreational facility, or any other area of periodic high-density population; or any officially recognized wildlife preserve	14 Cal. Code Regs. § 1724.3
		300 (91 m)	Well deemed a "critical well" if within 300 ft of a residence or airport runway	
State of California (Fire Code)	2011	100 (30 m)	Wells shall not be within 100 ft of buildings not necessary to the operation of the well	24 Cal. Code Regs. § 5706.3
		300 (91 m)	Wells shall not be drilled within 300 feet of building with an occupancy in Group A, E, or I (see definitions below)	
City of Arvin	2018	300 (91 m)	"Property boundaries of any public school, public park, clinic, hospital, long-term health care facility"; "property boundaries of any residence or residential zone" *[relevant to new development]*	Arvin, Cal. Code Ord. § 17.46.022 (2018)
		600 (183 m)	Sensitive sites such as parks, schools and hospitals *[relevant to new drilling]*	
City of Carson	2015	750 (229 m)	"property boundaries of any public school, public park, clinic, hospital, long-term health care facility"; "property boundaries of any residence or residential zone..."; property boundaries of the commercially designated zone"	Carson, Cal. Muni. Code § 9521 (2015)
		50 (15 m)	"any dedicated public street, highway, public walkway, or nearest rail of a railway being used as such"	

Jurisdiction	Year Adopted	Setback Distance (ft)	Setback Receptors	Source
City of Los Angeles	2011	200 (61 m)	School, hospital, sanitarium, or assembly occupancy	Los Angeles, Cal. Muni. Code § 91.6105 (2019)
		50 (15 m)	Building (>400 ft^2 area, 36 ft tall)	
Los Angeles County	2013	100 (30 m)	Building not necessary to the operation of a well	Los Angeles Co., Cal. Code Ord. tit. 32 (2021)
		300 (91 m)	Place of assembly, institution, or school	
Kern County	2015	210 (64 m)	Single or multi-family dwelling unit, place of public assembly, institution, school or hospital	KCPNRD (2016)
		100 (30 m)	"Any public Major or Secondary highway or building not necessary to the operation of the well"; "any building utilized for commercial purposes, not used for oil and gas operations"	
Ventura County	2020	1,500 (457 m)	"Residential dwellings"	Ventura County (2020)
		2,500 (762 m)	"Any school"	

[a]UNGD = unconventional natural gas drilling
[b]CNGD = conventional natural gas drilling

While not a wellhead location restriction, according to 14 Cal. Code Regs. (C.C.R.) § 1720, the state defines a "critical well" as one within 300 ft (91 m) of a residence or airport runway or within 100 ft (30 m) of a dedicated public street, highway, or operating railway; any navigable body of water; any public recreational facility, or any other area of periodic high-density population; or any officially recognized wildlife preserve. The California Geologic Energy Management Division (CalGEM) requires operators to disclose if a proposed well for drilling meets the definition of a critical well when applying for a permit to drill. The nature of the nearby entities defined in the critical well designation implies that wells in close proximity may pose greater risk to public health and safety. However, the state deems these health and safety risks as sufficiently mitigated through provisions related to how the well is maintained and operated, specifically through requirements related to surface- and subsurface-safety devices (see 14 Cal. Code Regs. § 1724.3).

State regulations that address well location restrictions or setbacks more directly are found in 24 C.C.R. § 5706.3 as part of the California fire code whereby:

> *"Wells shall not be within 100 ft of buildings not necessary to the operation of the well" (24 Cal. Code Regs. § 5706.3.1.3)*

Additionally,

> *"Wells shall not be drilled within 300 feet of building with an occupancy in Group A, E, or I." (24 Cal. Code Regs. § 5706.3.1.3.1)*

Generally, building groups are defined in terms of their occupancy classifications, where buildings in Group A refer to buildings where persons gather such as churches, civic buildings, restaurants, movie theaters, etc. Buildings in Group E refer to educational use types such as daycare facilities and schools. And finally, building Group I refers to institutional use types generally referring to health care facilities and correctional facilities.

Also of note with the California Fire Code are regulations related to the siting of new buildings in relation to existing wells, commonly referred to as a reverse setback:

> *"Where wells are existing, buildings shall not be constructed within the distances set forth in Section 5706.3.1 for separation of wells or buildings." (24 Cal. Code Regs. § 5706.3.1.3.2)*

No explicit exceptions are defined in the State Fire Code, however, jurisdictions may amend to include exceptions. From the hyperlocal proximity section (Section 7.4.5), it's clear that a number of active-producing wells are within these setback distances of 100 ft (30 m) from buildings not necessary to the operation of the well.

7.2.3. California's well siting regulations and relevance to public health

At the time of writing this report, California's 100 to 300 ft (30 to 91 m) setback distances are the least stringent of all major oil and gas producing states (**Table 7.1**, **Table 7.2**). In terms of distance, Ventura County exhibits the most stringent setback regulation, with 1,500 ft (457 m) for residential dwellings and 2,500 ft (762 m) for schools. California's oil and gas regulations are conditional in nature and apply to both the source (i.e., gas storage wells) and receptor (i.e., building use type). However, the recently updated regulations for underground gas storage wells implies differential risk treatment by well type or function (14 Cal. Code Regs. § 1726, 2021). This type of provision could be adopted in future setback regulations to address certain well types and extraction techniques that are relatively unique to California, such as steam flooding secondary recovery, as well as various stimulation techniques (e.g., hydraulic fracturing, acid fracturing) with risks that warrant differential treatment. The recently updated underground gas storage regulations also adopted more formal risk management plans, which require evaluation of surrounding areas to better determine where people live and recreate and how those areas are predicted to change in the future (14 Cal. Code Regs. § 1726.3, 2018). This type of formal, proactive risk management regime, which considers future population growth, is unprecedented and could be adopted in other producing regions to better plan for ongoing population sprawl in certain areas of California.

Regarding reverse setbacks, the well location restrictions within the California Fire Code indicate that high occupancy buildings merit special protection (24 Cal. Code Regs. § 5706.3.1.3.1). For example, hospitals and schools require a 300 ft (91 m) setback, compared to 100 ft (30 m) for other building use types (**Table 7.2**). Similarly, designating a well as "critical" based upon its location in relation to nearby entities provides precedent for treating a subset of wells more stringently based solely upon location to nearby receptors. It is unclear, however, whether the critical well designation occurs retroactively in the event of new building construction within 100 to 300 ft (30 to 91 m) of an existing well. Nonetheless, the critical well inclusion criteria could be expanded to include similar pollution control mitigation measures, in addition to safety systems based upon the current understanding of adverse human health impacts associated with increased risks of exposure from nearby oil and gas activity. The presence of reverse setback within the California Fire Code is unique — no other state exhibits a statewide reverse setback regulation (Fry et al., 2017), though some local governments in the United States have adopted a reverse setback (Fry et al., 2017).

7.2.4. Summary of oil and gas sources and receptors considered in setback policies in California and beyond

7.2.4.1 Sources targeted by setback policies

Generally, oil and gas related surface setback regulations originate from the wellhead location. Very often though, the wellhead does not represent the primary hazard source on an extraction site. Human health and safety hazards on an OGD site vary across many different factors, including the nature of the activity and presence of certain equipment and systems. Some support infrastructure (e.g., condensate and circulation tanks, produced water tanks, pneumatic devices, flares) may represent important pollutant emissions sources; however, support infrastructure

generally entails a separate permitting process and therefore much less information is available related to their presence on site (Koehler et al., 2018). Moreover, regulatory permitting processes generally focus on an individual well as the functional unit of interest (CalGEM, 2019). Therefore, well location is typically used to proxy for the entirety of an OGD site in the context of setback regulations (**Table 7.1**).

To be more inclusive of surface infrastructure on well sites, Colorado recently enacted new setback regulations. Instead of a wellhead, the setbacks are measured from the boundary of the working pad surface (COGCC Rules 600 Series, 2021). This area boundary designation was intended to encompass all pad-related activity, creating a more inclusive setback source target. This was likely in response to the increasing use of larger, multi-well well pads that in some cases could legally permit receptors such as homes to be located directly against a well pad fence line if the well(s) were on the opposite end of the well pad. The justification of the working pad setback target can be justified by the following thought experiment. Depending on the size and orientation of the well(s) on a well pad, it is conceivable that a shorter setback distance targeted at the working pad boundary could encompass more surrounding land area than a longer setback distance targeted at individual wells. Therefore, defining the setback at the boundary of the working pad can better guarantee that distance set is adhered to regardless of the location of wells and infrastructure on a well pad.

7.2.4.2 Setback receptors targeted by setback policies

Compared to oil and gas sources, policies defining setback receptor types have varied much more in practice. The most commonly defined setback receptors are buildings, although some conditionality exists related to likelihood of inhabitation or explicit building use type. For example, in the Pennsylvania state code (and as it is applied in Pennsylvania's well siting requirements), a building is defined as:

> *"an occupied structure with walls and a roof within which individuals live or customarily work" (58 Pa. Cons. Stat. § 3301, 2016).*

This indicates that the building setback regulation in Pennsylvania is conditional upon the presence of human activity, not necessarily by a land use type designation like "residential," as was explicitly defined in Colorado's regulations:

> *"No Working Pad Surface will be located more than 500 feet and less than 2,000 feet from 1 or more Residential Building Units or High Occupancy Building Units"* (COGCC Rules 600 Series, 2020).

Restrictions on what counts as a building depend on the local jurisdiction's definition of a building. Some jurisdictions put no additional qualifying definitions on "building," while others place size requirements, such as in the City of Los Angeles (e.g., >400 ft^2 [37 m^2] area, 36 ft [11 m] tall). Some localities define a building as any structure not utilized for oil and gas development (Los Angeles, CA Muni. Code § 91.6105, 2019).

Outside of general building-use definitions, many jurisdictions have also enacted more stringent setback requirements for sensitive receptor locations and typically occupied spaces alongside the more general building setback regulation (**Table 7.1**, **Table 7.2**). Some jurisdictions have enacted setback provisions for certain water-related and environmentally sensitive receptors, such as drinking water wells, groundwater intake of a public water supply, surface water bodies, and perennial streams and springs. However, the most common sensitive receptors related to oil and gas well setbacks have been schools, hospitals, senior care facilities, faith institutions, parks and places of public assembly. Notably, some jurisdictions have defined these types of receptors at the property line boundaries as opposed to a physical structure on the property. Defining receptors at a property line boundary provides additional criteria designed to reduce potential exposures to persons that may frequent the areas adjacent to the building in question.

7.2.5. Exemptions and exceptions considered in setback policies

Given the importance of distance in reducing the exposure risks and health effects for populations near oil and gas development, exemptions or exceptions to setback provisions are important to consider. In practice, exemptions and exceptions also have a bearing on land use co-locations and impacts from oil and gas development on surrounding populations. Here we briefly discuss a range of codified setback exemptions and exception provisions that have been applied elsewhere in the United States, and examine the current understanding related to data on the frequency of setback exemptions and exceptions.

In the United States, mineral rights can be owned by private landowners, private companies, and federal, state, or local governments (Fry, 2013). The ownership of mineral rights generally affords the owner the right to exploit or produce said minerals even if the mineral rights owner may not own the overlying surface rights (i.e., split estate). Thus, within the context of regulatory setback provisions, some exemptions and exceptions (e.g., landowner consent waivers, regulatory distance variance) exist so as to not limit a mineral rights owners' right to realize access to owned resources.

Conditional exemptions and exceptions are often clearly stated alongside well location restrictions. For example, Pennsylvania's setback regulation applies only to new wells drilled on new well pads — effectively exempting new wells on the more than 2,000 existing well pad areas that predated the regulation (Michanowicz et al., 2021). Pennsylvania allows for exceptions from its 500 ft (152 m) building setback requirement through two mechanisms, typically referred to as a consent waiver or request for variance, respectively:

- Where written consent from the surface landowner is submitted with the Permit Application to Drill and Operate an Unconventional Well.
- If the applicant "submit[s] a Request for Variance from Distance Restriction to the regulator detailing additional terms and conditions to be in place to ensure safety and protection to persons and property."

Recently, Colorado passed a 2,000 ft (610 m) setback for residential buildings, high occupancy buildings, schools, and childcare centers with varied exception language for each (COGCC Rules 600 Series, 2021). Unlike Pennsylvania, existing well pad locations were not exempted from

updated well siting restrictions. Colorado does however allow setback exceptions. For a well to be sited within 2,000 ft (610 m) of a residential building unit in Colorado, one or more of the following conditions must be met:

- The residential building unit owners and tenants and high occupancy building unit owners and tenants within 2,000 feet (610 m) of the working pad surface explicitly agree with informed consent to the proposed oil and gas location;
- The location is within an approved comprehensive area plan that includes preliminary siting approval pursuant to Rule 314.b.(5) or an approved comprehensive drilling plan;
- Any wells, tanks, separation equipment, or compressors proposed on the oil and gas location will be located more than 2,000 feet (610 m) from all residential building units or high occupancy building units; or
- The commission finds, after a hearing pursuant to Rule 510, that the proposed oil and gas location and conditions of approval will provide substantially equivalent protections for public health, safety, welfare, the environment, and wildlife resources, including disproportionately impacted communities (COGCC, 2020).

Overall, very little data has been reported on how often exemptions or exceptions result in a well placed within the setback distance. Requests for variances are common in some areas, however. Data from Flower Mound, Texas, shows that since its gas-drilling ordinance began in 2003, almost 80% of pad sites received a variance to drill at a distance less than the 1,500 ft (457 m) setback (American Bar Association, 2018). Similarly, 13 of the 16 wellpads constructed since 2001 in Arlington, Texas, received waivers to drill within its 600 ft (183 m) setback requirement (Thibodeaux, 2018). Outside of Texas, a 2014 West Virginia land use study showed that five wellpads surrounding forty homes were within the state's setback distance of 625 ft (191 m). However, many of the wellpads likely predate West Virginia's 2012 setback regulation (W. Va. Code § 22-6A-12) thereby exempting them from regulation (Hansen et al., 2017).

More recently, Michanowicz et al. (2021) assessed the effectiveness of a statewide setback regulation by evaluating the Pennsylvania Oil and Gas Act (Act 13) of 2012, which increased the unconventional natural gas (UNG) well-to-building setback requirement from 200 to 500 ft (61 to 152 m). A detailed spatial analysis revealed trends in wellhead locations and proximity to likely occupied buildings between 2008–2018. On average, one out of every 13.7 UNG wells drilled in Pennsylvania were drilled within the setback distance after the passage of Act 13 in 2012. The authors found that despite the strengthened setback regulation, some wells were still sited within the setback distance. This is likely due to existing well pad exemptions (35%) and a combination of landowner consent and regulatory distance variances, rather than encroaching building development. After adjusting for the underlying well-to-building trend over time, the researchers found that Act 13 did not significantly alter how wells were sited in relation to nearby buildings — observing no change to the underlying trend. From this analysis the authors concluded,

"Despite the regulation's intent, the study found no significant change in how wells were sited after Act 13 took effect in 2012. These findings suggest that exemptions, variances, and consent waivers provide opportunities to avoid or weaken well-siting requirements."

Because Pennsylvania exempted existing well sites from the setback regulation, researchers also tested whether the new regulation actually increased drilling on existing well pads to potentially avoid well siting restrictions but did not observe this phenomenon. The researchers did, however, find that if existing well pads had not been exempted and no new setback incidents occurred on these pre-Act 13 well pads, then Act 13 would have significantly reduced the setback incident rate by up to 46% (Michanowicz et al., 2021).

The following policy recommendations were included that are applicable to California:

- New setback regulations should include additional protective mitigation measures when an existing well pad is altered and/or require both regulatory approval and landowner consent.
- Regulators could routinely track and report well siting exemption rates and rationales, and, if warranted, consider changes to setback rules to narrow exemptions that are used too frequently.
- Regulators could ensure better landowner consent provisions; for instance, by requiring that the operator demonstrate to the landowner and the regulator that there is no alternative siting possible before landowner consent can be obtained.
- Regulators could increase transparency by making setback exemption permits publicly available online alongside other commonly reported well permit information.

7.2.6. Summary of findings from previous California proximity analyses

There have been multiple studies of populations living near oil and gas development in California (Deschenes et al., 2021; Gonzalez et al., 2020; Shamasunder et al., 2018; K. V. Tran et al., 2020), resulting in both new understandings of potential health effects and key insights into California's unique land use issues, particularly in urban settings. At least 10 formal proximity analyses have been performed in the state of California. Appendix F.7 lists these studies, along with brief descriptions of their inclusion criteria and key findings. Results are summarized below.

In 2014, the Natural Resources Defense Council (NRDC) conducted a proximity analysis (Srebotnjak & Rotkin-Ellman, 2014). This analysis found that approximately 5.4 million California residents live within 1 mi (1,609 m) of more than 84,000 existing oil and gas wells.[1] When accounting for environmental burden, the NRDC found that more than 1.8 million (~33%) of these residents also reside in census tracts most burdened by environmental (soil, air, water) pollution. Czolowski et al. (2017) performed a national-level human population proximity analysis. Using a much more conservative well inclusion criteria restricted to active wells, the study found an estimated 2.09 million Californians living within 1 mi (1,609 m) of an oil or gas well in 2014.

[1] This analysis accounted for all active and new wells (including unconventional wells) using the California Division of Oil, Gas and Geothermal Resources (DOGGR, now CalGEM) "AllWells" and "Well Stimulation Treatment Notices Index" databases, the South Coast Air Quality Management District (SCAQMD) "Oil and Gas Wells Activity Notification" database, and the chemicals disclosure registry database provided by FracFocus.org.

In 2015, pursuant to SB 4, the California Council on Science and Technology (CCST) produced a report on well stimulation in California. An assessment within this report found that approximately 12% of the South Coast Air Basin (i.e., Los Angeles Metropolitan Area) population (~2.3 million people) lives within 2 km (6,562 ft) of an active oil and gas well (Shonkoff and Gautier, 2015). In addition, an estimated 184 daycare facilities, 213 elderly care facilities and approximately 628,000 residents are within 800 m (2,625 ft) of an active oil and gas well in the Los Angeles Basin. Additionally, 32,000 residents, including approximately 2,300 children less than five years old, live within 100 m (328 ft) of an active well (Shonkoff and Gautier, 2015). A state-wide analysis by Ferrar (2020) found about 2.17 million Californians live within 2,500 ft (762 m) of an operational oil and gas well, with an estimated 7.37 million Californians within 1 mi (1,609 m).

The Oil and Gas Threat Map from Earthworks (2016) used a half-mile (2,640 ft, 805 m) as the setback distance, or "threat radius", when evaluating proximity to oil and gas infrastructure. A key finding was that 1,126,071 people were estimated to live within a half-mile of oil and gas infrastructed with an estimated 309,135 students in the radius, and 678 schools and daycare centers. Shonkoff and Hill (2019) found that as of 2015, about 630,000 residents, 130 schools, 213 elderly care facilities, and 184 daycare facilities were sited within a half-mile (2,625 ft, 800 m) of an active oil and gas well in the Los Angeles Basin alone. The authors noted that more than 32,000 people in the Los Angeles Basin are estimated to live within 100 m (328 ft) of an active oil and gas well.

In summary, these proximity analyses show that a large number of California residents and sensitive receptors are close to upstream oil and gas activities. The estimates provide context for the population-level burdens facing many communities. However, key limitations exist. Four of the studies were performed before 2016 or used pre-2016 well data, so their well and population counts are likely outdated. Of the studies that assessed the entire state of California and used all producing well types, only one used census block data (Czolowski et al., 2017) — the highest spatial resolution available within the U.S. Census. However, Czolowski et al. (2017) only used active wells that produced hydrocarbons in 2014, effectively undercounting the idle wells that are prevalent in California. Czolowski et al. (2017) also did not remove non-habitable land uses prior to allocating populations to buffer-areas around wells.

7.2.7. Implications of setbacks for decarbonization, production, air quality, and health

Most recently, a study commissioned by the California Environmental Protection Agency (CalEPA) examined various pathways and implications of decarbonizing California's oil extraction and refining sectors (Deschenes et al., 2021). Broad in scope, the study examined 1,440 different scenarios related to extractive industries in California, with projections across multiple outcomes including greenhouse gas and air pollutant emissions, health benefits, and labor market impacts with a specific focus on equity. Most applicable to this report are two policy scenarios related to setbacks and a statewide crude oil production quota. First, it was found that a 2,500 ft (762 m) setback scenario alone was not sufficient to achieve 80–90% decarbonization by 2045. A 2,500 ft (762 m) setback between wells and residences, schools, playgrounds, daycare centers, elderly

care facilities and hospitals leads to a 49% greenhouse gas reduction between 2019–2045. Increasing the setback to 5,280 ft (1 mile, 1,609 m) results in a greenhouse gas reduction of 58%. In addition to greenhouse gas reductions, they found that setbacks generate statewide health benefits to nearby populations in terms of reductions in air pollution. Specifically, premature mortality and the incidence of adverse health outcomes are projected to decline by 17% to 37% cumulatively over 2019–2045, depending upon the setback distance promulgated with greater health benefits for larger setbacks compared to a scenario without a setback policy.

The authors also found that a second policy type — a statewide production quota or equivalent severance tax on extraction — was found to disproportionately reduce impacts on disadvantaged communities. Under this production quota, the authors identified an "equity benefit" whereby a greater share of the reduced air pollution exposure occurred in disadvantaged communities. This occurs since higher cost extraction activities tend to be co-located in areas with more disadvantaged communities. Therefore, under this policy scenario, these more expensive extraction activities may be more likely to be attenuated given their relative costs compared to less costly production fields that are not located in or near disadvantaged communities. Overall, they found that between 27% to 39% of the projected health benefits and between 50% to 59% of the reduced population exposure to air toxics accrue to disadvantaged communities. Further examining these results showed that a significant share of the health benefits is captured by neighborhoods in the city of Bakersfield.

7.3. Updated California Proximity Analysis: Approach & Methods

As a basis for understanding potential public health hazards attributable to upstream oil and gas development, we evaluated the spatial relationships of active (producing) oil and gas wells and wastewater disposal locations to the surrounding population and selected sites considered to be sensitive receptors. The analyzed sensitive receptors include schools (pre-K to 12th grade), childcare facilities, healthcare facilities, senior care facilities, correctional facilities, parks, and residential buildings. We also characterized the demographics, susceptibility factors, and socioeconomic profiles of the communities in proximity to areas of increased well densities. Other chapters in this report also inform our proximity analysis, including Chapter 2, stressors associated with OGD; Chapter 3, epidemiological studies; Chapter 4, air quality risk assessment studies; and Chapter 5, produced water management studies. In addition to these chapters, methodological considerations were also informed by previous California proximity studies, existing surface setback and well siting location regulations in California and throughout the United States, and distributional inequities observed within the peer-reviewed literature (**Figure 7.1**).

Overall, the new proximity analysis presented here improves upon previous California proximity analyses in three main ways. First, this proximity analysis provides the most spatially precise estimates of populations living within California to date. This proximity analysis overcomes common issues of downscaling populations to census aerial units (particularly in rural areas) by utilizing a combination of census blocks, residential tax parcels, and building footprint data depending upon the relative population density at hand. Second, this analysis includes numerous demographic and contextual variables and key sensitive receptors at the building footprint and

area extent resolutions such as schools, health care facilities, and — unique to this analysis — residentially-zoned buildings. And finally, with use of individual building footprint locations, we were able to assess hyperlocal proximities between homes and wells at distances less than 500 ft (152 m) (see Section 7.4.5). This degree of spatial accuracy has not been used before in California or elsewhere in performing a similar proximity analysis.

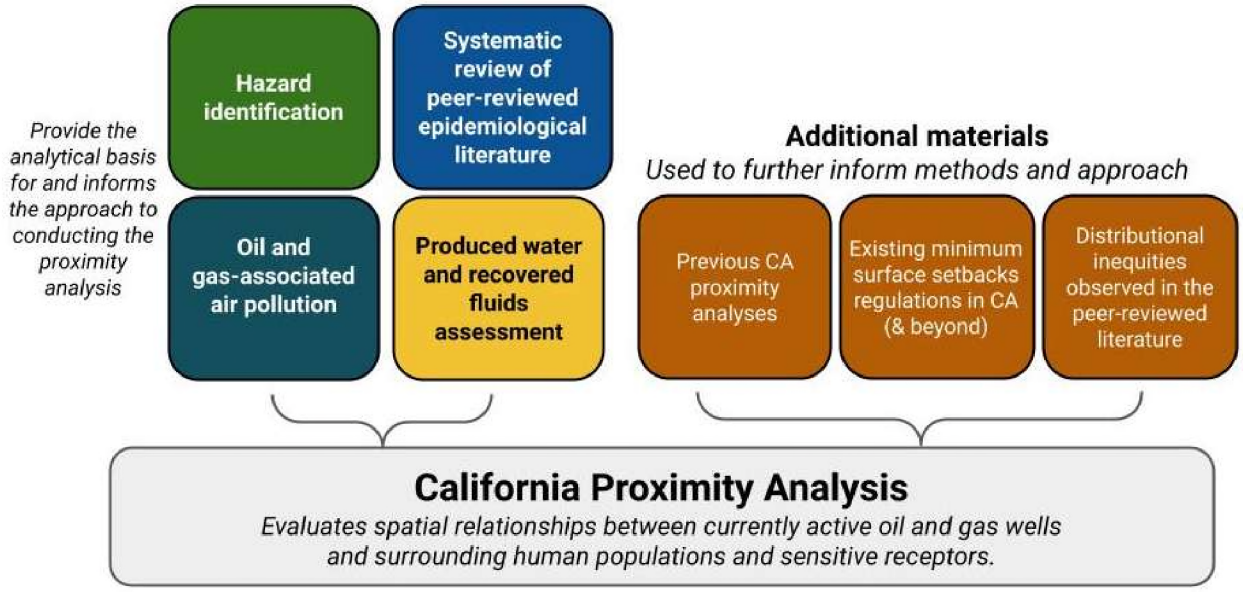


Figure 7.1. Approach to inform the California proximity analysis.

7.3.1. Methods

Details concerning data sources and methods used in the proximity analysis are provided in Appendices F.1 and F.2, respectively. Briefly, the proximity analysis is organized into four main analytical components:

- Population counts and demographics at the sub-census block level near active-producing oil and gas wells and wastewater locations (i.e., active produced water ponds and all-status water disposal wells).
- Counts of sensitive land uses and receptors[2] near oil and gas wells and wastewater locations.
- An assessment of active well density and population-level factors at the census tract level.
- An assessment of hyperlocal proximity between wells and sensitive receptors <500 ft (<152 m).

[2] Spatial resolutions of sensitive receptors ranged from the area extent of the land use parcel to the nearest building footprint and are included as footnotes for all relevant tables. Receptor area extents were available only for public schools (K–12), universities and community colleges, and parks. Two-dimensional building footprints were used for all other sensitive receptors available from Microsoft. Receptors that were only available as geographic coordinates such as childcare centers and senior care facilities, were spatially joined to the nearest building footprint.

The study area encompasses the entire state of California, with some aggregate analyses performed at the California air basin level. The most up to date oil and gas well and wastewater data were used in the proximity analysis (current up to January 2021). Our well inclusion criteria were designed to capture wells capable of producing hydrocarbons as of March 2021 and took into account a well's status and type, resulting in 83,834 "active-producing" wells across California. Our well selection criteria is discussed briefly below, with additional detail provided in Appendices F.1 and F.2, respectively.

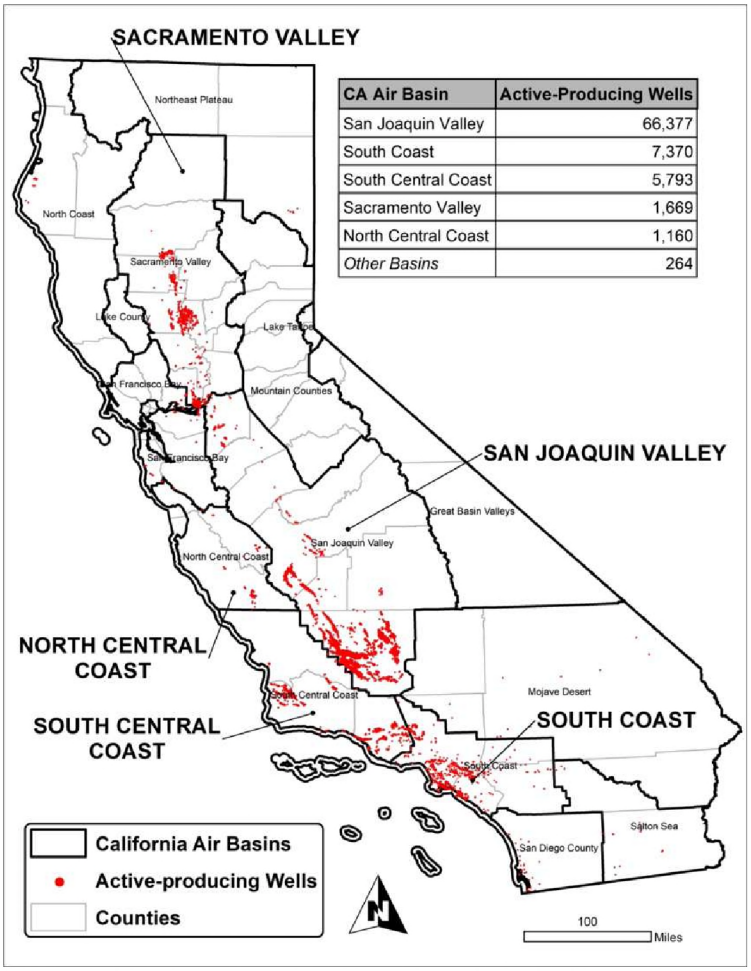
Oil and gas extraction in California is supported by numerous well types in various operating conditional states (i.e., status). Thus, our well inclusion criteria aimed to capture wells that were capable of producing hydrocarbons at the time of writing this report and into the near future. To capture wells capable of producing hydrocarbons, both well type and well status were considered in tandem. Because not all well types produce oil or gas, first we determined which well types were capable of producing any oil or gas. We defined "producing" wells as any well type whereby at least 1% of the wells within that well type produced oil or gas within the past five years. If this 1% threshold was met, all wells of that type were deemed capable of producing and were carried on to the subsequent stage of filtering — filtering by well status. "Producing" wells were then deemed "active", only if they held one of the following statuses — *active, new, or idle* — as of January 21, 2021. By using these criteria, 83,834 wells were identified and included in this proximity analysis. Wells hereafter are referred to as "active-producing."

Of the 2,389 pond features in the aggregated produced water disposal pond dataset, only those with a status of "active" (n=682) were included and were joined to all wells with a type of "water disposal" from the CalGEM "All Wells" dataset (n=2,295). Thus, a total of 2,977 wastewater disposal features were considered for the wastewater portion of the statewide proximity analysis.

7.4. Results

7.4.1. Socioeconomic disparities and total populations in proximity to oil and gas development

An estimated 3 million, or roughly 1 in 12 (~8%), California residents live within 1 km (3,281 ft) of an active-producing oil and gas well (**Table 7.3**). The 1 km (3,281 ft) radial buffer areas around all wells encompass just 1.7% of all land area in California, indicating that wells are disproportionately clustered in more densely populated areas. More than 95% of active-producing wells included in this analysis are within three California Air Basins — the San Joaquin Valley, the South Central Coast, and the South Coast (**Figure 7.2**). The degree of well clustering in some areas has implications for public health. Some schools and healthcare facilities are located within 1 km (3,281 ft) of hundreds of active oil and gas wells.



CA Air Basin	Active-Producing Wells
San Joaquin Valley	66,377
South Coast	7,370
South Central Coast	5,793
Sacramento Valley	1,669
North Central Coast	1,160
Other Basins	264

Figure 7.2. Active-producing oil and gas wells within each California Air Basin.

Nearly 15% of the 3 million California residents that live within 1 km (3,281 ft) of OGD are susceptible to health risks from exposure to poor air quality due to age alone (i.e., under 5 or over 64 years old). These age-groups were not found to be overrepresented in areas proximal to wells as was observed for certain socio-economic classifications. Across the landscape of oil and gas development (OGD) in California, we observed exposure disparities by race and ethnicity, as well as disparities for linguistically isolated households, renter status, and educational attainment. We evaluated demographic metrics to determine if certain populations were disproportionately represented in areas near OGD throughout California (**Figure 7.3**). Disparities were calculated by comparing the proportion of each demographic group living within 1 km (3,281 ft) of OGD to the proportion of that group present throughout the state (see Appendix F.2.4).

Overall, these demographic metrics indicate that non-Hispanic Black populations are disproportionately exposed to nearby OGD throughout California — non-Hispanic Black populations are about 50% (factor of ~1.5) more likely to have at least one well within 1 km (3,281 ft) of their residence (**Figure 7.3**) compared to the California average. Compared to non-Hispanic White populations in California, non-Hispanic Black populations are 87% more likely to reside in areas that contain OGD within 1 km (3,281 ft). Population-level inequities were also observed for populations who identify as Hispanic. White populations are 20% less likely than the average

Californian to live in areas with OGD within 1 km (3,281 ft). Overall, these findings indicate that environmental justice concerns exist for OGD throughout California.

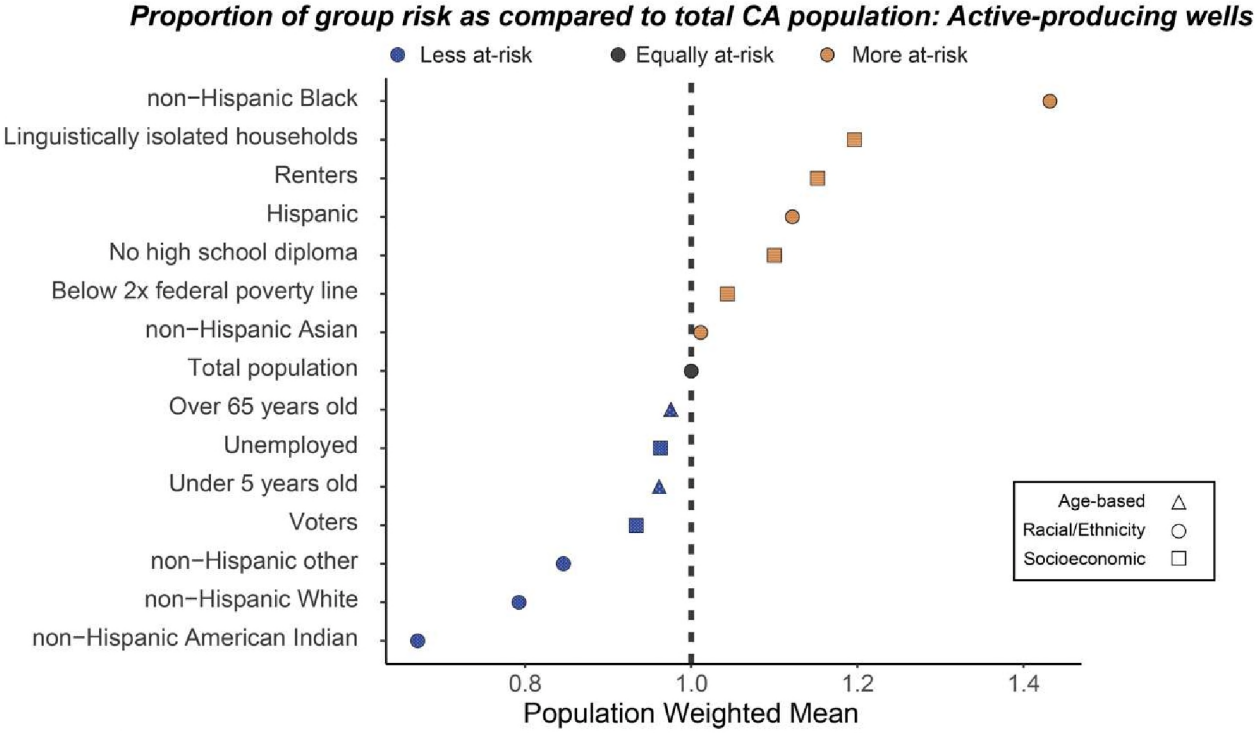


Figure 7.3. Distributional inequities of demographic groups living within 1 km (3,281 ft) of active-producing oil and gas wells as compared to state population totals derived from the 2013–2017 American Community Survey (ACS) at the census block scale. Orange markers indicate a population weighted mean greater than one, indicating a level of subgroup overrepresentation in areas that contain OGD within 1 km (3,281 ft). Blue markers indicate a level of subgroup underrepresentation in areas that contain OGD within 1 km (3,281 ft).

Table 7.3. Total counts and associated age, racial, and socioeconomic demographic metrics of populations living in proximity to active-producing oil and gas wells in 2021. Percentages are based on state totals.

	0–500 ft (0–152 m)	0–1,000 ft (0–305 m)	0–1,500 ft (0–457 m)	0–2,000 ft (0–610 m)	0–2,500 ft (0–762 m)	0–3,281 ft (0–1,000 m)	0–5,280 ft (0–1,609 m)
	Count (%)	Count (%)	Count (%)	Count (%)	Count (%)	Count (%)	Count (%)
Total Population	219,681 (0.6)	590,116 (1.5)	1,032,255 (2.6)	1,551,743 (4.0)	2,123,961 (5.4)	3,080,713 (7.9)	5,772,699 (14.8)
Age Based							
under 5 years old	15,110 (0.6)	39,476 (1.5)	68,909 (2.6)	103,736 (3.8)	141,733 (5.3)	205,027 (7.6)	384,810 (14.3)
over 64 years old	30,959 (0.6)	82,984 (1.6)	143,807 (2.7)	212,905 (4.0)	287,705 (5.4)	412,674 (7.7)	760,877 (14.2)
Race/Ethnicity							
non-Hispanic White	65,646 (0.4)	183,978 (1.2)	321,774 (2.1)	479,522 (3.2)	650,338 (4.3)	938,185 (6.3)	1,715,501 (11.5)
Hispanic	90,842 (0.6)	246,340 (1.6)	438,719 (2.9)	669,110 (4.4)	923,441 (6.0)	1,357,219 (8.9)	2,639,604 (17.2)
non-Hispanic Black	17,745 (0.8)	48,233 (2.1)	86,994 (3.8)	134,633 (5.8)	185,633 (8.0)	262,347 (11.3)	458,697 (19.8)
non-Hispanic Asian	42,687 (0.8)	99,443 (1.8)	161,873 (2.9)	232,534 (4.1)	313,918 (5.6)	448,648 (8.0)	817,887 (14.6)
non-Hispanic American Indian	1,056 (0.5)	2,385 (1.1)	4,001 (1.9)	5,869 (2.8)	7,909 (3.7)	11,299 (5.3)	21,110 (9.9)
non-Hispanic other	7,328 (0.5)	18,800 (1.3)	32,142 (2.3)	48,202 (3.4)	65,911 (4.6)	94,843 (6.7)	175,381 (12.4)
Socioeconomic							
below 2x federal poverty line	78,089 (0.6)	204,924 (1.5)	361,224 (2.7)	548,096 (4.1)	757,742 (5.6)	1,107,556 (8.2)	2,124,356 (15.8)
unemployed	11,905 (0.6)	30,562 (1.4)	53,393 (2.5)	80,136 (3.8)	109,808 (5.1)	160,954 (7.6)	306,800 (14.5)
median household income	$77,711	$77,556	$77,542	$77,260	$76,873	$76,266	$74,354
no high school diploma	44,978 (0.6)	118,312 (1.6)	208,960 (2.8)	318,387 (4.3)	440,478 (5.9)	648,729 (8.7)	1,259,987 (16.9)
voters	143,407 (0.5)	386,717 (1.4)	677,431 (2.5)	1,017,076 (3.7)	1,389,846 (5.1)	2,011,686 (7.4)	3,774,238 (13.9)
renters	129,440 (0.7)	325,718 (1.9)	549,488 (3.1)	815,155 (4.6)	1,108,908 (6.3)	1,599,720 (9.1)	3,016,193 (17.2)
linguistically isolated households	11,794 (0.9)	27,282 (2.0)	45,417 (3.3)	66,871 (4.9)	89,993 (6.6)	128,834 (9.5)	242,573 (17.8)

7.4.2. Socioeconomic disparities and total populations in proximity to wastewater

An estimated 400,000, or roughly 1 in 100 (1%), California residents live within 1 km (3,281 ft) of an active produced water disposal pond, or any water disposal well (**Table 7.4**). Overall, population trends for proximity to wastewater features are generally similar to total population trends for active-producing wells. For example, no significant disparities were observed between age groups. This is likely due to the significant geographic overlap (at least 70%) between wastewater features and active-producing wells (further discussed in Appendix F.4, Table F.5). This reflects the nature of OGD, where it is common for other portions of the oil and gas supply chain, such as wastewater disposal systems, to be co-located with wells.

The remaining 30% of land surface area that is unique to wastewater feature buffer areas appears to contain populations that are distinct from populations within active-producing well buffer areas. Consequently, slightly different population-level disparities are observed within water feature buffer areas. Nonetheless, non-Hispanic Black populations are also disproportionately exposed to nearby wastewater locations throughout California (**Figure 7.4**), though slightly less than the disparities observed for active-producing wells (**Figure 7.3**). In contrast to the oil and gas well analysis above, here we observe over-representation of non-Hispanic White populations living within 1 km (3,281 ft) of wastewater facilities. Populations two times below the poverty line were least likely to live near a wastewater feature. Combined, these results indicate that wastewater facilities do not completely mimic population-level inequities observed for OGD, suggesting that different populations across California may be disproportionately burdened by various sub-sectors of the oil and gas supply chain. From a policy perspective, these findings have implications for understanding which populations will be most and least protected under different regulatory scenarios for oil and gas activities in California.

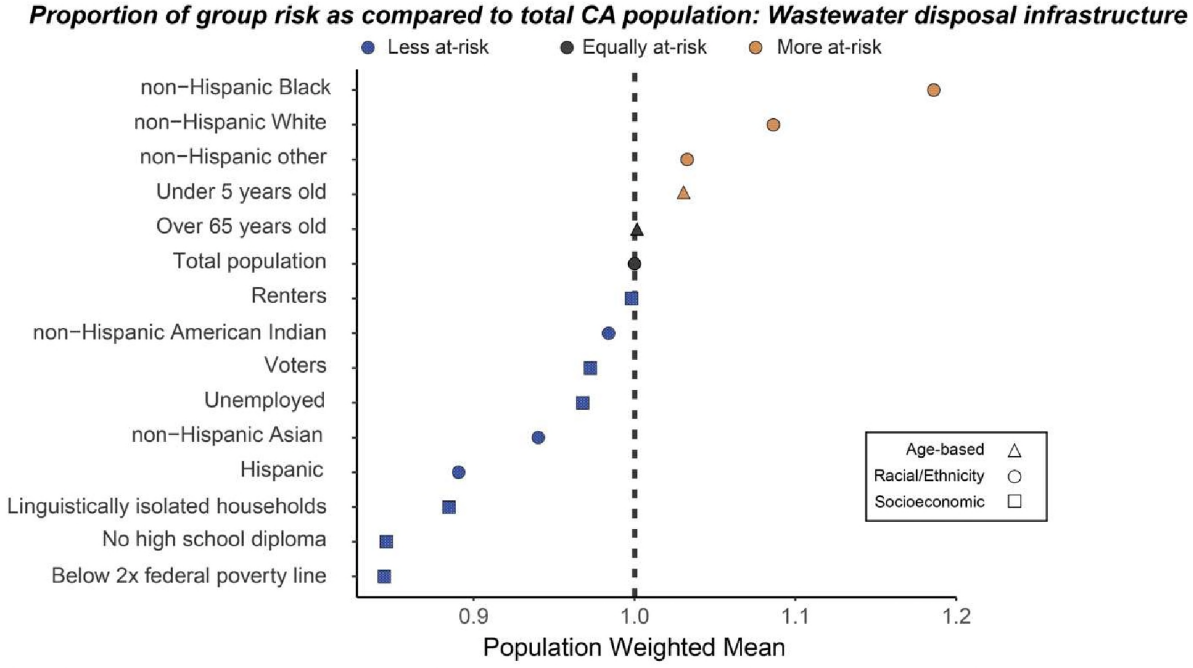


Figure 7.4. Distributional inequities of demographic groups living within 1 km (3,281 ft) of active produced water disposal ponds and water disposal wells as compared to total population. Orange markers indicate a population weighted mean greater than one indicating a level of subgroup overrepresentation in areas that contain OGD within 1 km (3,281 ft). Blue markers indicate a level of subgroup underrepresentation in areas that contain OGD within 1 km (3,281 ft).

Table 7.4. Total counts and associated age, racial, and socioeconomic demographic metrics of populations living in proximity to active produced water disposal ponds and any water disposal wells in 2021. Percentages are based on state totals.

	0–500 ft (0–152 m) Count (%)	0–1,000 ft (0–305 m) Count (%)	0–1,500 ft (0–457 m) Count (%)	0–2,000 ft (0–610 m) Count (%)	0–2,500 ft (0–762 m) Count (%)	0–3,281 ft (0–1,000 m) Count (%)	0–5,280 ft (0–1,609 m) Count (%)
Total Population	7,058 (<0.1)	33,253 (0.1)	80,099 (0.2)	149,654 (0.4)	236,921 (0.6)	402,463 (1.0)	1,023,614 (2.6)
Age Based							
under 5 years old	624 (<0.1)	2,411 (0.1)	5,602 (0.2)	10429 (0.4)	16,910 (0.6)	28,706 (1.1)	72,115 (2.7)
Over 64 years old	1,147 (<0.1)	5,004 (0.1)	11,645 (0.2)	21357 (0.4)	32,923 (0.6)	55,346 (1.0)	132,782 (2.5)
Race/Ethnicity							
non-Hispanic White	2,672 (<0.1)	13,553 (0.1)	33,185 (0.2)	62115 (0.4)	98,754 (0.7)	167,957 (1.1)	398,169 (2.7)
Hispanic	2,499 (<0.1)	11,377 (0.1)	27,833 (0.2)	51166 (0.3)	80,604 (0.5)	141,102 (0.9)	405,774 (2.7)
non-Hispanic Black	922 (<0.1)	3,348 (0.1)	6,880 (0.3)	12243 (0.5)	18,126 (0.8)	28,323 (1.2)	70,707 (3.0)
non-Hispanic Asian	1,031 (<0.1)	4,487 (0.1)	10,464 (0.2)	20450 (0.4)	33,330 (0.6)	54,603 (1.0)	122,999 (2.2)
non-Hispanic American Indian	120 (0.1)	281 (0.1)	572 (0.3)	928 (0.4)	1,357 (0.6)	2,165 (1.0)	4,842 (2.3)
non-Hispanic other	393 (<0.1)	1,502 (0.1)	3,383 (0.2)	6007 (0.4)	9,312 (0.7)	15,121 (1.1)	34,705 (2.4)
Socioeconomic							
below 2x federal poverty line	2,128 (<0.1)	9,471 (0.1)	22,918 (0.2)	4,3093 (0.3)	67,829 (0.5)	117,070 (0.9)	333,441 (2.5)
unemployed	533 (<0.1)	1,908 (0.1)	4,298 (0.2)	7,865 (0.4)	12,471 (0.6)	21,140 (1.0)	54,944 (2.6)
Median Household Income	$ 80,630	$ 80,356	$ 80,154	$ 80,509	$ 80,129	$ 79,459	$ 75,982
no high school diploma	1,215 (<0.1)	5,318 (0.1)	12,656 (0.2)	23,326 (0.3)	37,154 (0.5)	65,144 (0.9)	194,110 (2.6)
voters	4,876 (<0.1)	22,619 (0.1)	54,557 (0.2)	102,009 (0.4)	160,832 (0.6)	273,598 (1.0)	680,967 (2.5)
renters	3,094 (<0.1)	14,533 (0.1)	35,164 (0.2)	66,949 (0.4)	106,818 (0.6)	181,056 (1.0)	492,002 (2.8)
linguistically isolated households	307 (<0.1)	1,178 (0.1)	2,546 (0.2)	4,690 (0.3)	7,293 (0.5)	12,442 (0.9)	34,011 (2.5)

7.4.3. Sensitive receptors in proximity to oil and gas development

Sensitive receptors, defined as schools (pre-K to 12th grade), childcare facilities, healthcare facilities, senior care facilities, correctional facilities, parks, and residential buildings, near at least one active oil and gas well or wastewater location are summarized in **Table 7.5–Table 7.10.** Of all sensitive receptors analyzed, healthcare facilities exhibited the greatest co-location burden with nearby OGD. Nearly 1 in 10 (n=207, 10%) healthcare facilities in California are within 1 km (3,281 ft) of at least one active-producing well. Just behind healthcare facilities, 461 parks (9%, or approximately 12.8 mi^2 [33.2 km^2] of park lands) are within 1 km (3,281 ft) of at least one active-producing well. An estimated 1,749 (~8%) pre-K through 12th grade schools are within 1 km (3,281 ft) of at least one active-producing well. There are also a significant number of senior care facilities and correctional institutions within 1 km (3,281 ft) of at least one active-producing well — both of which may contain large permanent populations that are mostly restricted to the confines of those respective spaces. There are also a significant number of senior care facilities and correctional institutions within 1 km (3,281 ft) of at least one active-producing well — both of which may contain large permanent populations that are mostly restricted to the confines of those respective spaces.

Compared to active-producing oil and gas wells, significantly fewer sensitive receptors are located near wastewater disposal features (CalGEM, 2021).[3] However, due to the co-location of wastewater disposal features and active-producing wells, sensitive receptors in proximity to wastewater disposal features are also generally in proximity to active-producing wells. On average, producing wells and wastewater disposal features share about 80% of the observed land uses with sensitive receptors. In other words, only 20% of the population and OGD co-locations are unique to wastewater disposal features. A detailed discussion of the overlap of water and active-producing well buffer areas can be found in Appendix F.4. Senior care facilities (n=91, 1% of California senior care facilities) were the sensitive receptor type with the greatest percentage of features within 1 km (3,281 ft) of wastewater disposal features (**Table 7.7**). Parks were the sensitive receptor with the next highest count (n=70, or approximately 3.7 mi^2 [9.6 km^2] of park lands) located within 1 km (3,281 ft) of wastewater disposal features (**Table 7.7**). Correctional facilities have the next highest proportion of the state total, with 7 (~2%) of the total correctional facilities in the state located within 1 km (3,281 ft) of water disposal features (**Table 7.7**). Consequently, the discussion within this section is largely focused on sensitive receptors in proximity to active-producing wells.

It is also important to note that although we considered a sensitive receptor to be impacted by OGD if there was one nearby well, many receptors are near multiple wells. Related to potential risks of exposures, it is valuable therefore to understand if the relationships are one receptor to one well or perhaps one receptor to many wells. For example, each of the sensitive receptors counted in **Table 7.5** need only have a single nearby well to be counted. What is not reflected in **Table 7.5** are the total number of wells located nearby those sensitive receptors. In some cases, sensitive receptors are located in areas with very high nearby well densities. Therefore, we took

[3] Wastewater disposal features include active produced water disposal ponds and wells designated "Water Disposal" in the CalGEM "All Wells" dataset (CalGEM, 2021).

the sensitive receptors from **Table 7.5** and counted the total number of unique nearby wells for each distance band. The results of this exercise are shown in **Table 7.6.** and provide a relative sense of the total number of wells driving the observed land use co-locations between sensitive receptors and OGD. In addition, the same companion tables for schools and associated wells are shown in **Table 7.8** and **Table 7.9**, respectively.

Only a small proportion of total oil and gas wells in California (2-7% depending on receptor) have a school, childcare facility, healthcare facility, senior care facility, correctional facility, or park within 1 km (3,281 ft) (with the exception of residential buildings). For example, 2,377 out of 83,834 (roughly 1 in 35) wells are within 1 km (3,281 ft) of a healthcare facility (**Table 7.6**). This represents just 3% of the total well inventory, with nearly 97% of wells beyond 1 km (3,281 ft) of any Californian healthcare facility. Other sensitive receptors (except residential buildings) follow the same trend — having a disproportionately small number of wells responsible for co-locations with OGD. Another way to consider these findings is by noting that a large proportion of co-locations between OGD and sensitive receptors could be eliminated by shutting in only about 5% of California's total active-producing well inventory. Overall, these disproportionate well-to-receptor counts have important implications for informing policy and present an opportunity to realize significant risk reductions by addressing only a small proportion of existing well sites.

While a relatively small proportion of total wells in California are responsible for the sensitive receptor co-locations observed here, it is also important to determine if these wells are clustered in proximity to sensitive receptor locations. Like the analysis performed to produce **Table 7.6** — total well counts near all sensitive receptors within certain distances — we further disaggregated these data to examine the distribution of wells near individual sensitive receptor locations. Some healthcare facilities and schools are surrounded by more than 200 wells within 1 km (3,281 ft) (**Figure 7.5** and **Figure 7.6**), suggesting that there is a large range of potential risks of exposure if increased OGD density is associated with an increased risks of exposure or impacts. From a public health perspective, sensitive receptors that have hundreds of wells located within 1 km (3,281 ft) likely represent both areas of greatest risks of exposure to sensitive populations and the greatest opportunity to reduce any potential risks of exposure or harms.

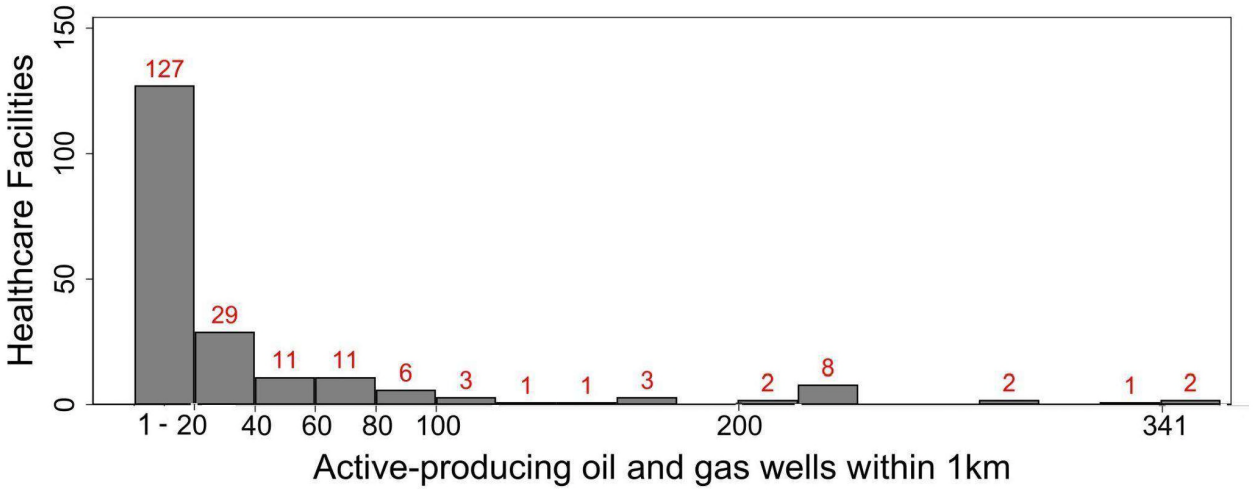


Figure 7.5. Frequency histogram of the 207 healthcare facilities in 2021 that contain at least one active-producing well within 1 km (3,281 ft). The number above each bar indicates the number of healthcare facilities within that bar. Note: the first bar of 127 healthcare facilities may contain between 1–20 wells within 1 km (3,281 ft).

7.4.3.1 Healthcare facilities

Healthcare facilities and senior care facilities are important to highlight due to the likelihood of inherent susceptibilities of individuals present at these facilities. Individuals more than 65 years old may be more susceptible to air pollution-related illnesses such as stroke, asthma, heart disease, lung cancer, and other respiratory diseases. Similarly, people with medical conditions requiring treatment at or admission to hospitals and other healthcare facilities, may suffer from exacerbation of their conditions and, further, may have increased risk of developing air pollution-related illnesses.

Nearly 1 in 10 (n=207, 10%) healthcare facilities in California are within 1 km (3,281 ft) of at least one active-producing well, representing the largest overlapping percentage observed across receptors. While only a small number of wells (~3%) are driving the land use co-locations with healthcare facilities, these wells are also highly concentrated around some healthcare facilities. For example, the 207 exposed healthcare facilities have a total of 2,377 wells within 1 km (3,281 ft). The frequency histogram of these 207 healthcare facilities and their associated 2,377 wells demonstrates a right-skewed, long-tail distribution: most healthcare facilities have fewer than ten wells nearby, whereas a few outliers have hundreds of wells within 1 km (3,281 ft) (**Figure 7.5).** Across these 207 healthcare facilities, 69% have multiple wells within 1 km (3,281 ft), with an overall median of three wells but a mean and standard deviation of 49, and 79, respectively, indicating the long-tailed nature of the distribution. Notably, 21 healthcare facilities have more than 100 active producing wells within 1 km (3,281 ft), and 14 facilities have more than 200 — each of which is located in Los Angeles.

7.4.3.2 Schools

Schools are a particularly important sensitive receptor type, due to the presence of children and adolescents and their associated physiological susceptibilities to pollution exposures, particularly for younger children (e.g., developing lung structure and immune systems). Additionally, school

children are generally confined to the school buildings or school grounds for a substantial portion of the day. Outdoor recreation associated with recess, physical education, and extracurricular activities may also place students in closer contact to associated exposures from nearby oil and gas activity.

An estimated 1,749 (~8%) pre-K through 12th grade schools are within 1 km (3,281 ft) of at least one active-producing well (**Table 7.8**). Of these, 659 are childcare centers, which include the youngest children. Similar to other sensitive receptors, fewer pre-K through 12th grade schools are within 1 km (3,281 ft) of wastewater disposal features, with only 239 (~1%) schools residing within this buffer distance (**Table 7.10**). Of those 239 schools, only 42 are unique to a wastewater disposal feature. Higher education facilities also exhibited land use co-locations with nearby wells, with 9% and 13% of community colleges and California universities, respectively, within 1 km (3,281 ft) of an active-producing well. Unlike active-producing wells, equal proportions (n=4) of universities (~3% state total) and community colleges (~2% state total) are located near wastewater infrastructure (**Table 7.10**). Only two of these higher education facilities are unique to a wastewater disposal feature.

Compared to other sensitive receptors, a larger proportion of wells are co-located with pre-K through 12th grade schools. An estimated 6,006 wells are within 1 km (3,281 ft) of at least one school, or 7.2% of active-producing wells in California. This is likely due, in part, to the large number of schools throughout California, but also the fact that schools are centered in populated areas where we also observe significant land use co-locations with residentially zoned buildings.

The distribution of unique wells within 1 km (3,281 ft) of schools (i.e., well density), like healthcare facilities, also demonstrates a right-skew with a long distributional tail (**Figure 7.6)**. Notably, of the 1,749 schools with at least one well within one kilometer, 58% of schools contain multiple active-producing wells nearby. Of these multiple-well schools, we observed a median of three wells and mean and standard deviation of 38 and 76 wells, respectively. Of the higher end of the distribution, 107 schools have over 100 wells within 1 km (3,281 ft) with 33 schools surrounded by more than 300 wells within 1 km (3,281 ft) — the majority located in Los Angeles. One Los Angeles school is surrounded by 421 wells within 1 km (3,281 ft) — the highest well density near a school observed throughout the state. Overall, due to the high degree of well clustering observed in California, sensitive receptors located near these areas are likely to have multiple wells in their proximity. Hyperlocal proximity was also observed for schools at the 500 ft (152 m) buffer distance, with an estimated 226 schools and childcare centers containing at least one active-producing well within 500 ft (152 m) of the school building. Likewise, some schools contain multiple wells within 500 ft (152 m), as indicated by the associated 865 wells counted around the 226 schools. We also assessed school-level exposure using building footprints. Consequently, students may be exposed to additional wells near outdoor school grounds that is not reflected in the proximity analyses to building footprints (e.g., playgrounds, parking lots, recreational fields).

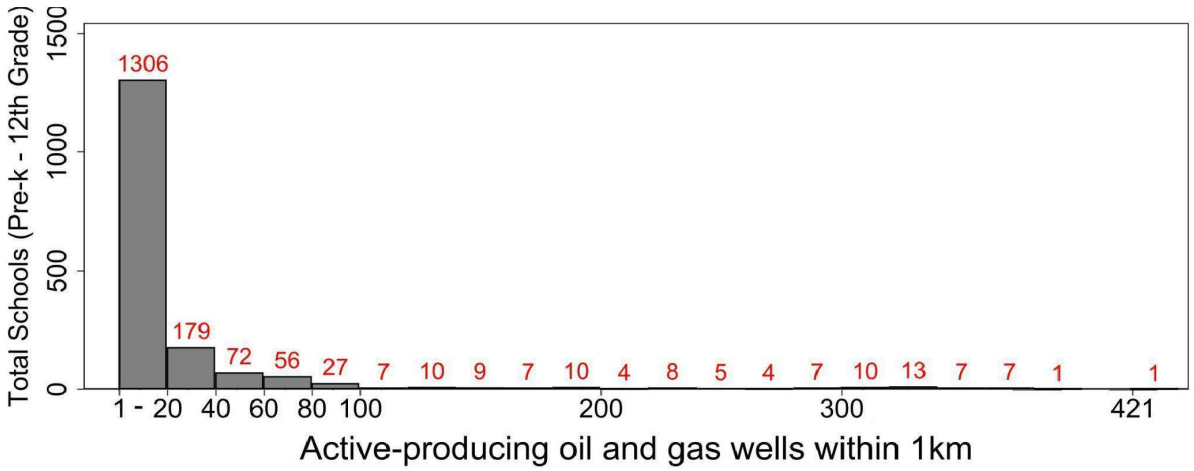


Figure 7.6. Frequency histogram of the 1,749 schools that contain at least one active-producing well within 1 km (3,281 ft). The number above each bar indicates the number of schools within that bar. Note the first bin of 1,306 schools may contain between 1–20 wells within 1 km (3,281 ft). An estimated 67 schools have at least 200 wells within 1 km (3,281 ft).

7.4.3.3 Total buildings and homes

To further verify the spatial relationships observed between populations and nearby oil and gas activity (**Table 7.3** and **Table 7.4**), we also include explicit counts of both total buildings and residentially-zoned buildings located nearby oil and gas activity (**Table 7.5** and **Table 7.7**).

In our analysis, we identified approximately 738,000 buildings within 1 km (3,281 ft) of an active-producing oil and gas well, and approximately 116,000 buildings within 1 km (3,281 ft) of a wastewater disposal feature. Only ~19,000 of the buildings near wastewater disposal features are not encompassed by the 1 km (3,281 ft) buffer extending from active-producing oil and gas wells, further illustrating that active-producing wells impact a substantially larger number of nearby receptors than wastewater disposal features.

The 738,000 buildings within 1 km (3,281 ft) of an active-producing well correspond to roughly 7% (or 1 in 13) of all buildings in the state of California, representing a substantial overlap. Importantly, an estimated 673,000 of the 738,000 total exposed buildings are located in residential-type tax parcels, indicating that the majority (over 90%) of these buildings are likely homes, not industrial or commercial buildings. We also observed that 37% of the active-producing wells (30,775) in California are within 1 km (3,281 ft) of at least one residential building.

These residential building counts almost certainly underestimate actual residential housing unit counts in these well areas, because the building data registers multi-unit residences and apartment buildings only as a single building footprint (Microsoft Maps, 2021). This underestimate is also supported by the fact that the total population estimated to live within 1 km (3,281 ft) of a well (n=~3 million) would result in an average person per household value of 4.57 — a value much higher than the actual state estimated average person per household of 2.95. These well-to-building relationships hold for all other buffer distances, with more than 25,000 wells within 2,500 ft (0.76 km) of an estimated 461,246 homes, and 6,564 wells responsible for the 500 ft (152 m) co-locations observed for nearly 45,000 homes. In sum, this analysis supports the census-based population estimates and further highlights California's land use issues where active oil and gas production occurs in many residential urban and suburban areas.

Table 7.5. Sensitive receptors in proximity to at least one of the 83,834 active-producing hydrocarbon wells in California. Percentage (%) represents the percent of total receptors within the respective buffer distance.

Buffer Distance from Wells	Correctional Facilities[1]	Parks[1]	Park Area[1] (mi^2)	Healthcare Facilities[2]	Senior Care Facilities[2]	All Buildings[2]	Residential Buildings[2]
Total Receptors	408	4,983	143.3	2,131	7,246	10,988,525	12,577,497
0–500 ft (0–152 m)	7 (2%)	90 (2%)	0.7 (<1%)	25 (1%)	44 (1%)	55,370	44,994
0–1,000 ft (0–305 m)	9 (2%)	154 (3%)	2.3 (2%)	59 (3%)	118 (2%)	142,480	123,167
0–1,500 ft (0–457 m)	15 (4%)	208 (4%)	4.3 (3%)	87 (4%)	176 (2%)	249,779	221,262
0–2,000 ft (0–610 m)	18 (4%)	276 (6%)	6.5 (5%)	116 (5%)	237 (3%)	373,241	334,816
0–2,500 ft (0–762 m)	21 (5%)	344 (7%)	8.9 (6%)	156 (7%)	324 (4%)	509,785	461,246
0–3,281 ft (0–1,000 m)	28 (7%)	461 (9%)	12.8 (9%)	207 (10%)	466 (6%)	738,467	673,068
0–5,280 ft (0–1,609 m)	55 (13%)	841 (17%)	23.9 (17%)	364 (17%)	832 (11%)	1,373,393	1,260,567

[1]Spatial resolution of receptor was the entire area extent of the land use parcel and was the basis for inclusion in the proximity. "Parks" are instances where any portion of the park intersects with a well buffer. "Park area" is the land area in square miles that intersects with a well buffer.
[2]Spatial resolution of the receptor was the building footprint and was the basis for inclusion in the proximity. Note that the total count for Residential Buildings was referenced from tax parcel data, and therefore includes counts of multi-building unit residences.

Table 7.6. Counts of unique active-producing wells associated with the sensitive receptors in **Table 7.7**.

Buffer Distance from Wells	Counts of wells near Correctional Facilities[1]	Counts of wells near Parks[1]	Counts of wells near Healthcare Facilities[2]	Counts of wells near Senior Care Facilities[2]	Counts of wells near Residential Buildings[2]
0–500 ft (0–152 m)	24	463	287	82	6,564
0–1,000 ft (0–305 m)	96	1,214	587	337	11,969
0–1,500 ft (0–457 m)	159	2,143	865	730	16,933
0–2,000 ft (0–610 m)	242	3,210	1,218	1,210	21,378
0–2,500 ft (0–762 m)	358	3,905	1,609	1,733	25,632
0–3,281 ft (0–1,000 m)	619	4,957	2,377	2,356	30,775
0–5,280 ft (0–1,609 m)	1,375	7,771	4,319	4,591	46,695

[1]Spatial resolution of receptor was the entire area extent of the land use parcel and was the basis for inclusion in the proximity.
[2]Spatial resolution of the receptor was the building footprint and was the basis for inclusion in the proximity.

Table 7.7. Sensitive receptors in proximity to at least one hydrocarbon extraction-related wastewater location in California. Percentage (%) represents the percent of total receptors within the respective buffer distance.

Buffer Distance from Wells	Correctional facilities[1]	Parks[1]	Park Area[1] (mi^2)	Healthcare[2] (ND)[a]	Senior Care[2]	All Buildings[2]	Residential Buildings[2]
Total Receptors	408	4,983	143.3	2,131	7,246	10,988,525	12,577,497
0–500 ft (0–152 m)	1 (<1%)	9 (<1%)	0.1 (<1%)	0 (0%)	4 (<1%)	3,574	926
0–1,000 ft (0–305 m)	2 (<1%)	12 (<1%)	0.4 (<1%)	3 (<1%)	12 (<1%)	11,881	4,982
0–1,500 ft (0–457 m)	4 (1%)	19 (<1%)	0.7 (<1%)	6 (<1%)	21 (<1%)	25,622	13,307
0–2,000 ft (0–610 m)	6 (1%)	33 (<1%)	1.1 (<1%)	10 (<1%)	35 (<1%)	45,053	26,476
0–2,500 ft (0–762 m)	7 (2%)	47 (<1%)	1.7 (1%)	10 (<1%)	59 (1%)	68,837	43,643
0–3,281 ft (0–1,000 m)	7 (2%)	70 (1%)	3.7 (3%)	26 (1%)	91 (1%)	116,186	98,667
0–5,280 ft (0–1,609 m)	16 (4%)	172 (3%)	10.2 (7%)	58 (3%)	201 (3%)	274,098	200,848

[a]ND (No duplicates) indicates that duplicate entities are represented by single feature location.

[1]Spatial resolution of receptor was the entire area extent of the land use parcel. "Parks" are instances where any portion of the park intersects with a well buffer. "Park area" is the land area in square miles that intersects with a well buffer.

[2]Spatial resolution of the receptor was the building footprint. Note that the total count for Residential Buildings was referenced from tax parcel data, and therefore includes counts of multi-building unit residences.

Table 7.8. Schools and higher education facilities near at least one of the 83,834 active-producing wells in California. The number of wells driving the land use co-locations are shown in parentheses next to receptor counts where available. Percentage (%) represents the percent of total receptors within the respective buffer distance.

Buffer Distance from Wells (feet)	Total Schools[1] (Pre-K to 12th Grade) (% total)	Childcare facilities[2]	Total Public Schools[1]	Total Public Schools (ND)[a,1]	Total Private Schools[2]	Total Private Schools (ND)[a,2]	Universities[1] (250+ Campus Housing)	Community Colleges[1]
Total Receptors	22,452	8,867	10,630	10,076	2,955	2,880	118 // 145[b]	116 // 266[b]
0–500 ft (0–152 m)	226 (1%)	68 (1%)	136 (1%)	125 (1%)	22 (1%)	22 (1%)	7 (5%)	3 (1%)
0–1,000 ft (0–305 m)	439 (2%)	122 (1%)	262 (2%)	240 (2%)	55 (2%)	52 (2%)	9 (6%)	8 (3%)
0–1,500 ft (0–457 m)	668 (3%)	218 (2%)	362 (3%)	340 (3%)	88 (3%)	84 (3%)	12 (8%)	12 (5%)
0–2,000 ft (0–610 m)	990 (4%)	336 (4%)	521 (5%)	491 (5%)	133 (5%)	129 (5%)	13 (9%)	14 (5%)
0–2,500 ft (0–762 m)	1,293 (6%)	451 (5%)	657 (6%)	622 (6%)	185 (6%)	178 (6%)	16 (11%)	18 (7%)
0–3,281 ft (0–1,000 m)	1,749 (8%)	659 (7%)	881 (8%)	832 (8%)	269 (9%)	258 (9%)	19 (13%)	23 (9%)
0–5,280 ft (0–1,609 m)	3,245 (14%)	1,262 (14%)	1,498 (14%)	1,421(14%)	485 (16%)	470 (16%)	28 (19%)	36 (14%)

[a]ND (No duplicates) indicates that duplicate entities are represented by single feature location.

[b]Universities and community colleges can often entail places and buildings in distinct geographic locations (e.g., off-campus athletic fields or administrative buildings); we therefore report the total receptors as individual buildings on a campus as opposed to one campus = one receptor. Counts represent any time a well is within the said distance of a building associated with the university or community college.

[1]Spatial resolution of receptor was the entire area extent of the land use parcel.

[2]Spatial resolution of the receptor was the building footprint.

Table 7.9. Counts of unique active-producing wells associated with the sensitive receptor in **Table 7.10.**

Buffer Distance from Wells	Counts of wells near Total Schools[1] (Pre-K to 12th Grade)	Counts of wells near Childcare facilities[2]	Counts of wells near Total Public Schools[1]	Counts of wells near Total Private Schools[2]	Counts of wells near Universities[1]	Counts of wells near Community Colleges[1]
0–500 ft (0–152 m)	865	350	614	126	16	8
0–1,000 ft (0–305 m)	1,654	867	1,290	425	29	55
0–1,500 ft (0–457 m)	2,571	1,555	2,070	808	53	130
0–2,000 ft (0–610 m)	3,327	2,135	2,780	1,150	98	245
0–2,500 ft (0–762 m)	4,344	2,772	3,823	1,656	119	363
0–3,281 ft (0–1,000 m)	6,006	4,046	5,232	2,380	139	639
0–5,280 ft (0–1,609 m)	11,365	8,121	10,107	5,336	405	1,840

[a]ND (No duplicates) indicates that duplicate entities are represented by single feature location.

[1]Spatial resolution of receptor was the entire area extent of the land use parcel.

[2]Spatial resolution of the receptor was the building footprint.

Table 7.10. Schools and higher education facilities in proximity to at least one hydrocarbon extraction-related wastewater location in California. Percentage (%) represent percent of total receptors within the respective buffer distance.

Buffer Distance from Wells	Total Schools[1] (Pre-K to 12th Grade) (% total)	Childcare facilities[2] (% total)	Total Public Schools[1]	Total Public Schools (ND)[a,1]	Total Private Schools[2]	Total Private Schools (ND)[a,2]	Universities[1] (% total) (250+ Campus Housing)	Community Colleges[1] (% total)
Total Receptors	22,452	8,867	10,630	10,076	2,955	2,880	118 // 145[b]	116 // 266[b]
0–500 ft (0–152 m)	12 (<1%)	2 (<1%)	10	9 (<1%)	0	0 (0%)	1 (<1%)	1 (<1%)
0–1,000 ft (0–305 m)	25 (<1%)	4 (<1%)	18	16 (<1%)	3	3 (<1%)	1 (<1%)	1 (<1%)
0–1,500 ft (0–457 m)	49 (<1%)	13 (<1%)	29	27 (<1%)	7	7 (<1%)	1 (<1%)	3 (1%)
0–2,000 ft (0–610 m)	94 (<1%)	30 (<1%)	49	46 (<1%)	15	15 (<1%)	1 (<1%)	3 (1%)
0–2,500 ft (0–762 m)	149 (<1%)	48 (<1%)	81	75 (<1%)	20	20 (<1%)	2 (1%)	4 (2%)
0–3,281 ft (0–1,000 m)	239 (1%)	84 (<1%)	132	125 (1%)	31	30 (1%)	4 (3%)	4 (2%)
0–5,280 ft (0–1,609 m)	611 (3%)	229 (3%)	302	283 (3%)	80	79 (3%)	9 (6%)	9 (3%)

[a]ND (No duplicates) indicates that duplicate entities are represented by single feature location.

[b]Universities and community colleges can often entail places and buildings in distinct geographic locations (e.g., disparate athletic field). We therefore report both the total number of all merged locations (first number), and the total number of individual parcels and buildings (second number). Counts here represent any time a well is within the said distance of any place or building associated with the university or community college.

7.4.4. Density of oil and gas development

Studies of health effects associated with oil and gas development commonly employ two related organizing principles to characterize potential exposures to populations: distance from, and intensity of, oil and gas development (Gonzalez et al., 2020; Johnston et al., 2021; Shamasunder et al., 2018; K. V. Tran et al., 2020). More recently, studies have modeled distance and density simultaneously to capture both proximity and intensity of operations. For example, Gonzalez et al. (2020) used inverse distance-squared weighting of oil and wells in California to study risk of adverse birth outcomes. The exposure metrics that result from inverse distance-squared weighting account for both distance and well density, where an exposure index of 1 is equivalent to having one well located 1 km (3,281 ft) away from the maternal residence or 100 wells located 10 km (6.2 mi) away.

To assess well density and associated population-level characteristics, we adopted methods similar to Shonkoff and Hill (2019), including counting wells within census tract areas to calculate well density (i.e., number of wells per square mile). Shonkoff and Hill (2019) included a 1,000 ft (305 m) buffer area around all census tracts before performing the spatial join with well locations to account for edge effects. We followed this method, and also reported well counts and density without the 1,000 ft buffer areas around each census tract (**Table 7.11**).

Shonkoff and Hill (2019) determined areas of relatively higher well density by first enumerating wells at the census tract level and then grouping or "clustering" adjacent census tracts that met a certain well density threshold (approximately 10 wells/mi^2) that was derived by observing a natural break in the frequency distribution. Here, 10 wells/mi^2 pertains to approximately the 80th percentile statewide when considering the distribution frequency of census tracts that contain wells. We similarly grouped adjacent census tracts that met the threshold of 10 wells/mi^2 to support relative comparisons of well density clusters throughout California (**Table 7.11**).

Of the 83,834 active-producing wells we assessed, 82,676 fell within a census tract boundary because 1,158 wells are located on offshore islands. An estimated 615 census tracts (~8% of census tracts) contain at least one active-producing well, resulting in a mean well density of 2.01 wells/mi^2 (0.78 wells/km^2) across a total area of over 41,000 mi^2 (106,000 km^2). These census tract areas encompass an estimated population of 2.8 million Californians. This population estimate differs from the well-distance estimates because the coincident census tract counting method here does not account for nearby populations that are just beyond census tract boundaries.

To identify areas and neighborhoods that exhibit clustering and relatively higher well densities, all adjacent census tracts that met the 80th percentile were aggregated together and assigned a place name akin to the largest nearby neighborhood or locational identifier. These census tract cluster locations were then ranked and presented alongside numerous population-level metrics

available from CalEnviroScreen 3.0[4] (**Table 7.11**) (OEHHA, 2018). Location names were labeled manually by the authors to capture the largest nearby city and note that some neighborhoods may be included within these areas but are not labeled.

Overall, we found that 157 census tracts in 16 areas have a well density of at least 10 wells/ km^2 and 180 census tracts in 23 distinct areas have a well density >10 wells/mi^2. These 16 areas encompass over 628,000 people, and 64 of these 157 census tracts (~40%) have CalEnviroScreen 3.0 scores that designate them as disadvantaged communities with disproportionate socioeconomic, health, and environmental burdens, in addition to the burdens associated with upstream OGD. Because a quarter of all California census tracts are designated as disadvantaged communities based on CalEnviroScreen scores, this finding indicates that disadvantaged communities are overrepresented (1.6 times more likely) in census tracts that contain ≥10 wells/km^2 These communities may include, but are not limited to:

- Areas disproportionately affected by environmental pollution and other hazards that can lead to negative public health effects, exposure, or environmental degradation.
- Areas with concentrations of people with low income, high unemployment, low levels of home ownership, high rent burden, sensitive populations, or low levels of educational attainment.

The highest mean well density was observed in the Los Angeles cluster location, where an area just over 5 mi^2 (13 km^2) contains 866 active-producing wells. This results in a mean well density of nearly 200 wells/mi^2 (77 wells/km^2). The area also has the highest population density in the state, with over 112,000 of California's residents — the majority of which reside in disadvantaged communities per CalEnviroScreen 3.0. Notably, the maximum well density value is in a downtown Los Angeles census tract, with 51 active producing wells within an area of 0.06 mi^2 (0.15 km^2). These results agree with Shonkoff and Hill (2019) — the population density within Los Angeles is significantly higher than most places studied in the peer-reviewed literature of oil and gas activity and health outcomes. This suggests that any hazards or emissions from oil and gas activity in Los Angeles could impact a relatively large number of people.

[4] CalEnviroScreen 3.0 was the available version of CalEnviroScreen at the time of analysis (OEHHA, 2018). Since that time, an updated version, CalEnviroScreen, 4.0, was released.

Table 7.11. Analysis of locations with the highest oil and gas well densities within California.

Location	Well count	Well count (including 1,000 ft buffer)	Density (km^2) (including 1,000 ft buffer)	Cluster Area Mean Well Density (km^2)	Total Population	Census Tract Counts	Total Disadvantaged Communities	Mean CES 3.0 Percentile	Maximum CES 3.0 Percentile
Los Angeles	866	3,463	76.8	73.3	112,464	34	23	81.1	97
Long Beach	1,317	3,308	32.7	15.6	89,869	25	14	66.6	99
Signal Hill	594	1,368	30.0	29.1	44,228	11	4	64.1	97
Baldwin Hills	661	1,352	29.9	25.8	31,790	7	0	53.3	73
Taft	34,576	35,351	20.6	16.7	15,568	4	2	67.3	80
Newhall	323	550	20.0	20.0	14,407	3	0	38.7	41
Beverly Hills	237	692	16.5	16.6	67,860	18	1	43.5	85
Bakersfield	15,214	15,723	16.0	16.0	32,185	7	4	72.6	81
Huntington Beach	426	642	15.4	17.2	47,751	9	0	19.9	46
Coalinga	126	305	13.9	7.7	5,277	1	0	62.0	62
Seal Beach	153	280	11.8	12.5	15,830	5	0	27.6	65
Ventura	758	897	11.7	8.3	8,371	2	1	68.0	78
Brea	1,029	1,578	11.0	10.7	88,458	16	1	38.6	79
Sante Fe Springs	232	471	10.9	9.4	23,984	6	6	89.5	97
Montebello	149	244	10.7	11.8	15,098	4	3	77.8	86
Athens	87	193	10.7	10.1	14,972	5	5	95.4	99
Total	**56,748**	**66,417**	-	-	**628,112**	**157**	**64**	-	-

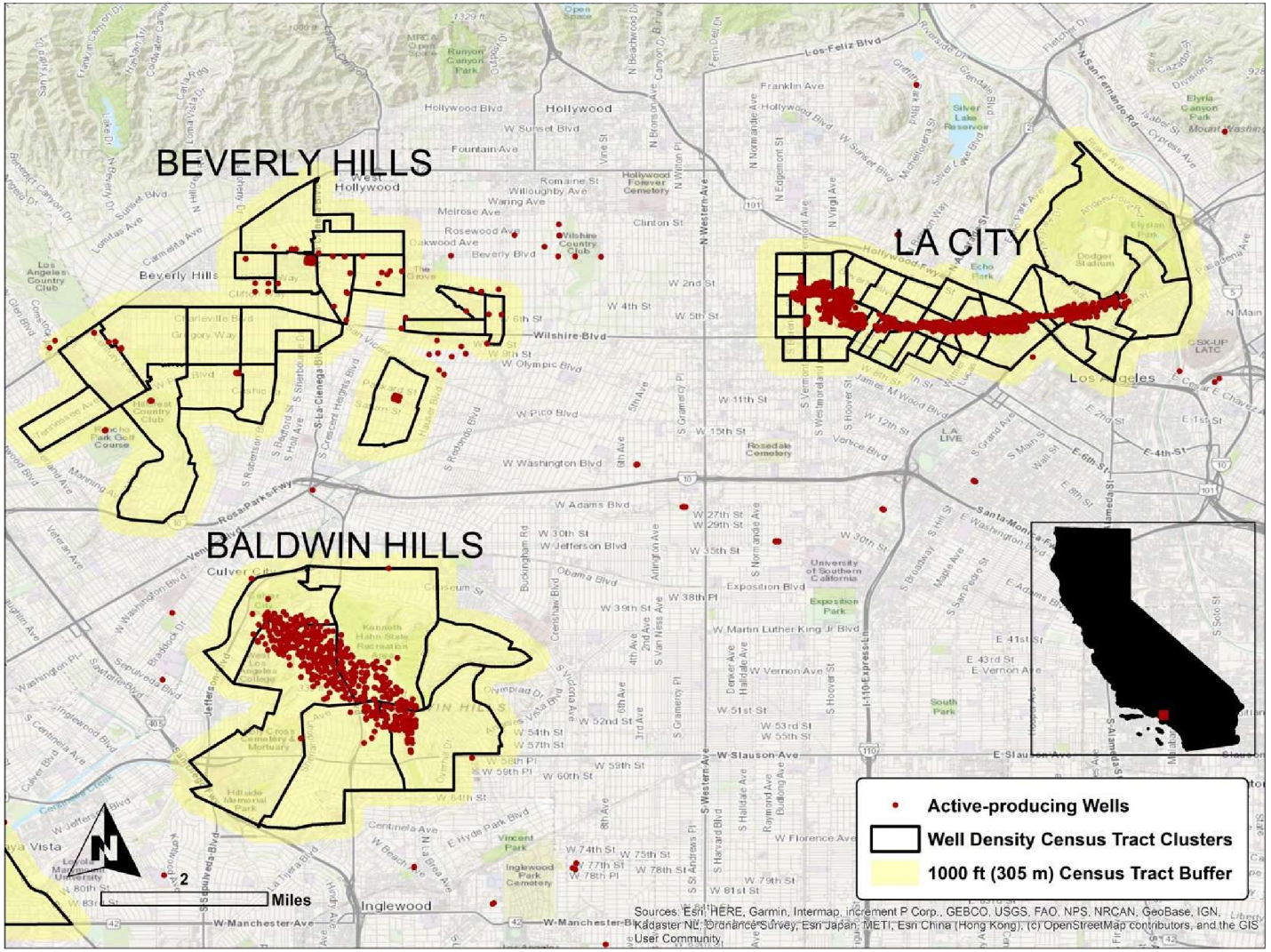


Figure 7.7. Well density near Los Angeles, Baldwin Hills, and Beverly Hills using the coincident wells within census tract method. Outlined census tract areas (black color) indicate areas that exceed 10 wells/km^2. Yellow areas represent the 1,000 ft (305 m) buffer areas around census tracts used to count wells beyond census tract boundaries to reduce the impact of edge effects. Note: Singular name is shown as representing select areas to simplify this visualization; however, these areas are broadly described and include various communities.

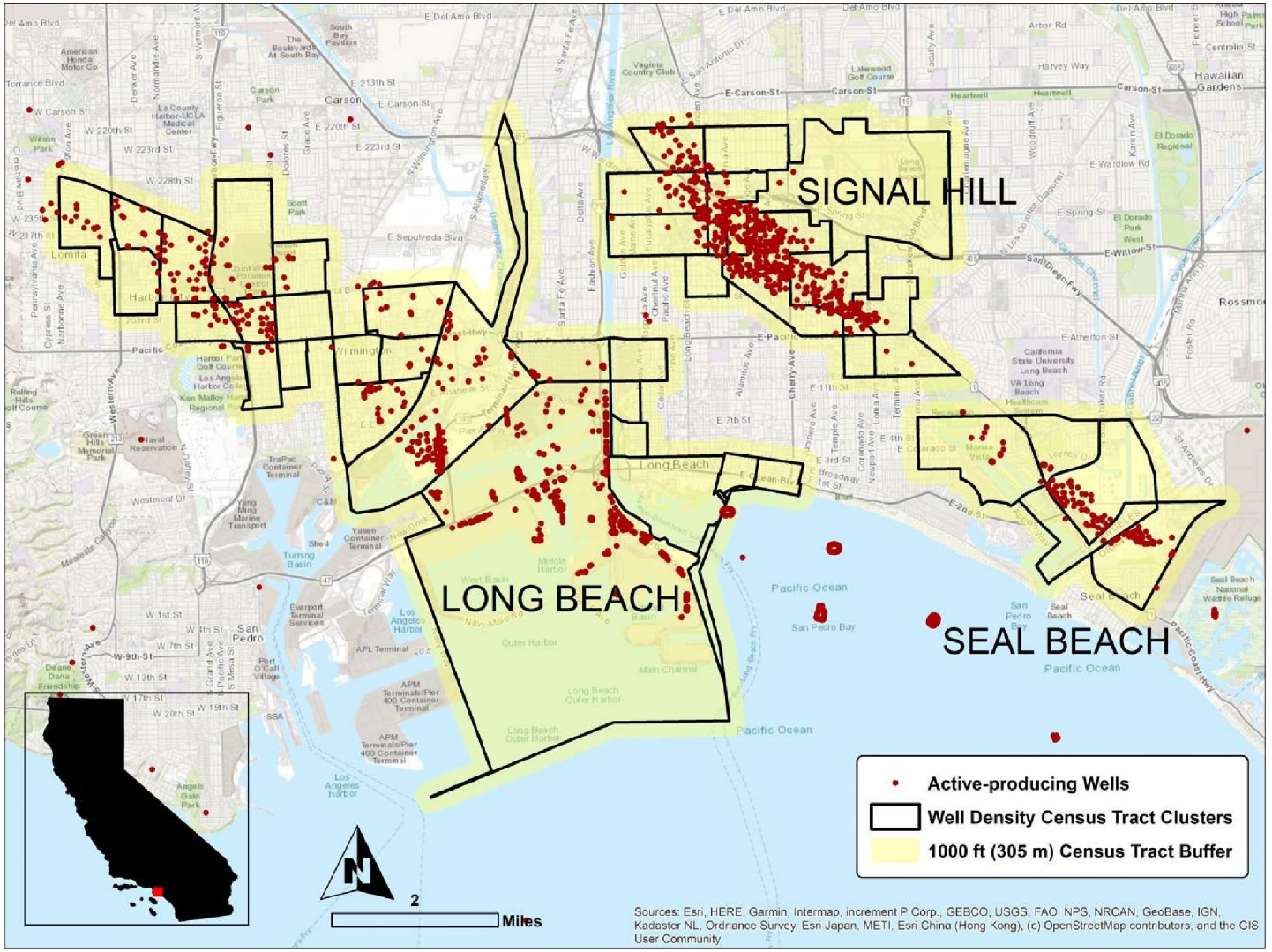


Figure 7.8. Well density near Long Beach (including Harbor City), Signal Hill, and Seal Beach using the coincident wells within census tract method. Outlined census tract areas (black color) indicate areas that exceed 10 wells/km^2. Yellow areas represent the 1,000 ft (305 m) buffer areas around census tracts used to count wells beyond census tract boundaries to reduce the impact of edge effects. Note: Singular name is shown as representing select areas to simplify this visualization; however, these areas are broadly described and include various communities.

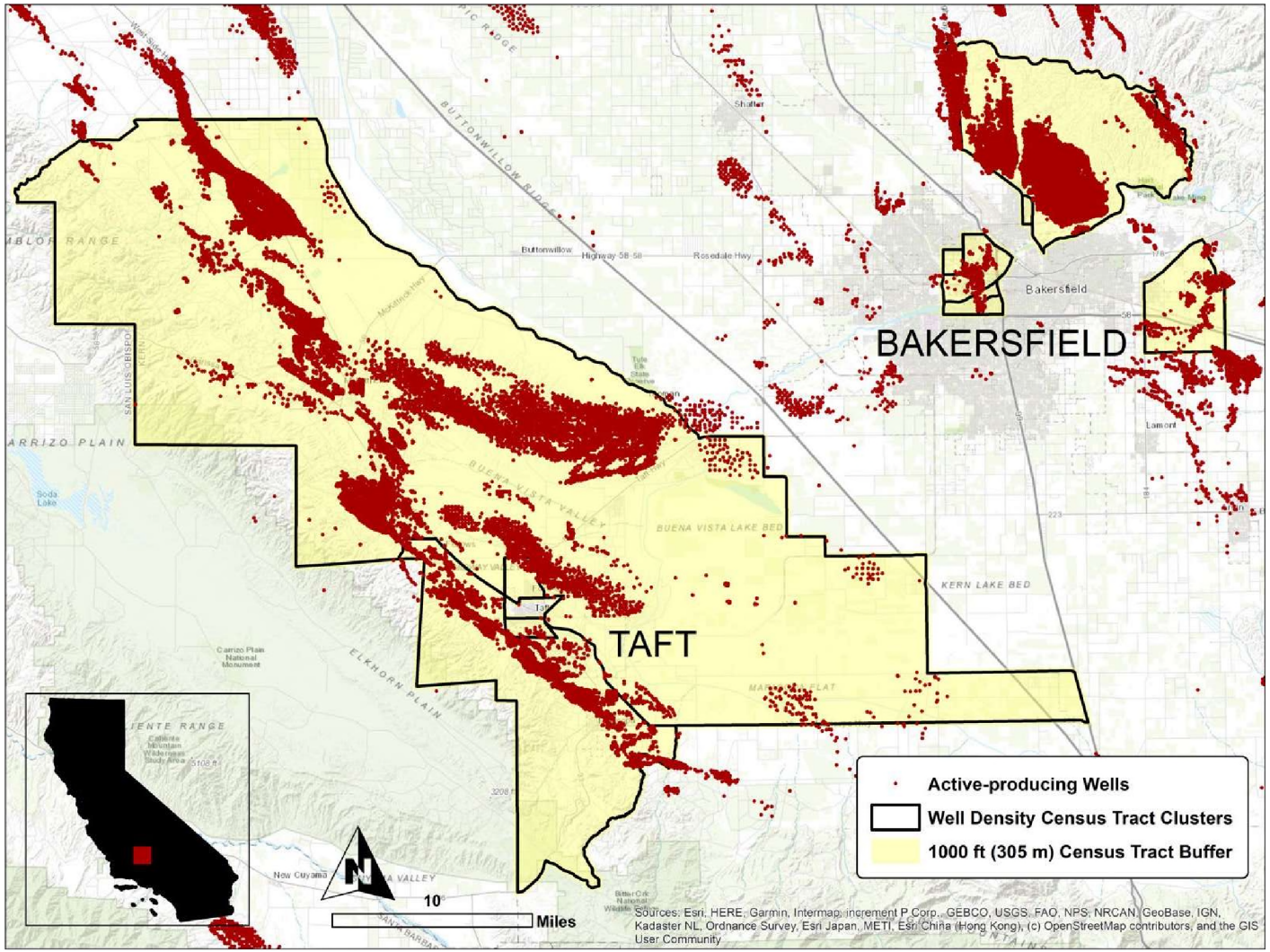


Figure 7.9. Well density near Taft and Bakersfield using the coincident wells within census tracts method. Note the difference in scale compared to **Figure 7.7** and **Figure 7.8**. Also, the Bakersfield location included census tracts that were not directly adjacent. Outlined census tract areas (black color) indicate areas that exceed 10 wells/km^2. Yellow areas represent the 1,000 ft (305 m) buffer areas around census tracts used to count wells beyond census tract boundaries to reduce the impact of edge effects. Note: Singular name is shown as representing select areas to simplify this visualization; however, these areas are broadly described and include various communities.

7.4.5. Hyperlocal proximity: Within 500 feet of oil and gas development

The peer-reviewed literature suggests that closer population proximities to OGD results in greater risks of exposures. While much of the analysis above focuses on providing counts and estimates of populations and receptors within a set of distinct distance thresholds away from wells (e.g., populations living within 1 km [3,281 ft] of active-producing wells), we know that certain hazards follow distinct distance-decays such as noise (Basner & McGuire, 2018; Broner, 2010; Hays et al., 2017) and air pollution (see Chapter 4). With the advancement of geospatial mapping and satellite imagery we can now pinpoint precise locations of oil and gas wells, land use parcels, and even individual buildings. By using both the discrete locations of oil and gas wells and residentially zoned buildings, we can determine just how close some California residents live near active oil and gas wells.

Across California, we identified 1,663 active-producing wells (2% of all active-producing wells) that are within 100 ft (30 m) of at least one residentially-zoned building (n=3,661). California State Fire Code regulation § 5706.3 prohibits location of oil and gas wells within 100 ft of any building not necessary to the operation of the well; however, local jurisdictions may amend the regulation (24 Cal. Code Regs. § 5706.3). This number likely is an underestimate, because we limited the count to residentially zoned buildings only. For example, an active well (yellow marker) surrounded by a residential community in Bakersfield (**Figure 7.10**) illustrates the extent to which some Californians live very close to active oil and gas, with one home within 50 ft (15 m) of the well and many others within 100 ft (30 m). It also helps to further contextualize the counts of populations (**Table 7.3**) and residential buildings within 500 ft (152 m) of wells (**Table 7.5**).



Figure 7.10. Active-producing well (yellow marker) near Bakersfield depicting the hyperlocal proximity to nearby homes (tan color). Radial distances from the well are depicted in red approximately 50 ft and 100 ft from the wellhead. Distances between buildings and their nearest well as shown here were used to create the frequency histogram as shown in **Figure 7.11**.

Thousands of homes in California are located in very close proximity to OGD (**Figure 7.11).** For example, more than 21,000 residential buildings are within 300 ft (91 m) of at least one active-producing well (**Figure 7.11a**, blue dashed line). Thus, approximately 2,200 wells technically meet California's "critical well" status, being located with 300 ft (91 m) of a residential building. Moreover, in reference to the California Fire Code (24 Cal. Code Regs. § 5706.3.1.3), there are ~4,100 residential buildings within 100 ft (30 m) of an OGD well (**Figure 7.11a**, red dashed line); however, some jurisdictions have been amended to include exceptions. Note that residential buildings are represented once though they may have multiple wells within 500 ft (152 m). From a public health standpoint, these hyperlocal co-locations of homes and wells likely represent areas of increased risk of adverse exposure from OGD operations and should be priority candidate areas for reducing the associated public health and safety burdens faced these communities.

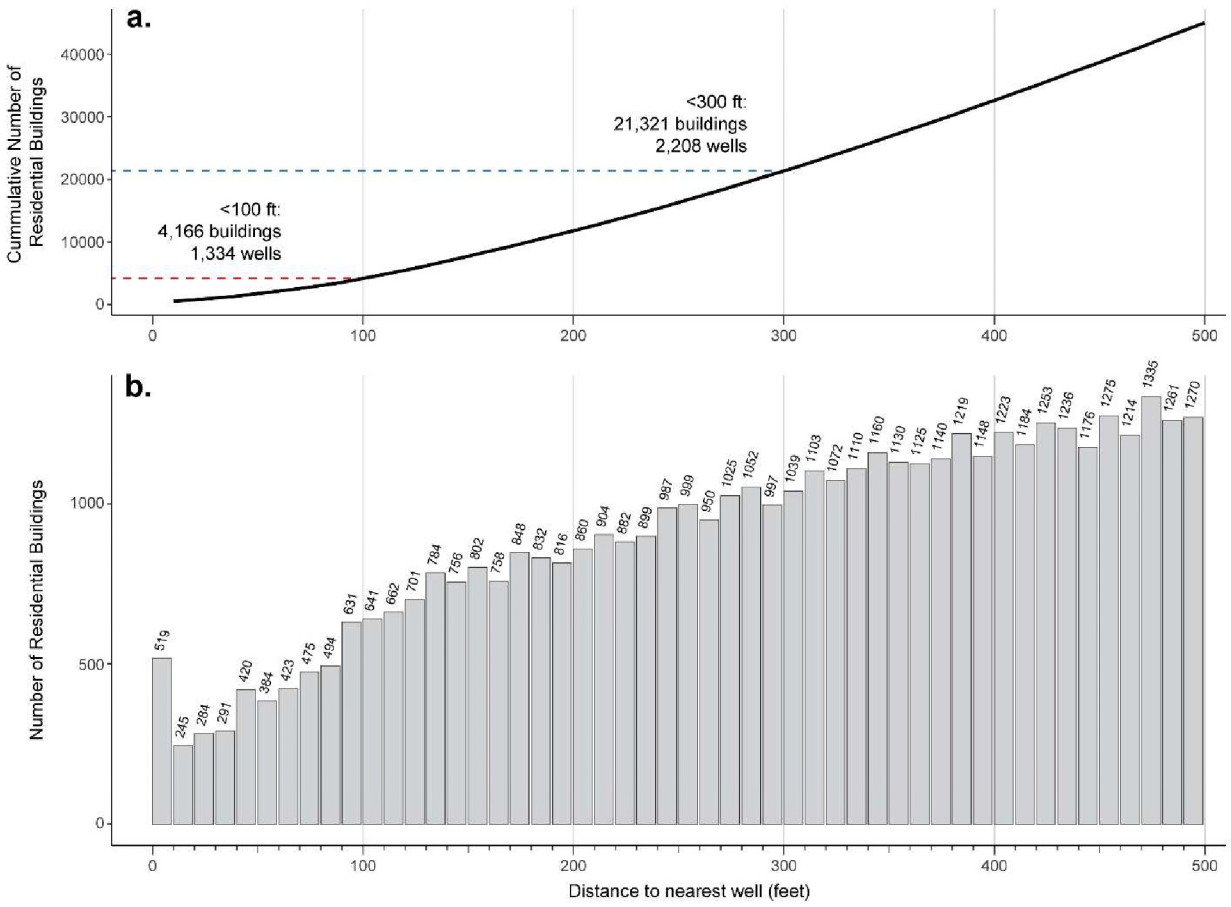


Figure 7.11. Frequency histogram of cumulative counts (a) and binned counts (b) of residential buildings binned by distance to their nearest active-producing oil and gas well from 0–500 ft (0–152 m). The blue dashed line indicates the 300 ft (91 m) distances that demarcates California's "critical well" status. Note: residential buildings are represented once though they may have multiple wells within 500 ft (152 m).

7.5. Discussion

The goals of this California proximity analysis were to provide:

1. Tangible metrics that contextualize the associated public health and safety burdens of communities in proximity to existing oil and gas activity.
2. A comparison of spatial relationships to inform future minimum surface setback regulations for new extractive activities, and identify the associated populations benefitted by various setback distances.
3. New information that is particularly unique to California regarding how close some homes and residents are to oil and gas development.
4. Assessment of existing racial and socioeconomic inequities to determine whether oil and gas development (OGD) is more likely to be located in proximity to disadvantaged communities in California.

To inform these goals, we first investigated the state of the science related to population allocation methodologies and related geospatial techniques. We also incorporated several other content areas to inform our OGD proximity analysis. These included the findings and conclusions

presented in previous chapters of this report, previous proximity analyses performed in California, existing surface setback and well siting location regulations in California and throughout the United States, and distributional inequities observed within the peer-reviewed literature across a range of disciplines (**Figure 7.1**). Summation of these topics were presented in the Background and Justification section. Our analytical results were structured into four main interrelated sections:

1. Racial and socioeconomic disparities and estimated total populations in proximity to oil and gas development;
2. Sensitive receptors in proximity to oil and gas development;
3. Density of oil and gas development; and
4. Hyperlocal proximity: Within 500 (152 m) feet of oil and gas development.

The proximity analysis we conducted largely overcomes the common areal unit weighting problem, particularly for downscaling population data in more rural areas by using novel, highly spatially resolved population information in the form of Census blocks, residential tax parcels, and building footprints. In the United States, population data are publicly available at aggregated areal units (e.g., census blocks, census tracts), and represent "nighttime populations," that is, areas where people reside, not necessarily reflective of daytime exposures related to school, occupation, or other activities. However, conducting proximity analyses using area-level population estimates, as in the current analysis, necessitates assumptions about the spatial distribution of populations within that area. Typically, researchers assume that populations are uniformly distributed within aerial units (proportional weighting). This tenuous assumption is a form of the modifiable areal unit problem. Studies that rely on census data or similar data to estimate populations at sub-census area scales are constrained by the modifiable areal unit problem that can lead to bi-directional errors that increase as search areas become smaller (Michanowicz et al., 2019). Because the built environment is not homogenous but is highly variable, the goal in downscaling aggregated census information (e.g., to the building level) is to capture only habitable land uses. This was done using residential parcels from the California Air Resources Board (CARB) parcel data, census population at the block group and block-levels (from 2013–2017 and 2010, respectively) and building footprints from Microsoft's U.S. buildings dataset.

Therefore, this proximity analysis is novel in our application of population and sociodemographic data resolved at the sub-block level (Depsky et al., 2022). As this assessment utilized a novel dasymetric dataset, no other OGD proximity analysis included in our review contained population data at this fine of a resolution. Compared to less spatially precise methods, this method is particularly helpful for determining more accurate estimates of populations living near OGD.

Our criteria for identifying active oil and gas locations in California resulted in the inclusion of 83,834 "active-producing" wells and a total of 2,977 wastewater disposal features. Notably, 95% of OGD in California is located within three CARB-defined air basins, and it is clear that the clustering of wells in some areas has important implications for public health. This analysis also includes numerous demographic and contextual variables and key sensitive receptors at the building footprint and area extent resolutions such as schools, healthcare facilities, and

residentially zoned buildings. Finally, with use of individual building footprint locations, we assessed hyperlocal proximities between homes and wells at distances less than 500 ft (152 m).

While we attempted to utilize the most spatially accurate data available, healthcare facilities and senior care facilities locations were limited to point locations that were later manually joined to nearest building locations. This process may have resulted in misclassification of facility locations if, for example, the matched building footprints were not accurate. Additionally, using the extent of building footprints (the spatial feature we used to determine proximity to wells) may have led to underestimates of the physical spaces where people spend time near buildings. For example, most schools have outdoor areas, such as playgrounds and athletic fields, where students spend time. In the context of regulatory setback distances for sensitive receptors, special consideration should be given to these frequently occupied outdoor spaces that extend beyond the building walls. Therefore, a more encompassing setback approach would entail a receptor boundary defined at a parcel boundary or property line, rather than a building structure to anchor the setback distance.

Across the landscape of OGD in California, we observed proximity disparities by race/ethnicity and by indicators of socioeconomic marginalization including residing in linguistically-isolated households, living in a renter-occupied residence, and relatively low educational attainment (i.e., no high school diploma). Non-Hispanic Black people are 87% more likely to reside in areas that contain OGD within 1 km (3,281 ft) compared to non-Hispanic white populations in California. These results were supported by the well density analysis where we found that disproportionately high well densities exist in previously identified disadvantaged communities throughout California, based on assessments in CalEnviroScreen 3.0.

Inequities in exposure to environmental pollution have been well documented in California (Morello-Frosch, 2002; Pastor et al., 2006). Such inequities arise due to historic and current development patterns, regulatory frameworks, and environmental racism (Balazs & Ray, 2014; Bullard, 2011). While causal links between environmental pollution exposure from individual sources and adverse health effects can be difficult to establish due to methodological challenges and etiological limitations (Morello-Frosch, 2002), a large body of evidence has demonstrated the connection between proximity to significant pollutant sources and health risks (Bergstra et al., 2018; Linder et al., 2008). Such fence line communities tend to be disproportionately lower income and Black, Indigenous, and people of color, and these trends have been previously observed in California, further supporting the population-level inequities observed herein (Balazs et al., 2011; OEHHA, 2018; Pastor et al., 2006). Most recently, Gonzalez et al. (2022) found that across the United States, the siting of oil and gas wells was associated with historic redlining practices, which could help explain, in part, the racial and socioeconomic disparities in proximity to wells reported in our proximity study. Redlining encompasses the historic and persistent racist policies in housing, lending, and urban planning policies. Briefly, following the Great Depression, the U.S. federal government established the Home Owners' Loan Corporation (HOLC) and the Federal Housing Administration (FHA), which directed widespread neighborhood appraisals to determine investment risk, referred to as "redlining," that took into account residents' race. The authors found that, across the 33 included cities, redlined D-graded neighborhoods had an average of 12.2 ± 27.2 wells/km^2, which was nearly twice the density of wells in neighborhoods graded A or "Best"

(6.8 ± 8.9 wells/km^{-2}). These findings were consistent in Los Angeles and may account for the disproportionate siting of OGD in racially marginalized neighborhoods observed in the present day.

A large number of sensitive receptors such as schools, healthcare facilities, senior care facilities, parks, etc., are also in proximity to at least one (and often many) active oil and gas wells or wastewater locations. However, it is important to note that though counts of sensitive receptors require only one nearby well at a certain search distance, a portion of receptors contain multiple nearby wells, and in some cases, very high nearby well densities. For example, 21 healthcare facilities have more than 100 active-producing wells within 1 km (3,281 ft), and 14 facilities have more than 200 — all of which are located in the City of Los Angeles. Similarly,107 schools have over 100 wells within 1 km (3,281 ft), with 33 schools surrounded by over 300 wells within 1 km (3,281 ft), the majority of which are also located in the City of Los Angeles. From a public health standpoint, the Los Angeles area represents a unique combination of higher well density and high population density that does not exist in other parts of the United States.

The other major finding related to OGD and proximity to sensitive receptors is that these land use co-locations are driven, in part, by only a small fraction of the total active-producing well inventory in California. Even greater disproportionate well-to-receptor distributions were observed at increasingly shorter buffer distances. Notably, all schools and well co-locations at the 1 km (3,281 ft) distance could be eliminated by addressing just 7% of California's total well inventory. Overall, these disproportionate well-to-receptor counts have important implications for informing policy and present an opportunity to realize significant risk reductions by addressing only a small proportion of existing well sites.

Considerable land use co-locations between populations and OGD were also observed for wastewater locations. An estimated 400,000, or roughly 1 in 100 (1%), California residents live within 1 km (3,281 ft) of an active produced water disposal pond and any status water disposal well. Within this distance lie an estimated 99,000 residentially zoned buildings, 239 pre-K through 12th grade schools, 91 senior care facilities, and 26 healthcare facilities. With the relative lack of knowledge pertaining to depositional patterns of pond emissions, it is unknown precisely how many of these receptors are impacted by potential emissions. Moreover, while we do see significant overlap of population dynamics between wastewater and production wells, wastewater facilities do not completely mimic population-level inequities observed for OGD. This result indicates that different populations across California may be disproportionately burdened by various sub sectors of the oil and gas supply chain. From a policy perspective, this observation has implications for understanding the protections that will be afforded to certain subgroups depending upon how and what portions of oil and gas activity are further regulated.

Fluxes of organic compounds emitted from produced water ponds also present a public health risk, but these hazards are poorly characterized. Specifically, only one study has measured organic compound concentrations in emissions from produced water ponds in California (Schmidt & Card, 2020). Summary statistics for all detected constituents within this study, and a discussion of knowledge gaps of airborne emissions are provided in Chapter 5, Section 5.5.3. Because this study did not measure transport distances of these compounds, the exact area affected by these

detected emissions is unknown. Similarly, other studies (Lyman et al., 2018; Mansfield et al., 2018; Thoma, 2009; H.N.Q. Tran et al., 2018) have measured concentrations of organic compounds in emissions from produced water ponds in other states, but these studies also do not include a distance component to their measurements. As such, the associated exposures to proximal populations from these compounds is relatively unknown.

The scientific consensus from peer-reviewed studies strongly suggests that the public health risks and impacts from exposure to upstream oil and gas activity increase as a function of distance from oil and gas development and nearby well density. The science is sufficiently clear that the development of oil and gas immediately adjacent to places where people live, work, play and learn poses hazards and risks to public health, and that a minimum surface setback distance between sensitive receptors and oil and gas sources should be considered. While California does indeed maintain both a forward- and reverse setback regulation for oil and natural gas wells in relation to nearby buildings based upon the California Fire Code, the 100–300 ft setback distances are the least stringent of all major oil and gas producing states and therefore has likely contributed to the significant numbers of Californians that currently live in proximity to OGD. Existing regulatory setback distances from wells to residences, including those established in California, may not be adequate to reduce human health risks, and a more robust, statewide setback policy is needed.

7.6. Summary

An estimated 3 million (8%) California residents live within 1 km (3,281 ft) of at least one active-producing[5] oil and gas well. Based on satellite imagery, an estimated 670,000 residentially zoned buildings, or 6% of all California buildings, are within 1 km (3,281 ft) of at least one active-producing well. Many sensitive receptors, such as schools, childcare facilities, healthcare facilities, senior care facilities, correctional facilities, and parks, are also located in close proximity to oil and gas development in California **(Table 7.12)**.

The observed close proximity between active-producing oil and gas wells and sensitive receptors like schools and healthcare facilities are driven by a small fraction of the total active-producing wells in California. For example, an estimated 6,006 active-producing wells (7.2% of all wells) are within 1 km (3,281 ft) of at least one school. Similarly, 2,377 wells (~3% of all wells) are responsible for all of the co-location with healthcare facilities at the 1 km (3,281 ft) distance.

An estimated 1,663 active-producing wells are within 100 ft (30 m) of at least one home (n=3,661 homes). California State Fire Code regulation 24 C.C.R. § 5706.3 prohibits location of oil and gas wells within 100 ft of any building not necessary to the operation of the well; however, local jurisdictions may amend the regulation.

[5] Active-producing oil or gas wells were defined as *active* if reported as active, new, or idle and *producing*. i.e., a well that was part of a class where at least 1% of wells of that type produced hydrocarbons, indicating that the well was capable of producing.

Table 7.12. Residents and sensitive receptors in proximity to at least one of the 83,000 active-producing oil and gas wells in California, January 2021.

Buffer Distance	Number of Residents	Under 5 years old	Over 64 years old	Schools (pre-K to 12th grade)	Child-care Facilities	Health-care Facilities	Senior care Facilities	Correct-ional Facilities	Parks	Residential Buildings
Statewide Total	**38,984,806**	**2,698,315**	**5,352,812**	**22,452**	**8,867**	**2,131**	**7,246**	**408**	**4,983**	**12,577,497**
500 ft (152 m)	219,681	15,110	30,959	226	68	25	44	7	90	44,994
1,000 ft (305 m)	590,116	39,476	82,984	439	122	59	118	9	154	123,167
1,500 ft (457 m)	1,032,255	68,909	143,807	668	218	87	176	15	208	221,262
2,000 ft (610 m)	1,551,743	103,736	212,905	990	336	116	237	18	276	334,816
2,500 ft (762 m)	2,123,961	141,733	287,705	1,293	451	156	324	21	344	461,246
3,281 ft (1 km)	3,080,713	205,027	412,674	1,749	659	207	466	28	461	673,068
5,280 ft (1.6 km; 1 mile)	5,772,699	384,810	760,877	3,245	1,262	364	832	55	841	1,260,567

The statewide analysis of parcel and census data (2015–2019 American Community Survey) shows that the proportions of Hispanic, non-Hispanic Black, and non-Hispanic Asian people, linguistically isolated households, renters, individuals without a high school diploma, and populations with household incomes below two times the federal poverty line were higher in areas within 1 km (3,281 ft) of at least one active-producing well compared to the overall proportion of each of these groups in California. Additionally, compared to non-Hispanic White Californians, non-Hispanic Black Californians are 87% more likely to reside within 1 km (3,281 ft) to at least one active-producing oil and gas well. Similarly, the proportion of Hispanic Californians living within 1 km (3,281 ft) of at least one active-producing oil and gas well is 42% higher than non-Hispanic White people.

Findings indicate that compared to non-Hispanic White and more socioeconomically advantaged populations, non-Hispanic Black, non-Hispanic Asian, Hispanic populations, and those of lower socioeconomic status were more likely to live near upstream oil and gas development activities where exposures to stressors are likely to be higher.

Many California communities contain a high density of wells, and a disproportionate number of these communities are designated as disadvantaged. Among California's 8,057 census tracts, 157 (1.9%) contained 10 or more wells per square kilometer. Sixty-four of these 157 census tracts (~41%) have a CalEnviroScreen 3.0 (OEHHA, 2018) score that designates them as a disadvantaged community with disproportionate socioeconomic, health, and environmental burdens, in addition to the burdens associated with upstream oil and gas development. Because a quarter of all California census tracts are designated as disadvantaged communities based on CalEnviroScreen scores, this finding indicates that disadvantaged communities are overrepresented (1.6 times more common) in census tracts that contain 10 or more wells per square kilometer.

Active-producing wells in California are often spatially clustered, with 95% located in just three Air Basins. Spatial clustering or high well density suggests that proximity to one well likely means proximity to many wells. For example, 21 healthcare facilities have more than 100 active-producing wells within 1 km (3,281 ft), and 14 facilities have more than 200. Similarly, 107 schools have over 100 wells within 1 km (3,281 ft), with 33 schools are surrounded by over 300 wells within 1 km (3,281 ft).

An estimated 400,000 California residents live within 1 km (3,281 ft) of an active produced-water disposal pond and any-status water-disposal well.[6] Within this distance are an estimated 98,700 residentially zoned buildings, 239 schools (pre-K through 12th grade), 91 senior care facilities, and 26 healthcare facilities. Emissions of volatile organic compounds (VOCs) have been measured from produced water ponds in California; however, the distances that these compounds travel and their corresponding atmospheric concentrations have not been assessed. Moreover, publicly available data on drinking water well spatial locations in California are unreliable. This

[6] Wells designated as 'Water Disposal' in CalGEM 'All Wells' dataset (CalGEM, 2021).

hinders the ability to evaluate risk of drinking water contamination from subsurface migration of fluids from produced water disposal processes.

Exemption and conditional exception mechanisms reduce the effectiveness and public health protections of minimum surface setbacks between oil and gas development operations and receptors. In other states, exemptions, variances, and consent waivers provide opportunities to avoid or weaken well-siting requirements, and therefore have resulted in setback distances that vary widely in practice. The effectiveness of minimum surface setback policies depends not only on the required setback distance, but also on the exemptions that are permitted.

References

14 Cal. Code Regs. § 1720 (2006). https://casetext.com/regulation/california-code-of-regulations/title-14-natural-resources/division-2-department-of-conservation/chapter-4-development-regulation-and-conservation-of-oil-and-gas-resources/subchapter-1-onshore-well-regulations/article-2-definitions/section-1720-definitions

14 Cal. Code Regs. § 1724.3. https://www.law.cornell.edu/regulations/california/14-CCR-1724.3#:~:text=(a)%20Surface%20safety%20devices.,abnormal%20pressures%20in%20the%20flowlines.

14 Cal. Code Regs. § 1726 (2021). https://www.law.cornell.edu/regulations/california/14-CCR-1726

14 Cal. Code Regs. § 1726.3 (2018). https://www.law.cornell.edu/regulations/california/14-CCR-1726.3#:~:text=(a)%20For%20each%20underground%20gas,Division%20for%20review%20and%20approval.

24 Cal. Code Regs. § 5706.3.

58 Pa. Cons. Stat. § 3215 (2016).

58 Pa. Cons. Stat. § 3301 (2016).

American Bar Association. (2018). *Natural Gas Drilling and its Effect on Property Values: A Municipal Perspective*. https://www.americanbar.org/publications/state_local_law_news/2014-15/winter/natural_gas_drilling_and_its_effect_property_values_municipal_perspective.html.

Arvin, Cal. Code Ord. § 17.46.022 (2018). https://library.municode.com/ca/arvin/codes/code_of_ordinances?nodeId=TIT17ZO_CH17.46OIGACO_PT2DESTPEOP_17.46.022SERE

Balazs, C., Morello-Frosch, R., Hubbard, A., & Ray, I. (2011). Social Disparities in Nitrate-Contaminated Drinking Water in California's San Joaquin Valley. *Environmental Health Perspectives*, *119*(9), 1272–1278. https://doi.org/10.1289/ehp.1002878

Balazs, C. L., & Ray, I. (2014). The drinking water disparities framework: On the origins and persistence of inequities in exposure. *American Journal of Public Health*, *104*(4), 603–611. https://doi.org/10.2105%2FAJPH.2013.301664

Basner, M., & McGuire, S. (2018). WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Effects on Sleep. *International Journal of Environmental Research and Public Health*, *15*(3), 519. https://doi.org/10.3390/ijerph15030519

Bergstra, A. D., Brunekreef, B., & Burdorf, A. (2018). The effect of industry-related air pollution on lung function and respiratory symptoms in school children. *Environmental Health*, *17*(1), 30. https://doi.org/10.1186/s12940-018-0373-2

Broner, N. (2010). A Simple Criterion for Low Frequency Noise Emission Assessment. *Journal of Low Frequency Noise, Vibration and Active Control*, *29*(1), 1–13. https://doi.org/10.1260/0263-0923.29.1.1

Bullard, R. D. (2011). Sacrifice Zones: The Front Lines of Toxic Chemical Exposure in the United States *by Steve Lerner* . Cambridge, MA:MIT Press, 2010. 346 pp. ISBN: 978-0-262-01440-3, $29.95. *Environmental Health Perspectives*, *119*(6), a. https://doi.org/10.1289/ehp.119-a266

Cal. Pub. Res. Code § 3690 (1971).

CalGEM (California Geologic Energy Management Division). (2018, August 19). *WellSTAR Oil and Gas Facilities: Pits and Sumps*. https://maps-cnra-cadoc.opendata.arcgis.com/datasets/b57f3a89b43147ec93d79529295824b4_1

CalGEM. (2019). *Permitting, Forms, and Compliance*. https://www.conservation.ca.gov/calgem/for_operators

CalGEM. (2021). *GIS Mapping – All Wells.* https://www.conservation.ca.gov/calgem/maps

CalHHS (California Health & Human Services Agency). (2021, March 12). *Licensed and Certified Healthcare Facility Listing*. https://data.chhs.ca.gov/dataset/healthcare-facility-locations

CARB (California Air Resources Board). (2005). *Air Quality & Land Use Handbook: A Community Health Perspective*. https://files.ceqanet.opr.ca.gov/221458-6/attachment/UNr-g159CW-r0G4DR8q6daNdAKT3RJTd8gGQCfz4wqFfl-eNdZNQEqjf8tfls1x6Gsae7YqpXwtFIZBd0

Carson, Cal. Muni. Code § 9521 (2015). https://www.codepublishing.com/CA/Carson/#!/Carson09/Carson09050200.html#9521

CDE (California Department of Education). (2021). *Private School Data—School & District Information (CA Dept of Education)*. https://www.cde.ca.gov/ds/si/ps/index.asp

CDFW (California Department of Fish and Wildlife). (2009). *NAIP 2009 4-Band, California*. https://data-cdfw.opendata.arcgis.com/datasets/59cf9ca48bde47af896911c0c199491f

CDFW. (2014). *NAIP 2014 4-Band, California*. https://data-cdfw.opendata.arcgis.com/datasets/0da6be522cfa41c8aa75103e40d2e5ad

CDSS (California Department of Social Services). (2020). *Community Care Licensing—Residential Elder Care Facility Locations*. https://data.chhs.ca.gov/dataset/community-care-licensing-residential-elder-care-facility-locations

CEJA (California Environmental Justice Alliance) & PlaceWorks. (2017). *SB 1000 Implementation Toolkit* (p. 164). https://caleja.org/2017/09/sb-1000-toolkit-release/

COGCC (Colorado Oil & Gas Conservation Commission) (2020). 200-600 Series - Revised Draft Rules. https://drive.google.com/drive/u/0/folders/1EukVjyPPeFI8_8UH6tFaT7wfi70-MXil

COGCC (2021) Rules 600 Series. https://cogcc.state.co.us/documents/reg/Rules/Older/archive/Rules/2021/600%20Series%20-%20Safety%20and%20Facility%20Operations%20Regulations.pdf

Czolowski, E. D., Santoro, R. L., Srebotnjak, T., & Shonkoff, S. B. C. (2017). Toward Consistent Methodology to Quantify Populations in Proximity to Oil and Gas Development: A National Spatial Analysis and Review. *Environmental Health Perspectives*, *125*(8), 086004. https://doi.org/10.1289/EHP1535

Depsky, N. (2021). Personal communication.

Depsky, N. J., Cushing, L., & Morello-Frosch, R. (2022). High-resolution gridded estimates of population sociodemographics from the 2020 census in California. *PloS ONE*, *17*(7), e0270746. https://doi.org/10.1371/journal.pone.0270746

Deschenes, O., Deshmukh, R., Lea, D., Meng, K., Weber, P., Cobian, T., Cortes, D. H., Lee, R., Malloy, C., Mangin, T., Meng, M., Oliver, M., Sum, S., Thivierge, V., Uppal, A., Kordell, T., Clemence, M., O'Reilly, E., & Kelley, A. (2021). *Enhancing Equity While Eliminating Emissions in California's Supply of Transportation Fuels.* California Carbon Neutrality Study 2 Research Report. https://ww2.arb.ca.gov/sites/default/files/2021-06/ucsb_sp_kickoff_june2021_0.pdf

Earthworks. (2016, April 14). *Oil & Gas Threat Map | California*. The Oil & Gas Threat Map. https://oilandgasthreatmap.com/threat-map/california/

ESRI. (2019, June 18). *USA Parks—Overview & Dataset Download*. https://www.arcgis.com/home/item.html?id=578968f975774d3fab79fe56c8c90941

Ferrar, K. J. (2020, December 17). People and Production: Reducing Risk in California Extraction. *FracTracker Alliance*. https://www.fractracker.org/2020/12/people-and-production/

Ferrar, K. J. (2021, September 9). California Prisons are Within 2,500' of Oil and Gas Extraction. *FracTracker Alliance*. https://www.fractracker.org/2021/09/california-prisons-are-within-2500-of-oil-and-gas-extraction/

Fry, M. (2013). Urban gas drilling and distance ordinances in the Texas Barnett Shale. *Energy Policy*, *62*, 79–89. https://doi.org/10.1016/j.enpol.2013.07.107

Fry, M., Brannstrom, C., & Sakinejad, M. (2017). Suburbanization and shale gas wells: Patterns, planning perspectives, and reverse setback policies. *Landscape and Urban Planning*, *168*, 9–21. https://doi.org/10.1016/j.landurbplan.2017.08.005

Gonzalez, D. J. X., Sherris, A. R., Yang, W., Stevenson, D. K., Padula, A. M., Baiocchi, M., Burke, M., Cullen, M. R., & Shaw, G. M. (2020). Oil and gas production and spontaneous preterm birth in the San Joaquin Valley, CA: A case–control study. *Environmental Epidemiology*, *4*(4), e099. https://doi.org/10.1097/EE9.0000000000000099

Gonzalez, D. J. X., Nardone, A., Nguyen, A. V., Morello-Frosch, R., & Casey, J. A. (2022). Historic redlining and the siting of oil and gas wells in the United States. *Journal of Exposure Science & Environmental Epidemiology*, 1–8. https://doi.org/10.1038/s41370-022-00434-9

GreenInfo Network. (2018). *California Protected Areas Database*. https://www.calands.org/cpad/

GreenInfo Network. (2021). *California School Campus Database*. https://www.californiaschoolcampusdatabase.org/

Haley, M., McCawley, M., Epstein, A. C., Arrington, B., & Bjerke, E. F. (2016). Adequacy of Current State Setbacks for Directional High-Volume Hydraulic Fracturing in the Marcellus, Barnett, and Niobrara Shale Plays. *Environmental Health Perspectives*, *124*(9), 1323–1333. https://doi.org/10.1289/ehp.1510547

Hansen, E., Cushing, L. J., Betcher, M., & Thomas, C. (2017). *In Everyone's Backyard: Assessing Proximity of Fracking to Communities At-Risk in West Virginia's Marcellus Shale*.

Hays, J., McCawley, M., & Shonkoff, S. B. C. (2017). Public health implications of environmental noise associated with unconventional oil and gas development. *Science of The Total Environment*, *580*, 448–456. https://doi.org/10.1016/j.scitotenv.2016.11.118

Ill. Senate Bill No. 1715 (2013). https://ilga.gov/legislation/billstatus.asp?DocNum=1715&GAID=12&GA=98&DocTypeID=SB&LegID=72606&SessionID=85&SpecSess=

Johnston, J. E., Enebish, T., Eckel, S. P., Navarro, S., & Shamasunder, B. (2021). Respiratory Health, Pulmonary Function and Local Engagement in Urban Communities Near Oil Development. *Environmental Research*, 111088. https://doi.org/10.1016/j.envres.2021.111088

KCPNRD (Kern County Planning and Natural Resources Department). (2016). *Kern County Oil and Gas Permitting Handbook*.

Koehler, K., Ellis, J. H., Casey, J. A., Manthos, D., Bandeen-Roche, K., Platt, R., & Schwartz, B. S. (2018). Exposure Assessment Using Secondary Data Sources in Unconventional Natural Gas Development and Health Studies. *Environmental Science & Technology*, *52*(10), 6061–6069. https://doi.org/10.1021/acs.est.8b00507

LACDPH (Los Angeles County Department of Public Health). (2018). *Public Health and Safety Risks of Oil and Gas Facilities in Los Angeles County*. http://publichealth.lacounty.gov/eh/docs/ph_oilgasfacilitiesphsafetyrisks.pdf

Linder, S. H., Marko, D., & Sexton, K. (2008). Cumulative Cancer Risk from Air Pollution in Houston: Disparities in Risk Burden and Social Disadvantage. *Environmental Science & Technology*, *42*(12), 4312–4322. https://doi.org/10.1021/es072042u

Los Angeles, Cal. Muni. Code § 91.6105 (2019). https://codelibrary.amlegal.com/codes/los_angeles/latest/lamc/0-0-0-176574

Los Angeles Co., Cal. Code Ord. tit. 32 (2021). https://library.municode.com/ca/los_angeles_county/codes/code_of_ordinances?nodeId=TIT32FICO

Lyman, S. N., Mansfield, M. L., Tran, H. N. Q., Evans, J. D., Jones, C., O'Neil, T., Bowers, R., Smith, A., & Keslar, C. (2018). Emissions of organic compounds from produced water ponds I: Characteristics and speciation. *Science of the Total Environment*, *619–620*, 896–905. https://doi.org/10.1016/j.scitotenv.2017.11.161

Mansfield, M. L., Tran, H. N. Q., Lyman, S. N., Bowers, R. L., Smith, A. P., & Keslar, C. (2018). Emissions of organic compounds from produced water ponds III: Mass-transfer coefficients, composition-emission correlations, and contributions to regional emissions. *Science of The Total Environment*, *627*, 860–868. https://doi.org/10.1016/j.scitotenv.2018.01.242

Md. Code Regs. § 26.19.01.09 (2020). https://casetext.com/regulation/maryland-administrative-code/title-26-department-of-the-environment/part-4-subtitles-19-27/subtitle-19-oil-and-gas-resources/chapter-261901-oil-and-gas-exploration-and-production/section-26190109-criteria-for-approval-of-drilling-and-operating-permit

Michanowicz, D. R., Williams, S. R., Buonocore, J. J., Rowland, S. T., Konschnik, K. E., Goho, S. A., & Bernstein, A. S. (2019). Population allocation at the housing unit level: Estimates around underground natural gas storage wells in PA, OH, NY, WV, MI, and CA. *Environmental Health*, *18*(1), 58. https://doi.org/10.1186/s12940-019-0497-z

Michanowicz, D. R., Buonocore, J. J., Konschnik, K., Goho, S. A., & Bernstein, A. S. (2021). The effect of Pennsylvania's 500 ft surface setback regulation on siting unconventional

natural gas wells near buildings: An interrupted time-series analysis. *Energy Policy*, *154*, 112298. https://doi.org/10.1016/j.enpol.2021.112298

Microsoft Maps. (2021). *US Building Footprints*. https://github.com/Microsoft/USBuildingFootprints

Mohnot, S., Bishop, J., & Sanchez, A. (2019). *Making Equity Real in Climate Adaptation and Community Resilience Policies and Programs: A Guidebook* (p. 104). Greenlining Institute. https://greenlining.org/wp-content/uploads/2019/08/Making-Equity-Real-in-Climate-Adaption-and-Community-Resilience-Policies-and-Programs-A-Guidebook-1.pdf

Morello-Frosch, R. A. (2002). Discrimination and the Political Economy of Environmental Inequality. *Environment and Planning C: Government and Policy*, *20*(4), 477–496. https://doi.org/10.1068/c03r

NCSL (National Conference of State Legislatures). (2021). *Energy State Bill Tracking Database*. https://www.ncsl.org/research/energy/energy-legislation-tracking-database.aspx

N.D. Cent. Code § 38-08-05. https://www.ndlegis.gov/cencode/t38c08.pdf#nameddest=38-08-05

Oak Ridge National Laboratory. (2020). *Prison Boundaries*. https://hifld-geoplatform.opendata.arcgis.com/datasets/prison-boundaries

OEHHA (California Office of Environmental Health Hazard Assessment). (2018). *CalEnviroScreen 3.0*. https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30

Pastor, M., Morello-Frosch, R., & Sadd, J. L. (2006). Breathless: Schools, Air Toxics, and Environmental Justice in California. *Policy Studies Journal*, *34*(3), 337–362. https://doi.org/10.1111/j.1541-0072.2006.00176.x

R Core Team. (2020). *R: A language and environment for statistical computing* (4.0.3). R Foundation for Statistical Computing. https://www.R-project.org/

Richardson, N., Gottlieb, M., Krupnick, A., & Wiseman, H. (2013). *The State of State Shale Gas Regulation*. Resources for the Future.

Schmidt, C., & Card, T. R. (2020). *Measurement of Produced Water Air Emissions from Crude Oil and Natural Gas Operations* (RFP No. 16ISD005; p. 50). California Air Resources Board. https://ww2.arb.ca.gov/sites/default/files/2020-07/CARB%20Oil%20Wastewater%20Emissions%20Final%20Report_05.11.2020_ADA.pdf

Shamasunder, B., Collier-Oxandale, A., Blickley, J., Sadd, J., Chan, M., Navarro, S., Hannigan, M., & Wong, N. J. (2018). Community-Based Health and Exposure Study around Urban Oil Developments in South Los Angeles. *International Journal of Environmental Research and Public Health*, *15*(1). https://doi.org/10.3390/ijerph15010138

Shonkoff, S. B. C., & Gautier, D. (2015). A Case Study of the Petroleum Geological Potential and Potential Public Health Risks Associated with Hydraulic Fracturing and Oil and Gas Development in The Los Angeles Basin. In *An Independent Scientific Assessment of Well Stimulation in California*. California Council on Science and Technology. https://ccst.us/wp-content/uploads/160708-sb4-vol-III-4.pdf

Shonkoff, S. B. C., Hill, L. L., Czolowski, E. D., Prasad, K., Hammond, S. K., & McKone, T. E. (2017). Chapter 1, Section 1.4: Human health hazards, risks and impacts associated with underground natural gas storage in California. In *Long-Term Viability of Underground Natural Gas Storage in California: An Independent Review of Scientific and Technical Information.* California Council on Science and Technology. https://ccst.us/wp-content/uploads/Chapter-1-v2-Section-1-4.pdf

Shonkoff, S. B. C., & Hill, L. L. (2019). *Human health and oil and gas development: A review of the peer-reviewed literature and assessment of applicability to the City of Los Angeles*. PSE Healthy Energy. https://www.psehealthyenergy.org/wp-content/uploads/2022/08/Literature-Review.pdf

Srebotnjak, T., & Rotkin-Ellman, M. (2014). *Drilling in California: Who's at risk?* (NRDC Report R:14-09-A). National Resources Defense Council.

SWRCB (California State Water Resources Control Board). (2019). *Produced Water Ponds Status Report: January 31, 2019*. https://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/docs/pwpondsreport_january2019.pdf

SWRCB. (2021). *Geotracker*. https://geotracker.waterboards.ca.gov/

Tex. H.B. No. 40 (2015). https://capitol.texas.gov/tlodocs/84R/billtext/html/HB00040F.htm

Thibodeaux, J. (2018). Environmentalists push back against reduced drilling setback in Arlington. *Green Source DFW*. https://greensourcedfw.org/articles/environmentalists-push-back-drilling-setback-arlington

Thoma, E. (2009). *Measurement of Emissions from Produced Water Ponds: Upstream Oil and Gas Study #1 Final Report* (EPA/600/R-09/132). Air Pollution Prevention and Control Division, National Risk Management Research Laboratory. https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NRMRL&dirEntryId=213869

Tran, H. N. Q., Lyman, S. N., Mansfield, M. L., O'Neil, T., Bowers, R. L., Smith, A. P., & Keslar, C. (2018). Emissions of organic compounds from produced water ponds II: Evaluation of flux chamber measurements with inverse-modeling techniques. *Journal of the Air & Waste Management Association*, *68*(7), 713–724. https://doi.org/10.1080/10962247.2018.1426654

Tran, K. V., Casey, J. A., Cushing, L. J., & Morello-Frosch, R. (2020). Residential Proximity to Oil and Gas Development and Birth Outcomes in California: A Retrospective Cohort Study of 2006–2015 Births. *Environmental Health Perspectives*, *128*(6), 067001. https://doi.org/10.1289/EHP5842

Ventura County. (2020). *VC2040 General Plan Update—Home*. https://vc2040.org/

W. Va. Code § 22-6-21. https://www.wvlegislature.gov/wvcode/chapterentire.cfm?chap=22&art=6&section=21

W. Va. Code § 22-6A-12. https://www.wvlegislature.gov/wvcode/ChapterEntire.cfm?chap=22&art=6A&section=12

Appendix F

F.1. Proximity Analysis Study Area and Data Sources

F.1.1. Study area

The geographic focus of this study is the entire state of California. Using GIS techniques, all datasets were limited to the boundaries of the state of California. Some analyses were aggregated by air basin, county or by census tract. All geospatial analyses were performed using the California Teale Albers projection.

F.1.2. Oil and gas data

Oil and gas wells

The following oil and gas well datasets were provided by CalGEM on January 21, 2021, and were used for all analyses:

1) CalGEM "All Wells" file (current as of January 21, 2021).
2) CalGEM "2010 Present Production Injection Volumes" — gas, oil, water quarterly production (2010–2020).

These datasets were used to identify wellhead locations and well status, type, and quantitative production volumes. While oil and gas extraction in California is supported by numerous well types in various operating conditional states (i.e., status), our well inclusion criteria were aimed to capture wells that are capable of producing hydrocarbons at the time of writing this report. Therefore, to provide these "active-producing" wells and their locations for the proximity analysis, the two datasets listed above were first joined by American Petroleum Institute (API) well number — a unique identifier allowing for common examination across individual well status, type and hydrocarbon production activity over the past ten years. For the "active-producing wells", data were refined so that all wells included in the analysis were, according to CalGEM, *active, new, or idle* statuses as of January 21, 2021 (**Table F.1**).

Because not all well types routinely produce oil or gas, we next examined proportions of wells by type that have produced any oil or gas within the past six years. We selected a 1% cut-off value for the well type inclusion criteria, meaning that at least 1% of wells within a certain well type must have produced hydrocarbons over the past five years to be included in the proximity analysis. If a well type met these criteria, all wells of that type that were also status *new, active, or idle* were included in the final well dataset. **Table F.2** shows these percentages in the far-right column, with rows highlighted in green indicating well types that were included in the "active-producing" well dataset. Note that the well type "gas" did not meet the 1% threshold but was still included due to its likelihood to function as a producing well akin to "dry gas" and "oil and gas" well types.

Table F.1. All-type hydrocarbon-related extraction wells by well status as of January 21, 2021. Rows in light grey indicate consideration for inclusion in proximity analysis. Note: some wells can produce both oil and gas.

Status	Well Count	Oil Producing Wells 2015–2020	Gas Producing Wells 2015–2020	Wells Included by Well Status
Plugged	126,400	1857	988	
Active	60,937	45,041	25,808	60,937
Idle	38,557	9,435	5,589	38,557
Canceled	8,991	9	6	
New	5,426	712	347	5,426
Plugged Only	177	12	6	
Unknown	111	1	0	
Abeyance	1	0	0	
Total	**240,600**	**57,067**	**32,744**	**104,920**

The final well selection criteria (**Figure F.1**) resulted in a final well count of 83,834. Notably, 206 wells reported duplicate well locations even though no duplicate API numbers were present. In some cases only the API number differed. In other cases, well status or well type differed, indicating that the same well may have been repurposed to a subsequent operating type. However, no well activity dates were provided within this dataset to test this hypothesis. It is also possible that two wells exist on the same well pad but were geolocated to the same well pad centroid location. Irrespective of cause, duplicate well locations were removed to not double count proximate populations or sensitive receptors.

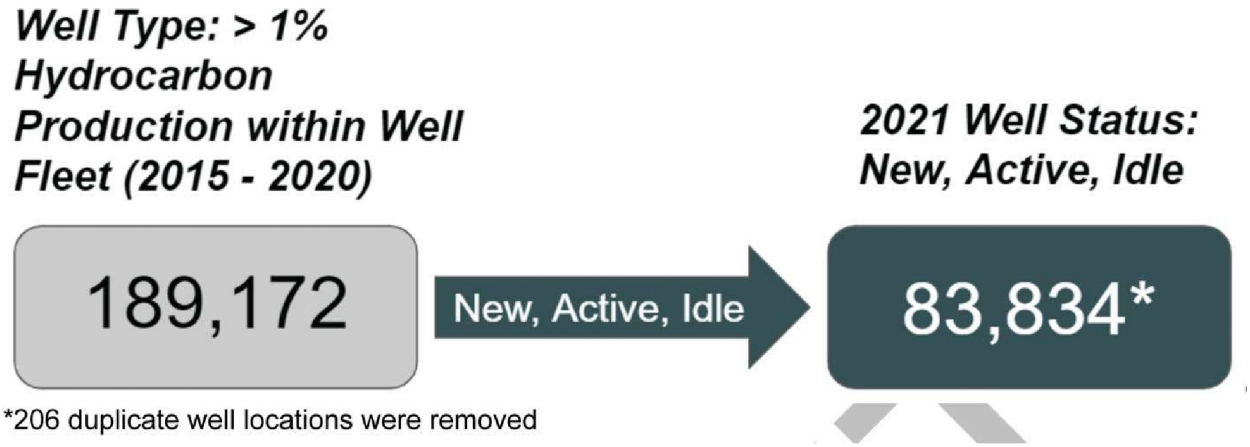


Figure F.1. Well dataset selection criteria and the resulting final count. Note: 206 wells reported duplicate well locations. To not double count populations and sensitive receptors, these duplicates were removed resulting in a final "active" well count of 83,834.

Table F.2. All-status hydrocarbon-related extraction wells by well type with counts and proportion of producing wells. Rows in light grey indicate consideration for inclusion in proximity analysis.

Well Type	Well Count	Oil Producing Wells 2015–2020	Gas Producing Wells 2015–2020	Oil or Gas Production 2015–2020	Percent of Producing Wells 2015–2020	Wells Included by Type
Oil & Gas	157,426	39,782	27,702	40,117	25.48	157,426
Cyclic Steam	21,000	16,529	3,658	16,531	78.72	21,000
Dry Hole	16,743	0	0	0	0.00	
Steamflood	12,605	71	4	71	0.56	
Waterflood	11,170	86	60	86	0.77	
Dry Gas	5,003	134	1,187	1,187	23.73	5,003
Observation	4,857	21	11	21	0.43	
Multi-Purpose	2,922	215	73	216	7.39	2,922
Water Disposal	2,295	7	0	7	0.31	
Injection	1,705	1	0	1	0.06	
Core Hole	1,451	0	0	0	0.00	
Gas	1,418	0	3	3	0.21	1,418
Unknown	952	84	42	84	8.82	952
Gas Storage	451	135	3	137	30.38	451
Water Source	248	1	0	1	0.40	
Pressure Maintenance	141	1	1	1	0.71	
Gas Disposal	115	0	0	0	0.00	
Air Injection	92	0	0	0	0.00	
Liquefied Gas	6	0	0	0	0.00	
Total	**240,600**	**57,067**	**32,744**	**58,463**		**189,172**

Oil and gas wastewater disposal infrastructure

Locations of produced water were compiled from three sources:

1. Latest (January 31, 2019) State Water Resources Control Board (SWRCB) Produced Water Pond Status Report (SWRCB, 2019),
2. Pits and sumps dataset in the California Geologic Energy Management Division's (CalGEM) WellSTAR Statewide Tracking and Reporting System (CalGEM, 2018), and
3. Locations of ponds provided in the SWRCB's Geotracker system (SWRCB, 2021).

Occasionally, locations of ponds in Geotracker were provided in the Public Land Survey System notation (e.g., section, township, range). In these cases, the California utility of Earth Point in Google Earth was used to determine the centroid in latitude and longitude of the section, township, and range. Since there was no common shared key between all three of the datasets, ponds in each dataset were joined by the latitude and longitude values in R to create a compiled dataset (R Core Team, 2020). The compiled dataset was then imported into ArcGIS 10.8.1, and duplicated features were joined manually by comparing to multiple years (2009, 2014) of high-resolution (~1 m, 3.3 ft) aerial imagery (CDFW, 2009, 2014). After the removal of duplications, there were a total of 2,389 pond features remaining which were considered in the statewide proximity analysis. Of these features, only those with a status of "active" (n=682) were joined to all wells with a type of "Water Disposal" (n=2,295) from the CalGEM "All Wells" dataset (CalGEM, 2021). This combined dataset (2,977 features) was then used in the proximity analysis to characterize populations living within proximity to oil and gas wastewater infrastructure.

F.1.3. Population data

California statewide parcel data

Tax assessor real estate land parcel data were obtained from the California Air Resources Board (CARB) for the entire state of California. These parcel data included land use types (e.g., single-family residential) and were used to distinguish between residential and non-residential parcels for use in downscaling Census block data to these high-resolution parcel areas. Population data available at the census block-level was downscaled to these residential-type parcels using a proportional distribution method further described in the "populated areas" methods section below.

Population and demographic data

U.S. Census blocks were utilized for all population and demographic information. Unfortunately, the most recent block-level population information was enumerated from the 2010 decennial census. To provide more recent population estimates, block group-level data in the ongoing five-year American Community Survey (ACS) was utilized. Block-level populations from the 2010 decennial census were extrapolated forward in time using population estimates from the 2013–2017 ACS for parent block-groups; proportional distribution of population amongst the blocks within each block group was kept constant according to patterns observed in 2010, but with updated totals to reflect values in the ACS dataset.

F.1.4. Sensitive receptors data

Building footprint data

Geospatial building footprint data were available from Microsoft, which provides deep learning generated building footprint vectors for the entire United States, representing the built environment as of June 2018 (Microsoft Maps, 2021). In addition to supporting the population model, building locations were also used to represent sensitive receptors where spatial resolution of administration data was available only as single points. This applied to private school locations, daycare locations, all healthcare facilities, and senior care facility locations. To assign these point data to building geometries, we employed the near function to capture the nearest building followed by a spatial join to append the sensitive receptor attributes to the nearest building geometry. In some cases, the underlying point data represents multiple entities, such as multiple healthcare facilities. This also resulted in duplicate building geometries following the near and join functions. Therefore, we present counts of sensitive receptors both with and without duplicates as indicated by the "ND" notation, indicating "no duplicates" and any duplicate co-located entities equaling n=1.

CalEnviroScreen 3.0

CalEnviroScreen 3.0[7] is a screening tool that identifies communities most affected by and vulnerable to the effects of many sources of pollution and population-based disparities (OEHHA, 2018). It aggregates statewide environmental, health, and socioeconomic information to produce scores for every census tract in the state. A census tract with a high score is considered more disadvantaged than a community with a low score as a result of pollution burden and population characteristics. When overlaid with climate impact and exposure data, CalEnviroScreen can provide insight into built and environmental exposure factors that contribute to vulnerability (Mohnot et al., 2019; OEHHA, 2018).

Schools and childcare facilities

The California School Campus Database provided land parcel location data for all California Public Schools kindergarten through 12th grade as well as all California Community College campuses and University land parcel locations that are believed to house at least 250 students on campus (GreenInfo Network, 2021). Private school locations were available from California Department of Education Open Data (CDE, 2021).

Correctional facilities

Correctional facilities were available from the Homeland Infrastructure Foundation — a provision via the federal Department of Homeland Security (Oak Ridge National Laboratory, 2020). Facilities included within this database range from federal (excluding military) jurisdiction to local

[7] CalEnviroScreen 3.0 was the available version of CalEnviroScreen at the time of analysis (OEHHA, 2018). Since that time, an updated version of CalEnviroScreen (4.0) was released.

governments. These features are represented by polygon geometry that "describes the extent of where the incarcerated population is located (fence lines or building footprints)."

Parks and playgrounds

Area locations of parks and playgrounds were derived by combining spatial data from three datasets:

- Real estate tax parcels provided by CARB; park parcels were identified by "use code."
- The California Protected Areas Database, a dataset maintained and updated by the Greeninfo Network (GreenInfo Network, 2018) that captures open space lands, parks, conservation easements, and preserves statewide.
- USA Parks, a geospatial dataset produced by ESRI in partnership with TomTom, a private company specializing in location technologies and digital geodatabase products and services (ESRI, 2019). This layer is considered to be ESRI's "authoritative" data on parks, gardens and forests, combined with boundary information for national, state and local parks.

When compared to current (2018) aerial imagery, it is apparent that some parks are represented by polygons in two or more of these data layers. It is also apparent that no one dataset is sufficiently comprehensive to be used alone to represent parks and sensitive land uses for this project. From these three data layers, a single composite and validated dataset was produced by using aerial imagery to identify each candidate site ("parks and playgrounds" as defined by CARB in their Air Quality and Land Use Handbook) and selecting from each layer the polygon(s) that best represent that site visible in the aerial imagery. The aerial imagery was also used to determine which of these parks qualify as a site, using the presence of improvements such as athletic facilities, play structures, etc.

Health care facilities

Individuals with pre-existing medical conditions, such as people admitted in hospitals and other healthcare facilities, are more prone to developing air pollution-related illnesses (CARB, 2005). Point locations for health care facilities were available from California Health and Human Services, updated as of March 12, 2021, and accessed March 27, 2021, (CalHHS, 2021). Facilities include California's licensed/certified facilities that are currently operating as per the most recent update. The source of the data is provided via the State of California Electronic Licensing Management System (ELMS). Point locations were spatially joined to the nearest building footprint (Microsoft Maps, 2021) to provide representation at the building boundary.

Senior care facilities

Senior care facilities, such as nursing homes, are considered sensitive land uses, as individuals within these types of facilities are the most vulnerable to health risks from exposure to harmful air pollutants (CARB, 2005). Individuals older than 64 years of age are more susceptible to air pollution-related illnesses such as stroke, asthma, heart disease, lung cancer, and other respiratory diseases. Point locations for elder care facilities were available from the California Department of Social Services, updated as of December 2020 and accessed March 27, 2021

(CDSS, 2020). Point locations were spatially joined to the nearest building footprint (Microsoft Maps, 2021) to provide representation at the building boundary.

F.2. Methods to Determine Populations and Sensitive Receptors in Proximity to Oil and Gas Activity

F.2.1. Search-area buffer distances

To quantify populations and sensitive receptors in proximity to oil and gas development (OGD), search areas around OGD sites must be defined at the outset. Selection of radial buffer distances were informed by epidemiological studies of adverse health effects associated with living in proximity to active OGD and previous proximity analyses performed in the U.S. Within these considerations, a range of radial distances around wells were selected to both fully characterize spatial relationships and to support comparison across distances. The selected buffer distances are listed below and represent the radial areas around oil and gas features (i.e., active-producing oil and gas wells, and active produced water ponds and all-status water disposal wells):

- 500 ft (152 m)
- 1,000 ft (305 m)
- 1,500 ft (457 m)
- 2,000 ft (610 m)
- 2,500 ft (762 m)
- 3,281 ft (1 km)
- 5,280 ft (1 mile, 1,609 m)

Geodesic buffers were created in ArcGIS 10.8.1. Individual buffers around features were dissolved to produce one buffer encompassing all features (e.g., the 500 ft [152 m] buffer around wells encompasses all of the area in the state of California within 500 ft [152 m] of an active-producing oil and gas well). These buffers were then intersected with the population area polygons in ArcGIS 10.8.1, to determine the proportion (ranging from 0–1) of each population area polygon falling within the examined buffer distance. Details of how these proportions were calculated are provided in the following area-weighted metrics section.

F.2.2. Downscaling Census population data

In the United States, population data are publicly available at aggregated aerial units (e.g., census blocks), and represent "nighttime populations." This population data type is useful, as census surveys capture where respondents reside, rather than time spent working and traveling. Unfortunately, when these data are used for analyses like counting populations, the nature of these spatially aggregated data can lead to bi-directional errors and decreasing accuracy with decreasing search areas (Michanowicz et al., 2019). Studies that rely on census data or similar data to estimate populations at sub-census area scales are constrained by the modifiable areal unit problem and therefore are required to make assumptions about the spatial structure of populations — typically the assumption that populations are homogeneously distributed within aerial units (i.e., proportional weighting).

In essence, the goal in downscaling aggregated census information is to capture only habitable land uses. This was done using residential parcels from the CARB parcel data, census population at the block group and block-levels (from 2013–2017 and 2010, respectively) and building footprints from Microsoft's U.S. buildings dataset. The final map of population using these data was made in the following steps:

1. Extrapolate block-level populations from the 2010 decennial census forward in time using population estimates from the 2013–2017 ACS for parent block-groups. Proportional distribution of population amongst the blocks within each block group was kept constant according to patterns observed in 2010, but with their totals updated to reflect values in the ACS dataset.
2. Identify residential parcels from the CARB parcel data using the "USE_CODE_2" classification, which has some 278 unique land use types, of which 30 were identified as being residential (e.g., "Single Family Residential" and "Apartment House (5+units)"). We also included "planned residential unit developments" because many of these parcels have already been developed, as evidenced by recent satellite imagery.
3. Create a spatial polygon layer of only residential parcels.
4. Of this parcel subset, identify those residential parcels that likely contain a large amount of open, unpopulated space. This was defined as individual parcels with an area of more than 1 acre (0.4 hectares) for low-density residential classes (e.g., "single-family residential") or with more than 50 acres (20 hectares) for high-density residence classes (e.g., "apartment house (100+ units)"). The distinction in thresholds between low- and high-density residence types was made due to the observation that for most low-density uses, parcels may be large but only contain a small portion where a home is located and for which people likely are present., leading to the 1-acre (0.4-hectares) cutoff. However, in densely populated regions, it is common to see single parcels encompass large apartment or condominium developments that can span large areas of urban space, leading to the 50-acre (20-hectares) area cutoff for these parcels.
5. Assume that all parcels not excluded in step 4 (<1 acre or <50 acre areas, <0.4 or <20 hectares), are populated areas, with population distribution assumed to be uniform within each individual parcel. These parcel areas account for roughly 91.8% of the state's total population.
6. For those parcels excluded in step 4 (>1-acre or >50-acres, >0.4 or >20 hectares), identify the buildings within these parcels using the Microsoft U.S. buildings layer, and assume that the population within these large parcels is distributed only amongst the building areas within it. These areas account for roughly 4.9% of the population.
7. For any blocks with a non-zero population but containing no residential parcels, identify buildings within them and assume population is distributed in these buildings. These areas represent roughly 3.0% of the population.
8. Finally, for any blocks with non-zero population but which contain neither residential parcels nor buildings, simply assume that its population is uniformly distributed across the entire block area. This pertains to blocks containing only roughly 0.3% of the population.
9. Using a combination of these four polygon geometries: 1) small residential parcels; 2) buildings within large residential parcels; 3) buildings within populated blocks with no

residential parcels; and 4) boundaries of populated blocks with no residential parcels or buildings); create a polygon layer representing the union of all of them and assign the block level population totals only to these areas within each block, assuming uniform population density throughout the block.

Table F.3. Geographic scales of population data used in proximity analysis (Source: Depsky, University of California, personal communication, 2021).

Step	Data Used for Residential "Footprint"	Share of CA Pop.
1	**Residential parcels** less than 1 acre (0.4 hectares) in area, or less than 50 acres (20 hectares) for parcels with high-density residential use codes (e.g., apartment complexes, condos, etc.).	91.8%
2	**Building areas** within residential parcels excluded in Step 1 (area >1 acre [0.4 hectares] or area >50 acre [20 hectares] for high-density parcels). Located generally in sparsely populated or mixed-use areas.	4.9%
3	**Building areas** within populated blocks with no residential parcels present. Located generally in sparsely populated or mixed-use areas.	3.0%
4	**Entire block areas** for blocks with no residential parcels nor buildings detected. Located generally on small street segments or rural/open areas.	0.3%

Resulting from this process, the geographic scale of the population data used in this analysis was primarily (>90%) at the tax assessor real estate parcel level, with the remainder primarily at building-level (**Table F.3**).

F.2.3. Area-weighted metrics to determine proportions of populated areas and populations in proximity to oil and gas activity

To determine the demographic makeup of populations living within the selected well-area buffer distances, we weighted all metrics of interest by the intersection area of the well-area buffer and the population area polygon (**Figure F.2**).

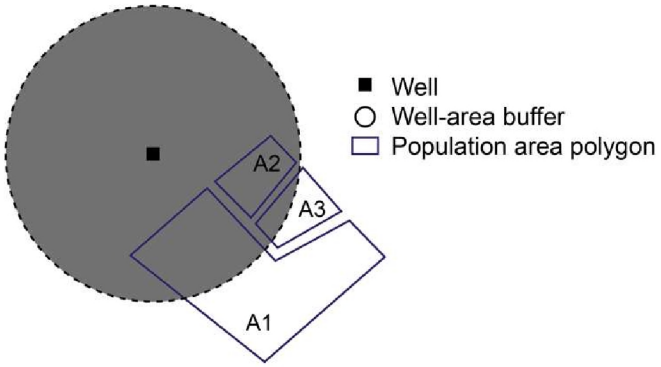


Figure F.2. A visual representation of area-weighting.

In this example, 100% of the population within polygon A2 would be assigned to the well-area buffer, and portions of the population corresponding to the ratio of the shaded area to the total polygon area for polygons A3 and A1 would be assigned to the well-area buffer. Mathematically this corresponds to:

$$Area\ weighted\ Metric\ =\ (Intersection\ Area/Total\ Area)\ x\ Metric\ of\ Interest$$

where $Intersection\ Area$ is the area of the well-area buffer that intersects a population area polygon, $Total\ Area$ is the total area of a population area polygon, and $Metric\ of\ Interest$ is the metric of interest (e.g., proportion of people over 64 years old).

For demographic metrics only, the area-weighted population was multiplied by the demographic metric of interest (e.g., percent of people aged younger than five years old). After calculating the individual area weighted value for each intersection area, values were aggregated over the entire buffer distance by taking either the sum or mean of all values. Different aggregating functions were applied on a per demographic indicator basis in R (**Table F.4**) (R Core Team, 2020).

While area-weighting functions likely introduce bias to population aggregation calculations via their inherent assumptions (i.e., populations are uniformly distributed over the spatial units of interest), the high-resolution population area data we use in our analyses should greatly minimize these biases. Specifically, as previously discussed, non-habitable areas (e.g., roadways, industrial areas) have been painstakingly eliminated from the population area polygons dataset we use for our analyses, and thus edge effects should be greatly reduced, if not eliminated completely.

Table F.4. Functions used to aggregate values for each demographic metric.

Demographic Metric	Aggregation Function	Demographic Metric	Aggregation Function
Under 5 years old	Sum	non-Hispanic White	Sum
Over 64 years old	Sum	Hispanic	Sum
No high school diploma	Sum	non-Hispanic Black	Sum
Voters	Sum	non-Hispanic Asian	Sum
Linguistically isolated households	Sum	non-Hispanic American Indian	Sum
Unemployed	Sum	non-Hispanic other	Sum
Below 2x federal poverty line	Sum	non-Hispanic people of color	Sum
Renter	Sum	Median Household Income	Mean

F.2.4. Calculating demographic group risk ratios

Population weighted demographic group specific risk ratios were calculated to compare the relative risk for each examined demographic group where:

$$Group\ Risk\ Ratio = \frac{\frac{\Sigma Population_{group\ within\ buffer\ area}}{\Sigma Population_{group\ within\ CA}}}{\frac{\Sigma Population_{total\ within\ buffer\ area}}{\Sigma Population_{total\ within\ CA}}}$$

Where $\Sigma Population_{group\ within\ buffer\ area}$ is the total population of a demographic group living within a buffer area (e.g., total number of Californians over 64 living within 3,281 ft (1 km) of an active-producing well), $\Sigma Population_{group\ within\ CA}$ is the total population of a demographic group within the entire state of California (e.g., total number of Californians over 64), $\Sigma Population_{group\ within\ CA}$ is the total population living within a buffer area, and $\Sigma Population_{total\ within\ CA}$ is the total population of California (~39 million people). Risk ratios provide a way to quantify the relative risk of any group. Groups who experience a relatively higher amount of risk will have risk ratios greater than 1, and those that experience the same amount of risk as the general population will have ratios equal to 1.

F.2.5. Counts of sensitive land uses

Sensitive land uses in proximity to oil and gas wells and wastewater systems were enumerated using the same well-area buffer distances to determine intersection or overlap between well-areas and a sensitive land use.

F.3. Community Vulnerability Metrics and Justification for Inclusion

F.3.1. CalEnviroScreen 3.0 (CES 3.0)[8]

This statewide tool provides information regarding environmental health indicators at the census tract levels across the entire state. Commissioned and maintained by the California Environmental Protection Agency (CalEPA) and, more specifically, the Office of Environmental Health Hazard Assessment (OEHHA), this database serves as a tool for information transfer and environmental screening at the community level. The newest iteration of this product, version 3.0, incorporates a wide array of pollution, demographic and socioeconomic metrics to estimate cumulative environmental burdens facing communities. This product is widely used both by policymakers, practitioners, academics, and community organizations in order to identify and implement policies that are sensitive and responsive to environmental inequities.

Cumulative burdens are reported in terms of raw scores (ranging from roughly 0 to 95.0), which are calculated via a multi-step algorithm that incorporates the multiple factors considered, as well as in percentile terms (ranging from 0–100), which provides a relative measure of burden experienced by a given community compared to the rest of the state. Both the raw scores and

[8] CalEnviroScreen 3.0 was the available version of CalEnviroScreen at the time of analysis (OEHHA, 2018). Since that time, an updated version of CalEnviroScreen (4.0) was released.

percentiles were provided in this analysis and may each be appropriate for use in assessing community vulnerability, depending on the context of the research being done or questions being asked. Using the raw scores will provide a true reflection of the actual cumulative burden experienced by each census tract, while using percentiles will only provide a relative measure. Using a simplified example, suppose there are only ten tracts in the state, three of which have a score of 30.0, one of which has a raw score of 80.0, and the remaining six with scores of 95.0.

F.3.2. Racial Composition

Analysis of racial and ethnicity-based metrics is commonly done when assessing issues of community vulnerability and environmental equity/justice more broadly. Given the legacy of segregation, inequality, and marginalization of communities of color in the United States, they are often disproportionately exposed to hazards, environmental and otherwise. There is a very strong precedent for including such metrics in environmental health and community vulnerability studies, especially in the last three to four decades.

F.3.3. Healthcare and senior care facilities

Senior centers and medical facilities such as hospitals, health clinics, and nursing homes are all considered sensitive land uses, as individuals within these types of facilities are the most susceptible to health risks from exposure to poor air quality. Individuals older than 64 years of age are more susceptible to air pollution-related illnesses such as stroke, asthma, heart disease, lung cancer, and other respiratory diseases. Similarly, those individuals with pre-existing medical conditions, such as those people admitted in hospitals and other healthcare facilities, are more prone to developing air pollution-related illnesses (CARB, 2005).

F.3.4. Parks

Park are sensitive land uses in which populations uniquely susceptible to environmental hazard exposures, including children and older adults, are likely to spend time. While parks bring health benefits through facilitating outdoor physical activities, performing physical activities in polluted environments also has adverse health effects. Therefore, reducing potentially hazardous exposures to pollution in parks can ensure their net health benefits.

F.3.5. Correctional Facilities

Compared with the general population, individuals in correctional facilities tend to have higher rates of underlying health conditions, including higher odds of chronic (e.g., asthma, cardiovascular disease, arthritis, and cancer) and infectious diseases (e.g., HIV, hepatitis, and tuberculosis), and mental disorders. By virtue of being incarcerated, individuals in correctional facilities have little to no control over their living conditions and are also likely to have inadequate access to health care. Furthermore, individuals in correctional facilities are faced with poorer living conditions such as overcrowding, which in turn leads to the prevalence of infectious diseases and mental disorders. These conditions can make this community uniquely susceptible to the adverse health effects of environmental hazard exposures.

F.3.6. Schools and Daycares

Children are sensitive to pollution given their small size, high metabolic rates, and developing lung structure and immune systems. In addition to health consequences, air pollution may cause some students to be absent from school, leading to other social cost (e.g., school dropout, parents missing work, and cuts in attendance-based school funding). For children with respiratory issues, not going to school on a heavily polluted day is either a result of respiratory problems triggered by air pollution or a preventive measure. Since children spend more time indoors, their exposures are strongly correlated with pollution concentration in schools and home environments and during transportation.

F.4. Comparison of Buffer Areas

In general, most water disposal infrastructure is sited relatively close to active-producing oil and gas wells. Consequently, buffers extended from active produced water ponds and/or disposal wells overlap with buffers extended from active-producing wells. This overlap ranges from roughly 70% to 90% of the total area encompassed by a water feature buffer, and the overlap area generally increases with increasing buffer distance (**Table F.5**). As such, at best, only 30% of the area of any water feature buffer is unique to produced water disposal infrastructure.

The relatively large amount of overlap between water infrastructure buffers and active-producing well buffers means that a relatively large amount of sensitive receptors in proximity to water disposal infrastructure are already encompassed by buffers extended from active-producing oil and gas wells. For example, 611 schools in California are within one mile (1,609 m) of a water disposal feature. However, only 79 of these schools do not fall within the area encompassed by the one-mile buffer extended from active-producing wells (**Table F.6**). This number corresponds to less than 0.5% of the schools in California. Similarly, this trend exists at the smallest buffer distance (500 ft, 152 m), albeit less pronounced. Specifically, 12 schools are located within 500 ft (152 m) of a water feature, and 10 (<0.1% of the state total) of them are not located within the 500 ft (152 m) buffer extended from active-producing wells (**Table F.6**). As a result, the discussion of sensitive receptors in proximity to oil and gas related features is largely focused on those in proximity to active-producing wells, whose buffers largely encompass areas covered by buffers extended from wastewater disposal features.

Table F.5. Comparison of overlap between water disposal infrastructure and active-producing well buffer areas.

Buffer Distance	Area of water disposal infrastructure buffer (mi^2)	Area of water disposal infrastructure buffer intersecting well buffer (mi^2)	% Overlap
500 ft (152 m)	56.0	41.1	73%
1,000 ft (305 m)	167	115	69%
1,500 ft (457 m)	307	235	77%
2,000 ft (610 m)	465	375	81%
2,500 ft (762 m)	636	530	83%
3,281 ft (1,000 m)	918	789	86%
5,280 ft (1,609 m)	1,689	1,506	89%

Table F.6. Count and percentage of the state total of sensitive receptors unique to water disposal infrastructure for each buffer distance.

Receptor	500 ft (152 m)	1,000 ft (305 m)	1,500 ft (457 m)	2,000 ft (610 m)	2,500 ft (762 m)	3,281 ft (1,000 m)	5,280 ft (1,609 m)	State Total
Correctional Facilities	1 (0.25%)	1 (0.25%)	0 (0%)	1 (0.25%)	1 (0.25%)	1 (0.25%)	4 (0.98%)	408
Parks	6 (0.12%)	6 (0.12%)	12 (0.24%)	14 (0.28%)	19 (0.38%)	20 (0.4%)	21 (0.42%)	4,983
Healthcare Facilities	0 (0%)	0 (0%)	1 (0.05%)	2 (0.09%)	2 (0.09%)	3 (0.14%)	1 (0.05%)	2,131
Senior Care	1 (0.01%)	5 (0.07%)	7 (0.1%)	10 (0.14%)	18 (0.25%)	25 (0.35%)	21 (0.29%)	7,246
All Buildings	1,535 (0.01%)	3,193 (0.03%)	5,778 (0.05%)	9,113 (0.08%)	12,440 (0.11%)	18,551 (0.17%)	32,808 (0.3%)	10,988,525
Total Schools	10 (0.04%)	13 (0.06%)	16 (0.07%)	21 (0.09%)	35 (0.16%)	42 (0.19%)	79 (0.35%)	22,452
Community Colleges	1 (0.38%)	1 (0.38%)	2 (0.75%)	2 (0.75%)	2 (0.75%)	1 (0.38%)	0 (0%)	266
Universities	1 (0.69%)	1 (0.69%)	1 (0.69%)	0 (0%)	0 (0%)	2 (1.38%)	2 (1.38%)	145

F.5. Population and Demographic Counts Within Between-Buffer Areas

Table F.7. Between-buffer area specific total counts and associated demographic metrics of populations living in proximity to active-producing wells.

	0–500 ft (0–152 m)	501–1,000 ft (153–305 m)	1,001–1,500 ft (306–457 m)	1,501–2,000 ft (458–610 m)	2,001–2,500 ft (611–762 m)	2,501–3,281 ft (763–1,000 m)	3,281–5,280 ft (1,001–1,609 m)
Total Population	219,700	370,400	442,155	519,488	572,218	956,752	2,691,986
Age Based							
under 5 years old	15,110	24,366	29,433	34,827	37,997	63,294	179,783
over 64 years old	30,959	52,025	60,823	69,098	74,800	124,969	348,203
Racial							
non-Hispanic White	65,646	118,332	137,796	157,748	170,816	287,847	777,316
Hispanic	90,842	155,498	192,379	230,391	254,331	433,778	1,282,385
non-Hispanic Black	17,745	30,488	38,761	47,639	51,000	76,714	196,350
non-Hispanic Asian	42,687	56,756	62,430	70,661	81,384	134,730	369,239
non-Hispanic American Indian	1,056	1,329	1,616	1,868	2,040	3,390	9,811
non-Hispanic other	7,238	11,562	13,342	16,060	17,709	28,932	80,538
Economic							
below 2x federal poverty line	78,089	126,835	156,300	186,872	209,646	349,814	1,016,800
unemployed	11,905	18,657	22,831	26,743	29,672	51,146	145,846
Education							
no high school diploma	44,978	73,334	90,648	109,427	122,091	208,251	611,258
Miscellaneous							
voters	143,407	243,310	290,714	339,645	372,770	621,840	1,762,552
renters	129,440	196,278	223,770	265,667	293,753	490,812	1,416,473
linguistically isolated households	11,794	15,488	18,135	21,454	23,122	38,841	113,739

Table F.8. Between-buffer area specific total counts and associated demographic metrics of populations living in proximity to active produced water disposal ponds and any water disposal wells.

	0–500 ft (0–152 m)	501–1,000 ft (153–305 m)	1,001–1,500 ft (306–457 m)	1,501–2,000 ft (458–610 m)	2,001–2,500 ft (611–762 m)	2,501–3,281 ft (763–1,000 m)	3,281–5,280 ft (1,001–1,609 m)
Total Population	7,058	26,195	46,846	69,555	87,267	165,542	621,151
Age Based							
under 5 years old	624	1,787	3,191	4,827	6,481	11,796	43,409
over 64 years old	1,147	3,857	6,641	9,712	11,566	22,423	77,436
Racial							
non-Hispanic White	2,672	10,881	19,632	28,930	36,639	69,203	230,212
Hispanic	2,499	8,878	16,456	23,333	29,438	60,498	264,672
non-Hispanic Black	922	2,426	3,532	5,363	5,883	10,197	42,384
non-Hispanic Asian	1,031	3,456	5,977	9,986	12,880	21,273	68,396
non-Hispanic American Indian	120	161	291	356	429	808	2,677
non-Hispanic other	393	1,109	1,881	2,624	3,305	5,809	19,584
Economic							
below 2x federal poverty line	2,128	7,343	13,447	20,175	24,736	49,241	216,371
unemployed	533	1,375	2,390	3,567	4,606	8,669	33,804
Education							
no high school diploma	1,215	4,103	7,338	10,670	13,828	27,990	128,966
Miscellaneous							
voters	4,876	17,743	31,938	47,452	58,823	112,766	407,369
renters	3,094	11,439	20,631	31,785	39,869	74,238	310,946
linguistically isolated households	307	871	1,368	2,144	2,603	5,149	21,569

F.6. Residential Parcels

We utilized a comprehensive, statewide shapefile of all California parcels obtained from CARB. Each parcel in this dataset has a number of attributes pertaining to various use code classifications which were used to distinguish between residential and non-residential parcels.

The following residential type classifications were included in the final population allocation model and to distinguish residential type buildings as listed in the sensitive receptor counts:

- Apartment house (100+ units)
- Apartment house (5+ units)
- Apartments (generic)
- Cluster home (Residential)
- Comm/OFC/Res mixed use
- Condominium (Residential)
- Cooperative (Residential)
- Dormitory, group quarters (Residential)
- Duplex (2 units, any combination)
- Fraternity house, Sorority house
- Garden Apt, Court Apt (5+ units)
- Highrise apartments
- Homes (retired, handicap, rest; convalescent; nursing)
- Manufactured, modular, pre-fabricated homes
- Misc residential improvement
- Mobile home
- Mobile home park, Trailer park
- Multi-family dwellings (Generic, any combination 2+)
- Planned unit development (PUD) (Residential)
- Quadruplex (4 units, any combination)
- Residential (general) (single)
- Residential common area (Condo/PUD/etc.)
- Residential income (General) (Multi-family)
- Rural residence (Agricultural)
- Single family residential
- Stores & Apartments
- Timeshare (Residential)
- Townhouse (Residential)
- Triplex (3 units, any combination)
- Zero lot line (Residential)

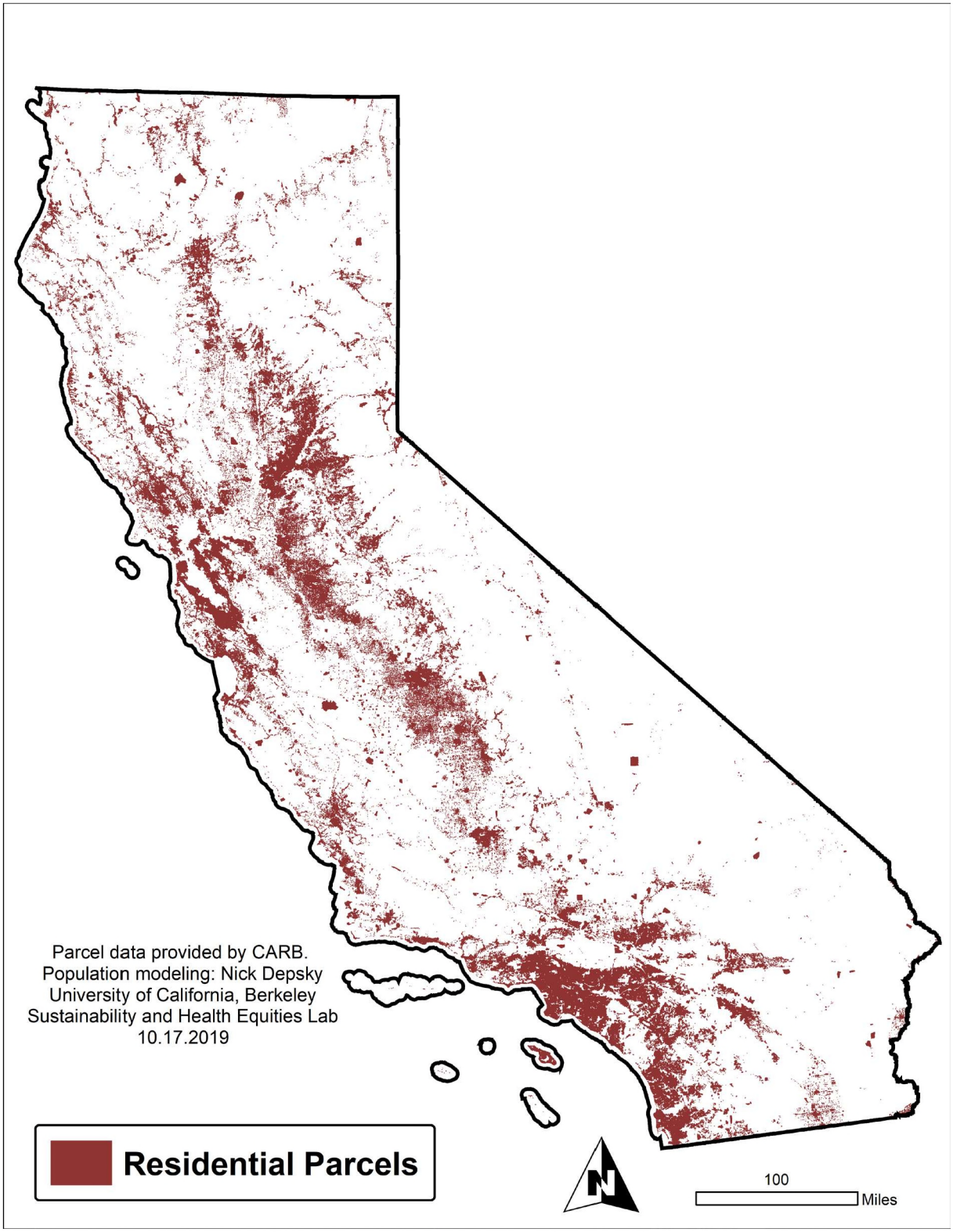


Figure F.3. Residential parcels shown in red utilized to construct the downscaled population model and to determine residential buildings counts.

F.7. Previous California Proximity Analyses

Table F.9. Analyses that have quantified and/or characterized proximity of receptors to oil and gas development in California. Assessments are organized in chronological order of publication.

Proximity Analysis	O&G Sources	Geographic Scope & Receptors	Distance	Data Sources & Years	Key findings
Srebotnjak & Rotkin-Ellman (2014)	Active and new oil and gas wells	California (statewide) Individual residents (no age limitation)	~5,280 ft (1.6 km)	**Well data** (1) DOGGR "All Wells" and "Well Stimulation Treatment Notices Index" (2) SCAQMD "Oil and Gas Wells Activity Notification" (3) the chemicals disclosure registry database FracFocus.org (July 2014) Demographic data (4) CalEnviroscreen 2.0	~5.4 million people (14% of CA population) live within 5,280 ft (1.6 km) of one, or more than 84,000 existing oil and gas wells. ~1.8 million people also live in areas most burdened by environmental pollution; ~1.65 million of these people (92%) are people of color.
Shonkoff and Gautier (2015)	Active oil and gas wells, including stimulated wells	**Los Angeles Basin** **Individuals** (total population, under five y.o, over 75 y.o., children attending school) **Demographics** (race/ethnicity, education, income, employment) **Buildings or zones** (number of schools, elderly care facilities, daycare facilities)	328–6,562 ft (100–2,000 m)	**Well data** DOGGR (All Wells database, SB 4 Well Stimulation Notices, Well Production database); SCAQMD (Rule 1148.2 Oil and Gas Well Electronic Notification and Reporting); FracFocus 1.0 & 2.0 — Accessed 12/14/14, included 2013 and 2014 production wells **Demographic data** U.S. Census (2010) American Community Survey (2013 five-year estimates) **Building/zone data** State of California Geoportal (2014); CA Department of Education (2013/2014 enrollment); CA Dept of Social Services (2014); GreenInfo Network (2012)	In the Los Angeles Basin: • "approximately 1.7 million people live **within one mile [5,280 ft, 1.6 km]** of an active oil and gas well" • "130 schools, 184 day care facilities, 213 residential elderly homes and nearly 628,000 residents" are located **within 800 m [2,625 ft]** of an active oil and gas well. • ">32,000 people live **within 100 m [328 ft]** of an active oil and gas well." • "while it is clear that oil and gas is being developed in low-income communities and communities of color, there does not appear to be a disproportionate burden of oil and gas development on any one demographic..."
Czolowski et al. (2017)	Active oil and gas wells that produced in 2014	Nationwide; **Demographics** (race/ethnicity, education, income, employment)	328–6,562 ft (100–2,000 m)	**Well data:** Drillinginfo (now Enverus) **Demographic data:** U.S. Census (2010) American Community Survey (2013 five-year estimates)	"...an estimated 2.09 million Californians living **within one mile (5,280 ft, 1.6 km)** of an oil and gas well" On a national level, California was found to have the third highest amount of people (2.1 million) living **within one mile (5,280 ft, 1.6 km)** of an active oil and/or gas well.

Proximity Analysis	O&G Sources	Geographic Scope & Receptors	Distance	Data Sources & Years	Key findings
Earthworks (2016)	Oil and gas wells, compressors and processors	Nationwide; Population estimates, medical facilities, schools and daycares	2,640 ft (805 m)	**Population:** 2010 Census **Schools/Medical:** US Department of Homeland Security's Homeland Infrastructure Foundation-Level Data **Oil and Gas Wells:** Fractracker Alliance, 2016 and 2017 **Compressors and Processors:** EPA Greenhouse Gas Reporting Program, EIA, Oil And Gas Journal, Marchese et al. (2015), EDF, EPA's National Emissions Inventory by the Clean Air Task Force	1,126,071 people live within threat radius **(2,640 ft, 805 m)** in California. 309,135 students in threat radius, 678 schools and daycares within the threat radius. 12,344 childhood asthma attacks. 9,010 lost school days due to oil and gas ozone smog. 1,281 square miles (3,318 square km) of land within the threat radius **(2,640 ft, 805 m)**
Shonkoff and Hill (2019)	Active, inactive, and new oil and gas wells	Greater Los Angeles area; City of Los Angeles Population density, well density	1,000 ft (305 m) (well density)	**Demographic data:** ACS five-year data (2009–2017); **Well data:** California Division of Oil, Gas, and Geothermal Resources (DOGGR) well data - accessed March 2019	**Greater Los Angeles:** "The highest well density in/near the City of Los Angeles is in the Baldwin Hills neighborhood which has **216 wells per square mile** (83 wells per square kilometer)" **City of Los Angeles:** "The highest well density within the City of Los Angeles is in the LA City Neighborhood (Koreatown, Westlake and Chinatown) with **162 wells per square mile** (63 wells per square kilometer)." "Population density is approximately **8,940 people per square mile** (3,430 per square kilometer) throughout the City of Los Angeles and surrounding areas." "The three highest population densities in high well density areas are found in the Jefferson **(22,257 per square mile)**, University Park **(22,237 per square mile)** and LA City (Koreatown, Westlake, and Chinatown) **(21,803 per square mile)** neighborhoods."

Proximity Analysis	O&G Sources	Geographic Scope & Receptors	Distance	Data Sources & Years	Key findings
Ferrar (2020)	Active oil and gas wells	California (statewide) Individuals, residences, schools, licensed child daycare centers, & healthcare facilities	2,500–5,280 ft (762–1,609 m)	**Well data:** CalGEM "AllWells" file - updated 10/1/2020; CalGEM annual production data; **Demographic data:** American Community Survey (2018 five-year estimates); CalEnviroScreen 3.0; **Building data:** California Health & Human Services; California Department of Education	"approximately 2.17 million Californians live **within 2,500 of an operational oil and gas well,** and about 7.37 million Californians live **within 1 mile"** "California's Frontline Communities living closest to oil and gas extraction sites with high densities of wells are predominantly low-income households with non-white and Latinx demographics." "The majority of oil and gas wells are located in environmental justice communities most impacted by contaminated groundwater and air quality degradation resulting from oil and gas extraction, with high risks of low-birth weight pregnancy outcomes." "Adequate Setbacks for permitting new oil and gas wells will reduce health risks for Frontline Communities."
Shonkoff et al. (2017)	Active underground gas storage (UGS) wells and facilities 2006–2015	Statewide (California) **Individuals** (total population, under five y.o, over 75 y.o., children attending school) **Demographics** (race/ethnicity, education, income, employment) **Buildings or zones** (number of schools, elderly care facilities, daycare facilities)	0–5 miles (0–8 km)	**Well data** Underground gas storage facilities in California by considering storage wells from the 2015 California Division of Oil, Gas, and Geothermal Resources (DOGGR) "All Wells" dataset. **Demographic data** U.S. Census (2010) American Community Survey (2013 five-year estimates) **Sensitive Receptors** These locations consisted of schools (CDE, 2017a; CDE, 2017b; CDE, 2017c), daycare centers (CDE, 2017c; CDSS, 2017a; CDSS, 2017b), residential elderly care locations (CDSS, 2017a), and hospitals (California OSHPD, 2017).	Nearly 1.9 million Californians were estimated to live **within ~5 miles** (8 km) of an underground storage facility A total of 5,585 people were found to be living **within a 0 m buffer** distance of an underground storage facility. Of these Californians, 115,125 are children under the age of five, and 103,085 are adults aged 75 and older Additionally, there were an estimated 1,358 daycare centers, 556 schools, and 359 residential elderly care facilities located **within ~5 miles** (8 km) of an active underground storage facility. 55.9% of the buffer facility combinations had population densities of **≤100 people/km^2** " Population Exposures to Toxic Air Pollutants Increase with Higher Emissions, Closer Community Proximity and Higher Population Density" "UGS facilities pose more elevated health risks when located in areas of high population density, such as the Los Angeles Basin, because of the larger numbers of people nearby that can be exposed to toxic air pollutants."

Proximity Analysis	O&G Sources	Geographic Scope & Receptors	Distance	Data Sources & Years	Key findings
Michanowicz et al. (2019)	Active UGS wells	Six states: PA, OH, WV, MI, NY, CA Individuals & housing units	656 ft (200m) (length of city block)	**Well data** April 2016 Energy Information Administration-191 M Monthly Underground Gas Storage Report **Demographic data** U.S. Census (2010) Building data Housing unit counts, U.S. Census (2010); US Department of Transportation's National Address Database (NAD) (NY, OH) and OpenAddressess.io (PA, WV, MI) originally sourced from state geographic information systems departments, the U.S. Postal Service, and county property parcel datasets (current as of October 23, 2017). Geospatial building footprints and centroids were available via academic use waiver for various parts of the country from BuildingFootprintUSA (BFUSA, Albany, NY).	~65% of underground natural gas storage wells (over 6,000) in the United States are located in residential suburban areas - not commercial, industrial, or even rural areas like many new unconventional wells. 53,000 people across six states are living within **656 ft (200 m) of UGS wells.** 41% of the active UGS wells assessed had **at least one home within 656 ft (200 m).** California: Only 41 of CA's 346 UGS wells (12%) contained **a residential housing unit within 656 ft (200 m)** — the lowest percentage of the six states assessed. This may be an indication that results are not generalizable at the state level, as two wells in the Playa Del Rey field ranked first and third respectively in the number of residential units and population **within 200 m (656 ft).** Of the over 9,000 UGS wells examined in the 6 states, a well in the Playa Del Rey storage field has the most nearby homes and people — **150 homes and 341 people within 200 m (656 ft).**
Ferrar (2021)	Active oil and gas wells	California (statewide) Prisons/detention centers	2,500 ft (762 m)	**Well data:** CalGEM "AllWells" file - updated 10/1/2020 Sensitive receptors California Prison Boundaries from California Office of Emergency Services	Two-thirds (67%) of California prisons (federal, state, county and local) are located within census tracts ranked in the upper 50th percentile of pollution impacted areas. 90% of California's federal prisons are located within census tracts ranked in the upper 50th percentile of pollution impacted areas. Three-quarters (73%) of federal prisons in California are located within census tracts ranked in the upper 30th percentile of pollution impacted areas.

Acronyms and abbreviations

AB	Assembly Bill
ACS	American Community Survey
AEC	annual emissions concentrations
ALAN	artificial lights at night
ALBL	acute lymphoblastic leukemia
ALL	acute lymphocytic leukemia
ANCA	antineutrophil cytoplasmic antibody
APCD	Air Pollution Control District
API	American Petroleum Institute
AQI	air quality index
AQMD	Air Quality Management District
AQMP	air quality management plan
ATSDR	Agency for Toxic Substances and Disease Registry
B	boron
BACT	best available control technology
BARCT	best available retrofit control technology
bbls	barrels
BC	black carbon
BCF	billions of cubic feet
BMI	body mass index
BOE	barrels of oil equivalent
BOPD	barrels of oil per day
Bq	becquerel
BPD	barrels per day
BTEX	benzene, toluene, ethylbenzene, and xylenes
°C	Celsius
C	carbon
CAA	Clean Air Act
CAAQS	California Ambient Air Quality Standards
CalEPA	California Environmental Protection Agency
CalGEM	California Geologic Energy Management Division
CalOES	California Office of Emergency Services
CalWIMS	California Well Information Management System
CAP	criteria air pollutant
CARB	California Air Resources Board
CASRN	Chemical Abstract Service Registry Number
CBM	coalbed methane
CCR	California Code of Regulations
CCST	California Council on Science and Technology
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CDPHE AQCC	Colorado Department of Public Health and the Environment Air Quality

	Control Commission
CH_4	methane
CIWQS	California Integrated Water Quality System
Cl	chloride
CM	Congenital malformations
CNG	Compressed natural gas
CNGD	conventional natural gas drilling
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalents (methane, carbon dioxide, and nitrous oxide)
COGCC	Colorado Oil and Gas Conservation Commission
COPD	chronic obstructive pulmonary disease
CRC	California Resources Corporation
CWD	Cumulative well density
CVRWQCB	Central Valley Regional Water Quality Control Board
dBA	A-weighted decibels
dBC	C-weighted decibels
DBNPA	2,2-dibromo-3-nitriloprionamide
DBP	disinfection byproduct
DNDW	distance to nearest drilled well
DOGGR	Division of Oil, Gas and Geothermal Resources
DORV	double outlet right ventricle
DPM	diesel particulate matter
$DPM_{2.5}$	fine-diesel particulate matter
DRB	Delaware River Basin
DWSHA	Drinking Water Standards and Health Advisories
EC	electrical conductivity
ED	emergency department
EGDB	Energy Resources Program Geochemistry Laboratory Database
ELG	Effluent Limitation Guideline
EOR	enhanced oil recovery
ESL	effects screening level
°F	Fahrenheit
FEV1	first second of exhalation
FONSI	Finding of No Significant Impact
ft	feet
FVC	forced vital capacity
GHG	greenhouse gas
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
g/s	grams per second
GWPC	Ground Water Protection Council
H_2S	hydrogen sulfide
HAP	hazardous air pollutant
HDAP	health-damaging air pollutant

HF	hydraulic fracturing
HI	hazard index
HQ	hazard quotient
HSC	Health and Safety Code
IA-IDW	Intensity-adjusted inverse distance weighted
IAA	interrupted aortic arch
IARC	International Agency for Research on Cancer
IDW	inverse distance weighted
ICRP	International Commission on Radiological Protection
ISOR	Initial Statement of Reasons
kg/yr	kilograms per year
km	kilometer
L	liter
LACDPH	Los Angeles County Department of Public Health
LAER	lowest achievable emission rate
lbs/day	pounds per day
LBW	low birthweight
LDAR	leak detection and repair
LEL	lower explosive limit
LRTP	long-range transport potential
m	meter
MATES IV	Multiple Air Toxics Exposure Study IV
Mcf	thousand cubic feet
MCL	maximum contaminant level
mg	milligram
mg/L	milligrams per liter
MMbbl	millions of barrels
MPA	migraine probability algorithm
MPO	myeloperoxidase
mSv	millisievert
MRL	minimum risk level
MT	metric tons
N/A	not applicable
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standard
NATA	National Air Toxics Assessment
NCATS	National Center for Advancing Translational Science
ND	non detection
NESTAC	National Emission Standards for TACs
NHL	Non-Hodgkin's lymphoma
NIEHS	National Institute of Environmental Health Sciences
NIH	National Institutes fo Health
NIOSH	National Institute for Occupational Safety and Health
NMVOC	non-methane volatile organic compound

NMHC	non-methane hydrocarbons
NO_2	nitrogen dioxide
NORM	naturally occurring radioactive materials
NOV	Notice of Violation
NO_X	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRDC	Natural Resources Defense Council
NSF	National Science Foundation
NSPS	new source performance standards
NSR	new source review
NTO	Notice to Operator
NTP	National Toxicology Program
O&G	oil and gas
O_3	ozone
OAQPS	(U.S. EPA) Office of Air Quality Planning and Standards
OEHHA	Office of Environmental Health Hazard Assessment
OGD	oil and gas development
OH	hydroxyl radicals
OSHPD	California Office of Statewide Health and Planning
PADEP	Pennsylvania Department of Environmental Protection
PADOH	Pennsylvania Department of Health
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
pCi	picocurie
pCi/L	picocurie per liter
PFAS	per- and polyfluoroalkyl substances
PHMSA	Pipeline and Hazardous Materials Safety Administration
PI	principal investigator
PLSS	Public Land Survey System
PM	particulate matter
$PM_{2.5}$	fine particulate matter with a diameter of 2.5 microns or less
PM_{10}	fine particulate matter with a diameter of 10 microns or less
PMF	positive matrix factorization
POTW	publicly owned treatment works
ppb	parts per billion
ppbv	parts per billion volume
ppm	parts per million
ppmv	parts per million volume
PR3	Persistent proteinase 3
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PSD	prevention of significant deterioration
PSE	Physicians, Scientists, and Engineers for Healthy Energy

PTFE	polytetrafluoroethylene
QA/QC	quality assurance and quality control
RACT	reasonably available control technology
RCRA	Resource Conservation and Recovery Act
REACH	European Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals
REL	reference exposure level
RMP	Regional Groundwater Monitoring Program
ROG	reactive organic gas
ROGER	Repository for Oil and Gas Energy Research
SAGE-IGERT	Systems Approach to Green Energy-Integrative Graduate Education and Research Traineeship
SB	Senate Bill
SCAQMD	South Coast Air Quality Management District
scfh	standard cubic feet per hour
SD	standard deviation
SDWA	Safe Drinking Water Act
SE	standard error
SGA	small for gestational age
SIP	state implementation plan
SIR	standardized incidence ratios
SJV	San Joaquin Valley
SJVAPCD	San Joaquin Valley Unified Air Pollution Control District
SNAPS	Study of Neighborhood Air Near Petroleum Sources
SO_2	sulfur dioxide
SOF	Solar Occultation Flux
SO_X	sulfur oxides
SWRCB	California State Water Resources Control Board
TAC	toxic air contaminant
TAPVC	total anomalous pulmonary venous connection
T-BACT	Toxic Best Available Control Technology
TCEQ	Texas Commission on Environmental Quality
TDS	total dissolved solids
TENORM	technologically enhanced naturally occurring radioactive materials
tpd	tons per day
tpy	tons per year
TRI	Toxic Release Inventory
TSCA	Toxic Substances Control Act
UGS	underground gas storage
µg	microgram
µg/l	microgram per liter
$\mu g/m^3$	microgram per cubic meter
µmhos/cm	micromhos per centimeter
µR	microroentgen

µSv	microsievert
UGS	underground gas storage facility
UIC	underground injection control
UNG	unconventional natural gas
UNGD	unconventional natural gas development
UOGD	unconventional oil and gas development
U.S.	United States
US EPA	United States Environmental Protection Agency
USDA	United States Department of Agriculture
USDW	Underground Sources of Drinking Water
USGS	United States Geological Survey
USGS EGDB	US Geological Survey Energy Resources Program Geochemistry Laboratory Database
VCAPCD	Ventura County Air Pollution Control District
VOC	volatile organic compound
WDR	water discharge requirements
WHO	World Health Organization
WOS	Web of Science
WSPA	Western States Petroleum Association
WST	well stimulation treatment

Exhibit P

2017 PSE Study on Oil Well Activities

PLOS ONE

RESEARCH ARTICLE

Comparison of chemical-use between hydraulic fracturing, acidizing, and routine oil and gas development

William T. Stringfellow[1,2], Mary Kay Camarillo[1,2], Jeremy K. Domen[1,2], Seth B. C. Shonkoff[3,4]*

1 Earth & Environmental Sciences Area, Lawrence Berkeley National Lab, Berkeley, CA, United States of America, **2** Ecological Engineering Research Program, School of Engineering & Computer Science, University of the Pacific, 3601 Pacific Avenue, Stockton, CA, United States of America, **3** PSE Healthy Energy, 1440 Broadway, Suite 205, Oakland CA, United States of America, **4** Department of Environmental Science, Policy and Management, University of California, Berkeley, Berkeley, CA, United States of America

* sshonkoff@psehealthyenergy.org

Check for updates

OPEN ACCESS

Citation: Stringfellow WT, Camarillo MK, Domen JK, Shonkoff SBC (2017) Comparison of chemical-use between hydraulic fracturing, acidizing, and routine oil and gas development. PLoS ONE 12(4): e0175344. https://doi.org/10.1371/journal.pone.0175344

Editor: John M. Senko, The University of Akron, UNITED STATES

Received: January 28, 2017

Accepted: March 26, 2017

Published: April 19, 2017

Copyright: © 2017 Stringfellow et al. This is an open access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Data Availability Statement: Data are available from the South Coast Air Quality Monitoring District (http://www.aqmd.gov/). Additional data in Research Gate: DOI: 10.13140/RG.2.2.19128.55041.

Funding: This material is based upon work supported by the Department of Energy under Award Number DE-IA0000018. This study was supported in part by grants from The Broad Reach Fund and Laboratory Directed Research and Development (LDRD) funding from Berkeley Lab,

Abstract

The potential hazards and risks associated with well-stimulation in unconventional oil and gas development (hydraulic fracturing, acid fracturing, and matrix acidizing) have been investigated and evaluated and federal and state regulations requiring chemical disclosure for well-stimulation have been implemented as part of an overall risk management strategy for unconventional oil and gas development. Similar evaluations for chemicals used in other routine oil and gas development activities, such as maintenance acidizing, gravel packing, and well drilling, have not been previously conducted, in part due to a lack of reliable information concerning on-field chemical-use. In this study, we compare chemical-use between routine activities and the more closely regulated well-stimulation activities using data collected by the South Coast Air Quality Monitoring District (SCAQMD), which mandates the reporting of both unconventional and routine on-field chemical-use for parts of Southern California. Analysis of this data shows that there is significant overlap in chemical-use between so-called unconventional activities and routine activities conducted for well maintenance, well-completion, or rework. A comparison within the SCAQMD shows a significant overlap between both types and amounts of chemicals used for well-stimulation treatments included under State mandatory-disclosure regulations and routine treatments that are not included under State regulations. A comparison between SCAQMD chemical-use for routine treatments and state-wide chemical-use for hydraulic fracturing also showed close similarity in chemical-use between activities covered under chemical disclosure requirements (e.g. hydraulic fracturing) and many other oil and gas field activities. The results of this study indicate regulations and risk assessments focused exclusively on chemicals used in well-stimulation activities may underestimate potential hazard or risk from overall oil field chemical-use.

provided by the Director, Office of Science, of the U.S. Department of Energy under Contract No. DE-AC02-05CH1123.

Competing interests: The authors have declared that no competing interests exist.

Introduction

Scientific, regulatory, and public debates on the environmental and public health dimensions of oil and gas development have been focused on hazardous chemicals used for hydraulic fracturing and other well-stimulation treatments, such as matrix acidizing, that are classified as "unconventional" oil and gas development methods [1–4]. Consequently, new regulations that govern oil and gas development require disclosure of chemical-use during well stimulation activities, but do not require disclosure of chemicals used for any other oil and gas field activities [1,2,4]. However, potentially hazardous chemicals are used throughout the entire oil and gas development process, not just during well stimulations [5–9], so there is interest in examining overall chemical-use on oil and gas fields and comparing chemical-use between regulated "unconventional" development activities and other oil and gas field activities.

Disclosure of chemical-use during well stimulation is considered an important requirement for the protection of human and environmental health, since knowledge of the types and amounts of chemicals used is fundamental to risk assessment [10]. Recent Federal and State regulations mandate chemical disclosures for well stimulations, including hydraulic fracturing and in some cases matrix acidizing and acid fracturing, but reporting chemical-use for other oil and gas field activities, such as well drilling, well completion, well maintenance, and well re-work is not required, unless pressures above the fracture gradient are used [1,2,4,11]. Given the public and scientific concern regarding the use and release of hazardous chemicals during the current oil and gas development boom [12] and the reuse of oil and gas field produced water for beneficial purposes in arid regions [13–15], it is important to evaluate the potential environmental and public health impacts of all chemical additives used in oil and gas development.

Chemicals are used routinely in oil and gas development as part of drilling and cementing of the well casing, repair of formation damage, wellbore clean-outs, scale and corrosion control, and for other production activities. Chemical additives are also used in enhanced oil recovery (EOR) to change fluid properties of oil (e.g. viscosity) and to otherwise increase production of oil within the formation [16]. During well construction, hazardous chemicals may be added to drilling fluids, drilling muds, and cements and are also used to remove debris from wellbores prior to cementing of the annular space between the steel casing and geological formations [9,17]. Chemical additives, including strong acids, are also used for well completion and rework to facilitate hydrocarbon production.

While large numbers and masses of chemical additives are used in routine oil and gas development activities, only a few surveys of routine chemical-use by the oil and gas industry have been conducted [5–8,18]. There is widespread use of potential chemicals of concern, including biocides, quaternary ammonium compounds, and corrosion inhibitors both off-shore and on-shore [5–8,18]. In contrast, several studies examined chemical-use during well stimulation activities, including hydraulic fracturing and matrix acidizing [19–24]. It has been established that chemicals used during well stimulation treatments have environmental pathways of exposure which include accidental spills, reuse of treated produced water, improper zonal isolation of fluids in the subsurface infrastructure and geologies, and discharge of wastewaters to aquatic ecosystems [3,21,24]. It is also known that produced water has similar exposure pathways, so it is of interest to determine overall oil and gas field chemical-use when evaluating the potential environmental and health impacts of oil and gas development.

The reuse of produced water for agricultural purposes is permissible in the western US and produced water is being reused for irrigation, watering livestock, aquifer recharge, and other purposes [13–15,24–26]. In California, produced water from oil fields is used for food crop irrigation, livestock watering, groundwater recharge, and for wetlands and other environmental purposes [15,27]. There are concerns that oil field chemicals or their degradation products

will occur in produced water and that these chemicals may pose an unrecognized hazard or risk for produced water beneficial reuse, since potential exposure pathways from beneficial reuse include chemical uptake or deposition on food crops, contamination of regional aquifers through recharge, and the direct contact of farmworkers with produced water [15]. The hazard posed by oil and gas field chemicals would be in addition to other hazards associated with naturally occurring constituents of produced water, such as salts, metals, aromatic hydrocarbons, and naturally occurring radioactive material. The increased interest in reusing produced water [13,28] suggests that the hazards associated with oil and gas field chemicals should be evaluated.

The objective of this study is to assess chemical-use during routine oil and gas development and to compare chemical-use in routine production activities with chemical-use during well stimulation. To our knowledge, only one regulatory agency in the US, the South Coast Air Quality Management District (SCAQMD) in Southern California, requires mandatory disclosure of on-field chemical-use for well drilling, well completion, and well rework activities. These data were used by Abdullah et al. [19] to characterize chemical-use in acidizing. We use these data to compare chemical additive use between well-stimulation (hydraulic fracturing and matrix acidizing treatments) and routine oil field activities to determine similarities and differences in chemical-use. We summarize the chemicals used with respect to frequency of use, masses applied, and toxicity data. Similar data driven approaches have been used previously to evaluate hazards associated with hydraulic fracturing and matrix acidizing [19,21]. The results of our analysis are interpreted in the context of public and scientific concerns about hydraulic fracturing and the beneficial reuse of produced water.

Methods

Chemical-use data reported to the South Coast Air Quality Management District (SCAQMD) in southern California was analyzed in this study [29]. Under SCAQMD Rule 1148.2, which went into effect on June 4, 2013, operators and chemical suppliers are required to submit and make publicly available chemical usage data related to routine oil and gas activities (well drilling, well completion, and well rework) and well stimulation (hydraulic fracturing, matrix acidizing) in the California counties of San Bernardino, Orange, Riverside, and Los Angeles, including the City of Los Angeles [29]. These counties represent the second most productive oil and gas region in the third largest oil producing state in the United States. Chemical-use for enhanced oil recovery (EOR) and activities beyond upstream oil and gas development such as refining, transmission, and storage are not included in the SCAQMD datasets and are not included in this analysis.

Data on chemical type, mass injected, and water volumes used in oil and gas operations were downloaded from the SCAQMD database for the period of June 4, 2013 to September 2, 2015 [29]. The dataset used for this study consists of 51,514 entries from 1,207 oil and gas "events" conducted at 302 unique locations (identified by latitude and longitude). Events were categorized by operators as well drilling, completion, or rework activities. For completion, activities were further categorized as acidizing, gravel packing, hydraulic fracturing, maintenance acidizing, matrix acidizing, or acid fracturing. In order to focus on routine oil and gas activities, we separated well stimulation events (hydraulic fracturing, matrix acidizing and acid fracturing) from other routine events in our dataset. Entries were edited to standardize chemical names and to validate the assigned Chemical Abstracts Services Registry Number (CASRN). Changes to names of proprietary chemicals that could not be identified by CASRN were limited to correcting obvious spelling errors (e.g., aicd to acid, kerosine to kerosene), changing capitalization, and altering punctuation (e.g. removing dashes). Proprietary chemicals with singular and plural names that indicate chemical mixtures (e.g., ionic surfactant vs ionic surfactants) were maintained as

separate entries. In cases where duplicate event IDs were reported, data were consolidated into one event ID entry. In cases where multiple chemical information documents were reported for the same event ID, data were individually assessed and duplicates, where apparent, were deleted.

For the chemical additives identified by CASRN, toxicological data were collected from online chemical databases [30–41]. Computational models within the U.S. EPA EPI Suite software (e.g., BIOWIN) were used to fill data gaps when experimental data were unavailable. Rat, mouse, and rabbit acute oral toxicity data and rat and mouse inhalation toxicity data were collected to represent and compare mammalian toxicity among the chemical constituents. To assess acute environmental toxicity, data for water flea (*Daphnia magna*), fathead minnow (*Pimephales promelas*), rainbow trout (*Oncorhynchus mykiss*), and green algae were collected. Mammalian median lethal dose (LD50) and median lethal concentration (LC50) were used to assess mammalian hazard. Median effective concentration (EC50) and LC50 data were used to assess aquatic species hazard. Toxicity ratings were assigned using the United Nations Globally Harmonized System (GHS) of Classification and Labelling of Chemicals [42]. In the GHS system, lower numbers indicate higher toxicity, with a designation of "1" indicating the most toxic category. When multiple GHS values were available for a given chemical, the lowest value was used. Chemicals for which the LD50, LC50, or EC50 exceeded the least toxic GHS category were classified as non-toxic.

Chemical were identified for further hazard assessment based on frequency of use, median mass of chemical-use per event, and available toxicity data. Frequency of use was calculated by dividing the number of events that utilized a given chemical by the total routine oil and gas events reported in the SCAQMD database. The median mass of chemical usage per event represents the median mass for all events containing that chemical. Where chemical mixtures were reported, individual chemical masses were calculated by multiplying the total mixture mass by the maximum individual chemical concentration. When multiple entries for a given chemical were reported for a single event, the chemical masses were summed within that event.

We compared the chemical-use in routine oil and gas activities in the SCAQMD dataset to hydraulic fracturing chemicals disclosed in the state of California via the voluntary FracFocus chemical disclosure registry, as summarized by Stringfellow et al. [21]. This dataset contains records of chemical use for 1,623 individual hydraulic fracturing operations conducted in California between January 30, 2011 and May 19, 2014. Stringfellow et al. [21] identified 338 unique additives based on name and CASRN combinations, of which 228 were reported with a CASRN and 110 were identified by chemical or common name only or had proprietary designations. The additives included chemicals, mineral proppants and carriers, and base fluids consisting of water, salt, and brine solutions. There were 326 unique additive names identified in the database [21].

Results and discussion

Chemical-use in the SCAQMD

In total, 548 chemical additives were used in the SCAQMD between June 2013 and September 2015, with 525 of these being used for routine oil and gas development activities. The most frequently used chemicals include solvents (e.g. methanol), petroleum products (e.g. distillates), and salts (e.g. sodium chloride) that are employed in formulating commercial blends of production chemicals (S1 Table). Also on the list of frequently used chemicals are carboxylic acids (e.g. citric acid and erythorbic acid) used for scale and iron control, biocides, and corrosion inhibitors. For routine acidizing (e.g., acid cleaning for well-maintenance), hydrochloric acid (HCl) and hydrofluoric acid (HF) were used extensively and in large quantities (mean masses

Table 1. Number of chemicals used and their summed masses per event for oil and gas development (does not include water)[a].

		Chemicals per event				Mass per event (kg)			
Pooled Activities	Events[a]	Mean	Median	Min	Max	Mean	Median	Min	Max
Acidizing	256	25	20	1	41	4,132	3,459	10	24,043
Gravel packing	169	6	3	1	65	24,655	6,297	61	710,722
Hydraulic fracturing	13	25	23	15	37	129,910	142,245	4,526	243,219
Maintenance acidizing	390	30	35	2	52	2,779	2,028	155	15,548
Maintenance acidizing and gravel packing	3	27	27	27	27	7,712	6,632	6,518	9,985
Matrix acidizing	7	21	20	20	23	4,210	3,055	1,970	10,791
Well completion and rework—type not specified	43	20	21	1	71	16,287	8,028	215	100,566
Well drilling	186	46	54	3	72	1,828,619	97,669	96	309,284,305
Well drilling with gravel packing	136	57	58	26	66	239,305	181,098	21,552	1,233,365

[a]There are 1,207 events in the data set but four events have only water listed so they are not included in this table (N = 1,203).

https://doi.org/10.1371/journal.pone.0175344.t001

of 1,791 and 161 kg per event, respectively). These quantities are consistent with the analysis by Abdullah et al. [19], who reported mean values of 1,908 kg HCl and 175 kg HF per acidizing event (also exclusive of matrix acidizing). Our values may differ due to the different study periods or deletion of duplicate entries by operators. Other additives used in the highest masses include minerals and other chemicals used for gravel packing (e.g. silica), cementing of well casings (e.g. Portland cement and additives), and sealing wells (e.g. bentonite) (S2 Table).

Table 1 is presented as an analysis of chemical use (numbers of chemicals used and masses) by reported activity. There were only a limited number of well-stimulation events in the SCAQMD during this period and no acid fracturing events were reported. Acidizing, maintenance acidizing, well drilling, and gravel packing accounted for the majority of the 1,207 events in the data set (Table 1). Chemical-use for these types of oil and gas field activities is only subject to mandatory reporting in the SCAQMD region.

Comparison of chemical-use between routine activities and well-stimulation treatments within the SCAQMD

Overall, a large number of constituents were used in both routine activities and well-stimulation activities and chemicals were applied in large masses (Table 1). The masses used in hydraulic fracturing were high because of the large quantities of proppants used. Similarly, well drilling uses large quantities of Portland cement and minerals for well construction. Comparison of the chemicals used for different on-field activities showed significant overlap in the chemicals used for hydraulic fracturing and routine oil and gas development operations (Fig 1). Only 23 (4.2%) chemicals were used exclusively for hydraulic fracturing in the SCAQMD. However, the SCAQMD dataset includes only a small number of hydraulic fracturing operations (13) and the degree of overlap in chemical use between different oil field operations may not be representative of other regions. A comparison of chemical use for routine oil and gas development as reported in the SCAQMD database and chemical use for fracturing in the whole state of California, indicates the degree of overlap is less.

Examining different types of acidizing within the SCAQMD, the median numbers of chemicals used in routine acidizing (20 for acidizing and 35 for maintenance acidizing) were similar in number to the median value of 20 used in matrix acidizing (Table 1). An analysis of chemicals used for acid treatments shows that there is considerable overlap in the chemicals used for the different applications of acid (Fig 2). The one compound used exclusively for matrix acidizing was identified only as "DDBSA salt," presumably a dodecylbenzenesulfonic acid salt, but

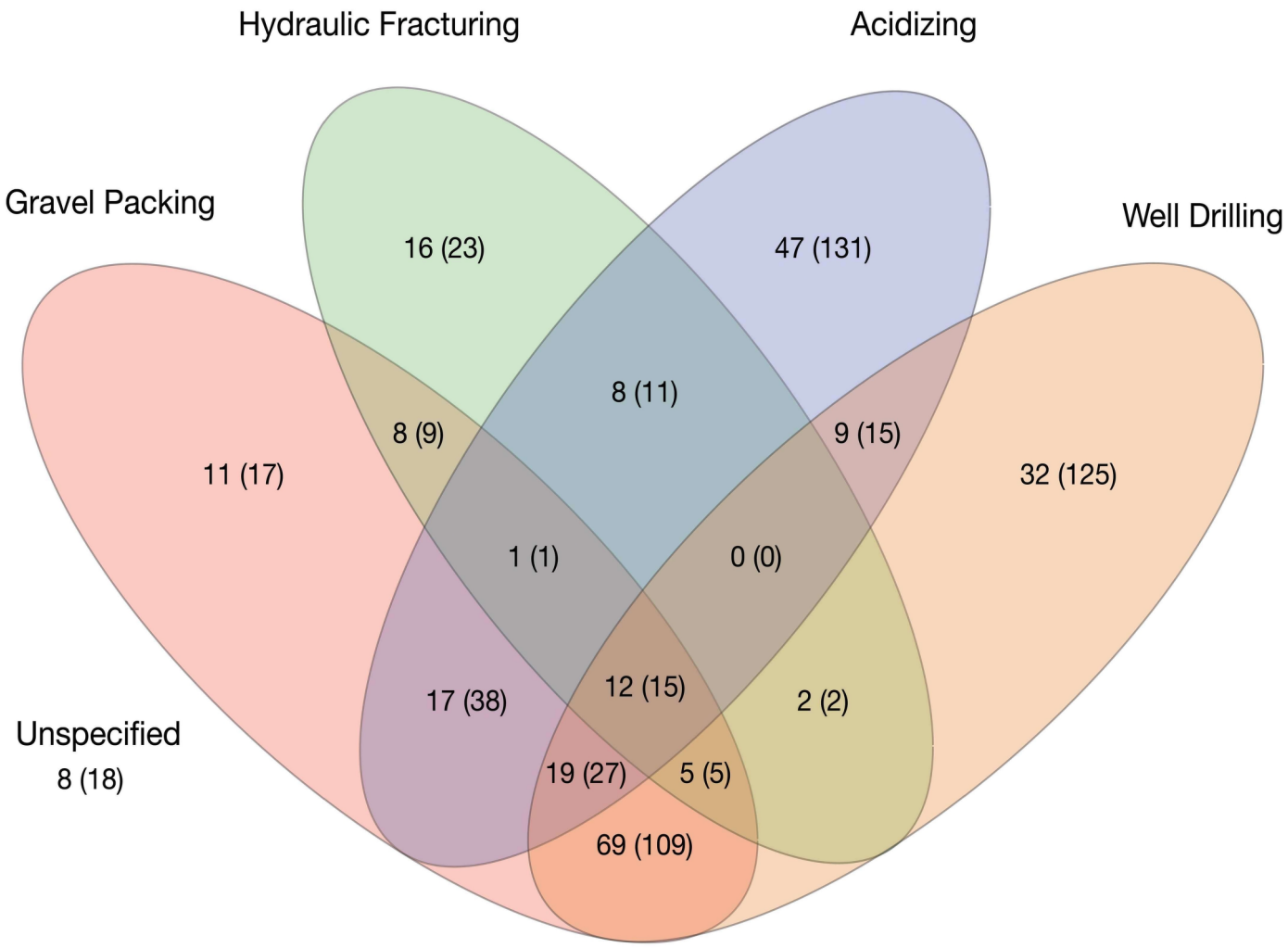


Fig 1. Venn diagram showing number of chemicals used in oil and gas production. The first number represents chemicals with CASRN and the number in parentheses represents the total number of reported chemicals. Does not include base fluids. Acidizing includes matrix acidizing, acidizing, and maintenance acidizing.

https://doi.org/10.1371/journal.pone.0175344.g001

without a corresponding CASRN, this identification is tentative. Maintenance acidizing used a lower median mass of chemicals (2,028 kg) than treatments reported as acidizing (3,459 kg) or matrix acidizing (3,055 kg). These quantities demonstrate that additives usage in other acidizing is not appreciably different than what is used in matrix acidizing (classified as well stimulation).

Concentrations of hydrochloric acid (HCl) and hydrofluoric acid (HF) used in all types of acidizing events were similar, as were the total masses of additives used (Figs 3 and 4). Hydrochloric acid concentrations ranged from approximately 0–15% (Fig 3) while HF concentrations were approximately 0–3% (Fig 4). In California, the distinction between routine acidizing and acid stimulation (matrix acidizing and acid fracturing) is based on calculation of the acid threshold volume that is determined based on wellbore volume and formation porosity [1]. The acid threshold volume cannot be calculated without site-specific information that is not reported to the publically available SCAQMD database. However, it is apparent that large quantities of acid and high concentrations are being used in all types of acidizing events. Since there is clear overlap in concentrations and amounts of acid used for events reported as

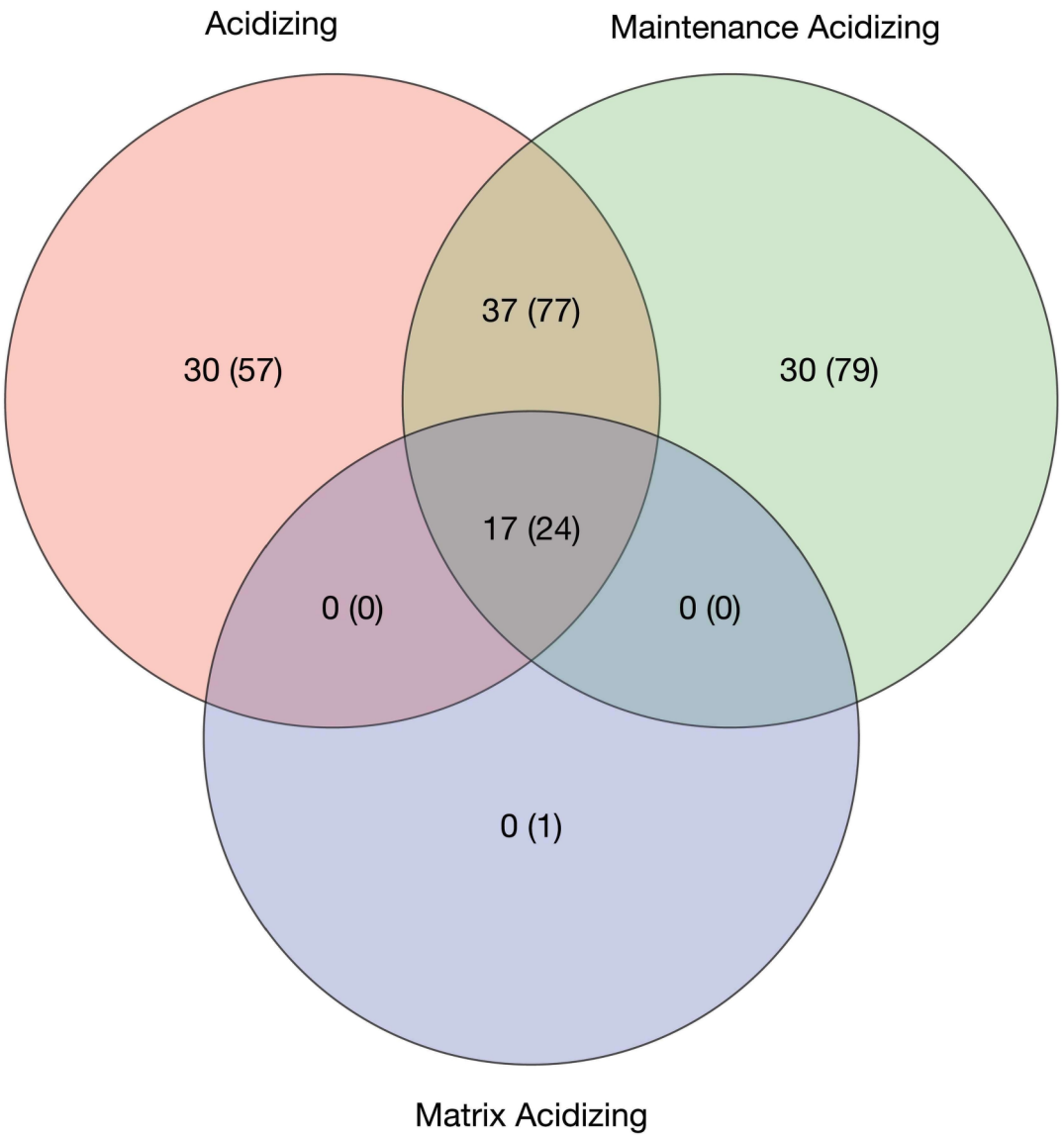


Fig 2. Venn diagram showing number of chemicals used for acidizing operations (routine and well stimulation). The first number represents chemicals with CASRN and the number in parentheses represents the total number of reported chemicals. Does not include base fluids.

https://doi.org/10.1371/journal.pone.0175344.g002

matrix acidizing, which are potentially regulated by state law, and routine maintenance acidizing (Figs 3 and 4), these results suggest that regulations focused only on disclosures of chemicals used in well stimulation events may not be sufficiently protective of public or environmental health.

Comparison of chemical-use between routine oil and gas development activities in the SCAQMD and hydraulic fracturing throughout California

The number of chemicals used in routine oil and gas development activities in the SCAQMD is as high or higher than the number of chemicals used for hydraulic fracturing throughout the State of California [21]. In Stringfellow et al. [21], 338 unique chemical additives were identified as used in hydraulic fracturing fluids in California, with 228 of these identified by CASRN.

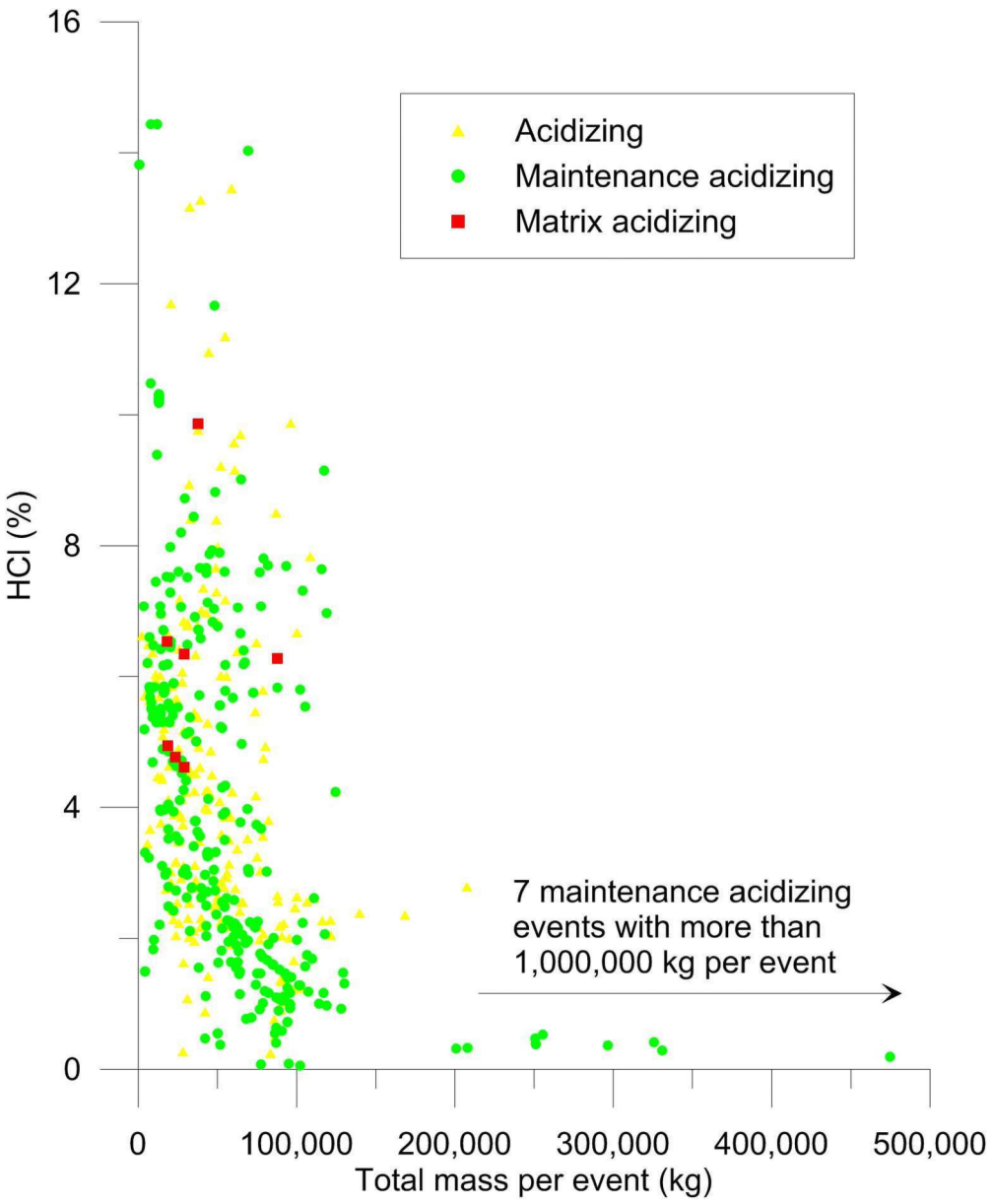


Fig 3. Concentrations of hydrochloric acid (HCl) used in acidizing. Sixteen events where water was not reported were excluded because the concentrations could not be calculated.

https://doi.org/10.1371/journal.pone.0175344.g003

These data were reported voluntarily by industry, but are believed to be representative of hydraulic fracturing as practiced in California [21,24,43,44]. Here, we identified 525 additives used in routine oil and gas production, with 249 identified by CASRN. In Stringfellow et al. [21], there was a median of 23 components per hydraulic fracturing treatment, inclusive of base fluids and proppants. In the SCAQMD, the number of additives per event varied by activity (Table 1). The median number of chemical additives was as low as three for gravel packing and the median number of chemical additives used in well drilling was much higher (54).

In the SCAQMD, the median mass used per hydraulic fracturing event was high (142,245 kg), but when water and quartz sand proppants were removed, the median mass of chemical additives was 6,725 kg. This is approximately three times higher than the value of 2,057 kg

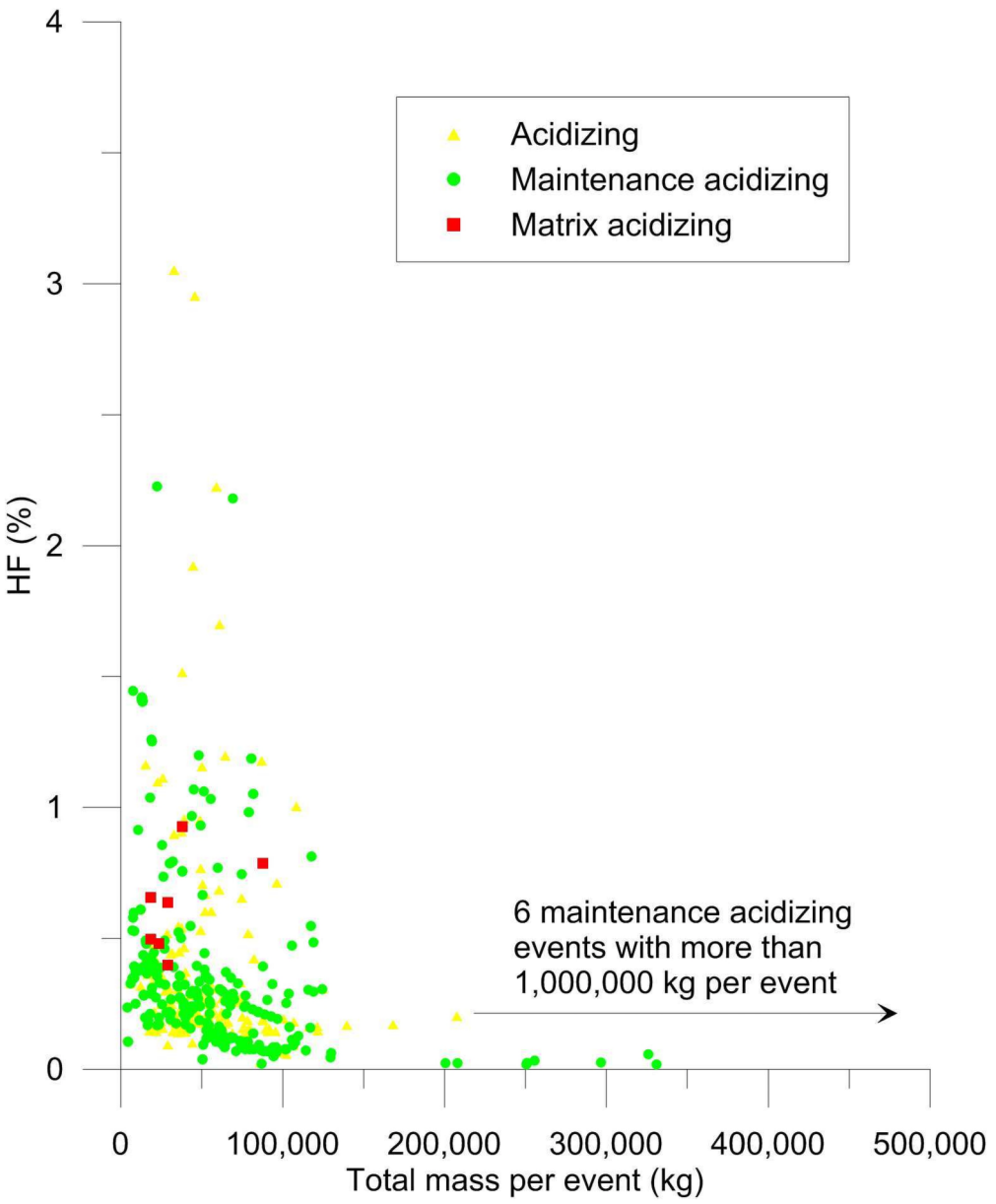


Fig 4. Concentrations of hydrofluoric acid (HF) used in acidizing. Sixteen events where water was not reported were excluded because the concentrations could not be calculated.

https://doi.org/10.1371/journal.pone.0175344.g004

obtained by Stringfellow et al. [21], who analyzed voluntarily reported data from the whole state of California. This difference may be attributed to differences in regional reservoir geology between the SCAQMD and the rest of California [44] and corresponding hydraulic fracturing practices: most of the data analyzed by Stringfellow et al. [21] was reported from Kern County, CA while the data here originated primarily from Orange and Los Angeles Counties.

Of the 249 chemicals identified by CASRN that are used for routine oil and gas development in the SCAQMD (Table 2), 124 (24%) were identified by Stringfellow et al. [21] as being used for hydraulic fracturing in California, further demonstrating overlap in chemical usage between hydraulic fracturing and routine activities. Further examination of the types of chemicals used in routine oil and gas development activities and in hydraulic fracturing yields both

similarities and differences. As an example, ten biocides were identified in the hydraulic fracturing data set reported by Stringfellow et al. [21] while only six were identified here as used in routine activities. The biocides were used in 63% of routine activities conducted in the SCAQMD compared to 93% of hydraulic fracturing treatments [21]. In routine use, the most commonly used biocides were formaldehyde, used in 677 (57%) events, and glutaraldehyde, used in 274 (23%) events. In the hydraulic fracturing treatments, isothiazolones were used in 73% of treatments [21,24]. This demonstrates that biocides are used extensively in different types of oil and gas production activities.

Corrosion inhibitors were used more extensively in routine operations than in hydraulic fracturing treatments. Ten corrosion inhibitors were identified in both the current data set and in the hydraulic fracturing data set [21], although the numbers are likely higher since many chemicals used as corrosion inhibitors also have other functions in oil and gas production (e.g. surfactants). In routine operations in the SCAQMD, corrosion inhibitors were used in 894 events (75% of all events), but they were only used in 6% of the hydraulic fracturing treatments [21]. The prevalent use of corrosion inhibitors in the SCAQMD is not surprising given the common use of strong acids in well maintenance and completion activities.

The substantial overlap between chemicals used in hydraulic fracturing fluids and those used in routine oil and gas development processes clearly demonstrate that the regulatory focus on reporting chemical-use for well-stimulation activities (e.g. hydraulic fracturing) to the exclusion of routine maintenance activities (e.g. wellbore cleaning) does not fully address potential environmental and public health concerns from on field chemical-use, particularly in the context of beneficial reuse of produced water for agriculture [15]. A more complete understanding of chemical usage–including type; toxicity and environmental profile; and mass, timing, frequency used–in routine oil and gas development is needed to support decision making with respect to beneficial reuse of produced water and this study contributes to filling this data gap.

Comparison of chemical-use between routine oil and gas development activities in the SCAQMD and other oil and gas fields throughout the U. S. and World

It is difficult to determine with certainty if chemical use on oil fields in the SCAQMD is representative of chemical-use on oil fields throughout the U.S. or the world, since data on chemical-use is rarely collected by governments or published by industry. Hudgins analyzed and published chemical-use data provided voluntarily by off-shore operations in the Gulf of Mexico [7] and the North Sea [8]. Comparison of the Hudgins' studies with chemicals used in the SCAQMD shows that chemicals are used for common purposes, such as microbial control, scale control, and cleaning, at all locations [7,8]. Hudgins' studies did not identify chemicals by CASRN, but some chemicals were identified sufficiently by name to allow positive identification of 47 chemicals from the North Sea study [8] and 25 chemicals from the Gulf of Mexico study [7]. Thirty-five chemicals could be positively identified as being used in both the North Sea and in the SCAQMD and 15 were positively identified as being used in both the Gulf of Mexico and the SCAQMD. Overall, these results, combined with a review of industrial literature, patents, and other sources, suggests that many of the chemicals used on the SCAQMD, or closely related compounds, would be found on oil fields worldwide [5–8,19–22,45].

Analysis of chemical hazards using data science approaches

One of the important requirements of regulations directed at oil and gas development and production is the disclosure of the types and amounts of chemicals used on-field [1,2,4,11,46].

Table 2. Data availability for chemicals used in routine oil and gas development.

Number of chemicals	Proportion of all chemicals	CASRN	Mass data	Toxicity data
151	30%	Available	Available	Available[a]
1	0%	Available	Unavailable	Available[a]
97	18%	Available	Available	Unavailable[a]
43	8%	Unavailable	Available	Unavailable
233	44%	Unavailable	Unavailable	Unavailable

[a]Does not include EPI Suite computational estimates for green algae ecotoxicity

https://doi.org/10.1371/journal.pone.0175344.t002

Chemical disclosure is widely recognized as a fundamental prerequisite for the open and transparent analysis of the hazards and risks associated with chemicals [2,4,10,27,45,46]. Previous studies have shown that many oil and gas field chemicals are not expected to have negative environmental or health impacts, but that some compounds, including surfactants, biocides, and corrosion inhibitors may be harmful to the environment, and that in many cases there is insufficient information to confidentially evaluate the potential environmental impact of chemicals that are used in significant amounts on oil and gas fields [19–24,47,48].

A preliminary hazard assessment for oil field chemicals being used in the SCAQMD was conducted using data science methods applied against hydraulic fracturing chemicals [20,21]. As shown in Table 2, 52% of the chemicals used in the SCAQMD were reported without a CASRN and could therefore not be evaluated using a data science approach, which requires CASRN to match compounds with corresponding environmental and toxicity information. Of the 53 chemicals used most frequently (top 10%), 18 were reported without a corresponding CASRN. The top 10% of the chemicals used in the highest median masses per event also did not always have associated CASRN (S2 Table). For example, the fourth most commonly used additive is a proprietary chemical identified only as "polyoxyalkylenes," which could be any one of potentially hundreds of chemicals or chemical formulations. Compounds reported by CASRN mostly had corresponding mass-usage information, important for risk analysis, but 97 did not have toxicity profiles in the public databases used in this study (Table 2; S3 Table). Altogether, 70% of the chemical additives reported in the SCAQMD could not be fully evaluated using data-based hazard analysis approaches [20,21,47], suggesting that current reporting requirements may need to be strengthened, if the regulatory objective includes generating data needed for risk assessments.

Analysis of chemicals by mammalian toxicity revealed that five chemicals were classified as GHS Category 2 contaminants based on acute mammalian oral exposure and 13 were classified as GHS Category 1 or 2 for acute mammalian inhalation toxicity (Table 3). These results are similar to results found by Stringfellow et al. [21] for hydraulic fracturing operations. Several of the most toxic chemicals identified are biocides: 5-chloro-2-methyl-3(2H)-isothiazolone, DBNPA (2,2-dibromo-3-nitrilopropionamide), formaldehyde, and glutaraldehyde. Corrosion inhibitors are also represented on the list of most toxic chemical additives: propargyl alcohol and thioglycolic acid (Table 3). Mammalian toxicity data were unavailable for 105 (42%) of the 249 chemicals with CASRN.

Analysis of ecotoxicity characteristics of the chemicals revealed that 58 chemical additives were classified as GHS Category 1 or 2 (Table 4). Twenty-six of these classifications were determined using computational estimates from the U.S. EPA Ecological Structure Activity Relationships (ECOSAR) software for green algae ecotoxicity, available through EPI Suite. The remainder of the ecotoxicity determinations were made using experimental data. A wide range of chemicals were identified as being toxic to aquatic organisms. The list includes acids,

Table 3. Chemicals used in routine oil and gas development that are classified by the United Nations Globally Harmonized System (GHS) Categories 1 and 2 for acute mammalian toxicity[a].

Chemical name	CASRN	Oral toxicity ratings			Inhalation toxicity ratings		Frequency of use (% events)	Median mass per event (kg)
		Rat	Mouse	Rabbit	Rat	Mouse		
2-Butoxyethanol (Ethylene glycol butyl ether)	111-76-2	4	4	3	2	-	26.5%	545
5-Chloro-2-methyl-3(2H)-isothiazolone	26172-55-4	4	-	-	2	-	0.1%	5.2
DBNPA (2,2-dibromo-3-nitrilopropionamide)	10222-01-2	3	-	3	1	-	0.3%	4.1
Ethylene oxide	75-21-8	3	3	-	2	3	1.0%	<0.1
Ferric chloride	7705-08-0	2	4	-	-	-	0.5%	30
Formaldehyde	50-00-0	2	2	-	2	2	57.0%	<0.1
Glutaraldehyde	111-30-8	3	3	-	1	-	23.1%	75
Glycolic acid	79-14-1	4	4	-	1	-	0.1%	89
Hydrofluoric acid	7664-39-3	-	-	-	2	2	43.6%	96
Lithium hydroxide	1310-65-2	3	4	-	2	-	0.2%	22
Petroleum distillates	64741-44-2	-	-	-	2	-	0.1%	138,679
Propargyl alcohol	107-19-7	2	2	-	3	-	53.8%	3.7
Sulfuric acid	7664-93-9	5	-	-	2	-	2.1%	<0.1
Tetrasodium ethylenediaminetetraacetate	64-02-8	4	2	-	-	-	0.3%	<0.1
Thioglycolic acid	68-11-1	3	3	3	1	-	0.1%	98
Toluene	108-88-3	4	-	-	>4	2	1.4%	6.7
Zinc sulfate	7733-02-0	3	2	4	-	-	0.2%	50

[a]Only chemicals with valid CASRN could be evaluated.

https://doi.org/10.1371/journal.pone.0175344.t003

hydrocarbons, biocides, corrosion inhibitors, surfactants, and other industrial chemicals (e.g. tall oil). Experimental ecotoxicity data were unavailable for 146 (59%) of the 249 chemicals with CASRN; when ECOSAR estimates were included, ecotoxicity data were unavailable for 129 (52%) chemicals with CASRN.

Although a complete risk assessment is beyond the scope of this study, evaluation of the frequency of chemical use and the mass of chemical used can provide context for the potential risk associated with the use of hazardous chemicals. Of the 17 chemicals with high mammalian toxicity only four of these were used in more than 25% of events (Table 3). Quantities of the most toxic chemicals used varied. Seven of the toxic chemicals were used in median quantities of less than 10 kg per treatment, while nine were used in larger amounts. Glutaraldehyde (used in 23% of events) was applied with a median quantity per treatment of 75 kg. While formaldehyde was used more frequently (57% of events), the median quantity added was less than 1 kg per treatment. The complexity of toxicity information, paired with data on frequency of use and quantities applied (Table 3), suggest that while hazard assessments such as this as useful for characterizing chemical-use, more detailed risk assessments are needed.

Nine of the most toxic chemicals from an aquatic perspective were used in more than 25% of events (Table 4). The most frequently used chemicals on the list were hydrochloric acid, propargyl alcohol, ammonium chloride, and naphthalene, used in 48% of events or more. Propargyl alcohol and naphthalene were used in small quantities (median masses of less than 5 kg per treatment) although hydrochloric acid and ammonium chloride were used in much higher

Table 4. Chemicals used in routine oil and gas development that are classified by the United Nations Globally Harmonized System (GHS) in Categories 1 and 2 for ecotoxicity[a].

Chemical name	CASRN	Water Flea[b]	Fathead Minnow[c]	Rainbow Trout[d]	Green Algae[e]	Frequency of use (% events)	Median mass per event (kg)
1,2,3-Trimethylbenzene	526-73-8	-	-	-	2	0.3%	1.0
1,2,4-Trimethylbenzene	95-63-6	2	2	-	2	5.7%	1.6
1,3,5-Trimethylbenzene	108-67-8	2	-	-	2	0.3%	2.3
2-Mercaptoethyl alcohol	60-24-2	2	-	-	2	0.7%	2.5
2-Methyl-3(2H)-isothiazolone	2682-20-4	1	-	1	1	0.2%	2.6
5-Chloro-2-methyl-3(2H)-isothiazolone	26172-55-4	1	-	1	1	0.1%	5.2
Acrylamide	79-06-1	3	>3	>3	1	0.8%	<0.1
Alcohols, C10-14, ethoxylated	66455-15-0	-	-	-	1	0.6%	64
Aluminum	7429-90-5	-	-	1	-	16.5%	9.1
Ammonium chloride	12125-02-9	>3	2	>3	-	48.4%	454
Benzene, c10-c16 alkyl derivatives	68648-87-3	-	-	-	1	0.9%	<0.1
Benzene, tetrapropylene-	25265-78-5	-	-	-	1	0.1%	2.7
Benzoisothiazolinone	2634-33-5	1	-	1	1	0.1%	<0.1
Bis(isopropyl)naphthalene	38640-62-9	-	-	-	1	2.0%	1.8
Canola oil	120962-03-0	-	-	-	1	0.3%	92
Cocamidopropyl betaine	61789-40-0	2	-	-	>3	0.7%	<0.1
Cyclohexasiloxane, 2,2,4,4,6,6,8,8,10,10,12,12-dodecamethyl-	540-97-6	-	-	-	1	0.3%	<0.1
Cyclopentasiloxane, 2,2,4,4,6,6,8,8,10,10-decamethyl-	541-02-6	-	-	-	1	0.3%	<0.1
DBNPA (2,2-dibromo-3-nitrilopropionamide)	10222-01-2	1	1	1	1	0.3%	4.1
Dodecylbenzene	123-01-3	-	-	-	1	0.1%	5.4
Dodecylbenzene sulfonic acid	27176-87-0	2	-	2	3	1.4%	<0.1
Ethanesulfonic acid, 2-[methyl[(9z)-1-oxo-9-octadecen-1-yl]amino]-, sodium salt (1:1)	137-20-2	-	-	-	2	0.6%	53
Ethoxylated C14-15 alcohols	68951-67-7	1	1	1	1	1.3%	2.4
Ethoxylated hexanol	68439-45-2	2	-	2	>3	0.3%	16
Ethylbenzene	100-41-4	2	2	2	2	31.3%	2.9
Fatty acids, tall-oil	61790-12-3	>3	-	-	1	0.4%	7.1
Fatty acids, tall-oil, reaction products with triethanolamine	67784-78-5	-	-	-	2	1.3%	<0.1
Ferric chloride	7705-08-0	2	3	-	-	0.5%	30
Glutaraldehyde	111-30-8	1	2	2	2	23.1%	75
Glyoxal	107-22-2	>3	>3	0	2	23.0%	3.6

(*Continued*)

Table 4. (*Continued*)

Chemical name	CASRN	Water Flea[b]	Fathead Minnow[c]	Rainbow Trout[d]	Green Algae[e]	Frequency of use (% events)	Median mass per event (kg)
Hydrochloric acid	7647-01-0	1	-	2	-	54.8%	1,311
Hydrotreated light petroleum distillate	64742-47-8	-	3	2	1	32.9%	17
Isopropylbenzene	98-82-8	3	2	2	2	29.5%	0.3
Lecithins	8002-43-5	-	-	-	1	0.3%	1.4
Lithium hypochlorite	13840-33-0	1	-	1	-	0.2%	129
Naphtha (petroleum), heavy catalytic reformed	64741-68-0	-	-	-	2	0.2%	18
Naphthalene	91-20-3	1	1	1	2	48.4%	0.3
Octamethylcyclotetrasiloxane	556-67-2	-	-	-	1	0.3%	<0.1
Petroleum distillate-mineral oil grade	8002-05-9	1	-	-	1	0.1%	30
Petroleum distillates	64741-44-2	-	-	-	1	0.1%	138,679
Petroleum distillates	64742-46-7	-	-	-	1	0.1%	138,679
Poly(oxy-1,2-ethandiyl), a-(nonylphenyl)-w-hydroxy-	9016-45-9	2	-	2	2	13.2%	4.6
Polyethylene glycol monostearate	9004-99-3	-	-	-	1	1.3%	<0.1
Polypropylene	9003-07-0	-	-	-	1	1.1%	56
Polysiloxanes, di-Me	63148-62-9	3	-	-	1	1.6%	<0.1
Propargyl alcohol	107-19-7	-	2	-	>3	53.8%	3.7
Quinoline	91-22-5	3	1	-	3	18.8%	0.1
Sodium chloroacetate	3926-62-3	>3	-	-	1	0.3%	<0.1
Sodium hypochlorite	7681-52-9	1	1	1	>3	0.2%	2.3
Sodium silicate	1344-09-8	1	-	-	-	0.7%	72
Solvent naphtha, petroleum, heavy arom.	64742-94-5	1	3	2	2	39.0%	1.8
Solvent naphtha, petroleum, light arom.	64742-95-6	2	-	2	2	5.8%	1.7
Sorbitan monostearate	1338-41-6	-	-	-	1	1.3%	<0.1
Stearic acid	57-11-4	-	-	-	1	12.1%	150
Sulfonic acids, c14-16-alkane hydroxy and c14-16-alkene, sodium salts	68439-57-6	2	-	-	3	0.1%	5.4
Tall oil	8002-26-4	-	-	-	1	0.8%	13
Xylenes	1330-20-7	-	3	2	2	32.0%	1.5

(*Continued*)

Table 4. (*Continued*)

Chemical name	CASRN	Water Flea[b]	Fathead Minnow[c]	Rainbow Trout[d]	Green Algae[e]	Frequency of use (% events)	Median mass per event (kg)
Zinc sulfate	7733-02-0	1	1	1	-	0.2%	50

[a]Only chemicals with valid CASRN could be evaluated.
[b]Daphnia magna
[c]Pimephales promelas
[d]Oncorhynchus mykiss
[e]computational estimates from EPI Suite.

https://doi.org/10.1371/journal.pone.0175344.t004

amounts (median masses of 1,311 and 454 kg per treatment). The higher number of chemical additives posing ecotoxicity issues and the frequent use of these chemicals, suggests that the ecosystem risks need to be fully evaluated in produced water reuse projects.

Evaluation of chemical hazards using regulatory lists

To further investigate the potential hazards associated with chemicals used in routine oil and gas development activities, six regulatory lists were referenced (S4 Table). The result of the comparison with these regulatory lists was that twenty-two of the chemicals were on the California Toxic Air Contaminant List [41], 12 were on the California Proposition 65 List [40], 10 were on the U.S. EPA Drinking Water Standards and Health Advisories List [49], six were present on the U.S. EPA Contaminant Candidate List 4 [50], three were on the European Chemicals Agency Substance of Very High Concern Candidate List [51], and two were on the OSPAR List of Substances of Possible Concern [45]. These results demonstrate that some of the chemicals used in routine oil and gas development activities are chemicals of concern, as identified by multiple state, federal, and international environmental agencies due to their toxicities. However, the actual risk proposed by these chemicals would need to be determined in the context of their use and potential release into the environment.

It should be noted that comparison with regulatory lists also indicate that many of the chemicals used in the SCAQMD are expected to present little or no human health or ecotoxicity hazard, even if discharged into the environment. Of the chemicals reported with CASRN, 56 are on the OSPAR list of chemicals not expected to pose environmental harm [22]. These chemicals include inert minerals (e.g. silica, graphite, mica, diatomaceous earth), common salts (e.g. calcium carbonate, calcium chloride, sodium carbonate, etc.), chemicals that rapidly degrade in the environment (e.g. acetic acid, ethylene glycol, 1-butanol), and food additives (e.g. xanthan gum, guar gum, sodium erythorbate, starch).

Conclusions

In this study we compared routine oil and gas field chemical use, which is not typically subject to disclosure regulations, with chemical use for hydraulic fracturing and other well stimulation techniques that are subject to regulation mandating chemical disclosure. Our results indicate that there is substantial overlap between the chemicals used in well stimulation and those used in routine oil and gas development activities. Similarities were observed in the numbers of chemicals used, the masses in which they were applied, the frequency of use, and their toxicological profiles. Our analysis shows that hydraulic fracturing is just one of many applications of hazardous chemicals on oil and gas fields and suggests that limiting disclosure requirements for oil and gas field chemical-use to hydraulic fracturing and other well-stimulation events

may not be fully protective of human and environmental health, especially in the context of beneficial reuse of produced water for irrigation, wildlife, livestock watering, and groundwater recharge.

Supporting information

S1 Table. Constituents used for routine oil and gas development activities (exclusive of well stimulation) in the SCAQMD, June 4, 2013 to September 2, 2015, sorted by frequency of use. Total number of events is 1,187.
(PDF)

S2 Table. The top 10% median masses of additives used in routine oil and gas development activities (exclusive of well stimulation) in the SCAQMD, June 4, 2013 to September 2, 2015. Total number of events is 1,187.
(PDF)

S3 Table. Chemicals reported to the SCAQMD and used in routine oil and gas production for which experimental toxicity information could not be located (N = 97).
(PDF)

S4 Table. Chemicals reported to the SCAQMD and used in routine oil and gas development activities considered chemicals of concern based on six reference lists consulted.
(PDF)

Acknowledgments

This material is based upon work supported by the Department of Energy under Award Number DE-IA0000018 (CERC-WET). This study was also supported by grants from The Broad Reach Fund and Laboratory Directed Research and Development (LDRD) funding from Berkeley Lab, provided by the Director, Office of Science, of the U.S. Department of Energy under Contract No. DE-AC02-05CH1123.

Author Contributions

Conceptualization: WTS SBCS MKC.

Data curation: MKC JKD WTS.

Formal analysis: MKC JKD WTS.

Funding acquisition: WTS SBCS.

Investigation: MKC JKD WTS SBCS.

Methodology: MKC JKD WTS.

Project administration: WTS SBCS.

Resources: WTS SBCS.

Supervision: WTS SBCS.

Validation: WTS MKC.

Visualization: JKD MKC WTS SBCS.

Writing – original draft: MKC JKD SBCS WTS.

Writing – review & editing: WTS MKC.

References

1. California Department of Conservation. SB 4 Well Stimulation Treatment Regulations, Final Text of Regulations, Chapter 4. Development, Regulation, and Conservation of Oil and Gas Resources, Subchapter 2. Environmental Protection. December 30; Sacramento, CA: Division of Oil, Gas, and Geothermal Resources; 2014.
2. Richardson N, Gottlieb M, Krupnick A, Wiseman H. The State of State Shale Gas Regulation. Washington, D.C.: Resources for the Future; 2013 June.
3. Brantley SL, Yoxtheimer D, Arjmand S, Grieve P, Vidic R, Pollak J, et al. Water resource impacts during unconventional shale gas development: The Pennsylvania experience. Int J Coal Geol. 2014; 126:140–56.
4. Bureau of Land Management. Oil and Gas; Hydraulic Fracturing on Federal and Indian Lands, Final Rule, 43 CFR Part 3160, RIN 1004–AE26. Washington, DC 2012.
5. Fink J. Petroleum Engineer's Guide to Oil Field Chemicals and Fluids. 2nd ed. Burlington, MA: Elsevier Science; 2015.
6. Kelland M. Production Chemicals for the Oil and Gas Industry. 2nd ed. Boca Raton, FL: CRC Press; 2014.
7. Hudgins CM. Chemical treatments and usage in offshore oil and gas production systems. J Pet Technol. 1992; 44(5):604–11.
8. Hudgins CM. Chemical use in North Sea oil and gas E&P. J Pet Technol. 1994; 46(1):67–74.
9. Economides MJ, Hill AD, Ehlig-Economides C, Zhu D. Petroleum Production Systems, 2nd ed. Upper Saddle River, NJ: Prentice Hall; 2013.
10. National Research Council. Science and Decisions: Advancing Risk Assessment. Washington, DC: The National Academies Press; 2009.
11. California Department of Conservation. Well Stimulation Treatment (WST) Sacramento, CA: Division of Oil, Gas, and Geothermal Resources; 2016 [cited 2016 July 29]. Available from: http://www.conservation.ca.gov/dog/Pages/WST.aspx.
12. Doman L. United States remains largest producer of petroleum and natural gas hydrocarbons. Washington, D.C.: U. S. Energy Information Administration; 2016 May 23.
13. Guerra K, Dahm K, Dundorf S. Oil and Gas Produced Water Management and Beneficial Use in the Western United States, S&T Report No. 157. Denver, CO: U.S. Department of the Interior, Bureau of Reclamation; 2011.
14. Veil J. U.S. Produced Water Volumes and Management Practices in 2012. Oklahoma City, OK: Ground Water Protection Council, 2015 April.
15. Heberger M, Donnelly K. Oil, Food, and Water: Challenges and Opportunities for California Agriculture. Oakland, CA: Pacific Institute; 2015 December.
16. Muggeridge A, Cockin A, Webb K, Frampton H, Collins I, Moulds T, et al. Recovery rates, enhanced oil recovery and technological limits. Phil Trans R Soc A. 2014; 372:20120320.
17. Nelson EB. Well cementing fundamentals. Oilfield Rev. 2012; 24(2):59–60.
18. OSPAR Commission. OSPAR Report on Discharges, Spills and Emissions from Offshore Oil and Gas Installations in 2013. London, UK; 2015. Available from: http://www.ospar.org/documents?v=33826
19. Abdullah K, Malloy T, Stenstrom MK, Suffet IHM. Toxicity of acidization fluids used in California oil exploration. Toxicol Environ Chem. 2017; 99(1):78–94.
20. Stringfellow WT, Domen JK, Camarillo MK, Sandelin WL, Borglin S. Physical, chemical, and biological characteristics of compounds used in hydraulic fracturing. J Hazard Mater. 2014; 275:37–54. https://doi.org/10.1016/j.jhazmat.2014.04.040 PMID: 24853136
21. Stringfellow WT, Camarillo MK, Domen JK, Sandelin WL, Varadharajan C, Jordan PD, et al. Identifying chemicals of concern in hydraulic fracturing fluids used for oil production. Environ Pollut. 2017; 220:413–20. https://doi.org/10.1016/j.envpol.2016.09.082 PMID: 27743793
22. OSPAR Commission. OSPAR List of Substances Used and Discharged Offshore which Are Considered to Pose Little or No Risk to the Environment (PLONOR). London, UK: OSPAR Commission; 2013 [updated June; cited 2015 Nov]. Available from: http://www.ospar.org/documents?d=32939.
23. Shonkoff S, Maddalena R, Hays J, Stringfellow W, Wettstein Z, Harrison R, et al. Chapter 6: Potential Impacts of Well Stimulation on Human Health in California. An Independent Scientific Assessment of

Well Stimulation in California, Volume II: Generic and Potential Environmental Impacts of Well Stimulation Treatments. Sacramento, CA: California Council on Science and Technology; 2015.

24. Stringfellow WT, Cooley H, Varadharajan C, Heberger M, Reagan M, Domen JK, et al. Chapter 2: Impacts of Well Stimulation on Water Resources. An Independent Scientific Assessment of Well Stimulation in California, Volume II: Generic and Potential Environmental Impacts of Well Stimulation Treatments. Sacramento, CA: California Council on Science and Technology; 2015.
25. Pattanayek M, DeShields B. Risk-Based Screening Levels for the Protection of Livestock Exposed to Petroleum Hydrocarbons, Publication Number 4733. Washington, D.C.: American Petroleum Institute; 2004 July.
26. Vengosh A, Jackson RB, Warner N, Darrah TH, Kondash A. A critical review of the risks to water resources from unconventional shale gas development and hydraulic fracturing in the United States. Environ Sci Technol. 2014; 48(15): 8334–48. https://doi.org/10.1021/es405118y PMID: 24606408
27. Long JCS, Birkholzer JT, Feinstein LC. Summary Report: An Examination of Hydraulic Fracturing and Acid Stimulations in the Oil and Gas Industry. An Independent Scientific Assessment of Well Stimulation in California. Sacramento, CA: California Council on Science and Technology; 2015.
28. Shaffer DL, Chavez LHA, Ben-Sasson M, Castrillon SRV, Yip NY, Elimelech M. Desalination and Reuse of High-Salinity Shale Gas Produced Water: Drivers, Technologies, and Future Directions. Environ Sci Technol. 2013; 47(17):9569–83. https://doi.org/10.1021/es401966e PMID: 23885720
29. South Coast Air Quality Management District (SCAQMD). Notification and Reporting Requirements for Oil and Gas Wells and Chemical Suppliers Rule 1148.2: South Coast Air Quality Management District; 2013 [cited 2016 March 15]. Available from: http://www.aqmd.gov/home/regulations/compliance/1148-2.
30. Hazardous Substances Data Bank: A TOXNET Database [Internet]. Bethesda, MD: U.S. National Library of Medicine, National Institute of Health; 2015 [cited 2015 Nov]. Available from: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB.
31. ChemIDplus Advanced: A TOXNET Database [Internet]. Bethesda, MD: U.S. National Library of Medicine, National Institute of Health; 2015 [cited 2015 Nov]. Available from: http://chem.sis.nlm.nih.gov/chemidplus/.
32. SciFinder [Internet]. Colombus, OH: American Chemical Society; 2014 [cited 2015 Nov]. Available from: https://scifinder.cas.org.
33. SRC I Physprop Database [Internet]. Syracuse, NY: SRC, Inc.; 2013 [cited 2015 Nov]. Available from: http://esc.syrres.com/fatepointer/search.asp.
34. World Health Organization. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans [Internet]. International Agency for Research on Cancer (IARC); 2015 [updated October 24; cited 2015 Nov]. Available from: http://monographs.iarc.fr/ENG/Classification/ClassificationsCASOrder.pdf.
35. Chemical Risk Information Platform (CHRIP) [Internet]. Tokyo, Japan: National Institute of Technology and Evaluation; 2015 [cited 2015 Nov]. Available from: http://www.nite.go.jp/en/chem/chrip/chrip_search/systemTop.
36. U.S. Environmental Protection Agency. EPI Suite™-Estimation Program, version 4.11,. Washington, D.C.: U.S. Environmental Protection Agency; 2012. Available from: https://www.epa.gov/tsca-screening-tools/epi-suitetm-estimation-program-interface.
37. Aggregated Computational Toxicology Resource (ACToR) Database [Internet]. Washington, D.C.: U.S. Environmental Protection Agency; 2015 [cited 2015 Nov]. Available from: http://actor.epa.gov/actor/faces/ACToRHome.jsp.
38. ECOTOXicology Database (ECOTOX) Release 4.0 [Internet], Washington, D.C.: U.S. Environmental Protection Agency; 2015 [cited 2015 Nov]. Available from: http://cfpub.epa.gov/ecotox/quick_query.htm.
39. European Chemicals Agency. International Uniform Chemical Information Database (IUCLID) Year 2000 Edition [CD- ROM]. 2000.
40. Office of Environmental Health Hazard Assessment. Current Proposition 65 List. Sacramento, CA; 2015 [cited 2015 Nov]. Available from: http://oehha.ca.gov/prop65/prop65_list/Newlist.html.
41. California Air Resources Board. Toxic Air Contaminant (TAC) Identification List. Sacramento, CA; 2010 [cited 2015 Nov]. Available from: http://www.arb.ca.gov/toxics/cattable.htm.
42. United Nations. Globally Harmonized System of Classification and Labelling of Chemicals (GHS), 4th Revised Edition. New York and Geneva; 2013. Report No.: ST/SG/AC.10/30/Rev.5.
43. Long J, Birkholzer J, Feinstein L. Summary Report: An Examination of Hydraulic Fracturing and Acid Stimulations in the Oil and Gas Industry. Sacramento, CA: California Council on Science and Technology; 2015.

44. Long JCS, Feinstein LC, Birkholzer J, Jordan P, Houseworth J, Dobson PF, et al. An Independent Scientific Assessment of Well Stimulation in California, Volume I: Well Stimulation Technologies and their Past, Present, and Potential Future Use in California. Sacramento, CA: California Council on Science and Technology; 2015.

45. OSPAR Commission. List of Substances of Possible Concern. London, UK: OSPAR Commission; 2015 [cited 2015 Nov]. Available from: http://www.ospar.org/work-areas/hasec/chemicals/possible-concern/list.

46. OSPAR Commission. Common Interpretation on which Chemicals are Covered and not Covered by the Harmonised Mandatory Control System under OSPAR Decision 2000/2. London, UK: OSPAR Commission; 2002 [cited 2015 Nov]. Available from: www.ospar.org/documents?d=32731

47. Camarillo MK, Domen JK, Stringfellow WT. Physical-chemical evaluation of hydraulic fracturing chemicals in the context of produced water treatment. J Environ Manage. 2016; 183: 164–74. https://doi.org/10.1016/j.jenvman.2016.08.065 PMID: 27591844

48. Kahrilas GA, Blotevogel J, Stewart PS, Borch T. Biocides in hydraulic fracturing fluids: A critical review of their usage, mobility, degradation, and toxicity. Environ Sci Technol. 2015; 49(1): 16–32. https://doi.org/10.1021/es503724k PMID: 25427278

49. U.S. Environmental Protection Agency. 2012 Edition of the Drinking Water Standards and Health Advisories. Washington, D.C.; 2012 [cited 2015 Nov]. Report No.: EPA 822-S-12-001. Available from: http://water.epa.gov/action/advisories/drinking/upload/dwstandards2012.pdf.

50. U.S. Environmental Protection Agency. Contaminant Candidate List (CCL) 4 and Regulatory Determination. Washington, D.C.; 2015 [cited 2015 Nov]. Available from: http://www2.epa.gov/ccl/chemical-contaminants-ccl-4.

51. European Chemicals Agency. Candidate List of Substances of Very High Concern for Authorisation. Helsinki, Finland; 2015 [cited 2015 Nov]. Available from: http://echa.europa.eu/candidate-list-table.

Exhibit Q

CEQA Operator Notices from 2019 and 2023

California
Department of Conservation
Division of Oil, Gas, and Geothermal Resources

Gavin Newsom, Governor
David D. Bunn, Director

NOTICE TO OPERATORS 2019-16

October 24, 2019
(Amending NTO 2018-10 issued on September 4, 2018) CEDA COMPLIANCE

This document amends the "CEQA COMPLIANCE" Notice to Operators (NTO) 2018-10, dated September 4, 2018, and signed by Kenneth A. Harris Jr. see enclosed. NTO 2018-10 provided details to operators on documenting compliance with the California Environmental Quality Act (CEQA) when seeking a permit or project approval from the Department of Conservation's Division of Oil. Gas, and Geothermal Resources (DOGGR) in connection with oil, gas, or geothermal operations.

CEQA Operator Checklist and WellSTAR:

WellSTAR Release 5.0 is scheduled to be operational on October 28, 2019 and will modify DOGGR's CEQA compliance process. WellStar will include a "CEQA Information" step within the permit and project application review processes already in WellSTAR (Well Maintenance, Well Stimulation Treatment, Underground Injection Control, and Underground Gas Storage).

The CEQA review process and required documentation for the "CEQA Information" step will continue to be consistent across all DOGGR programs. The questions in the ***CEQA Operator Checklist*** will be integrated into the WellSTAR system. As a result, operators will no longer need to complete and upload the *CEQA Operator Checklist* unless the operator : (1) is a geothermal operator; or (2) cannot access WellSTAR and therefore must provide hardcopies of all permit/application materials to DOGGR.

Operators must continue to provide other applicable documentation necessary for DOGGR to complete its CEQA review of the proposed project. Operators should upload documents into WellSTAR or provide a URL address where DOGGR may readily access the document if it is too large to upload. The documentation needed for a proposed project may include, but not be limited to: approved local permit, and any environmental documents and notices that CEQA or the National Environmental Policy Act (NEPA) may require.

Please note that the local lead agency must also file a copy of their Notice of Determination with the Office of Planning and Research/State Clearinghouse (SCH) if discretionary approval is required from any State agency, such as DOGGR (CEQA Guidelines,§§ 15075, subd. (d), and 1 5094, subd. (d)).

To facilitate the application re view process, operators should consult with the local permitting authorities for any permits and CEQA reviews required for the proposed project before applying to DOGGR for permit or project approval. The only exception is for a geothermal exploration project outside of Imperial County. Operators should ensure that all information provided to DOGGR is accurate and complete. Incorrect or incomplete CEQA information may delay the permit or application review process and may be returned to the operator for correction or completeness. Operators that intentionally submit false information may be subject to an enforcement action.

Materials are available on DOGGR's CEQA website at: https://www.conservation.ca.gov/dog /CEQA. Check the website regularly, as additional guidance materials on how to complete the "CEQA Information " step in WellSTAR will be developed and uploaded in November. Assistance is also availableby selecting the "Help" button at the top of the WellSTAR page.

Indemnity Agreement:

In addition to the *CEQA Operator Checklist,* NTO 2018-10 required that all operators submit a signed ***Indemnity Agreement*** (IA) concurrently with any "Notice of Intention" (NOI) (see Pub. Resources Code, § 3203, subd. (a)), or other application or proposal. This amended NTO discontinues the requirement that all operators submit a signed IA concurrently with every application for a permit or other approval, effective on **October 28, 2019.** DOGGR reserves its right to require operators to sign IA's for CEQA, on a case-by-case basis in connection with any permit or other approval sought by an operator.

All CEQA forms, guidance documents, and other CEQA-related materials are available to view and download from the CEQA website, located at: http://www.conservation.ca.gov/ dog/CEQA/ .

Please send any question(s) concerning this amended NTO to DOGGR's CEQA Unit at CEQA@conservation.ca.gov.

Jason R. Marshall

Acting State Oil and Gas Supervisor

State of California • Natural Resources AgencyDepartment of Conservation
Division of Oil, Gas, and Geothermal Resources
801K street • MS 18-05 Sacramento, CA 95814
(916) 445-9686 • FAX (916) 319-953

Edmund G. Brown Jr., *Governor*
Kenneth A- Harris Jr.,
State Oil and Gas Supervisor

Enclosure

THIS NTO HAS BEEN AMENDED MY NTO 2019-16

NOTICE TO OPERATORS
NTO 2018-10

SEPTEMBER 4, 2018

CEQA COMPLIANCE

This Notice to Operators (NTO) provides details on documenting compliance with the California Environmental Quality Act (CEOA) when requesting a permit or project approval from the Department of Conservation's, Division of Oil, Gas, and Geothermal Resources (DOGGR) for any oil, gas, or geothermal activity.

CEOA and its implementing Guidelines require state and local public agencies to identify the potential for environmental impacts that may result from their actions, and to avoid or mitigate those impacts, where feasible. Since DOGGR is a public agency, it is required to comply with CEOA when it undertakes an activity or makes a discretionary decision on a permit or approval, which is defined as a "project" by CEQA (CEOA Guidelines §15378). A "project" refers to the whole of an action that has the potential to cause a physical change to the environment (direct or indirect), and requires discretionary action from the public agency (exercises its judgment in deciding whether and how to approve or carry out a project). This includes all phases of a project that are reasonably foreseeable, and all related activities that are directly linked to the project. For DOGGR, typical "projects" would include issuing of permits or project approval letters for oil, gas, and geothermal activities (inside and outside administrative field boundaries). Prior to approval, all submitted permit requests and applications ("projects") that involve a discretionary approval from DOGGR will require some level of environmental review (or "CEOA review"), pursuant to CEQA (Public Resource Code §21065; **CEQA** Guidelines §15002 (i)) . In performing that review, DOGGR acts as either a: (1) Responsible Agency under CEQA, relying on the local lead agency 's environmental document that includes the proposed project within its scope; or (2) Lead Agency, determining whether the proposed project is exempt or the type of environmental document that may be required, if an environmental document was not initially prepared by the local jurisdiction.

CEQA REVIEW PROCESS:

To facilitate its CEQA review process, DOGGR developed a *CEQA Operator Checklist* for operators to complete that will assist in identifying and collecting the types of information that DOGGR will typically need to comply with CEOA. Detailed information on the CEOA review process can be found in the *CEQA Guidance for Operator: CEOA Compliance* on DOGGR's CEOA website.

How DOGGR conducts its CEOA review depends on our CEQA agency role as either *Lead Agency* or *Responsible Agency.*

Where a local jurisdiction or other state agency must issue a permit, generally, it would be consideredthe *Lead Agency.* When the local jurisdiction or another state agency is the *Lead Agency,* then DOGGR assumes the *Responsible Agency* role in its CEOA review, relying on the Lead Agency's environmental document. However, if there is no other *Lead Agency,* and no environmental document to rely on, DOGGR assumes the *Lead Agency* role in its CEQA review. DOGGR's CEQA review as a *Lead Agency* is a more complex review and may require more time to complete (e.g.; estimated times range from a few days for an exemption determination, and up to 180 days for a Negative Declaration, or one year for an Environmental Impact Report) .

CEQA OPERATOR CHECKLIST:

The purpose of DOGGR's CEOA Operator Checklist (Checklist) is to assist Operators to identify and collect the documents necessary for DOGGR to evaluate the application and to comply with CEOA. Ultimately, the Checklist will ensure that DOGGR's CEOA review is consistent and completed in an efficient and timely manner.

All operators applying for a permit or project approval should submit a completed Checklist at the same time as the NOI or Application. A single Checklist may be used for projects that involve multiple wells and may be submitted as either an upload into WellSTAR or mailed directly to DOGGR. The Checklist itemizes documents typically needed for DOGGR's CEOA review, some of which may be familiar and some of which may not, such as the following:

- **Indemnity Agreement.** All operators must submit a signed Indemnity Agreement (IA) when the NOI or Application is submitted to DOGGR. Only one IA needs to be submitted per project, which may consist of either one or multiple wells. The IA is for the operator (or applicant) to indemnify DOGGR for costs incurred when defending any lawsuit brought against DOGGR under CEOA resulting from permit or project approvals.
- **CEQA Filing Fees.** The California Department of Fish and Wildlife (CDFW) requires CEQA Filing Fees to defray the costs of managing and protecting California's fish and wildlife resources (Fish & Game Code, §711.4). The CEOA Filing Fee may be waived if a project has no effect on fish and wildlife; therefore, an operator may request a *No Effect Determination* (NED) from CDFW, in lieu of paying the filing fee. Additional information on the CEOA Filing Fee and NED process can be found on the CDFW website at https://www wildlife.ca.gov/Conservation /CEOA/Fees/. Projects that are exempt from CEOA are not subject to the filing fee and do not require an NED; therefore, this requirement is only applicable when DOGGR is the *Lead Agency* and files a Notice of Determination (NOD) with the State Clearinghouse. The Filing Fee or NED must be submitted with the NOD at the same time of its filing, which is within 5 working days after project approval; therefore, the operator will be notified when it is time to submit their NED or payment for the CEOA Filing Fee to DOGGR, about one week before the permit or project is scheduled to be approved.
- **NEPA Documents.** DOGGR published NTO 2017-03 to clarify its legal authority to issue permits and approvals for oil, gas, and geothermal activities in California, including oilfield operations on land administered by the Bureau of Land Management (BLM). When DOGGR issues permits or approvals for oilfield activities on lands that the BLM owns in total (both surface and mineral rights), it will act as the State CEOA *Lead Agency,* while BLM will act as the Federal National Environmental Policy Act (NEPA) *Lead Agency.* Operators will need to submit any required Federal permit(s) and associated NEPA documents to DOGGR, along with the NOI or Application package. As the CEOA *Lead Agency,* DOGGR typically uses the NEPA documents in lieu of preparing a separate CEOA document for the same project, as applicable, thereby reducing time and costs when conducting our own CEOA reviews and in issuing the permits.

A CEOA Compliance Workshop for operators is scheduled to be held in conjunction with the Sensitive Gas Pipelines Compliance Workshop, on the same dates and at the same locations. The CEOA workshop will be held on:

- **September 18, 2018** from 1 :00 - 4:00 PM in the Ronald Reagan State Building Auditorium, located at 300 South Spring Street, Los Angeles
- **September 19, 2018** from 5:00 PM - 8:00 PM in the Four Points by Sheraton, located at 5101 California Avenue, Bakersfield

This NTO, CEOA Operator Checklist, CEOA Guidance for Operators, Indemnity Agreement , and all other CEOA-related materials are available to view and download from the CEOA Website, located at http://conservation.ca/dog/CEQA. Be sure to check our website regularly, as additional CEOA Guidance documents will be developed and uploaded onto our website to help facilitate the CEOA review process.



Kenneth A. Harris Jr.
State Oil and Gas

California
Department of
Conservation
Geologic Energy Management

CEQA Guidance for Operators
Project Description

Revised: January 05, 2023

Disclaimer: This guidance document is for information purposes only. This document has neither the force of law nor regulation and should not be cited as a California Environmental Quality Act (CEQA) requirement. Refer to applicable laws and regulations on current legal requirements.

Introduction

A project[1] description is required for every Notice of Intention (NOI) or similar application[2] that an operator submits to the California Geologic Energy Management Division (CalGEM) for approval to conduct oil, gas, or geothermal activities.[3] The project description is the starting point for CalGEM to conduct review in accordance with CEQA (Pub. Resources Code, § 21000 et seq.).

A project description summarizes the proposed project, the physical activity involved with the project, where such activity would occur, and the potential environmental effects of the project. A project description assists CalGEM staff in determining whether CalGEM is a Responsible Agency or the Lead Agency under CEQA and the level of environmental analysis that CEQA requires. A project description also aids CalGEM in identifying whether it needs additional information from the operator to conduct the environmental review in compliance with CEQA.

A project description should be project-specific, written in a clear narrative format, and use simple language where practical. An operator may develop and use a template for project descriptions if the template contains the elements described below. A project description may cover a single or multiple NOIs. If one project description is intended to cover multiple NOIs, include a list of all wells associated with the proposed project description. Operators are encouraged to group multiple wells with similar locations in singular project descriptions.

---

[1] A "project" is the "whole" action that could result in a direct physical change in the environment or a reasonably foreseeable indirect physical change in the environment. Permits and other approvals for land uses issued by a public agency can be projects (Pub. Resources Code, 21065; Cal. Code Regs., tit. 14, § 15378).
[2] NOI (oil & gas and geothermal), PRC §§ 3203, 3724, CCR tit. 14, §§ 1714, 1914, 1931; UIC, CCR tit. 14, §1724.6; UGS, PRC § 3180, CCR tit. 14, § 1726.2; Well Stim, PRC § 3160 CCR tit. 14, § 1783.
[3] Cal. Code Regs., tit. 14, §1682, 1682.1, 1683.1, 1720.1, 1751, 1783, 1783.1, and 1784.

An operator should upload or enter the project description for oil and gas projects in the text box in WellSTAR.[4] For geothermal projects, an operator should submit the project description along with the rest of the geothermal application package to the CalGEM District in which the project is located. Please note that not providing the information identified in this document or requested by CalGEM during the environmental review can significantly delay the CEQA review and required compliance process.

Data Collection and Upload

To facilitate the application review process, operators should consult with the local permitting authorities for any permits and CEQA reviews required for the proposed project before applying to CalGEM for permit or project approval.[5]

List the title, date, and State Clearinghouse number of the environmental document that covers the proposed project, list the specific section and page numbers. The environmental document should have a CEQA notice such as a Notice of Determination (if an EIR) or a Notice of Intent to Adopt (if an ND/MND).

What Information Should be Included in the Project Description?

The CCR tit. 14, § 15124 of the CEQA Guidelines defines the types of information that should be included in a project description:

The description of the project shall contain the following information but should not supply extensive detail beyond that needed for evaluation and review of the environmental impact.

a) The precise location and boundaries of the proposed project shall be shown on a detailed map, preferably topographic. The location of the project shall also appear on a regional map.

b) A statement of objectives sought by the proposed project. A clearly written statement of objectives will help the lead agency develop a reasonable range of alternatives to evaluate in the EIR and will aid the decision makers in preparing findings or a statement of overriding considerations, if necessary. The statement of objectives should include the underlying purpose of the project.

c) A general description of the project's technical, economic, and environmental characteristics, considering the principal engineering proposals if any and supporting public service facilities.

d) A statement briefly describing the intended uses of the EIR.

    1. This statement shall include, to the extent that the information is known to the Lead Agency,

[4] See the WellSTAR CEQA User Guide on the CalGEM CEQA webpage for information on how to fill out the CEQA Information step in WellSTAR.
[5] NTO-2019-16-Compliance

A. A list of the agencies that are expected to use the EIR in their decision making, and

B. A list of permits and other approvals required to implement the project.

C. A list of related environmental review and consultation requirements required by federal, state, or local laws, regulations, or policies. To the fullest extent possible, the lead agency should integrate CEQA review with these related environmental review and consultation requirements.

2. If a public agency must make more than one decision on a project, all its decisions subject to CEQA should be listed, preferably in the order in which they will occur. On request, the Office of Planning and Research will provide assistance in identifying state permits for a project.

Project Name

Enter the project name as submitted to CalGEM. If there is an assigned CalGEM project number provided by CEQA Program staff, please include it here.

Operator Name

Identify the operator responsible for the proposed project.

Proposed Project

The information describing the proposed project shall address the following elements but should not supply more detail than needed to evaluate and review the potential environmental impacts of the proposed project. CCR tit. 14, § 15124.

Provide a statement of the proposed project objectives, purpose, and benefits. Examples of a proposed project purpose are enhancing or complying with safety measures, abandoning idle wells, or developing additional wells now and in the future. Describe, with quantifiable metrics, whether the proposed project would increase production and expand associated facilities (e.g., increase processing capacity, addition or expansion of flowlines, the addition of flares, or steam generation capacity).

Describe any change in the proposed project scope. Include information regarding any modification, expansion, or supplement to an existing permit (e.g., new wells drilled in an existing oil field, rework, abandonment of an existing well, or modification or expansion of a previously permitted project). If the proposed project is a modification or expansion from an earlier permit, briefly describe the original permit, the proposed changes, and the purpose of the proposed changes.

Describe the surface and subsurface activities. Use plain language (e.g., depth, geologic formations, or the vibration radius resulting from the proposed project) to describe the surface and subsurface activities associated with the proposed project.

Describe each phase of the proposed project. Include information to the extent feasible where details of each phase are not currently known or flushed out. Each phase includes timing, duration, equipment needed (e.g., construction, testing, completion, or operation), and associated construction activities (e.g., well pad, flow lines, new or widening access roads, or power poles).

Disclose, describe, and quantify existing and proposed development, exploration, construction activities. Include the level of disturbance as a direct and indirect result of proposed project activity (temporary and permanent). Provide acreage for temporary and permanent disturbance. Identify if the proposed project has an existing well pad(s), other facilities, or pipelines or if the ground surface is graded or developed. Describe the proposed water use, including quantity, source, source owner and water right, compliance with Groundwater Sustainability Plan(s), travel plan, and transportation method. Include transportation required for chemicals, equipment, and waste, and describe the disposition of all waste materials and the facility where the operator will manage them.

Underground Injection Control (UIC) - For UIC project applications, identify if the project application is for a new project, modification, or merger of multiple UIC projects. Give detailed information on previously approved Project Approval Letters (PALs) and the relationship to the proposed project.

For individual NOIs, identify if an NOI is part of an approved UIC project, a new project, or a modification and give the PAL number and when CalGEM approved the PAL. Upload a copy of the approved PAL in WellSTAR. Give detailed information on previously approved PALs and their relationship to the proposed project. NOIs that do not have an approved PAL may be placed on hold by CalGEM or returned to the operator by CalGEM.

Geothermal - For geothermal projects identify if the application is for exploratory wells (resource development) or field development of a geothermal power plant. Include discussion of new wells, reworks, and abandonment of wells for an existing power plant.

For geothermal NOIs not associated with geothermal power plants, explain the purpose of the well and if it is for commercial or personal use, and give detailed information on the proposed project.

Identify Best Management Practices (BMPs). This includes all BMPs intended to avoid or reduce any potential impact(s) on the environment that may result from the proposed project. Correlate all BMPs to each proposed activity.

Project Location

The operator should identify the city(-ies) and county(-ies) where a proposed project is located; whether all or part of the proposed project lies within incorporated city limits; whether the proposed project is within or extends beyond a designated oil field boundary.

Include all critical well locational details, such as the presence, distance, and location of nearby areas where the public may occur (e.g., dwellings, parks, schools, and businesses). CCR tit. 14, § 1720.

Environmental Setting

Describe the current environmental conditions in the proposed project area and the land use for the proposed project location and surrounding land use(s) (e.g., agricultural, residential, commercial, established oil field, hazardous waste facility, or other industrial processing or disposal).

When describing the proposed project site, expressly identify any known sensitive receptors (e.g., schools, parks and playgrounds, daycare centers, residences, hospitals, and nursing homes). If the operator identifies vegetation, indicate the acreage of vegetation to be cleared both temporarily and permanently. Include timelines that qualify as temporary and permanent and identify the permit and agency that approved the vegetation clearing if vegetation is already removed.

Disclose and describe all environmental, scenic, historical, and cultural resources that may be impacted by the proposed project activities (e.g., ecological resources such as threatened or endangered species and their habitat, species of concern and their habitat, and other public trust resources). Select a distance that captures the possible project impacts.

Where supplemental information on the environmental setting or incidental take permits exists (e.g., a biological assessment, consultation with fish and wildlife agencies), the operator is to provide it by uploading that information into WellSTAR or, in the case of a geothermal project, submit it with the initial application.

Images and Maps

When submitting images and maps clearly display the proposed project vicinity, features, and boundary; include all activities related to the proposed project. Information can be shown with aerial photos, images.

Outlining the proposed project in a bold border can help delineate the proposed project area. The maps or images should show the Public Land Survey System or latitude and longitude, a legend for features, a north arrow, a scale, and the date the operator created the map or captured the photo or image.

Notes

Provide citations and references for all statements and data in the proposed project description, supported by complete copies of the referenced materials as attachments.

Operators may find additional information on CEQA compliance at: https://www.conservation.ca.gov/calgem/CEQA or by contacting the CEQA Program at CEQA@conservation.ca.gov.

Exhibit R

L.A. City Planning Emails with Operators on CalGEM Permits

Edber Macedo <edber.macedo@lacity.org>

S-65 at San Vicente

5 messages

Ted Cordova <tcordova@ebresources.com> Fri, Jan 17, 2020 at 11:03 AM
To: Edber Macedo <edber.macedo@lacity.org>

Hi Edber,

Happy Friday to you. I hope you are doing well. I wanted to see if we have sign off on S-65 at San Vicente? Thanks for looking into for me.

Kind regards,

Ted

Edber Macedo <edber.macedo@lacity.org> Fri, Jan 17, 2020 at 12:34 PM
To: Ted Cordova <tcordova@ebresources.com>

Good afternoon Ted, thank you for checking in on this.

I had briefed Vanessa Soto on everything and she was going to follow up with the Chief ZA to get their review and insight. That happened right around the holidays so I think I just need to check in with them and see where they landed at for the sign-off. Vanessa is out today and I'm out Monday/Tuesday next week so I can get you the update next Wednesday.

Best,
Edber M.

[Quoted text hidden]

--

Edber Macedo
City Planning Associate
Los Angeles City Planning
200 N. Spring Street, Room 763
Los Angeles, CA. 90012
Planning4LA.org
T: (213) 978-1198

Ted Cordova <tcordova@ebresources.com> Fri, Jan 17, 2020 at 3:46 PM
To: Edber Macedo <edber.macedo@lacity.org>

Thank you Edber.

Have a great weekend,

Ted

[Quoted text hidden]

Edber Macedo <edber.macedo@lacity.org> Wed, Jan 29, 2020 at 3:48 PM
To: Ted Cordova <tcordova@ebresources.com>

Good afternoon Ted,

Thank you for your patience as we gather the information needed for an accurate assessment of the re-work at S-65. We have determined that the proposed scope of work involving re-casing will require the operator to file a Land Use Application for Gas Project Conditional Approval with our office. In accordance with the guidelines outlined in ZA Memo 133 and LAMC 13.01-H, the re-casing does trigger discretionary review with City Planning since it is "maintenance" to an existing well operation.

We are unable to sign-off on the CEQA Operator Checklist at this time and would only be able to do so until after we process your application & assign it the appropriate CEQA level of review. Please let me know when you're available to talk or if you could direct me to the staff at E&B so I can explain next steps on filing.

Cordially,
Edber M.
[Quoted text hidden]

ZA MEMO 133.pdf
988K

Ted Cordova <tcordova@ebresources.com> Thu, Jan 30, 2020 at 2:07 PM
To: Edber Macedo <edber.macedo@lacity.org>

Hi Edber,

I hope all is well with you. I am on the heels of my voice message to you. Let me know when it is a good time to reach you. I can be reached at 310-489-4972

Thanks,
Ted

[Quoted text hidden]

Edber Macedo <edber.macedo@lacity.org>

WTU Central - CEQA

7 messages

Ana Tovar <atovar@warrenresources.com> Tue, Mar 29, 2022 at 4:43 PM
To: Edber Macedo <edber.macedo@lacity.org>
Cc: Kevin McCoy <kmccoy@warrenresources.com>

Good Afternoon,

Attached is a CEQA Project description for three wells inside our WTU facility.

Please let me know if you require any additional information or have any questions.

Thanks!

Ana D. Tovar
Senior Engineering Technician
Warren E&P, Inc.

625 E. Anaheim Street | Wilmington, CA 90744

Cell 310-991-9233

Fax 310-549-1911

http://www.warrenresources.com

CEQAOperatorChecklist-Program Description_2022-03-28.pdf
839K

Edber Macedo <edber.macedo@lacity.org> Wed, Mar 30, 2022 at 9:10 AM
To: Ana Tovar <atovar@warrenresources.com>
Cc: Kevin McCoy <kmccoy@warrenresources.com>

Good morning Ana,

Thank you for the email. I will review this over today and try to get back to you by Friday at the latest.

Best,
Edber
[Quoted text hidden]
--

Edber Macedo (he/him)
City Planning Associate

LOS ANGELES CITY PLANNING

Los Angeles City Planning
200 N. Spring St., Room 763
Los Angeles, CA 90012
T: (213) 978-1198| Planning4LA.org
E-NEWS

Edber Macedo <edber.macedo@lacity.org> Mon, Apr 4, 2022 at 11:27 AM
To: Ana Tovar <atovar@warrenresources.com>
Cc: Kevin McCoy <kmccoy@warrenresources.com>

Good morning Ana,

Thank you again for sending over the CEQA operator form with the proposed scope of work. After reviewing the project, my office has determined that the Rework project description qualifies as "well maintenance" and pursuant to LAMC Section 13.01-H & -I that Warren E&P will need to file a formal application with the Department of City Planning. See the LAMC titled document attached for the code section language.

I am personally available to walk you through this process and assist in any way that I can. As a discretionary review, there will be a CEQA clearance assigned to the project and if a Zoning Administrator (the city's land use decision-maker in this instance) approves your project, there may be Conditions of Approval associated with the project, similar to when a NOI is approved by CalGEM. I am attaching a document titled ZA Memo No. 133 that outlines the application requirements and then a separate folder with the actual City Planning application documents.

Let me know if you have questions, happy to jump on a call.

Cordially,
Edber
[Quoted text hidden]

---

3 attachments

ZA Memo.133 (1).pdf
592K

L.A. City Planning app documents.zip
1123K

LAMC 13.01 - Oil Drilling (2).pdf
214K

Ana Tovar <atovar@warrenresources.com> Wed, Apr 6, 2022 at 6:18 PM
To: Edber Macedo <edber.macedo@lacity.org>
Cc: Kevin McCoy <kmccoy@warrenresources.com>

Hello,

Sorry for the delayed response, I was out sick the past two days.

I will ask our Agent how he would like to proceed.

Side question, I am drafting another CEQA but this one is for an abandonment in our Wilmington Townlot Unit. Would an abandonment warrant a similar process?

I can provide additional information if needed.

Thanks for your reply,

Ana D. Tovar
Senior Engineering Technician
Warren E&P, Inc.

625 E. Anaheim Street | Wilmington, CA 90744

Cell 310-991-9233

Fax 310-549-1911

http://www.warrenresources.com

From: Edber Macedo [mailto:edber.macedo@lacity.org]
Sent: Monday, April 04, 2022 11:28 AM
To: Ana Tovar <atovar@warrenresources.com>
Cc: Kevin McCoy <kmccoy@warrenresources.com>
Subject: Re: WTU Central - CEQA

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Good morning Ana,

Thank you again for sending over the CEQA operator form with the proposed scope of work. After reviewing the project, my office has determined that the Rework project description qualifies as "well maintenance" and pursuant to LAMC Section 13.01-H & -I that Warren E&P will need to file a formal application with the Department of City Planning. See the LAMC titled document attached for the code section language.

I am personally available to walk you through this process and assist in any way that I can. As a discretionary review, there will be a CEQA clearance assigned to the project and if a Zoning Administrator (the city's land use decision-maker in this instance) approves your project, there may be Conditions of Approval associated with the project, similar to when a NOI is approved by CalGEM. I am attaching a document titled ZA Memo No. 133 that outlines the application requirements and then a separate folder with the actual City Planning application documents.

Let me know if you have questions, happy to jump on a call.

Cordially,

Edber

On Wed, Mar 30, 2022 at 9:10 AM Edber Macedo <edber.macedo@lacity.org> wrote:

> Good morning Ana,
>
> Thank you for the email. I will review this over today and try to get back to you by Friday at the latest.
>
> Best,
>
> Edber
>
> On Tue, Mar 29, 2022 at 4:43 PM Ana Tovar <atovar@warrenresources.com> wrote:
>
> > Good Afternoon,
> >
> > Attached is a CEQA Project description for three wells inside our WTU facility.
> >
> > Please let me know if you require any additional information or have any questions.
> >
> > Thanks!
> >
> > **Ana D. Tovar**
> > Senior Engineering Technician
> > *Warren E&P, Inc.*
> >
> > 625 E. Anaheim Street | Wilmington, CA 90744
> >
> > Cell 310-991-9233
> >
> > Fax 310-549-1911
> >
> > http://www.warrenresources.com

--

Edber Macedo (he/him)

City Planning Associate
Los Angeles City Planning

200 N. Spring St., Room 763

Los Angeles, CA 90012

T: (213) 978-1198| Planning4LA.org

--

Edber Macedo (he/him)

City Planning Associate
Los Angeles City Planning

200 N. Spring St., Room 763

Los Angeles, CA 90012

T: (213) 978-1198| Planning4LA.org

Edber Macedo <edber.macedo@lacity.org> Thu, Apr 7, 2022 at 7:44 AM
To: Ana Tovar <atovar@warrenresources.com>
Cc: Kevin McCoy <kmccoy@warrenresources.com>

Good morning Ana, I hope you are feeling better.

For abandonment projects, the Local Agency (Planning) does not require CEQA review nor does it require operators to apply for a discretionary review. Well abandonment is a ministerial project in the City of L.A.

Sincerely,
Edber
[Quoted text hidden]
--

Edber Macedo (he/him)
City Planning Associate
Los Angeles City Planning
200 N. Spring St., Room 763
Los Angeles, CA 90012
T: (213) 978-1198| Planning4LA.org

Ana Tovar <atovar@warrenresources.com> Tue, Apr 12, 2022 at 4:37 PM
To: Edber Macedo <edber.macedo@lacity.org>
Cc: Kevin McCoy <kmccoy@warrenresources.com>

Good Afternoon Edber,

I discussed this matter with our team. At this point in time, we don't plan on proceeding with the proposed work for the wells listed in the WTU Central- CEQA.

And as previously agreed upon, I will notify your office of any future abandonments.

Thank you for looking in to this matter,

[Quoted text hidden]

Edber Macedo <edber.macedo@lacity.org> Thu, Apr 14, 2022 at 7:00 AM
To: Ana Tovar <atovar@warrenresources.com>
Cc: Kevin McCoy <kmccoy@warrenresources.com>

Good morning Ana,

I understand. Please let me know if things change and I'd happy to walk your team through the application process and answer any questions.

Kind regards,
Edber
[Quoted text hidden]
--

LOS ANGELES CITY PLANNING

Edber Macedo (he/him)
City Planning Associate
Los Angeles City Planning
200 N. Spring St., Room 763
Los Angeles, CA 90012
T: (213) 978-1198| Planning4LA.org
E-NEWS

Edber Macedo <edber.macedo@lacity.org>

CEQA Project Description - WTU 1911i

9 messages

Ana Tovar <atovar@warrenresources.com> Fri, Sep 9, 2022 at 2:37 PM
To: Edber Macedo <edber.macedo@lacity.org>
Cc: Kevin McCoy <kmccoy@warrenresources.com>

Good Afternoon,

Attached is the project description for the injector WTU 1911i located in our WTU Main Facility.

Per CalGEM, we are seeking approval of this CEQA Project Description.

If you have any additional questions feel free to reach out to Kevin McCoy.

Thanks and have a great weekend,

Ana D. Tovar
Senior Engineering Technician
Warren E&P, Inc.

625 E. Anaheim Street | Wilmington, CA 90744

Cell 310-991-9233

Fax 310-549-1911

http://www.warrenresources.com

CEQA-Program Description_WTU 1911_2022-09-09.pdf
2629K

Edber Macedo <edber.macedo@lacity.org> Fri, Sep 9, 2022 at 5:09 PM
To: Ana Tovar <atovar@warrenresources.com>
Cc: Kevin McCoy <kmccoy@warrenresources.com>

Good afternoon Ana,

Thank you for your email. I anticipate reviewing the checklist and its content by next week and will follow up shortly thereafter.

Sincerely,
Edber
[Quoted text hidden]

--

Edber Macedo (he/him)
City Planner
Los Angeles City Planning
200 N. Spring St., Room 763
Los Angeles, CA 90012
T: (213) 978-1198| Planning4LA.org
E-NEWS

Edber Macedo <edber.macedo@lacity.org> Fri, Sep 16, 2022 at 3:08 PM
To: Ana Tovar <atovar@warrenresources.com>
Cc: Kevin McCoy <kmccoy@warrenresources.com>

Good afternoon Ana,

I have reviewed the project description and I have a question regarding the scope.

The project description on page 4 reads as this is for a Rework permit, but the Abandon/Re-Abandon box is checked off on the first page. Can you please clarify this discrepancy?

Thank you,
Edber

[Quoted text hidden]

Ana Tovar <atovar@warrenresources.com> Wed, Oct 5, 2022 at 4:12 PM
To: Edber Macedo <edber.macedo@lacity.org>
Cc: Kevin McCoy <kmccoy@warrenresources.com>

Good Afternoon Edber,

I apologize for the late response.

Speaking to our staff, they state that this is not a rework since we only moved the existing retrievable packer in the hole. There was no change in the casing of the well.

I do not believe any of the boxes apply to the work.

I erroneously checked the “Abandonment” box.

Please let us know if you have any additional questions.

Thanks,

Ana D. Tovar
Senior Engineering Technician
Warren E&P, Inc.

625 E. Anaheim Street | Wilmington, CA 90744

Cell 310-991-9233

Fax 310-549-1911

http://www.warrenresources.com

From: Edber Macedo <edber.macedo@lacity.org>
Sent: Friday, September 16, 2022 3:08 PM
To: Ana Tovar <atovar@warrenresources.com>
Cc: Kevin McCoy <kmccoy@warrenresources.com>
Subject: Re: CEQA Project Description - WTU 1911i

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Good afternoon Ana,

I have reviewed the project description and I have a question regarding the scope.

The project description on page 4 reads as this is for a Rework permit, but the Abandon/Re-Abandon box is checked off on the first page. Can you please clarify this discrepancy?

Thank you,

Edber

On Fri, Sep 9, 2022 at 5:09 PM Edber Macedo <edber.macedo@lacity.org> wrote:

> Good afternoon Ana,
>
> Thank you for your email. I anticipate reviewing the checklist and its content by next week and will follow up shortly thereafter.

Sincerely,

Edber

On Fri, Sep 9, 2022 at 2:38 PM Ana Tovar <atovar@warrenresources.com> wrote:

> Good Afternoon,
>
> Attached is the project description for the injector WTU 1911i located in our WTU Main Facility.
>
> Per CalGEM, we are seeking approval of this CEQA Project Description.
>
> If you have any additional questions feel free to reach out to Kevin McCoy.
>
> Thanks and have a great weekend,
>
> **Ana D. Tovar**
> Senior Engineering Technician
> *Warren E&P, Inc.*
>
> 625 E. Anaheim Street | Wilmington, CA 90744
>
> Cell 310-991-9233
>
> Fax 310-549-1911
>
> http://www.warrenresources.com

--

Edber Macedo (he/him)

City Planner
Los Angeles City Planning

200 N. Spring St., Room 763

Los Angeles, CA 90012

T: (213) 978-1198| Planning4LA.org

--

Edber Macedo (he/him)

City Planner
Los Angeles City Planning

200 N. Spring St., Room 763

Los Angeles, CA 90012

T: (213) 978-1198| Planning4LA.org

Edber Macedo <edber.macedo@lacity.org> Wed, Oct 5, 2022 at 4:59 PM
To: Ana Tovar <atovar@warrenresources.com>
Cc: Kevin McCoy <kmccoy@warrenresources.com>

Thank you for clarifying. I will circle back with a determination by the week of 10/17.

Sincerely,
Edber

[Quoted text hidden]

--

LOS ANGELES CITY PLANNING

Edber Macedo (he/him)
City Planner
Los Angeles City Planning
200 N. Spring St., Room 763
Los Angeles, CA 90012
T: (213) 978-1198| Planning4LA.org

E-NEWS

Kevin McCoy <kmccoy@warrenresources.com> Fri, Oct 21, 2022 at 7:02 AM
To: Edber Macedo <edber.macedo@lacity.org>, Ana Tovar <atovar@warrenresources.com>
Cc: Kevin McCoy <kmccoy@warrenresources.com>

Edber:

Just following up with reference to the following email from you back at the beginning of the month.

Has any decision been made wrt WTU 1911i?

Kevin McCoy, PE
Petroleum Engineering Manager/Agent

Warren Resources/Warren E&P, Inc.

625 E. Anaheim Street

Wilmington, CA 90744

Mobile 713-252-4519

[Quoted text hidden]

Edber Macedo <edber.macedo@lacity.org> Fri, Oct 21, 2022 at 2:52 PM
To: Kevin McCoy <kmccoy@warrenresources.com>
Cc: Ana Tovar <atovar@warrenresources.com>, Kevin McCoy <kmccoy@warrenresources.com>

Good afternoon Kevin and Ana,

Thank you for your patience.

After reviewing the project's scope of work, my office has determined that the Rework project is permitted in the underlying zone and may be reviewed for conditional approval. The Rework project qualifies as "well maintenance" and pursuant to LAMC Section 13.01-H & -I. This means that Warren E&P will need to file a formal application with the Department of City Planning. See the LAMC titled PDF doc that is attached for the code section language for LAMC 13.01-H and -I.

I am personally available to walk you through this process, provide an overview, and/or walk you through the application steps. As a discretionary review, there will be need to be a CEQA clearance assigned to the project and if a Zoning Administrator (the city's land use decision-maker in this instance) approves your project, there may be Conditions of Approval associated with the project, similar to when a NOI is approved by CalGEM. If an approval is issued, then the project's CEQA clearance is what I would use to sign off on the CEQA Operator Checklist. I am attaching a PDF titled ZA Memo No. 133 that outlines the application requirements and then a separate folder with the actual City Planning application documents.

Let me know if you have questions, happy to jump on a call.

Cordially,
Edber
[Quoted text hidden]

---

3 attachments

ZA Memo.133 PDF.pdf
592K

LAMC 13.01 - Oil Drilling PDF.pdf
214K

L.A. City Planning application materials for Oil.zip
1123K

Kevin McCoy <kmccoy@warrenresources.com> Mon, Oct 24, 2022 at 8:52 AM
To: Edber Macedo <edber.macedo@lacity.org>
Cc: Ana Tovar <atovar@warrenresources.com>, Kevin McCoy <kmccoy@warrenresources.com>, Greg Fox <gfox@warrenresources.com>, "James A. Watt" <jawatt@warrenresources.com>

Dear Edber:

I am in receipt of your email dated October 21, 2022, and have a number of questions as a result.

The city once again has refused Warren the ability to conduct normal business operations as is required for a going concern. The City, it would seem, believes that they have final control and authority over Oil and Gas Operations, whereas the state agency, California Geologic Energy Management Division (CalGEM), was created by the state to provide oversight of the oil, natural gas, and geothermal industries, while working to help California achieve its climate change and clean energy goals. CalGEM administers state regulations for the permitting, drilling, inspecting, testing, and sealing of these wells. The Environmental Protection Agency (EPA) has delegated primacy authority over oil and gas injection wells—categorized as Class II injection wells —to the CalGEM UIC Program. Authority of this programme was *not given or assigned* to the City of Los Angeles City Planning.

With reference to your comment that there will be need to be a CEQA clearance assigned to the project and if a Zoning Administrator (the city's land use decision-maker in this instance) approves your project, there may be Conditions of Approval associated with the project, similar to when a NOI is approved by CalGEM, Warren has a valid CEQA document that covers operations at the Wilmington facility. An environmental document does not have a "use by date" or an expiration date, therefore, Warren does not need to apply for, conduct or obtain any clearance related to CEQA.

The Final Subsequent Mitigated Negative Declaration for: Warren E&P, Inc. WTU Central Facility, New Equipment Project State Clearinghouse No. 2006041043, was approved July 2011. With reverence to said document, "*The Project's emissions and ambient air quality impacts are below the SCAQMD's thresholds for all criteria air pollutants. No significant adverse air quality impacts are expected, either individually or cumulatively. Therefore, the Project is not expected to result in significant adverse cumulative impacts pursuant to CEQA Guidelines Section 15130(a)(2)*". No expiry date is stated, therefore the MND is in force and operationally Warren does not need City Planning approval via the Zoning Administrator.

Warren contacted City Planning at the behest of CalGEM regarding WTU 1911 so as to obtain approval for a simple standard annular pressure test with is required to place an injector back on injection per: *§1724.10.1. Mechanical Integrity Testing Part One – Casing Integrity …… the repositioning or replacement of downhole equipment, or whenever requested by the Division.* Warren only repositioned the packer which by any normal and customary oilfield understanding is a workover, which is typically defined as the repair of an existing well.

If my understanding of the various petroleum terms is incorrect, please enlighten me as the actual terms and definitions as used by City Planning. Without the specificity of those terms, any arguments put forth by City Planning is moot.

Warren does not believe that Los Angeles City Planning has the authority to regulate injectors, as Class II wells fall under the authority of the Environmental Protection Agency which delegated primacy to CalGEM and not the City of Los Angeles. CalGEM requesting that Warren contact LA City Planning is in error given LA City Planning has no authority in this matter.

WTU 1911i is not a Rework Project. It is normal well work operations as required by a regulatory agency. Once again, I request approval to place the well back (only because of CalGEM's insistence and not that City Planning has authority over Class II injection wells) on injection.

[Quoted text hidden]

Edber Macedo <edber.macedo@lacity.org> Tue, Oct 25, 2022 at 5:22 PM

To: Kevin McCoy <kmccoy@warrenresources.com>

Good afternoon Kevin,

Thank you for your email.

My office has identified the path forward for your team to carry your scope of work through the proper land use review and possible approval so your team can complete the project. CalGEM redirects operators to receive CEQA review from the local agency, my office, and Planning has determined that this project requires CEQA clearance. The project description for the aforementioned 2006 MND does not reference rework activities as part of its scope of environmental review.

Please see my email dated October 21, 2022 for steps on how to proceed with a City Planning question so that a Zoning Administrator may review your project and, if approved, issue a CEQA clearance that would allow my office to sign off on your CEQA Operator Checklist for this Rework project.

Sincerely,
Edber
[Quoted text hidden]

Exhibit S

Correspondence on

Well Maintenance & Land Use Impacts

Edber Macedo <edber.macedo@lacity.org>

5/27 | Unpermitted Acid Maintenance Job at the Murphy Drill Site

Erica Blyther <erica.blyther@lacity.org> Thu, May 27, 2021 at 11:07 AM
To: Richard Parks <richard@redeemercp.org>
Cc: Fernando Campos <fernando.campos@lacity.org>, Edber Macedo <edber.macedo@lacity.org>, Angela Johnson Meszaros <ameszaros@earthjustice.org>, Byron Chan <bchan@earthjustice.org>, Kartik Raj <kraj@earthjustice.org>, Brittney Lu <brittney@redeemercp.org>

Hello Richard,

I had a conversation with Ted Cordova of E&B. He confirmed that there is an acid job occuring at Murphy on an injector well. He's talked to his engineers and air quality specialists and their interpretation is that since the work is on an injector well, it does not require the permitting that is needed for an oil or gas producing well. However this work will be reported to CalGEM at the end of the year.
He will follow-up with me on the volumes of acid used on this project. He is also happy to talk to the community if there are any concerns and wanted to share his phone number with you 310-489-4972.

Separately I am following up with the AQMD rules team to get their interpretation. In looking at 1148.2 definitions under 16 (http://www.aqmd.gov/docs/default-source/rule-book/reg-xi/rule-1148-2.pdf?sfvrsn=6), it looks like 1148.2 notifications should apply to injectors (a well into which fluids are injected).

I will also follow-up with CalGEM and see if they have the same interpretation on oil well versus injector well.

Thank you for reaching out on this.

I will be in touch,

Erica

On Thu, May 27, 2021 at 10:10 AM Richard Parks <richard@redeemercp.org> wrote:
> Dear Ms. Blyther,
> Thank you for your email. FYI, the
> operator has now set out signs warning "DANGER HIGH PRESSURE CHEMICALS IN USE". Red caution tape now encircles the trucks. Final preparations are under way for releasing the acid.
>
> Thank you for your help.
>
> Kind Regards,
> Richard
>
> On Thu, May 27, 2021, 9:48 AM Erica Blyther <erica.blyther@lacity.org> wrote:
>> Hi Richard,
>>
>> Thanks. Let me call E&B and ask about this.
>>
>> Thanks,
>>
>> Erica
>>
>> On Thu, May 27, 2021 at 9:34 AM Richard Parks <richard@redeemercp.org> wrote:
>>> Good morning Ms. Blyther,
>>> I hope you are well. Congratulations on your appointment as Petroleum Administrator. We look forward to working with you.



Right now, E&B is preparing to conduct an unpermitted acid maintenance job at the Murphy Drill Site, located at 2126 W. Adams Blvd. Are you able to intervene to stop it before the acid flows?

Kind regards,
Richard Parks

--
President
Redeemer Community Partnership

PO BOX 180499
Los Angeles, CA 90018
(323) 285-1949
www.redeemercp.org



--

Erica Blyther, MS, REHS
Petroleum Administrator
Office of Petroleum and Natural Gas Administration
City of Los Angeles | Department of Public Works
200 N. Spring Street, Rm 358 (MS 465)
Los Angeles, CA 90012
O: (213) 978-2679

--

Erica Blyther, MS, REHS
Petroleum Administrator
Office of Petroleum and Natural Gas Administration
City of Los Angeles | Department of Public Works
200 N. Spring Street, Rm 358 (MS 465)
Los Angeles, CA 90012
O: (213) 978-2679

Edber Macedo <edber.macedo@lacity.org>

5/27 | Unpermitted Acid Maintenance Job at the Murphy Drill Site

Richard Parks <richard@redeemercp.org> Thu, May 27, 2021 at 11:21 AM
To: Erica Blyther <erica.blyther@lacity.org>
Cc: Fernando Campos <fernando.campos@lacity.org>, Edber Macedo <edber.macedo@lacity.org>, Angela Johnson Meszaros <ameszaros@earthjustice.org>, Byron Chan <bchan@earthjustice.org>, Kartik Raj <kraj@earthjustice.org>, Brittney Lu <brittney@redeemercp.org>

Dear Ms. Blyther,
Thank you for the update. You are correct that the clear language of Rule 1148.2 applies to all wells. However, SCAQMD staff have capriciously decided to exempt injectors.

The issue here is that the Planning Department's Memorandum 133 requires a determination of conditions for well maintenance. This includes acid well maintenance. E&B did not seek the OZA's approval nor did it receive conditions. Therefore, this acid job is unpermitted and illegal according to the City's own rules. It should not be allowed to proceed.

Again, thank you for your help.

Kind regards,
Richard
[Quoted text hidden]

Edber Macedo <edber.macedo@lacity.org>

5/27 | Unpermitted Acid Maintenance Job at the Murphy Drill Site

Richard Parks <richard@redeemercp.org> Thu, May 27, 2021 at 12:26 PM
To: Erica Blyther <erica.blyther@lacity.org>
Cc: Fernando Campos <fernando.campos@lacity.org>, Edber Macedo <edber.macedo@lacity.org>, Angela Johnson Meszaros <ameszaros@earthjustice.org>, Byron Chan <bchan@earthjustice.org>, Kartik Raj <kraj@earthjustice.org>, Brittney Lu <brittney@redeemercp.org>

Dear Ms. Blyther,
Following up, I wanted to offer a correction. LAMC 13.01-H Drilling Site Requirements requires a determination of conditions for any operator desiring to maintain an oil well--not Memo 133 as I had stated earlier. LAMC 13.01-H reads,

> "Any person desiring to drill, deepen or maintain an oil well in an oil drilling district...shall file an application in the Department of City Planning on a form provided by the Department, requesting a determination of the conditions under which the operations may be conducted."

E&B did not file an application for a determination of conditions. Therefore, this acid job is illegal.

Sorry for any confusion. Again, thank you for your help.

Kind regards,
Richard
[Quoted text hidden]
--
[Quoted text hidden]

Edber Macedo <edber.macedo@lacity.org>

5/27 | Unpermitted Acid Maintenance Job at the Murphy Drill Site

Edber Macedo <edber.macedo@lacity.org> Wed, Jun 2, 2021 at 11:34 AM
To: Richard Parks <richard@redeemercp.org>
Cc: Erica Blyther <erica.blyther@lacity.org>, Angela Johnson Meszaros <ameszaros@earthjustice.org>, Brittney Lu <brittney@redeemercp.org>, Byron Chan <bchan@earthjustice.org>, Fernando Campos <fernando.campos@lacity.org>, Kartik Raj <kraj@earthjustice.org>, Estineh Mailian <estineh.mailian@lacity.org>, Vanessa Soto <vanessa.soto@lacity.org>

Good morning Richard,

Thank you for your email and for the photographic documentation of the activity & work that occurred/is occurring at the drill site. We will be reviewing this material. Thank you.

Cordially,
Edber
[Quoted text hidden]
[Quoted text hidden]

Exhibit T

Correspondence to Operator

Concerning Maintenance Acidizing

OFFICE OF ZONING ADMINISTRATION
200 N. SPRING STREET, ROOM 763
LOS ANGELES, CA 90012-4801
(213) 978-1318

ESTINEH MAILIAN
CHIEF ZONING ADMINISTRATOR

ASSOCIATE ZONING ADMINISTRATORS
JACK CHIANG
HENRY CHU
JONATHAN A. HERSHEY, AICP
THEODORE L. IRVING, AICP
CHARLES J. RAUSCH JR.
CHRISTINA TOY LEE

CITY OF LOS ANGELES
CALIFORNIA

ERIC GARCETTI
MAYOR

LOS ANGELES DEPARTMENT
OF CITY PLANNING
EXECUTIVE OFFICES

VINCENT P. BERTONI, AICP
DIRECTOR

KEVIN J. KELLER, AICP
EXECUTIVE OFFICER

SHANA M.M. BONSTIN
DEPUTY DIRECTOR

ARTHI L. VARMA, AICP
DEPUTY DIRECTOR

LISA M. WEBBER, AICP
DEPUTY DIRECTOR

planning.lacity.org

July 28, 2021

E & B Natural Resources (Op)
1608 Norris Road
Bakersfield, CA 93308
Attention: Ted Cordova

CASE NO. ZA-15227-O-PA4
LETTER OF COMMUNICATION
2126 West Adams Boulevard
South Los Angeles Community Plan
Zone: [Q] R4-1-O-HPOZ
D.M.: 123B193
C.D: 10 -- Ridley-Thomas
Legal Description: Lot A, P M 1641

Mr. Cordova,

The Department of City Planning was informed of work activities that occurred on May 27 and May 28, 2021 at 2126 West Adams Boulevard (commonly known as the Murphy Drill Site). The Department requests that you provide an explanation of the scope of work that occurred on May 27 through May 28, 2021.

Recent Activities at the Drill Site

The Department of City Planning was provided with photographic evidence and testimony that allegedly depict substantial oil extraction, maintenance, and/or production occurring at the Murphy Drill Site starting on May 27, 2021. The photographic evidence shows workers, heavy machinery, and large tanker trucks present at the subject property.

The Department is concerned that the activity conducted at the site may qualify as well maintenance and could potentially be a violation of LAMC Section 13.01-H as illustrated here:

> *H. Drilling Site Requirements. Any person desiring to drill, deepen or maintain an oil well in an oil drilling district that has been established by ordinance, or to drill or deepen and subsequently maintain an oil well in the M3 Zone within 500 feet of a more restrictive zone shall file an application in the Department of City Planning on a form provided by the Department, requesting a determination of the conditions under which the operations may be conducted. (Para. Amended by Ord. No. 173,492, Eff. 10/10/00.)*

Instructions to Drill Site Operator

The Department requests that E&B Natural Resources provide a description of the work completed at the site on May 27 and May 28, 2021. This description shall include information regarding the following:

- Presence of large tanker trucks
- Permits secured for the scope of work
- Type of heavy machinery and equipment used
- Number of crew required for the scope of work
- Duration of the work activity, including times and dates of commencement and completion
- Volume and type of materials and/or chemicals used
- Identification of all well(s) involved in this activity

The Department requests a response within 60 calendar days from when this letter is dated. If you have any questions regarding this matter, please contact the Office of Zoning Administration. Initial communication should be directed to Edber Macedo at (213) 978-1198 or at edber.macedo@lacity.org.

ESTINEH MAILIAN
Chief Zoning Administrator

EM:VS:ecm

Cc: Councilmember Ridley-Thomas, Tenth Council District
Jennifer Tobkin, Office of the City Attorney
Captain Diana Igawa, Los Angeles Fire Department
Osama Younan, Los Angeles Department of Building and Safety
Erica Blyther, Office of Petroleum and Natural Gas Administration and Safety
Roman Catholic Archdiocese of Los Angeles, Property Owner
Richard Parks, Redeemer Community Partnership

Attachments: ZA-15227-O-PA4 determination, dated 09/14/2007
Photographic Evidence Submitted to City Planning for May 27-28, 2021 Oil Well Activity

Attachment 1: Photographic Evidence of Activity at Murphy Drill Site, 5/27-5/28, 2021



Attachment 1: Photographic Evidence of Activity at Murphy Drill Site, 5/27-5/28, 2021



Attachment 1: Photographic Evidence of Activity at Murphy Drill Site, 5/27-5/28, 2021



Exhibit U

Well Maintenance Project & “Odor Event”

Reference Document

South Coast Air Quality Management District

NC E51096

Run Date : 7/20/2021 07:44:03

Company

Facility:	E&B NATURAL RESOURCES MANAGEMENT CORP (ID: 191119)
Location Address:	2126 W ADAMS, BLVD LOS ANGELES, CA 90018-2039
Mailing Address:	1608 NORRIS, RD BAKERSFIELD, CA 93308
AIRS ID	

Violation

Notice Issued Date:	6/9/2021
Violation Date:	6/4/2021
Serve To:	GILBERT ALFEREZ
Title:	PRODUCTION SUPERVISOR
Issue By:	JARLATH GREANEY (Team: Z)
Assignment No.:	1910614
Compliance Achieved Date:	07/09/2021
Equipment Description:	Crude oil production well 'Murphy_23.'
Compliance Requirements:	Conduct a specific cause analysis for the 6/4/2021 confirmed odor event and submit the specific cause analysis report as required by rule 1148.1(f).

Disposition

Final Action Code:	
Due Date:	7/10/2021
Violation Days:	0

Rule/Comment

1148.1 (f)

Emittent

Follow-Up

Status: INCOMP Inspector ID: JG04 Inspection Date: 07/09/21 00:00 Number:

Device IDs.

Inspector Comment

INSPECTOR: _____ DATE: _____
signature

SUPERVISOR: _____ DATE: _____
signature

User ID: lramos

NATURAL RESOURCES

1608 Norris Road • Bakersfield, CA 93308

Jarlath Greaney
South Coast Air Quality Management District
21865 Copley Drive
Diamond Bar, CA 91765

RE: **Compliance with Notice to Comply No. E51096**

Dear Mr. Greaney:

I am pleased to submit this Specific Cause Analysis Report prepared for Notice to Comply No. E51096.

Background
On June 3, 2021, E&B Natural Resources Management Corporation (E&B) conducted well servicing at its Murphy facility located at 2126 W Adams Ave, Los Angeles, CA 90018. A workover rig and crew removed rods and tubing from Well M-23. In accordance with South Coast Air Quality Management District (SCAQMD) Rule 1148.1, a rubber grommet was used to remove excess fluid from the rods and tubing, and a plastic sheet was placed in the cellar to catch any oil that might have otherwise dropped into the cellar around M-23's wellhead.

The well was shut-in overnight, and servicing was completed the following day with the reinstallation of rods and tubing. There were no spills or leaks from the well during servicing, nor were there spills or leaks from any other equipment at the facility.

Murphy's fenceline monitors measured 0 ppm H2S, 0 ppm CO, and 0 ppm VOC throughout the two days of well servicing. The monitoring data is attached to this report.

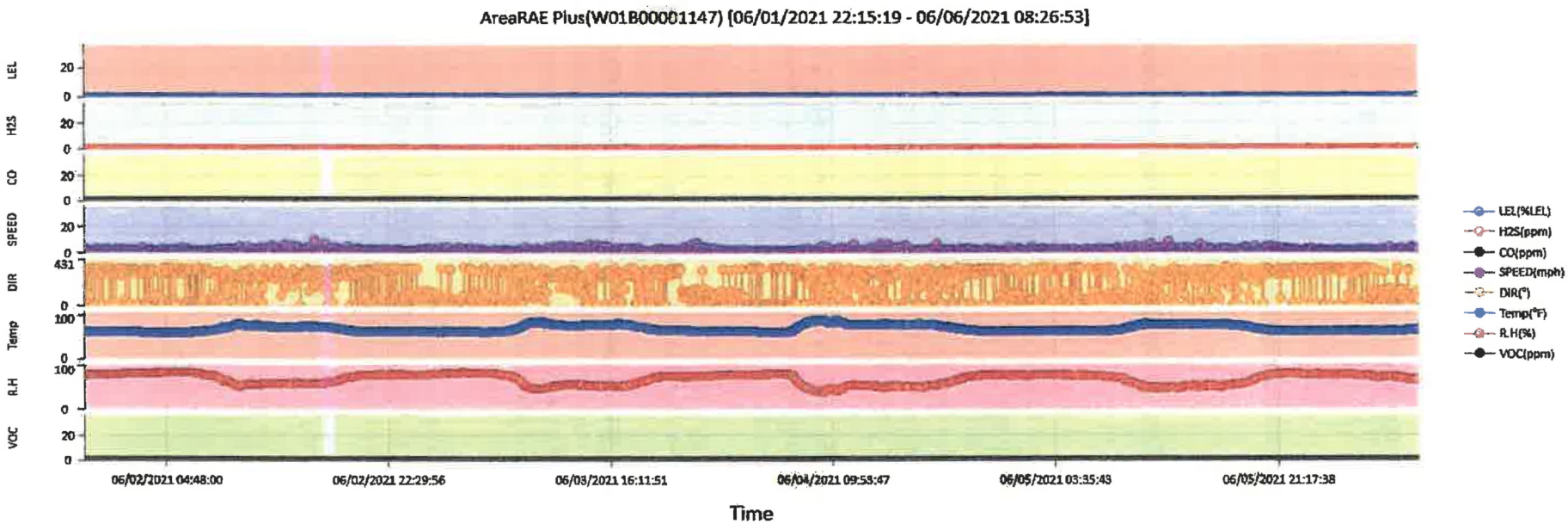
While the fenceline monitors did not detect H2S or VOC, SCAQMD stated that the Murphy facility was the source of the odor described in the complaints that SCAQMD received on June 4, 2021. It is possible that the servicing of Well M-23 was the cause of the odor detected by SCAQMD. All other equipment was operating normally.

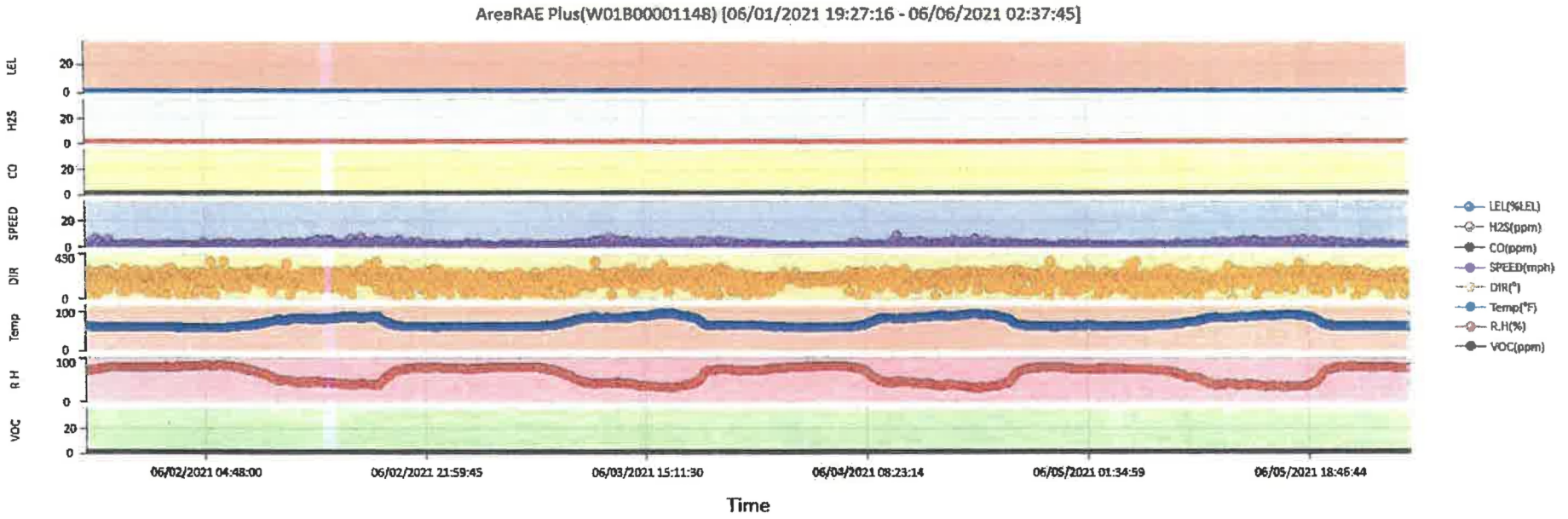
Corrective Action
E&B has purchased and installed an aromatic diffuser system to mitigate any future odors that might occur, and has put a procedure in place to ensure that the odor control system is activated for the entire duration of all future well servicing work at the Murphy facility.

Should you have any questions or desire additional information, please do not hesitate to contact me at (562) 522-5016.

Sincerely,

Christopher Hassler
Environmental Coordinator


AreaRAE Plus(W01B00001147) [06/01/2021 22:15:19 - 06/06/2021 08:26:53]
LEL
H2S
CO
SPEED
DIR
Temp
R.H
VOC
20
0
431
100
06/02/2021 04:48:00
06/02/2021 22:29:56
06/03/2021 16:11:51
06/04/2021 09:53:47
06/05/2021 03:35:43
06/05/2021 21:17:38
Time
LEL(%LEL)
H2S(ppm)
CO(ppm)
SPEED(mph)
DIR(°)
Temp(°F)
R.H(%)
VOC(ppm)


AreaRAE Plus(W01B00001148) [06/01/2021 19:27:16 - 06/06/2021 02:37:45]
LEL
H2S
CO
SPEED
DIR
Temp
R.H
VOC
20
0
450
100
06/02/2021 04:48:00
06/02/2021 21:59:45
06/03/2021 15:11:30
06/04/2021 08:23:14
06/05/2021 01:34:59
06/05/2021 18:46:44
Time
LEL(%LEL)
H2S(ppm)
CO(ppm)
SPEED(mph)
DIR(°)
Temp(°F)
R.H(%)
VOC(ppm)

Edber Macedo <edber.macedo@lacity.org>

South Coast AQMD Inspections // Question from City Agency

3 messages

Edber Macedo <edber.macedo@lacity.org> Tue, Apr 20, 2021 at 8:16 AM
To: Bullington Pham <BPham@aqmd.gov>

Hi Inspector Pham, I hope this message finds you in good health and spirits.

My name is Edber and I work at the Planning Department for the City of Los Angeles. I work on land use and oil/gas issues for the city. We spoke several months ago in 2020 regarding the Playa Del Rey gas storage facility.

I am reaching out because I have a quick question. By any chance do you know if there is a directory of inspectors corresponding to the regions/sites they are responsible for? I am trying to identify the inspector that oversees South L.A. (specifically, facility ID#: 175159).

Any information would be greatly appreciated. Thank you so much for your time!

Best,
Edber

--



Edber Macedo (he/his)
City Planning Associate
Los Angeles City Planning
200 N. Spring Street, Room 763
Los Angeles, CA. 90012
Planning4LA.org
T: (213) 978-1198



Bullington Pham <BPham@aqmd.gov> Tue, Apr 20, 2021 at 11:13 AM
To: Edber Macedo <edber.macedo@lacity.org>
Cc: Jarlath Greaney <JGreaney@aqmd.gov>, Joseph Liaw <JLiaw1@aqmd.gov>, Thomas J Lee <tlee2@aqmd.gov>, Adam Tavasolian <atavasolian@aqmd.gov>

Good morning Edber,

With regard to the business at 2126 W. Adams, LA, 90018, the current owner/operator is E & B Resources, Facility ID#191119 (purchased from Sentinel Peak Resources in 2019; prior to that was Freeport McMoran).

Currently, Inspector Greaney is the assigned inspector for this facility.

Here are some links for our directory [Office of Compliance & Enforcement]:

https://www.aqmd.gov/nav/about/offices#CE

With the organization chart here, specifically Page 5:

https://www.aqmd.gov/docs/default-source/default-document-library/organizational-chart.pdf?sfvrsn=132

Team Z – ENERGY (current staff)

Rafael Reynosa, Senior Enf. Mgr	rreynosa@aqmd.gov
Joseph Liaw, Supervising AQ Inspector	jliaw1@aqmd.gov
Bullington Pham, AQ Inspector III	bpham@aqmd.gov
Thomas Lee, AQ Inspector II	tlee2@aqmd.gov
Adam Tavasolian, AQ Inspector II	atavasolian@aqmd.gov
Philip Chen, AQ Inspector I	pchen@aqmd.gov
Jarlath Greaney, AQ Inspector I	jgreaney@aqmd.gov
Philip Nguyen, AQ Inspector I	pnguyen2@aqmd.gov

Feel free to contact me if you have any further questions.

Regards,

Bullington Pham

AQ Inspector III | 909.396.**2288**

South Coast AQMD | Compliance & Enforcement | **Energy** Oil, Gas, Powerplants

[Quoted text hidden]

Edber Macedo <edber.macedo@lacity.org> Tue, Apr 20, 2021 at 11:15 AM
To: Bullington Pham <BPham@aqmd.gov>

Thank you so much! I sincerely appreciate the information provided. Have a safe rest of the week.
[Quoted text hidden]

Exhibit V

Jefferson Drill Site and

Maintenance Acidizing Activities from 2014

R1148.2 (d) Notification

User Information

EForm Status: COMPLETED

Date Stored: 7/18/2014

Time Stored: 11:05 AM

Operator Information

Event ID: 1952

Facility ID*: 144664

Facility Name*: PLAINS EXPLORATION AND PRODUCTION CO

Operator Name*: FREEPORT MCMORAN OIL & GAS

Well Information

Well Name /ID*: JEFFERSON 8

API Well Number*: 04-037-00277

Well Type*: OIL

Well Geographical Coordinates (NAD 83 Format)

Well Latitude*: 34.026404

County*: LOS ANGELES

Well Longitude*: -118.296342

Zip Code*: 90007

Notification Type

Notification Type*: ORIGINAL

Previous Event ID for Cancellation, Revision Date or Other:

Description of Well Activities

Select all that apply. If conducting a series of, or any combination of well production stimulation or treatment activities, identify all types of well production stimulation or treatment activity conducted.

Please click the Add button to the right to enter Well Activities — Add

Well Activity*: WELL REWORK

Start Date*: 07/21/2014

Type of Drilling:

- [ ] Hydraulic Fracturing
- [ ] Gravel Packing
- [x] Maintenance Acidizing
- [ ] Matrix Acidizing
- [ ] Acid Fracturing

Other (Please List): ROUTINE CLEANOUT

Receptor Type
RESIDENCE

Receptor Distance to Well in feet
60

Address
3023 BUDLONG AVE

City
LOS ANGELES

Zip Code
90007

Certification Statement

Pursuant to SCAQMD Rule 1148.2(d), this form shall be submitted to the District no more than 10 days and no less than 24 hours prior to the start of well drilling, well completion, or well rework. If the start date(s) of subject activities is modified, the owner or operator shall notify the District at least 24 hours prior to the new start date if modified to occur earlier than the original start date, or within 24 hours prior to the original start date if modified to occur after the original start date, or if the original start date is cancelled. By clicking the checkbox below, I certify that I am the duly-authorized person to submit this form. I hereby attest, to the best of my knowledge, that the information contained herein is true, accurate and complete. With regard to information that I do not have personal knowledge of, I hereby attest that I have accurately entered the information contained herein from authorized personnel who represented that the information is true, accurate and complete.

☐ I Agree to the above Certification Statement *

R1148.2 (d) Notification

User Information

EForm Status: COMPLETED

Date Stored: 7/11/2014

Time Stored: 8:49 AM

Operator Information

Event ID: 1924

Facility ID*: 144664

Facility Name*: PLAINS EXPLORATION AND PRODUCTION CO

Operator Name*: FREEPORT MCMORAN OIL & GAS

Well Information

Well Name /ID*: JEFFERSON 19

API Well Number*: 04-037-00281

Well Type*: OIL

Well Geographical Coordinates (NAD 83 Format)

Well Latitude*: 34.013474

County*: LOS ANGELES

Well Longitude*: -118.177417

Zip Code*: 90007

Notification Type

Notification Type*: ORIGINAL

Previous Event ID for Cancellation, Revision Date or Other:

Description of Well Activities

Select all that apply. If conducting a series of, or any combination of well production stimulation or treatment activities, identify all types of well production stimulation or treatment activity conducted.

Please click the Add button to the right to enter Well Activities — Add

Well Activity*: WELL REWORK

Start Date*: 07/14/2014

Type of Drilling:

- [ ] Hydraulic Fracturing
- [ ] Gravel Packing
- [x] Maintenance Acidizing
- [ ] Matrix Acidizing
- [ ] Acid Fracturing

Other (Please List): ROUTINE CLEANOUT

Receptor Type
RESIDENCE

Receptor Distance to Well in feet
60

Address
3023 BUDLONG AVE

City
LOS ANGELES

Zip Code
90007

Certification Statement

Pursuant to SCAQMD Rule 1148.2(d), this form shall be submitted to the District no more than 10 days and no less than 24 hours prior to the start of well drilling, well completion, or well rework. If the start date(s) of subject activities is modified, the owner or operator shall notify the District at least 24 hours prior to the new start date if modified to occur earlier than the original start date, or within 24 hours prior to the original start date if modified to occur after the original start date, or if the original start date is cancelled. By clicking the checkbox below, I certify that I am the duly-authorized person to submit this form. I hereby attest, to the best of my knowledge, that the information contained herein is true, accurate and complete. With regard to information that I do not have personal knowledge of, I hereby attest that I have accurately entered the information contained herein from authorized personnel who represented that the information is true, accurate and complete.

☐ I Agree to the above Certification Statement *

R1148.2 (d) Notification

User Information

EForm Status: COMPLETED

Date Stored: 7/15/2014

Time Stored: 6:54 AM

Operator Information

Event ID: 1934

Facility ID*: 144664

Facility Name*: PLAINS EXPLORATION AND PRODUCTION CO

Operator Name*: FREEPORT MCMORAN OIL & GAS

Well Information

Well Name /ID*: JEFFERSON 19

API Well Number*: 04-037-00281

Well Type*: OIL

Well Geographical Coordinates (NAD 83 Format)

Well Latitude*: 34.013474

County*: LOS ANGELES

Well Longitude*: -118.177417

Zip Code*: 90007

Notification Type

Notification Type*: REVISION DATE

Previous Event ID for Cancellation, Revision Date or Other: 1924

Description of Well Activities

Select all that apply. If conducting a series of, or any combination of well production stimulation or treatment activities, identify all types of well production stimulation or treatment activity conducted.

Please click the Add button to the right to enter Well Activities — Add

Well Activity*: WELL REWORK

Start Date*: 07/15/2014

Type of Drilling:

- [ ] Hydraulic Fracturing
- [ ] Gravel Packing
- [x] Maintenance Acidizing
- [ ] Matrix Acidizing
- [ ] Acid Fracturing

Other (Please List): ROUTINE CLEANOUT

Receptor Type
RESIDENCE

Receptor Distance to Well in feet
60

Address
3023 BUDLONG AVE

City
LOS ANGELES

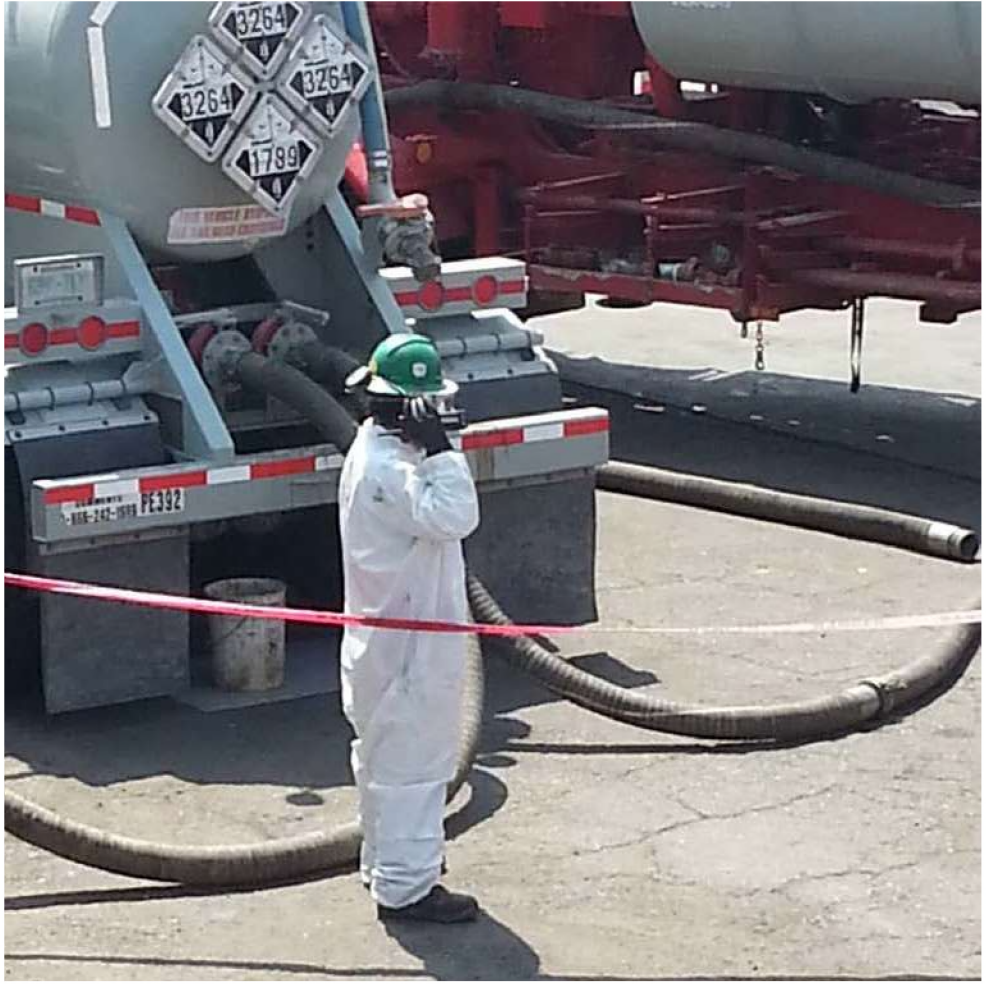
Zip Code
90007

Certification Statement

Pursuant to SCAQMD Rule 1148.2(d), this form shall be submitted to the District no more than 10 days and no less than 24 hours prior to the start of well drilling, well completion, or well rework. If the start date(s) of subject activities is modified, the owner or operator shall notify the District at least 24 hours prior to the new start date if modified to occur earlier than the original start date, or within 24 hours prior to the original start date if modified to occur after the original start date, or if the original start date is cancelled. By clicking the checkbox below, I certify that I am the duly-authorized person to submit this form. I hereby attest, to the best of my knowledge, that the information contained herein is true, accurate and complete. With regard to information that I do not have personal knowledge of, I hereby attest that I have accurately entered the information contained herein from authorized personnel who represented that the information is true, accurate and complete.

☐ I Agree to the above Certification Statement *


REDEEMER



REDEEMER




1
2
3
4



Exhibit W

STAND-LA Letter of Correspondence Regarding Maintenance Acidizing for CF 24-1580

May 6th, 2025

Los Angeles City Council
200 N Spring Street
Los Angeles, CA 90012

Dear Energy and Environment Committee Members,

The STAND-LA Coalition (Stand Together Against Neighborhood Drilling - Los Angeles) is writing to urge you to pass the motion regarding acid maintenance, CF 24-1580, at the Energy and Environment Committee hearing on May 6th, 2025. Our organizations represent frontline communities in South Los Angeles and Wilmington that have been fighting for over a decade to halt the toxic extraction of oil in our neighborhoods and whose communities have been disproportionately impacted by the recent uptick in acid maintenance at drill sites.

Under the phaseout ordinance passed in December 2022, no oil wells were allowed to be "maintained, drilled, re-drilled, or deepened, except to prevent or respond to a threat to public health, safety, or the environment, as determined by the Zoning Administrator". Acid maintenance was defined as maintenance in the Zoning Administrator's Interpretation on Well Maintenance, which was released in October 2023. This meant that acid maintenance was prohibited while the phaseout ordinance was in effect. However, when the phaseout ordinance was struck down in September 2024, the City was no longer able to enforce the regulations on acid maintenance. From October 4th, 2023 - September 1st, 2024, there were no instances of acid maintenance in the City of LA. However, from September 2nd, 2024 - March 12th, 2025, after the ordinance was struck down, there were 32 notices of acid maintenance from operators to the South Coast AQMD. This dramatic increase is due to the City's inability to enforce the ban on acid maintenance after the ordinance was struck down.

Additionally, during the devastating wildfires that recently ravaged Los Angeles, 17 different notices for acid maintenance were issued by operators in LA City (from 1/7/25-1/31/25), adding even more toxins to the already highly toxic air resulting from the wildfires.

Acid maintenance (or acidizing) is a well-stimulation technique that uses thousands of gallons of strong acids, like hydrofluoric or hydrochloric acid, to dissolve rock formations and clean out wellbores. This process helps oil flow more easily, extending the life of aging wells—many of which are in densely populated areas like LA, posing severe risks to public health and the environment.

Many of the chemicals used during acid maintenance, including xylene, polyethyl benzenes, and methanol, are linked to long-term health impacts, including endocrine disruption, cancer, and birth defects. Despite these negative health impacts, acid maintenance at drill sites continues with little oversight, disproportionately impacting frontline communities—many of whom already suffer from higher rates of respiratory illnesses, cancers, and other chronic conditions due to oil extraction operations. The release of hazardous pollutants from acidizing treatments contributes to worsening air quality, endangering residents who live, work, and go to school near these sites.

Allowing this practice to continue runs counter to Los Angeles' commitment to environmental justice and public health protection. Given the recent setback in the fight to phase out oil drilling, we must take every available measure to prevent further harm to our communities. We urge the committee to pass the acid maintenance motion. The health and safety of our residents should not be compromised for the benefit of fossil fuel companies. We need bold leadership to protect frontline communities from preventable harm.

Sincerely,

Emma Silber, Co-Coordinator, STAND-LA Coalition

Maro Kakoussian, Director of Climate and Health Programs
Physicians for Social Responsibility Los Angeles, Co-Chair of STAND-LA

Tianna Shaw-Wakeman, Environmental Justice Program Manager
Black Women for Wellness

Wendy Miranda, Policy Associate
Esperanza Community Housing

Richard Parks, President
Redeemer Community Partnership

Reverend Louis Chase, Minister of Community Outreach
Holman United Methodist Church

Roberto Cabrales, SoCal Program Co-Director
Communities for a Better Environment, Co-Chair of STAND-LA

Agustin Cabrera, Policy Director
Strategic Concepts in Organizing and Policy Education (SCOPE)

E&B and Warren E&P Notice to Residents:

AVISO DE ACTIVIDADES DE MANTENIMIENTO

En cumplimiento y según lo exigido por la Norma 1148.2 (d)(10) del Distrito de Gestión de la Calidad del Aire de la Costa Sur ("SCAQMD"), Requisitos de Notificación e Informes para Pozos de Petróleo y Gas y Proveedores de Sustancias Químicas, por la presente se le notifica que se llevará a cabo un mantenimiento rutinario de pozos

E&B NATURAL RESOURCES

¿POR QUÉ ESTOY RECIBIENDO ESTE AVISO?

Recibe este aviso porque vive cerca de nuestras actividades de mantenimiento. Para asegurarnos de que estamos produciendo el único petróleo compatible con el clima en el mundo y siguiendo todas las regulaciones estatales, federales y locales, se realiza un mantenimiento regular para garantizar que nuestras instalaciones sigan operando de manera segura, eficiente y de acuerdo con las regulaciones estatales. Como su proveedor de energía comunitaria, estamos comprometidos a mantener los más altos estándares de salud y seguridad, y a reducir aún más, nuestra dependencia del petróleo extranjero.

Owner and Operator of Wells:	**E&B Natural Resources 18471 Mt. Langley Street, Suite P, Fountain Valley, CA 92708 | 714-968-4770**		
Well Name(s) and API Well Numbers:	S-14;037-20835 S-23;037-20989	S-59;037-21248 S-80;037-22187	S-84;037-21071 S-93;037-23770
Geographic Well Coordinates:	**34.0750818/-118.3780764**		
Projected Start Date(s) and Time(s):	ON OR AFTER 1/6/2025 6:00am	ON OR AFTER 1/6/2025 6:00am	ON OR AFTER 1/6/2025 6:00am
Anticipated Chemicals to be Used:	Low-pH hydrochloric solvent, low-pH hydrofluoric solvent		

Para obtener más información sobre estas operaciones, escanee aquí:

https://www.cipa.org/files/public/SCAQMD_FAQ_2023_v4.pdf

¿Tiene preguntas sobre nuestras operaciones? Comuníquese llamando al teléfono 714-968-4770

[redacted]

E&B NATURAL RESOURCES

Presort Std U.S. Postage **PAID** Permit #134 Anaheim, CA

NOTICE OF MAINTENANCE ACTIVITIES

In compliance with and as required by South Coast Air Quality Management District ("SCAQMD") Rule 1148.2 (d)(10), Notification and Reporting Requirements for Oil and Gas Wells and Chemical Suppliers, you are hereby notified that routine well maintenance will be conducted.

WHY AM I RECEIVING THIS NOTICE?

You are receiving this notice because you live within proximity to our maintenance activities. To ensure we are producing the world's only climate compliant oil and following all state, federal and local regulations, regular maintenance is conducted to ensure our facilities continue to operate safely, efficiently, and in accordance with state regulations. As your community energy producer, we are committed to upholding the highest health and safety standards, and further reducing our reliance on foreign oil.

Owner and Operator of Wells:	**E&B Natural Resources 18471 Mt. Langley Street, Suite P, Fountain Valley, CA 92708 | 714-968-4770**		
Well Name(s) and API Well Numbers:	S-14;037-20835 S-23;037-20989	S-59;037-21248 S-80;037-22187	S-84;037-21071 S-93;037-23770
Geographic Well Coordinates:	**34.0750818/-118.3780764**		
Projected Start Date(s) and Time(s):	ON OR AFTER 1/6/2025 6:00am	ON OR AFTER 1/6/2025 6:00am	ON OR AFTER 1/6/2025 6:00am
Anticipated Chemicals to be Used:	Low-pH hydrochloric solvent, low-pH hydrofluoric solvent		

To learn more about these operations scan here:

https://www.cipa.org/files/public/SCAQMD_FAQ_2023_v4.pdf

Have questions about our operations? Give us a call at 714-968-4770

[redacted]

Warren E&P

625 E Anaheim CA 90744

11/25/2024

Dear Resident:

Per South Coast Air Quality Management District Rule 1148.2 (d)(10), please be advised that an acidizing procedure for an oil and gas or water injection well is scheduled to take place.

Querido Residente:

De acuerdo con la regla 1148.2 (d)(10) del South Coast Air Quality Management District, tenga en cuenta que está programado que se lleve a cabo un procedimiento de acidificación para un pozo de inyección de petróleo y gas o agua.

Projected Start Dates and Times/ Fechas y Horas de inicio proyectadas:

12/06/2024 @ 7 AM - 02/28/2025 @ 7 AM

Anticipated Chemicals to be Used / Sustancias Químicas Previstas Que Se Utilizarán:

- *Hydrochloric Acid (HCL)/Ácido Clorhídrico (HCl)*
- *Xylene (CH3)2C6H4/Xylene (CH3)2C6H4*
- *Hydrofluoric Acid (HF)/Ácido Fluorhídrico (HF)*
- *These chemicals are commonly used in various household cleaners, pool treatments, and cough medicines. / Estos químicos se usan comúnmente en varios limpiadores domésticos, tratamientos para piscinas y medicamentos para la tos.*

Questions regarding SCAQMD Rule 1148.2 can be addressed to the SCAQMD at 909-396-2000.

Las preguntas sobre la Regla 1148.2 de SCAQMD pueden dirigirse al Distrito al 909-396-2000.

Names/ Nombres	API	Coordinates/Coordenadas	Names/ Nombres	API	Coordinates/Coordenadas
WTU 2128 I	03726972	33.78204727 , -118.25547028	WTU 2274 I	03726976	33.78182983 , -118.25570679
WTU 2144 I	03730285	33.78236008 , -118.25547791	WTU 2296 I	03726625	33.78219223 , -118.25572968
WTU 2145	03727339	33.78272629 , -118.25547028	WTU 2301 I	03726692	33.78226471 , -118.25571442
WTU 2147I	03726556	33.78236008 , -118.25547791	WTU 2314 I	03726845	33.78247833 , -118.25572968
WTU 2162 I	03726661	33.78261948 , -118.25551605	WTU 2316 I	03726693	33.78251266 , -118.25572968
WTU 2163	03727126	33.78262329 , -118.25550079	WTU 2320 I	03726780	33.78258514 , -118.25576019
WTU 2170 I	03726743	33.78274536 , -118.25552368	WTU 2332	03726793	33.78275681 , -118.25485229
WTU 2186 I	03730291	33.7816925 , -118.25544739	WTU 2343 I	03726878	33.7816461 , -118.2556858
WTU 2187 I	03730399	33.78170776 , -118.25544739	WTU 2347I	03726907	33.78171921 , -118.25572205
WTU 2189 I	03726623	33.7817421 , -118.25544739	WTU 2349 I	03726905	33.78174591 , -118.25569153
WTU 2194 I	03726552	33.78182983 , -118.25547028	WTU 2353 I	03726622	33.78181839 , -118.25572968
WTU 2199 I	03726621	33.78190994 , -118.25547791	WTU 2373 I	03726620	33.78213882 , -118.25572205
WTU 2217 I	03730312	33.78220367 , -118.25548553	WTU 2384 I	03730080	33.78232193 , -118.2557373
WTU 2234 I	03726705	33.78248215 , -118.25550842	WTU 2387 I	03730172	33.78237152 , -118.25574493
WTU 2235	03727221	33.78249741 , -118.25550842	WTU 2392 I	03730123	33.78245163 , -118.25575256
WTU 2244 I	03726750	33.78265381 , -118.25553894	WTU 2396 I	03726846	33.78252029 , -118.25577545
WTU 2246i	03730395	33.78268051 , -118.25552368	WTU 2404 I	03726788	33.78265762 , -118.25578308
WTU 2248 I	03726746	33.78271866 , -118.25554657	WTU 2413	03726795	33.78279877 , -118.25577545
WTU 2254 I	03726751	33.78281784 , -118.2555542	WTU 2543 I	03726906	33.78164673 , -118.2556839
WTU 2263 I	03726879	33.78164673 , -118.25567627			

Should you have any questions or concerns, please contact Warren E & P, Inc at:
Si tiene alguna pregunta o inquietud, comuníquese con Warren E & P Inc. al:
(877)587-9494

Exhibit X

E&B Natural Resources

Letter of Correspondence for CF 24-1580

Communication from Public

Name:	Matthew Wickersham
Date Submitted:	05/05/2025 04:42 PM
Council File No:	24-1466
Comments for Public Posting:	Please see attached comment letter

ALSTON & BIRD

333 South Hope Street, 16th Floor
Los Angeles, CA 90071-1410
213-576-1000 | Fax: 213-576-1100

Matthew Wickersham Direct Dial: **+1 213 576 1185** Email: **matt.wickersham@alston.com**

May 5, 2025

VIA LACouncilComment.com

Energy & Environment Committee
Los Angeles City Council
200 North Spring Street, Room 350
Los Angeles, CA 90012

Re: Comment Letter regarding Agenda Item No. 6 & 7 (Council File Nos. 24-1466 & 24-1580), May 6, 2025, E&E Committee Meeting

Dear Councilmembers:

We represent E & B Natural Resources Management Corporation, Hillcrest Beverly Oil Corporation, E&B ENR I, LLC, and Elysium Natural Resources, LLC (collectively, "E&B") regarding the City of Los Angeles's ("City") Agenda Item Nos. 6 & 7 (Council File Nos. 24-1466 & 24-1580) for its May 6, 2025 Energy & Environment committee meeting, concerning a closed session hearing on both the litigation previously filed by E&B against the City's Oil Well Ordinance (Ordinance No. 187709, effective January 18, 2023) and a motion to prepare an interim control ordinance that would prohibit well cleanout maintenance.

In its prior comment letters and legal complaint against the City, E&B has previously explained why the City should not move forward with either the City's Oil Well Ordinance or an interim control ordinance on well cleanout maintenance. (See attached Ex. A [Complaint], Ex. B [March 24, 2025 Comment Letter].) As discussed in these documents, the actions of oil and gas operators within the City (including its maintenance activities) are extensively regulated by state and local agencies, including the California Geologic Energy Management Division ("CalGEM"), the South Coast Air Quality Management District, and the Los Angeles Fire Department.

In addition, before it may move forward with either of these actions, the City must comply with the terms set forth in the stipulation between E&B and the City for entry of judgment in the prior litigation on the Oil Well Ordinance. (See attached Ex. C.) This stipulation states that before the City may take any action to re-adopt an ordinance that is substantially similar to the City's Oil Well Ordinance, the City will conduct at least two

stakeholder meetings, one of which must be at least 60 days prior to the initial hearing on the new ordinance. The interim control ordinance contemplated by File No. 24-1580 prohibits a type of operation squarely at issue in the City's prior Oil Well Ordinance, and so cannot be used by the City as a way to circumvent the conditions that the City previously agreed to.

Further, the City must take into account the recent notice by the County of Los Angeles that the County will prepare an Environmental Impact Report before adopting any ordinance that may result in the phase-out of existing oil and gas operations. (Ex. D [NOP].) The City must likewise consider the significant environmental impacts that will result from its phase-out of the existing land uses for these fields, as well as the City's efforts to impede the local production of oil and gas. For instance, in an environmental impact report certified on July 1, 2015, analyzing the impacts of well stimulation ("WST EIR"), CalGEM has previously acknowledged that a decrease in oil production within the state "would require importing oil from other sources to meet demand, thus increasing ship, rail, and tanker truck traffic to the State from the foreign and domestic suppliers."[1] CalGEM explained in detail why the importation of crude oil from out of state will have increased environmental impacts, particularly increased greenhouse gas emissions:

> "Sources of GHG at oil and gas fields outside of California are not subject to California's regulatory setting, which ensures that GHG sources in the business of oil and gas production in California are subject to multiple programs aimed at reducing GHG. Emissions of GHG that occur at a point of oil and gas extraction outside of California are not subject to the Cap-and-Trade Program, and by increasing the activity of oil and gas extraction outside of California, this alternative would cause increased GHG from sources that are not required to offset the GHG to comply with California's cap, resulting in an overall net increase in GHG emissions compared with both existing conditions and the project."
>
> "Although the oil and gas extraction and associated GHG emissions would occur outside California, California would continue to experience the adverse environmental effects of global climate change driven by GHG emissions worldwide. This impact would occur from GHG sources that are not covered by California's regulatory setting and outside of the potential control of [CalGEM] to feasibly mitigate. As a result of increasing GHG emissions from sources beyond California's control, no feasible mitigation would be available."[2]

---

[1] Ex. E [WST EIR] at 12.2-49; see also *id.* at C.2-84, available at https://www.conservation.ca.gov/calgem/Pages/SB4_Final_EIR_TOC.aspx.

[2] *Id.* at p. 12.2-37; see also *id.* at p. C.2-63 ("[CalGEM] has given considerable weight to the fact

Finally, the City's proposed interim control ordinance targets maintenance activities that are widely-used and necessary to maintain the pressure levels in injection wells within regulatory limits. As discussed in the attached excerpt from the American Petroleum Institute, this type of maintenance would be described as "acid washing," and used to clean out scale built up within the well, just like descaling a coffee pot. (Ex. F [API Briefing Paper re Acidizing] ["Acid washing is most commonly performed with hydrochloric acid (HCl) mixtures to clean out scale (such as calcium carbonate), rust, and other debris restricting flow in the well"].) This is a common maintenance technique for all oil and gas operators, not just "the low producing oil well industry" as claimed in the December 13, 2024, Motion.[3]

For all of these reasons, we urge the City to meet with the affected operators to understand better the impact of these proposed actions.

Sincerely,

Matthew Wickersham

---

that increased oil imports would lead to increased greenhouse gas generation").

[3] The API briefing paper also discussed matrix acidizing and fracture acidizing. These techniques require a well stimulation permit from CalGEM, and so are not at issue here. (See Cal. Public Resources Code 3158, 3160, subd. (d); Cal. Code Regs., tit. 14, 1761, 1783.) The maintenance techniques conducted in the City of Los Angeles are simply used to clean the inner wellbore of existing wells, and they are not used to dissolve the rock of the surrounding formation.

EXHIBIT A

[Alston & Bird's MAY 5, 2025 Comment Letter]

NICKI CARLSEN (SBN 151222)
MATTHEW C. WICKERSHAM (SBN 241733)
GARRETT B. STANTON (SBN 324775)
YTRAN L. HOANG (SBN 348103)
ALSTON & BIRD LLP
333 South Hope Street, 16th Floor
Los Angeles, CA 90071-1410
Telephone: 213-576-1000
Facsimile: 213-576-1100
Email: Nicki.Carlsen@alston.com
Matt.Wickersham@alston.com

Attorneys for Petitioners and Plaintiffs
E & B NATURAL RESOURCES MANAGEMENT CORPORATION, HILLCREST BEVERLY OIL CORPORATION, E&B ENR I, LLC, and ELYSIUM NATURAL RESOURCES, LLC

SUPERIOR COURT OF THE STATE OF CALIFORNIA

FOR THE COUNTY OF LOS ANGELES

E & B NATURAL RESOURCES MANAGEMENT CORPORATION, a California corporation; HILLCREST BEVERLY OIL CORPORATION, a California corporation; E&B ENR I, LLC, a Delaware limited liability company; and ELYSIUM NATURAL RESOURCES, LLC, a New York limited liability company,

Petitioners and Plaintiffs,

v.

CITY OF LOS ANGELES, CITY COUNCIL OF THE CITY OF LOS ANGELES, THE MAYOR OF THE CITY OF LOS ANGELES, and DOES 1 through 100, inclusive

Respondents and Defendants.

Case No.: 23STCP00070

Related to 23STCP00060; 23STCP00085; 23STCP00106; 23STCP01217

CEQA CASE

VERIFIED SECOND AMENDED PETITION FOR WRIT OF MANDATE AND COMPLAINT FOR DECLARATORY RELIEF, CONSTITUTIONAL VIOLATIONS, INVERSE CONDEMNATION, AND DAMAGES

Dept 82, Honorable Curtis A. Kin
Filing Date: January 10, 2023
Trial Date: August 1, 2024

Petitioners and Plaintiffs E & B NATURAL RESOURCES MANAGEMENT CORPORATION ("E&B"), HILLCREST BEVERLY OIL CORPORATION ("HBOC"), E&B ENR I, LLC ("E&B ENR"), and ELYSIUM NATURAL RESOURCES, LLC ("ENR") (E&B, HBOC, E&B ENR, and ENR referred to collectively as "Plaintiffs") hereby petition this Court for a writ of mandamus pursuant to Code of Civil Procedure § 1085 (or alternatively under Section 1094.5), directed to Respondents and Defendants City of Los Angeles ("City"), the City Council of the City of Los Angeles ("City Council"), and the Office of the Mayor of the City of Los Angeles ("Mayor," and with the City and City Council sometimes referred to collectively as the "City") and hereby bring this Petition for Writ of Mandate and Complaint for Declaratory Relief, Constitutional Violations, Inverse Condemnation, and Damages. By this verified pleading, Plaintiffs hereby allege as follows:

INTRODUCTION

1. Plaintiffs hold fee and leasehold interests in mineral rights that are under active operation within the City. E&B and HBOC are also operators of oil and gas facilities located within the City.

2. This action challenges the City's adoption of the Oil and Gas Drilling Ordinance (CPC-2022-4864-CA) ("Oil Ordinance") amending Sections 12.03, 12.20, 12.23, 12.24, and 13.01 of the Los Angeles Municipal Code ("LAMC") to Prohibit New Oil and Gas Extraction and Make Existing Activities a Nonconforming Use in All Zones, the Mitigated Negative Declaration (Case No. ENV-20220-4865-MND) ("MND") analyzing the draft Oil Ordinance, and the City Planning Department's issuance of Zoning Administrator Memorandum 141 ("ZA Memo 141") and a Zoning Administrator's Interpretation, Case No. ZA-2022-8997-ZAI-1A ("ZAI") relating to implementation of the Oil Ordinance. The ZA Memo 141 and ZAI are collectively referred to as the "ZA Documents."

3. Plaintiffs seek a writ of mandamus compelling the City to vacate and rescind the decision to adopt the Oil Ordinance and ZA Documents because (1) the City's findings were arbitrary, capricious, unreasonable, entirely lacking in evidentiary support, and contradicting the evidence available; (2) the Oil Ordinance and ZA Documents are preempted by state law; (3) amortization is inapplicable within the context of oil and gas; (4) the City has not found that the Oil Ordinance and ZA Documents are consistent with the General Plan; (5) the City failed to comply with the California

Environmental Quality Act ("CEQA") prior to adopting the Oil Ordinance and ZA Documents; and (6) the City's adoption of the Oil Ordinance and ZA Documents violated Article 1, section 19 of the California Constitution and the Takings Clause of the Fifth and Fourteenth Amendments to the United States Constitution.

4. In the Complaint for Declaratory Relief and Damages, Plaintiffs seek declaratory relief and damages on the grounds that:

a. The adoption of the Oil Ordinance and ZA Documents is a temporary and permanent taking of Plaintiffs' private property for public use without prior compensation in violation of Article I, section 19 of the California Constitution and the Takings Clause of the Fifth Amendment of the United States Constitution, as incorporated by the Fourteenth Amendment.

b. The Oil Ordinance and ZA Documents violate Article I, section 19 of the California Constitution and Article I, section 10 of the United States Constitution, which prohibit the enactment of laws affecting a "substantial impairment" of contracts.

c. The Oil Ordinance and ZA Documents violate Plaintiffs' rights to substantive due process under Article I, section 7 of the California Constitution and the Fourteenth Amendment of the United States Constitution. The Oil Ordinance and ZA Documents infringe Plaintiffs' property rights in an arbitrary and irrational manner, which is not related to any legitimate governmental purpose.

d. The Oil Ordinance and ZA Documents impair Plaintiffs' vested rights in the continuation of oil and gas production within the City, which is an extractive business, and as a result of these vested rights, the City may not prohibit the activities authorized by Plaintiffs' permits through the Oil Ordinance and ZA Documents.

e. The City has intentionally interfered with Plaintiffs' contractual rights with their royalty owners and mineral rights holders, and the City has breached its lease contracts with HBOC.

5. In pursuing this action, which involves enforcement of important rights affecting the public interest, Plaintiffs will confer a substantial benefit on the general public, citizens of the City,

and the State of California, and therefore will be entitled to attorneys' fees and costs pursuant to Code of Civil Procedure § 1021.5. In addition, Plaintiffs will be entitled to recover attorneys' fees and costs as part of their claim for inverse condemnation pursuant to Code of Civil Procedure § 1036.

PARTIES

6. E&B is a California corporation in possession of fee and leasehold interests in mineral rights that are under active operation within the City and are affected by the Oil Ordinance. E&B also operates oil and gas facilities within the City that would be affected by the Oil Ordinance. E&B is focused on acquisition, development, and exploration of oil and gas assets, primarily focusing on oil development in California.

7. HBOC is a California corporation in possession of fee and leasehold interests in mineral rights that are under active operation within the City and are affected by the Oil Ordinance. HBOC also operates oil and gas facilities within the City that would be affected by the Oil Ordinance. HBOC is focused on acquisition, development, and exploration of oil and gas assets in California.

8. E&B ENR is a Delaware limited liability company in possession of fee and leasehold interests in mineral rights that are under active operation within the City and are affected by the Oil Ordinance. E&B ENR is focused on acquisition, development, and exploration of oil and gas assets in California.

9. ENR is a New York limited liability company in possession of fee and leasehold interests in mineral rights that under active operation within the City affected by the Oil Ordinance. ENR is focused on acquisition, development, and exploration of oil and gas assets in California.

10. Plaintiffs are all affiliates that are under common control.

11. The City is a charter city within the meaning of article XI, section 5, of the California Constitution, located in Los Angeles County, California. The City is the "lead agency" for purposes of Public Resources Code section 21067, with responsibility for conducting environmental review and approving the Oil Ordinance.

12. The City Council is a fifteen-member elected legislative body for the City of Los Angeles. The City Council is responsible for governing the City, providing policy direction, and approving the City budget. The City Council has authority to pass ordinances, such as the Oil

Ordinance.

13. The Mayor is the office for an elected official who approves or vetoes ordinances passed by the City Council and is named herein in official capacity only.

14. The names and capacities, whether corporate, individual, or otherwise, of Respondents and Defendants Does 1 through 100, inclusive, are unknown to Plaintiffs at this time. Plaintiffs, therefore, sue these Respondents and Defendants, and each of them, by such fictitious names. Plaintiffs will seek leave of court to amend this complaint to show the true names and capacities of the Doe Respondents and Defendants when they are fully ascertained. Plaintiffs are informed and believe that the Doe Respondents and Defendants are responsible and liable to Plaintiffs for the events, happenings, and occurrences set forth herein.

JURISDICTION AND VENUE

15. This Court has jurisdiction over this action pursuant to California Code of Civil Procedure § 1085 (alternatively § 1094.5) and 526; and Public Resources Code § 21168.5 (alternatively § 21168).

16. Venue is proper in Los Angeles County in accordance with Code of Civil Procedure §§ 393(b), 394(a), and 395 because the Respondents in this action are located in Los Angeles County, and all the acts and omissions alleged herein occurred in Los Angeles County.

17. Plaintiffs have performed any and all conditions precedent to filing this instant action and have exhausted any and all administrative remedies to the extent required by law, including, but not limited to, submitting extensive written comments and evidence objecting to the adoption of the Oil Ordinance. All issues raised in the petition for a writ of mandamus were raised before the City by Plaintiffs, other members of the public, or public agencies prior to the adoption of the Oil Ordinance.

18. Plaintiffs have complied with Public Resources Code § 21167.5 by serving a notice upon the City indicating their intention to file the original Petition. Plaintiffs served the notice on January 10, 2023. Proof of service of this notification, with the notification, is attached as **Exhibit A**. Proof of service of notification of the Amended Petition is attached as **Exhibit D**.

19. Plaintiffs have elected to prepare the record of proceedings in the above-captioned proceeding or to pursue an alternative method of record preparation pursuant to Public Resources Code

§ 21167.6(b)(2). Notification of the Election to Prepare the Administrative Record is attached as **Exhibit B**.

20. Plaintiffs have complied with the requirements of Public Resources Code § 21167.7 and Code of Civil Procedure § 388 by mailing a copy of the original Petition and Complaint to the California Attorney General on January 10, 2023. A copy of the letter transmitting the Petition and Complaint to the Attorney General with proof of service is attached as **Exhibit C**. A copy of the Amended Petition and Complaint was mailed to the California Attorney General on April 7, 2023. A copy of the letter transmitting the Amended Petition and Complaint to the Attorney General with proof of service is attached as **Exhibit E**. A copy of the Second Amended Petition and Complaint was mailed to the California Attorney General within 10 days after filing. A copy of the letter transmitting the Second Amended Petition and Complaint to the Attorney General with proof of service is attached as **Exhibit F**.

21. The Original Petition and Complaint was timely filed within 30 days after the posting of the City's Notice of Determination in accordance with Public Resources § 21167.

22. On December 8, 2022, Plaintiffs presented written claims to the City for intentional interference with contractual relations and breach of contract with respect to the City's adoption of the Oil Ordinance pursuant to the claim presentation requirements of the California Tort Claims Act. Gov. Code § 910 (City of Los Angeles Claim Nos. C23-24688, C23-24689, C23-24691, and C23-24692). A copy of the claim submission to the City is attached as **Exhibit G**. On February 13, 2023, the City rejected Plaintiffs' written claims. A copy of the rejection letter is attached as **Exhibit H.** Plaintiffs have timely amended their causes of action for interference with contractual relations and breach of contract pursuant to Gov. Code § 945.6.

23. On January 31, 2023, Plaintiffs filed an application appealing the City Planning Department's determination to adopt and implement the ZA Documents. On the same day, the City Planning Department accepted Plaintiffs' appeal for the ZAI, but rejected the appeal for ZA Memo 141 because there was allegedly "no appeal mechanism" for ZA Memo 141. Attached as **Exhibit I** is a true and correct copy of the City's notice rejecting the appeal for ZA Memo 141. Plaintiffs submitted supplemental statements in support of their appeal for the ZAI on September 5 and 7, 2023.

24. On September 14, 2023, the City Planning Commission ("CPC") heard Plaintiffs' ZAI appeal. On October 4, 2023, the CPC rendered a written Letter of Determination, granting the appeal as to one narrow issue and denying the other appeal points. The City modified the case number from ZA-2022-8997-ZAI to ZA-2022-8997-ZAI-1A to reflect the slightly revised version.[1]

25. Plaintiffs have no plain, speedy, or adequate remedy in the court of ordinary law because Plaintiffs will be irreparably harmed by the ensuing damage caused by adoption and implementation of the Oil Ordinance and ZA Documents and the City's violations of law, as alleged herein. In the absence of such remedies, the City's approval of the Oil Ordinance and ZA Documents will remain in effect in violation of law.

26. The City stipulated, as filed on October 24, 2023, that Plaintiffs are not required to file government tort claims pursuant to Gov. Code § 910 for intentional interference with contractual relations or breach of contract with respect to the ZA Documents since such claims were sufficiently presented to the City via Plaintiffs' previous written claims (City of Los Angeles Claim Nos. C23-24688, C23-24689, C23-24691, and C23-24692).

FACTUAL AND LEGAL STATEMENT

A. Plaintiffs' Operations in the City of Los Angeles

27. In Los Angeles, there are 26 oil and gas fields with more than 5,000 oil and gas wells. Wells are found in all parts of the City, including but not limited to Wilmington, Harbor Gateway, Downtown, West Los Angeles, South Los Angeles, and the Northwest San Fernando Valley.

28. Plaintiffs are California-based oil and gas producers. Plaintiffs collectively produce over 8,000 barrels of oil per day for Californians including Los Angelenos. Over 250 staff work for Plaintiffs, many in the Los Angeles area.

29. E&B currently conducts oil and gas operations at several locations within the City of Los Angeles. The San Vicente facility is located in the vicinity of San Vicente Boulevard and West Third Street. The Packard facility is located in the vicinity of Pico Boulevard and Genesee Avenue in the City of Los Angeles, CA. The San Vicente and Packard facilities collectively extract from 1,297

[1] For purposes of this Petition, "ZAI" may refer to either version issued as either ZA-2022-8997-ZAI or ZA-2022-8997-ZAI-1A.

acres of mineral interests. The Murphy facility is located in the vicinity of West Adams Boulevard and Western Avenue, and it extracts from 960 acres of mineral interests. E&B conducts oil production operations within the City in the South Torrance oilfield in the vicinity of East Pacific Coast Highway and Wilmington Boulevard and extracting from 330 acres of mineral interests. E&B also conducts oil production operations within the City in the Wilmington oilfield in the vicinity of W. Sepulveda Boulevard and S. Main Street and extracting from 146 acres of mineral interests.

30. HBOC currently conducts oil and gas operations at the Hillcrest Country Club facility, located in the vicinity of West Pico Boulevard and Avenue of the Stars, and at the Rancho Park Golf Club facility, located in the vicinity of West Pico Boulevard and Beverly Glen Boulevard. These two facilities collectively extract from 617 acres of mineral interests.

31. In addition to owning some mineral rights directly in fee, Plaintiffs also lease mineral rights from mineral interest owners. E&B ENR holds mineral interests in fee and leasehold for the San Vicente and Packard facilities. ENR holds mineral interests in fee and leasehold for the Murphy facility and for some of E&B's operations within the Torrance oilfield. HBOC also holds mineral interests in fee and leasehold for its operations at the Hillcrest Country Club and Rancho Park Golf Club facilities. E&B also holds mineral interests in fee and leasehold for its operations at the Torrance and Wilmington oilfields.

32. Plaintiffs' operations in the City of Los Angeles have approximately 15,000 royalty owners. Plaintiffs annually pay approximately $11 million annually in royalty payments and related payments, such as advanced royalty payments or surface rentals to royalty owners. These royalty payments are computed based on the value of production from each mineral lease.

B. The City's Adoption of the Oil Ordinance

33. On January 26, 2022, the Los Angeles City Council approved a motion directing the Department of City Planning and the City Attorney's Office to draft an ordinance to prohibit new oil and gas extraction and make extraction activities a nonconforming use in all areas of the City. The motion also directed the Los Angeles Office of Petroleum and Natural Gas Administration and Safety to hire an expert to conduct an amortization period for existing wells, as a purported prerequisite to decommissioning existing oil fields, in order to allow an oil company to recoup its investment.

34. On July 26, 2022, the City Planning Department issued a "Notice to Proceed To Prepare CEQA Technical Analyses For A Citywide Oil And Gas Drilling Ordinance" to Impact Sciences, Inc. and commissioned a "CEQA technical analyses for a citywide oil and gas drilling ordinance."

35. On August 9, 2022, just two weeks after the City Planning Department commissioned the creation of an initial study for the CEQA environmental review, it released the Proposed Termination Ordinance No. 187709 ("Proposed Ordinance"). No environmental review or expert study regarding the proposed amortization period was released with the Proposed Ordinance.

36. On August 30, 2022, the City Planning Department held a public community hearing to present the Proposed Ordinance, but no environmental review materials were made available for public examination at the time. Despite not receiving any environmental review materials, Plaintiffs submitted a comment letter as part of the public hearing voicing their opposition to the Proposed Ordinance and its proposed amendments to the Los Angeles Municipal Code ("LAMC").

37. Thereafter, on September 13, 2022, the City Planning Department issued a revised Proposed Ordinance, along with an 893-page Staff Recommendation Report. The Staff Recommendation Report provides that the CPC is being asked to recommend that the City Council find "after consideration of the whole of the administrative record, including the Mitigated Negative Declaration…and all comments received, with the imposition of mitigation measures, there is no substantial evidence that the project will have a significant effect on the environment." (Staff Recommendation Report at p. 1-2, and at pg. A-8.)

38. On September 14, 2022, the revised Proposed Ordinance was posted onto the CPC's agenda for September 22, 2022.

39. On September 15, 2022, the City Planning Department publicly posted the Draft MND on the City Planning Department's "Public Notices" webpage.[2] The City Planning Department provided the public with a 30-day comment period, ending on October 17, 2022.

40. Ahead of the CPC's scheduled meeting on September 22, 2022 to present and discuss the Proposed Ordinance, Plaintiffs, by and through their counsel of record, submitted on September

[2] Los Angeles City Planning, Negative Declaration Public Notices, available at https://planning.lacity.org/development-services/negative-declaration-public-notices.

20, 2022 an extensive comment letter opposing the MND, Proposed Ordinance, and proposed amendments to the LAMC. Specifically, Plaintiffs' comment letter urged the CPC to take more time to review the issues raised by the Proposed Ordinance, including that (1) the Proposed Ordinance would not be a legitimate exercise of the City's police power, (2) amortization does not apply to the extraction of oil and gas, (3) the 20-year amortization period is both illusory and arbitrary as it is completely unsupported by evidence, (4) the City Planning Department's inadequate CEQA analysis, (5) the Proposed Ordinance is subject to preemption, (6) the Proposed Ordinance triggers several constitutional violations including the taking and impairment of vested rights, due process, equal protection, rights under section 183, and contractual relations, and (7) the Proposed Ordinance may serve as a breach of contract between the City and Plaintiffs.

41. Despite these comments from Plaintiffs and other members of the public, along with the incomplete CEQA analysis and the open comment period for the MND, the Proposed Ordinance was presented before the CPC on September 22, 2022 at a scheduled meeting. Following the CPC's recommendation made at the September 22, 2022 meeting, the Proposed Ordinance was advanced to the City Council for consideration.

42. On October 5, 2022, Plaintiffs submitted a comment letter to the Energy, Climate Change, Environmental Justice, and River Committee ("Environmental Committee") detailing the negative impacts for which the Proposed Ordinance may have on the public.

43. Nevertheless, on October 6, 2022, the Environmental Committee likewise approved the Proposed Ordinance before the comment period closed and CEQA review was complete.

44. On October 13, 2022, an "Oil and Gas Drilling Ordinance Responses to Comments" was transmitted to the City Council (File No. 17-0447-S2) purportedly responding to comments received from September 15, 2022 through October 17, 2022. However, the responses did not sufficiently address the public's comments and concerns regarding the Proposed Ordinance.

45. On October 17, 2022, Plaintiffs submitted a further comment letter that urged the City Council to fully consider all of the comments to the MND. Moreover, Plaintiffs' October 17, 2022 comment letter reiterated many of the same arguments raised in their previous letters and detailed that the MND failed to comply with the provisions of CEQA, the MND analysis was incomplete, the

MND's analysis was an improper piecemealing of environmental effects under CEQA, and CEQA's fair argument standard requires the preparation of an Environmental Impact Report ("EIR"), among other considerations against the Proposed Ordinance.

46. The public comment period on the MND closed on October 17, 2022.

47. On October 27, 2022, a supplemental "Oil and Gas Drilling Ordinance Responses to Comments" submitted from October 12, 2022 through October 17, 2022 was published. However, the supplemental response did not sufficiently respond to or address Plaintiffs' comments on the MND.

48. On November 17, 2022, Deputy City Attorney Jennifer K. Tobkin and Director of Planning Vincent P. Bertoni approved and signed the Proposed Ordinance. At a previous public meeting held by the Environmental Committee on November 17, 2020, the City Attorney staff, led by Deputy City Attorney Jennifer Tobkin, detailed what would be necessary to defend the plan to phase out oil wells and the amortization period. Specifically, she stated that the Proposed Ordinance must be supported by an expert study and there must be proper environmental review under CEQA.

49. On November 22, 2022, the City Council held a meeting and voted to adopt the MND and CEQA findings and to approve the Proposed Ordinance and its proposed amendments to the LAMC.

50. After previously approving the MND and Oil Ordinance, the City of Los Angeles published on November 28, 2022, a further "Oil and Gas Drilling Ordinance Topical Responses to Comments" detailing its responses to six (6) categories of topical responses including "Processing, Applicability, and Adequacy of the Draft IS/MND, Piecemealing, Air Quality, Greenhouse Gas ("GHG") Emissions, Health Risks, [and] Noise." It also improperly concludes that "[n]one of the comments received during the entirety of the Initial Study/Mitigated Negative Declaration (IS/MND) circulation period offers any new evidence or any evidence that any fact, analysis, or determination in the IS/MND is incorrect. None of the comments make a fair argument, supported by substantial evidence, that the Ordinance may cause a significant impact on the environment." Finally, it purported to issue a Revised MND and Revised Mitigation Monitoring Program ("MMP"), adding a measure to address significant impacts from air quality caused by the Project.

51. On December 2, 2022, the City Council held a meeting and voted 12-0 (with 2

absences) to adopt the revised MND and MMP and to re-adopt the Proposed Ordinance, sending the Proposed Ordinance to Mayor Eric Garcetti for final approval.

52. On December 8, 2022, Mayor Eric Garcetti signed the Proposed Ordinance, approving its proposed amendments to the LAMC, despite insufficient and incomplete CEQA studies regarding the environmental impacts and no expert study regarding the 20-year amortization period.

53. On January 17, 2023, the City adopted the ZA Documents relating to implementation of the Oil Ordinance, both of which are supposedly intended "to serve as guidance for operators and the public regarding oil drilling regulations in the City."[3]

54. On January 31, 2023, Plaintiffs filed an application appealing the City Planning Department's determination to adopt and implement the ZA Documents. On the same day, the City Planning Department accepted Plaintiffs' appeal for the ZAI, but rejected the appeal for ZA Memo 141 because there was allegedly "no appeal mechanism" for ZA Memo 141. Plaintiffs submitted supplemental statements in support of their appeal for the ZAI on September 5 and 7, 2023.

55. On September 14, 2023, the City Planning Commission ("CPC") heard Plaintiffs' ZAI appeal. The CPC rendered a written Letter of Determination, largely denying the ZAI appeal and adopting ZA-2022-8997-ZAI-1A, on October 4, 2023.

C. The Oil Ordinance Unlawfully Phases Out Oil and Gas Production within the City

56. The Oil Ordinance amends sections 12.03, 12.20, 12.23, 12.24, and 13.01 to the LAMC to prohibit new oil and gas extraction and make existing extraction activities a nonconforming use in all zones within the City. Specifically, the Ordinance amends the LAMC to (1) eliminate the provisions of the LAMC that allow for the creation of new "O" Oil Drilling Supplemental Use Districts; (2) end by-right oil and gas extraction in the M3-Heavy Industrial Zones; (3) declare existing oil and gas extraction within the City a nonconforming use to terminate within 20-years; and (4) prohibit new or expanded oil and gas extraction activities (such as the drilling of new wells or the redrilling or deepening of existing wells).

57. The Oil Ordinance prohibits oil "well maintenance, drilling, redrilling, and deepening

[3] Department of City Planning Email to Stakeholders, Jan. 17, 2023.

except to prevent or respond to a threat to public health, safety, or the environment, as determined by the Zoning Administrator." (LAMC § 12.23-C.4, subd. (a).) In the revised version of the ZAI, the Zoning Administrator interpreted "well maintenance" to include any scope of work that meets either of the following two criteria:

> (1) "A scope of work that requires a Notice of Intention to 'Rework Permit' to carry out a rework project on a well from the California Geologic Energy Management Division (CalGEM)."
>
> (2) "A scope of work that requires online notification per the South Coast Air Quality Management District's (SCAQMD) Rule 1148.2 – "Notification and Reporting Requirements for Oil and Gas Well and Chemical Suppliers" for "Well Rework" and/or "Injection" including one or more of the following activities: acidizing, hydraulic fracturing, gravel packing, maintenance acidizing, matrix acidizing, and acid fracturing.

(ZA-2022-8997-ZAI-1A, issued Oct. 4, 2023, at pp. 1-2.)

58. The Oil Ordinance also exempts from its requirements wells that are operated by a public utility that is regulated by the California Public Utilities Commission. The Oil Ordinance further creates an amortization period of twenty years (20 years) from the effective date, requiring all nonconforming, non-exempt oil and gas extraction uses to be terminated by the end of that period.

59. ZA Memo 141, which applies to all Citywide oil wells, including those that were formerly by-right operations in the M3 zone, purports to "establish a comprehensive set of procedures and policies for the acceptance and processing of applications for projects, at existing non-conforming sites, where drilling, redrilling, deepening, or well maintenance is proposed to either prevent or respond to a threat to public health, safety, or the environment," intended to implement the limited exception provided in the Ordinance.[4] ZA Memo 141 also "identifies the steps that operators are required to complete prior to commencing proposed scopes of work and outlines the discretionary review procedures and policies for operators." (*Id.*, at p. 2.)

60. ZA Memo 141 provides that the Zoning Administrator has discretionary review "[f]or projects that propose to maintain, drill, re-drill, or deepen an existing well for oil, gas or other

[4] Chief Zoning Administrator, Department of City Planning, Estineh Mailian, mem. to Office of Zoning Administration, Department of City Planning, and Department of Building and Safety, Jan. 17, 2023 ("ZA Memo 141"), p. 1 <https://planning.lacity.org/odocument/1e0e2f89-cfaa-448b-aac5-0858bdb499fc/ZA_Memo_141-_Health_and_Safety_Exception_Projects.pdf> (as of March 23, 2023).

hydrocarbon substances in order to prevent or respond to a threat to public health, safety, or the environment." (*Id.*, at p. 4.) Additionally, projects that demonstrate "an urgent need to commence [] due to an imminent emergency threat to public health, safety, or the environment[,]" will be subject to the administrative review process "by a Zoning Administrator or assigned/delegated City Planning staff." (*Ibid.*)

61. Under this discretionary review process, "an operator shall submit all the required application materials for a Health and Safety Exception request," which will be subject to discretionary review by the Zoning Administrator pursuant to LAMC section 12.23-C.4. (*Id.*, at p. 5.) The Zoning Administrator is required to set a public hearing in which evidence and testimony may be received. Notice of the hearing is given 24-days in advance of the public hearing, but ZA Memo 141 does not include a requirement for the hearing to be set within a certain amount of time. (*Id.*, at p. 7.) Once a decision is made, the Zoning Administrator will issue a written determination, providing a 15-day appeal period. (*Id.*, at p. 8.)

62. The Oil Ordinance became effective on January 18, 2023.

FIRST CAUSE OF ACTION

(Petition for Writ of Traditional Mandamus under Code of Civil Procedure § 1085, or, alternatively, Administrative Mandamus under Code of Civil Procedure § 1094.5) – Abuse of Discretion)

(By All Plaintiffs Against All Defendants)

63. Plaintiffs reallege and incorporate by reference the foregoing paragraphs as though fully set forth herein.

64. Plaintiffs seek a writ of traditional mandamus pursuant to Code of Civil Procedure § 1085, or, alternatively, a writ of administrative mandamus pursuant to Code of Civil Procedure § 1094.5.

65. The City's adoption of the Oil Ordinance (including its implementation through the ZA Documents) must be vacated as it was arbitrary, capricious, entirely lacking in evidentiary support, and contrary to established public policy.

66. There is no legitimate public purpose, reasonable basis in fact, or substantial evidence

to support the City's decision to adopt the Oil Ordinance and ZA Documents and to terminate Plaintiffs' rights to operate their lawful business in the City.

67. The City's decision to adopt the Oil Ordinance and ZA Documents and to terminate Plaintiffs' rights to conduct oil and gas production activities within the City will result in the loss of good-paying industry jobs. There is no legitimate public purpose, reasonable basis in fact, or substantial evidence to support the City's decision to adopt the Oil Ordinance and ZA Documents, which by their very terms would result in the loss of jobs associated with oil and gas production activities.

68. The City's decision to adopt the Oil Ordinance and ZA Documents contravenes the State's policy of "*encourag[ing]* the wise development of oil and gas resources," and "to *permit*" the use of "*all*" practices that will increase the recovery of oil and gas. Cal. Pub. Res. Code § 3106, emphasis added. There is no legitimate public purpose, reasonable basis in fact, or substantial evidence to support the City's decision to adopt the Oil Ordinance and ZA Documents, which contravenes the State's express policy.

69. The City also failed to consider less restrictive means to achieve the purported purposes of the Oil Ordinance and ZA Documents. Instead, the Oil Ordinance and ZA Documents impose arbitrary and capricious restrictions on Plaintiffs' ability to operate their business which are wholly lacking in evidentiary support. The City fails to forecast the probable effect of the ordinance, fails to identify the competing interests involved, and fails to justify why the Oil Ordinance and ZA Documents reflect a reasonable accommodation of competing interests. For example, the Oil Ordinance excludes certain uses but applies to all oil and gas operations across the City without distinguishing among different locations or operations, even though the City acknowledges that some locations are situated in heavy industrial areas.

70. Accordingly, the City has acted arbitrarily, capriciously, and abused its discretion by terminating oil and gas uses in the City without a legitimate public purpose, reasonable basis in fact, or substantial evidence.

71. Plaintiffs have no plain, speedy, and adequate remedy at law to challenge the Oil Ordinance and ZA Documents other than the relief sought herein. The language of the Oil Ordinance

and ZA Documents do not contain any alternative remedy available for Plaintiffs to bring all of the challenges alleged herein, nor has the City made available any other remedy at law that will adequately determine the merits of Plaintiffs' challenge to the Oil Ordinance and ZA Memo 141. Without the resolution of these challenges, Plaintiffs will be permanently, irreparably harmed by the implementation of the Oil Ordinance (including through application of the ZA Documents).

72. Because the enactment of the Oil Ordinance and ZA Documents is quasi-legislative in nature and not adjudicatory, Plaintiffs bring this action under Code of Civil Procedure § 1085. In the alternative, however, Plaintiffs also seek a writ of mandamus under Code of Civil Procedure § 1094.5 to the extent, if any, that the Court concludes Section 1094.5 is applicable here.

SECOND CAUSE OF ACTION

(Petition for Writ of Traditional Mandamus under Code of Civil Procedure § 1085, or, alternatively, Administrative Mandamus under Code of Civil Procedure § 1094.5 – Amortization Improper)

(By All Plaintiffs Against All Defendants)

73. Plaintiffs reallege and incorporate by reference the foregoing paragraphs as though fully set forth herein.

74. Plaintiffs seek a writ of traditional mandamus pursuant to Code of Civil Procedure § 1085, or, alternatively, a writ of administrative mandamus pursuant to Code of Civil Procedure § 1094.5.

75. In adopting the Oil Ordinance, the City imposes a 20-year amortization period on oil and gas operations within the City, but the City has no evidence or factual support for this chosen 20-year period.

76. Amortization is inapplicable in the context of oil and gas because the "diminishing asset doctrine" applies, which permits oil and gas operators and others in extractive industries to exhaust the mineral value of their property. The utility of an oil field depends on its productivity, which requires ongoing infrastructure investment.

77. The amortization concept is based upon the idea that the property owner must be given an opportunity to recoup its investment and be made whole. The application of the concept to oil fields

does not achieve the same goals.

78. Additionally, the challenges presented by the variability of the price of oil to establish an appropriate amortization period over the next several decades further support that the extraction of mineral resources cannot be subject to amortization.

79. Plaintiffs have clearly exhibited an intent to continue and to complete the development and production of their oil and gas resources within the City. The continued development of these resources is a progression of the extractive activity within the City as authorized by Plaintiffs' permits, agreements, or conditions to operate.

80. Even assuming that amortization could apply to the extraction of mineral resources, the City has no factual or evidentiary support for the 20-year period of amortization adopted by the Oil Ordinance. This "phase-out" period is economically unsupportable and arbitrary.

81. The City's purported "amortization period" is also illusory as the Oil Ordinance and ZAI effectively prohibit well maintenance, which is required to operate the existing wells. The City claims that it will allow maintenance under certain circumstances, but if any oil and gas operator sought to seek an approval from the City under ZA Memo 141 to conduct maintenance based on health and safety purposes, the approval process could extend beyond one year, resulting in "deemed terminated" finding for "discontinued" operations.

82. Accordingly, the City acted arbitrarily and capriciously in adopting an amortization period for all oil and gas operations within the City.

83. Plaintiffs have no plain, speedy, and adequate remedy at law to challenge the Oil Ordinance other than the relief sought herein. The language of the Oil Ordinance itself contains no alternative remedy available for Plaintiffs to bring all of the challenges alleged herein, nor has the City made available any other remedy at law that will adequately determine the merits of Plaintiffs' challenge to the Oil Ordinance. Without resolution of these challenges, Plaintiffs will be permanently and irreparably harmed by the implementation of the Oil Ordinance.

84. Because the enactment of the Oil Ordinance is quasi-legislative in nature and not adjudicatory, Plaintiffs bring this action under Code of Civil Procedure § 1085. In the alternative, however, Plaintiffs also seek a writ of mandamus under Code of Civil Procedure § 1094.5 to the extent,

if any, that the Court concludes Section 1094.5 is applicable here.

THIRD CAUSE OF ACTION

(Petition for Writ of Traditional Mandamus under Code of Civil Procedure § 1085, or, alternatively, Administrative Mandamus under Code of Civil Procedure § 1094.5 - Preemption)

(By All Plaintiffs Against All Defendants)

85. Plaintiffs reallege and incorporate by reference the foregoing paragraphs as though fully set forth herein.

86. Plaintiffs seek a writ of traditional mandamus pursuant to Code of Civil Procedure § 1085, or, alternatively, a writ of administrative mandamus pursuant to Code of Civil Procedure § 1094.6.

87. The adoption of the Oil Ordinance and ZA Documents is preempted because the City is preempted from intruding upon the State's exclusive jurisdiction over certain parts of oil and gas regulations.

88. California has adopted numerous statutes and regulations that comprehensively regulate virtually all aspects of oil and gas operations. Oil and gas operations are specifically governed by Division 3 of the Public Resources Code (Pub. Res. Code § 3000, et seq.) and its implementing regulations (14 Cal. Code Regs. § 1712, et seq.). By and through this all-encompassing statutory and regulatory scheme, the State of California, through CalGEM, has exclusive jurisdiction over the field of oil and gas operations, methods, and procedures to the exclusion of local legislation.

89. The Oil Ordinance and ZA Documents impermissibly seek to regulate how Plaintiffs conduct their oil and gas production operations within the City.

90. The Attorney General has concluded that a conflict arises whenever local government attempts to "exercise control over subsurface activities," whether "directly or indirectly." 59 Ops.Cal.Atty. Gen 461, 478; see also *Desert Turf Club v. Bd. of Supervisors*, 141 Cal. App. 2d 446, 452 (1956).

91. The Oil Ordinance and ZA Documents are preempted by state law, providing that CalGEM has exclusive jurisdiction to regulate the drilling, operation, maintenance, and abandonment

of oil and gas wells and attendant facilities. The Oil Ordinance and ZA Documents attempt to exercise improper control over how oil and gas operations are conducted within the City, and they regulate maintenance, abandonment and restoration activities in direct contravention of applicable law.

92. The Oil Ordinance and ZA Documents conflict with Public Resources Code section 3106, which identifies the State's policy as "*encourag[ing]* the wise development of oil and gas resources," and expressly provides that the State will supervise the drilling of oil wells "so as to *permit*" the use of "*all*" practices that will increase the recovery of oil and gas. Cal. Pub. Res. Code § 3106, emphasis added. In so doing, section 3106 plainly lodges the authority to permit "all methods and practices" firmly in the State's (*not* the City's) hands. Section 3106 makes no mention whatsoever of any reservation to local entities, such as the City, or any power to limit the State's authority to permit well operators to engage in these "methods and practices." Yet the Oil Ordinance and ZA Documents unlawfully seize the State's authority by regulating the "method and practices" of oil and gas operations.

93. The City's adoption of the ZAI is further preempted by state law for the reason that it specifically defines "maintenance" based on permitting and/or regulatory activities that are exclusively regulated by CalGEM or the SCAQMD.

94. The City's adoption of the ZA Memo 141 is further preempted by state law for the reason that it allows the City to determine whether to allow methods and practices of oil production that are exclusively regulated by the State.

95. By adopting the Oil Ordinance and ZA Documents, the City has acted unlawfully and beyond the scope of statutory and regulatory authority as set forth in California law.

96. The City has acted arbitrarily and capriciously and has abused its discretion.

97. Plaintiffs have a beneficial interest in ensuring that the City does not enforce the Oil Ordinance and ZA Documents, which exceed the City's authority and are preempted by California law. Plaintiffs have operating interests in mineral rights within the City and have an interest in ensuring their right to continue production of oil and gas within the City, which is directly impacted by the Oil Ordinance and ZA Documents.

98. The City's enactment of the Oil Ordinance and ZA Documents irreparably harms and

will continue to irreparably harm Plaintiffs based on the substantial economic harm and operational harm that will flow from application of the Oil Ordinance and ZA Documents.

99. Plaintiffs have no plain, speedy, and adequate remedy at law to challenge the Oil Ordinance and ZA Documents other than the relief sought herein. The language of the Oil Ordinance and ZA Documents contain no alternative remedy available for Plaintiffs to bring all of the challenges alleged herein, nor has the City made available any other remedy at law that will adequately determine the merits of Plaintiffs' challenge to the Oil Ordinance and ZA Documents. Without the resolution of these challenges, Plaintiffs will be permanently and irreparably harmed by the implementation of the Oil Ordinance and ZA Documents.

100. Because the adoption of the Oil Ordinance and ZA Documents is quasi-legislative in nature and not adjudicatory, Plaintiffs bring this action under Code of Civil Procedure section 1085. In the alternative, however, Plaintiffs also seek a writ of mandamus under Code of Civil Procedure section 1094.5 to the extent, if any, that the Court concludes section 1094.5 is applicable here.

FOURTH CAUSE OF ACTION

(Petition for Writ of Traditional Mandamus under Code of Civil Procedure § 1085, or, alternatively, Administrative Mandamus under Code of Civil Procedure § 1094.5 – Inconsistency with General Plan)

(By All Plaintiffs Against All Defendants)

101. Plaintiffs reallege and incorporate by reference the foregoing paragraphs as though fully set forth herein.

102. Plaintiffs seek a writ of traditional mandamus pursuant to Code of Civil Procedure § 1085, or, alternatively, a writ of administrative mandamus pursuant to Code of Civil Procedure § 1094.5.

103. The City failed to demonstrate how the Oil Ordinance and ZA Documents are compatible and consistent with the General Plan in order to adopt the Oil Ordinance and ZA Documents. See Gov. Code § 65860.

104. The City's determination that the Oil Ordinance and ZA Documents are consistent with the General Plan is wholly lacking in evidentiary support. It is not sufficient merely to state in a

conclusory fashion that the Oil Ordinance and ZA Documents are consistent with the General Plan if unsupported by the evidence.

105. Accordingly, the City has acted arbitrarily and capriciously and abused its discretion.

106. Plaintiffs have no plain, speedy, and adequate remedy at law to challenge the Oil Ordinance and ZA Documents other than the relief sought herein. The language of the Oil Ordinance and ZA Documents contain no alternative remedy available for Plaintiffs to bring all of the challenges alleged herein, nor has the City made available any other remedy at law that will adequately determine the merits of Plaintiffs' challenge to the Oil Ordinance and ZA Documents. Without the resolution of these challenges, Plaintiffs will be permanently, irreparably harmed by the implementation of the Oil Ordinance and ZA Documents.

107. Because the enactment of the Oil Ordinance and ZA Documents is quasi-legislative in nature and not adjudicatory, Plaintiffs bring this action under Code of Civil Procedure § 1085. In the alternative, however, Plaintiffs also seek a writ of mandamus under Code of Civil Procedure § 1094.5 to the extent, if any, that the Court concludes Section 1094.5 is applicable here.

FIFTH CAUSE OF ACTION

(Violation of CEQA – Public Resources Code § 21000, *et seq.*)

(By All Plaintiffs Against All Defendants)

108. Plaintiffs reallege and incorporate by reference the foregoing paragraphs as though fully set forth herein.

109. CEQA applies whenever a government agency approves a discretionary project, defined as "an activity which may cause either a direct physical change in the environment, or a reasonably foreseeable indirect physical change in the environment." Pub. Res. Code § 21065.

110. **Improper Piecemealing**. CEQA defines "project" as the "whole of an action" and prohibits segmentation of project activities in an effort to minimize the evaluation of environmental effects. "Accordingly, CEQA forbids piecemeal review of the significant environmental impacts of a project." *Banning Ranch Conservancy v. City of Newport Beach*, 211 Cal. App. 4th 1209, 1222 (2012) (internal citations omitted). "Agencies cannot allow environmental considerations to become submerged by chopping a large project into many little ones." *Id.*

111. The entire activity before the City is the phasing-out of oil operations within its City limits, but the MND illegally only analyzes a portion of that project. The City has stated an intent to conduct further studies and ordinance amendments regarding amortization, abandonment, and remediation of existing well sites. The City concluded that the ZA Documents are not "projects" as that term is defined in CEQA Guidelines, Section 15378, and despite explicitly refusing to consider the impact of the ZA Documents in the MND, the City also stated that it evaluated the ZA Documents in the Initial Study prepared by the City to support the MND. In fact, neither the Oil Ordinance nor the MND adopted in conjunction provided any definition for the term "maintenance," which the City later defined in the ZAI (and which is currently the subject of an appeal to the City Planning Commission). Similarly, the City leaves for future determination and analysis the environmental impacts of the abandonment and future condition of the former oil sites, including how those compare to the current oil operations. The analysis does not examine the impacts from remediation and/or future development of the existing well sites. All of this activity is reasonably foreseeable as a result of the initial "project."

112. These foreseeable Ordinance amendments and regulatory guidance will change the scope and nature of the Oil Ordinance and ZA Documents and their environmental effects. By failing to analyze these changes in the MND, the MND understates the actual impact from the Project.

113. **Inadequate Analysis of Potential Impacts.** Under the "fair argument" standard, an EIR is required whenever substantial evidence in the record supports a "fair argument" that significant impacts may occur. *No Oil, Inc. v. City of Los Angeles*, 13 Cal.3d 68 (1974); *Friends of B Street v. City of Hayward*, 106 Cal.App.3d 988 (1980); Cal. Publ. Res. Code §§ 21080(c), 21080(d) and 21100(a); CEQA Guidelines, § 15064(f)(1).

114. The Oil Ordinance (as implemented by the ZA Documents) will undoubtedly impact the availability of mineral resources in the City and the State since the stated goal of the City is to stop oil production within the City limits. "Mineral resources" are an environmental factor pursuant to CEQA, and the "loss of availability of a known mineral resource that would be a value to the region and the residents of the state" or the "loss of availability of a locally important mineral resource recovery site" constitutes an adverse environmental impact. CEQA Guidelines, Appendix G, § XII(a),

(b); Public Resources Code § 21060.5. The City's own Oil and Gas Health Report dated July 25, 2019, which is incorporated herein by reference, confirms that *1.6 billion barrels* of recoverable oil and gas reserves remain beneath the City: "Even after more than century of prolific production, the US Geological Survey estimates 1.6 billion barrels of recoverable oil remain in place beneath the City, *rivaling the reserves in the Middle Eastern countries, like Saudi Arabia, Iraq, and Kuwait 14,000 miles away.*"[5]

115. The MND does not evaluate the impacts to air quality, GHG, and energy from replacing the State's and the City's demand for oil and gas products as a result of the restrictions by the Oil Ordinance and ZA Documents on the production of oil and gas within the City. The elimination of oil and gas produced in the City of Los Angeles does not eliminate the State's demand, or the City's demand for oil and gas products. Every barrel of oil per day that is not produced in the City will need to be produced elsewhere, and likely imported from other countries. Over the past several years, California sources of petroleum have been replaced by Alaskan and foreign sources.[6] Substantial evidence supports a fair argument that the air quality, GHG, and energy effects of this transition may have significant environmental effects requiring further review under CEQA.

116. The MND fails to analyze the potentially significant environmental effects to air quality, aesthetics, traffic, odor, and noise as a result of the accelerated rate of abandonment activities as a result of the Oil Ordinance and ZA Documents.

117. The City's MND fails to analyze the potential impacts from inconsistency with the City's General Plan and Community Plans. Many policies of both the General Plan and the various Community Plans support the extraction and production of oil within the City.

118. **Cumulative and Indirect Impacts**. The MND fails to consider cumulative impacts from other reasonably foreseeable restrictions on oil operations, such as a similarly restrictive ordinance proposed by the County of Los Angeles and the passage of SB 1137 by the State (imposing

---

[5] City of Los Angeles, Office of Petroleum and Natural Gas Administration and Safety, Oil and Gas Health Report, dated July 25, 2019, available at https://clkrep.lacity.org/onlinedocs/2017/17-0447_rpt_BPW_07-29-2019.pdf at page 19.

[6] California Energy Commission, Oil Supply Sources To California Refineries, available at https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/oil-supply-sources-california-refineries.

setbacks and increased restrictions on oil wells within a "health protection zone). These cumulative impacts will result in increased well abandonments. CEQA also requires an analysis of other past, current, and probable future projects (including those unrelated to oil production restrictions). The MND contains no discussion of *any* other projects. The MND also fails to analyze the cumulative impacts from increased GHG and other air emissions from increased imports of oil as a result of the reduced local production. Accordingly, the MND fails to meet the minimum standards of CEQA for cumulative impacts analysis.

119. The MND also fails to discuss reasonably foreseeable indirect impacts. This requirement extends to the adoption of lead agency ordinances that result in changes to land use patterns. There is no discussion as to the potential impacts that may result from the development of the sites as they are abandoned. Basic information, such as the zoning for the consolidated well sites, is not even included in the MND even though this information is readily available. If a direct change in the physical environment will cause another change in the environment, the secondary effect must be evaluated as an indirect effect of the project. CEQA Guidelines, § 15064(d). The impact analysis must also consider the potential for growth-inducing impacts. CEQA Guidelines, § 15358(a). Yet the MND fails entirely to consider these impacts.

120. **Improper Baseline.** A CEQA document must describe the physical environmental conditions in the vicinity of a proposed project as they exist at that time. This environmental setting will normally constitute the baseline physical conditions by which a lead agency will determine whether a project may have a significant impact on the environment. Without a comparison of existing baseline physical conditions to the conditions expected to be produced by a project, an initial study or EIR will not inform decision makers and the public of the project's significant environmental impacts, as CEQA mandates.

121. The MND fails to describe accurately the existing setting. For example, the MND inappropriately assumes that oil and gas operations have been associated with negative health and safety impacts, although it identifies no evidence of widespread negative health impacts from local oil and gas operations, and comment letters in the record identified multiple studies from local agencies making the opposite conclusion. The MND also failed to properly quantify the existing setting, such

as for existing air quality and ambient sound conditions.

122. **Procedural Violations**. The City violated CEQA and its own procedures by the fact that the committees of the City Council did not have an opportunity to consider the final MND and all of the comments submitted regarding the MND. Both the Environmental Committee and the PLUM Committee are established pursuant to the City Charter, requiring the City Council and the Committees to become fully informed of the business of the City. (Resolution, January 12, 2021, City Council Committees.) It is the duty of the committees "to report to the Council any information or recommendations necessary to enable the Council to properly legislate." (Resolution, January 12, 2021, City Council Committees.)

123. Further, the City improperly adopted a revised MND and MMP after previously adopting the MND on November 22, 2022. The City was required to re-circulate the revised MND for public comment based on the prior adoption of the MND and the substantial revisions to the document.

124. Accordingly, the MND is fundamentally flawed and does not comply with the basic legal requirements of CEQA, thereby depriving the public and City decision makers of relevant information needed for informed deliberation and consideration.

125. The City's actions in adopting the Oil Ordinance without full compliance with the requirements of CEQA, as alleged herein, were arbitrary, capricious, and an abuse of discretion. The City's failure to conduct sufficient CEQA review prior to approving the Oil Ordinance further constituted a prejudicial abuse of discretion for failure to proceed in a manner required by law. Pub. Res. Code § 21168.5.

126. Plaintiffs performed any and all conditions precedent prior to filing this action and have exhausted all available administrative remedies to the extent required by law.

127. For the foregoing reasons, a writ of mandate should issue, commanding the City to rescind its action approving the Oil Ordinance, until such time as the City has properly complied with the requirements of CEQA.

SIXTH CAUSE OF ACTION

(Declaratory Relief - Preemption)

(By All Plaintiffs Against All Defendants)

128. Plaintiffs reallege and incorporate by reference the foregoing paragraphs as though fully set forth herein.

129. Plaintiffs seek a declaration from this Court that the Oil Ordinance and ZA Documents are preempted by state law. Plaintiffs further seek a declaration that, as a result of this preemption, the Oil Ordinance and ZA Documents are invalid.

130. Such a declaration is necessary and appropriate at this time in order to determine the validity of the Oil Ordinance and ZA Documents.

131. The City disputes the contention that the Oil Ordinance and ZA Documents are preempted by state law and is thus invalid. Therefore, there is a present and actual controversy between Plaintiffs and the City.

132. Pursuant to federal and state law, the power and authority to regulate oil and gas operations, methods, and procedures in California lies exclusively in the State of California, including with CalGEM. The Oil Ordinance and ZA Documents purport to regulate, restrict, prohibit, impair, and then terminate subsurface operations within the City, and they are in direct conflict with superior California law, including, without limitation, the sections of the California Public Resources Code relating to oil and gas production.

133. The City lacks the power, authority, and jurisdiction to indirectly prohibit or impair subsurface operations by imposing restrictive policies, as that power is exclusively a function of the State of California. Moreover, the laws of the State of California preempt and fully occupy regulation of the methods and practices for oil and gas operations. The Oil Ordinance and ZA Documents are preempted, in whole or in part, by state law, and, as such, are invalid and without effect.

134. The City disputes the contentions set forth above.

135. Judicial intervention in these disputes, and a declaration by the Court, is necessary to resolve whether the Oil Ordinance and ZA Documents are preempted, in whole or in part, by state law.

SEVENTH CAUSE OF ACTION

(Declaratory Relief - Impairment of Plaintiffs' Vested Rights)

(By All Plaintiffs Against All Defendants)

136. Plaintiffs reallege and incorporate by reference the foregoing paragraphs as though fully set forth herein.

137. Plaintiffs seek a declaration from this Court that Plaintiffs have fully-vested rights to continue and to complete the development and production of their oil and gas resources within the City, consistent with their long-established operations to extract oil and gas pursuant to the appropriate agency entitlements. Plaintiffs further seek a declaration that, as a result of these vested rights, the City may not use the Oil Ordinance and ZA Documents to prohibit the activities authorized by Plaintiffs' permits, agreements, or conditions to operate.

138. Plaintiffs or their predecessors have drilled wells and installed equipment with the expectation that additional wells could be drilled, and oil and gas resources could be extracted.

139. The doctrine of vested rights seeks to protect property owners and developers who have substantially relied on past permits and proceeded accordingly with the government's acknowledgement. The doctrine protects a permit holder's right not only to construct, but also to use the premises as authorized by the permit. *Cnty. of San Diego v. McClurken*, 37 Cal. 2d 683, 691 (1951).

140. Plaintiffs have vested rights to develop and produce oil and gas resources within the City, consistent with long-established plans and Plaintiffs' vested rights. Plaintiffs' vested rights are not limited to the production value of the existing wells, and instead include all prudent and feasible means to develop and produce oil and gas resources as contemplated by state law and existing permits. These vested rights include the drilling of future wells and the redrilling of existing and future wells, with such drilling and re-drilling in numbers and within timeframes based on the ability to recover these oil and gas resources.

141. In the alternative, the "diminishing asset doctrine" applies, which permits oil and gas operators and others in extractive industries to exhaust the mineral value of their property. There are many years of oil and minerals yet to be extracted from Plaintiffs' mineral leases within the City.

Plaintiffs' reasonable, investment-based expectation was that they would continue to produce and develop oil and gas until their leased assets are no longer capable of producing oil and gas in commercial quantities. The City's actions will have the direct result of substantially diminishing Plaintiffs' reasonable investment-backed expectations.

142. Plaintiffs have clearly exhibited an intent to continue and to complete the development and production of their oil and gas resources within the City. The continued development of these resources is a progression of the extractive activity within the City as authorized by Plaintiffs' permits, agreements, or conditions to operate.

143. The City disputes Plaintiffs' contention and intends to impair Plaintiffs' vested rights through adoption and implementation of the Oil Ordinance and ZA Documents.

144. Plaintiffs seek a judicial declaration of the rights and obligations of the respective parties.

145. Judicial intervention in this dispute and a declaration by the Court are necessary to resolve whether Plaintiffs have vested rights to continue and to complete the development and production of their oil and gas resources within the City.

146. The City's enactment and adoption of the Oil Ordinance and ZA Documents and impairment of Plaintiffs' rights irreparably harm and will continue to irreparably harm Plaintiffs based on the substantial economic harm and operational harm that will flow from application of the Oil Ordinance and ZA Documents.

EIGHTH CAUSE OF ACTION

(Petition for Writ of Traditional Mandamus under Code of Civil Procedure § 1085, or, alternatively, Administrative Mandamus under Code of Civil Procedure § 1094.5 –Taking or Damaging Property for Public Use Without Prior Compensation)

(By All Plaintiffs Against All Defendants)

147. Plaintiffs reallege and incorporate by reference the foregoing paragraphs as though fully set forth herein.

148. Plaintiffs seek a writ of traditional mandamus pursuant to Code of Civil Procedure § 1085, or, alternatively, a writ of administrative mandamus pursuant to Code of Civil Procedure

§ 1094.5 commanding the City to vacate and set aside its adoption of the Oil Ordinance and ZA Documents because they constitute a taking of Plaintiffs' oil and gas resources within the City for the benefit of the public without prior compensation to Plaintiffs or, in the alternative, a reasonable amortization period to allow recovery of the investment in violation of Article 1, section 19 of the California Constitution and the Takings Clause of the Fifth and Fourteenth Amendments to the United States Constitution.

149. The City's adoption of the Oil Ordinance is part of an effort to stop oil and gas production within the City purely due to political pressure and without regard to ongoing business interests.

150. The City's adoption of the Oil Ordinance also substantially impairs Plaintiffs' property rights within the City for the benefit of the public without prior compensation to Plaintiffs or, in the alternative, a reasonable amortization period to allow recovery of Plaintiffs' investment.

151. The Oil Ordinance and ZA Documents force Plaintiffs to bear public burdens which, in all fairness and justice, should be borne by the public as a whole.

152. In taking action to adopt the Oil Ordinance and ZA Documents, the City violated Article 1, section 19 of the California Constitution, which prohibits the temporary or permanent taking or damaging of private property for public use without prior, just compensation. Further, the City violated the takings clause of the Fifth Amendment to the U.S. Constitution, as incorporated by the Fourteenth Amendment, which prohibits the temporary or permanent taking of private property for public use without prior, just compensation.

153. Plaintiffs' interests and investment-backed expectations will be materially, substantially, and irreparably harmed by the Oil Ordinance and ZA Documents.

154. Because the enactment of the Oil Ordinance and ZA Documents is quasi-legislative in nature and not adjudicatory, Plaintiffs bring this action under Code of Civil Procedure § 1085. In the alternative, however, Plaintiffs also seek a writ of mandamus under Code of Civil Procedure § 1094.5 to the extent, if any, that the Court concludes Section 1094.5 is applicable here.

NINTH CAUSE OF ACTION

(Declaratory Relief - Inverse Condemnation)

(By All Plaintiffs Against the City of Los Angeles)

155. Plaintiffs reallege and incorporate by reference the foregoing paragraphs as though fully set forth herein.

156. The Oil Ordinance and ZA Documents are invalid because they substantially impair Plaintiffs' vested rights in the continuation of oil and gas production within the City.

157. The City eliminates substantially all of Plaintiffs' economically viable use of their oil and gas resources within the City for the benefit of the public without prior compensation to Plaintiffs or, in the alternative, a reasonable amortization period to allow recovery of the investment. The City, therefore, violated Article 1, section 19 of the California Constitution and the Takings Clause of the Fifth and Fourteenth Amendments to the United States Constitution by adopting the Oil Ordinance and ZA Documents.

158. The City's adoption of the Oil Ordinance and ZA Documents is part of an effort to stop oil and gas production within the City purely due to political pressure and without regard to ongoing business interests.

159. The City's adoption of the Oil Ordinance and ZA Documents also substantially impairs Plaintiffs' property rights within the City for the benefit of the public without prior compensation to Plaintiffs or, in the alternative, a reasonable amortization period to allow recovery of Plaintiffs' investment.

160. The Oil Ordinance and ZA Documents force Plaintiffs to bear public burdens which, in all fairness and justice, should be borne by the public as a whole.

161. In taking action to adopt the Oil Ordinance and ZA Documents, the City violated Article 1, section 19 of the California Constitution, which prohibits the temporary or permanent taking or damaging of private property for public use without prior, just compensation. Further, the City violated the takings clause of the Fifth Amendment to the U.S. Constitution, as incorporated by the Fourteenth Amendment, which prohibits the temporary or permanent taking of private property for public use without prior, just compensation.

162. Plaintiffs' interests and investment-backed expectations will be materially, substantially, and irreparably harmed by the Oil Ordinance and ZA Documents.

163. A bona fide and actual controversy exists between Plaintiffs and the City in that Plaintiffs allege, and the City denies, that the adoption of the Oil Ordinance and ZA Documents violates Article 1, section 19 of the California Constitution and the Takings Clause of the Fifth and Fourteenth Amendments to the United States Constitution.

164. Plaintiffs desire a judicial determination of the validity of the Oil Ordinance and ZA Documents to save themselves from the harm caused by its adoption, which will terminate Plaintiffs' oil and gas operations within the City. Plaintiffs' interests will be materially, substantially, and irreparably harmed by the Oil Ordinance and ZA Documents.

TENTH CAUSE OF ACTION

(Damages for Taking or Damaging Property for Public Use Without Prior Compensation in Violation of Article 1, § 19 of the California Constitution and Violation of the Takings Clause of the Fifth and Fourteenth Amendments to the United States Constitution)

(By All Plaintiffs Against the City of Los Angeles)

165. Plaintiffs reallege and incorporate by reference the foregoing paragraphs as though fully set forth herein.

166. At the time the City adopted the Oil Ordinance and ZA Documents, Plaintiffs owned fee and leasehold interests in mineral rights in land within the City.

167. For years prior to the City's action in adopting the Oil Ordinance and ZA Documents, Plaintiffs had vested rights to continue drilling operations within the City as a matter of right.

168. The enactment of the Oil Ordinance and ZA Documents substantially impairs Plaintiffs' vested rights in the continuation of oil and gas production within the City and eliminates substantially all of Plaintiffs' economically viable use of their oil and gas resources within the City for the benefit of the public without prior compensation to Plaintiffs or, in the alternative, a reasonable amortization period to allow recovery of the investment.

169. In taking action to adopt the Oil Ordinance and ZA Documents, the City violated Article 1, section 19 of the California Constitution, which prohibits the temporary or permanent taking

or damaging of private property for public use without prior, just compensation. Further, the City violated the takings clause of the Fifth Amendment to the U.S. Constitution, as incorporated by the Fourteenth Amendment, which prohibits the temporary or permanent taking of private property for public use without prior, just compensation.

170. As a direct result of the City's actions as alleged herein, the enactment of the Oil Ordinance and ZA Documents will interfere with the reasonable investment-backed expectations of Plaintiffs.

171. To date, Plaintiffs have not received any compensation from the City on account of the above alleged taking of, or damage to, their property rights within the City. The City failed to ascertain the just compensation due to Plaintiffs prior to adoption of the Oil Ordinance and ZA Documents.

172. As a direct and proximate result of the City's violation of Article 1, section 19 of the California Constitution and the takings clause of the Fifth Amendment of the U.S. Constitution, as alleged above, Plaintiffs have been and will be damaged from the interference with their reasonable investment-backed expectations in their fee and leasehold interests in mineral rights in land within the City and will suffer further damages in an amount to be determined at trial.

173. Plaintiffs are entitled to damages and attorneys' fees for the City's constitutional violation under Sections 1983 and 1988 of the Federal Civil Rights Act of 1871.

ELEVENTH CAUSE OF ACTION

(Declaratory Relief - Violation of Article 1, Section 7 of the California Constitution and Violation of the Fourteenth Amendment to the United States Constitution [Due Process])

(By All Plaintiffs Against the City of Los Angeles)

174. Plaintiffs reallege and incorporate by reference the foregoing paragraphs as though fully set forth herein.

175. Under the United States Constitution and the California Constitution, the City may not deprive Plaintiffs of property rights without due process of law. U.S. Const. amend. XIV, § 1; Cal. Const. art. I, § 7, subd. (a).

176. Arbitrary or irrational governmental action that infringes on a property owner's rights

violates substantive constitutional due process.

177. Here, the City's adoption of the Oil Ordinance and ZA Documents was arbitrary, discriminatory, and not reasonably related to any legitimate governmental purpose. Oil and gas operations within the City are the only operations affected by the Oil Ordinance and ZA Documents. The clear purpose of the Oil Ordinance is to terminate and prohibit oil and gas operations within the City due to political pressure, despite ongoing successful operation for decades. For these reasons, the adoption of the Oil Ordinance and ZA Documents violates Plaintiffs' due process rights under Article 1, section 7 of the California Constitution, as well as the Due Process Clause of the Fourteenth Amendment to the United States Constitution.

178. There is no legitimate interest in terminating oil and gas operations within the City.

179. There is no legitimate interest in eliminating an industry that is already regulated, permitted by various government entities, and contributes to the local economy.

180. The Oil Ordinance and ZA Documents also interfere with Plaintiffs' vested rights to complete the development and production of oil and gas resources within the City. There are substantive due process requirements that vested rights cannot be terminated or impaired by ordinary police power regulations and can be revoked or impaired only to serve a "compelling state interest," such as harm, danger, or menace to public health and safety or public nuisance, and that the government's interference with the vested rights be narrowly tailored to address the compelling interest and its magnitude. The City has not identified any compelling state interest to justify terminating or impairing Plaintiffs' vested rights. Nor is there any.

181. In the City's rush to adopt an amortization ordinance, the City has not followed the necessary procedures to demonstrate that oil and gas production in the City results in any environmental, health, or safety hazards. The City has failed to prepare any amortization study to support its purported 20-year amortization period. The Oil Ordinance would prohibit maintenance to operate the wells, further curtailing operations. Further the City staff recommended action by the City Council before completing the CEQA process.

182. Moreover, the ZA Documents improperly burden operators to show maintenance is needed to prevent any alleged threat to public health or safety, even if needed to maintain existing

operations. The process prescribed by ZA Documents fails to provide a timeframe, putting oil wells at risk of abandonment before the determination process can even conclude.

183. The Oil Ordinance and ZA Documents impose impermissible and arbitrary restrictions on Plaintiffs, which are not imposed on similarly situated persons or businesses.

184. A bona fide and actual controversy exists between Plaintiffs and the City in that Plaintiffs allege, and the City denies, that the adoption of the Oil Ordinance and ZA Documents violated Article 1, section 7 of the California Constitution and the Due Process Clause of the Fourteenth Amendment to the United States Constitution.

185. Plaintiffs desire a judicial determination of the validity of the Oil Ordinance and ZA Documents to save themselves from the harm caused by their adoption, which will terminate Plaintiffs' oil and gas operations within the City. Plaintiffs' interests will be materially, substantially, and irreparably harmed by the Oil Ordinance and ZA Documents.

186. Plaintiffs are entitled to damages and attorneys' fees from the City of Los Angeles for the City's constitutional violation under Sections 1983 and 1988 of the Federal Civil Rights Act of 1871. *See Monell v. Dept. of Social Services*, 436 U.S. 658 (1978).

TWELFTH CAUSE OF ACTION

(Declaratory Relief - Impairment of Contractual Relations in Violation of Article 1, § 9 of the California Constitution and Article 1, § 10 of the United States Constitution)

(By All Plaintiffs Against the City of Los Angeles)

187. Plaintiffs reallege and incorporate by reference the foregoing paragraphs as though fully set forth herein.

188. The Oil Ordinance and ZA Documents violate Article 1, § 9 of the California Constitution and Article 1, § 10 of the United States Constitution, which prohibit the enactment of laws affecting a "substantial impairment" of contracts, which applies to public contracts as well as contracts between private parties.

189. Plaintiffs hold leasehold interests with the owners of mineral rights surrounding Plaintiffs' oil production operations. Plaintiffs are parties to contracts in the form of leases between them and the property owners, which impose obligations on Plaintiffs that continue beyond the date

the amortization period expires.

190. By prohibiting the expansion of oil and gas uses, requiring Plaintiffs to terminate their operations within the City within 20 years, restricting the use of maintenance, and imposing unreasonable and vague procedures that will effectively restrain or eliminate the ability to maintain oil wells and extract essential mineral resources, the Oil Ordinance and ZA Documents impair those contractual relations, prevent Plaintiffs from meeting contractual obligations to lessors, and will undermine Plaintiffs' reasonable expectations under the contracts.

191. The record shows that there is no valid basis for the City's exercise of police power or legitimate local interest that would justify the impairment of Plaintiffs' contractual relations imposed by the Oil Ordinance and ZA Documents.

192. The City also failed to consider less restrictive means to achieve the purported purposes of the Oil Ordinance and ZA Documents. Instead, the Oil Ordinance and ZA Documents impose an arbitrary, capricious and unsupported amortization period and restrictions on necessary maintenance without any consideration of existing or potential mitigation of the purported health, safety, and environmental concerns, much less any credible scientific basis for the purported health, safety, and environmental concerns asserted in the Oil Ordinance and ZA Documents.

193. The Oil Ordinance and ZA Documents operate as a substantial and unjustified impairment of the obligations of those contractual relationships in violation of the Impairments Clause of the California and United States Constitution.

194. As a direct and proximate result of the City's violation of Article 1, § 9 of the California Constitution and Article 1, § 10 of the United States Constitution, as alleged herein, Plaintiffs' interest will be materially, substantially, and irreparably harmed by the Oil Ordinance and ZA Documents.

195. A bona fide and actual controversy exists between Plaintiffs and the City in that Plaintiffs allege, and the City denies, that the adoption of the Oil Ordinance and ZA Documents violated Article 1, § 9 of the California Constitution and Article 1, § 10 of the United States Constitution.

196. Plaintiffs desire a judicial determination of the validity of the Oil Ordinance and ZA Documents to save themselves from the harm caused by its adoption, which will terminate Plaintiffs'

oil and gas operations within the City. Plaintiffs' interests will be materially, substantially, and irreparably harmed by the Oil Ordinance and ZA Documents.

197. Plaintiffs are entitled to damages and attorneys' fees from the City of Los Angeles for the City's constitutional violation under Sections 1983 and 1988 of the Federal Civil Rights Act of 1871. *See Monell v. Dept. of Social Services*, 436 U.S. 658 (1978).

THIRTEENTH CAUSE OF ACTION

(Intentional Interference with Contractual Relations)

(By All Plaintiffs Against the City of Los Angeles)

198. Plaintiffs reallege and incorporate by reference the foregoing paragraphs as though fully set forth herein.

199. The City has intentionally interfered with the contractual relations between certain property owners within the City and Plaintiffs.

200. Certain property owners within the City lease their mineral rights to Plaintiffs. Plaintiffs are parties to valid contracts in the form of leases between Plaintiffs and the mineral rights owners.

201. The City was aware of these contracts at the time it adopted and enacted the Oil Ordinance and ZA Documents.

202. The Oil Ordinance and ZA Documents cause an actual disruption of the contractual relationships between the property owners and Plaintiffs because they prohibit the expansion of oil and gas uses, require Plaintiffs to terminate their operations within the City within 20 years, restrict the use of maintenance, and impose unreasonable and vague procedures that will effectively restrain or eliminate the ability to maintain oil wells and extract essential mineral resources. These actions will impair those contractual relations, preventing Plaintiffs from meeting contractual obligations to lessors and undermining Plaintiffs' reasonable expectations under the contracts.

203. As a direct and proximate result of the City's adoption and enactment of the Oil Ordinance and ZA Documents, as alleged above, Plaintiffs have been and will be damaged from the disruption of their contractual relationships with their property lessors within the City, and Plaintiffs will suffer further damages in an amount to be determined at trial.

204. On December 8, 2022, Plaintiffs presented written claims to the City for intentional interference with contractual relations pursuant to the claim presentation requirements of the California Tort Claims Act. Gov. Code § 910 (City of Los Angeles Claim Nos. C23-24688, C23-24689, C23-24691, and C23-24692). On February 13, 2023, the City rejected Plaintiffs' written claims. Plaintiffs have timely filed this cause of action pursuant to Gov. Code § 945.6.

FOURTEENTH CAUSE OF ACTION

(Breach of Contract)

(By HBOC Against the City of Los Angeles)

205. Plaintiffs reallege and incorporate by reference the foregoing paragraphs as though fully set forth herein.

206. HBOC is a party to lease agreements with the City for its oil and gas operations at the Rancho Park Golf Course. These leases provide HBOC with the right to occupy certain land within the City of Los Angeles for oil operations, with limited exceptions for early termination by the City.

207. HBOC's leases with the City also incorporate the implied covenant of good faith and fair dealing.

208. The City's adoption and enactment of the Oil Ordinance and ZA Documents have breached explicit provisions in HBOC's leases with the City and with the City's implied covenant of good faith and fair dealing.

209. As a direct and proximate result of the City's adoption and enactment of the Oil Ordinance and ZA Documents, as alleged above, HBOC has been and will be damaged by the City's breach of the express and implied covenants of its leases with HBOC, and HBOC will suffer further damages in an amount to be determined at trial.

210. On December 8, 2022, HBOC presented a written claim to the City for breach of contract pursuant to the claim presentation requirements of the California Tort Claims Act. Gov. Code § 910 (City of Los Angeles Claim No. C23-24689). On February 13, 2023, the City rejected HBOC's written claim. HBOC has timely filed this cause of action pursuant to Gov. Code § 945.6.

PRAYER FOR RELIEF

WHEREFORE, Plaintiffs pray for judgment and further relief as follows:

1. For alternative and peremptory writs of mandate commanding the City to vacate and set aside its decision to adopt the Oil Ordinance and ZA Documents;

2. For alternative and peremptory writs of mandate commanding the City to prepare and certify a legally adequate CEQA document for the Oil Ordinance and ZA Documents and to suspend any and all activity pursuant to the City's adoption of the Oil Ordinance and ZA Documents that could result in an adverse change or alteration to the physical environment until the City has complied with all requirements of CEQA and all other applicable state and local laws, policies, ordinances, and regulations as are directed by this Court pursuant to Public Resources Code § 21168.9;

3. For interlocutory and permanent injunctive relief enjoining the City from engaging in any activity pursuant to the Oil Ordinance and ZA Documents until the Oil Ordinance complies with CEQA and all other applicable state and local laws, policies, ordinance, and regulations;

4. For a declaration that the City violated CEQA in adopting the Oil Ordinance and ZA Documents;

5. For a declaration that the Oil Ordinance and ZA Documents are preempted, in whole or in part, by state law, and are invalid and without effect;

6. For a declaration that Plaintiffs have vested rights to continue and to complete the development and production of their oil and gas resources within the City and that as a result, the Oil Ordinance and ZA Documents are not enforceable as to Plaintiffs' operations within the City;

7. For a declaration that the Oil Ordinance and ZA Documents violate Plaintiffs' due process rights;

8. For a declaration that the Oil Ordinance and ZA Documents violate provisions of the California Constitution and the United States Constitution;

9. For damages for just compensation and interest thereon, according to proof, for the temporary and permanent taking of Plaintiffs' property in violation of the Fifth Amendment to the United States Constitution and Article I, § 19 of the California Constitution;

10. For a preliminary and permanent injunction enjoining the City from taking any action in furtherance of, or to implement, the Oil Ordinance and ZA Documents;

11. For an award of damages against the City according to proof;

12. For Plaintiffs' costs of suit incurred herein;

13. For reasonable attorneys' fees authorized by Code of Civil Procedure §§ 1021.5 and 1036, Sections 1983 and 1988 of the Federal Civil Rights Act of 1871, and other pertinent law; and

14. For such other and further relief as the Court deems just and proper.

DATED: November 6, 2023

ALSTON & BIRD LLP



Matthew Wickersham
Attorneys for Plaintiffs and Petitioners
E & B NATURAL RESOURCES MANAGEMENT CORPORATION, HILLCREST BEVERLY OIL CORPORATION, E&B ENR I, LLC, and ELYSIUM NATURAL RESOURCES, LLC

VERIFICATION

I, Gary Richardson, am Vice President of Administrative and Business Development of E & B Natural Resources Management Corporation, and I am Authorized Representative of Hillcrest Beverly Oil Corporation, E&B ENR I, LLC, and Elysium Natural Resources, LLC. I am authorized to execute this verification on behalf of them. I have read the attached Verified Second Amended Petition for Writ of Mandate and Complaint for Constitutional Violations, Inverse Condemnation, and Damages and am familiar with its contents. The facts provided in the petition and complaint are true of my personal knowledge, except for those alleged on information and belief, and I believe those to be true.

DATED: October 27, 2023

Gary Richardson

EXHIBIT B

[Alston & Bird's MAY 5, 2025 Comment Letter]

ALSTON & BIRD

333 South Hope Street, 16th Floor
Los Angeles, CA 90071-1410
213-576-1000 | Fax: 213-576-1100

Matthew Wickersham Direct Dial: **+1 213 576 1185** Email: **matt.wickersham@alston.com**

March 24, 2025

VIA LACouncilComment.com

Planning and Land Use Management Committee
Los Angeles City Council
200 North Spring Street, Room 701
Los Angeles, CA 90012

Re: Opposition to Agenda Item No. 5 (Council File No. 24-1580), March 25, 2025, PLUM Committee Meeting

Dear Councilmembers:

We represent E & B Natural Resources Management Corporation, Hillcrest Beverly Oil Corporation, E&B ENR I, LLC, and Elysium Natural Resources, LLC (collectively, "E&B") regarding the City of Los Angeles's ("City") Agenda Item No. 5 (Council File No. 24-1580) for its March 25, 2025 PLUM committee meeting, concerning a motion "relative to instructing the Department of City Planning... to prepare an interim control ordinance that would halt the practice of oil well acid maintenance...."

The City's proposed interim ordinance seeks to prohibit normal and necessary maintenance functions required for ongoing, authorized petroleum operations. Well cleaning, also known as descaling the interior of an oil well, is essential for ensuring the operating equipment runs efficiently and safely. It is similar to a car needing regular oil changes to keep the vehicle operating as designed for its intended purpose. Moreover, California has the strictest environmental regulations, and the oil and gas industry continuously adheres to these rules. By using best practice cleaning methods, which include well cleaning activities like acid maintenance activities, E&B and other oil operators ensure field and worker safety.

E&B now submits this letter ahead of the March 25, 2025 public hearing that is planned to include a consideration of Council File No. 24-1580.

I. Well Cleaning is Short in Duration, Involves Minimal Equipment, and is Akin to Routine Cleaning Activities.

Well cleaning activities have been safely performed by operators for decades. Well cleaning is short in duration, requires relatively minimal equipment, and is very similar to other types of cleaning conducted in everyday activities. Cleaning a well typically takes anywhere from a couple of hours to less than a day depending on the extent of servicing needed. Additionally, routine maintenance is preferable as it shortens the cleaning duration and is legally required to keep operations within regulatory compliance.

E&B and other oil operators adhere to closed-loop fluid management, to ensure that no chemicals or wastewater are released into the environment and to promote fluid recycling. In doing so, cleaning solutions and solvents are captured and stored to avoid exposure to workers or the public.

Well cleaning is similar to other cleaning activities that are allowed to proceed in everyday activities and at many other City-owned properties. For instance, well cleaning is similar to pool cleaning. As with well cleaning, pool filtration systems are descaled using acid (e.g., muriatic acid) to remove mineral buildup, just as acids are used in oil wells. As another example, descaling a coffee pot with vinegar to remove mineral buildup mirrors the use of acids in well cleaning to break down scale. Acid-based solutions are also used to clean underground water tanks and pipes, much like the cleaning process in oil wells.

II. E&B and Other Oil Operators Adhere to Strict Environmental Standards Concerning Well Cleaning.

Oil well cleaning must comply with state regulations, including California Department of Conservation, Geologic Energy Management Division's ("CalGEM") guidelines. Furthermore, the cleaning and maintenance of injection wells fall under the Underground Injection Control ("UIC") regulations of the Safe Drinking Water Act ("SDWA"), enforced by the United States Environmental Protection Agency ("EPA"). These rules are designed to ensure best engineering practices are followed in the field to ensure equipment and worker safety. E&B and oil operators throughout the City make safety a priority during well-cleaning, and their work follows the strict safety procedures outlined by existing regulations throughout the process. Pursuant to SCAQMD Rule 1148.2, oil operators must also notify nearby communities if these activities occur within a specific distance from sensitive receptors like schools, hospitals, or homes, ensuring residents are informed of maintenance activity. The Motion will prohibit operators from conducting routine well maintenance, ultimately leading to a well not meeting regulatory compliance requirements, becoming subject to Notices of Violation, and creating an unintended consequence of an unsafe condition for its workers and the surrounding community.

The Motion will also ultimately lead to the loss of local oil production. A decrease in local oil production would require importing oil from other sources to meet demand, thus increasing ship, rail, and tanker truck traffic to the State from foreign suppliers. The importation of crude oil from out of state will have increased environmental impacts, particularly increased greenhouse gas ("GHG") emissions. Sources of GHG at oil and gas fields outside of California are not subject to California's regulatory setting, which ensures that GHG sources in the business of oil and gas production in California are subject to multiple programs aimed at reducing GHG. By increasing the activity of oil and gas extraction outside of California, the City would cause increased GHG from sources that are not required to offset the GHG to comply with California's laws, resulting in an overall net increase in GHG emissions compared with both existing conditions and the project.

Beyond the clear negative impacts, the City has failed to conduct an analysis under the California Environmental Quality Act to consider these potentially significant environmental impacts. The City is also acting in conflict with the policies and objectives in its General Plan, including to "enable appropriate, environmentally sensitive extraction of petroleum deposits located within the city's jurisdiction so as ... to reduce the city's dependency on imported petroleum and petroleum products." (See, e.g., City of Los Angeles Conservation Element at II-64.)

III. The Interim Control Ordinance Is Not Appropriate Under Government Code Section 65868.

The City's Motion proposes adopting an interim control ordinance that will prohibit well cleanouts pursuant to Government Code section 65858, which authorizes local agencies to:

> "adopt as an urgency measure an interim ordinance prohibiting any uses that may be in conflict with a contemplated general plan, specific plan, or zoning proposal that the legislative body, planning commission or the planning department is considering or studying or intends to study within a reasonable time."

Section 65868 is only intended to "*preserve the status quo....*" (*CEEED v. California Coastal Zone Conservation Com.* (1974) 43 Cal.App.3d 306, 314-315, italics added.) However, prohibiting a method of well cleaning does not preserve the status quo, nor does it relate to the prohibition of a use in conflict with governing land use documents. The use – the operation of an oil well – is already authorized by existing law. Likewise, well cleanouts do not constitute new projects, as they make up an ongoing and necessary component of operating the lawfully existing production sites.

Section 65858 also requires the City Council to find a current and immediate threat to the public health, safety, or welfare. (Govt. Code § 65858, subd. (c).) Yet, these well

cleanouts have taken place at the City's drill sites since their inception, and no threat has been identified. The City would be unable to make findings of a "current and immediate threat to the public health, safety, or welfare."

Based on the recent judgment issued in the litigation challenging Ordinance No. 187709 ("Ordinance"), Zoning Administrator Memorandum 141 ("ZA Memo 141") and Zoning Administrator's Interpretation, Case No. ZA-2022-8997-ZAI-1A, as modified on October 4, 2023, ("ZAI"), the City is enjoined from enforcing any provisions in these documents, including those that specifically restricted the use of well acid maintenance. In agreeing to the issuance of the judgment in that litigation, the City also stipulated that, before the City moves forward with a substantially similar version of the Ordinance, the City agreed to conduct at least two stakeholder meetings. By seeking to adopt an Interim Control Ordinance that would prohibit a core subject of the prior Ordinance before conducting these stakeholder meetings, the City is not acting in good faith with respect to its prior agreement.

IV. The Interim Control Ordinance is Preempted by Federal and State Law.

The decision by the California Supreme Court in *County of Monterey* specifically held that local governments are preempted from interfering in the regulation of oil and gas operations. (*Chevron U.S.A. Inc. v. Cty. of Monterey* (2023) 15 Cal.5th 135 ("*County of Monterey*").) The Legislature attempted to negate this holding in adopting AB3233 and adding section 3106.1 to the Public Resources Code, however, the preemption determination made by the Court in *County of Monterey* was based on the constitutional provisions providing for preemption by state law over conflicting local ordinances. The California Supreme Court is the final arbiter on these state constitutional issues unless a constitutional amendment is adopted.

The Motion is also preempted by federal law as it will conflict with the delegation of authority to CalGEM to regulate the UIC program under the SDWA. "Congress intended that states retain authority respecting underground injection so long as it does not impinge on the UIC program administered by the EPA." (*Bath Petroleum Storage, Inc. v. Savas* (N.D.N.Y. 2004) 309 F.Supp.2d 357, 367-368.) "[S]urely the prohibition above prevents such local law from altogether preventing UIC activity." (*EQT Prod. Co. v. Wender* (S.D.W.Va. 2016) 191 F. Supp. 3d 583, 601, affd. on other grounds (4th Cir. 2017) 870 F.3d 322.) By prohibiting routine maintenance on all wells, including injection wells regulated by the SDWA, the City's proposed ordinance is preempted by federal law.

The City also cannot simply prohibit activity that is the subject of SCAQMD's notification requirements. The SCAQMD has extensive rules regarding the air quality concerns that the City purportedly seeks to address by its new, proposed halting of acid maintenance activities. (*See, e.g.*, SCAQMD Rules 1148.1 and 1148.2.) The State, in partnership with the Environmental Protection Agency, regulates air pollutants pursuant

to the Mulford-Carrell Air Resources Act and the federal Clean Air Act. (See Cal. Health & Saf. Code, § 39000 *et. seq.*; 42 U.S.C. § 7401 *et seq.*) The Clean Air Act establishes the maximum concentration levels of certain pollutants and requires each state to adopt a state implementation plan to "meet federal ambient air quality standards in each state's air basins." (*So. Cal. Gas Co. v. So. Coast Air Quality Mgmt. Dist.* (2012) 200 Cal.App.4th 251, 268-69; 42 U.S.C.A. §§ 7408-7409; Health & Saf. Code, § 39602.5 ["The state board shall adopt rules and regulations pursuant to Section 43013 that, in conjunction with other measures adopted by the state board, the districts, and the United States Environmental Protection Agency, will achieve ambient air quality standards required by the federal Clean Air Act (42 U.S.C. Sec. 7401 *et seq.*) in all areas of the state by the applicable attainment date, and to maintain these standards thereafter"].) The State seeks to achieve these air quality standards through "an intensive, coordinated, state, regional, and local effort to protect and enhance the ambient air quality of the state." (Health & Saf. Code, § 39001.)

As part of this coordinated effort, "[t]he Legislature has designated ***regional air pollution districts*** as the primary enforcers of air quality regulations." (*So. Cal. Gas Co. v. So. Coast Air Quality Mgmt. Dist.*, *supra*, 200 Cal.App.4th at 269, emphasis added; *Western Oil & Gas Assn. v. Monterey Bay Unified Air Pollution Control Dist.* (1989) 49 Cal.3d 408, 417-418 ["The air pollution control district is ***the*** agency charged with enforcing both statewide and district emission controls"], emphasis original.) They "are the mechanism through which the State meets and maintains state and federal air quality standards under the federal Clean Air Act and California law." (*Beentjes v. Placer Cnty. Air Pollution Control Dist.* (9th Cir. 2005) 397 F.3d 775, 782.) Subject to the powers and duties of the State Board, ***air districts*** are authorized to adopt rules and regulations to achieve and enforce the state and federal air quality standards. (Health & Saf. Code, § 40001(a), emphasis added.) The State Board then "coordinate[s] the activities of all ***districts*** necessary to comply with [the Clean Air Act]." (Health & Saf. Code, § 39602, emphasis added.) The State has delegated authority specifically to air districts—not the City—to protect the State's air resources.

Thus, the air districts are delegated authority to regulate air standards, and the City's prohibition of certain activities, which are otherwise allowed by the SCAQMD, contradicts SCAQMD's delegated authority to determine how air quality standards should be met.

V. The Interim Control Ordinance Will Interfere with E&B's Vested Rights without Appropriate Procedural Safeguards

In addition to the fact that the interim control ordinance will be entirely preempted by state and federal law, it will also improperly interfere with E&B's vested property rights. E&B engages in significant oil production at several sites throughout the

City of Los Angeles. E&B has a vested property interest in continued oil production in these sites, which has been legally permitted by the City. E&B operates within oil drilling districts that were enacted by ordinance by the Los Angeles City Council pursuant to Los Angeles Municipal Code section 13.01.

E&B has received permits or zoning approvals from the City to conduct oil production operations on its properties. These permits establish conditions, as well as a process for additional modifications or condition review of these existing permits. These permit conditions are being invalidated by the City. In order to rescind existing permit approvals, the City must show that such action is necessary to abate a nuisance. The City has made no attempt to make that showing.

In 2017, the City adopted ZA Memo 133, which, among other things, requires a public hearing and environmental review under CEQA for any modification of previously approved determination of conditions. In an appeal related to a challenge to ZA Memo 133, the California Court of Appeal upheld the validity of ZA Memo 133 on the basis that the City would still need to comply with the nuisance abatement procedures in Section 12.27.1 before it could modify, discontinue or revoke a previously approved condition in an existing permit:

> In other words, the authority that Memorandum 133 explicitly confers upon the City with respect to modifications of previously approved conditions is authority that has existed all along. Nothing in Memorandum 133 indicates that the notice and hearing protections set forth in City Code section 12.27.1 would not apply before the City decided to modify, discontinue, or revoke a previously approved condition in an existing permit.

(*Youth for Envtl. Justice v. City of L.A.*, No. B282822, 2019 Cal. App. Unpub. LEXIS 1110, at *42 (Feb. 15, 2019) ("YEJ v. City of LA").[1]

By prohibiting normal maintenance activities, the interim control ordinance would revoke previously approved conditions in an existing permit that were allowed under its existing permits. The appellate court in *YEJ v. City of LA* held that the City must still initiate a nuisance abatement proceeding in order to modify, discontinue or revoke a previously approved condition. Notwithstanding this holding, the proposed ordinance would prohibit maintenance activities allowed under all existing permits without any attempt to show that such action is necessary to abate a nuisance. (L.A. Municipal Code § 13B.6.)

---

[1] While the *YEJ v. City of LA* opinion is not a published opinion, it remains binding upon the City under the principles of collateral estoppel. (*Parklane Hosiery Company, Inc. v. Shore* (1979) 439 U.S. 322, 332-333.)

Further, the interim control ordinance would purport to prohibit normal and necessary operations that are vested under E&B's existing permits. As an operator of an extractive use, E&B has a right to conduct the maintenance operations needed to continue operating its existing wells. "The very nature and use of an extractive business contemplates the continuance of such use of the entire parcel of land as a whole, without limitation or restriction to the immediate area excavated at the time the ordinance was passed." (*Hansen Bros. Enters. v. Board of Supervisors* (1996) 12 Cal.4th 533, 553.) The California Supreme Court in *Hansen* recognized the "diminishing asset" doctrine and defined the scope of vested rights for mining, quarrying and other extractive uses, recognizing the unique qualities of extractive uses and holding that it includes an expansion of those uses. The interim control ordinance entirely disregards these legal principles. By taking E&B's property rights without the payment of just compensation, the City is acting in violation of the Takings Clauses of the federal and state constitutions.

VI. The Interim Control Ordinance constitutes a breach of the City's contracts with E&B.

E&B are parties to lease agreements with the City of Los Angeles for certain drillsites. For example, Hillcrest Beverly Oil Corporation is a party to a lease originally entered into in 1959 for the Hillcrest Site. This lease specifically contemplates that the lessee will be allowed to conduct drilling, redrilling, maintenance and servicing of wells as part of the lease. If it adopts the interim control ordinance, the City is in material breach of its lease agreements with E&B.

* * *

For all of these reasons, we urge the Committee to deny the Motion under Agenda Item No. 5 (Council File No. 24-1580) for its March 25, 2025 meeting, "instructing the Department of City Planning... to prepare an interim control ordinance that would halt the practice of oil well acid maintenance...." as it is unnecessary, environmentally harmful and runs contrary to well-established law.

Sincerely,



Matthew Wickersham

EXHIBIT C

[Alston & Bird's MAY 5, 2025 Comment Letter]

Electronically Received 03/03/2025 03:36 PM

NICKI CARLSEN (SBN 151222)
MATTHEW C. WICKERSHAM (SBN 241733)
ALSTON & BIRD LLP
333 South Hope Street, 16th Floor
Los Angeles, CA 90071-1410
Telephone: 213-576-1000
Facsimile: 213-576-1100
Email: Nicki.Carlsen@alston.com
Matt.Wickersham@alston.com

Attorneys for Petitioners and Plaintiffs
E & B NATURAL RESOURCES MANAGEMENT CORPORATION, HILLCREST BEVERLY OIL CORPORATION, E&B ENR I, LLC, and ELYSIUM NATURAL RESOURCES, LLC

FILED
Superior Court of California
County of Los Angeles
03/03/2025
David W. Slayton, Executive Officer / Clerk of Court
By: M. Mort Deputy

SUPERIOR COURT OF THE STATE OF CALIFORNIA

FOR THE COUNTY OF LOS ANGELES

E & B NATURAL RESOURCES MANAGEMENT CORPORATION, a California corporation; HILLCREST BEVERLY OIL CORPORATION, a California corporation; E&B ENR I, LLC, a Delaware limited liability company; and ELYSIUM NATURAL RESOURCES, LLC, a New York limited liability company,

Petitioners and Plaintiffs,

v.

CITY OF LOS ANGELES, CITY COUNCIL OF THE CITY OF LOS ANGELES, THE MAYOR OF THE CITY OF LOS ANGELES, and DOES 1 through 100, inclusive

Respondents and Defendants.

Case No.: 23STCP00070

Related to 23STCP00060; 23STCP00085; 23STCP00106; 23STCP01217

CEQA CASE

Assigned to the Hon. Curtis A. in, Dept.

STIPULATION FOR ENTRY OF JUDGMENT AND WRIT; [proposed] JUDGMENT; [proposed] WRIT

Petition/ Complaint filed: 1/10/2023
Trial date: 9/3/2024

JURY TRIAL DEMANDED

Petitioners and Plaintiffs Warren E&P, Inc., Warren Resources of California, Inc., and Warren Resources, Inc. ("Warren Petitioners") (Case No. 23STCP00060), E & B Natural Resources Management Corporation, Hillcrest Beverly Oil Corporation, E&B ENR I, LLC, and Elysium Natural Resources, LLC ("E&B Petitioners") (Case No. 23STCP00070), Native Oil Producers and

Employees of California and Western States Petroleum Association ("NOPEC Petitioners") (Case No. 23STCP00085), and National Association of Royalty Owners-California, Inc., Mekusukey Oil Company, LLC, NJB Wolf Family LLC, and The Termo Company ("NARO Petitioners") (Case No. 23STCP00106) (collectively "Petitioners") and Respondents and Defendants City of Los Angeles, Los Angeles City Council, Los Angeles City Planning Commission, and the Mayor of the City of Los Angeles (collectively, "Respondents," and together with Petitioners, the "Parties"), enter into this Stipulation for Entry of Judgment ("Stipulation"), and agree that judgment be entered against Respondents, and in favor of the Warren Petitioners, E&B Petitioners and NARO Petitioners, as described below:

RECITALS

WHEREAS, on December 8, 2022, Respondents adopted Ordinance No. 187709 ("Ordinance"), effective January 18, 2023, which would make existing oil wells a nonconforming use, ban the drilling of new wells, and prohibit the maintenance, drilling, re-drilling, or deepening of existing wells except to prevent or respond to a threat to public health, safety, or the environment, as determined by the Zoning Administrator;

WHEREAS, upon adoption of the Ordinance, the Los Angeles City Council also instructed the Los Angeles Department of City Planning to "incorporate the ordinance once adopted by the Council into the LAMC, Chapter 1A, New Zoning Code, subject to changes to conform to the format and style of the New Zoning Code" (See Council File No. 17-0447-S1, Report from Planning and Land Use Management Committee, filed 11/1/22);

WHEREAS, Warren Petitioners filed a legal challenge to the Ordinance through their Verified Petition for Writ of Mandate and Complaint for Declaratory and Injunctive Relief and Damages on January 10, 2023, which was subsequently amended on February 3, 2023, April 18, 2023, September 15, 2023, and November 20, 2023;

WHEREAS, E&B Petitioners filed a legal challenge to the Ordinance through their Verified Petition for Writ of Mandate and Complaint for Declaratory Relief, Constitutional Violations, Inverse Condemnation, and Damages on January 10, 2023, which was subsequently amended on April 7, 2023 and November 6, 2023;

WHEREAS, NOPEC Petitioners filed a legal challenge to the Ordinance through their Verified Petition for Writ of Mandate on January 11, 2023;

WHEREAS, NARO Petitioners filed a legal challenge to the Ordinance through their Verified Petition for Writ of Mandate and Complaint for Constitutional Violations, Inverse Condemnation, and Damages on January 12, 2023, which was subsequently amended on January 29, 2024;

WHEREAS, on January 17, 2023, the City Planning Department of the City of Los Angeles issued Zoning Administrator Memorandum 141 ("ZA Memo 141") and a Zoning Administrator's Interpretation (which was later modified on October 4, 2023), Case No. ZA-2022-8997-ZAI-1A ("ZAI");

WHEREAS, on September 3, 2024, the Court held a trial on the causes of action related to preemption alleged by the Warren Petitioners, E&B Petitioners and NARO Petitioners;

WHEREAS, on September 6, 2024, the Court issued a ruling granting (1) the thirteenth and fourteenth causes of action in the Warren Petitioners' Fourth Amended Petition; (2) the third and sixth causes of action in the E&B Petitioners' Second Amended Petition; and (3) the first and second causes of action in the NARO Petitioners' First Amended Petition;

WHEREAS, on September 25, 2024, Governor Newsom signed into law AB 3233, which will add section 3106.1 to the Public Resources Code. Section 3106.1 states, in part, that "[n]otwithstanding any other law, and notwithstanding any notice of intention, supplemental notice, well stimulation treatment permit, or similar authorization issued by the supervisor or district deputy, a local entity may, by ordinance, prohibit oil and gas operations or development in its jurisdiction or impose regulations, limits, or prohibitions on oil and gas operations or development that are more protective of public health, the climate, or the environment than those prescribed by a state law, regulation, or order";

WHEREAS, AB 3233 becomes operative on January 1, 2025;

WHEREAS, rather than litigate whether AB 3233 can be applied retroactively to the Ordinance, Respondents intend to consider the re-adoption of the same or a similar ordinance after AB 3233 has become operative;

WHEREAS, the Parties have agreed to resolve the remaining claims in the pending litigation challenging the Ordinance, and accordingly have determined to reach a compromise in accordance with the provisions of this Stipulation;

WHEREAS, Petitioners have agreed to dismiss their remaining claims, and have further agreed to waive all damages claims whether pled or unpled in their Petitions, as they relate to the Ordinance, ZA Memo 141 and the ZAI, but Petitioners do not intend to waive any claims with respect to other actions that have been taken or may be taken in the future by Respondents, in particular any claims whatsoever in connection with the re-adoption of any identical or similar ordinance; and

WHEREAS, Respondents have agreed to entry of judgment herein in the forms attached hereto as **Exhibits 1-4**, and issuance of a writ in the forms attached as **Exhibits 5-7**.

NOW, WHEREFORE, the Parties hereby agree and stipulate as follows:

1. The Court will enter judgments in the forms attached as **Exhibits 1-4** in favor of (1) the thirteenth and fourteenth causes of action in the Warren Petitioners' Fourth Amended Petition; (2) the third and sixth causes of action in the E&B Petitioners' Second Amended Petition; and (3) the first and second causes of action in the NARO Petitioners' First Amended Petition, and against Respondents. The Judgments declare that the Ordinance, the ZAI and ZA Memo 141 are preempted by state law and declared to be void and invalidated. The Judgments further direct the issuance of the writs in the forms attached as **Exhibit 5-7**.

2. Respondents shall not contest any entry of judgment pursuant to this Stipulation, and waive any and all rights to contest such entry of judgment including, but not limited to, appeal, motion for reconsideration, stay of judgment, and/or stay of execution of the judgment.

3. The Warren Petitioners, E&B Petitioners, and NARO Petitioners agree to dismiss the remaining causes of action not addressed by the Judgment in their entirety, and agree to waive any and all claims for damages relating to the Ordinance, ZA Memo 141, and ZAI, whether pled or not pled in their Petitions, and incurred from the date of enactment of the Ordinance to entry of the attached Judgment.

/ / /

4. The NOPEC Petitioners agree to dismiss their Petition in its entirety, and agree to waive any and all claims for damages relating to the Ordinance, ZA Memo 141, and ZAI, whether pled or not pled in their Petition, and incurred from the date of enactment of the Ordinance to entry of the attached Judgment.

5. In the event that Respondents re-adopt an ordinance after January 1, 2025, that is the same or substantially similar to the Ordinance (the "New Ordinance"), Petitioners expressly do not waive any rights to file a complaint alleging any relevant causes of action challenging the New Ordinance, including causes of action the same or similar to those alleged in this litigation and specifically including claims that the New Ordinance remains preempted under state law.

6. In the event Respondents choose to exercise their discretion and adopt a New Ordinance, Respondent City of Los Angeles, through the Department of City Planning (Department), agrees to conduct at least two stakeholder meetings open to the public and all interested parties, the first of which is to occur at least 60 days prior to the City Planning Commission's hearing on a draft New Ordinance. The Department shall publicly release the contents of the proposed New Ordinance prior to the second stakeholder meeting. The second meeting shall occur at least 15 days in advance of the presentation of a draft New Ordinance to the City Planning Commission. Any member of the public or interested party may submit written comments for the Department's review and consideration prior to the City Planning Commission meeting.

7. The Parties agree that the certified administrative record in this litigation will be used in any subsequent litigation challenging a New Ordinance, subject to supplementation as needed for any subsequent legislative action by Respondents and subject to any Party's request for the Court to admit additional evidence.

8. Respondents are enjoined from enforcing Ordinance No. 187709, the ZAI and ZA Memo 141, including any version of Ordinance No. 187709, the ZAI and/or ZA Memo 141 incorporated into Chapter 1A (New Zoning Code) of the Los Angeles Municipal Code (see Council File No. 17-0447-S2, 11/1/22 Report from City Council's Planning and Land Use Management Committee).

9. In light of the declaratory and injunctive relief in the Stipulated Judgment, and the trial court's ruling that the Ordinance, ZA Memo 141, and ZAI are preempted by state law, and following entry of the attached Judgment and issuance of the Writ, Respondents agree to take the necessary action to rescind and/or vacate Ordinance No. 187709, ZA Memo 141, and the ZAI.

10. Petitioners' releases and waivers in favor of the Respondents shall remain in effect notwithstanding the discovery or existence of additional or different facts.

11. Petitioners warrant that they have not assigned or transferred, or agreed to assign or transfer, to any third party or entity, any interest in any of the claims that are alleged in the pleadings in the above-captioned Petitions.

12. Nothing in this agreement shall in any way limit or control the discretion legally vested in Respondents, including the discretion to legislate and adopt a New Ordinance.

13. This Stipulation may be executed electronically in one or more counterparts or executed on one or more separate signature pages, each of which shall be deemed an original, but all of which taken together shall constitute one and the same instrument.

14. The Parties are to bear their own costs and attorneys' fees.

15. The Parties respectfully request that the Court approve this Stipulation and enter the Judgments attached as **Exhibit 1-4** and the Writ attached as **Exhibit 5-7**.

DATED: February 14, 2025

DAY CARTER & MURPHY LLP

By: _____
Tracy K. Hunckler
Attorneys for Petitioners and Plaintiffs
WARREN E&P, INC.; WARREN RESOURCES OF CALIFORNIA, INC.; and WARREN RESOURCES, INC.

[ADDITIONAL SIGNATURES ON FOLLOWING PAGES]

DATED: February 14, 2025

ALSTON & BIRD LLP

By: _____

Nicki Carlsen
Matt Wickersham
Attorneys for Petitioners and Plaintiffs
E & B NATURAL RESOURCES MANAGEMENT CORPORATION; HILLCREST BEVERLY OIL CORPORATION; E&B ENR I, LLC; and ELYSIUM NATURAL RESOURCES, LLC

DATED: February 21, 2025

MANATT, PHELPS & PHILLIPS, LLP

By: _____

David Moran
Sigrid Waggener
Attorneys for Petitioners and Plaintiffs
NATIVE OIL PRODUCERS AND EMPLOYEES OF CALIFORNIA and WESTERN STATES PETROLEUM ASSOCIATION

DATED: February 18, 2025

HANNA AND MORTON LLP

By: _____

Edward S. Renwick
Attorneys for Petitioners and Plaintiffs
NATIONAL ASSOCIATION OF ROYALTY OWNERS-CALIFORNIA, INC.; MEKUSUKEY OIL COMPANY, LLC; NJB WOLF FAMILY LLC; and THE TERMO COMPANY

DATED: February 28, 2025

LOS ANGELES CITY ATTORNEY'S OFFICE

By: _____

John W. Heath
Jennifer Tobkin
Marvin Bonilla
Grant Hutchins
Attorneys for Respondents and Defendants
CITY OF LOS ANGELES; LOS ANGELES CITY COUNCIL; LOS ANGELES CITY PLANNING COMMISSION; and THE MAYOR OF THE CITY OF LOS ANGELES

EXHIBIT D

[Alston & Bird's MAY 5, 2025 Comment Letter]

LA COUNTY PLANNING

AMY J. BODEK, AICP
Director,
Regional Planning

DENNIS SLAVIN
Chief Deputy Director,
Regional Planning

NOTICE OF PREPARATION OF AN ENVIRONMENTAL IMPACT REPORT AND PUBLIC SCOPING MEETING

DATE: March 27, 2025

TO: State Clearinghouse, Registrar-Recorder/County Clerk, Responsible Agencies, Trustee Agencies, Organizations and Interested Parties

SUBJECT: Notice of Preparation of an Environmental Impact Report in Compliance with Title 14, section 15082(a) of the California Code of Regulations

The County of Los Angeles ("County") is the lead agency pursuant to the California Environmental Quality Act ("CEQA") and intends to prepare an Environmental Impact Report ("EIR") for the proposed project identified below. The County has prepared this Notice of Preparation ("NOP") to provide Responsible Agencies and other interested parties with information describing the project and to identify its potential environmental effects pursuant to State requirements.

AGENCIES: The County requests your agency's input on the scope and content of the environmental information relevant to your agency's statutory responsibilities in connection with the proposed project, in accordance with Title 14, section 15082(b) of the California Code of Regulations. Your agency will need to use the EIR prepared by the County when considering any permits that your agency must issue, or other approval for the project.

ORGANIZATIONS AND INTERESTED PARTIES: The County requests your comments and concerns regarding the environmental issues associated with construction and operation of the proposed project.

PROJECT & PERMIT(S): Revised Oil Well Ordinance (ROWO), Project No. PRJ2025-000212, Ordinance RPPL2025000276, General Plan Amendment RPPL2025000277, Environmental Plan RPPL2025000284

PROJECT APPLICANT: County of Los Angeles Department of Regional Planning

PROJECT LOCATION: Unincorporated Los Angeles County (Countywide)

PROJECT DESCRIPTION: The project includes: i) Amendments to Title 22 – Planning & Zoning of the Los Angeles County Code to prohibit new oil wells and production facilities, designate existing oil wells and production facilities as nonconforming due to use, and modify standards for oil wells during the amortization period; ii) Amendments to the Baldwin Hills Community Standards District (CSD) to be consistent with countywide prohibition of oil wells and production facilities and standards for oil wells during the amortization period; iii) Amendments to Title 12 – Environmental Protection of the Los Angeles County Code to remove noise exemptions for oil wells; and iv) Amendments to the County of Los Angeles General Plan in support of sustainability and environmental justice goals by phasing out oil production in unincorporated Los Angeles County.

i. Amendments to Title 22 – Planning & Zoning: Under the proposed project, no new oil wells or production facilities may be established in any zone. Pursuant to Section 22.172 of the County Code (Nonconforming Uses, Buildings, and Structures), existing, legally established oil wells or production facilities operating without an approved Conditional Use Permit or other discretionary permit will be considered nonconforming and subject to a 20-year amortization period. In addition, the ordinance establishes performance standards addressing signage, comment and complaint logging, site maintenance, bonding, well plugging, and site abandonment and restoration. This ordinance would apply to all oil wells in unincorporated Los Angeles County, except in the Coastal Zone.

ii. Amendments to the Baldwin Hills CSD: The project amends the Baldwin Hills CSD to align with and implement the provisions of the Title 22 amendments described above, ensuring consistent application of the new regulations and standards within the Baldwin Hills CSD.

iii. Amendments to Title 12 – Environmental Protection: The project eliminates the current exemption for oil and gas wells from the Noise Control regulations set forth in Title 12 of the County Code. Consequently, these wells will be subject to all provisions of the Noise Control chapter, ensuring better management of noise impacts related to oil and gas extraction activities.

iv. Amendments to the General Plan: The project amends the General Plan. Specifically, it revises the Land Use Element, Conservation and Natural Resources Element, and Safety Element to prohibit new oil well operations and remove designations that support oil production activities.

POTENTIAL ENVIRONMENTAL EFFECTS OF THE PROJECT: Based on a preliminary review of the proposed project consistent with section 15060 of the CEQA Guidelines, the County has determined that an EIR should be prepared for this proposed project. In addition, consistent with section 15082 of the CEQA Guidelines, the County has identified the following probable environmental effects of the project, which will be addressed in the EIR for this project:

• Mineral Resources

The County has determined that there is not a likelihood of potentially significant effects related to the following environmental topics:

- Aesthetics
- Agricultural Resources
- Air Quality
- Biological Resources
- Cultural Resources
- Energy
- Geology and Soils
- Greenhouse Gas Emissions
- Hazards and Hazardous Materials
- Hydrology and Water Quality
- Land Use and Planning
- Noise
- Population and Housing
- Public Services
- Recreation
- Transportation
- Tribal Cultural Resources
- Utilities and Services Systems
- Wildfire
- Mandatory Findings of Significance

The County proposes that the EIR indicate the reasons why these effects were determined not to be significant and are therefore not addressed in detail in the EIR.

NOTICE OF SCOPING MEETING: The County will conduct a virtual public scoping meeting for the purpose of soliciting oral and written comments from interested parties as to the appropriate scope and content of the EIR.

All interested parties are invited to attend the meeting to assist in identifying issues to be addressed in the EIR. The meeting will include a brief presentation of the project to be addressed in the EIR and will provide attendees with an opportunity to provide input to the scope of the EIR. The meeting will be held online.

Thursday, April, 17, 2025
6:00 PM–7:00 PM (Pacific Time)—Via Zoom Meeting
Please use the following link to access the webinar: bit.ly/4hYN0WB

The meeting will include language access service in Spanish, Cantonese, and Mandarin. Translation in other languages can be made available at the meeting upon request. Please submit translation requests at least seven business days in advance of each scheduled meeting to ordinance@planning.lacounty.gov.

PUBLIC REVIEW PERIOD: The County has determined to make this NOP available for public review and comment pursuant to Title 14, Section 15082(b) of the California Code

of Regulations. The comment period for the NOP begins on March 27, 2025 and ends on April 26, 2025.

Any comments provided should identify specific topics of environmental concern and your reason for suggesting the study of these topics in the EIR.

Please direct all written comments to the following address:

Ken Warner
LA County Planning
Ordinance Studies Section
320 West Temple Street, Floor 13
Los Angeles, CA 90012
Tel: (213) 974-6432
ordinance@planning.lacounty.gov

All written responses will be included as Appendices in the Draft EIR and their contents considered in accordance with State and County environmental guidelines.

DOCUMENT AVAILABILITY: The NOP and Initial Study are available for public review during regular business hours at the LA County Planning address listed above and the following locations:

- 1340 W 106th St, Los Angeles, CA 90044
- 11949 Alondra Blvd, Norwalk, CA 90650
- 18801 Elaine Avenue, Artesia, CA 90701
- 150 E El Segundo Blvd, Los Angeles, CA 90061
- 9945 E Flower St, Bellflower, CA 90706
- 240 W Compton Blvd, Compton, CA 90220
- 4420 E Rose St, East Rancho Dominguez, CA 90221
- 7807 Compton Ave, Los Angeles, CA 90001
- 1900 E Firestone Blvd, Los Angeles, CA 90001
- 11940 Carson St, Hawaiian Gardens, CA 90716
- 12000 Garfield Ave, South Gate, CA 90280
- 4990 Clark Ave, Lakewood, CA 90712
- 12350 Imperial Hwy, Norwalk, CA 90650
- 6600 Del Amo Blvd, Lakewood, CA 90713
- 16254 Colorado Ave, Paramount, CA 90723
- 13800 La Mirada Blvd, La Mirada, CA 90638
- 3798 Martin Luther King Jr. Blvd, Lynwood, CA 90262
- 11543 Colima Road, Whittier, CA 90604
- 4035 Tweedy Blvd, South Gate, CA 90280
- 11737 Wilmington Ave, Los Angeles, CA 90059
- 4411 E Gage Ave, Bell, CA 90201

- 7110 S Garfield Ave, Bell Gardens, CA 90201
- 4025 E City Terrace Dr, Los Angeles, CA 90063
- 5218 Santa Ana St, Cudahy, CA 90201
- 4837 E 3rd St, Los Angeles, CA 90022
- 4264 E Whittier Blvd, Los Angeles, CA 90023
- 1060 S Greenwood Ave, Montebello, CA 90640
- 6518 Miles Ave, Huntington Park, CA 90255
- 8511 Duchess Drive, Whittier, CA 90606
- 4323 E Slauson Ave, Maywood, CA 90270
- 1550 W Beverly Blvd, Montebello, CA 90640
- 9001 Mines Ave, Pico Rivera, CA 90660
- 3965 Cesar E Chavez Ave, Los Angeles, CA 90063
- 7828 S Serapis Ave, Pico Rivera, CA 90660
- 8800 Valley Blvd, Rosemead, CA 91770
- 500 S Del Mar Ave, San Gabriel, CA 91776
- 20540 E Arrow Highway Suite K, Covina, CA 91724
- 208 N Harvard Ave, Claremont, CA 91711
- 21800 Copley Dr, Diamond Bar, CA 91765
- 1301 Buena Vista St, Duarte, CA 91010
- 3224 Tyler Ave, El Monte, CA 91731
- 16010 La Monde St, Hacienda Heights, CA 91745
- 15920 E Central Ave, La Puente, CA 91744
- 3640 D St, La Verne, CA 91750
- 22 W Live Oak Ave, Arcadia, CA 91007
- 4550 N Peck Rd, El Monte, CA 91732
- 1850 Nogales Street, Rowland Heights, CA 91748
- 145 N Walnut Ave, San Dimas, CA 91773
- 1430 North Central Avenue, South El Monte, CA 91733
- 840 N Puente Ave, La Puente, CA 91746
- 21155 La Puente Rd, Walnut, CA 91789
- 1601 W West Covina Pkwy, West Covina, CA 91790
- 14433 Crenshaw Blvd, Gardena, CA 90249
- 17906 S Avalon Blvd, Carson, CA 90746
- 625 N San Vicente Blvd, West Hollywood, CA 90069
- 5335 W 135th St, Hawthorne, CA 90250
- 1731 W Gardena Blvd, Gardena, CA 90247
- 4359 Lennox Blvd, Lennox, CA 90304
- 24200 Narbonne Ave, Lomita, CA 90717
- 1320 Highland Ave, Manhattan Beach, CA 90266
- 12700 Grevillea Ave, Hawthorne, CA 90250
- 550 Pier Ave, Hermosa Beach, CA 90254
- 14615 Burin Ave, Lawndale, CA 90260

- 33792 Crown Valley Rd, Acton, CA 93510
- 122 N Topanga Canyon Blvd, Topanga, CA 90290
- 4545 N Oakwood Ave, La Canada Flintridge, CA 91011
- 2809 Foothill Blvd, La Crescenta, CA 91214
- 16921 E Avenue O #A, Palmdale, CA 93591
- 601 W Lancaster Blvd, Lancaster, CA 93534
- 29901 Ladyface Court, Agoura Hills, CA 91301
- 35119 80th St East, Littlerock, CA 93543
- 27971 Sloan Canyon Rd, Castaic, CA 91384
- 5040 West Avenue M-2, Quartz Hill, CA 93536
- 217 N Maclay Ave, San Fernando, CA 91340
- 6934 Broadway Ave, Whittier, CA 90606
- 31220 Oak Crest Dr, Westlake Village, CA 91361
- 215 Sumner Ave, Avalon, CA 90704
- 151 E Carson St, Carson, CA 90745
- 4975 Overland Ave, Culver City, CA 90230
- 3854 W 54th St, Los Angeles, CA 90043
- 4181 Baldwin Park Blvd, Baldwin Park, CA 91706
- 25950 The Old Road, Stevenson Ranch, CA 91381
- 5939 Golden West Ave, Temple City, CA 91780

The public is also encouraged to visit LA County Planning's website to review the initial study at https://planning.lacounty.gov/long-range-planning/revised-oil-well-ordinance/.

Thank you for your participation in the environmental review of this project.

EXHIBIT E

[Alston & Bird's MAY 5, 2025 Comment Letter]

scale), EIR Sections 10.12.3 and 11.12.3 for a description of the affected environment for greenhouse gas emissions (as applicable at either a study region or field-specific scale), and EIR Section 10.12.4 for details regarding the impact methodology and significance criteria that have been used.

12.2.12.2 Programmatic Level Analysis of the Project

Impact GHG-1 Generate greenhouse gas emissions that may have a significant impact on the environment

This alternative would restrict future oil and gas activity by halting well stimulation activities in areas under State jurisdiction. This would avoid GHG emissions that occur in areas under State jurisdiction as a result of oil and natural gas production made possible by well stimulation, and it would also lead to a decrease in California oil production. Therefore, there would be no direct impacts (Class IV). But there are greater indirect impacts from increased oil and gas imports that cause significant and unavoidable GHG emissions from out-of-state oil and gas producers (Class I). There are also indirect impacts associated with additional conventional wells and abandonment activities, or stimulation activities on lands under federal or tribal jurisdiction, to make up for lost production.

Under this alternative, an additional 57 million barrels of crude per year would need to be supplied from fields outside of California (EIR Section 8.3.1), which currently supply about 380 million barrels annually (ARB, 2014c). Oil and natural gas producers outside of California would need to increase production in response, and this would increase GHG emissions from the oil and gas industry outside of California.

Sources of GHG at oil and gas fields outside of California are not subject to California's regulatory setting (EIR Section 10.12.2), which ensures that GHG sources in the business of oil and gas production in California are subject to multiple programs aimed at reducing GHG. Emissions of GHG that occur at a point of oil and gas extraction outside of California are not subject to the Cap-and-Trade Program, and by increasing the activity of oil and gas extraction outside of California, this alternative would cause increased GHG from sources that are not required to offset the GHG to comply with California's cap, resulting in an overall net increase in GHG emissions compared with both existing conditions and the project. Although the oil and gas extraction and associated GHG emissions would occur outside California, California would continue to experience the adverse environmental effects of global climate change driven by GHG emissions worldwide. This impact would occur from GHG sources that are not covered by California's regulatory setting and outside of the potential control of DOGGR to feasibly mitigate. As a result of increasing GHG emissions from sources beyond California's control, no feasible mitigation would be available. This alternative would increase GHG emissions from sources that could not be prevented, reduced, offset, or otherwise mitigated by DOGGR or another California agency tasked with reducing GHG emissions. The GHG emissions increase would cause a potentially significant impact on the environment, and because these emissions would occur beyond California's control, Impact GHG-1 would be Class I: Significant and Unavoidable.

Some of the mitigation measures developed in this EIR, though usually written for implementation by DOGGR through the issuance of well stimulation treatment permits, provide guidance that other agencies could follow in fashioning their own mitigation strategies for relevant project approvals coming under their jurisdiction. DOGGR's relevant model mitigation measures in this context include the following:

MM AQ-2b **Reduce Emissions from Portable Equipment and Mobile Sources.** (Full text in EIR Section 10.3.5.)

MM GHG-1a **Prevent Methane Emissions from Associated Gas and Casinghead Gas.** (Full text in EIR Section 10.12.5.)

Impact GHG-2 Conflict with an applicable plan, policy or regulation adopted for the purpose of reducing the emissions of greenhouse gases

Because this alternative would cause some future oil and gas production to be lost, California end users of oil and gas would need to rely on a replacement supply. Using a replacement crude supply could result in an incremental change in life-cycle GHG emissions of California's crude supply, which could be an increase or decrease depending the carbon intensity of the replacement supply. The carbon intensity for production and transport of an average unit of crude oil used in California (about 11.4 g CO2e/MJ) is lower than that of an average crude produced in California (12.9 g CO2e/MJ) (ARB, 2012). Life-cycle GHG from the production and transport of 57 million barrels of crude at the average carbon intensity for crude produced in California are around 4,600,000 MTCO2e, and depending on the field-specific factors of the replacement supply imported, life-cycle GHG for the same amount of average supply used in California is around 4,100,000 MTCO2e. Although this implies that replacing in-state production with average imports could incrementally reduce life-cycle GHG emissions, all crude produced for use in California is subject to the LCFS, regardless of the location of the supply.

Despite the greater average carbon intensity of crude oil produced in California compared with oil produced in places that would export their oil to California, an increase in imports into California would still result in an overall net increase in GHG emissions compared with both existing conditions and the project. This is ~~alternative could conflict with California's existing programs to reduce GHG~~ because in-state production is not only subject to the LCFS but also subject to the Cap-and-Trade Program. These programs require oil and gas production to operate within an overall statewide cap, which is lowered over time. The Cap-and-Trade Program limits in-state GHG emissions to ensure that the AB 32 goals will be achieved and the statewide emission target of 431 MMTCO2e by 2020 will not be exceeded (ARB, 2007; ARB, 2014b). Producers of the replacement supply of oil and gas under this alternative if outside of California would not be subject to California's statewide GHG cap. Out-of-state oil and gas producers create GHG emissions during extraction that are uncovered and not limited by the Cap-and-Trade Program. These emissions will not be captured by California's cap, but would be in addition to it. As a result, in addition to total statewide emissions of 431 MMTCO2e by 2020 allowed by the Cap-and-Trade Program, this alternative would also increase GHG from out-of-state crude oil recovery and transport activities by around 4.1 MMTCO2e, depending on the replacement supply. The ARB is directed to take steps to "minimize leakage" in implementing AB 32 regulations [HSC Section 38562(b)(8))], and this alternative would conflict with that requirement by potentially offsetting an in-state reduction of GHG emissions with an increase in GHG emissions outside the state. By increasing these uncovered emissions at sources that are beyond the control of California's regulations and any recommended mitigation, this alternative would conflict with California's programs aimed at reducing GHG, and Impact GHG-2 would be would be Class I: Significant and Unavoidable.

There are potentially feasible and effective strategies for mitigating, at least to some degree, the adverse indirect effects of Alternative 1, though these strategies would in most instances have to imposed or implemented by agencies other than DOGGR, as most of the effects would be caused by activities beyond DOGGR's control. Even so, some of the mitigation measures developed in this EIR, though usually written for implementation by DOGGR through the issuance of well stimulation treatment permits, provide guidance that other agencies could follow in fashioning their own mitigation strategies for relevant project approvals coming under their jurisdiction. DOGGR's relevant model mitigation measures in this context include the following:

12.2.16.2 Programmatic Level Analysis of the Project

Alternative 1 would prohibit all future well stimulation activities in areas under State jurisdiction, as described in EIR Chapter 7 (Description of the Project). Therefore, there would be no disruptions to existing and permitted land uses from well stimulation activities in those areas. But there are indirect impacts associated with additional conventional wells, or increased stimulation activities on lands under federal or tribal jurisdiction; also, indirect impacts of well abandonment may free up areas of existing oil and gas wells for other uses. Prohibiting well stimulation in areas under State jurisdiction would require importing oil from other sources to meet demand, thus increasing ship, rail, and tanker truck traffic to the State from the foreign and domestic suppliers. It is assumed that imports would be transported by way of existing transportation routes and no new rail lines or roads would be required, except locally at any new or expanded terminals that might be developed to handle the imports.

This alternative would require new legislation to revise or repeal PRC Sections 3106(b) and 3160(b), which currently authorize well stimulation treatments. The new legislation would need to specify that all current or future well stimulation treatments are not allowable in areas under State jurisdiction.

Impact LU-1	**Preclude existing or permitted land uses, or create a disturbance that would diminish the function of land uses**

Implementation of Alternative 1 would prohibit all current and future well stimulation activities in areas under State jurisdiction, which would decrease the amount of oil and gas produced in California as compared to allowing well stimulation in those areas. Under this alternative there would be no direct activities associated with well stimulation and thus no related disruptions that would preclude or diminish an existing or permitted land use or diminish the function of land uses. No impacts would occur (Class IV).

However, this alternative could both decrease activity at some existing fields through the abandonment of oil and gas fields that become unproductive, or increase the intensity of activities an existing oil and gas field where additional conventional wells are developed and/or enhanced recovery methods are employed or their use increased, or if stimulation activities increase on lands under federal or tribal jurisdiction. Because these activities are within existing fields, they would have less than significant impacts (Class III) on surrounding land uses. Prohibiting well stimulation would cause an increase in activities associated with the importation of oil and gas products into the State. Increased importation would be along existing transportation routes; with regard to land uses, this would be primarily rail and highway routes. The volume of traffic passing any point along a route may be substantially greater than current conditions, but this would depend on the volume of the imports. Absent detailed information on specific routes and nearby land uses, it is not feasible to determine the degree of impact. In some situations the volume of traffic on the route could disrupt traffic and site access (e.g., at rail crossings) or create increased noise, air quality emissions, and other conditions that could diminish a land use's function. In this situations theses impacts would be significant and unavoidable and their effect on land use and planning would significant and unavoidable (Class I).

Therefore, under Alternative 1, for Impact LU-1, direct impacts would be avoided at potential well stimulation locations by prohibiting the practice in areas under State jurisdiction (Class IV). Impacts resulting from the prohibition could be less than significant (Class III) at existing fields where increased levels of conventional drilling and enhanced recovery occur, or where stimulation activities are increased on lands under federal or tribal jurisdiction. Along transportation corridors impacts could be significant and unavoidable (Class I) at some locations, depending on the volume of imports and the nature and location of land uses near the transportation corridor.

Rather, agencies, at the time of project approval, must focus on particular significant impacts of proposed projects, and see whether such impacts can be mitigated to less than significant levels. If the answer is yes, then the agency has fully satisfied its obligations under CEQA. If the answer is no, then the agency must go on to consider whether any of the alternatives in the EIR are environmentally superior with respect to those particular significant, unmitigated impacts of the project. If one of these alternatives is feasible, the agency may be required to adopt it (or to deny the project if a private project proponent will not accept being "stuck" with an alternative it does not like). If none of these alternatives is feasible, the agency must describe the reasons why they are infeasible, and thus reasons must be supported by substantial evidence.[216]

Nothing in the reference to "the environmentally superior" alternative in Section 15126.6 of the State CEQA Guidelines requires lead agencies, in trying to identify that alternative, to focus their analysis on those handful of impacts that might be significant and unavoidable for "the project." Rather, the lead agency's determination is apparently intended to focus on the *overall* characteristics of the various action alternatives. This requirement, then, is not directly related to the substantive policy of CEQA, but rather is more informational in nature. Thus, a decision making body's awareness of which of the EIR alternatives is "the environmentally superior alternative" might inspire the body to approve that alternative, but CEQA's substantive policy will not necessarily require the approval of that alternative, even if it is feasible. As explained above, agencies are frequently able to fully comply with the substantive policy without approving what they had determined to be the environmentally superior alternative.

Since State CEQA Guidelines Section 15126.6(e)(2) provides no directions or instructions as to *how* lead agencies should make such a determination, the exercise is inevitably and necessarily somewhat subjective, as it implicitly requires agencies to balance competing kinds of environmental impacts against each other, and to assign more weight to some than to others.

Here, lacking methodological direction in the law, DOGGR, in the Draft EIR, "explain[ed] the environmental advantages and disadvantages of each alternative in comparison with the project," as recommended in the above-quoted CEQA treatise.[217] But DOGGR also went further, identifying "the project" as mitigated as the environmentally superior alternative. In doing so, DOGGR gave considerable weight to two factors: first, the fact that, following common practice, the project (unlike the alternatives) would be subject to numerous mitigation measures addressing impacts not specifically addressed by the permanent regulations;[218] and second, the fact that, by avoiding a reduction in oil output in California, the project would avoid the indirect effects associated with increased importation of oil.[219]

Although reasonable minds could have reached a different conclusion, DOGGR has given considerable weight to the fact that increased oil imports would lead to increased greenhouse gas generation. As explained in Global Response GR-19, California is strongly committed to reducing its greenhouse gas emissions, and is pursuing a whole series of policies to facilitate such reductions. As the Final EIR

---

[216] See, e.g., *Flanders Foundation v. City of Carmel-by-the-Sea* (2012) 202 Cal.App.4th 603, 620-623; *California Native Plant Society v. City of Santa Cruz* (2009) 177 Cal.App.4th 957, 996-1003. See also State CEQA Guidelines Section 15091(a)(3), (b).

[217] Kostka and Zischke, *supra*, at p. 15-43.

[218] The Draft EIR also mentioned that the project would be subject to the four proposed Resource Protection Standards. As explained in Response GR-1 and GR-6, these standards have been transformed into more traditional mitigation measures, though two of them (relating to Water Recycling and Surface Water) are being converted into proposed regulations.

[219] Draft EIR, pp. 14-12 – 14-13.

explains with respect to Alternative 1 (No Future Well Stimulation Practices Alternative) (Final EIR Section 12.2.12):

> The additional importation of oil and gas would create much greater significant and unmitigable (Class I) impacts to greenhouse gas emissions (Impacts GHG-1 and GHG-2) compared to the project or any of the other alternatives (except the No Project Alternative [Alternative 6] since well stimulation would occur and mitigation measures and project standards for resource protection would not be implemented).

As further explained in Final EIR Section 12.2.12:

> Sources of GHG at oil and gas fields outside of California are not subject to California's regulatory setting (EIR Section 10.12.2), which ensures that GHG sources in the business of oil and gas production in California are subject to multiple programs aimed at reducing GHG. Emissions of GHG that occur at a point of oil and gas extraction outside of California are not subject to the Cap-and-Trade Program, and by increasing the activity of oil and gas extraction outside of California, this alternative would cause increased GHG from sources that are not required to offset the GHG to comply with California's cap, resulting in an overall net increase in GHG emissions compared with both existing conditions and the project. Although the oil and gas extraction and associated GHG emissions would occur outside California, California would continue to experience the adverse environmental effects of global climate change driven by GHG emissions worldwide. This impact would occur from GHG sources that are not covered by California's regulatory setting and outside of the potential control of DOGGR to feasibly mitigate. As a result of increasing GHG emissions from sources beyond California's control, no feasible mitigation would be available. This alternative would increase GHG emissions from sources that could not be prevented, reduced, offset, or otherwise mitigated by DOGGR or another California agency tasked with reducing GHG emissions. The GHG emissions increase would cause a potentially significant impact on the environment, and because these emissions would occur beyond California's control, Impact GHG-1 would be Class I: Significant and Unavoidable.

This same logic also applies to Alternative 2, though to a lesser degree, insofar as a prohibition against well stimulation except in existing fields could, over time, lead to an increase in exports compared with what would occur in the absence of such a prohibition. (See Final EIR Table 14.4.1 (Comparison of Alternatives), and Final EIR Section 12.3.12.)

Although it may seem paradoxical that well stimulation treatment would produce fewer GHG emissions than alternatives with lesser amounts of oil and gas production, oil and gas production in California is subject to mitigation requirements, including the State's Cap and Trade program, not found elsewhere. These are described in detail in Section 10.12 of the Draft EIR. Oil shipped by tanker from Iraq, Saudi Arabia, and other countries is not subject to such requirements; nor is oil brought in by train from other states such as North Dakota.

In response to various commenters' suggestion that DOGGR was incorrect to assume, in the Draft EIR, that the mitigation measures formulated with respect to "the project" would not apply to the other action alternatives, DOGGR notes that, although that assumption followed the conventions of CEQA analysis, as described above, DOGGR's ultimate conclusion that "the project" is the environmentally superior alternative would not change if the opposite assumption were made (i.e., that the other action alternatives would include the same mitigation measures as "the project"). Each such alternative, even

Figure C-2[272] shows the State's progress toward achieving its Renewable Portfolio Standard (RPS) goal of satisfying 33 percent of the State's energy demand with renewable energy sources by 2020.

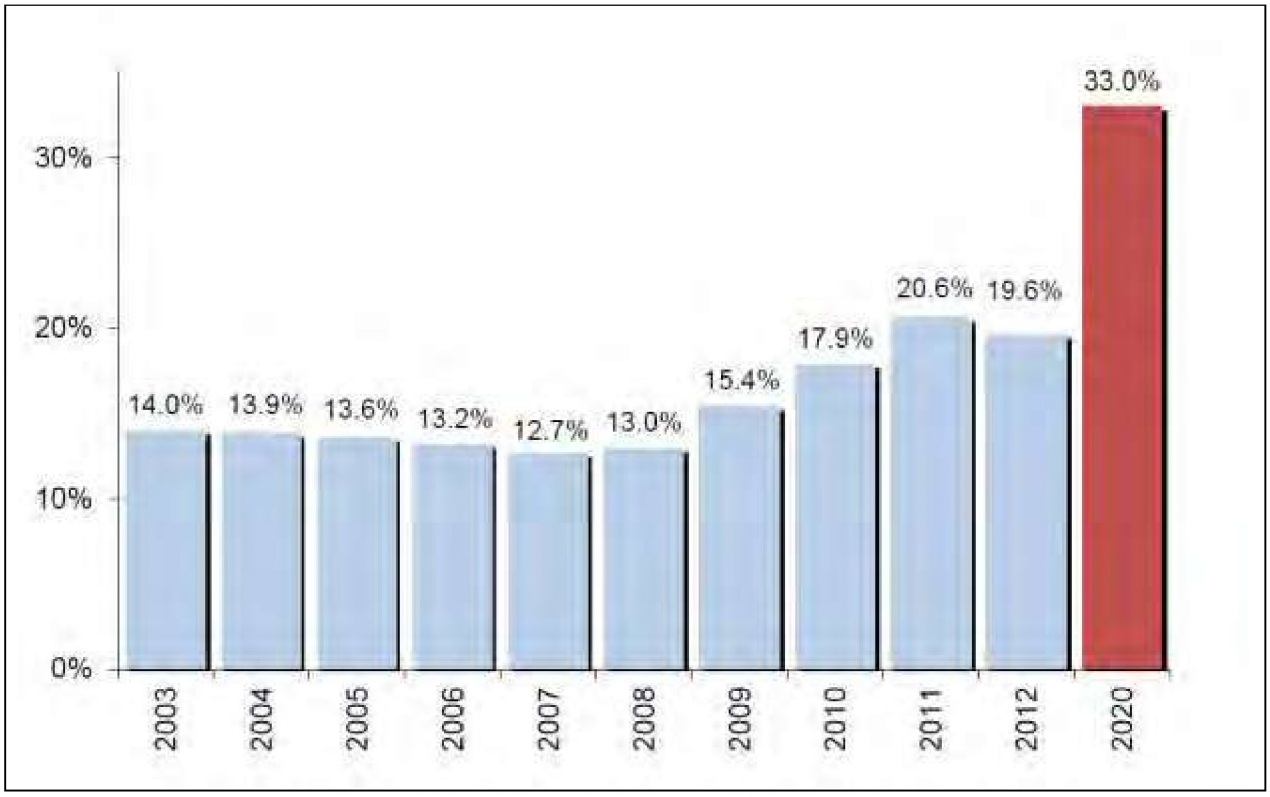


Figure C-2. California's RPS Progress
Source: California Public Utilities Commission

Experts in the field are skeptical as to whether California utilities will to meet their RPS goals on time.[273] Even with new sources of renewable energy being added to the system, increased growth in demand has outpaced progress toward supplying that demand.

Furthermore, the well stimulation treatment activities addressed in this EIR do not necessarily translate into an increase in GHG emissions, even in the short term. As explained above, dependence on fossil fuels will continue in the State during the period of transition to greater use of renewable energy sources, regardless of whether well stimulation occurs here or elsewhere. Oil consumption in California is not dependent upon California's in-state oil production; rather, it is tied directly to consumer demand and indirectly to global oil prices. If California disallows well stimulation, the lost oil that would otherwise have come from the State will likely be produced in the Middle East, North Dakota, or other parts of the nation and world with less stringent environmental laws. On a global scale, this switch to a greater reliance on imported fuels will lead to more GHG emissions, as those emissions will not be subject to offset requirements or caps as they would be in California. (Draft EIR, 12.2-37.) GHGs are not confined locally, but instead disperse and affect the global atmosphere. This EIR, recognizing that well stimulation specifically, and oil and gas production generally, will occur *somewhere*, evaluates such activities within the context of CEQA and the environmental protections that law provides.

[272] *Knowledge is Power*, *supra*, at p. 7.

[273] CLEE, *In Our Backyard* (Nov. 2011 update) at p. 7.

EXHIBIT F

[Alston & Bird's MAY 5, 2025 Comment Letter]



Acidizing

Briefing Paper

Treatment in Oil and Gas Operators

Background

Oil and gas operators have used acid treatment (acidizing) to improve well productivity for almost 120 years. Acidizing predates all other well stimulation techniques, including hydraulic fracturing which was not developed until the late 1940s. However, until the early 1930's, acidizing use was limited by the lack of effective acid corrosion inhibitors to protect the steel tubulars in the wells. With the development of effective corrosion inhibitors, the use and further development of acid treatment (acidizing) of oil and gas wells proliferated, leading to the establishment of the well stimulation services industry. Today, acidizing is one of the most widely used and effective means available to oil and gas operators for improving productivity (stimulation) of wells. Acidizing is commonly performed on new wells to maximize their initial productivity and on aging wells to restore productivity and maximize the recovery of the energy resources.

Acidizing Basics

Acidizing involves pumping acid into a wellbore or geologic formation that is capable of producing oil and/or gas. The purpose of any acidizing is to improve a well's productivity or injectivity. There are three general categories of acid treatments: **acid washing; matrix acidizing; fracture acidizing.**

In acid washing, the objective is simply tubular and wellbore cleaning. Treatment of the formation is not intended. Acid washing is most commonly performed with **hydrochloric acid (HCl)** mixtures to clean out scale (such as calcium carbonate), rust, and other debris restricting flow in the well. Matrix and fracture acidizing are both formation treatments.

In matrix acidizing, the acid treatment is injected below the formation fracturing pressure. In fracture acidizing, acid is pumped above the formation fracturing pressure.

The purpose of matrix or **fracture acidizing** is to restore or improve an oil or gas well's productivity by dissolving material in the productive formation that is restricting flow, or to dissolve formation rock itself to enhance existing, or to create new flow paths to the wellbore. Two key factors dominate the treatment selection and design process when planning an acid job; formation type – carbonate, sandstone, or shale, and formation permeability – the ability of fluid to flow through the formation in its natural state.

Formation type determines the type(s) of acid necessary and formation permeability determines the pressure required for pumping the acid into the formation.

© Copyright 2014 – American Petroleum Institute (API), all rights reserved. Digital Media | DM2014-113 | 05.14 | PDF

Exhibit Y

Rescission of Oil and Gas Drilling Ordinance
(Ordinance No. 188,623)

ORDINANCE NO. 188623

An ordinance rescinding Ordinance No. 187,709, which prohibited new oil and gas extraction and made existing extraction activities a nonconforming use in all zones.

THE PEOPLE OF THE CITY OF LOS ANGELES
DO ORDAIN AS FOLLOWS:

Section 1. Ordinance No. 187,709, which prohibited new oil and gas extraction and made existing extraction activities a nonconforming use in all zones, is rescinded.

Sec. 2. Upon the rescission of Ordinance No. 187,709, the amended or deleted definitions, paragraphs, subdivisions or subsections of Sections 12.03, 12.20, 12.23, 12.24, and 13.01 of Chapter 1 of the Los Angeles Municipal Code, shall return to the same language and effect as they had prior to their amendment or deletion by Ordinance No. 187,709.

Sec. 3. The City Clerk shall certify to the passage of this ordinance and have it published in accordance with Council policy, either in a daily newspaper circulated in the City of Los Angeles or by posting for ten days in three public places in the City of Los Angeles: one copy on the bulletin board located at the Main Street entrance to the Los Angeles City Hall; one copy on the bulletin board located at the Main Street entrance to the Los Angeles City Hall East; and one copy on the bulletin board located at the Temple Street entrance to the Los Angeles County Hall of Records.

Approved as to Form and Legality

HYDEE FELDSTEIN SOTO, City Attorney

By _____
MARVIN BONILLA
Deputy City Attorney

Date May 5, 2025

File No. 17-0447-S2

m:\real prop_env_land use\land use\jennifer tobkin\oil litigation\council reports\r25-0221 draft ordinance (oil ordinance rescission) (final).docx

The Clerk of the City of Los Angeles hereby certifies that the foregoing ordinance was passed by the Council of the City of Los Angeles.

CITY CLERK

MAYOR

Ordinance Passed May 23, 2025

Approved 06/02/2025

Ordinance Posted: 06/06/2025
Ordinance Effective Date: 07/16/2025

INITIAL SUBMISSIONS

The following submissions by the public are in compliance with the Commission Rules and Operating Procedures (ROPs), Rule 4.3a. Please note that "compliance" means that the submission complies with deadline, delivery method (hard copy and/or electronic) AND the number of copies. The Commission's ROPs can be accessed at http://planning.lacity.org, by selecting "Commissions & Hearings" and selecting the specific Commission.

The following submissions are not integrated or addressed in the Staff Report but have been distributed to the Commission.

Material which does not comply with the submission rules is not distributed to the Commission.

ENABLE BOOKMARKS ONLINE:

**If you are using Explorer, you will need to enable the Acrobat  toolbar to see the bookmarks on the left side of the screen.

If you are using Chrome, the bookmarks are on the upper right-side of the screen. If you do not want to use the bookmarks, simply scroll through the file.

If you have any questions, please contact the Commission Office at (213) 978-1300.

ALSTON & BIRD

350 South Grand Avenue, 51st Floor
Los Angeles, CA 90071
213-576-1000 | Fax: 213-576-1100

Matthew Wickersham Direct: 213-576-1185 matt.wickersham@alston.com

VIA ELECTRONIC MAIL

September 29, 2025

City Planning Commission of Los Angeles
200 North Spring Street, Room 701
Los Angeles, CA 90012
cpc@lacity.org

Re: Supplemental Submission in support of Appeal, Case No. ZA-2025-2976-ZAI-1A, Agenda Item No. 12 for the October 9, 2025, CPC meeting

Dear Commissioners,

We represent E & B Natural Resources Management Corporation, Hillcrest Beverly Oil Corporation, E&B ENR I, LLC, and Elysium Natural Resources, LLC (collectively, "E&B") regarding E&B's Appeal of the City of Los Angeles Department of City Planning's ("City Planning") "Zoning Administrator's Interpretation" ("ZAI" or "2025 ZAI"), issued on June 12, 2025. E&B requests reconsideration of the 2025 ZAI for the reasons provided in its appeal submitted on June 26, 2025, as well as the prior arguments and submissions made by E&B in connection with its appeal of the prior version of the ZAI that was adopted on January 17, 2023. In addition to these legal arguments, E&B submits the accompanying material. These recent documents provide further support regarding the fundamental deficiencies underlying the 2025 ZAI.

For instance, the County of Los Angeles has conceded that actions to restrict oil and gas production may have a significant effect on the environment, and therefore an environmental impact report is required. In addition, the California Energy Commission released a report recommending that the State take actions to "[s]tabilize in-state crude oil production and distribution to bolster supply for California refineries and support the petroleum fuels system." (See attached 6/27/25 CEC Report at p. 4.) The remaining documents provide further evidence of how restricting local oil production throughout the City of Los Angeles will only increase our dependence on foreign oil, which will result in greater environmental impacts and higher gasoline prices. Indeed, the Governor's office and state legislature have shown a growing recognition that these policies to curtail domestic oil production have resulted in the shutdown of the State's refineries, increased the cost of petroleum products, and caused significant environmental impacts.

For all of these reasons, we urge the City to reconsider the adoption of the ZAI unless and until it cures its numerous legal defects.

Sincerely,



Matthew C. Wickersham

Enclosure

ENVIRONMENTAL CHECKLIST FORM

INITIAL STUDY

LA COUNTY PLANNING

PROJECT SUMMARY

Project Title	Revised Oil Well Ordinance
Project No./Case No.	PRJ2025-000212
Related Case No(S).	RPPL2025000276, RPPL2025000277, RPPL2025000284
Lead Agency Name & Address	County of Los Angeles Department of Regional Planning ("LA County Planning") 320 W. Temple Street, 13th Floor Los Angeles, CA 90012
Location & Custodian of Record of Proceedings	LA County Planning 320 W. Temple Street, 13th Floor Los Angeles, CA 90012
Staff Contact	Kenneth Warner
Staff Email & Phone Number	ordinance@planning.lacounty.gov (213) 974-6432
Project's Sponsor/ Project Applicant's Name & Address	LA County Planning 320 W. Temple Street, 13th Floor Los Angeles, CA 90012
Project Location	Los Angeles County (Countywide)
Assessor's Parcel Number (APN)	N/A
USGS Quad	N/A
Gross Acreage	Approximately 1,696,000 acres (approximately 2,650 square miles)
Supervisorial District	Countywide
General Plan or Community/Area Plan Designation	Implementation of the Revised Oil Well Ordinance, once approved, would occur throughout unincorporated Los Angeles County in all General Plan and Area Plan designations.
Planning Area	Implementation of the Revised Oil Well Ordinance, once approved, would occur throughout unincorporated Los Angeles County in all Planning Areas.
Zoning/Community Standards District (if applicable)	Implementation of the Revised Oil Well Ordinance, once approved, would occur throughout unincorporated Los Angeles County in all zoning designations and Community Standards Districts.

Brief Description of Project:

The project includes: i) Amendments to Title 22 – Planning & Zoning of the Los Angeles County Code to prohibit new oil wells and production facilities, designate existing oil wells and production facilities as nonconforming due to use, and modify standards for oil wells during the amortization period ii) Amendments to the Baldwin Hills Community Standards District (CSD) to be consistent with Countywide prohibition of oil wells and production facilities and standards for oil wells during the amortization period, iii) Amendments to Title 12 - Environmental Protection of the Los Angeles County Code to remove noise exemptions for oil wells, and iv) Amendments to the General Plan in support of sustainability and environmental justice goals by phasing out oil production in unincorporated Los Angeles County.

Surrounding Land Uses & Setting:

The affected areas are adjacent to open space, residential, commercial, and industrial zones in urban, suburban, and rural settings across Los Angeles County.

Native American Consultation:
Have California Native American tribes traditionally and culturally affiliated with the project area requested consultation pursuant to Public Resources Code § 21080.3.1?

☐ Yes ☒ No

If so, is there a plan for consultation that includes, for example, the determination of significance of impacts to tribal cultural resources, procedures regarding confidentiality, etc.?

LA County Planning has notified California Native American tribes pursuant to AB 52. LA County Planning will comply with all provisions of AB 52 and SB 18.

Note: Conducting consultation early in the CEQA process allows tribal governments, lead agencies, and project proponents to discuss the level of environmental review, identify and address potential adverse impacts to tribal cultural resources, and reduce the potential for delay and conflict in the environmental review process. (See Public Resources Code section 21080.3.2.) Information may also be available from the California Native American Heritage Commission's Sacred Lands File per Public Resources Code section 5097.96 and the California Historical Resources Information System administered by the California Office of Historic Preservation. Please also note that Public Resources Code section 21082.3(c) contains provisions specific to confidentiality.

Other public agencies whose approval is required (e.g. permits, financial approval, or participation agreements):

Public Agency	*Approval Required*
None	None

Concurrent projects in the area:

Project/Case No.	*Description and Status*
None	None

Reviewing Agencies:

Responsible Agencies

- ☒ None
- Regional Water Quality Control Board:
  - ☐ Los Angeles Region
  - ☐ Lahontan Region
- ☐ Coastal Commission
- ☐ Army Corps of Engineers
- ☐ LAFCO

Special Reviewing Agencies

- ☒ None
- ☐ Santa Monica Mountains Conservancy
- ☐ National Parks
- ☐ National Forest
- ☐ Edwards Air Force Base
- ☐ Resource Conservation District of Santa Monica Mountains

Regional Significance

- ☒ None
- ☐ SCAG Criteria
- ☐ Air Quality
- ☐ Water Resources
- ☐ Santa Monica Mtns. Area

Trustee Agencies

- ☒ None
- ☐ State Dept. of Fish and Wildlife
- ☐ State Dept. of Parks and Recreation
- ☐ State Lands Commission
- ☐ University of California (Natural Land and Water Reserves System)

County Reviewing Agencies

- ☒ DPW
- ☒ Fire Department
  - Forestry, Environmental Division
  - Health Hazmat
- ☐ Sanitation District
- ☒ Public Health/Environmental Health Division: Drinking Water Program (Private Wells), Toxics Epidemiology Program (Noise)
- ☐ Sheriff Department
- ☐ Parks and Recreation
- ☐ Subdivision Committee

ENVIRONMENTAL FACTORS POTENTIALLY AFFECTED

The environmental factors checked below would be potentially significant impacts affected by this project.

- ☐ Aesthetics
- ☐ Agriculture & Forestry
- ☐ Air Quality
- ☐ Biological Resources
- ☐ Cultural Resources
- ☐ Energy
- ☐ Geology & Soils
- ☐ Greenhouse Gas Emissions
- ☐ Hazards & Hazardous Materials
- ☐ Hydrology/Water Quality
- ☐ Land Use/Planning
- ☒ Mineral Resources
- ☐ Noise
- ☐ Population/Housing
- ☐ Public Services
- ☐ Recreation
- ☐ Transportation
- ☐ Tribal Cultural Resources
- ☐ Utilities/Service Systems
- ☐ Wildfire
- ☐ Mandatory Findings of Significance

DETERMINATION (To be completed by the Lead Agency)

On the basis of this initial evaluation:

☐ I find that the proposed project **COULD NOT** have a significant effect on the environment, and a **NEGATIVE DECLARATION** will be prepared.

☐ I find that although the proposed project could have a significant effect on the environment, there will not be a significant effect in this case because revisions in the project have been made by or agreed to by the project proponent. A **MITIGATED NEGATIVE DECLARATION** will be prepared.

☒ I find that the proposed project MAY have a significant effect on the environment, and an **ENVIRONMENTAL IMPACT REPORT** is required.

☐ I find that the proposed project MAY have a "potentially significant impact" or "potentially significant unless mitigated" impact on the environment, but at least one effect 1) has been adequately analyzed in an earlier document pursuant to applicable legal standards, and 2) has been addressed by mitigation measures based on the earlier analysis as described on attached sheets. An **ENVIRONMENTAL IMPACT REPORT** is required, but it must analyze only the effects that remain to be addressed.

☐ I find that although the proposed project could have a significant effect on the environment, because all potentially significant effects (a) have been analyzed adequately in an earlier **EIR** or **NEGATIVE DECLARATION** pursuant to applicable standards, and (b) have been avoided or mitigated pursuant to that earlier **EIR** or **NEGATIVE DECLARATION**, including revisions or mitigation measures that are imposed upon the proposed project, nothing further is required.

Kenneth Warner		3/27/25
Print Name (Project Planner)	Signature (Project Planner)	Date

Bruce Durbin		3/27/25
Print Name (Section Head)	Signature (Section Head)	Date

EVALUATION OF ENVIRONMENTAL IMPACTS:

1) A brief explanation is required for all answers except "No Impact" answers that are adequately supported by the information sources the lead agency cites in the parentheses following each question. A "No Impact" answer is adequately supported if the referenced information sources show that the impact simply does not apply to projects like the one involved (e.g., the project falls outside a fault rupture zone). A "No Impact" answer should be explained where it is based on project-specific factors as well as general standards (e.g., the project will not expose sensitive receptors to pollutants, based on a project-specific screening analysis).
2) All answers must take account of the whole action involved, including off-site as well as on-site, cumulative as well as project-level, indirect as well as direct, and construction as well as operational impacts.
3) Once the lead agency has determined that a particular physical impact may occur, then the checklist answers must indicate whether the impact is potentially significant, less than significant with mitigation, or less than significant. "Potentially Significant Impact" is appropriate if there is substantial evidence that an effect may be significant. If there are one or more "Potentially Significant Impact" entries when the determination is made, an EIR is required.
4) "Negative Declaration: Less Than Significant With Mitigation Incorporated" applies where the incorporation of mitigation measures has reduced an effect from "Potentially Significant Impact" to a "Less Than Significant Impact." The lead agency must describe the mitigation measures and briefly explain how they reduce the effect to a less than significant level. (Mitigation measures from Section XVII, "Earlier Analyses," may be cross-referenced.)
5) Earlier analyses may be used where, pursuant to the tiering, program EIR, or other CEQA processes, an effect has been adequately analyzed in an earlier EIR or negative declaration. (State CEQA Guidelines § 15063(c)(3)(D).) In this case, a brief discussion should identify the following:
    a) Earlier Analysis Used. Identify and state where they are available for review.
    b) Impacts Adequately Addressed. Identify which effects from the above checklist were within the scope of, and adequately analyzed in, an earlier document pursuant to applicable legal standards, and state whether such effects were addressed by mitigation measures based on the earlier analysis.
    c) Mitigation Measures. For effects that are "Less than Significant with Mitigation Measures Incorporated," describe the mitigation measures which were incorporated or refined from the earlier document and the extent to which they address site-specific conditions for the project.
6) Supporting Information Sources: A source list should be attached, and other sources used, or individuals contacted should be cited in the discussion.
7) The explanation of each issue should identify: the significance threshold, if any, used to evaluate each question, and mitigation measures identified, if any, to reduce the impact to less than significant. Sources of thresholds include the County General Plan, other County planning documents, and County ordinances. Some thresholds are unique to geographical locations.

PROJECT DESCRIPTION

Overview

The project is an ordinance amending the Los Angeles County Code and an amendment to the County of Los Angeles General Plan.

This ordinance and general plan amendment establish a regulatory framework to phase out oil production activities in unincorporated Los Angeles County. Specifically, the project includes amendments to the Los Angeles County Planning & Zoning Code (Title 22) including the Baldwin Hills Community Standards District (CSD), the County Environmental Protection Code (Title 12), and the County of Los Angeles General Plan. These updates will align County land use policies with regional sustainability and environmental justice goals, while ensuring the safe and orderly phase out of oil production activities.

1. Title 22 (Planning & Zoning) Oil Well Ordinance:

   Under the proposed ordinance, no new oil wells or production facilities may be established in any zone. Pursuant to Section 22.172 of the County Code (Nonconforming Uses, Buildings, and Structures), existing, legally established oil wells or production facilities operating without an approved Conditional Use Permit or other discretionary permit will be considered nonconforming and subject to a 20-year amortization period. In addition, the ordinance establishes performance standards addressing signage, comment and complaint logging, site maintenance, bonding, well plugging, and site abandonment and restoration. This ordinance would apply to all oil wells in unincorporated Los Angeles County, except in the Coastal Zone.

2. Baldwin Hills Community Standards District (CSD) Amendment:

   The project amends the Baldwin Hills CSD to align with and fully implement the provisions of the Title 22 Oil Well Ordinance described above, ensuring consistent application of the new regulations and standards within the Baldwin Hills CSD area.

3. Removal of Title 12 (Environmental Protection) Exemption for Oil & Gas Wells:

   The project eliminates the current exemption of oil and gas wells from the Noise Control regulations set forth in Title 12 of the County Code. Consequently, these wells will be subject to all provisions of the Noise Control chapter, ensuring better management of noise impacts related to oil and gas extraction activities.

4. General Plan Amendment:

   The project amends the General Plan. Specifically, it revises the Land Use Element, Conservation and Natural Resources Element, and Safety Element to prohibit new oil well operations and remove designations that support oil production activities.

Background

Los Angeles County has a long history of oil production, much of it occurring in densely populated and environmentally sensitive areas. Over time, concerns about oil production's potential negative impacts to public health, safety, and environmental quality—especially near homes, schools, and parks—have intensified. In response, the County of Los Angeles Board of Supervisors has prioritized environmental justice and transition away from fossil fuel dependence. Key actions informing this project include:

- A 2021 Board Motion emphasizing the protection of public health and directing the development of an Oil Well Ordinance.
- Findings from the Baldwin Hills Community Standards District (CSD) and its associated EIRs, which identified air quality degradation, potential hazards, and other risks stemming from oil production.

Building upon these initiatives, this project aligns with the County's sustainability goals by reducing stationary pollution sources and promoting healthier, more livable communities. The project will amend the General Plan and Los Angeles County Code to provide a regulatory framework for phasing out oil operations in the unincorporated areas. Although the County plays a key role, oil wells and production facilities are also regulated and permitted by a network of federal, state, regional, and local agencies. These include California Department of Transportation (Caltrans), California Water Boards (RWQCB), California Department of Conservation Geologic Energy Management Division (CalGEM), California Department of Toxic Substances Control (DTSC), California Occupational Safety and Health Administration (CalOSHA), Department of Transportation (USDOT), Environmental Protection Agency (USEPA), Governor's Office of Emergency (Cal OES), Occupational Safety and Health Administration (OSHA), South Coast Air Quality Management District (SCAQMD), and State Fire Marshall. In addition to the Department of Regional Planning (DRP), Los Angeles County agencies include the Fire Department, Department of Public Health (DPH), and Public Works (PW).

Recent statewide legislation complements the project and reinforces the County's sustainability and environmental justice efforts, including:

- Senate Bill 1137 (2022): Establishes 3,200-foot health protection zones around sensitive receptors like residences, schools, and hospitals, prohibiting new oil and gas wells within these areas and imposing stricter standards on existing operations. While SB 1137 sets state-level restrictions based on proximity to sensitive receptors, the project takes a broader approach, prohibiting new wells countywide in unincorporated areas, as well as phasing out existing oil operations.
- Assembly Bill 1866 (2024): Increases fees for idle wells statewide and requires stricter Idle Well Management Plans (IWMPs) to compel operators to properly close and remediate wells.
- Assembly Bill 2716 (2024): Targets low-production wells in the Inglewood Oil Field, requiring all such wells there to be closed and abandoned by December 31, 2030.
- Assembly Bill 3233 (2024): Strengthens local authority by confirming the power of local governments to regulate or prohibit oil and gas operations via ordinance.

Proposed Performance Standards During Amortization

During the amortization period for existing oil wells and production facilities, the Title 22 (Planning & Zoning) Oil Well Ordinance and Baldwin Hills Community Standards District (CSD) Amendment,

described above, propose a set of performance standards designed to ensure that ongoing operations are safe, orderly, and minimally impactful to surrounding communities during the phase-out process. These standards apply countywide to any oil well or production facility subject to the Title 22 Oil Well Ordinance or Baldwin Hills CSD Amendment and will be phased in according to specific timelines. Requirements for signage, complaint tracking, site maintenance, bonding, and well abandonment ensure that the eventual retirement and restoration or conversion of each site proceeds in a responsible manner.

1. Applicability and Compliance Schedule

Existing oil wells and production facilities become nonconforming uses upon the effective date of this project, unless they already operate under a discretionary permit with a defined expiration. These nonconforming wells must comply with certain provisions immediately, such as site maintenance and well abandonment requirements, while other standards take effect after one or two years. This tiered compliance schedule allows operators time to update signage, institute complaint-tracking procedures, post bonds, and address other operational details before permanently shutting down their wells.

2. Signage Requirements

To maintain orderly operations and facilitate oversight, operators must install specific signs at each well site or production facility. Sites where oil production is the sole use will display entrance identification signs that include the operator's name, the lease name, and relevant contact numbers for odor complaints (South Coast Air Quality Management District) and land-use inquiries. Wells on lots with other primary uses will also post signage at any fenced perimeter. These signage rules, along with requirements for well identification signs, ensure that members of the public and regulators can quickly identify an operator and locate the correct reporting channel for issues.

3. Complaint and Comment Log

Operators must establish a written log tracking all incoming comments and complaints about site operations, whether conveyed by phone or email. This log records the date, time, and nature of each complaint, as well as the response offered. Operators must respond within 24 hours (or the next business day), providing an update on actions taken to address the issue. The log must be available to the Director of Regional Planning upon request, promoting accountability and enabling prompt resolution of nuisance or hazard concerns.

4. Site Maintenance Provisions

Recognizing that oil production facilities can affect local aesthetics and public safety, the project imposes rigorous site maintenance rules. Operators must keep all structures, fences, walls, and equipment in good condition, free of graffiti, rust, or staining. Pools of oil, water, or debris must be removed, and any weeds or dry brush within 25 feet of wells or production facilities must be cleared to reduce fire risk. Any drilling or repair equipment that is no longer in use must be removed within 90 days. Once a well is abandoned, the site must be restored to its original condition as nearly as practicable.

5. Bonding Requirements

To safeguard against potential financial shortfalls that could leave wells improperly closed or sites unremediated, operators will be required to post indemnity bonds. The Director of Regional Planning sets the amount (no less than $152,000 per well), based on the site's complexity and operational scope. The bond ensures coverage of well plugging, reabandonment if required by the

California Geologic Energy Management Division (CalGEM), and remediation efforts if contamination is discovered. These bonds may be reassessed every five years and are released only when all wells on a site have been fully plugged and the lot restored to the Director's satisfaction.

6. Well Plugging and Abandonment

In alignment with CalGEM standards, this project confirms that wells must be properly sealed, equipment removed, and contaminated materials disposed of in an approved manner. Operators are required to clear unused pipelines and clean the well site of oil and debris. The closure process must be completed expeditiously—within 60 days following plugging—while final restoration must occur no later than one year after the last well on a lot is abandoned, unless CalGEM approves a longer timeline.

These performance standards ensure that operators fulfill all environmental and public health obligations until the completion of site restoration. Items such as signage and complaint logging address the immediate need for transparency and responsiveness, while bonding and well-abandonment provisions protect against long-term risks, including soil contamination, fire hazards, and visual blight. The project thus facilitates a responsible phase-out of oil production, striking a balance between operator feasibility and community welfare.

Plugging & Abandoning Oil Wells in California

The California Geologic Energy Management Division (CalGEM) and state legislature have established specific requirements for plugging and abandoning oil wells in California to protect public health and prevent environmental hazards. These regulations, codified under Title 14 of the California Code of Regulations and Chapter 1 of the Public Resources Code, ensure that all wells are safely decommissioned. Key requirements include:

1. Cement Plugging: Wells must be sealed with cement plugs to isolate oil and gas zones and prevent contamination of freshwater aquifers. Cement plugs are typically placed at the bottom of the well, across oil or gas zones, and at intervals to ensure complete isolation.
2. Freshwater Protection: Cement barriers are required to protect freshwater zones from potential contamination by hydrocarbons or other harmful substances. This includes placing a minimum 200-foot cement plug across fresh-saltwater interfaces.
3. Removal of Equipment: All production equipment, pipelines, and associated infrastructure must be removed from the site during abandonment. Any materials that pose contamination risks must be properly disposed of in accordance with state and federal regulations.
4. Surface Restoration: After the plugging process, the well site must be restored to its original condition or adapted for future use. This includes regrading the site, reseeding vegetation, and addressing any soil contamination.
5. Inspection and Compliance: CalGEM inspectors oversee plugging and abandonment operations to ensure compliance with applicable standards. This includes verifying the proper placement of cement plugs, the removal of equipment, and the adequacy of surface restoration efforts.
6. Idle and Hazardous Wells: Idle wells that are not currently producing oil or gas must be managed under strict guidelines to prevent them from becoming environmental hazards. Hazardous or deserted wells are prioritized for immediate abandonment and remediation.

7. Financial Assurance: Operators are required to post indemnity bonds or other financial assurances to cover the costs of plugging, abandonment, and site restoration. The amount of the bond depends on the well's depth, location, and complexity.
8. Special Requirements: In some cases, additional measures may be necessary, such as enhanced cementing techniques for fractured formations or the use of bridge plugs to secure specific zones within a well.

These regulations ensure that abandoned oil wells do not pose ongoing risks to public health, safety, or the environment. The Title 22 (Planning & Zoning) Oil Well Ordinance and Baldwin Hills Community Standards District (CSD) Amendment, described above, require that wells are plugged and abandoned in compliance with all CalGEM regulations.

ENVIRONMENTAL SETTING

Project Location

Los Angeles County spans approximately 4,083 square miles and is home to 88 cities and unincorporated areas totaling approximately 2,656 square miles. These unincorporated regions feature diverse landscapes, ranging from densely populated urban neighborhoods to rural and agricultural areas. The project applies to the unincorporated areas of Los Angeles County.

The project area hosts a broad range of land use designations, including residential, industrial, open space, and agricultural zones, many of which are directly adjacent to existing oil production activities. These oil production activities, especially concentrated in areas like the Baldwin Hills CSD area within the Inglewood Oil Field, raise concerns about land use compatibility, environmental quality, and negative impacts to public health.

Figures 1 and 2 provide maps of the unincorporated areas and the boundaries of the Baldwin Hills CSD to illustrate the project's geographic scope.

Site Background

The unincorporated areas of Los Angeles County span diverse and distinct regions. To provide a mechanism for local communities to work with the County to develop plans that respond to their unique character, the County of Los Angeles General Plan establishes 11 Planning Areas. The project specifically addresses areas where oil production activities are currently active or could potentially expand, including but not limited to the areas detailed below for each Planning Area:

1. Antelope Valley Planning Area
    a. Characterized by vast, open desert terrain and lower population densities, oil production is limited in this region but located near agricultural and rural residential uses.
2. Coastal Islands Planning Area
    a. No known major oil resources.
3. East San Gabriel Valley Planning Area
    a. The Whittier Oil Field, in the Puente Hills near the city of Whittier, was discovered in 1897 and became a significant oil producer in the early 20th century. The area has a history of oil drilling, with several companies operating in the region. The Whittier Oil Field is located near natural habitats and urban areas.
4. Gateway Planning Area
    a. While sparse oil operations exist in the unincorporated communities of the Gateway Planning Area, the Area's major oil fields—including Santa Fe Springs, Long Beach, and Seal Beach—are largely within incorporated cities.
5. Metro Planning Area
    a. Discovered in 1923, the Dominguez Oil Field is situated beneath the Dominguez Hills near Carson, California, approximately fourteen miles south of downtown Los Angeles. It became a significant oil producer from its inception through the 1960s, leading to the establishment of numerous refineries and industrial complexes in the area. The field is adjacent to urban areas, educational institutions, and residential neighborhoods.

6. San Fernando Valley Planning Area
    a. Located in the Santa Susana Mountains north of the Porter Ranch neighborhood, the Aliso Canyon Oil Field was discovered in 1938. It peaked as an oil producer in the 1950s and was later repurposed as a natural gas storage facility in the 1970s.
7. Santa Clarita Valley Planning Area
    a. Nestled between the Santa Susana, San Gabriel, and Sierra Pelona Mountains, this region encompasses active oil production areas such as Pico Canyon and Placerita Canyon. Historically significant as the site of California's first commercially successful oil well, the valley's oil activities are now located near residential areas, open space preserves, recreational, and institutional uses.
8. Santa Monica Mountains Planning Area
    a. Santa Monica Mountains North Area: Known for its scenic and ecological significance, this region has a limited number of oil production activities primarily located near the northern foothills and adjacent valleys. While extraction is less intensive here compared to other regions, operations are in proximity to protected open spaces, wildlife corridors, and recreational areas.
9. South Bay Planning Area
    a. Discovered in 1932, the Wilmington Oil Field is one of the largest in the United States, originally containing approximately three billion barrels of oil. It extends from San Pedro Bay through Long Beach and east of the Palos Verdes Peninsula, including the unincorporated community of West Carson.
10. West San Gabriel Valley Planning Area
    a. Discovered in 1917, the Montebello Oil Field is situated in the Montebello Hills, adjacent to the city of Montebello. This discovery transformed the area from its agricultural roots into a major oil-producing region. At its peak, the field contributed to approximately one-eighth of California's crude oil production. Over the years, the surrounding landscape has urbanized, with the oil field now bordered by residential neighborhoods, commercial developments, and recreational areas.
11. Westside Planning Area
    a. Baldwin Hills Community Standards District (CSD): The Baldwin Hills CSD comprises much of the Inglewood Oil Field. It is bordered by residential neighborhoods, schools, and Kenneth Hahn State Recreation Area.

Oil field operations encompass activities such as well drilling, maintenance, fluid production and processing, including temporary storage. Drilling operations typically require substantial surface grading, construction of sound suppression walls, and installation of well pads, taking 7–14 days per pad. Drilling occurs 24 hours a day over a 10-day period for each well, powered by diesel engines. Additionally, secondary containment and stormwater management systems mitigate risks from spills, leaks, and heavy rainfall.

The Inglewood Oil Field has been a center of oil production activities in Los Angeles County, producing over 368 million barrels of oil since its inception in 1924. This Oil Field lies adjacent to Kenneth Hahn State Recreation Area. Drainage from portions of the field flows into retention basins designed to contain spills and manage stormwater runoff, ultimately discharging into the Los Angeles County storm drain system and natural watercourses such as Ballona Creek.

Residents and communities surrounding the Inglewood Oil Field have long expressed concerns regarding air quality, noise, vibration, and potential health risks associated with oil production activities. The field operates amidst densely populated urban areas, including residential neighborhoods and schools. Emissions from oil production activities and drilling operations

contribute to cumulative air quality impacts, while noise from drilling rigs, trucks, and other equipment also affects nearby residents.

In recent decades, advancements in oil production technology and evolving regulatory oversight have shaped its operational landscape. However, historical practices left behind environmental contamination, including hydrocarbons in soil and localized contamination in perched groundwater zones adjacent to densely urbanized residential neighborhoods, schools, recreational areas and environmentally sensitive habitats. Modern operations are subject to stricter environmental regulations, including bioremediation programs treating hydrocarbon-impacted soil and stormwater management plans to prevent offsite contamination.

Proactive remediation programs have recently treated over 220,000 cubic yards of hydrocarbon-impacted soil using bioremediation. Retention basins and advanced spill response plans further mitigate environmental risks. However, localized contamination in soil and perched groundwater remains a legacy issue of historical operations, requiring continued oversight and management.

The project seeks to phase out oil operations in unincorporated Los Angeles County, transitioning the project sites to other uses. This transition aligns with County sustainability goals and reflects broader regional priorities for environmental protection, equitable land use planning, and a just transition to a fossil-fuel-free economy.

Existing Conditions/Site Characteristics

The project area features a broad range of urban, suburban, rural, and natural landscapes. These areas include residential neighborhoods, schools, parks, sensitive habitats, and recreational spaces, many of which are adjacent to or impacted by existing oil production facilities. The environmental setting provides the context for understanding the potential impacts of the project.

Surrounding Land Uses

The project encompasses the unincorporated communities throughout Los Angeles County. Los Angeles County is bordered by Ventura County to the west, Kern and San Bernardino Counties to the north and east, and Orange County to the southeast, with each neighboring area having distinct characteristics and land uses that influence the regional context of the project. For example:

- To the north: Kern County's oil production zones illustrate regional significance of fossil fuel operations but contrast with Los Angeles County's push toward sustainability and land use compatibility.
- To the east, west, and south: Urban and suburban neighborhoods intermingle with industrial zones, underscoring the need for careful regulation to prevent land use conflicts.

Within the unincorporated areas of Los Angeles County, significant portions of land near oil operations are designated for residential, recreational, or sensitive environmental uses.

PURPOSE OF THIS INITIAL STUDY

The purpose of this Initial Study is to evaluate the potential environmental impacts of the proposed regulatory framework to phase out oil production activities in unincorporated Los Angeles County. This study is conducted in compliance with the California Environmental Quality Act (CEQA), pursuant to the California Public Resources Code (PRC) § 21000 et seq. and the CEQA Guidelines (California Code of Regulations [CCR], Title 14, § 15000 et seq.). CEQA requires public agencies to identify and assess the environmental consequences of their actions and to adopt feasible mitigation measures where significant impacts may occur (PRC § 21002, CEQA Guidelines § 15021).

Specifically, this Initial Study aims to:

1. Determine whether the proposed project may result in significant environmental effects that necessitate the preparation of an Environmental Impact Report (EIR), or whether a Negative Declaration (ND) or Mitigated Negative Declaration (MND) may suffice (CEQA Guidelines § 15063).
2. Provide a transparent, public-facing document that outlines the environmental setting, evaluates potential impacts, and considers the project's consistency with applicable land use and environmental policies (CEQA Guidelines § 15125).
3. Ensure compliance with CEQA by addressing direct, indirect, and cumulative impacts associated with the proposed amendments to the County Planning & Zoning Code, the Baldwin Hills Community Standards District, the County General Plan, and the County Environmental Protection Code (CEQA Guidelines §§ 15064, 15130).
4. Facilitate informed decision-making by County officials and provide opportunities for meaningful public and stakeholder participation (PRC § 21003, CEQA Guidelines § 15082).

While CEQA requires a Mitigation Monitoring and Reporting Program (MMRP) for projects with significant impacts that require mitigation (PRC § 21081.6, CEQA Guidelines § 15097), the Revised Oil Well Ordinance project has only two significant impacts, both related to the loss of mineral resources (CEQA Guidelines Appendix G, Section XIII [Mineral Resources]). These impacts are unavoidable and cannot be mitigated due to the nature of the project, which involves phasing out oil production activities. All other potential impacts have been determined to be less than significant and do not require mitigation measures. These impacts are effectively managed through compliance with existing federal, state, and local regulations. This Initial Study reflects the project's alignment with CEQA's goals of minimizing environmental harm and promoting sustainable land use practices (PRC § 21001).

ENVIRONMENTAL IMPACT ANALYSIS

I. Aesthetics

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Except as provided in Public Resources Code §21099, would the project:				
a. **Have a substantial adverse effect on a scenic vista?**	☐	☐	☒	☐
b. **Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?**	☐	☐	☒	☐
c. **In nonurbanized areas, substantially degrade the existing visual character or quality of public views of the site and its surroundings? (Public views are those that are experienced from publicly accessible vantage point). If the project is in an urbanized area, would the project conflict with applicable zoning and other regulations governing scenic quality?**	☐	☐	☒	☐
d. **Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?**	☐	☐	☒	☐

a. Have a substantial adverse effect on a scenic vista?

Less than Significant Impact. The project is expected to have a beneficial effect on scenic vistas within unincorporated Los Angeles County over the long term by phasing out oil production activities and removing associated industrial infrastructure. Scenic vistas are typically valued for their unobstructed views of natural or urban landscapes, including significant ridgelines, coastal areas, and other important visual resources identified in the County of Los Angeles General Plan.

Currently, existing oil wells, pump jacks, and related equipment can disrupt or diminish the quality of scenic vistas by introducing industrial elements into the landscape. By prohibiting new oil wells and phasing out existing operations, the project will lead to the eventual removal of these visible disruptions.

In the short term, temporary visual disturbances could occur during decommissioning activities. These may include the presence of heavy equipment, temporary fencing, or staging areas. However, such impacts would be localized, limited in duration, and would diminish once the dismantling and restoration processes are complete. By incorporating Site Maintenance standards in the proposed Title 22 (Planning & Zoning) Oil Well Ordinance and Baldwin Hills Community Standards District (CSD) Amendment, the project ensures orderly and aesthetically sensitive operations. These standards require keeping sites free from debris and obstructions, removing equipment within specified timeframes, and maintaining structures in good condition. As a result, any negative effects on scenic vistas would be limited and temporary.

Furthermore, the proposed Signage requirements would not substantially detract from scenic views. While operators must install or maintain visible identification and safety signs, the project limits their size, location, and design, thereby minimizing any visual intrusion.

The project does not introduce new structures that would adversely affect designated scenic highways, significant ridgelines, or other identified scenic resources as mapped by the County or adjacent jurisdictions. Instead, it supports existing County policies aimed at protecting and enhancing scenic character. Therefore, while minor temporary effects may occur, the overall long-term impact on scenic vistas is expected to be beneficial. Any short-term adverse visual effects associated with decommissioning would be less than significant.

b. Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?

Less than Significant Impact. The project would phase out existing oil production operations and remove associated infrastructure in unincorporated Los Angeles County. It does not involve constructing new buildings, major grading, or other activities that would substantially damage scenic resources such as trees, rock outcroppings, or historic buildings. Instead, it focuses on eliminating existing oil facilities and restoring or converting affected sites to land uses more compatible with surrounding communities and natural features. Decommissioning activities and interim operations are subject to the project's Well Plugging and Abandonment and Site Maintenance requirements that protect the surrounding environment by mandating the timely removal of equipment, debris, and any hazardous materials.

Sites affected by the project are not located adjacent to or within the viewshed of any state-designated scenic highways, as identified by the California Department of Transportation or the General Plan. Without proximity to a designated scenic highway or other identified scenic resources, the likelihood of adverse effects on views from or toward these landscapes is minimal. Any short-term visual changes during decommissioning, such as the presence of construction equipment, would be temporary and managed to reduce visual clutter. In the rare event that project activities occur near a scenic resource, compliance with the project's Site Maintenance and Bonds provisions would safeguard against impacts. The required Bonds ensure the County can address or correct any unremedied impacts if an operator fails to comply with restoration obligations. The project's Signage standards encourage neat, appropriately sized identification signs, which further reduces the potential for visual clutter.

Moreover, the removal of oil infrastructure may enhance the visual quality of previously industrialized landscapes over time, potentially improving the overall scenic character of the affected areas. Compliance with existing ordinances and best management practices ensures that the project avoids unnecessary damage to scenic elements.

In summary, the project's activities—limited to removing existing infrastructure, regulating interim operations, and restoring disturbed sites—would not substantially damage scenic resources within a state scenic highway corridor or similar protected area. Therefore, potential impacts to scenic resources are considered less than significant.

c. In nonurbanized areas, substantially degrade the existing visual character or quality of public views of the site and its surroundings? (Public views are those that are experienced from publicly accessible vantage point). If the project is in an urbanized area, would the project conflict with applicable zoning and other regulations governing scenic quality?

Less than Significant Impact. In nonurbanized areas of unincorporated Los Angeles County, existing oil infrastructure—such as pump jacks, tanks, and pipelines—introduces industrial elements that contrast with surrounding natural landscapes. Public views from trails, parks, scenic roads, or other publicly accessible vantage points can be adversely affected by these operations. Phasing out oil production and removing associated facilities—combined with the project's required Well Plugging and Abandonment provisions—would ultimately restore and improve the visual integrity of these areas. Over time, this would create a more harmonious visual environment, enhancing public views and scenic quality. During the amortization period, the project's Site Maintenance standards would limit any unsightly debris, graffiti, or abandoned equipment that could erode visual quality.

During the interim decommissioning and site restoration period, the use of heavy equipment, temporary fencing, and staging areas may result in short-term, localized visual changes. However, these effects are limited in duration and would not substantially degrade the overall visual character or quality of public views. The project's required Comment and Complaint Log mechanism also provides a pathway for addressing any aesthetic concerns raised by residents or visitors. Once decommissioning is complete and the sites are restored, the landscape would be returned to a more natural or compatible condition, resulting in a long-term improvement.

In urbanized areas, the project aligns with applicable zoning and existing regulations intended to protect and enhance visual quality. By designating existing oil wells as nonconforming uses and phasing them out, the project supports local and Countywide objectives for improved community aesthetics and land use compatibility. Existing standards—such as those within the County's Zoning Ordinance, Area Plans, or Community Standards Districts—already govern building form, signage, massing, and architectural style. Compliance with these regulations would further ensure that the project does not conflict with zoning or other requirements meant to preserve and enhance scenic quality in urbanized settings.

Overall, the project is expected to improve the visual environment in both nonurbanized and urbanized areas. Any temporary visual disturbances during the removal of oil infrastructure would be less than significant, and the long-term outcome would be a more visually cohesive, aesthetically pleasing landscape.

d. Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?

Less than Significant Impact. Existing oil production operations in unincorporated Los Angeles County often involve nighttime lighting for safety and operational purposes, as well as infrastructure (e.g., storage tanks, pipes) that can reflect sunlight and create glare during the day. By phasing out and removing oil wells and associated facilities, the project is anticipated to reduce these existing sources of artificial light and glare, thereby improving nighttime visibility and diminishing daytime glare conditions.

Temporary lighting may be required during the decommissioning process for worker safety and efficient site restoration. Such lighting would be limited to short-term periods, focused on the immediate work area, and shielded or directed downward to the extent feasible, thus minimizing potential off-site impacts. The project's Site Maintenance standards minimize potential nuisances by ensuring the timely removal of unnecessary equipment or visual disturbances. No new permanent facilities or features are proposed that would introduce substantial sources of light or glare.

Moreover, any new or existing lighting would be subject to County standards and regulations—such as the Rural Outdoor Lighting District Ordinance—to ensure appropriate shielding, directionality, and intensity control. Compliance with these standards helps prevent light trespass and reduces potential night sky illumination.

Overall, the project would not create a new source of substantial light or glare that would adversely affect day or nighttime views. Instead, it would likely result in a net reduction of glare and artificial light compared to existing conditions, rendering any impacts less than significant.

II. Agriculture and Forestry

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Department of Conservation as an optional model to use in assessing impacts on agriculture and farmland. In determining whether impacts to forest resources, including timberland, are significant environmental effects, lead agencies may refer to information compiled by the California Department of Forestry and Fire Protection regarding the state's inventory of forest land, including the Forest and Range Assessment Project and the Forest Legacy Assessment project; and forest carbon measurement methodology provided in Forest Protocols adopted by the California Air Resources Board.				
Would the project:				
a. **Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?**	☐	☐	☐	☒
b. **Conflict with existing zoning for agricultural use, with a designated Agricultural Resource Area, or with a Williamson Act contract?**	☐	☐	☐	☒
c. **Conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code § 12220 (g)), timberland (as defined in Public Resources Code § 4526), or timberland zoned Timberland Production (as defined in Government Code § 51104(g))?**	☐	☐	☐	☒
d. **Result in the loss of forest land or conversion of forest land to non-forest use?**	☐	☐	☐	☒
e. **Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use or conversion of forest land to non-forest use?**	☐	☐	☐	☒

a. Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?

No Impact. The project involves phasing out oil production activities and does not authorize any new development that would convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance to non-agricultural uses. Project activities are limited to previously developed, industrialized sites where oil wells and related infrastructure are currently or were historically located. Since the project does not propose extending into agricultural lands or altering existing farmland operations, no agricultural soils designated as Prime, Unique, or of Statewide Importance

would be converted to urban or non-farming uses. Therefore, there is no impact related to the conversion of important farmland.

b. Conflict with existing zoning for agricultural use, with a designated Agricultural Resource Area, or with a Williamson Act contract?

No Impact. The project would phase out oil production activities and remove associated infrastructure within unincorporated Los Angeles County. It does not involve new development that would convert or conflict with agricultural uses, nor does it introduce land uses incompatible with agricultural zoning, designated Agricultural Resource Areas (ARAs), or Williamson Act contracts.

The project does not propose converting farmland to non-agricultural uses or altering lands currently zoned for agriculture. Instead, it focuses on decommissioning oil wells and related equipment on sites already devoted to industrial energy production. As such, there is no encroachment into ARA lands or conversion of prime farmland, Farmland of Statewide Importance, Farmland of Local Importance, or Unique Farmland to other uses. The project's activities remain consistent with existing regulations and do not impede or interfere with agricultural operations.

The only remaining contracts under the Williamson Act in the County are located on Catalina Island and primarily serve as open space set-asides. Since the project does not affect these contract lands or other properties under the Williamson Act, there is no conflict with such agreements.

Given that the project neither alters agricultural zoning nor conflicts with ARAs or Williamson Act contracts, the impact related to agricultural land use designations and agreements is considered less than significant.

c. Conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code § 12220 (g)), timberland (as defined in Public Resources Code § 4526), or timberland zoned Timberland Production (as defined in Government Code § 51104(g))?

No Impact. The unincorporated areas of Los Angeles County do not include any zones designated solely for forest land, timberland, or timberland production as defined in Public Resources Code §§12220(g), 4526, and Government Code §51104(g). The project involves phasing out oil production activities and removing associated infrastructure from existing industrially used areas, without introducing new uses that would require rezoning to or from forest or timberland designations.

While the County does contain portions of National Forests, the project does not propose any activities within or adjacent to these federal forest lands that would necessitate rezoning or conflict with existing forest management objectives. Additionally, no timberland production zones (TPZ) exist in the unincorporated areas governed by the project's proposed regulations.

Since the project does not involve changes to forest- or timberland-related zoning, nor does it require the conversion, removal, or rezoning of such lands, there is no potential to conflict with existing zoning for forest or timberland uses. Therefore, the project has no impact regarding forest land and timberland zoning.

d. Result in the loss of forest land or conversion of forest land to non-forest use?

No Impact. The project involves decommissioning oil production infrastructure in unincorporated areas that are generally not characterized as forest land. The County does not have zoning designations strictly for forest land or timberland production in these project locations, and the sites in question are previously disturbed oil fields rather than forested tracts. Because no forested areas or timberland-zoned parcels would be affected by the project, there is no potential for converting forest land to non-forest use. As a result, no impact to forest resources would occur.

e. Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use or conversion of forest land to non-forest use?

No Impact. The project does not introduce new land uses, infrastructure, or policies that would indirectly pressure farmland or forest land to convert to another use. It does not entail expanding urban services, constructing roads into rural areas, or altering land use designations in ways that encourage development in areas currently used or zoned for farming or forestry. Instead, the project removes oil wells and industrial features from already disturbed sites, reducing rather than increasing the likelihood of encroaching into agricultural or forested regions. Therefore, there are no foreseeable indirect changes that would prompt farmland or forest land conversion, resulting in no impact.

III. Air Quality

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Where available, the significance criteria established by the applicable air quality management district or air pollution control district may be relied upon to make the following determinations. Would the project:				
a. **Conflict with or obstruct implementation of applicable air quality plans of either the South Coast AQMD (SCAQMD) or the Antelope Valley AQMD (AVAQMD)?**	☐	☐	☒	☐
b. **Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard?**	☐	☐	☒	☐
c. **Expose sensitive receptors to substantial pollutant concentrations?**	☐	☐	☒	☐
d. **Result in other emissions (such as those leading to odors) adversely affecting a substantial number of people?**	☐	☐	☒	☐

a. Conflict with or obstruct implementation of applicable air quality plans of either the South Coast AQMD (SCAQMD) or the Antelope Valley AQMD (AVAQMD)?

Less than Significant Impact. The project would eliminate oil production activities in unincorporated Los Angeles County, effectively reducing emissions associated with active wells and related infrastructure. Oil production operations typically release criteria pollutants (e.g., volatile organic compounds [VOCs], particulate matter [PM10 and PM2.5], and nitrogen oxides [NOx]) as well as methane, a potent greenhouse gas that also contributes to regional air quality concerns. The State of California, through agencies such as the California Air Resources Board (CARB) and the California Energy Commission, has identified methane leaks from active, idle, and abandoned oil wells as significant sources of emissions. By mandating that all California Geologic Energy M anagement Division (CalGEM) requirements be fulfilled related to the plugging and abandonment of a well, the project would help minimize or eliminate methane emissions from aging and improperly sealed wells. By phasing out and mitigating these sources of emissions, the project aligns with ongoing state research and mitigation priorities and directly supports the overall objectives of the South Coast Air Quality Management District (SCAQMD) and Antelope Valley Air Quality Management District (AVAQMD) to improve air quality and meet or maintain state and federal ambient air quality standards.

Both the SCAQMD and AVAQMD rely on Air Quality Management Plans (AQMPs) to guide strategies for reducing emissions and attaining clean air standards. By eliminating existing and future oil production activities, the project is expected to reduce pollutant loads and thus assist in achieving AQMP goals. In addition, the project is consistent with local and regional land use policies and does not introduce land uses that would increase vehicle miles traveled or population beyond what was envisioned in the General Plan. Therefore, it would not conflict with or obstruct the implementation

of the applicable AQMPs, which rely on consistency with adopted land use plans to project and manage emissions.

Temporary emissions may occur during well decommissioning, primarily from construction equipment. These short-term emissions would be subject to existing regulations and best management practices designed to minimize impacts and would be minimal relative to the long-term reduction in stationary source emissions achieved by the project. Consequently, the project would not conflict with or obstruct the implementation of the SCAQMD or AVAQMD air quality plans, and any temporary emissions during decommissioning would be less than significant.

b. Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard?

Less than Significant Impact. The project, which phases out oil production activities in unincorporated areas of Los Angeles County, would ultimately decrease stationary emissions of criteria pollutants. The region is currently non-attainment for several pollutants, including ozone (O3), particulate matter (PM10 and PM2.5), and nitrogen dioxide (NO2). Oil production operations typically emit volatile organic compounds (VOCs) and nitrogen oxides (NOx)—both ozone precursors—as well as particulate matter. By eliminating these sources, the project would support regional efforts to achieve and maintain compliance with federal and state air quality standards.

While short-term emissions may occur during the decommissioning and closure of wells, these activities would be temporary, localized, and comparatively minor in scale. Such emissions, including limited amounts of NOx and PM, would be subject to South Coast Air Quality Management District (SCAQMD) or Antelope Valley Air Quality Management District (AVAQMD) regulations, as well as best management practices designed to minimize construction-related air quality impacts. Compliance with these measures ensures that any temporary increases in pollutant emissions are effectively controlled and reduced.

Over the long term, the project removes a recognized source of ongoing emissions, thereby reducing the cumulative pollution burden in an area already designated as non-attainment. Because the project results in an overall net decrease in criteria pollutants over time, rather than a meaningful increase, it does not contribute to a cumulatively considerable net increase of non-attainment pollutants.

Therefore, considering both the temporary, controlled nature of decommissioning emissions and the permanent reduction in ongoing pollutant sources, the project's impact on cumulative non-attainment pollutants would be less than significant.

c. Expose sensitive receptors to substantial pollutant concentrations?

Less than Significant Impact. The project would phase out oil production activities in unincorporated Los Angeles County, reducing ongoing emissions of criteria pollutants and other contaminants associated with active wells. Sensitive receptors—such as schools, hospitals, residences, childcare facilities, and senior centers—are more vulnerable to adverse health effects from poor air quality. Currently, oil production operations can generate air pollutants, including volatile organic compounds (VOCs), nitrogen oxides (NOx), and particulate matter (PM10 and PM2.5), which may affect nearby sensitive receptors.

By permanently closing and removing oil production facilities, the project would diminish a source of localized emissions, thereby improving long-term air quality conditions for sensitive receptors in the area. Although short-term construction-related emissions may occur during the decommissioning phase, these temporary increases in pollutants would be limited in duration and spatial extent. Standard dust control measures, proper equipment maintenance, and compliance with South Coast Air Quality Management District (SCAQMD) or Antelope Valley Air Quality Management District (AVAQMD) regulations would minimize these effects. In addition, best management practices (BMPs) can be implemented to further reduce dust and diesel emissions during the removal of existing infrastructure.

No new long-term emission sources would be introduced, and the overall effect of the project would be to reduce, rather than increase, pollutant concentrations in areas where sensitive receptors may be present. Therefore, while there may be minimal, short-term construction-related impacts, they would not be substantial, and the project's long-term benefit of removing a stationary source of air pollution ensures that exposures to sensitive receptors would not be significantly affected. As a result, impacts related to exposing sensitive receptors to substantial pollutant concentrations would be less than significant.

d. Result in other emissions (such as those leading to odors) adversely affecting a substantial number of people?

Less than Significant Impact. Oil production activities commonly emit odorous compounds—such as volatile organic compounds (VOCs) and, in some cases, hydrogen sulfide (H_2S)—that can negatively affect nearby communities. By phasing out and removing oil wells and related infrastructure, the project would eliminate these long-term sources of nuisance odors. This reduction in odorous emissions would improve the quality of life in surrounding areas, particularly where sensitive receptors (e.g., residences, schools, or healthcare facilities) could be affected.

During the short-term decommissioning period, certain activities—such as operation of diesel-powered equipment or soil disturbance—could produce temporary odors. These odors, however, would be localized, transitory, and subject to existing regulations, including South Coast Air Quality Management District (SCAQMD) or Antelope Valley Air Quality Management District (AVAQMD) Rule 402, which prohibits emissions that cause nuisance odors affecting a substantial number of people. Compliance with applicable air quality regulations and best management practices would minimize and control any transient odor issues.

In the long run, the project would substantially reduce the presence of odorous emissions in areas currently affected by oil production activities. As a result, any short-term odors during decommissioning would be minimal, temporary, and managed through adherence to regulatory standards. Therefore, the project's impact related to other emissions, including odors, would be less than significant.

IV. Biological Resources

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Wildlife (CDFW) or U.S. Fish and Wildlife Service (USFWS)?	☐	☐	☒	☐
b. Have a substantial adverse effect on any sensitive natural communities (e.g., riparian habitat, coastal sage scrub, oak woodlands, non-jurisdictional wetlands) identified in local or regional plans, policies, regulations or by CDFW or USFWS?	☐	☐	☒	☐
c. Have a substantial adverse effect on state or federally protected wetlands (including, but not limited to, marshes, vernal pools, coastal wetlands, etc.) through direct removal, filling, hydrological interruption, or other means?	☐	☐	☒	☐
d. Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?	☐	☐	☒	☐
e. Convert oak woodlands (as defined by the state, oak woodlands are oak stands with greater than 10% canopy cover with oaks at least 5 inch in diameter measured at 4.5 feet above mean natural grade) or other unique native woodlands (juniper, Joshua, southern California black walnut, etc.)?	☐	☐	☒	☐
f. Conflict with any local policies or ordinances protecting biological resources, including Wildflower Reserve Areas (L.A. County Code, Title 12, Ch. 12.36), the Los Angeles County Oak Tree Ordinance (L.A. County Code, Title 22, Ch. 22.174), the Significant Ecological Areas (SEAs) (L.A. County Code, Title 22, Ch. 102), Specific Plans (L.A. County Code, Title 22, Ch. 22.46), Community Standards Districts (L.A. County Code, Title 22, Ch. 22.300 et seq.), and/or Coastal Resource Areas (L.A. County General Plan, Figure 9.3)?	☐	☐	☒	☐
g. Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved state, regional, or local habitat conservation plan?	☐	☐	☐	☒

a. Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Wildlife (CDFW) or U.S. Fish and Wildlife Service (USFWS)?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure in unincorporated areas of Los Angeles County. Many existing oil operations occur in areas already disturbed, where native habitats and the sensitive species that depend on them have been substantially altered or displaced. By eliminating a source of ongoing disturbance and pollution, the project is expected to improve ecological conditions over time.

As oil facilities are removed and sites are restored or converted to compatible uses, habitats can recover, allowing native vegetation and wildlife to return. Over the long term, this would create more favorable conditions for candidate, sensitive, or special status species recognized by the California Department of Fish and Wildlife (CDFW), U.S. Fish and Wildlife Service (USFWS), or other regulatory agencies. Restoration efforts and compliance with all applicable federal, state, and local environmental regulations—including the California Endangered Species Act (CESA), Federal Endangered Species Act (FESA), and any local Significant Ecological Area (SEA) protections—would ensure that sensitive species and their habitats are protected.

During short-term decommissioning and restoration activities, limited ground disturbance could occur. In instances where sensitive biological resources may be present, the project would implement standard measures such as pre-construction surveys, consultation with CDFW or USFWS, avoidance of active nests or burrows during critical breeding seasons, and adherence to best management practices. These steps would minimize potential impacts and help maintain compliance with protective regulations.

Overall, the project would not adversely affect sensitive species populations. Instead, it would likely result in long-term habitat quality improvements once oil operations cease and disturbed sites are restored. Consequently, potential impacts to candidate, sensitive, or special status species would be less than significant.

b. Have a substantial adverse effect on any sensitive natural communities (e.g., riparian habitat, coastal sage scrub, oak woodlands, non-jurisdictional wetlands) identified in local or regional plans, policies, regulations or by CDFW or USFWS?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure in unincorporated areas of Los Angeles County. Many existing oil production sites are in areas already disturbed by industrial activity, limiting the extent and quality of sensitive natural communities—such as riparian habitats, coastal sage scrub, oak woodlands, or non-jurisdictional wetlands—that may be present. By eliminating these industrial uses, the project can improve long-term ecological conditions and increase the potential for these sensitive communities to recover or reestablish.

While short-term decommissioning actions (e.g., equipment staging, limited grading) could temporarily affect adjacent habitat areas, these impacts would be localized and transitory. Prior to and during these activities, compliance with applicable regulations—including any requirements related to Significant Ecological Areas (SEAs) and other protected habitats—would minimize and avoid substantial effects on sensitive natural communities. Such regulations may include conducting

biological surveys, following best management practices to control erosion and dust, and scheduling work to avoid sensitive wildlife breeding periods.

Over time, as oil production infrastructure is removed and sites are restored or converted to more compatible uses, habitats can regenerate and potentially support a greater abundance and diversity of native species. By reducing barriers, contamination, and noise sources, the project is likely to benefit sensitive natural communities in the long run. Therefore, any short-term disturbance during decommissioning would be minimal and controlled, and the overall impact on sensitive natural communities would be less than significant.

c. Have a substantial adverse effect on state or federally protected wetlands (including, but not limited to, marshes, vernal pools, coastal wetlands, etc.) through direct removal, filling, hydrological interruption, or other means?

Less than Significant Impact. The project would phase out oil production activities in unincorporated areas of Los Angeles County, generally reducing disturbance in areas that may currently be occupied by oil production infrastructure. While these facilities are often located in already disturbed or developed areas, if any state or federally protected wetlands (such as marshes, vernal pools, or coastal wetlands) are present on or near affected sites, they would receive indirect benefits over the long term due to the cessation of industrial activities.

In the near term, decommissioning activities—such as equipment operation or limited grading—could potentially cause minor, localized effects on nearby wetland areas if not properly managed. However, these impacts would be temporary and subject to existing regulatory requirements and best management practices (BMPs) designed to protect wetland resources. Project activities would be required to comply with all applicable federal, state, and local regulations, including those administered by the U.S. Army Corps of Engineers (Clean Water Act Section 404), the California Department of Fish and Wildlife (California Fish and Game Code Sections 1600–1616), and the Regional Water Quality Control Board (Porter-Cologne Water Quality Control Act).

These regulations and permitting requirements ensure that any work occurring near wetlands would be carefully evaluated and, if necessary, mitigated to avoid or minimize adverse impacts. Moreover, without ongoing oil production, the likelihood of long-term hydrological disruptions or contaminant inputs to wetland areas would be reduced. Although the project does not directly mandate restoration of these areas, removing oil operations could facilitate the transition of sites toward more compatible land uses that are less harmful to nearby wetland habitats.

As a result, any short-term effects on wetlands would be adequately controlled, and no substantial adverse impacts are anticipated. Therefore, the project's impact on state or federally protected wetlands would be less than significant.

d. Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?

Less than Significant Impact. Phasing out oil production activities and removing associated infrastructure in unincorporated Los Angeles County would generally reduce barriers to wildlife movement and improve connectivity over time. Oil production operations can fragment habitats, introduce noise and light, and impede wildlife corridors, including the movement of resident and

migratory species, as well as the use of nursery sites. By eliminating these industrial impacts, the project is expected to support habitat conditions more conducive to wildlife movement and breeding.

In the short term, decommissioning activities—such as equipment use, grading, and staging—may temporarily disturb local wildlife movement. These effects would be limited in duration and scope, and would be managed in compliance with federal, state, and local regulations protecting native species. For example, the Migratory Bird Treaty Act and California Fish and Game Code protect active nests and breeding birds from harm or disturbance. Best management practices, including pre-construction surveys and seasonal avoidance measures, can be implemented to prevent impacts to active nests, nursery sites, or established wildlife corridors during decommissioning.

Over the long run, phasing out oil operations can facilitate land uses that are less disruptive to wildlife. While the project does not directly mandate habitat restoration, the cessation of ongoing industrial activities inherently reduces disturbance. This reduction in noise, lighting, and physical barriers would likely enhance habitat connectivity, supporting wildlife corridors and facilitating the safe and unobstructed movement of native and migratory species. As a result, any temporary impacts during the decommissioning phase would be minimal and less than significant.

e. Convert oak woodlands (as defined by the state, oak woodlands are oak stands with greater than 10% canopy cover with oaks at least 5 inch in diameter measured at 4.5 feet above mean natural grade) or other unique native woodlands (juniper, Joshua, southern California black walnut, etc.)?

Less than Significant Impact. The project would phase out oil production activities, reducing ongoing disturbances associated with these operations. Oil production sites are often established in previously disturbed areas where oak woodlands or other unique native woodlands have been largely cleared or degraded. As a result, the likelihood of the project directly removing or converting intact oak woodlands or other unique native woodlands (e.g., juniper, Joshua, southern California black walnut) is low.

While the project itself does not mandate restoration, eliminating oil operations may reduce barriers and pressures on nearby natural communities. Any future uses of these sites would still be subject to existing local and state regulations designed to protect native woodlands, including oak trees. Should oak trees or native woodlands be present, compliance with relevant ordinances (such as the Oak Tree Permit Ordinance) and consultation with County biologists would ensure that avoidance, minimization, or mitigation measures are employed as needed. This would prevent significant impacts to oak woodlands or other native woodlands.

Therefore, any potential impacts related to converting oak woodlands or other unique native woodlands would be less than significant.

f. Conflict with any local policies or ordinances protecting biological resources, including Wildflower Reserve Areas (L.A. County Code, Title 12, Ch. 12.36), the Los Angeles County Oak Tree Ordinance (L.A. County Code, Title 22, Ch. 22.174), the Significant Ecological Areas (SEAs) (L.A. County Code, Title 22, Ch. 102), Specific Plans (L.A. County Code, Title 22, Ch. 22.46), Community Standards Districts (L.A. County Code, Title 22, Ch. 22.300 et seq.), and/or Coastal Resource Areas (L.A. County General Plan, Figure 9.3)?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure in unincorporated Los Angeles County, thereby reducing industrial

disturbances that can affect local biological resources. While the project itself does not mandate restoration, the cessation of oil operations creates conditions more favorable to uses that are compatible with local policies and ordinances designed to protect biological resources.

- Wildflower Reserve Areas (Title 12, Ch. 12.36): The project is not expected to affect these designated areas, as oil facilities are generally not located within them. By removing oil operations, adjacent natural landscapes can be maintained or improved, supporting the integrity of wildflower areas.
- Oak Tree Permit Ordinance (Title 22, Ch. 22.174): Should any oak trees or oak woodlands be present on or adjacent to former oil production sites, future site activities would be subject to the Oak Tree Ordinance, including any required permits, mitigation, and best management practices. Compliance with these requirements ensures no substantial conflict with oak tree protections.
- Significant Ecological Areas (SEAs) (Title 22, Ch. 102): Eliminating oil production can reduce habitat fragmentation and improve ecological integrity within or near SEAs. Any future use of these sites would need to comply with SEA regulations, ensuring that sensitive habitats and species are protected.
- Specific plans and community standards districts (CSDs) (Title 22, Divisions 10 and 11): The project is consistent with relevant specific plans and CSD requirements, including those that regulate oil production. By ending such activities, the project aligns with long-term planning goals that often emphasize environmental protection.

Decommissioning activities may produce short-term, localized effects, but these would be managed under existing regulations and permit requirements to avoid conflicts with local environmental protections. Overall, the project supports rather than conflicts with local policies and ordinances aimed at conserving biological resources. Any temporary impacts would be less than significant, as ongoing compliance with existing regulations ensures effective protection of sensitive habitats and species.

g. Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved state, regional, or local habitat conservation plan?

No Impact. The project would phase out oil production activities in unincorporated Los Angeles County, potentially reducing disturbances that could conflict with habitat conservation efforts. Currently, there are several habitat conservation and natural community conservation plans at the state, regional, and local levels, as well as other conservation initiatives (such as the County's SEAs Program) that aim to maintain and restore ecological integrity within the County.

By discontinuing oil production, the project would lessen industrial impacts, such as noise, habitat fragmentation, and potential contamination, thereby aligning more closely with the goals and provisions of these conservation plans. Even though the project does not mandate restoration, transitioning away from oil production allows for future land uses that are more compatible with habitat conservation objectives. Any site-specific changes would continue to be subject to applicable laws, permits, and ordinances that protect biological resources. Should any Habitat Conservation Plan (HCP), Natural Community Conservation Plan (NCCP), or similar conservation framework apply, project-related activities would need to comply with all related requirements, including consultation with the appropriate regulatory agencies if necessary.

In the short term, limited construction-related activities associated with decommissioning may occur, but these would be regulated by existing environmental protections and best management

practices to minimize any potential adverse effects. In the long term, the reduction of industrial activities supports the conservation objectives of these plans rather than conflicts with them.

Therefore, the project would not conflict with adopted HCPs, NCCPs, or other approved habitat conservation strategies, and impacts would be less than significant.

V. Cultural Resources

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. **Cause a substantial adverse change in the significance of a historical resource pursuant to CEQA Guidelines § 15064.5?**	☐	☐	☒	☐
b. **Cause a substantial adverse change in the significance of an archaeological resource pursuant to CEQA Guidelines § 15064.5?**	☐	☐	☒	☐
c. **Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?**	☐	☐	☒	☐
d. **Disturb any human remains, including those interred outside of dedicated cemeteries?**	☐	☐	☒	☐

a. Cause a substantial adverse change in the significance of a historical resource pursuant to CEQA Guidelines § 15064.5?

Less than Significant Impact. The project would phase out oil production activities without proposing physical alterations or removal of historical resources in unincorporated Los Angeles County. Most affected areas are previously disturbed sites, limiting historical features. However, two notable exceptions require consideration.

Within the Baldwin Hills area, the Cone Trust House is recognized as a potentially significant historic architectural resource. The Baldwin Hills Community Standards District (CSD) includes measures to protect the structure's historic integrity from adjacent oil operations. These protections would remain under the project, ensuring no substantial adverse change to the Cone Trust House.

Another key site is Well No. 4 in the Pico Canyon Oil Field, located approximately seven miles west of Newhall, California, within the Santa Susana Mountains. Drilled in 1876, this well became California's first commercially successful oil well, spurring the growth of the state's petroleum industry. Well No. 4 is designated as a National Historic Landmark (NHL), listed on the National Register of Historic Places (NRHP), and designated as a California Historical Landmark (CHL), recognizing its cultural and industrial significance. The project prohibits new wells and phases out existing ones without requiring the demolition, relocation, or physical alteration of Well No. 4 or its contributing historical features.

Any future actions affecting Well No. 4, such as permanent modifications to structures contributing to its historical character, would be subject to review under federal and state preservation laws. Section 106 of the National Historic Preservation Act (NHPA) requires a review when a federal agency funds, permits, licenses, or approves an action that could affect historic properties. This review process involves identifying historic resources, assessing potential impacts, and consulting with stakeholders to resolve adverse effects, ensuring Well No. 4's historical integrity remains intact. At the state level, the California Environmental Quality Act (CEQA) requires agencies to evaluate and mitigate significant environmental impacts, including those affecting historical resources. Any action involving modifications to Well No. 4 would require separate environmental review under

CEQA to assess potential impacts on its historical significance. Since Well No. 4 was plugged and abandoned in September 1990 after 114 years of operation, this project itself would not require any further modifications to the site.

Outside of these two identified resources, the project affects highly disturbed oil-related sites that do not appear to host intact historic structures or features. If any such sites contain a previously unidentified historical resource, CEQA Guidelines Section 15064.5 requires evaluation and mitigation to prevent harm to the resource's integrity. Because the project aims to phase out oil extraction operations without authorizing new development or encouraging major construction, it would not result in physical alterations to potential historic buildings or districts.

The project does not facilitate direct changes to recognized historic resources, and any future actions requiring physical modifications at Well No. 4 or the Cone Trust House would be subject to separate evaluation and regulatory oversight. As a result, the project would not cause a substantial adverse change to a known historical resource, and any impact related to historical resources under CEQA is considered less than significant.

b. Cause a substantial adverse change in the significance of an archaeological resource pursuant to CEQA Guidelines § 15064.5?

Less than Significant Impact. The project would eliminate oil production activities in unincorporated Los Angeles County, focusing on areas already disturbed by industrial operations. Such sites are generally considered to have a lower likelihood of containing intact archaeological resources due to previous ground disturbance.

Where applicable, existing regulations and requirements—such as those established by the Baldwin Hills Community Standards District (CSD)—provide protection for archaeological resources. For example, within the Baldwin Hills Oil Field, construction personnel must receive archaeological training, ensuring that potential discoveries are handled appropriately. If previously unidentified archaeological materials are encountered during ground-disturbing activities, work would be halted in the immediate area until a qualified archaeologist, approved by the Department of Regional Planning, evaluates the find and recommends any necessary treatment or mitigation measures.

In addition, if any portion of the project site is located in an area with a known potential for archaeological resources, standard best management practices and compliance with General Plan mitigation measures (such as consulting the South Central Coastal Information Center and adhering to applicable CEQA guidelines) would be followed. These measures ensure that any significant archaeological materials are identified, evaluated, and protected as required by law.

Because the project does not involve new development in previously undisturbed areas, and due to the regulatory framework and requirements in place, the potential for a substantial adverse change in the significance of an archaeological resource is minimal. Therefore, impacts would be less than significant.

c. Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?

Less than Significant Impact. The project would phase out oil production activities in unincorporated areas of Los Angeles County, affecting sites that have largely been subject to past ground disturbance. Such disturbed industrial landscapes present a low likelihood of containing

intact paleontological resources or unique geologic features. Consequently, it is unlikely that discontinuing oil production and removing associated infrastructure would directly or indirectly destroy these types of resources.

If future site activities involve ground disturbance, standard procedures and best management practices would apply. For example, if a project component were to involve grading more than six feet in depth, compliance with General Plan Mitigation Monitoring and Reporting Program (MMRP) measures, such as CULT-5, may require a qualified paleontologist to monitor grading and excavation activities. Additionally, if there is any indication that paleontological resources could be present, the applicant would be advised to consult with the Natural History Museum of Los Angeles County (NHM) to determine the potential for such resources. If any fossils or unique geologic features are unexpectedly discovered during project activities, work would be halted until a qualified paleontologist has evaluated the find and implemented appropriate treatment or mitigation measures.

Overall, because the project affects previously disturbed sites and includes provisions for compliance with relevant regulations and procedures, it would not result in a substantial adverse effect on paleontological resources or unique geologic features. Therefore, the impact would be less than significant.

d. Disturb any human remains, including those interred outside of dedicated cemeteries?

Less than Significant Impact. The project would phase out oil production activities in areas that have largely been disturbed by previous industrial use, making the discovery of human remains on-site unlikely. If any ground-disturbing activities occur during decommissioning, standard procedures are in place should human remains be unexpectedly encountered. In accordance with California Health and Safety Code § 7050.5, work in the vicinity of the find would stop immediately, and the County Coroner would be notified. If the Coroner determines the remains are Native American, the Native American Heritage Commission would be contacted, and consultation with the most likely descendant would guide the appropriate treatment of the remains, as required by Public Resources Code § 5097.98.

Because the project area consists of previously disturbed industrial sites and due to the regulatory protocols that must be followed if human remains are encountered, the potential for significant impacts is very low. Any impact related to disturbing human remains would be less than significant.

VI. Energy

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. **Result in potentially significant environmental impact due to wasteful, inefficient, or unnecessary consumption of energy resources, during project construction or operation?**	☐	☐	☒	☐
b. **Conflict with or obstruct a state or local plan for renewable energy or energy efficiency?**	☐	☐	☒	☐

a. Result in potentially significant environmental impact due to wasteful, inefficient, or unnecessary consumption of energy resources, during project construction or operation?

Less than Significant Impact. The project would phase out oil production activities in unincorporated Los Angeles County, thereby reducing long-term energy demands associated with drilling, pumping, and processing. While short-term construction-related energy use would occur during the decommissioning of oil wells and associated infrastructure, these activities would be limited in duration and scope. The temporary use of fuel and electricity during this phase would be typical of standard construction practices and not considered wasteful or inefficient.

Moreover, no new energy-intensive operations are proposed as part of the project. Once oil production ceases, the eliminated industrial activities would substantially decrease on-site energy consumption, aligning with local and state objectives to reduce reliance on nonrenewable energy sources. Any subsequent land uses would remain subject to applicable energy efficiency requirements, such as those in the California Green Building Standards Code (CALGreen) and Los Angeles County's Green Building Standards (Title 31), further ensuring energy conservation in future development scenarios.

Given that decommissioning activities represent a temporary and necessary energy use and considering the long-term reduction in energy demand resulting from the cessation of oil production, the project would not lead to wasteful, inefficient, or unnecessary consumption of energy resources. Therefore, impacts would be less than significant.

b. Conflict with or obstruct a state or local plan for renewable energy or energy efficiency?

Less than Significant Impact. The project would phase out oil production activities in unincorporated Los Angeles County, thereby reducing energy consumption tied to fossil fuel production and supporting the state's and County's overarching goals for energy efficiency and renewable energy development. By eliminating oil pumping and processing operations, the project inherently aligns with California's Renewable Portfolio Standard (RPS) and Senate Bill 100, which seek to transition the state's electricity supply to 100% renewable energy by 2045. The project supports the Los Angeles County Climate Action Plan objectives to reduce greenhouse gas emissions and transition to sustainable land uses. By phasing out oil operations, the project helps achieve the County's energy and sustainability targets.

In addition, any subsequent activities on the project sites would be subject to existing energy efficiency standards set forth by Title 24 of the California Code of Regulations and Los Angeles County Green Building Standards Code. These requirements ensure that future developments or uses of the property maintain high standards of energy efficiency, further advancing state and local energy conservation objectives.

Because the project would not introduce any new energy-intensive operations and would remove existing fossil fuel extraction activities, it would not conflict with or obstruct state or local renewable energy or energy efficiency plans. Instead, it supports the broader transition toward sustainable energy use, resulting in a less than significant impact.

VII. Geology and Soils

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. Directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving:				
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.	☐	☐	☒	☐
ii) Strong seismic ground shaking?	☐	☐	☒	☐
iii) Seismic-related ground failure, including liquefaction?	☐	☐	☒	☐
iv) Landslides?	☐	☐	☒	☐
b. Result in substantial soil erosion or the loss of topsoil?	☐	☐	☒	☐
c. Be located on a geologic unit that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse?	☐	☐	☒	☐
d. Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial direct or indirect risks to life or property?	☐	☐	☒	☐
e. Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater?	☐	☐	☐	☒
f. Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	☐	☐	☒	☐
g. Conflict with the Hillside Management Area Ordinance (L.A. County Code, Title 22, Ch.22.104)?	☐	☐	☐	☒

a. (i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map or known fault?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure in unincorporated areas of Los Angeles County. While the region is seismically active and includes numerous known faults (such as the Newport-Inglewood Fault Zone, among others), the project does not involve the construction of new habitable structures that could be subject to fault rupture hazards. Instead, it reduces the number of operational oil facilities that might otherwise be at risk.

In areas subject to the Alquist-Priolo Earthquake Fault Zoning Act, new structures for human occupancy are prohibited from being placed directly on active fault traces. Because the project does not authorize new construction for human occupancy, it avoids increasing exposure to fault rupture hazards. Any decommissioning activities (e.g., plugging wells, removing equipment) would be temporary, localized, and would comply with all applicable safety regulations and standard engineering practices. If any future site redevelopment occurs after oil operations cease, it would be subject to existing seismic safety regulations—including fault rupture avoidance measures—as required by the California Building Code and County ordinances.

By removing industrial infrastructure rather than adding new structures, the project effectively reduces the overall level of seismic risk on affected sites. Adherence to existing regulatory frameworks and best management practices ensures that the project does not expose people or new structures to significant fault rupture hazards. Therefore, impacts related to the rupture of a known earthquake fault would be less than significant.

(ii) Strong seismic ground shaking?

Less than Significant Impact. The project would phase out oil production activities and remove related infrastructure in unincorporated Los Angeles County. While the region is seismically active and could experience strong ground shaking during an earthquake, the project does not involve constructing new habitable buildings or increasing the number of people exposed to seismic hazards. Instead, it focuses on plugging and abandoning oil wells and removing industrial equipment associated with oil production.

Any decommissioning activities would be short-term, localized, and conducted under standard safety protocols. Because no new permanent structures for human occupancy would be added, the project does not increase exposure to strong seismic ground shaking. If future redevelopment occurs on these sites, such projects would be subject to the latest California Building Code and County regulations governing seismic design, ensuring that any new development is adequately designed to resist ground shaking.

By reducing industrial infrastructure rather than adding new sensitive uses, the project does not introduce new risks associated with strong seismic ground shaking. Therefore, impacts related to this hazard would be less than significant.

(iii) Seismic-related ground failure, including liquefaction?

Less than Significant Impact. Some areas in unincorporated Los Angeles County are identified as liquefaction zones, where water-saturated, loose soils could lose strength during intense seismic activity. While portions of the project area may be prone to liquefaction, the project does not involve constructing new buildings or otherwise placing additional people or sensitive structures at risk. Instead, it would phase out and remove existing oil production infrastructure, activities which are limited in duration, occur primarily on already-disturbed sites, and do not substantially alter subsurface conditions.

Temporary ground-disturbing activities associated with decommissioning (e.g., removal of wells and equipment per all California Geologic Energy Management Division (CalGEM) requirements for plugging and abandonment) would be conducted in compliance with applicable seismic safety regulations and standard engineering practices. If site-specific conditions warrant, all project

activities would follow existing state and local requirements for addressing liquefaction risks, such as conducting geotechnical investigations prior to any substantial ground disturbance and implementing recommended stabilization or compaction measures.

Because the project does not introduce new habitable structures or long-term uses that could be adversely affected by liquefaction, and since any temporary work would comply with established safety protocols, the potential impact related to seismic-induced ground failure, including liquefaction, would be less than significant.

(iv) Landslides?

Less than Significant Impact. Some areas of unincorporated Los Angeles County, including portions of the Baldwin Hills, contain steep slopes or unstable terrain that may be subject to landslides, particularly during significant seismic events or heavy rainfall. However, the project does not involve constructing new buildings or conducting extensive grading that could destabilize slopes or increase landslide risk.

Instead, the project focuses on phasing out and removing existing oil production infrastructure. Ground-disturbing activities associated with well plugging, equipment removal, or minor grading for site restoration would be limited in scope and duration and would occur on sites previously disturbed by industrial operations. Compliance with standard construction practices, erosion control measures, and applicable California Building Code requirements would ensure that any temporary soil disturbance does not exacerbate landslide conditions. If necessary, site-specific evaluations and recommended stabilization measures would be implemented before and during decommissioning.

In the long term, removing oil production facilities may reduce the number of structures potentially affected by landslides and allow for restoration activities that improve slope stability (e.g., proper grading, revegetation). Because the project does not introduce new habitable structures or uses that would increase exposure to landslide hazards, and because all activities would adhere to existing regulations and best management practices, impacts related to landslides would be less than significant.

b. Result in substantial soil erosion or the loss of topsoil?

Less than Significant Impact. The project would phase out oil production activities and remove existing industrial infrastructure in unincorporated Los Angeles County. While limited ground-disturbing activities—such as grading, excavation, and equipment removal—may temporarily increase the potential for soil erosion, these activities would be short-term, localized, and occur primarily within previously disturbed, compacted industrial sites. Consequently, the likelihood of substantial topsoil loss is reduced.

To ensure protection against erosion, decommissioning activities must comply with applicable regulations and standard industry practices. For instance, if ground-disturbing activities exceed one acre, the project would need a Stormwater Pollution Prevention Plan (SWPPP) as part of the National Pollutant Discharge Elimination System (NPDES) General Construction Permit. Such a plan typically includes best management practices (BMPs) like silt fencing, fiber rolls, or stabilized construction entrances to minimize sediment runoff. Additionally, the Los Angeles County Grading Code and the County's Low Impact Development (LID) Ordinance provide guidelines and requirements that limit soil erosion and manage stormwater runoff effectively.

Following decommissioning, any subsequent site restoration or conversion—such as regrading, revegetation, or properly engineered construction—would help stabilize soils, reduce erosion potential, and prevent long-term topsoil loss. Because the project involves only temporary ground disturbance and must adhere to existing regulatory requirements designed to prevent erosion, impacts related to soil erosion or loss of topsoil would be less than significant.

c. Be located on a geologic unit that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure in areas already characterized by industrial disturbances. These sites have typically undergone previous grading, compaction, and other alterations to the natural soil profile. Since the project does not involve the construction of new, habitable structures or major grading that could create large new slopes or significantly alter the subsurface conditions, it is not expected to induce instability in underlying geologic units.

Some portions of unincorporated Los Angeles County may contain soils prone to subsidence, liquefaction, or lateral spreading, particularly those in proximity to historic oil extraction sites. However, by ending extraction activities, the project would help reduce future risks of subsidence associated with ongoing resource removal. Any temporary ground disturbance related to the plugging of wells or removal of infrastructure would be limited in scope and duration, and would comply with relevant building codes, seismic safety requirements, and grading regulations. Where necessary, site-specific investigations and engineering measures would be implemented to ensure that no significant instability is introduced. Over time, as oil operations cease, regrading and potential revegetation would help stabilize soils and slopes, improving long-term geotechnical conditions.

Because the project does not create new instability risks and instead reduces activities that can contribute to subsidence or soil weakening, the potential for on- or off-site landslides, lateral spreading, subsidence, liquefaction, or collapse would be less than significant.

d. Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial direct or indirect risks to life or property?

Less than Significant Impact. Some areas within unincorporated Los Angeles County may contain expansive soils, which swell or shrink with changes in moisture content. Such soils can pose a risk to structures if not properly managed. However, the project involves the phased cessation of oil production activities and the removal of existing industrial infrastructure—actions that generally reduce long-term structural risks rather than increase them. The project does not propose new habitable structures that would be susceptible to damage from expansive soils.

Any ground-disturbing activities associated with well plugging, equipment removal, or minor grading would be short-term and localized. Standard industry practices and compliance with the California Building Code and County grading ordinances would address potential soil stability issues, including those posed by expansive soils. If future uses are proposed on these sites, they would be subject to site-specific geotechnical evaluations and compliance with applicable engineering standards to ensure that soil conditions, including expansion potential, do not create substantial risks to life or property.

As a result, the project's activities would not lead to significant hazards associated with expansive soils. Any impact would be less than significant.

e. Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater?

No Impact. The project would phase out oil production activities in unincorporated Los Angeles County and does not involve new development or operations requiring on-site wastewater treatment systems such as septic tanks or alternative disposal methods. Therefore, the suitability of soils for supporting such systems is not a concern under this project.

If any limited, temporary wastewater needs arise during decommissioning (e.g., portable restrooms for workers), these would be managed through permitted and regulated services that do not rely on permanent on-site disposal systems. No new septic systems or alternative wastewater disposal facilities are proposed.

Since the project does not depend on soils for wastewater disposal, no impacts related to soils incapable of supporting septic tanks or similar systems would occur.

f. Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure at previously disturbed, industrialized sites in unincorporated Los Angeles County. Due to the long history of ground disturbance in these areas, the likelihood of encountering previously undisturbed paleontological resources or unique geologic features is low.

If any ground-disturbing activities occur, such as limited grading or excavation, they would be short-term and confined to already modified soils. Should previously unknown fossils or unique geological formations be encountered during decommissioning, standard procedures would be followed, including temporarily halting work in the immediate vicinity and consulting with a qualified paleontologist or geologist to evaluate the find and recommend appropriate treatment. Compliance with applicable local and state regulations ensures that such discoveries would be handled with care and properly documented, reducing any potential impact to a less than significant level.

Because the project would not introduce new large-scale development or require extensive grading in undisturbed areas, and due to compliance with established regulations and protocols, the potential for directly or indirectly destroying unique paleontological resources or unique geologic features is less than significant.

g. Conflict with the Hillside Management Area Ordinance (L.A. County Code, Title 22, Ch.22.104)?

No Impact. The project, which phases out oil production activities in unincorporated Los Angeles County, aligns with the objectives of the Hillside Management Area (HMA) Ordinance and is not expected to conflict with its provisions. The HMA Ordinance is designed to preserve the physical integrity, scenic value, and open space of hillside areas while ensuring development is compatible with community character.

Phasing out oil production activities supports the goals of the HMA Ordinance by reducing industrial impacts on hillside areas and improving scenic and environmental values. Restoration or conversion activities, such as regrading and revegetation, may help stabilize soils, reduce erosion, and enhance the natural landscape, further aligning with the ordinance's open space preservation goals.

The project does not propose new construction, grading-intensive activities, or development that would trigger the Conditional Use Permit (CUP) requirements under the HMA Ordinance. This avoids conflicts related to building placement, hillside grading, or scenic view disruption. Grading activities required for the removal of oil wells and associated facilities will adhere to all local regulations to minimize impacts. These activities are temporary and aim to restore, rather than alter, natural landforms. The project does not propose large-scale grading or landform changes that would affect the scenic or physical integrity of HMAs. The removal of oil wells and production facilities aligns with the HMA Ordinance's requirement to enhance the aesthetic value of hillside areas.

Per Section 22.104.030(H), development related to oil and gas production in the Baldwin Hills Community Standards District (CSD) is exempt from the HMA Ordinance CUP requirement, provided compliance with the provisions of the CSD.

The project supports the objectives of the Hillside Management Area Ordinance by phasing out industrial activities, restoring natural landscapes, and preserving scenic and physical hillside integrity. Temporary impacts during decommissioning are limited and managed in compliance with applicable regulations. Therefore, the project does not conflict with the provisions of the ordinance, and impacts are less than significant.

VIII. Greenhouse Gas Emissions

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. **Generate greenhouse gas (GHGs) emissions, either directly or indirectly, that may have a significant impact on the environment?**	☐	☐	☒	☐
b. **Conflict with any applicable plan, policy, or regulation adopted for the purpose of reducing the emissions of greenhouse gases?**	☐	☐	☒	☐

a. Generate greenhouse gas (GHGs) emissions, either directly or indirectly, that may have a significant impact on the environment?

Less than Significant Impact. The project, which phases out oil production activities in unincorporated Los Angeles County, is not expected to result in significant greenhouse gas (GHG) emissions. While temporary GHG emissions will be generated during decommissioning activities, the project's long-term benefits include the elimination of operational GHG emissions from oil production, aligning with state and local GHG reduction goals.

While the phase-out of local oil production could result in increased reliance on imported oil in the short term, potentially increasing GHG emissions from transport and production, the project supports long-term climate goals by reducing regional emissions and fostering a transition away from fossil fuels. The extent to which reliance on imported oil might increase, and the duration of any resulting GHG increase, is uncertain and dependent on factors like market dynamics, energy policies, and shifts in demand for oil. The project itself does not directly cause an increase in oil imports—it contributes to transitioning away from fossil fuel dependence.

Decommissioning activities will involve the use of heavy machinery, equipment, and vehicles, which emit GHGs such as carbon dioxide (CO_2) and nitrous oxide (N_2O) through fuel combustion. Transportation of materials, equipment, and waste to and from project sites will also contribute to temporary emissions. These emissions are limited to the duration of decommissioning activities, which are temporary and localized.

Oil production activities produce significant GHG emissions from processes such as pumping, refining, and transporting oil. Methane, a potent greenhouse gas, is also released during extraction. By phasing out oil production, the project eliminates these operational sources of emissions, providing a substantial and lasting reduction in the region's GHG footprint. Proper decommissioning of oil wells will seal and close wells, reducing the risk of methane leaks from abandoned or improperly managed wells, which are a significant source of GHG emissions.

The project supports California's GHG reduction targets outlined in Assembly Bill (AB) 32, Senate Bill (SB) 32, and Executive Order B-55-18, which aim to reduce emissions and achieve carbon neutrality by 2045. The project aligns with the County's Climate Action Plan (CAP) by contributing to reduced fossil fuel use, lowering emissions, and supporting transitions to more sustainable land uses. Given the temporary nature of decommissioning activities and the long-term cessation of oil

operations, GHG emissions generated by the project are expected to remain below the relevant thresholds (South Coast and Antelope Valley Air Quality Monitoring Districts).

While the project will generate temporary GHG emissions during decommissioning, these emissions are not significant when compared to the long-term reductions achieved by eliminating oil production operations. The project aligns with state and local climate action goals and does not generate GHG emissions at a level that would significantly impact the environment. Therefore, impacts are less than significant.

b. Conflict with any applicable plan, policy, or regulation adopted for the purpose of reducing the emissions of greenhouse gases?

Less than Significant Impact. The project would phase out oil production activities in unincorporated Los Angeles County. Although decommissioning efforts will temporarily generate greenhouse gas (GHG) emissions from construction equipment, trucks, and associated activities, these emissions would be short-term and limited in scope. No new operational sources of GHGs would be introduced once oil production ceases.

In the long term, ending oil production reduces a significant source of regional GHG emissions. Oil production processes release substantial amounts of carbon dioxide (CO_2) and methane (CH_4), both potent greenhouse gases. By decommissioning wells, sealing them properly, and removing facilities that support fossil fuel production, the project directly contributes to reducing these emissions. Over time, this aligns with California's overarching GHG reduction goals as set forth in Assembly Bill 32, Senate Bill 32, and Executive Orders aimed at carbon neutrality. It also supports the transition away from fossil fuels, consistent with the General Plan and 2045 Climate Action Plan (2045 CAP).

The 2045 CAP guides the County's approach to decreasing GHG emissions through various strategies and is part of the Air Quality Element of the General Plan. The project's elimination of a GHG-intensive industrial activity (oil production) is consistent with the County's climate policies, which encourage reducing reliance on fossil fuels and lowering overall GHG emissions. Additionally, because the project does not involve adding new GHG-generating uses and is consistent with the General Plan's designated land use and density, it may rely on the existing framework and analysis provided in the 2045 CAP. Thus, a separate, project-level GHG emissions analysis is not required under CEQA Guidelines Section 15183.5.

In summary, while minor, temporary GHG emissions would occur during decommissioning, the project facilitates long-term GHG reductions by permanently removing oil production operations. Therefore, any GHG emissions impact would be less than significant.

IX. Hazards and Hazardous Materials

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. Create a significant hazard to the public or the environment through the routine transport, storage, production, use, or disposal of hazardous materials?	☐	☐	☒	☐
b. Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials or waste into the environment?	☐	☐	☒	☐
c. Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of sensitive land uses?	☐	☐	☒	☐
d. Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code § 65962.5 and, as a result, would it create a significant hazard to the public or the environment?	☐	☐	☒	☐
e. For a project located within an airport land use plan, or where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard or excessive noise for people residing or working in the project area?	☐	☐	☒	☐
f. Impair implementation of, or physically interfere with, an adopted emergency response plan or emergency evacuation plan?	☐	☐	☒	☐
g. Expose people or structures, either directly or indirectly, to a significant risk of loss, injury or death involving fires, because the project is located:				
i) within a high fire hazard area with inadequate access?	☐	☐	☒	☐
ii) within an area with inadequate water and pressure to meet fire flow standards?	☐	☐	☒	☐
iii) within proximity to land uses that have the potential for dangerous fire hazard?	☐	☐	☒	☐
h. Does the proposed use constitute a potentially dangerous fire hazard?	☐	☐	☒	☐

a. Create a significant hazard to the public or the environment through the routine transport, storage, production, use, or disposal of hazardous materials?

Less than Significant Impact. The project would phase out oil production activities at previously industrialized sites in unincorporated Los Angeles County. Decommissioning oil wells and related

facilities may involve handling hazardous substances commonly associated with oil production, including residual hydrocarbons, drilling fluids, and possibly Naturally Occurring Radioactive Materials (NORM) on equipment. However, these activities would be temporary and subject to stringent regulatory controls.

All hazardous materials handling, storage, and transport would be conducted in accordance with state and federal regulations administered by agencies such as the Department of Toxic Substances Control (DTSC) and the Los Angeles County Fire Department's Health Hazardous Materials Division. Compliance with the Resource Conservation and Recovery Act (RCRA), the California Hazardous Waste Control Law, and other applicable regulations ensure that hazardous materials are properly identified, packaged, documented, and transported to permitted disposal or treatment facilities by licensed hazardous waste haulers. The project's integrated Site Maintenance requirements and Well Plugging and Abandonment standards ensure that any stored or transported hazardous materials are promptly cleaned up or removed, eliminating their long-term presence on-site. These regulations, combined with the project's new Bonds requirement, provide an additional layer of assurance that site remediation and proper waste disposal will be funded if an operator fails to act.

If any contaminated soil or materials are encountered, they would be handled following established protocols, including proper containment and disposal at approved facilities, to prevent releases that could harm the public or the environment. Given the oversight, best management practices, and emergency response plans in place, routine transport, use, and disposal of hazardous materials during decommissioning would not create a significant hazard.

No new long-term operations involving hazardous materials are proposed. Eliminating oil production activities would ultimately reduce the quantity of hazardous materials managed on-site over the long run. Therefore, any impacts related to hazardous materials handling and disposal during the project's limited decommissioning phase would be less than significant.

b. Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials or waste into the environment?

Less than Significant Impact. Decommissioning oil production facilities in unincorporated Los Angeles may involve handling potentially hazardous substances such as residual hydrocarbons, drilling fluids, and contaminated soil. While the presence of these materials carries some risk, the potential for accidents or unplanned releases is minimized through stringent regulatory oversight, established safety protocols, and best management practices.

Before and during decommissioning, operators must comply with applicable federal, state, and local regulations designed to prevent the release of hazardous materials. These regulations include requirements set forth by the California Geologic Energy Management Division (CalGEM) for proper well abandonment, and by the Department of Toxic Substances Control (DTSC) and the Los Angeles County Fire Department's Health Hazardous Materials Division for managing hazardous waste. Activities are conducted in accordance with approved hazardous materials handling plans, spill prevention and response measures, and ongoing inspections to ensure compliance.

The project's safety measures—particularly those required by Site Maintenance and Well Plugging and Abandonment provisions—mitigate the potential for releases. These standards require site operators to keep the vicinity free of oil pools or debris, promptly address spills, and remove

unneeded pipelines and equipment once wells are no longer in use. The project's Complaint and Comment Log requirement also provides an avenue for reporting any release or accidental spill, ensuring rapid response and corrective action.

If unknown contaminants are discovered, work would cease in the affected area until the material is characterized and removed in accordance with regulatory standards. Licensed hazardous waste haulers and permitted disposal facilities would be used for transporting and disposing of hazardous materials, reducing the likelihood of accidental releases during transport.

In the long run, by permanently phasing out oil operations, the project would eliminate ongoing risks associated with active extraction, storage, and processing of oil and related hazardous substances. Consequently, the potential for future accidents involving hazardous materials would be substantially reduced.

Given the robust regulatory framework, required safety measures, and careful handling procedures, the risk of creating a significant hazard to the public or the environment through accidental release of hazardous materials is minimized. Therefore, impacts would be less than significant.

c. Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of sensitive land uses?

Less than Significant Impact. Decommissioning oil production facilities in unincorporated Los Angeles County may require the handling of hazardous materials associated with well abandonment and infrastructure removal. These could include residual hydrocarbons, drilling fluids, contaminated soil, and other materials typical of oil production sites. Although such materials are hazardous, their handling is strictly regulated by federal, state, and local agencies, ensuring proper containment, transport, and disposal. Compliance with regulations under the California Hazardous Waste Control Law and oversight by the Los Angeles County Fire Department's Health Hazardous Materials Division would minimize any potential exposure risk. Compliance with the project's Site Maintenance provisions helps ensure proper containment, rapid spill response, and removal of materials that could pose risks to nearby sensitive receptors. Further, the project's Complaint and Comment Log requirement facilitates quick reporting and resolution of any issue related to emissions or potential exposures.

If sensitive land uses (e.g., residences, schools, healthcare facilities, daycare centers, or parks) exist within one-quarter mile of a project site, project activities would still be subject to stringent safety protocols designed to prevent hazardous emissions or releases. Standard best management practices—such as covering haul trucks, using spill containment measures, and implementing proper storage and disposal methods—would be employed to ensure that hazardous materials are handled safely and do not pose a risk to nearby sensitive populations.

Because the project does not introduce new long-term operations involving hazardous materials and is focused on removing existing petroleum-related infrastructure, any potential hazardous material handling would be temporary, controlled, and closely monitored. Given the robust regulatory framework and implementation of best management practices, the likelihood of hazardous emissions or materials affecting sensitive land uses within a quarter mile is very low. Therefore, impacts would be less than significant.

d. Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code § 65962.5 and, as a result, would it create a significant hazard to the public or the environment?

Less than Significant Impact. Some oil production sites within unincorporated Los Angeles County may be listed under Government Code § 65962.5 (often referred to as the Cortese List) due to past operations that potentially contaminated soil or groundwater with hazardous substances. However, the project would not introduce new contaminating activities; rather, it would phase out oil production and result in the removal of appurtenant infrastructure from affected sites.

If an oil production site is listed on the Cortese List, it would already be subject to investigation and cleanup requirements overseen by agencies such as the Department of Toxic Substances Control (DTSC) and the Regional Water Quality Control Board (RWQCB). Decommissioning and closure of oil wells, along with any required remediation, would follow applicable environmental regulations and established protocols to ensure that contaminated soils or other hazardous materials are handled and disposed of properly. The California Geologic Energy Management Division (CalGEM) standards for well abandonment, in conjunction with the DTSC oversight and compliance with the Resource Conservation and Recovery Act (RCRA), ensure that these operations mitigate existing hazards. The project further regulates these activities via its integrated Well Plugging and Abandonment and Bonds provisions, ensuring that operators or the County have sufficient resources to carry out remediation if contamination is discovered or if the operator fails to remediate a site. These measures bolster existing investigative and cleanup requirements under DTSC and RWQCB oversight.

By safely removing or remediating contaminated infrastructure and materials, the project would ultimately reduce long-term risks to the public and the environment. As a result, even if the site is listed on the Cortese List, the project's activities are anticipated to improve, rather than worsen, existing conditions. Therefore, any impacts related to site listings under Government Code § 65962.5 would be less than significant.

e. For a project located within an airport land use plan, or where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard or excessive noise for people residing or working in the project area?

Less than Significant Impact. The project would phase out oil production activities, resulting in the removal of associated infrastructure on sites that may or may not be located within an airport land use plan area or within two miles of a public airport. If a site does fall within an airport's area of influence, the activities resulting from the project involve dismantling existing facilities rather than introducing new development or uses that would increase safety hazards or expose people to excessive noise related to airport operations.

Any decommissioning work that may occur near an airport would be temporary and closely regulated. Tall equipment or cranes used during well plugging or facility removal would comply with Federal Aviation Administration (FAA) regulations and any applicable requirements of the local airport land use plan to ensure they do not create airspace obstructions or safety hazards. The project does not propose structures that would conflict with flight paths or increase the density of people living or working near runways or approach/departure zones. Additionally, the project's performance standards—such as the Site Maintenance rules—would keep sites free of debris or tall, unwieldy structures that might pose hazards to aircraft operations.

The cessation of oil production activities would ultimately reduce industrial noise and activity in the area, potentially improving the local noise environment over the long term. Existing regulations and review processes—such as consultation with the Los Angeles County Airport Land Use Commission, if applicable—ensure that any project activities within an airport land use plan or near an airport are consistent with safety guidelines and compatibility criteria.

Therefore, the project would not result in a significant safety hazard or create excessive noise for people residing or working in the project area, and impacts would be less than significant.

f. Impair implementation of, or physically interfere with, an adopted emergency response plan or emergency evacuation plan?

Less than Significant Impact. The project would phase out oil production activities, resulting in the removal of associated infrastructure in unincorporated Los Angeles County. While decommissioning activities may involve construction equipment and temporary work areas, these are not anticipated to interfere with established emergency response or evacuation routes.

Los Angeles County's Operational Area Emergency Response Plan (OAERP) and the Local All-Hazards Mitigation Plan guide the County's emergency response and recovery efforts. These plans designate specific disaster routes—shown in the County's General Plan Safety Element—to ensure that emergency vehicles can access affected areas and that evacuations can be carried out efficiently. Any temporary lane closures or traffic control measures required during well abandonment or equipment removal would be coordinated with local agencies and conducted in compliance with County regulations, ensuring that critical routes remain passable for emergency services.

Moreover, by eliminating oil production activities, the project would reduce the potential for hazards such as spills, fires, or explosions that could complicate emergency responses. Removing these sources of risk and potentially restoring sites to safer uses aligns with the County's hazard mitigation goals and supports long-term community resilience. The project's Site Maintenance provisions require clearing flammable materials and debris, and the Bonds required guarantee resources for safe site closure.

Because the project's short-term activities can be managed to avoid disrupting emergency routes, and the long-term effect of discontinuing oil production reduces hazard potential, the project would not impair or interfere with adopted emergency response or evacuation plans. Therefore, the impact is less than significant.

g. (i) Located within a high fire hazard area with inadequate access?

Less than Significant Impact. Some oil production sites in unincorporated Los Angeles County are located within Very High Fire Hazard Severity Zones (VHFHSZs), where the risk of wildfire is elevated. These areas often have steep slopes, dense vegetation, and other conditions that can contribute to intense fires. However, the project, which involves phasing out oil production and decommissioning associated infrastructure, does not introduce new development or permanent uses that would increase fire risk or strain emergency access. Instead, it phases out oil production activities and ensures proper site maintenance under the project's integrated Site Maintenance standards, which mandate the removal of combustible materials within 25 feet of wells and the clearance of debris. These standards, paired with existing Los Angeles County Fire Department regulations, help minimize the likelihood of wildfires.

Decommissioning activities would be temporary and conducted in compliance with all applicable fire safety regulations. The Los Angeles County Fire Department enforces stringent requirements for developments and projects within VHFHSZs, including maintaining adequate emergency access, ensuring sufficient fire flow, and removing flammable materials that could contribute to fire spread. The project's removal of oil-related infrastructure and hazardous materials would likely reduce the overall fire risk at the site over the long term.

While decommissioning work may involve construction equipment and temporary on-site personnel, these activities are short-term, localized, and subject to oversight by the County Fire Department. Compliance with fire codes, defensible space regulations, and any necessary vegetation management practices ensure that emergency access routes remain unobstructed and first responders can reach the site if needed. Moreover, eliminating ongoing oil production removes a source of potential fire hazard, thereby diminishing long-term fire risks.

In summary, although some project areas are located within high fire hazard zones, the project would not worsen fire risk or limit emergency access. Instead, by ceasing oil production and restoring the site, the project may improve conditions for fire safety. Therefore, impacts related to fire hazards and emergency access in high fire hazard areas would be less than significant.

(ii) Located within an area with inadequate water and pressure to meet fire flow standards?

Less than Significant Impact. The project would phase out oil production activities, resulting in the removal of associated infrastructure, rather than introducing new development that demands long-term water service or enhanced fire flow capacity. While some existing oil production sites may be in areas with limited water infrastructure and reduced water pressure, the project's activities are temporary, limited to decommissioning and restoration tasks.

Fire flow standards and requirements, established by the Los Angeles County Fire Department (LACoFD), are typically determined based on the nature of ongoing land uses and the types of structures present. Active oil production operations may have previously addressed fire safety needs through on-site measures—such as storage tanks or portable water supplies—to compensate for limited municipal water systems. As the project focuses on removing wells, equipment, and associated infrastructure, the need for substantial, long-term fire flows diminishes.

During decommissioning, water use would be minimal and largely confined to activities like dust suppression and equipment cleaning. These do not strain existing water supplies or pressure. In areas lacking robust municipal infrastructure, any required fire safety measures (e.g., on-site water storage or alternative fire suppression systems) can be implemented on a temporary basis.

The project's Site Maintenance and Well Plugging and Abandonment requirements reduce the presence of flammable materials, thus diminishing potential fire-fighting needs over the long term. Additionally, by eliminating a source of flammable materials and industrial hazards in the form of oil wells and production facilities, the project reduces fire risks over the long term, thereby lessening the reliance on high fire flow capacities in the future.

In all cases, compliance with local fire codes and LACoFD guidelines ensures that any short-term needs for fire suppression resources are adequately addressed. Consequently, even in areas with limited water availability and pressure, the project would not result in significant impacts related to inadequate fire flow.

(iii) Located within proximity to land uses that have the potential for dangerous fire hazard?

Less than Significant Impact. The project would phase out oil production activities, resulting in the removal of associated infrastructure and thereby reducing long-term fire risks at affected sites. While some oil operations may currently be located near land uses with potential fire hazards—such as wildlands, industrial facilities, or other areas storing flammable materials—the project's decommissioning process is designed to minimize immediate fire risks and align with all applicable safety regulations.

During decommissioning, any flammable substances or equipment will be handled and removed according to fire safety standards set by the Los Angeles County Fire Department, the California Fire Code, and the project's integrated the Site Maintenance standards that ensure prompt cleanup of any flammable fluids and mandatory vegetation clearance. Temporary increases in fire risk from construction equipment or handling of materials would be short-lived and mitigated through best management practices, emergency preparedness plans, and adherence to all relevant codes and regulations.

Over the long term, the cessation of oil production eliminates sources of potentially combustible materials and infrastructure that could have contributed to fire hazards. The resulting site conditions would be more compatible with surrounding land uses and less prone to fire incidents. As a result, impacts related to proximity to dangerous fire hazards would be less than significant.

h. Does the proposed use constitute a potentially dangerous fire hazard?

Less than Significant Impact. While the decommissioning of oil production activities may involve the use of machinery, handling of residual flammable substances, and activities that could generate heat or sparks, these operations are temporary, strictly regulated, and employ robust fire safety measures. All decommissioning activities must adhere to the applicable fire codes and standards enforced by the Los Angeles County Fire Department, including proper storage, handling, and disposal of flammable materials, the use of fire suppression equipment and emergency response protocols, and the project's integrated Site Maintenance rules for keeping oil and debris off-site.

By phasing out oil production activities, the project eliminates a long-term source of potential fire hazards—namely, the ongoing presence of combustible materials and equipment characteristic of active oil production. Once decommissioned, the absence of active oil operations significantly reduces the likelihood of dangerous fire hazards associated with industrial operations. Any temporary risks present during the removal of infrastructure are managed and mitigated through regulatory compliance and best management practices.

As a result, while the project's short-term activities are subject to fire safety precautions, the project does not constitute a potentially dangerous fire hazard. The long-term effect is a net reduction in fire risk compared to continued oil production operations. Thus, impacts would be less than significant.

X. Hydrology and Water Quality

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. Violate any water quality standards or waste discharge requirements or otherwise substantially degrade surface or groundwater quality?	☐	☐	☒	☐
b. Substantially decrease groundwater supplies or interfere substantially with groundwater recharge such that the project may impede sustainable groundwater management of the basin?	☐	☐	☒	☐
c. Substantially alter the existing drainage pattern of the site or area, including through the alteration of a Federal 100-year flood hazard area or County Capital Flood floodplain; the alteration of the course of a stream or river; or through the addition of impervious surfaces, in a manner which would:				
i) Result in substantial erosion or siltation on- or off-site?	☐	☐	☒	☐
ii) Substantially increase the rate, amount, or depth of surface runoff in a manner which would result in flooding on- or offsite?	☐	☐	☒	☐
iii) Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?	☐	☐	☒	☐
iv) Impede or redirect flood flows which would expose existing housing or other insurable structures in a Federal 100-year flood hazard area or County Capital Flood floodplain to a significant risk of loss or damage involving flooding?	☐	☐	☒	☐
d. Otherwise place structures in Federal 100-year flood hazard or County Capital Flood floodplain areas which would require additional flood proofing and flood insurance requirements?	☐	☐	☒	☐
e. Conflict with the Los Angeles County Low Impact Development Ordinance (L.A. County Code, Title 12, Ch. 12.84)?	☐	☐	☒	☐
f. Use onsite wastewater treatment systems in areas with known geological limitations (e.g. high groundwater) or in close proximity to surface water (including, but not limited to, streams, lakes, and drainage course)?	☐	☐	☐	☒
g. In flood hazard, tsunami, or seiche zones, risk release of pollutants due to project inundation?	☐	☐	☒	☐

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
h. **Conflict with or obstruct implementation of a water quality control plan or sustainable groundwater management plan?**	☐	☐	☒	☐

a. Violate any water quality standards or waste discharge requirements or otherwise substantially degrade surface or groundwater quality?

Less than Significant Impact. The project would phase out oil production activities, resulting in the removal of associated infrastructure in unincorporated Los Angeles County. Although decommissioning work involves ground disturbance and the handling of potentially hazardous materials, compliance with existing regulatory frameworks ensures that water quality standards and waste discharge requirements are not violated, and that surface and groundwater resources are protected.

During decommissioning, residual contaminants such as hydrocarbons or drilling fluids may be encountered. However, the California Geologic Energy Management Division (CalGEM) regulates well abandonment and requires wells to be properly sealed and secured to prevent fluid migration into groundwater. Any contaminated soil or materials discovered must be treated or disposed of in accordance with state and federal laws, including the Resource Conservation and Recovery Act (RCRA) and the California Hazardous Waste Control Law, ensuring that pollutants do not migrate to water resources. In addition, the project's Site Maintenance provisions require operators to promptly clean up and remove pools of oil or other fluids, and the Well Plugging and Abandonment standards impose a regulated closure process that further minimizes any potential for groundwater contamination.

If the project disturbs one acre or more of soil, it would be subject to the National Pollutant Discharge Elimination System (NPDES) Construction General Permit. Under this permit, a Storm Water Pollution Prevention Plan (SWPPP) would be prepared and implemented, incorporating best management practices (BMPs) such as silt fencing, wattles, or sediment basins to minimize erosion, sedimentation, and pollutant discharge into local waterways. These measures reduce the likelihood of contaminants leaving the project site and entering surface waters.

In addition, compliance with the Los Angeles County Low Impact Development Ordinance and any applicable requirements from the Regional Water Quality Control Board ensures that project activities do not degrade water quality. As the project phases out oil production, long-term risks of leaks, spills, or other contamination are reduced, ultimately benefiting regional water quality. The project's required Bonds also guarantee that financial resources are available for site remediation should an operator fail to perform adequate cleanup.

Given these regulatory controls, mandatory compliance measures, and the new performance standards for well abandonment, the project would not violate water quality standards or waste discharge requirements, nor would it substantially degrade surface or groundwater quality. Impacts would therefore be less than significant.

b. Substantially decrease groundwater supplies or interfere substantially with groundwater recharge such that the project may impede sustainable groundwater management of the basin?

Less than Significant Impact. The project would phase out oil production activities and remove related infrastructure, rather than introduce new long-term uses that significantly depend on or alter groundwater supplies. Any temporary water uses during the decommissioning phase (e.g., for dust suppression or soil remediation) would be minimal and not require the development of new groundwater wells. Water, if needed, would be sourced from existing municipal or permitted supplies, thus avoiding direct withdrawals from local aquifers.

By eliminating active oil operations, the project also removes infrastructure that can impede natural infiltration, such as paved well pads and compacted access roads. Subsequent site restoration efforts—such as regrading and revegetating formerly developed areas—may enhance natural percolation of rainwater into the soil, thereby promoting groundwater recharge. This restoration can offset any minor, short-term disturbance from decommissioning and may even improve long-term groundwater conditions compared to the status quo.

Furthermore, properly plugging and abandoning oil wells, as required by the California Geologic Energy Management Division (CalGEM) standards, prevents potential vertical pathways that could contaminate or affect groundwater flows. The project's performance standards—particularly the Well Plugging and Abandonment provisions—reinforce these requirements, reducing the risk that abandoned wells could allow pollutants to enter aquifers. Removing or remediating any site contamination supports sustainable groundwater management practices.

In summary, the project does not create substantial new demands on groundwater supplies, nor does it significantly interfere with groundwater recharge. Instead, it may lead to improved infiltration and reduced contamination risks over time. Therefore, impacts related to groundwater supplies and recharge would be less than significant.

c. (i) Result in substantial erosion or siltation on- or off-site?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure, potentially involving ground-disturbing activities like grading and soil excavation during the decommissioning phase. These short-term construction activities could temporarily increase the risk of erosion or siltation, particularly if rain events occur while soils are exposed. However, such risks would be effectively managed through compliance with existing regulatory requirements and the project's integrated performance standards.

For any soil disturbance of one acre or more, the project would be subject to the National Pollutant Discharge Elimination System (NPDES) Construction General Permit, which requires the preparation and implementation of a Stormwater Pollution Prevention Plan (SWPPP). The SWPPP outlines best management practices (BMPs) such as silt fencing, sediment basins, stabilized construction entrances, and other erosion-control measures to minimize soil loss and prevent sediments from entering waterways. Additionally, adherence to the Los Angeles County Low Impact Development Ordinance and grading regulations would further limit erosion and siltation both during and after construction.

In the long term, removing oil-related infrastructure and restoring the site can improve soil stability and reduce impervious surfaces, potentially enhancing natural infiltration and reducing runoff velocities. As a result, once decommissioning is complete, the site may experience reduced erosion compared to conditions present under active operations. Moreover, the project's Site Maintenance requirements ensure that operators remove debris and any potential sources of sediment promptly, decreasing the risk of erosion issues.

Given the project's compliance with existing regulatory frameworks and the implementation of BMPs, any potential erosion or siltation impacts would be short-term, controlled, and minimized. Therefore, the impact on erosion and siltation would be less than significant.

(ii) Substantially increase the rate, amount, or depth of surface runoff in a manner which would result in flooding on- or offsite?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure, potentially involving ground-disturbing actions like grading or soil excavation during the decommissioning phase. Such activities may slightly alter on-site drainage patterns and temporarily increase surface runoff. However, these changes would be localized and short-term.

Because project activities are subject to the National Pollutant Discharge Elimination System (NPDES) Construction General Permit requirements, Stormwater Pollution Prevention Plans (SWPPPs) would be prepared and implemented as required. These plans outline best management practices (BMPs) designed to control runoff, including measures to prevent water from accumulating on-site or overwhelming downstream drainage systems. Additionally, compliance with the Los Angeles County Low Impact Development Ordinance ensures that post-decommissioning conditions do not substantially increase runoff volumes or velocities.

Over the long term, the cessation of oil production and removal of impervious surfaces associated with industrial operations may improve infiltration and reduce runoff. Restoring or regrading the site and planting vegetation can enhance infiltration capacity and decrease the likelihood of on- or off-site flooding. The project's performance standards such as Site Maintenance provisions also require operators to keep areas free of debris and ensure adequate drainage, further reducing flood risks. Therefore, any short-term increase in surface runoff would be effectively managed, and the project would not cause substantial flooding. Thus, impacts related to surface runoff and flooding would be less than significant.

(iii) Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure, which may involve some short-term ground disturbance (e.g., grading, excavation) during decommissioning. While these activities could temporarily alter the site's runoff characteristics, compliance with applicable regulations and implementation of best management practices (BMPs) would ensure that any changes in runoff volume or quality do not exceed the capacity of existing or planned stormwater drainage systems, nor result in substantial additional sources of polluted runoff.

During decommissioning, construction-related pollutants such as sediment or hydrocarbons could potentially be carried off-site by stormwater runoff. However, if one acre or more of ground is disturbed, the project would be subject to the National Pollutant Discharge Elimination System (NPDES) Construction General Permit, requiring preparation and implementation of a site-specific Stormwater Pollution Prevention Plan (SWPPP). The SWPPP would include erosion and sediment controls, spill prevention measures, and other BMPs designed to minimize runoff impacts and prevent pollutants from entering the storm drain system. Additionally, compliance with the County's Low Impact Development Ordinance and stormwater regulations would further reduce runoff

volumes and improve runoff quality through on-site infiltration, retention, or treatment measures as appropriate.

Over the long term, removing oil wells and associated hardscape—such as pads, roads, and equipment areas—may decrease impervious surfaces and restore more natural infiltration conditions. This shift can improve on-site permeability, reduce peak runoff flows, and lower the potential pollutant load compared to ongoing oil production operations. Properly abandoning and sealing wells will eliminate potential contamination pathways, further reducing the risk of polluted runoff reaching stormwater systems. By also adhering to the project's Site Maintenance standards, operators must keep surfaces free of pooled liquids or debris that could contribute pollutants to the runoff.

Consultation with the County Public Works would ensure that any incremental runoff changes remain within the capacity of the local stormwater infrastructure. Given that the project's activities are designed to comply with regulatory standards and improve site conditions relative to existing industrial operations, the potential impacts associated with exceeding stormwater system capacity or adding significant sources of polluted runoff would be less than significant.

(iv) Impede or redirect flood flows which would expose existing housing or other insurable structures in a Federal 100-year flood hazard area or County Capital Flood floodplain to a significant risk of loss or damage involving flooding?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure, none of which are intended to result in new structures that could impede or redirect flood flows. While some existing oil production sites may be located within or near Federal Emergency Management Agency (FEMA)-designated 100-year flood hazard areas or County Capital Flood floodplains, the proposed decommissioning and restoration activities are not expected to significantly alter regional flooding patterns or increase flood risk to existing housing or insurable structures.

During decommissioning, activities such as grading, soil removal, and well plugging could temporarily modify on-site drainage patterns. However, these changes would be limited in extent and duration. Any work conducted within flood-prone areas would be subject to federal, state, and local floodplain management requirements, ensuring that surface contours are not altered in a way that would substantially impede or redirect flood flows. County Public Works would review proposed activities near flood hazard areas to verify compliance with all applicable regulations, including FEMA guidelines and County floodplain ordinances. If necessary, project activities would incorporate appropriate design measures or obtain required approvals (e.g., Conditional Letter of Map Revision) to ensure flood hazards are not exacerbated.

Furthermore, removing oil production infrastructure—such as well pads, tanks, and pipelines—can restore more natural floodplain function. Eliminating these potential obstructions may improve the flow and storage capacity of floodwaters, reducing the risk that floodwaters would be redirected toward existing developments. Site restoration efforts, including regrading and revegetation, would also promote infiltration and stabilize soils, potentially enhancing natural flood management functions over the long term.

By complying with all relevant floodplain management regulations, coordinating with responsible agencies, and removing industrial infrastructure that could impede floodwaters, the project would not expose existing housing or other insurable structures to increased flood risks. Therefore, impacts

related to impeding or redirecting flood flows within a 100-year flood hazard area or County Capital Flood floodplain would be less than significant.

d. Otherwise place structures in Federal 100-year flood hazard or County Capital Flood floodplain areas which would require additional flood proofing and flood insurance requirements?

Less than Significant Impact. The project would phase out and decommission existing oil production infrastructure rather than construct new permanent structures. Consequently, it would not introduce new buildings or facilities into Federal Emergency Management Agency (FEMA) 100-year flood hazard areas or County Capital Flood floodplains that would necessitate additional floodproofing measures or the purchase of flood insurance.

During the decommissioning phase, temporary equipment and staging areas may be used, but such activities are short-term and do not involve constructing permanent structures. Any work that occurs within or near flood hazard areas would comply with federal, state, and local floodplain management regulations. County Public Works and FEMA guidelines ensure that activities in these zones do not increase flood risk or require floodproofing measures beyond those already in place.

In addition, the removal of existing oil well pads, pipelines, and associated equipment from flood-prone areas can ultimately reduce flood-related risks by eliminating infrastructure that could otherwise impede flood flows or be damaged during flood events. Restoring or converting the site following decommissioning (e.g., regrading and revegetating surfaces) may enhance natural infiltration and stabilize soils, further reducing the likelihood that new flood protection measures or flood insurance requirements would arise.

Since the project does not involve placing permanent structures in flood hazard areas, no additional floodproofing or insurance mandates would be triggered. Therefore, the impact associated with placing structures in a FEMA 100-year flood hazard area or County Capital Flood floodplain is considered less than significant.

e. Conflict with the Los Angeles County Low Impact Development Ordinance (L.A. County Code, Title 12, Ch. 12.84)?

Less than Significant Impact. The project would phase out oil production activities and decommission existing infrastructure within unincorporated Los Angeles County, ultimately reducing impervious surfaces and improving on-site hydrologic conditions. Rather than introducing new impervious areas, the project involves the removal of oil well pads, paved access roads, and other industrial installations. These actions facilitate increased infiltration, reduce runoff volumes and velocities, and help restore more natural drainage patterns—measures that align with the goals of the Los Angeles County Low Impact Development (LID) Ordinance.

The LID Ordinance (Los Angeles County Code, Title 12, Chapter 12.84) aims to protect water quality, preserve natural hydrology, and minimize the impacts of stormwater runoff through strategies that retain, detain, or filter stormwater on-site. Although the ordinance typically applies to new or redevelopment projects that create additional impervious surfaces, the project does the opposite by removing industrial infrastructure and reducing impervious coverage. This results in fewer pollutant sources, improved infiltration, and reduced stormwater runoff, all of which support LID principles.

During the decommissioning phase, any temporary construction activities must comply with applicable local and state stormwater management regulations, including NPDES permits and

standard erosion and sediment control measures. Because the project's long-term effects promote, rather than hinder, natural hydrology and infiltration, it does not conflict with the LID Ordinance's requirements. Additionally, the project's integrated Site Maintenance requirements aid in keeping sites free from debris and contamination, further supporting LID objectives.

In summary, by eliminating oil production facilities and allowing sites to revert to conditions more supportive of infiltration and natural drainage, the project supports the LID Ordinance's core objectives. Consequently, the project would not conflict with, but instead complement, the LID Ordinance, resulting in a less than significant impact.

f. Use onsite wastewater treatment systems in areas with known geological limitations (e.g. high groundwater) or in close proximity to surface water (including, but not limited to, streams, lakes, and drainage course)?

No Impact. The project would phase out oil production operations and decommission associated infrastructure but does not include the installation or use of any onsite wastewater treatment systems such as septic tanks. Since no new development or land uses requiring wastewater disposal are introduced, there is no need for a septic system or other private sewage disposal method.

Onsite wastewater treatment systems can pose risks when sited in areas with high groundwater tables, unstable geologic conditions, or near surface waters like streams, lakes, or drainage courses, as they may contaminate groundwater or surface water. However, the project does not involve any activities that would generate or manage wastewater onsite. Decommissioning efforts and site restoration work are temporary and focus on removing oil-related equipment and restoring the site to conditions more supportive of natural infiltration and reduced pollution sources. No components of the project would result in increased wastewater flows, nor require the placement of wastewater systems close to sensitive water bodies.

Because the project does not propose septic tanks or other private sewage disposal systems, it avoids the potential pitfalls associated with onsite wastewater management in geologically constrained areas or near surface water features. Consequently, no impact would occur in this regard.

g. In flood hazard, tsunami, or seiche zones, risk release of pollutants due to project inundation?

Less than Significant Impact. The project would phase out existing oil production operations, removing infrastructure that could otherwise release pollutants if inundated by floodwaters, a tsunami, or a seiche event. By eliminating the industrial equipment and storage facilities associated with oil production, the project effectively reduces the potential for pollutant release during any future inundation scenario.

Portions of the project area may lie within flood hazard zones designated by the Federal Emergency Management Agency (FEMA), or within areas identified as susceptible to tsunamis or seiches. However, the project does not introduce new structures or operations that would store hazardous materials or otherwise increase the risk of pollutant release during an inundation event. Instead, decommissioning activities remove existing sources of potential contamination—such as pipelines, well pads, and processing equipment—and ensure that any residual hazardous materials are properly disposed of in accordance with applicable regulations. The project's included performance standards, including Site Maintenance and Well Plugging and Abandonment, further decrease the potential for pollutants to remain on-site in the long term.

All activities conducted within or near flood hazard, tsunami, or seiche zones must comply with federal, state, and local standards, including Los Angeles County floodplain ordinances and applicable emergency management and hazard mitigation plans. Compliance with these requirements ensures that the project's decommissioning activities do not exacerbate existing flood risks or introduce new pollutant sources vulnerable to inundation.

In the long term, removing industrial infrastructure from these hazard zones may improve environmental conditions by reducing the presence of potential contaminants. Thus, the project would not significantly increase the risk of pollutant release due to inundation in flood hazard, tsunami, or seiche zones. Impacts would be less than significant.

h. Conflict with or obstruct implementation of a water quality control plan or sustainable groundwater management plan?

Less than Significant Impact. The project would phase out oil production activities and remove related infrastructure, ultimately reducing potential pollutant sources and improving conditions for both surface and groundwater resources over time. Rather than introducing new contamination risks, the project focuses on eliminating existing industrial operations that could degrade water quality.

The project area spans the unincorporated area of Los Angeles County, which falls under the jurisdiction of the Los Angeles Regional Water Quality Control Board (RWQCB) and, in certain areas, the Lahontan RWQCB. Each RWQCB administers a Basin Plan with water quality objectives designed to protect beneficial uses of surface and groundwater. By removing oil wells, pipelines, and associated facilities, the project diminishes the likelihood of hydrocarbons, heavy metals, or other pollutants entering local waterways. Compliance with relevant NPDES permits, adherence to the Porter-Cologne Water Quality Control Act, and ongoing coordination with RWQCBs ensure that all decommissioning and restoration activities uphold the Basin Plan's standards for maintaining and enhancing water quality.

Los Angeles County includes several groundwater basins managed under the Sustainable Groundwater Management Act (SGMA). Sustainable groundwater management plans aim to maintain long-term groundwater quality, availability, and reliability. The project does not involve new groundwater extraction or substantial changes to groundwater recharge processes. Instead, decommissioning reduces the risk of groundwater contamination by properly plugging and abandoning oil wells in accordance with California Geologic Energy Management Division (CalGEM) regulations. This preventative measure is further supported by the project's Well Plugging and Abandonment standards, which ensure that wells are sealed and remediated, thereby aligning with SGMA goals to prevent aquifer pollution.

With the removal of industrial infrastructure, impervious surfaces may be reduced, potentially improving natural infiltration and supporting sustainable groundwater recharge over time. This shift aligns with both water quality control and groundwater management objectives, as it lessens the long-term pollution load and fosters more resilient water resources management.

In summary, by eliminating a source of industrial pollutants, adhering to all applicable regulatory requirements, and restoring sites to more natural conditions, the project neither conflicts with nor obstructs the implementation of applicable water quality control plans or sustainable groundwater

management plans. The overall effect is consistent with improving and maintaining water quality and groundwater sustainability, resulting in a less than significant impact.

XI. Land Use/Planning

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. **Physically divide an established community?**	☐	☐	☐	☒
b. **Cause a significant environmental impact due to a conflict with any County land use plan, policy, or regulation adopted for the purpose of avoiding or mitigating an environmental effect?**	☐	☐	☒	☐
c. **Conflict with the goals and policies of the General Plan related to Hillside Management Areas or Significant Ecological Areas?**	☐	☐	☒	☐

a. Physically divide an established community?

No Impact. The project involves phasing out oil production activities, resulting in the decommissioning of existing wells and related infrastructure, rather than introducing new development features that could disrupt existing neighborhoods or separate communities. The project does not include building new roads, walls, freeways, or other substantial barriers that would impede access or circulation within established communities. Instead, it focuses on restoring or converting affected sites to conditions more consistent with surrounding land uses.

By eliminating oil production operations and associated equipment, the project may improve the visual and functional integration of these areas with their surroundings. This reduction in industrial infrastructure could enhance community cohesiveness rather than diminish it. Furthermore, the project aligns with the County's long-term land use goals, which favor compatible and community-serving uses over industrial ones, thereby supporting local neighborhood character and connectivity.

Moreover, the project's performance standards—including Site Maintenance and Well Plugging and Abandonment—ensure that oil-related facilities are dismantled in a manner that removes residual industrial elements and prevents lingering hazards. These requirements help blend formerly industrial sites back into the surrounding environment without creating physical obstructions. Because the project neither introduces physical barriers nor alters the existing street grid or access routes, it would not create divisions within neighborhoods or disrupt existing community patterns. As a result, no impact related to the physical division of an established community would occur.

b. Cause a significant environmental impact due to a conflict with any County land use plan, policy, or regulation adopted for the purpose of avoiding or mitigating an environmental effect?

Less than Significant Impact. The project, which phases out oil production activities and removes associated industrial infrastructure, is designed to align with the County's land use plans, policies, and regulations adopted to avoid or mitigate environmental impacts. Rather than introducing potentially conflicting land uses, the project reduces the intensity of industrial operations and enhances compatibility with surrounding areas.

The General Plan emphasizes sustainable development, protection of environmental resources, public health, and compatibility between land uses. By decommissioning oil wells and appurtenant facilities, the project reduces potential sources of air, noise, and water pollution. This transition supports General Plan policies aimed at improving environmental quality, remediating incompatible uses, and promoting ecological restoration.

The project adheres to the County Zoning Code, including those pertaining to nonconforming uses. By designating existing oil wells as nonconforming and establishing a defined amortization period, the project facilitates phase-out of industrial operations. The project's integrated Site Maintenance standards and required Bonds further ensure that any interim operations are kept in compliance with regulations until final decommissioning, reducing potential land use conflicts. In areas with Community Standards Districts (CSDs) or other overlays—such as the Baldwin Hills CSD—the project's oil well prohibition and performance standards integrate with local requirements, safeguarding community character and mitigating environmental effects.

The project also complies with state and regional requirements enforced by entities such as the California Geologic Energy Management Division (CalGEM) and the Regional Water Quality Control Boards (RWQCBs). By removing potential pollutant sources, ensuring proper well abandonment, and preventing contamination risks, the project supports the goals of water quality control plans, air quality management strategies, and sustainable groundwater management efforts.

Because the project does not propose new development or uses that would create inconsistencies with established land use plans or environmental protection policies, it presents no conflicts. Instead, it lowers historical environmental risks and advances the County's objective of transitioning to more compatible land uses. Therefore, any potential impacts due to conflicts with County land use plans or policies are considered less than significant.

c. Conflict with the goals and policies of the General Plan related to Hillside Management Areas or Significant Ecological Areas?

Less than Significant Impact. The project, which phases out oil production activities and decommissions associated infrastructure, does not conflict with General Plan policies related to Hillside Management Areas (HMAs) or Significant Ecological Areas (SEAs). Instead, it supports the General Plan's environmental conservation objectives by removing industrial operations and restoring affected sites, thereby reducing impacts on sensitive hillside and ecological resources.

HMAs are designated to preserve natural landforms, minimize grading, protect scenic resources, and ensure environmentally sensitive hillside development. The project does not introduce new structures or extensive earthwork in hillside areas. Rather, it involves dismantling and removing oil production facilities that may currently disrupt natural slopes or views. Compliance with the County's HMA Ordinance and relevant design guidelines ensures that any temporary ground-disturbing activities during decommissioning are carefully managed. Additionally, the project's Site Maintenance provisions require operators to keep sites free of debris and combustible materials, aligning with policies that protect hillside integrity and scenic values.

SEAs are established to conserve habitat integrity, biodiversity, and ecological functions. Oil production can fragment habitats, introduce pollutants, and generate disturbances that negatively affect SEAs. By eliminating these industrial activities, the project removes pollution sources, reduces habitat disturbances, and allows for natural vegetation reestablishment. These actions directly support General Plan goals and SEA-related policies aimed at preserving sensitive habitats and

promoting ecological connectivity. The project's Well Plugging and Abandonment standards and required Bonds further ensure that decommissioning activities do not leave hazardous or obstructive remnants that could harm ecological resources.

Any short-term effects associated with dismantling equipment—such as localized soil disturbance or temporary noise—are minor, regulated, and take place within a framework of compliance with County ordinances and guidelines. Over the long term, removing oil infrastructure and restoring sites to more compatible uses fosters improved environmental conditions that are consistent with the General Plan's policies for HMAs and SEAs. Accordingly, the project does not conflict with the General Plan's goals and policies for hillside and ecological areas, and impacts are less than significant.

XII. Mineral Resources

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. **Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?**	☒	☐	☐	☐
b. **Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?**	☒	☐	☐	☐

a. Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?

Potentially Significant Impact. The project would prohibit new oil wells and phase out existing oil production operations, effectively curtailing the availability of locally-produced oil and gas—recognized mineral resources of regional and state importance. By permanently ending extraction at these sites, the project would foreclose future access to these known mineral resources, thereby resulting in their loss to the region and state.

Oil and gas have historically contributed to the local and regional economy, energy supply, and industrial base. While the project aligns with the State of California's and the County's policy goals to transition from fossil fuels to renewable energy sources, from a mineral resources perspective, discontinuing oil production operations represents a long-term loss of a valuable nonrenewable resource. Once these wells are plugged and abandoned, the potential to recover these materials in the future would be foregone.

Under CEQA, the permanent loss of availability of a known mineral resource is considered a significant impact. Although the project may have social, economic, and environmental benefits—such as improving public health, mitigating environmental justice concerns, and supporting climate policy objectives—this does not negate the fact that the mineral resource itself would no longer be accessible. Therefore, this aspect of the project results in a potentially significant impact related to the loss of a known mineral resource.

b. Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?

Potentially Significant Impact. The project would phase out oil production activities and prohibit new oil wells in unincorporated Los Angeles County. Many of the affected oil fields are identified in local land use documents—including the General Plan and the Baldwin Hills Community Standards District—as locally important mineral resource recovery sites. By eliminating oil production operations at these locations, the project would permanently remove the opportunity to recover these locally important mineral resources.

This loss of locally significant oil resources could have notable economic repercussions. Reduced extraction activities may diminish regional energy independence, decrease local tax revenues and

royalties, and lead to fewer employment opportunities in communities historically reliant on oil production.

The project's planned amendments to the General Plan would remove the existing designation of some oil fields as resource recovery sites, thereby solidifying the irreversible loss of locally available mineral resources. Once extraction ceases, these finite resources cannot be restored or utilized for future benefit. Although the project advances important goals such as environmental protection and land-use compatibility, the trade-off includes a permanent reduction in mineral resource availability.

Given that these sites are delineated as mineral resource recovery locations in local planning documents, and the project would effectively foreclose future resource extraction, the impact is considered potentially significant under CEQA.

XIII. Noise

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. Generation of a substantial temporary or permanent increase in ambient noise levels in the vicinity of the project in excess of standards established in the County General Plan or noise ordinance (Los Angeles County Code, Title 12, Chapter 12.08), or applicable standards of other agencies?	☐	☐	☒	☐
b. Generation of excessive groundborne vibration or groundborne noise levels?	☐	☐	☒	☐
c. For a project located within the vicinity of a private airstrip or an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☒	☐

a. Generation of a substantial temporary or permanent increase in ambient noise levels in the vicinity of the project in excess of standards established in the County General Plan or noise ordinance (Los Angeles County Code, Title 12, Chapter 12.08), or applicable standards of other agencies?

Less than Significant Impact. The project would phase out oil production operations, resulting in the removal of existing industrial infrastructure, which may generate temporary construction-related noise during the decommissioning process. While these activities could increase ambient noise levels, they would be short-term, localized, and subject to strict controls. By removing the existing exemption for oil wells from the County's noise ordinance (Title 12, Chapter 12.08), all construction and decommissioning activities must comply with allowable noise levels and time-of-day restrictions, as well as the General Plan policies aimed at minimizing noise impacts on sensitive receptors.

The provisions of Los Angeles County Code, Title 12, Chapter 12.08—such as maintaining equipment in good working order, using mufflers, and limiting construction hours—ensure that any temporary increase in noise remains below regulatory thresholds and does not constitute a substantial permanent increase in ambient noise levels. Additionally, the project's Comment and Complaint Log requirement provides a mechanism for community members to report noise issues, prompting swift responses from operators to address potential nuisances. Once decommissioning is complete, oil production-related noise sources would be removed, likely resulting in a net reduction of long-term ambient noise in the vicinity. As a result, the project would not exceed established noise standards or create a lasting noise impact, and any temporary noise increases would be less than significant.

b. Generation of excessive groundborne vibration or groundborne noise levels?

Less than Significant Impact. The project involves the decommissioning and removal of oil wells and associated industrial infrastructure. Decommissioning activities—such as well plugging, equipment removal, and on-site restoration—may temporarily generate groundborne vibration and noise from heavy machinery or occasional vibratory equipment. These operations would be short-term, localized, and subject to best management practices that limit vibration levels.

The Los Angeles County Code and General Plan policies establish requirements to prevent or minimize excessive groundborne vibration, protecting both structures and sensitive receptors. By adhering to these regulations, the project ensures that any vibration from decommissioning remains below thresholds associated with building damage or undue annoyance. Moreover, the project's Site Maintenance provisions dictate the timely removal of heavy equipment once well work is finished, further reducing the duration of vibration impacts.

Once decommissioning is complete, no long-term vibration sources would remain, and the removal of oil production infrastructure would likely reduce ongoing operational noise and vibration relative to existing conditions. Consequently, the potential for the project to cause excessive groundborne vibration or noise is minimized, and impacts would be less than significant.

c. For a project located within the vicinity of a private airstrip or an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?

Less than Significant Impact. The project would phase out oil production activities, resulting in the removal of appurtenant infrastructure in unincorporated Los Angeles County. This action does not involve adding residential units or other uses that would bring new long-term occupants into areas exposed to aircraft noise. Instead, it removes industrial operations that may currently exist in or near such areas.

If any oil production sites are located within an airport land use plan area, near a private airstrip, or within two miles of a public airport, these conditions are already established by existing land use patterns and regulations. Noise from airport operations—such as takeoffs, landings, and overflights—is regulated at the federal and state level, and the Airport Land Use Commission (ALUC) establishes compatibility guidelines to protect communities from excessive aircraft-related noise.

The project's decommissioning and restoration activities are short-term and temporary. While there may be intermittent periods of on-site work during well plugging, equipment removal, or remediation, these do not constitute permanent noise-sensitive uses (such as residential developments, schools, or hospitals) that would be adversely affected by airport-related noise. Temporary workers are not considered sensitive receptors in the same way long-term residents or employees would be, since they are present only for limited periods and are protected by occupational safety and health standards.

Furthermore, once decommissioning is complete, no new structures or uses that increase occupancy or sensitivity to noise would be introduced near airports or private airstrips. In fact, by removing industrial machinery and equipment, the project could slightly reduce the overall noise profile of the area. The project does not alter existing flight paths, airport operations, or any established noise mitigation measures in effect under airport land use plans.

In summary, the project neither introduces new permanent noise-sensitive uses into areas affected by airport-related noise nor alters conditions in a manner that would expose people to excessive

airport noise. Therefore, the potential impact related to noise exposure from airports or private airstrips remains less than significant.

XIV. Population/Housing

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. **Induce substantial unplanned population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?**	☐	☐	☒	☐
b. **Displace substantial numbers of existing people or housing, especially affordable housing, necessitating the construction of replacement housing elsewhere?**	☐	☐	☐	☒

a. Induce substantial unplanned population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?

Less than Significant Impact. The project would phase out existing oil production operations, resulting in the removal of associated infrastructure, without introducing new housing, businesses, or infrastructure that could directly or indirectly induce population growth. Unlike projects that increase development capacity—such as building new residential units or extending utilities to previously undeveloped areas—this project focuses on eliminating industrial uses, rather than creating conditions conducive to unplanned growth.

The project does not expand services like water, sewer, or roads that could open new areas to development. The County's growth forecasts and housing needs, as reflected in the General Plan and Housing Element, are met by existing designated areas and do not rely on continued oil production. In fact, by removing oil infrastructure, the project helps free land for more compatible uses identified in the General Plan's long-term vision without encouraging unplanned or accelerated population growth.

Any workforce associated with the decommissioning activities would be temporary and sourced from existing labor pools, not resulting in a permanent increase in population or housing demand. Consequently, the project would not alter population distribution, density, or growth rates beyond what the County's plans and projections anticipate. Thus, the project would not induce substantial unplanned population growth, and impacts would be less than significant.

b. Displace substantial numbers of existing people or housing, especially affordable housing, necessitating the construction of replacement housing elsewhere?

No Impact. The project would phase out oil production operations and decommission existing wells on sites historically dedicated to industrial activities, not residential use. Because these sites do not contain housing units—affordable or otherwise—no one would be displaced because of the project's implementation. The project does not involve the demolition or alteration of existing housing, nor does it require relocation of any residents.

Following decommissioning, the affected sites could be restored or converted to uses more compatible with surrounding communities, consistent with County land use policies and housing preservation goals. This transition supports broader community and environmental objectives without displacing existing residential areas.

Since the project does not remove or reduce available housing stock, including affordable housing, it does not create a need for replacement housing elsewhere. As a result, no impact would occur in relation to the displacement of existing people or housing.

XV. Public Services

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project create capacity or service level problems, or result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services:				
a. Fire protection?	☐	☐	☒	☐
b. Sheriff protection?	☐	☐	☒	☐
c. Schools?	☐	☐	☒	☐
d. Parks?	☐	☐	☒	☐
e. Libraries?	☐	☐	☒	☐
f. Other public facilities?	☐	☐	☒	☐

a. Fire protection?

Less than Significant Impact. The project involves phasing out existing oil production activities and removing associated infrastructure rather than introducing new development that would increase population or fire service demand. Because the project does not create new residential, commercial, or industrial uses, it does not generate a substantial additional need for fire protection services beyond what is already provided by the Los Angeles County Fire Department (LACoFD).

In the short term, decommissioning activities require compliance with all applicable fire safety regulations, including the California Fire Code and the project's integrated Site Maintenance provisions, which mandate clearing flammable materials and cleaning up potential ignition sources (e.g., oil spills, dry brush). By removing oil-related infrastructure, the project ultimately reduces long-term fire hazards often associated with active wells, such as the presence of combustible materials or fuel storage. The Bonds required by the project further ensure that funds are available for proper site remediation, preventing scenarios where abandoned equipment or poorly sealed wells might contribute to fire risk.

Because no new population centers or structures are introduced, and because the dismantling of hazardous facilities may reduce fire risks, there is no adverse impact on local fire service capacity or response times. Consequently, the project's effect on fire protection remains less than significant.

b. Sheriff protection?

Less than Significant Impact. The project does not involve creating new residential or commercial uses that would substantially increase population or generate additional law enforcement demands. Instead, it phases out oil production and removes associated equipment, thereby eliminating industrial operations that may occasionally require sheriff intervention for trespassing, theft, or accidental spills.

During the temporary decommissioning phase, there may be a brief increase in on-site workers, but this workforce is finite and focused on specialized tasks such as well plugging and equipment

removal. This short-term presence does not lead to a permanent change in local population or ongoing calls for service. Moreover, the project's Site Maintenance provisions require operators to keep areas secure and free of hazards, thereby minimizing circumstances that could require law enforcement response.

Because it does not necessitate new or expanded sheriff facilities, any impacts on sheriff protection are less than significant.

c. Schools?

Less than Significant Impact. The project would phase out existing oil production activities and remove associated infrastructure and does not include any new residential development or land uses that would increase the local population. Without introducing additional households or creating conditions that attract new families to settle in the area, the project does not generate demand for new or expanded school facilities.

Decommissioning and restoration activities are temporary, involving specialized workers who typically commute from established residences rather than relocating with their families. As such, no measurable increase in student enrollment at local schools would occur. The project area would not experience any long-term population growth that could strain existing school capacity or require construction of new school facilities because of project activities.

Because the project does not contribute to population growth or generate new students, it poses no risk of exceeding current school capacities or necessitating additional educational services. Therefore, any impacts related to schools are considered less than significant.

d. Parks?

Less than Significant Impact. The project would phase out existing oil production activities and remove associated infrastructure, without introducing new residential or commercial development that could increase the local population. As a result, it does not generate additional demand for parkland or recreational facilities.

Unlike projects that add housing units or attract new workers and patrons, this project primarily involves decommissioning wells and restoring or converting sites to uses more compatible with surrounding communities. Because it neither contributes to population growth nor encourages new economic activity that would bring more people to the area, it does not place added pressure on local or regional park resources. The temporary workforce involved in decommissioning activities will not significantly use nearby parks, as their presence on-site is short-term and focused on the task at hand.

Once decommissioning is complete, affected sites could potentially be restored or transformed in ways that benefit surrounding communities via uses that align with the County's General Plan goals for sustainable and balanced land use. In doing so, the project may indirectly enhance community livability over time. However, the project does not require new or expanded park facilities to maintain existing service levels, nor does it diminish current recreational resources, as it does not authorize any new development.

In summary, because the project does not increase population or long-term park use, no substantial changes to park facility demands occur. Therefore, the impact on parks would be less than significant.

e. Libraries?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure and does not introduce new residential or commercial uses that would increase local population or user demand for library services. Without a corresponding rise in the number of residents, employees, or patrons, there would be no need to expand library facilities or services.

Any temporary workforce involved in the decommissioning process would be on-site for a limited duration and focused on industrial tasks, making it unlikely that they would significantly utilize nearby library resources. After the project's completion, the restored or converted sites will not create conditions that generate sustained library use. This outcome is fully consistent with County of Los Angeles Public Library planning guidelines and does not reduce existing library service ratios.

Because the project neither induces population growth nor increases long-term demands on library infrastructure, it would not require new or expanded library facilities to maintain acceptable service levels. Therefore, the impact related to libraries would be less than significant.

f. Other public facilities?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure without introducing new development that could increase demands on public facilities other than those already considered (e.g., fire, law enforcement, schools, parks, libraries). It does not add residential, commercial, or industrial uses that would generate additional users of government offices, community centers, or other local services.

During decommissioning, a temporary workforce may be present, but their needs would be minimal, short-lived, and easily accommodated by existing public facilities. Once oil operations cease and affected sites are restored or converted to uses more compatible with surrounding communities, there would be no ongoing population increase or long-term need for expanded public services or infrastructure as the project does not authorize future development of affected project sites.

Given that the project neither induces new population growth nor significantly alters existing land use intensities, it does not require the construction or expansion of other public facilities to maintain acceptable levels of service. Therefore, impacts related to other public facilities would be less than significant.

XVI. Recreation

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. **Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?**	☐	☐	☒	☐
b. **Does the project include neighborhood and regional parks or other recreational facilities or require the construction or expansion of such facilities which might have an adverse physical effect on the environment?**	☐	☐	☒	☐
c. **Would the project interfere with regional trail connectivity?**	☐	☐	☒	☐

a. Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure and does not introduce new housing, commercial development, or other uses that would substantially increase the local population. Without added residents or a significant number of new workers or visitors, the project would not create additional demand for neighborhood or regional parks and other recreational facilities in the area.

While decommissioning activities may involve a temporary workforce on-site, these workers are focused on specialized industrial tasks and are unlikely to significantly use nearby parks. Any on-site presence is short-term and would not result in a noticeable increase in recreational facility usage. Once operations cease and affected sites are restored or converted to more community-compatible uses, the project may even contribute to improved environmental quality and potentially enhance local open space. However, this positive outcome would not place additional strain on existing parks.

Since the project neither draws new residents nor expands the local workforce in a way that would increase park visitation, it does not cause or accelerate physical deterioration of recreational facilities. As a result, impacts related to increased use of neighborhood or regional parks, or other recreational facilities, are considered less than significant.

b. Does the project include neighborhood and regional parks or other recreational facilities or require the construction or expansion of such facilities which might have an adverse physical effect on the environment?

Less than Significant Impact. The project would phase out existing oil operations and restore or convert affected sites, but it does not include constructing new neighborhood or regional parks or expanding existing recreational facilities. Nor does the project create conditions that would increase

population or demand for recreational services, as it does not involve residential development or attract new, long-term users to the area.

While restoration efforts may enhance open space and potentially support future compatible land uses, this outcome does not necessitate new or expanded park facilities to serve a larger population. Since the project does not generate substantial demand for recreation services, there is no need to construct additional recreational amenities that could result in adverse environmental effects.

In summary, the project does not include or require the development or enlargement of parks or recreational facilities that could negatively impact the environment. Therefore, any impacts related to recreation facilities construction or expansion would be less than significant.

c. Would the project interfere with regional trail connectivity?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure without introducing new development that would block, reroute, or permanently alter regional trails. Oil well sites are restricted areas, not within established trail corridors, and the project does not include facilities or operations that would disrupt existing regional trail networks.

While short-term decommissioning activities may temporarily require limited access restrictions or safety measures near active work areas, any such disruptions to trail connectivity would be localized and brief. Compliance with County guidelines, including coordination with appropriate agencies if trails exist near project sites, would ensure that any temporary effects on trail access or continuity are minimized.

Following decommissioning, restored or converted sites could potentially enhance open space quality and availability. In some cases, this might indirectly benefit nearby regional trails by improving scenic values or future open space planning. Because the project does not create permanent barriers or significantly change the landscape in a way that would impede trail connectivity, any impacts related to regional trails would be less than significant.

XVII. Transportation

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. **Conflict with an applicable program, plan, ordinance, or policy addressing the circulation system, including transit, roadway, bicycle, and pedestrian facilities?**	☐	☐	☒	☐
b. **Conflict or be inconsistent with CEQA Guidelines section 15064.3, subdivision (b)?**	☐	☐	☒	☐
c. **Substantially increase hazards due to a geometric design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?**	☐	☐	☒	☐
d. **Result in inadequate emergency access?**	☐	☐	☒	☐

a. Conflict with an applicable program, plan, ordinance, or policy addressing the circulation system, including transit, roadway, bicycle, and pedestrian facilities?

Less than Significant Impact. The project would phase out oil production activities and remove related infrastructure and does not introduce new development or land uses that would alter the region's circulation system or conflict with applicable transportation policies. Unlike projects that add homes, businesses, or large-scale facilities, this project does not generate significant new vehicle trips or demand for transit, bicycle, or pedestrian improvements.

Any transportation effects are tied to the short-term decommissioning phase, during which specialized equipment and materials would be delivered to and removed from the project sites. Although this may result in temporary increases in truck traffic, these trips would be limited in number and duration. The project's contractors would coordinate with local agencies to ensure compliance with existing roadway standards and traffic management regulations, minimizing disruptions. Measures such as scheduling deliveries during off-peak hours and following established haul routes can further reduce any temporary impact to vehicle, transit, bicycle, or pedestrian circulation.

The project does not involve permanent infrastructure changes or long-term activities that would necessitate modifications to transit routes, bicycle facilities, or sidewalks. Once decommissioning is complete, the affected sites could be restored or converted to uses more compatible with the surrounding communities without introducing circulation conflicts. Thus, the project remains consistent with local and regional transportation plans, ordinances, and policies, including those encouraging multimodal travel.

In summary, any short-term transportation effects would be managed and minor, and the project does not create conditions that would permanently conflict with or hinder established transportation policies or programs. As a result, impacts related to the circulation system are considered less than significant.

b. Conflict or be inconsistent with CEQA Guidelines section 15064.3, subdivision (b)?

Less than Significant Impact. CEQA Guidelines Section 15064.3(b) requires evaluating transportation impacts based on vehicle miles traveled (VMT) rather than traditional measures like congestion. The project, which entails decommissioning and removing oil production infrastructure, does not propose new developments that would generate long-term vehicle trips or substantially alter regional travel patterns.

Any transportation-related activities would be short-term and limited to the decommissioning phase, involving a temporary increase in trips associated with equipment and material delivery. These activities are short-lived, localized, and would not result in a permanent increase in VMT. Once the decommissioning work is complete, no ongoing VMT-generating operations remain.

By phasing out fossil fuel extraction, the project may indirectly reduce future transportation-related energy use and associated emissions over the long term. It does not create conditions that conflict with efforts to reduce VMT or hinder broader goals of State and Local CEQA Guidelines to minimize transportation-related environmental impacts.

In sum, the project neither introduces new long-term VMT sources nor conflicts with the objectives of CEQA Guidelines Section 15064.3(b). Therefore, impacts related to VMT are considered less than significant.

c. Substantially increase hazards due to a road design feature (e.g., sharp curves) or incompatible uses (e.g., farm equipment)?

Less than Significant Impact. The project does not involve constructing new roadways or altering existing ones in a manner that would introduce hazardous design features. It decommissions oil production operations and removes associated infrastructure, activities that occur within or adjacent to existing industrial sites already accessed by established roads designed to accommodate similar equipment and traffic.

During the temporary decommissioning period, the project may generate a limited number of trips by heavy trucks and specialized machinery. However, these vehicles would use existing roadways that currently serve industrial or similarly intensive uses. Compliance with local safety standards, permitting requirements, and traffic control measures will ensure that any short-term changes in traffic patterns are managed responsibly. This may include scheduling vehicle movements during off-peak hours and using proper signage or flaggers if necessary.

No modifications to road layouts, such as adding sharp curves or narrowing lanes, are proposed. The project also does not introduce long-term incompatible uses that would pose ongoing traffic safety concerns. Once decommissioning is complete, traffic will return to baseline levels, and no new hazards will be introduced.

As a result, the project does not substantially increase roadway hazards due to design features or incompatible uses, and any minor, short-term impacts on road use are effectively mitigated by adherence to existing traffic and safety regulations. The impact is therefore considered less than significant.

d. Result in inadequate emergency access?

Less than Significant Impact. The project would not introduce new structures, permanent changes to roadways, or ongoing activities that would impede emergency response routes. While

temporary decommissioning activities may generate short-term increases in truck traffic and occasional equipment movement, these effects would be carefully managed. Standard traffic control measures, coordinated with local authorities, would ensure that emergency vehicles maintain unobstructed access to and through the project area.

The project will comply with all applicable Los Angeles County fire and safety regulations, including those regarding emergency access in areas such as Very High Fire Hazard Severity Zones. Any temporary restrictions during decommissioning would be minimal, localized, and short-lived, with existing measures in place—such as scheduling deliveries during off-peak hours, using flaggers or temporary signage—to maintain emergency vehicle flow.

Once oil production activities cease and the sites are restored or converted to more compatible uses, there would be no long-term changes that compromise emergency access. In fact, removing industrial facilities may reduce certain risks associated with operational hazards. Therefore, the project would not result in inadequate emergency access, and impacts would be less than significant.

XVIII. Tribal Cultural Resources

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
a. Would the project cause a substantial adverse change in the significance of a tribal cultural resource, defined in Public Resources Code §21074 as either a site, feature, place, cultural landscape that is geographically defined in terms of the size and scope of the landscape, sacred place, or object with cultural value to a California Native American tribe, and that is:				
i) **Listed or eligible for listing in the California Register of Historical Resources, or in a local register of historical resources as defined in Public Resources Code § 5020.1(k)?**	☐	☐	☒	☐
ii) **A resource determined by the lead agency, in its discretion and supported by substantial evidence, to be significant pursuant to criteria set forth in subdivision (c) of Public Resources Code § 5024.1. In applying the criteria set forth in subdivision (c) of Public Resources Code § 5024.1, the lead agency shall consider the significance of the resource to a California Native American tribe?**	☐	☐	☒	☐

a. Listed or eligible for listing in the California Register of Historical Resources, or in a local register of historical resources as defined in Public Resources Code § 5020.1(k)?

Less than Significant Impact. The project would phase out oil production operations and remove associated infrastructure primarily located in previously disturbed industrial areas, where the likelihood of encountering intact tribal cultural resources is low. Under Public Resources Code §21074, tribal cultural resources include sites, features, places, cultural landscapes, sacred places, and objects with cultural value to a California Native American tribe that may be listed, or eligible for listing, in the California Register of Historical Resources or a local register of historical resources. Because the project does not introduce new ground-disturbing activities in previously undisturbed areas, the potential to affect such resources is minimal.

In accordance with Assembly Bill (AB) 52, the County initiated consultation with California Native American tribes that have requested notification of proposed projects in the area. This consultation process provides tribes with the opportunity to identify any known or suspected tribal cultural resources within or near the project sites. If any such resources are identified as listed or eligible for listing in the California Register or a local register, the County will work collaboratively with the tribe(s) and, if needed, a qualified archaeologist, to avoid or mitigate potential impacts. Standard treatment protocols would be implemented if tribal cultural resources are inadvertently discovered during decommissioning activities, including halting work in the immediate vicinity and consulting with tribal representatives and cultural resource professionals to determine appropriate next steps.

Given that the project sites are industrial in nature and previously disturbed, and that the County will comply with all applicable consultation and resource protection requirements, it is unlikely that tribal cultural resources would be adversely affected. Therefore, any impact to tribal cultural resources

listed or eligible for listing in the California Register of Historical Resources or a local register would be less than significant.

b. A resource determined by the lead agency, in its discretion and supported by substantial evidence, to be significant pursuant to criteria set forth in subdivision (c) of Public Resources Code § 5024.1. In applying the criteria set forth in subdivision (c) of Public Resources Code § 5024.1, the lead agency shall consider the significance of the resource to a California Native American tribe?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure from previously disturbed industrial sites. These areas are generally unlikely to contain intact tribal cultural resources that hold significance to California Native American tribes. Nonetheless, the County, as the lead agency, has complied with AB 52 requirements by notifying tribes traditionally and culturally affiliated with the project area early in the CEQA process, providing them with the opportunity to identify any tribal cultural resources of concern.

If any resource is brought to the County's attention during consultation, the County will evaluate its significance under the criteria in Public Resources Code §5024.1(c). This assessment would be informed by tribal input, cultural record searches, and professional archaeological expertise. Should a resource meeting the criteria be identified, the project would incorporate measures to avoid, preserve, or mitigate impacts to that resource, in cooperation with the tribes and consistent with state and local regulatory frameworks.

Given that the project area is already disturbed and no tribal cultural resources meeting the criteria set forth in Public Resources Code §5024.1(c) have been identified thus far, the likelihood of encountering a significant tribal cultural resource is low. In the unlikely event that previously unknown resources are discovered during decommissioning, work in the vicinity would cease until appropriate evaluation and treatment measures are implemented. As a result, potential impacts to tribal cultural resources under this category are anticipated to be less than significant.

XIX. Utilities/Service Systems

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. Require or result in the relocation or construction of new or expanded water, wastewater treatment, storm water drainage, electric power, natural gas, or telecommunication facilities, the construction or relocation of which could cause significant environmental effects?	☐	☐	☒	☐
b. Have sufficient water supplies available to serve the project and reasonably foreseeable future development during normal, dry and multiple dry years?	☐	☐	☒	☐
c. Result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?	☐	☐	☒	☐
d. Generate solid waste in excess of State or local standards, or in excess of the capacity of local infrastructure, or otherwise impair the attainment of solid waste reduction goals?	☐	☐	☒	☐
e. Comply with federal, state, and local management and reduction statutes and regulations related to solid waste?	☐	☐	☒	☐

a. Require or result in the relocation or construction of new or expanded water, wastewater treatment, storm water drainage, electric power, natural gas, or telecommunication facilities, the construction or relocation of which could cause significant environmental effects?

Less than Significant Impact. The project would phase out oil production operations and remove associated infrastructure on previously disturbed industrial sites. It would not introduce new development, housing, businesses, or other uses that increase long-term demands on public utilities and service systems. As a result, it is not expected to require or result in the relocation or construction of new or expanded water, wastewater treatment, stormwater drainage, electric power, natural gas, or telecommunication facilities that could lead to significant environmental impacts.

The project involves temporary decommissioning activities and does not introduce a new water demand or substantial wastewater generation. Any minimal water use during decommissioning would be short-term and easily accommodated by existing supplies and facilities. Compliance with the project's Site Maintenance requirements and Well Plugging and Abandonment standards ensures that vacated facilities do not become sources of ongoing utility burdens. No new sewer connections or expansions are needed because the project does not generate long-term wastewater discharges that would exceed current system capacities.

The project sites are already developed with industrial infrastructure. Decommissioning and restoration activities may improve natural infiltration or encourage more compatible future land uses that reduce reliance on engineered drainage systems. The project does not involve adding large areas of impervious surfaces or altering stormwater flow to such an extent that it would necessitate new or expanded stormwater drainage facilities. Compliance with the County's Low Impact Development (LID) standards ensures that potential changes in runoff are managed sustainably and within existing system capabilities.

Temporary electrical and other utility demands during decommissioning are minimal and can be met by existing infrastructure. No long-term operational changes would occur that increase demand for energy or communication services. Consequently, no new or upgraded utility infrastructure is needed beyond what is already in place.

Considering that the project does not increase permanent population, alter land uses to more intensive activities, or require substantial new infrastructure, impacts related to utilities and service systems are less than significant.

b. Have sufficient water supplies available to serve the project and reasonably foreseeable future development during normal, dry and multiple dry years?

Less than Significant Impact. The project would not introduce new residents, businesses, or long-term operations that significantly increase water demand. Instead, it involves the temporary use of minimal water supplies to support decommissioning activities, such as dust control and equipment cleaning, followed by site restoration or conversion to more compatible uses. Once oil production ceases, there is no ongoing need for substantial water consumption.

Any short-term water needs can be met by existing water sources and infrastructure, as these demands are neither continuous nor large enough to strain local supplies. The project does not meet thresholds that would trigger the preparation of a water supply assessment under Senate Bill (SB) 610 or SB 221, nor does it require new entitlements. It also does not alter regional water supply plans or compromise water availability during normal, dry, or multiple dry years.

Compliance with County and state water conservation measures and water quality standards ensures that any temporary water use will be managed responsibly. By requiring operators to meet Bonds obligations and fulfilling Well Plugging and Abandonment standards, the project ensures that old infrastructure is removed and sites do not demand future water resources. Because the project does not significantly increase water demand, impacts related to having sufficient water supplies for the project and reasonably foreseeable future development are less than significant.

c. Result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?

Less than Significant Impact. The project requires the decommissioning and removal of oil wells and associated infrastructure, which are not activities that would generate a substantial volume of wastewater. Any wastewater produced during decommissioning—such as from equipment cleaning or temporary sanitation facilities for workers—would be minimal, short-term, and easily accommodated by existing wastewater treatment infrastructure.

Once decommissioning is complete, the project does not introduce new land uses or operations that would produce ongoing wastewater flows. In fact, the cessation of oil production may reduce any previous wastewater loads associated with those activities, freeing up capacity in the long term. Because the project's limited and temporary wastewater demands do not approach the capacity limits of the existing service providers, no expansions or new wastewater treatment facilities would be required. The project's Site Maintenance and Well Plugging and Abandonment provisions help ensure that contaminants are properly contained, preventing any unexpected load on wastewater systems.

As a result, the project would not hinder a wastewater treatment provider's ability to serve its existing commitments or require adjustments to their operational capacity. Thus, the impact on wastewater treatment capacity would be less than significant.

d. Generate solid waste in excess of State or local standards, or in excess of the capacity of local infrastructure, or otherwise impair the attainment of solid waste reduction goals?

Less than Significant Impact. The project would decommission and remove oil wells and associated infrastructure, generating a temporary increase in construction and demolition debris rather than ongoing solid waste. Any waste produced during these decommissioning activities—such as piping, equipment, and concrete—would be managed in accordance with applicable State and local regulations, including those focused on waste diversion, recycling, and proper disposal.

California's solid waste regulations (e.g., AB 939) and the County's Integrated Waste Management Plan guide the proper handling and reduction of solid waste. A substantial portion of construction and demolition debris can often be recycled or reused, minimizing the amount sent to landfills. Existing regional landfill facilities have sufficient remaining capacity, as confirmed by regular assessments in the Integrated Waste Management Plan, to accommodate the temporary volume of materials generated by the project. Moreover, no new long-term waste streams would be created, and once decommissioning is complete, the project would not generate operational waste.

Compliance with established waste management standards ensures that the project's short-term increase in solid waste would not exceed State or local thresholds or hinder solid waste reduction goals. Adhering to the project's Site Maintenance provisions also ensures prompt removal of debris to avoid any accumulation or environmental hazards. As a result, impacts related to solid waste capacity and standards would be less than significant.

e. Comply with federal, state, and local management and reduction statutes and regulations related to solid waste?

Less than Significant Impact. The project would generate a limited amount of solid waste as part of the temporary oil well decommissioning process, including dismantled infrastructure and construction and demolition debris. All handling, storage, transportation, and disposal of this waste would occur in accordance with federal, state, and local statutes and regulations related to solid waste management and reduction.

All project activities must comply with the California Integrated Waste Management Act (AB 939), which mandates recycling and waste diversion, as well as local ordinances requiring construction and demolition waste diversion. This includes adherence to the County's Source Reduction and Recycling Element and compliance with regional and state-mandated diversion targets. Additionally, the project must follow the County's Construction and Demolition Debris Recycling Ordinance,

ensuring that a significant portion of generated debris is recycled or reused rather than disposed of in landfills.

Facilities receiving solid waste from the project would be properly permitted and operated in accordance with the Integrated Waste Management Plan and other relevant guidelines, ensuring adequate disposal capacity. Since the project does not create new sources of ongoing waste but merely addresses temporary demolition waste, it will not impair the County's ability to meet solid waste reduction goals. Under the project's Site Maintenance requirements, operators are responsible for removing demolition debris and potential contaminants in a timely, regulated manner. Licensed waste haulers and permitted disposal facilities ensure compliance with relevant codes, while performance standards in Bonds guarantee financial resources for any necessary remediation or proper waste handling. Furthermore, no permanent increase in solid waste generation will occur once the decommissioning is complete.

By adhering to all applicable solid waste regulations and policies, the project will ensure that any waste generated is managed responsibly and sustainably. As a result, the project's impact related to compliance with solid waste management and reduction statutes is considered less than significant.

XX. Wildfire

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
If located in or near state responsibility areas or lands classified as very high fire hazard severity zones, would the project:				
a. **Substantially impair an adopted emergency response plan or emergency evacuation plan?**	☐	☐	☒	☐
b. **Due to slope, prevailing winds, and other factors, exacerbate wildfire risks, and thereby expose project occupants to pollutant concentrations from a wildfire or the uncontrolled spread of a wildfire?**	☐	☐	☒	☐
c. **Require the installation or maintenance of associated infrastructure (such as roads, fuel breaks, emergency water sources, power lines or other utilities) that may exacerbate fire risk or that may result in temporary or ongoing impacts to the environment?**	☐	☐	☒	☐
d. **Expose people or structures to significant risks, including downslope or downstream flooding or landslides, as a result of runoff, post-fire slope instability, or drainage changes?**	☐	☐	☒	☐

a. Substantially impair an adopted emergency response plan or emergency evacuation plan?

Less than Significant Impact. The project requires the phasing out of oil production activities, resulting in the removal of existing appurtenant infrastructure. Project activities are expected to occur within existing industrial sites and rights-of-way, without introducing new permanent land uses or significant physical changes that could obstruct or interfere with emergency response routes or evacuation procedures.

Los Angeles County maintains emergency response and evacuation plans, such as the Operational Area Emergency Response Plan and the All-Hazards Mitigation Plan, which designate emergency routes and procedures. These plans are designed to ensure adequate public safety and effective disaster response across the County, including areas where oil wells are located.

During decommissioning activities, temporary increases in vehicle traffic and equipment staging may occur near project sites. However, these effects will be localized and short-term, and project activities will be required to coordinate with local agencies, such as the County Department of Public Works and Office of Emergency Management, to ensure compliance with emergency access requirements. Such coordination includes maintaining clear access to designated emergency routes and complying with traffic control measures to minimize disruptions.

Additionally, the project does not propose any alterations to critical infrastructure or public rights-of-way that would permanently impair emergency response capabilities. Compliance with existing regulatory frameworks, including building and safety codes, further reduces the potential for significant impacts. By removing industrial hazards and following the project's Site Maintenance

standards—such as clearing debris and combustible materials—the project may actually enhance overall safety.

Given the temporary and manageable nature of potential disruptions and the regulatory oversight in place, the project is not expected to substantially impair any adopted emergency response or evacuation plan. Therefore, the impact is considered less than significant.

b. Due to slope, prevailing winds, and other factors, exacerbate wildfire risks, and thereby expose project occupants to pollutant concentrations from a wildfire or the uncontrolled spread of a wildfire?

Less than Significant Impact. The project would phase out oil operations and remove associated infrastructure within areas already designated and managed for industrial use. Some project sites lie within or near Very High Fire Hazard Severity Zones (VHFHSZs), where factors such as slope and prevailing winds can contribute to wildfire risks. However, the project would not introduce new permanent development or occupants who could be exposed to wildfire-related hazards. Instead, it focuses on removing oil production infrastructure and restoring or converting disturbed areas to uses more compatible with surrounding communities.

Temporary decommissioning activities might involve equipment that could ignite sparks or generate heat. Compliance with applicable fire prevention and safety requirements—including coordination with the Los Angeles County Fire Department, adherence to the California Fire Code, and implementing best management practices such as spark prevention, regular equipment maintenance, and on-site fire suppression—will minimize fire risks during this short-term phase.

Once oil production equipment is removed, potential ignition sources decrease, potentially reducing long-term fire risks. Without the introduction of residents or employees to areas of elevated wildfire risk, there is no added population at risk of exposure to wildfire smoke or pollutant concentrations. While the site's natural conditions and climate factors remain unchanged, the project neither increases vulnerability to wildfires nor places people in harm's way.

In summary, due to strict compliance with fire safety measures, no permanent occupancy, and the elimination of industrial hazards, the project would not exacerbate wildfire risks or expose occupants to significant pollutant concentrations from a wildfire. Therefore, the impact is considered less than significant.

c. Require the installation or maintenance of associated infrastructure (such as roads, fuel breaks, emergency water sources, power lines or other utilities) that may exacerbate fire risk or that may result in temporary or ongoing impacts to the environment?

Less than Significant Impact. The project requires phasing out of oil production activities, which results in the removal of industrial infrastructure. The project would not create new infrastructure or facilities that could elevate fire risk or cause ongoing environmental impacts. Instead, it focuses on decommissioning and removing existing oil production equipment, with all work occurring within or adjacent to areas already served by established roads, utilities, and industrial access points.

No new roads, fuel breaks, emergency water sources, or additional power lines are needed to implement the project. Temporary modifications may occur during the decommissioning phase, such as using existing roads for equipment transport or making minor adjustments to existing utilities. However, these activities will be short-term and conducted in compliance with applicable fire

safety regulations (e.g., California Fire Code requirements) and environmental standards. All project activities must follow best management practices—such as controlling spark sources, maintaining defensible space, and ensuring the availability of fire suppression tools—to prevent increasing wildfire risk.

By eliminating oil production infrastructure, the project may reduce long-term fire hazards by removing potential ignition sources. No ongoing maintenance of new infrastructure is required, minimizing the potential for habitat disturbance or other environmental impacts.

The project does not involve the installation or maintenance of additional infrastructure that could exacerbate wildfire risk. Any temporary impacts during decommissioning are managed through adherence to existing safety and environmental protocols, ensuring that the overall impact remains less than significant.

d. Expose people or structures to significant risks, including downslope or downstream flooding or landslides, as a result of runoff, post-fire slope instability, or drainage changes?

Less than Significant Impact. The project would phase out oil production operations and remove associated industrial infrastructure on previously disturbed sites, rather than introducing new development or major land alterations. Consequently, it does not create conditions that would increase the likelihood of downslope or downstream hazards, including flooding or landslides, resulting from altered drainage or post-fire slope instability.

While decommissioning activities involve some ground disturbance, these are short-term and localized. Compliance with County grading and erosion control regulations, as well as adherence to stormwater management requirements, ensures that any disturbed areas are stabilized promptly. Restoration or conversion of the sites to more compatible land uses will improve soil stability and infiltration capacity, thereby reducing the potential for post-project runoff or slope destabilization.

Because the project does not create large expanses of impervious surfaces or modify slopes in ways that could exacerbate post-fire instability or alter natural drainage patterns, the risk of inducing new flood or landslide hazards is minimal. If any site work occurs near potentially sensitive slopes, geotechnical evaluations and corresponding mitigation measures would be applied, further reducing the risk of adverse effects.

In summary, by following existing regulatory standards and best management practices, the project will not expose people or structures to significant risks from runoff, post-fire slope instability, or drainage changes. Therefore, impacts are considered less than significant.

XXI. Mandatory Findings of Significance

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. Does the project have the potential to substantially degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, substantially reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?	☐	☐	☒	☐
b. Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)?	☐	☐	☒	☐
c. Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?	☐	☐	☒	☐

a. Does the project have the potential to substantially degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, substantially reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?

Less than Significant Impact. The project phases out oil production activities and removes associated industrial infrastructure from sites that are largely previously disturbed. Although decommissioning may involve short-term ground-disturbing activities, these occur under stringent regulatory frameworks and established best management practices (BMPs) that safeguard sensitive biological and cultural resources. Compliance with laws and regulations, such as the California Endangered Species Act, the Migratory Bird Treaty Act, and the County's Significant Ecological Area (SEA) protections, ensures that fish, wildlife, and plant communities are not substantially harmed. If any tribal cultural or archaeological materials are encountered, work would cease, and appropriate consultation and treatment measures would be implemented to prevent significant impacts to cultural resources.

Over the long term, ceasing oil production and removing infrastructure would likely improve local environmental conditions, reduce pollution sources, and allow for habitat recovery or more compatible land uses. Therefore, the project does not substantially degrade environmental quality or threaten ecological or cultural integrity. Any potential impacts are considered less than significant.

b. Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)?

Less than Significant Impact. The project does not introduce new development or activities that would notably increase population, traffic, or pollution. Instead, it phases out an existing source of environmental impacts—oil production—resulting in the removal of industrial infrastructure and associated emissions, hazards, and disturbance. This action aligns with broader regional and state goals to reduce fossil fuel reliance, improve air quality, and protect habitats, thus making an incremental positive contribution to cumulative environmental conditions.

While short-term decommissioning activities may generate minor increases in noise, dust, and localized emissions, these are temporary, controlled by BMPs and regulations, and do not significantly contribute to cumulative adverse conditions. Viewed alongside other past, current, and future projects aimed at environmental improvement and sustainable resource use, the project's incremental effects are beneficial rather than cumulatively considerable. Thus, the project's contribution to cumulative impacts is less than significant.

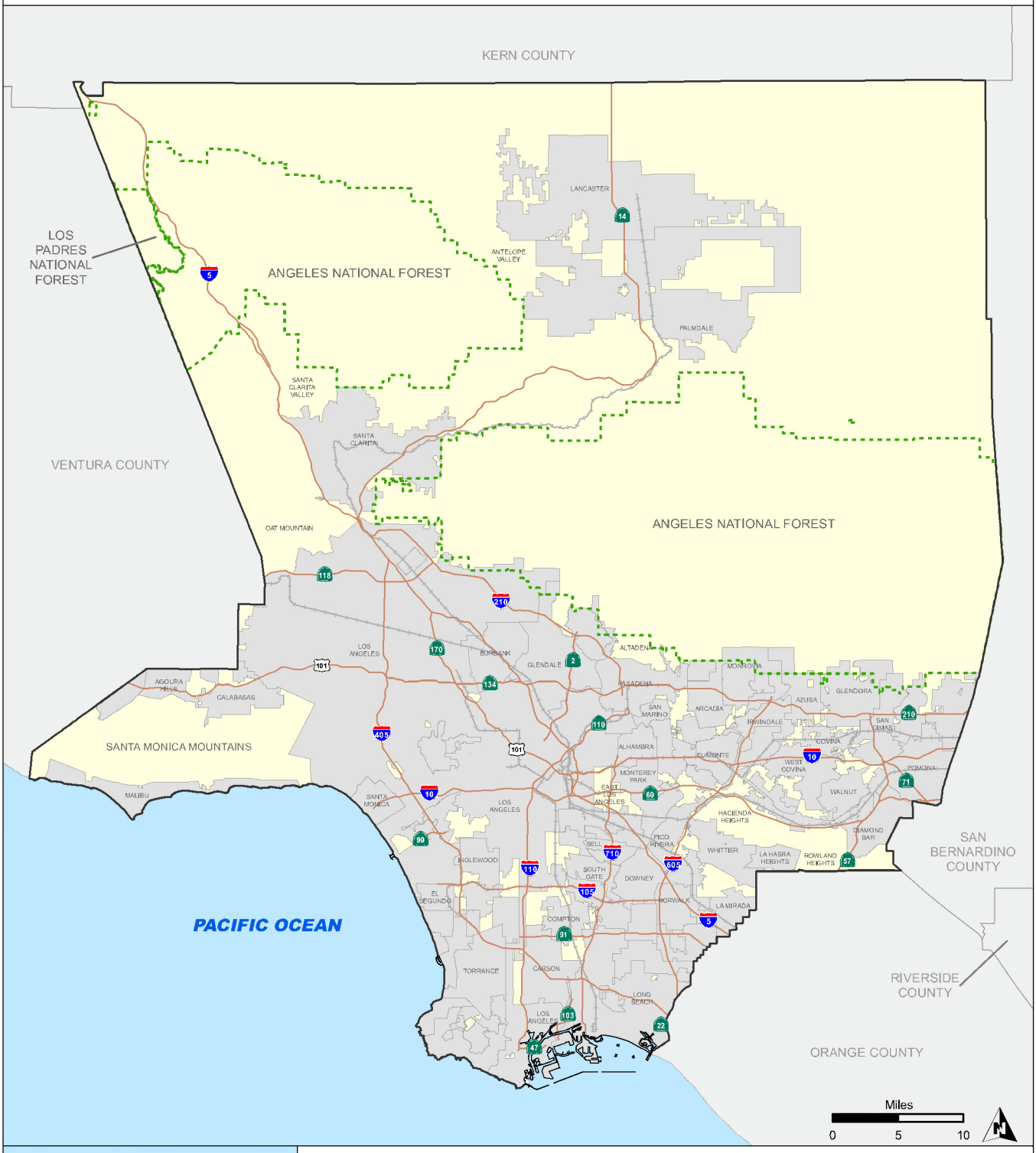
c. Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?

Less than Significant Impact. By eliminating oil production operations and associated hazards, the project is expected to improve local environmental quality over time, thereby reducing potential health risks to surrounding communities. Short-term construction-related effects—such as noise, dust, and limited equipment traffic—are temporary, subject to compliance with local ordinances, and minimized through standard control measures. There are no permanent increases in activities that would adversely affect public health, such as introducing new sources of pollution or hazards.

In the long term, the absence of operational oil wells and infrastructure reduces exposure to industrial contaminants, vibrations, and noise. This outcome supports better public health outcomes and environmental justice goals. Consequently, any direct or indirect effects on human beings are short-lived, well-managed, and less than significant.

Los Angeles County Unincorporated Areas

Figure 1





Unincorporated Areas

Cities

Source: Department of Regional Planning, May 2014

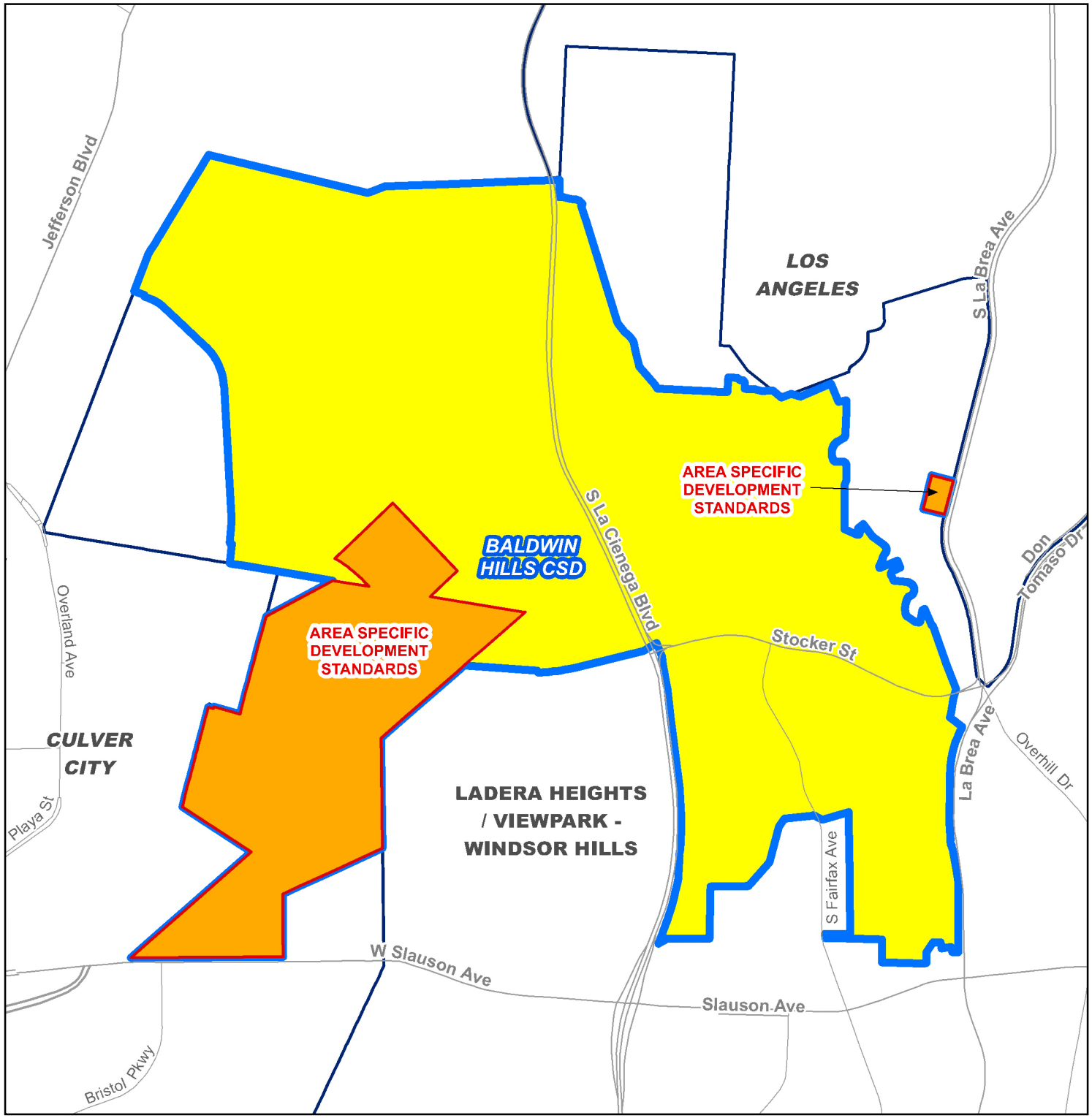


Figure 2

COUNTY OF LOS ANGELES

Baldwin Hills Community Standards District

LEGEND:

- Community Standards District
- Area Specific Standards
- City / Unincorporated

Key Map:



N

0 375 750 1,500 Feet

Los Angeles County
Dept. of Regional Planning
320 W. Temple St.
Los Angeles, CA 90012

..\OTHER\MAP_SERIES\supp_dist\map_documents\Supp_Dist_CSD_Baldwin_Hills

CALIFORNIA ENERGY COMMISSION

CALIFORNIA NATURAL RESOURCES AGENCY

June 27, 2025

Dear Governor Newsom,

Thank you for the opportunity to respond to your April 21, 2025, letter soliciting recommendations from our office on changes to state policy to ensure adequate transportation fuels supply during this pivotal time in our state's clean energy transition. In the months since receiving your letter, your energy team has engaged with the Petroleum Strategy Task Force, continued deep research into global petroleum market trends, convened roundtables and discussions with diverse stakeholders representing varied interests, and utilized new data afforded to us by legislation enacted over the last several years to better understand the petroleum industry.

This letter offers our strategies and recommendations to address your request for actions to ensure that Californians have access to safe, affordable, and reliable transportation fuels and that petroleum refiners continue to see value in serving the California market, even as in-state demand for petroleum-based fuels declines over the coming decades. These recommendations reflect the complexity of the issue, input from a multitude of stakeholders, and a faithful synthesis of robust data and discussions. We believe that these actions are necessary as the State considers its next steps to further our clean energy transition.

We look forward to working with members of the Legislature, fellow state agencies, industry, and stakeholders to implement these strategies. Together, we will evolve California's strategy to successfully phase out petroleum-based fuels by 2045 while protecting communities, workers, and consumers, and foster market conditions that support the industry's ability to operate safely, reliably, and successfully to meet demand through the transition.

Executive Summary

California's petroleum market is evolving rapidly, as California's pioneering climate and air quality policies, which are critical to protecting our communities' health, have accelerated the adoption of highly fuel-efficient conventional vehicles and zero emission vehicles (ZEVs), leading to a decline in demand for petroleum-based fuels. The decreasing demand for petroleum-based fuels underscores California's success in its transition to a sustainable, clean energy future. But the decreasing demand, economic factors, and volatility of the international petroleum market also introduces uncertainty to the petroleum industry, which impacts consumers, the workforce, and fenceline communities. That uncertainty has only been compounded this year by actions of the current federal administration, which have both added more shocks to the global petroleum market and sought to undermine California's transition away from reliance on petroleum-based fuels.

In California, recent years have been marked by higher gasoline retail prices, in-state petroleum refinery conversions and exits, and a growing reliance on fuel imports to meet consumer demand. These impacts are not isolated to California and are also being felt nationally and globally. To address dramatic gasoline retail price spikes, you partnered with the Legislature in 2023 and 2024 to provide the CEC with new industry and market transparency tools to better understand the causes behind gasoline price spikes and to develop strategies to protect consumers during the transition to clean, alternative fuels.

Current analysis indicates a continued decline in gasoline demand; a credible risk of rapid near-term conversions or exits of existing refineries, which is consistent with global refinery industry consolidation; impacts to other critical infrastructure across the upstream, midstream and downstream segments; and safety and reliability challenges associated with disinvestment along the petroleum value chain.

The success of California's decarbonization strategies are transforming the state's transportation sector from its early transition phase into its pivotal and challenging "mid transition" phase.[1] In this phase, demand for the

[1] Grubert and Hastings-Simon (2022). *Designing the mid-transition: A review of medium-term challenges for coordinated decarbonization in the United States*. WIREs Climate Change. https://doi.org/10.1002/wcc.768

incumbent petroleum-based fuel system, while declining, remains substantial, as the clean, alternative fuel system continues to scale. In this phase, investor confidence in the incumbent system is expected to falter due to long-term uncertainty about the trajectory and pace at which these two systems evolve.

During this mid-transition phase, the State must simultaneously continue supporting the rapid expansion of new clean, alternative fuels while actively managing a gradual responsible phase-down of the incumbent systems that millions of Californians will continue to depend upon for years to come. Successfully managing this transition and continuing the State's long-standing leadership in addressing climate, air quality, health, and environmental issues will require coordinated actions and strategic alignment of state, regional, and local jurisdictions.

As a result of all of these factors, immediate State actions are necessary to stabilize the near-term vulnerabilities of the entire transportation system and implement a comprehensive strategy to support a successful transition. Given sufficient time, the petroleum market is likely to find a new equilibrium following the disruption of a refinery closure, but in the near term, an abrupt loss of refining capacity and the increased need for imported fuel to compensate is likely to create new risks for stable fuel prices and supply. Keeping in-state and imported fuel competitive will be an important balancing act moving forward, because if the cost of refining fuel in state exceeds the cost of importing fuel, it could further accelerate additional petroleum refinery exits.

Collaboratively, we must harmonize regulations and processes to maximize market-driven solutions and continue to advance State policy goals. By doing so, the State can ensure safe and reliable operations through an orderly, managed transition of the petroleum sector that safeguards California consumers, workers, communities, and the environment.

Since receiving your April 21, 2025 letter, my office has continued its engagement with the cross-agency Petroleum Strategy Task Force, other relevant state and local regulators, industry, and impacted stakeholders and communities. Drawing from this engagement and lessons learned from energy transition challenges in other sectors nationally and internationally, we have identified both risks to fuel supply and

opportunities to support a managed transition in the transportation sector. Our office recommends the pursuit of three concurrent strategies:

1. Stabilize fuel supply through imports of refined fuels and maintaining in-state refining capacity.
    a. Support necessary import of refined fuel products (such as California-specific gasoline) by addressing regulatory and permitting issues that limit import capacity.
    b. Retain in-state petroleum refining capacity where possible to maintain resilience of the transportation fuels system.
2. Provide sufficient confidence to industry to invest in maintaining reliable and safe infrastructure operations to meet demand.
    a. Stabilize in-state crude oil production and distribution to bolster supply for California refineries and support the petroleum fuels system.
    b. Implement near-term statutory and regulatory changes that improve investment confidence while advancing state policy goals.
    c. Strengthen coordination across state, regional, and local authorities, communities, and stakeholders to inform policy implementation.
3. Develop and execute a holistic transportation fuels transition strategy.
    a. Implement a suite of policies and programs to ensure environmental, public health, labor, economic, and consumer protections for a successfully managed transportation fuels transition.

The recommendations laid out in this letter reflect the complexity of the issue, input from a multitude of stakeholders, and a faithful synthesis of robust data and discussions. We believe that these actions are necessary as the State considers its next steps in the clean energy transition.

Introduction and Background:

Over the past two decades, California has embarked on a transformative effort to decarbonize its economy. Through pioneering climate and air quality policies, the state has:

- Catalyzed the development of clean energy technologies,
- Fostered new clean energy industries employing tens of thousands of Californians,
- Decreased annual gasoline demand by more than 2 billion gallons (13.4%) in 8 years,
- Replaced more than 2 billion gallons of fossil diesel with renewable diesel, resulting in nearly 72% of diesel needs met by renewable diesel,
- Increased zero emission vehicle (ZEV) adoption from an annual rate of 7.8 percent new vehicle sales in 2020 to over 25 percent in 2024, and
- Made significant progress in improving air quality for communities across the state, including reducing over 77,500 tons of NOx since 2016, and
- As a result of the Low Carbon Fuel Standard (LCFS), the variety of transportation fuels and consumer choices have increased including rapid deployment of renewable diesel and zero emission infrastructure and will reduce fuel costs for Californians per mile by 42% translating to savings of over $20 billion in cost savings by 2045.

At every inflection point—whether driven by market changes, climate and public health imperatives, national and global policy shifts, or technological breakthroughs—California has enacted forward-looking policies, regulations, and processes to continue advancing its decarbonization goals while prioritizing affordability, safety, and reliability.

Now, as the transportation sector enters a new phase in its transition, marked by rapid changes in the petroleum fuels system, California needs to once again continue to evolve its strategy to ensure success. If a lack of proactive management during this phase of the transition leads to rising energy prices and less reliable fuel supplies, that instability could erode support for continued decarbonization. We must take the necessary steps to chart a path for an orderly and safe transition away from legacy

petroleum-based systems that maintains system reliability, protects communities, workers, and consumers, and continues to advance the state's decarbonization trajectory.

Shifts in Petroleum Fuel Supply: A Global Issue and Californian Opportunity

California's petroleum value chain is complex and must be considered holistically in managing the transportation fuels transition (Figure 1). It supplies gasoline, diesel, jet fuel and other petroleum derivatives, and consists of interdependent activities and infrastructure that include:

- Upstream activities related to production of crude oil,
- Mid-stream activities related to gathering, storing, processing, and transporting petroleum products, and
- Downstream activities related to refining and distribution, marketing and sale of refined products.

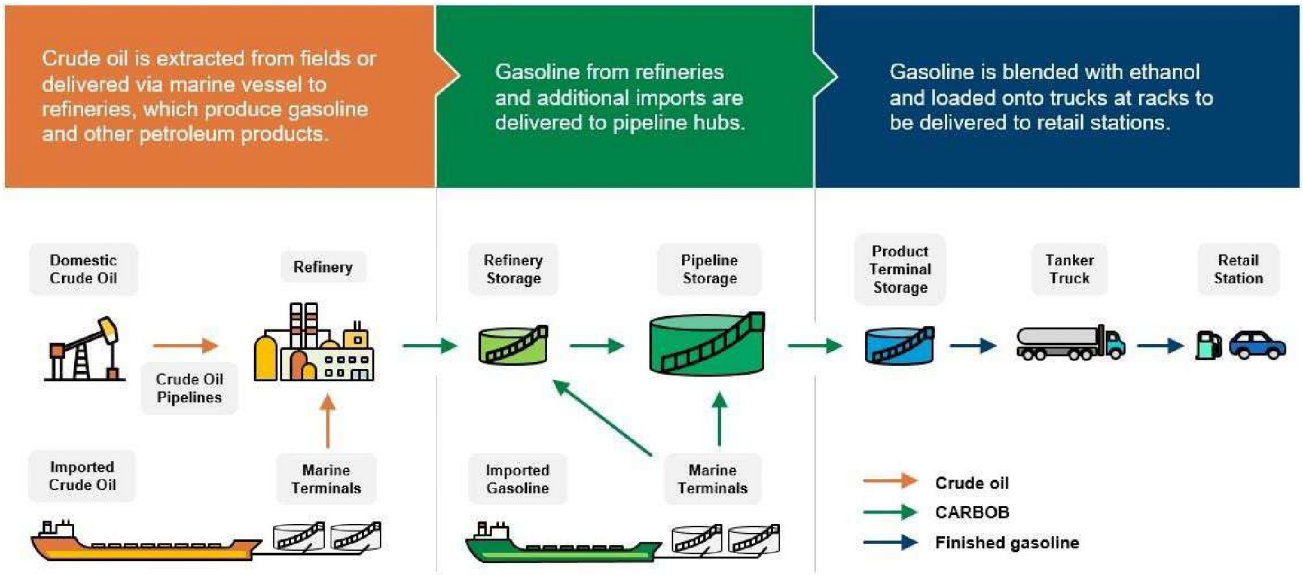


Figure 1. The petroleum value chain is complex and interdependent, and policies should consider the system holistically. Investments across the value chain are necessary for a managed decline.

California currently imports over 75% of its crude oil to meet the demand of in-state petroleum refineries and about 10-20% of its gasoline from out-of-state and foreign sources, depending on refinery maintenance

activities. Gasoline imports statewide could increase to 25-35% of demand by the summer of 2026, and up to 50% in the northern California region after the announced anticipated refinery closures, bringing risk of supply disruptions and price volatility. The interdependent elements of the petroleum-based system therefore cross state and national boundaries and contain critical vulnerabilities tied to changes in local, state, federal, and international policies, markets, and events.

A wide range of factors affecting the petroleum value chain are accelerating the decline and consolidation of the refining industry in many U.S. states, as well as developed economies across the globe. One in five refineries globally risk shutdown by 2030[2]. Across the nation, petroleum refiners face the conjoined challenges of rising operating costs, softening demand for some refined products, and competition from newer, more efficient mega-refineries in other countries. Geopolitical events and changing federal and foreign government policies are also impacting industry decisions. Further, many national petroleum refineries, including some in California, are well over 100 years old and require substantial financial investments to maintain safe and reliable operations. In recent years, these factors have driven the closure of petroleum refineries in places as diverse as Australia, the United Kingdom, and multiple states, including some that have been perceived as especially profitable settings, like Texas.

As a result of such factors and as California's policies continue to drive down demand for petroleum-based fuels, California's in-state petroleum refining capacity has been declining faster than its demand for refined petroleum products and has been supported by increase in imports of refined products. Future trends are uncertain: recent federal actions and policies, including undercutting California's clean air standards and its impact on ZEV adoption combined with global conflicts (currently, about 30% of crude supply to California's refineries comes from the Middle East), are creating further uncertainty in both in-state demand for refined gasoline and global petroleum markets. To prevent a further exacerbated imbalance of supply and demand from harming Californians—whether through disrupted fuel supply, insufficient facility maintenance, or ongoing pollution threatening public health—and to maintain resilience in the

[2] Wood Mackenzie (2025). *Global 2035 refinery closure threat update: Which assets are most at risk of closure?. https://www.woodmac.com/news/opinion/global-refinery-closure-outlook-2035/*

system in light of ongoing uncertainty, the State must actively manage the decline of its legacy petroleum-based systems while maintaining affordable, reliable, safe, and equitable access to transportation fuels statewide.

Proactively Navigating the Challenges of the Mid-Transition

California is entering a pivotal and challenging phase of decarbonization described in scholarly work as the "mid-transition," in which the demand for the incumbent petroleum-based system, while declining, remains substantial, and the clean alternative fuels, continue to scale up[3] (Figure 2). Over the past five years:

- Two Californian refineries, Marathon Martinez and Phillips 66 Rodeo, have converted to producing renewable fuels —transitions that support the State's shift to cleaner, less carbon-intensive fuels, but that have also reduced gasoline refining capacity in the state.
- Phillips 66 has announced its intent to close its Wilmington refinery in the fourth quarter of 2025. Phillips 66 has committed to working with California to maintain or increase levels of supply to meet consumer needs, including through imports[4].
- Valero has announced its intent to idle, restructure, or cease refining operations at its Benicia refinery by the end of April 2026.

[3] Grubert and Hastings-Simon (2022). *Designing the mid-transition: A review of medium-term challenges for coordinated decarbonization in the United States*. WIREs Climate Change. https://doi.org/10.1002/wcc.768

[4] https://investor.phillips66.com/financial-information/news-releases/news-release-details/2024/Phillips-66-provides-notice-of-its-plan-to-cease-operations-at-Los-Angeles-area-refinery/default.aspx

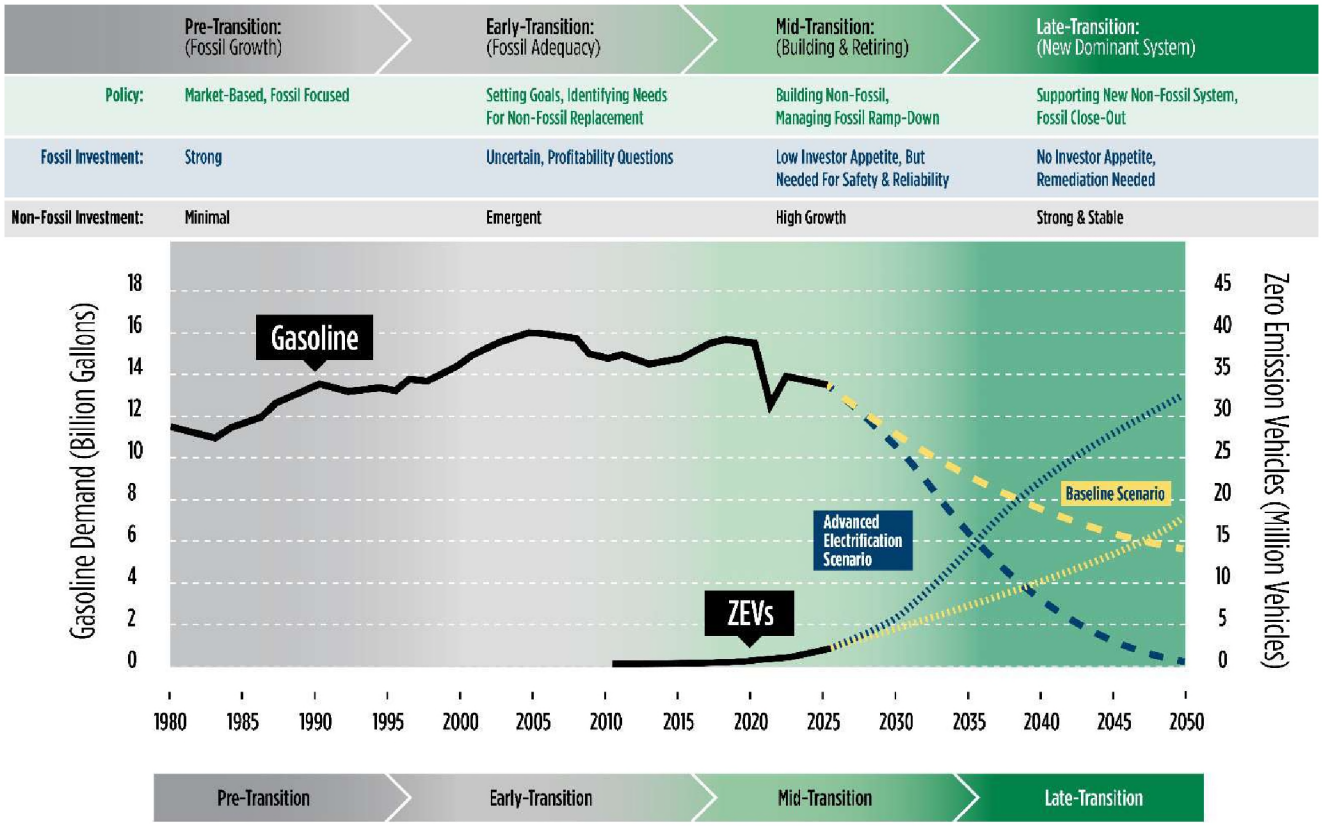


Figure 2. California has entered the mid-transition, a critical phase in which the State must not only support the growth of new clean energy systems but also manage the phase-out of their fossil-fueled predecessors. The CEC's 2024 Integrated Energy Policy Report (IEPR) includes two scenarios for gasoline demand and ZEV adoption: a baseline scenario and a higher transportation-electrification scenario.

To ensure energy reliability and economic stability, sustained investments in both legacy and emerging infrastructures are essential during the mid-transition to support the totality of market needs. Sudden and unmanaged exits of critical legacy energy infrastructure can have significant negative impacts on energy security, local governments, worker safety, consumer prices, public health, environmental protection, and the communities that depend on jobs and revenue from those industries.

To protect consumers, frontline communities, workers, the economy, and the environment, California's policies must simultaneously achieve two objectives:

1. Accelerate deployment of renewable and low-carbon technologies to sustain decarbonization momentum.
2. Establish clear mechanisms and incentives to keep legacy petroleum-based assets safe, reliable, and affordable until the new clean energy system can fully replace them.

Current analysis suggests that under today's market and regulatory conditions, California faces the prospect of continued reduction in in-state petroleum refining capacity that outpaces demand decline for petroleum-based fuels and closures of other critical parts of the state's petroleum-based fuel value chain. Without a clear, state-led transition pathway, these sudden exits create a very real risk of severe price spikes, supply constraints, and long-term liabilities at sites. The industry is likely to become more heavily concentrated with fewer but more powerful incumbent firms. Given sufficient time, the petroleum market is likely to find a new equilibrium following the disruption of a refinery closure, but in the near term, an abrupt loss of refining capacity and the increased need for imported fuel to compensate is likely to increase price volatility. Keeping in-state and imported fuel competitive will be an important balancing act moving forward, because if the state's regulatory paradigms lead to the cost of refining fuel in state exceeding the cost of importing fuel, it could further accelerate additional refinery exits.

By contrast, proactive state policy can not only prevent these potential severe risks, but also achieve a just, least-cost transition to clean energy, while securing major benefits for fenceline communities, consumers, petroleum industry workers, and the environment. It will be increasingly important to foster a competitive market open to all. Adjusting conditions that help steer the market in ways that align decline in California's petroleum-based fuel production with in-state and regional demand can also make California's energy systems more resilient in an increasingly unstable national and international context.

These market adjustments must also align with California's trailblazing climate policies. The State's longstanding commitment to protecting air quality, public health, and the environment, as well as recent actions to enhance consumer protections against gasoline retail price spikes, provide a strong foundation on which California can solve the interlocking challenges of the mid-transition. By learning the lessons of past industrial transitions and of refinery closures around the country and the world,

California can once again chart a groundbreaking policy path—this time, for the safe, effective, and necessary transition away from petroleum-based fuels.

In designing policies to manage the decline of California's petroleum fuel system, policymakers face a set of interlocking issues that must be addressed together to support a successful transition:

Reliability and Affordability of Supply: California faces an unusually tight set of constraints on its access to supplies of crude oil and refined petroleum products. Geography and the state's long energy history both largely limit the state to in-state production and marine imports. To combat air pollution and meet federally required air quality standards, California has also long used a specialized gasoline blend that is produced by a limited number of refineries worldwide. Domestic demand for this gasoline already outstrips in-state refineries' cumulative capacity. Under these supply constraints, even a single refinery outage can lead to gasoline price increases.

Increasing marine imports of gasoline to replace lost supply especially in the near term can be costly, slow, and constrained by bottlenecks in import infrastructure. Imports also introduce new vulnerabilities into the fuel supply by making the State more exposed to impacts of geopolitical events, external markets, and regulatory changes in other jurisdictions. Nonetheless, California is likely to become more dependent on imports of refined fuels if the decrease in in-state refining capacity continues to outpace declining demand and proactive planning is needed.

Safety and Reliability of Infrastructure: Petroleum refineries are high-hazard infrastructure that require regular investment in maintenance to protect workers and communities from accidents. Without policy intervention, declining capital inflows could lead to deferred maintenance and heightened dangers. Petroleum refinery accidents can pose grave health risks to workers and residents in the vicinity, and unplanned events impact fuel supply and retail prices, as well as impose unanticipated costs on petroleum refiners, potentially leading to sudden or accelerated closures. For example, Pennsylvania's PES Refinery closed suddenly in 2019 after a major explosion caused by a corroded 50-year-old pipe. Releases and spills can permanently damage entire ecosystems, with acute and chronic public health, ecological, and economic consequences, including potentially many hundreds of millions of dollars in remediation

per site and long-term withdrawal of land from other beneficial uses. It is imperative that refinery operators make necessary investments in refinery maintenance on a timely basis throughout the transition.

Employment Security: Recent petroleum refinery conversions and exits have revealed challenges for displaced workers in finding comparable employment. Workers across the petroleum value chain, including crude oil extraction, similarly face continued job losses and difficult hiring conditions in a declining field. These workers' skills will remain critical for maintaining safe and reliable fuel supplies throughout the duration of the energy transition. Moreover, existing skilled refinery craftsmen are leaving the state to seek similar work in other markets, reducing the experience level of the California petroleum refinery workforce. To retain these workers and their skills, state policy should help ensure that work remains safe and that job transitions are meaningfully supported.

Community Impacts: Petroleum refineries and other elements of the petroleum-based fuel system play significant roles in local economies but also impact the health and safety of fenceline communities. Many examples show that industrial decline can damage community safety, health, and the environment. Because fenceline communities are often dependent on their industrial facilities' tax payments, payrolls, and value chains, a single industrial closure can hollow out the local economy in ways that are very difficult to absorb. Proactive planning and resources will be necessary to prepare communities for a future without petroleum industry, including refineries, and to ensure that fossil fuel-related legacies do not cause new harm.

Smooth Transition for Successful Decarbonization: The many risks posed by an unmanaged clean energy transition also threaten California's continued climate progress. If energy prices rise and fuel supplies become less reliable during the mid-transition, support for continued decarbonization may erode. By contrast, creating clear, transparent, long-term plans for the phase-out of petroleum infrastructure can give the public confidence in the trajectory of state climate policy and create space for industry, state and local governments, and community groups to find least-cost, least-harm solutions to tackling the clean energy transition.

Strategies and Recommendations

Many impacted stakeholders, including representatives from industry, labor, environmental and environmental justice organizations, and state and local agencies continue to engage with the CEC in productively discussing the interlocking challenges of the clean energy transition. While not all groups align in their preferred strategies to address these challenges, there has been shared recognition of different constituencies' priorities and common goals. A holistic solutions framework developed from this consultation guides this response.

The cross-agency Petroleum Strategy Task Force has additionally provided valuable insight and recommendations for addressing these complex and cross-jurisdictional issues. Building off these engagements, lessons learned from transition challenges in petroleum and other sectors nationally and internationally, and previous work including the CEC's Transportation Fuels Assessment, the CEC has identified needs and opportunities to support affordable, reliable, equitable, and safe fuel supply through a managed transportation fuels transition that pursues three concurrent strategies:

1. Stabilize fuel supply through imports of refined fuels and maintaining in-state refining capacity.
2. Provide sufficient confidence to invest in maintaining reliable and safe infrastructure operations to meet demand.
3. Develop and execute a holistic transportation fuels transition strategy.

Solving the challenge of transportation fuel transition will require state policymakers to pursue solutions that achieve these three objectives together, including near-term stabilization actions as well as long-term holistic transition solutions, and that advance the state's commitment to its overarching priorities.

Strategy 1: Maintain capacity to stabilize fuel supply

TOPLINE: The CEC thinks it is prudent to immediately stabilize in-state supply by working to retain in-state refining capacity while demand persists, and by supporting sufficient imports, storage, and delivery of refined products.

PROBLEM: In-state petroleum refining capacity is declining faster than gasoline demand and the abrupt exit of a refinery has numerous consequences to consumers, workers, and communities. Northern

California is already experiencing a net regional shortage in refining capacity and is particularly vulnerable if the State fails to maintain existing Northern California refinery operations in the near term and upgrade the import infrastructure capabilities at Bay Area ports. Due to previously enacted legislation, the state receives a one-year notice prior to petroleum refinery operational changes that helps the State plan for the decline in refining capacity. To support system resilience as in-state refining capacity declines, the State needs to receive sufficient and timely volumes of marine-imported fuel.

1a: Supporting Imports of Refined Products

Background:

Crude oil, gasoline, jet fuel, and other petroleum products are imported into California via marine oil terminals, primarily at the Ports of Long Beach and Los Angeles and in the San Francisco Bay region that includes San Pablo Bay and Carquinez Strait. Gasoline refining capacity in California is already insufficient to meet demand, with the shortfall increasing during refinery maintenance events. The shortfall must be made up through marine imports of refined product. To keep fuel supply and prices stable, the import process must be efficient and surge capacity must be preserved. Investments in third-party marine oil terminals, facilities where oil and petroleum products are stored, are key to incrementally increasing import capacity; these terminals are not associated with one individual refiner and can be utilized by multiple market participants, which in turn increase market competition and protects consumers. Greater import capacity will be necessary to maintain resilience in the system as refining capacity in California continues to fall.

Permitting delays and investment uncertainty can be barriers to repairing, optimizing and increasing import, storage, and delivery capacity – in some instances, permit delays can obstruct project completion by months or years. While the rate at which import reliance will increase is uncertain, State action is needed in the short term to make sure California has an adequate supply of fuel to reliably and affordably serve demand. Projects that increase import capacity, without permitting delays, can take anywhere from three to 24 months, with most projects such as dock improvements or pipeline modifications taking between 12 and 18 months. Specific challenges and opportunities to increase capacity and efficiency vary by location and facilities.

Recommendations:

- Support confidence for the private sector to invest in import, storage, and delivery infrastructure through sector-wide regulatory coordination (see Strategy 2).
- Address regulatory and permitting issues to import capacity and efficiency, especially in regions with major refining capacity loss.
- Establish an interagency workgroup that includes the CEC, the State Lands Commission, relevant Air Districts, local governments, and ports to develop a plan to improve coordination, establish clear lines of communication to prioritize critical energy infrastructure projects, enhance early public engagement, and identify efficiencies and reduce redundancies in permitting.
- Explore ways to increase the throughput capacity of third-party terminals to receive and distribute gasoline and jet fuel.

1b: Prudent Retention of In-state Refining Capacity

Retaining in-state refining capacity while demand for refined fuel persists supports the resilience of the transportation fuels system in California. It can also maintain employment and local revenue while giving workers and communities time to plan for the future.

The CEC is engaging with market players to explore strategies to retain operations at existing refineries.

Strategy 2: Provide sufficient confidence to industry to invest in maintaining reliable and safe operations to meet continued demand

TOPLINE: System-wide needs must be addressed in the near term to protect consumers and fenceline communities and ensure needed investments are made to safely meet demand while achieving climate goals and public health protective standards.

PROBLEM: Increasing petroleum business uncertainty in California is leading to reduced industry confidence to invest in the state as they continually seek other, higher-return opportunities. This has prompted company decisions to discontinue operations in California, especially when faced with significant investment decisions (e.g. refinery turnarounds) and uncertain future returns on those investments. Disinvestment in fossil infrastructure with closure on the horizon poses risk to safety and reliability. Due to the interdependencies of the petroleum

value chain (up-, mid-, and downstream), disruptions can have widespread consequences to the entire system (Figure 1). Additional closures and operational challenges elsewhere in the value chain (e.g. viability of crude oil pipelines with low throughput volumes) are likely in the near term and inevitable in the long term.

Industry participants have identified several intersecting regulatory and administrative issues in maintaining system-wide stability: crude oil extraction and delivery, CEC's regulatory tools, At-Berth regulations, Cap-and-Trade, and issues related to other regional, state and local authorities. CEC continues to engage with a wide range of impacted stakeholders and communities to discuss these issues and possible solutions. While not all groups are unified in their preferred approach to these challenges, there has been general recognition of the benefit of a holistic approach and strategically aligning state and local regulation of the petroleum system to support the achievement of state goals and priorities.

In consultation with industry, labor, fenceline communities, and the cross-agency Petroleum Strategy Task Force, the CEC has identified a suite of measures to bolster confidence in the California market and ensure reliable and safe operations during the transportation sector's mid-transition. These measures are organized into two tiers:

- Tier 1 – Immediate Actions: Options for near-term adoption via administrative directives or statutory modifications.
- Tier 2 – Further Exploration: Options requiring additional analysis, stakeholder consultation, and impact assessment before implementation.

Tier 1: Issues to Prioritize for Immediate Action

1. Stabilizing In-State Crude Oil Production and Distribution.

Background:

Crude oil production in California in recent years has dropped far faster than demand from in-state refineries, largely because of California Environmental Quality Act (CEQA) litigation that stalled crude oil production permitting in Kern County. That decline in in-state crude oil production has forced a shift toward increased foreign and Alaskan crude oil imports. This rapid decline in crude production introduces several challenges that include:

- *Refinery Adaptation Challenges and Cost Pressures:* Many California refineries were engineered for the specific qualities of local crude oil. Several refineries are not logistically well set up to receive waterborne imported crude. Without retrofit investment, they incur higher processing costs and reduced efficiency when processing imported crude.
- *Pipeline Throughput Decline and Infrastructure Risk:* California has a network of pipelines, primarily from Kern County, that deliver crude oil to in-state refineries. Reduced in-state crude production has driven several crude pipelines to shut down due to low throughput. Several remaining crude oil pipelines now run intermittently due to low volumes, inflating crude transportation costs.
- *Exposure to Geopolitical Risks:* Relying heavily on imported crude oil ties California's energy security to volatile foreign-policy dynamics and geopolitical tensions.
- *Economic and Fiscal Impacts:* The contraction in domestic crude oil production erodes high-wage jobs and shrinks local tax bases, placing additional strain on oil-dependent communities and public services.

Recognizing the interdependence between in-state crude oil production and related critical infrastructure across the petroleum value chain, we think it is prudent to stabilize in-state crude production to support resilience in the petroleum system.

Recommendation:

As part of a managed transition strategy, we recommend that the State take action to achieve targeted stabilization of crude oil production in California to supply in-state refineries while ensuring that production is consistent with critical health and environmental protections. Specifically, limited production that is needed to achieve targeted stabilization should be prioritized in existing established, and densely developed oilfields, and outside of Health Protection Zones (HPZs) surrounding homes, schools, and other sensitive receptors where new permitting is prohibited by law; and production should not include methods that are prohibited by important environmental protection laws, such as California's ban on new offshore oil and gas leases and California's ban on well stimulation treatments.

The Legislature may wish to consider, for example, statutory changes to declare the Kern County Zoning Ordinance Second Supplemental Environmental Impact Report (SCH20130879) in compliance with CEQA and conclusive for purposes of its use by responsible agencies to allow the County's ministerial approval of oil and gas wells with the mandatory mitigation measures identified in the ordinance. This change would allow for a more appropriate amount of extraction in Kern County's well-established oil fields. While clarifying that oil extraction on those already-disturbed lands, away from neighborhoods, is permissible, the Legislature may also wish to expand the current limitations on new offshore oil and gas development and codify the ban on well stimulation treatments in statute.

Additional legislative or administrative actions could include a targeted regulatory framework that ties crude production and permitting more directly to demand over the transition period. The objective would be to facilitate more timely, predictable, and legally durable permitting for crude oil production outside of HPZs in established, densely developed oilfields coupled with a requirement to permanently seal at least two wells for each new well drilled – one located in that same oilfield and the other located in an HPZ. This would facilitate a managed production decline that aligns with and adapts to declining demand throughout the transition to create more certainty, maintain critical infrastructure investment, and protect consumers, workers, and fenceline communities.

2. Regulatory Tools.

Background:

Several intersecting regulatory authorities supporting the achievement of the State's climate, public health, and consumer protection priorities impact the petroleum industry. Strategic implementation of the State's suite of regulatory tools can support the necessary investment confidence to retain safe and reliable industry operations and achieve policy goals.

To protect California consumers from extraordinary spikes in retail gasoline prices, such as those during 2022 and 2023, you called for two special sessions of the Legislature in 2023 and 2024 resulting in the passage of SB X1-2 (Skinner, Chapter 1, Statutes of 2023 First Extraordinary Session) and AB X2-1 (Hart, Chapter 1, Statutes of 2024 Second Extraordinary Session). These efforts collectively:

- Expanded the CEC's data collection authority that significantly increased transparency into various aspects of the petroleum market and helped identify the key factors that contribute to fuel price volatility;
- Created a new independent market oversight division, the Division of Petroleum Market Oversight (DPMO), responsible for oversight, investigations, economic analysis, and policy recommendations regarding the transportation fuels market;
- Required development of two planning efforts 1) an assessment of California's transportation fuels market with potential strategies to address price spikes, and 2) a Transportation Fuels Transition Plan with CARB; and
- Provided CEC with new regulatory authorities to mitigate retail gasoline price spikes and protect consumers: establishing a maximum gross gasoline refinery margin (GGRM) and penalty, setting minimum inventory requirements for refiners, and establishing resupply requirements for planned refinery maintenance events.

The Legislature required that CEC engage in careful consideration of the impacts to consumers and the petroleum sector from implementing the new regulatory authorities. The CEC has exercised caution by focusing on gathering the necessary information to develop a holistic view of the petroleum value chain and establishing the best ways to protect consumers during this transition.

To protect the public health of local communities near ports, CARB adopted its at-berth regulation in 2007 to address emission reductions from ocean-going vessels when they are docked at California ports. The regulations were most recently amended in 2020 and as of January 2025, crude oil and petroleum product tankers at the Port of Los Angeles and the Port of Long Beach are subject to the regulation.

The majority of tanker industry partners are complying with the regulation through one of two approved pathways: (a) the Innovative Concepts, an alternative compliance approach that applies the emissions reductions from approved projects towards vessel visits, or (b) the Remediation Fund, used as an interim solution until their chosen primary control

technologies—such as shore power or barge-based capture systems—are installed. One barge-based system for tankers has received CARB approval, with additional systems under review. Small terminals may comply under the low-use exception or by using the Remediation Fund in combination with barge-based systems or shore power as approvals are finalized. While systems are undergoing approval, capture and control companies can offer research exceptions to vessel and terminal operators for participating in testing. Tankers will be subject to the regulation at all ports as of January 2027.

AB 32 (Nuñez, 2006) enables CARB to implement programs that are globally recognized as cost-effective tools for reducing carbon pollution and for generating billions in proceeds to support investment in innovative and pollution-reducing projects. One of these tools is the Cap-and-Trade program, which was officially launched in 2012 and carefully balances the steady decline of greenhouse gas emissions, provides utility ratepayer benefits through the climate credit, and provides industry credits to mitigate for leakage. Petroleum market participants are regulated entities under the Cap-and-Trade program.

Recommendation:

The CEC believes that its available refinery regulatory tools should be implemented holistically and prudently to maximize consumer benefit and avoid unintended consequences. The CEC's analyses have demonstrated a relationship between California's volume of gasoline inventory ("days of supply") and retail prices, whereby low inventory volumes are associated with higher retail prices. The CEC sees value in continuing to assess, in collaboration with the industry, how the resupply and minimum inventory strategies could be implemented to promote market liquidity during refinery outages and stabilize prices.

The CEC has determined that additional analytical work is necessary to establish a maximum GGRM and to impose a penalty for exceeding it that would protect California consumers as intended.

In order to prioritize CEC's development and implementation of the resupply and/or minimum inventory regulatory tools, we recommend that the CEC adopt a pause for a reasonable length of time on implementing a maximum GGRM and penalty.

We recognize that there are challenges in technological compliance specifically for tanker vessels and that the regulation can add unanticipated cost and operational burden. We recommend that you request that CARB meet with each refiner and terminal covered by the at-berth regulation and discuss current status and barriers to implementation of all technical tools intended to achieve emissions reductions from tankers at berth to assess the timelines for deployment of those emissions reductions.

We recommend that the Air Resources Board continue to work on the regulatory process for continued implementation of the Cap- and-Trade program, including progress towards required targets, cost containment strategies and minimizing leakage.

Tier 2: Issues for Further Exploration

3. Local and Regional Authority.

Background:

Petroleum infrastructure is subject to various local and regional regulations and often requires permits from a variety of local agencies.

In California, the local air districts have primary authority to regulate all non-mobile pollution sources of air pollution, including stationary sources. This means that local air districts are responsible for adopting regulations to reduce emissions from stationary sources, such as refineries, and for permitting of these sources. All districts with refineries have adopted, implemented, and are enforcing regulations to reduce emissions from the refineries. The regulations reflect the air quality issues in each area and aim to address criteria pollutant emissions in order to comply with the federally enforceable State Implementation Plan, and toxic emissions that impact local communities. The district permits generally require facilities to be in compliance with all applicable regulations, depending on the district and the facility type.

Industry has asserted that the stringency, inconsistency, and compliance costs of air quality requirements placed on refineries, along with extended permitting timelines at air districts and other local and regional agencies, pose uncertainty and risk to their longer-term planning. Industry also has asserted that the potential for new local taxation, fees, and regulatory initiatives causes significant investor uncertainty.

Recommendation:

As noted above, we recommend the formation of an interagency working group to address immediate coordination challenges. In addition, we recognize the importance of working with the Legislature and local stakeholders to address concerns. We think the Administration should consider partnering with the Legislature to advance solutions to strategically align regulations and permitting processes across all levels of government that could best support achievement of State policy goals.

Strategy 3: Holistic Transition Strategy

TOPLINE: Near- and medium-term actions must be part of a holistic transition strategy that is built on shared understanding, collaboration, and development of policies across state agencies and stakeholders. A managed transition is critical for protecting Californians and will depend on coordination and collective action.

PROBLEM: Transitioning California's transportation fuel system away from petroleum-based fuels is providing substantial benefits to consumers, workers, communities, and the environment, but an unmanaged transition poses significant and acute risks to safety, health, environment, economy, and affordability.

While concurrently addressing the previous objectives, the State should implement policies and plans to support a successful transition, which could include:

- Identify and pursue necessary transition funding to support climate, health, community, and worker priorities.
- Protect workers and communities such as through robust process safety management regulations at refineries, which has the added benefit of increasing reliability of the facilities.
- Support and protect California's authority to set emission standards and achieve climate goals.
- Further California's ability to diversify and evolve its transportation sector to comply with federal and state air quality standards and meet climate goals, such as by continuing to expand the availability and reduce the cost of ZEVs.
- Identify challenges, opportunities, and strategies for the future of land affected by the transition (e.g. remediation, marketability, and

value), such as Asset Retirement Obligations and standards for refinery remediation and decommissioning plans.

- Evaluate whether new approaches to California's fuel specifications could continue to protect public health and meet federally required air quality standards while making the State more resilient to disruptions during its fossil fuel transition.
- Continue to evaluate additional options presented in the Transportation Fuels Assessment, e.g. product reserve and production enhancement strategies such as E15 or Reid Vapor Pressure (RVP) modification.
- Explore further pathways to increase resilience in the system, such as improving connectivity between Northern and Southern California fuel markets, e.g. through increased marine oil terminal capacity or repurposing of existing fossil fuel transportation infrastructure.
- Develop strategies that can support a managed phase-out especially during the late transition phase of the transportation sector, such as state management or ownership of assets.

Conclusion

The problems laid out in this letter are complex but solvable. California has entered a critical but challenging phase in its transition to a decarbonized transportation sector, which is made more challenging by California's unique petroleum market, global changes in the refining sector and across the petroleum value chain, and new disruptions at the federal level. The strategies and recommendations laid out here represent our careful, comprehensive, collaborative assessment of the petroleum market and the future of the clean energy transition.

Thanks to your leadership and commitment and the expertise of agencies, stakeholders, and communities, California is rising to the challenge. Equipped with new data made available by forward-thinking policies led by you and the Legislature in the past two years, we have a much clearer understanding of the causes of gasoline price spikes and the strategies needed to protect consumers and communities in the future. We are working closely with a broad range of partners to continue to evolve the State's approach so that we may successfully 1) accelerate momentum to decarbonize California's economy, and 2) ensure that

petroleum firms can continue to supply petroleum-based fuels while the clean, alternative fuels continue to scale.

We are thankful for the opportunity to share this analysis with you, the Legislature, our partners, and the public. We look forward to collaborating with the Legislature, state and local agencies, industry partners, and impacted stakeholders to ensure a reliable, affordable, and safe clean energy future for all Californians.

Sincerely,

G. S. Gundhar

Siva Gunda
Vice Chair
California Energy Commission

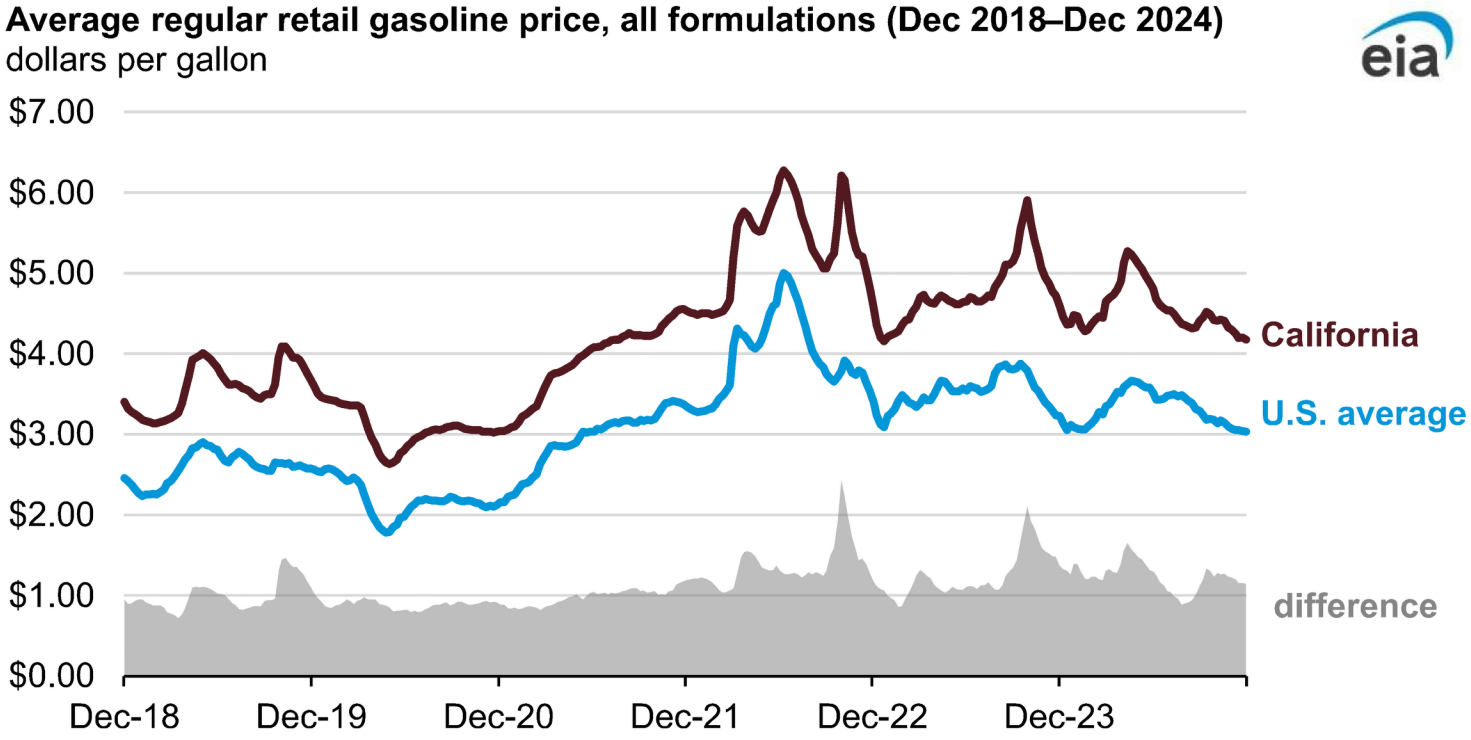
U.S. Energy Information Administration

Today in Energy

IN-DEPTH ANALYSIS

December 9, 2024

California law and refinery closure reflect ongoing challenges for the state's fuel market



Data source: U.S. Energy Information Administration, *Gasoline and Diesel Fuel Update*

On October 14, California Governor Gavin Newsom signed bill Abx2-1 into law, empowering California regulators to set and adjust minimum petroleum product inventory levels for refiners in the state, in part to address the state's fuel price volatility. Shortly after, refiner Phillips 66 announced plans to close its Wilmington refinery in Los Angeles by the end of 2025, citing uncertainty surrounding the long-term sustainability of the refinery.

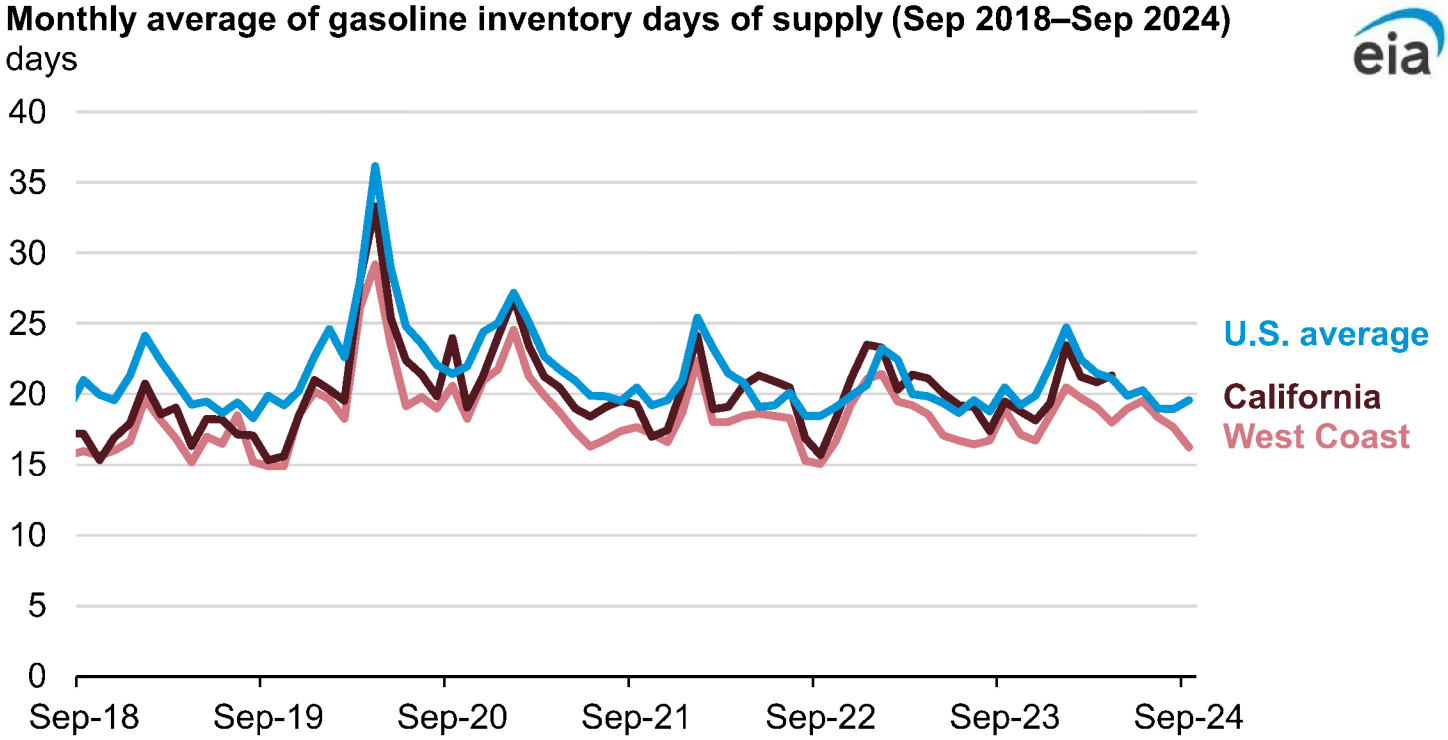
What will the new legislation do?

The new law empowers the California Energy Commission (CEC) to develop and impose minimum storage level requirements for refined transportation fuels for each refiner in the state. The law allows regulators to adjust minimum storage volumes based on regional and seasonal market conditions, refinery size, and storage capacity. It also empowers the CEC to consider the use of a tradable mechanism for compliance with the minimum inventory law, which the state has used in the past for programs such as its Low Carbon Fuel Standard (LCFS).

What is different about the California gasoline market?

The bill is intended to prevent wide swings in the gasoline price. California retail gasoline prices are consistently among the highest in the country and regularly exceed the U.S. average price by more than $1 per gallon. While multiple factors contribute to higher retail gasoline prices in California, including higher crude oil costs and higher refining costs on the West Coast, the region has also historically maintained lower inventory levels relative to the rest of the country.

Monthly average of gasoline inventory days of supply (Sep 2018–Sep 2024)



Data source: U.S. Energy Information Administration, *Petroleum Supply Monthly*; Federal Highway Administration
Note: Days of supply are calculated by dividing end-of-period inventories, excluding pipeline volumes, by consumption in barrels per day. California state data are produced using motor gasoline sales reported from the Federal Highway Administration.

Market participants often use inventories to assess the availability of petroleum products. If inventories drop too low, retailers can struggle to secure the product they need, which increases prices as product becomes scarce. After removing pipeline volumes from total inventories, gasoline inventories in California have been consistently lower than the U.S. average on a days-of-supply basis. Days of supply is a measure of inventory relative to demand and is taken by dividing stock levels (in barrels) by consumption (in barrels per day). California's inventory has averaged just over 20 days of supply over the last five years (2019–23), compared with the U.S. average of 21.6 days.

What will the refinery closure mean for California gasoline markets?

Shortly after the new California legislation was signed into law, refiner Phillips 66 announced on October 16 that it plans to stop refining operations at its 139,000-b/d Wilmington refinery in Los Angeles during the fourth quarter of 2025. In the announcement, Phillips 66 indicated it will continue to pursue other uses for the facility, which may include continuing to import fuels through its existing petroleum infrastructure.

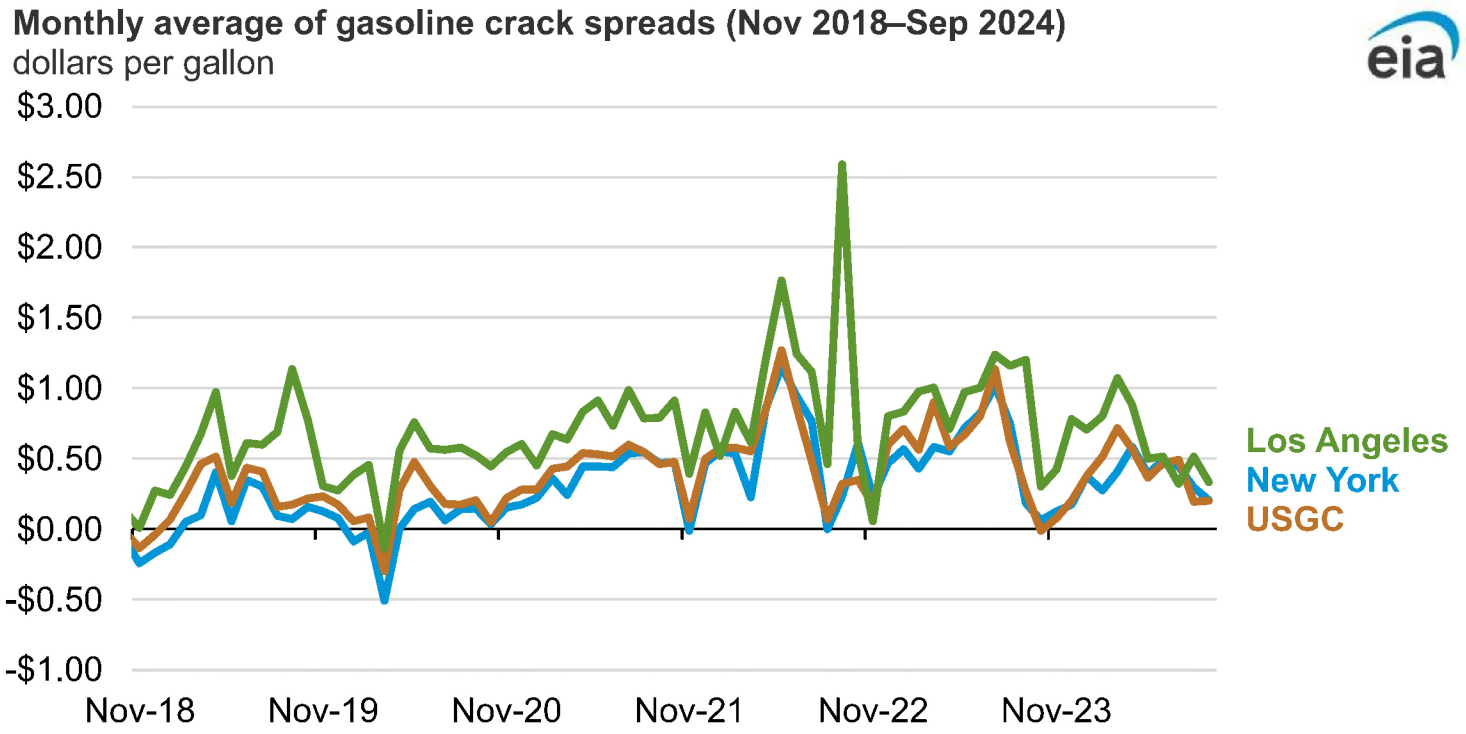
On October 29, Phillips 66's Chief Executive Officer said the company's decision to shut down its Los Angeles refinery in 2025 was not an immediate response to any policy changes in California but rather due to its expectation that refining business in the state would become increasingly challenging.

Earlier this year, Phillips 66 completed the transition of its Rodeo refinery near San Francisco into a renewable diesel production facility that no longer processes crude oil. With the end of operations at its Wilmington plant, the company will officially stop all crude oil refining operations in the state.

The Wilmington refinery accounts for less than 1% of U.S. refining capacity, about 5% of West Coast refining capacity, and about 8% of the refining capacity in the state of California, according to our *Refinery Capacity Report*. The West Coast possesses relatively less pipeline capacity and other infrastructure to transfer petroleum products between refining centers from elsewhere in the United States, such as the U.S. Gulf Coast. As a result, the lost petroleum product supply from the Wilmington refinery will likely need to be met through higher utilization of other California refineries and increased imports of products such as gasoline.

What is contributing to the refinery's closure?

Weak refinery margins have persisted on the West Coast and in the United States overall since the middle of this year. In May 2024, the crack spread for Los Angeles CARBOB (California Reformulated Blendstock for Oxygenate Blending)—an indicator of the profitability of refining gasoline from crude oil—dropped to 50 cents per gallon, about half of what it was the previous May. The Los Angeles spread hasn't been below 50 cents per gallon on average in the month of May since 2019. Lower crack spreads in the second half of 2024 have been an issue for all U.S. refiners, not only those on the West Coast. The narrower spreads partly reflect global market conditions including more international refining capacity and weaker demand compared with the higher margin environment in 2022 and 2023.



Data source: U.S. Energy Information Administration, *Petroleum Supply Monthly*, and Bloomberg L.P.
Note: Crack spreads are calculated by subtracting regional refiner acquisition costs for crude oil from monthly average wholesale gasoline spot prices for RBOB in New York, on the U.S. Gulf Coast (USGC), and for CARBOB in Los Angeles.

Refinery crack spreads on the West Coast are typically higher than they are in other parts of the country, in part because of tighter supply-demand balances in the region, reflected by the lower average days of supply. Refiners in California must comply with the state's Cap-and-Trade program, which requires them to bid for emissions allowances, as well as the state's LCFS, which requires refiners (and importers or wholesalers) to buy carbon credits according to the volume of carbon-emitting fuels (such as gasoline and petroleum diesel) that they supply to the market. The costs of compliance with these measures are partly reflected in the wider wholesale crack spreads. As a result, higher crack spreads alone may not necessarily indicate higher net profits for refiners in the state, although they do indicate relatively higher prices for gasoline overall. The West Coast also tends to have higher refiner acquisition costs for crude oil because crude oil production is limited in the region and routes to import crude oil are often longer. The higher acquisition costs do not directly affect the crack spread for gasoline, but they do contribute to higher overall fuel prices.

Despite the growing share of electric vehicles in California, the state remains a major destination for consumption of gasoline, ranking as the second-largest source of consumption of the fuel among the 50 states. However, regional refiners have struggled with the relative profitability of producing distillate fuel oil and jet fuel, some volume of which must also be produced with each barrel of crude oil refined to make gasoline. The increased penetration of renewable diesel into California's diesel market reduces demand for petroleum diesel in the region, presenting additional headwinds to overall profitability for refiners in the state.

The disconnect in gasoline and diesel prices suggests that gasoline imports are likely to grow in importance as a source of future supply for the state. Unlike increasing in-state refinery production, importers can import gasoline when they expect it will be in demand without producing surplus volumes of other fuels with lower margins. However, importers face longer shipping times between when an order is placed from abroad and when a cargo of gasoline or another fuel ultimately arrives in the state. Importers must also locate foreign refiners capable of meeting the specifications on California's unique gasoline formulation, CARBOB.

Principal contributor: Kevin Hack

JOBS >>

RIGZONE

CREATE ACCOUNT

OIL & GAS JOBS ▼ OIL & GAS NEWS ▼ OIL PRICES EVENTS TRAINING EQUIPMENT SOCIAL
SALARY / INSIGHTS AI▼

Latest Oil Prices

WTI Crude $65.72 +1.14%

Brent Crude $70.13 +1.02%

Natural Gas $3.21 +0.34%

Recruitment | Advertise

NEWS

California's Biggest Inland Oil Pipe On Course to Shut

by Bloomberg | E.Kamisher, N.Risser | Thursday, September 11, 2025 | 4:00 PM EST



California's largest inland oil pipeline is in danger of closing within months without state approval for a rate increase and other measures.

Image by trekandshoot via iStock

California's largest inland oil pipeline is in danger of closing within months without state approval for a rate increase and other measures, a shutdown that would choke off some crude supplies to at least two San Francisco-area refiners.

Crimson Midstream LLC's San Pablo Bay Pipeline that hauls oil from the Bakersfield area to Northern California refiners is losing $2 million a month, creating "severe financial distress" for the company, Robert Waldron, CEO of Crimson's parent CorEngery Infrastructure Trust, wrote in a letter to Governor Gavin Newsom's office this week.

The pipeline's fortunes have waned amid a "sudden and unexpected shift" of regional oil production to rival pipelines serving Los Angeles-area fuel makers, Waldron wrote. Crude pipelines are designed to pump certain quantities of oil and when volumes fall below the minimum ranges, the costs of operating them can soar.

The Western States Petroleum Association has been warning California lawmakers since last year that dwindling Central Valley oil production risked shuttering pipelines such as the San Pablo Bay conduit. Valero Energy Corp.'s Benicia refinery and PBF Energy Inc.'s Martinez plant, which account for roughly one-fifth of the state's fuel-making capacity, are dependent on Central Valley crude for some of their supplies.

Any interruption in San Pablo Bay Pipeline shipments would likely force Bay Area refiners to resort to more imports of ocean-borne crude, Waldron warned. Crimson is seeking a 37% increase in the fees it can charge to crude shippers, a temporary $3.75-a-barrel tariff hike, and other measures.

"Unfortunately, Crimson is now facing severe financial distress," Waldron wrote. "Without near-term relief, Crimson will likely be forced to shut down the SPB Pipeline this fall."

California crude output has fallen by more than 70% in the past four decades as fields first tapped in the early 20th century began to run dry, competition increased from lower-cost sources, and some of the nation's strictest environmental rules piled on costs. Newsom is seeking to make it easier for inland drillers to obtain permits and boost oil output, while further restricting offshore crude production.

The San Pablo Bay Pipeline is the larger of two conduits carrying crude to Northern California. The pipeline's minimum, daily operating capacity is around 60,000 to 65,000 barrels, according to consultant Turner, Mason & Co. Waldron noted that a shutdown risks shifting 15,000 barrels of daily crude supplies to highways aboard tanker trucks, suggesting the pipe already is running significantly below capacity.

WHAT DO YOU THINK?

POST A COMMENT

Generated by readers, the comments included herein do not reflect the views and opinions of Rigzone. All comments are subject to editorial review. Off-topic, inappropriate or insulting comments will be removed.

Energy Prices			Charts
INDEX	PRICE	%	TIME(EDT)
WTI Crude	$65.72	**+1.14**	4:59 PM
Brent Crude	$70.13	**+1.02**	4:58 PM
Natural Gas	$3.21	**+0.34**	4:59 PM

September 27, 2025 10:56 PM EDT

OIL & GAS JOB SUGGESTION

ASPEN CERTIFICATION ON PRES...
fake troubleshooting
Coil Tubing Field Coordinator
Remote Operations Center Te...
extensive employment experi...
System Management Auditor



RSS Feeds

Copyright © 1999 - 2025 Rigzone.com, Inc.

Energy Transition Squeeze: The Phillips 66 Los Angeles Refinery Closure

Megan Boutwell | Nov 20, 2024

As part of our consulting practice, Stillwater pays close attention the regulatory and market forces driving changes in the transportation energy transition and how these changes impact fuel supply and demand. The recent announcement from Phillips 66 that they'll be ceasing refining operations at the Los Angeles refinery complex at the end of 2025 is not surprising given the regulatory and market pressures California refiners are facing. In this article, we take a look at the compounding pressures on California refineries and provide analysis on the impact of the Phillips 66 LA refinery closure on near-term supply in Southern California. [1]

California refiners feeling the squeeze from regulatory and market pressures

California refiners face unique and compounding pressures, making continued operations a challenge. These range from overall gasoline and diesel demand destruction to declining California crude oil production, to the California Air Resources Board (CARB) expanded "At-Berth" regulation, and a new state law establishing a maximum gross gasoline margin.

Petroleum Product Demand Destruction: One of the key factors contributing to petroleum product demand destruction in California is the success of the low carbon fuel standard (LCFS) to incentivize the transition of the petroleum diesel pool to renewable diesel (RD) and biodiesel (BD). The most recent CARB data for the LCFS program shows RD and BD together made up 75% of the California diesel pool in the second quarter of 2024. This has contributed to length in the California petroleum diesel market, requiring excess production to be exported.

While gasoline has been difficult to replace with lower carbon alternatives, other factors including enhanced fuel efficiency for internal combustion engine vehicles (ICEVs), the adoption of zero emission vehicles (ZEVs), and remote work have led to a 10% drop in **California gasoline demand** since 2015.

California Crude Oil Production Decline: California crude oil production has been declining at an average rate of 2% per year since the 1980s. Starting in 2019, California restricted in-state crude oil production, leading to a **24% decline** in volume between 2019 and 2023. The production decline appears to be accelerating this year, as the first six months of 2024

showed production 12% lower than the first six months of 2023. The state's efforts to curb crude oil production have continued into 2024. **Governor Newsom** directed regulators to end the issuance of new permits for fracking by January 2024. The governor has also requested CARB analyze pathways to phase out oil extraction across the state by no later than 2045.

As local crude production delivered by pipeline has decreased, refiners have had to increase imports of waterborne alternatives to maintain fuel production. In 2023 the largest contributors of **foreign sources of crude oil** to the state included Iraq, Saudi Arabia, and Brazil. Most California refineries were engineered originally to process California crude oil. While refineries have adjusted to run alternate crudes, the quality does not match that of local production and results in decreased refinery utilization and efficiency. Bottom line: Importing waterborne crudes increases supply risk, lowers fuel production, and increases costs.

At-Berth Regulation: CARB's At-Berth regulation, authorized by the U.S. Environmental Protection Agency (EPA), requires that each vessel visiting a regulated California port or marine terminal must use a CARB Approved Emission Control Strategy (CAECS) to control emissions for the duration of each visit, unless the visit qualifies for an exception. Starting in 2023, the At-Berth regulation applied to container, reefer, and cruise vessels for visits to all regulated terminals. The regulation expands starting in 2025 to include roll-on-roll-off vessel visits to all regulated terminals and tanker vessels for visits to terminals at the Ports of Los Angeles and Long Beach. In 2027, the regulation will apply to tanker vessel visits to all regulated terminals. Stakeholders, including refiners, are concerned about the barriers to compliance which include significant infrastructure upgrades like shore power installations and retrofitting existing vessels to be shore power compatible. This creates challenges for foreign flag vessels that do not invest in retrofitting to meet the new regulation and decreases the supply of vessels that are available to charter. A smaller fleet of At-Berth compliant vessels available to charter will impact refiners' ability to export petroleum diesel and import crude oil and refined products, adding cost.

Maximum Gross Gasoline Refining Margin Regulation: In March 2023, the state legislature adopted **SBx 1-2, the California Gas Price Gouging and Transparency Law**, which authorizes the establishment of a maximum gross gasoline refining margin and the imposition of a financial penalty for refiner profits above the maximum margin. The regulation expands the reporting obligations related to maintenance and business of California refineries to the California Energy Commission (CEC). The law created the Division of Petroleum Market Oversight (DPMO) within the CEC to analyze the data provided by all participants in the state's petroleum industry. It authorizes the CEC to regulate the timing of refinery turnarounds and other maintenance activities in certain instances to mitigate supply shortages and price spikes.

In the case of Phillips 66, their West Coast Realized Margins are already tight and shrinking. According to their **most recent quarterly report,** West Coast Realized margins[1] for the first three quarters of 2024 was $9.34 per barrel. This is a significant loss as compared to the first three quarters of 2023 at $21.40 per barrel. While these margins sound like a lot, in fact P66's

3Q2024 net income was negative (showing a loss of $6.64 per barrel) because of high expenses.

What is the impact on product supply and demand?

To understand California product supply and demand balances, it's helpful to zoom out for a look at the U.S. West Coast (USWC) transportation fuel production and distribution landscape. The map below was developed for the **2015 EIA PADD 5** study. While production facilities and product flows have remained largely the same, many of the refineries shown on the map have changed hands over the nearly 10 years since this report was published. As well, Marathon and Phillips 66 have converted their Bay Area refineries to renewable fuel production. The table to the right of the figure lists the most up to date USWC refining companies, locations, and refinery capacity.

The P66 Los Angeles refinery (number 4 in the group of facilities identified on the map near Los Angeles) consists of two facilities which are five miles apart in Carson and Wilmington and are linked by pipeline. The refinery complex production capacity is 139 thousand barrels per day (kbd), producing about 70 kbd of gasoline and 40 kbd of diesel, along with other refined products. P66's LA refinery supplies refined products to customers in California, Nevada, and Arizona by pipeline and truck.

Current gasoline production capacity in Southern California is about 541 kbd, while diesel production is 138 kbd. P66's LA refinery closure takes about 13% of gasoline and 29% of diesel production out of the Southern California market. This leaves the market balanced for diesel but short for gasoline in the near term, requiring foreign imports. A short gasoline market, reliant on imports, will lead to an increase in retail gasoline price because of the cost to transport imported gasoline from supply sources in Korea, India, or the UK.

The transportation energy transition requires a forward-looking view of supply and demand balances

The transportation energy transition is going to get bumpy. Regulatory and market conditions are likely to squeeze other West Coast refiners out of the market before enough EVs can be adopted to further reduce demand. This will result in gasoline demand exceeding supply, which will raise prices due to increases in the volume of long-haul imports required.

Stillwater has developed a West Coast Supply and Demand Outlook, available to consulting clients, which offers a clear view of the impact of these forces on the market. **Contact us** to learn more.

We see things others miss.

From understanding policy shifts to emerging technology, we'll help you navigate the challenges in the transportation fuels market.

"Margin" refers to the difference between the price of the refined products a refinery sells and the cost of the crude oil it buys. This is different from "profit" which is the actual monetary gain after all expenses are deducted from the margin.

Takeaways by Bloomberg AI

- California's largest inland oil pipeline is in danger of closing within months without state approval for a rate increase and other measures.
- The pipeline's operator, Crimson Midstream LLC, is losing money and facing "severe financial distress" due to a decline in regional oil production and a shift to rival pipelines.
- A shutdown of the pipeline would likely force Bay Area refiners to resort to more imports of ocean-borne crude and could shift some crude supplies to highways aboard tanker trucks.

California's largest inland oil pipeline is in danger of closing within months without state approval for a rate increase and other measures, a shutdown that would choke off some crude supplies to at least two San Francisco-area refiners.

Crimson Midstream LLC's San Pablo Bay Pipeline that hauls oil from the Bakersfield area to Northern California refiners is losing $2 million a month, creating "severe financial distress" for the company, Robert Waldron, CEO of Crimson's parent CorEngery Infrastructure Trust, wrote in a letter to Governor Gavin Newsom's office this week.

The pipeline's fortunes have waned amid a "sudden and unexpected shift" of regional oil production to rival pipelines serving Los Angeles-area fuel makers, Waldron wrote. Crude pipelines are designed to pump certain quantities of oil and when volumes fall below the minimum ranges, the costs of operating them can soar.

The Western States Petroleum Association has been warning California lawmakers since last year that dwindling Central Valley oil production risked shuttering pipelines such as the San Pablo Bay conduit. Valero Energy Corp.'s Benicia refinery and PBF Energy Inc.'s Martinez plant, which account for roughly one-fifth of the state's fuel-making capacity, are dependent on Central Valley crude for some of their supplies.

Any interruption in San Pablo Bay Pipeline shipments would likely force Bay Area refiners to resort to more imports of ocean-borne crude, Waldron warned. Crimson is seeking a 37% increase in the fees it can charge to crude shippers, a temporary $3.75-a-barrel tariff hike, and other measures.

California Crude Output Has Been Sliding for Decades

Source: EIA

"Unfortunately, Crimson is now facing severe financial distress," Waldron wrote. "Without near-term relief, Crimson will likely be forced to shut down the SPB Pipeline this fall."

California crude output has fallen by more than 70% in the past four decades as fields first tapped in the early 20th century began to run dry, competition increased from lower-cost sources, and some of the nation's strictest environmental rules piled on costs. Newsom is seeking to make it easier for inland drillers to obtain permits and boost oil output, while further restricting offshore crude production.

The San Pablo Bay Pipeline is the larger of two conduits carrying crude to Northern California. The pipeline's minimum, daily operating capacity is around 60,000 to 65,000 barrels, according to consultant Turner, Mason & Co. Waldron noted that a shutdown risks shifting 15,000 barrels of daily crude supplies to highways aboard tanker trucks, suggesting the pipe already is running significantly below capacity.

Urgent Vulnerabilities and Risks in California's Fuel Supply Chain

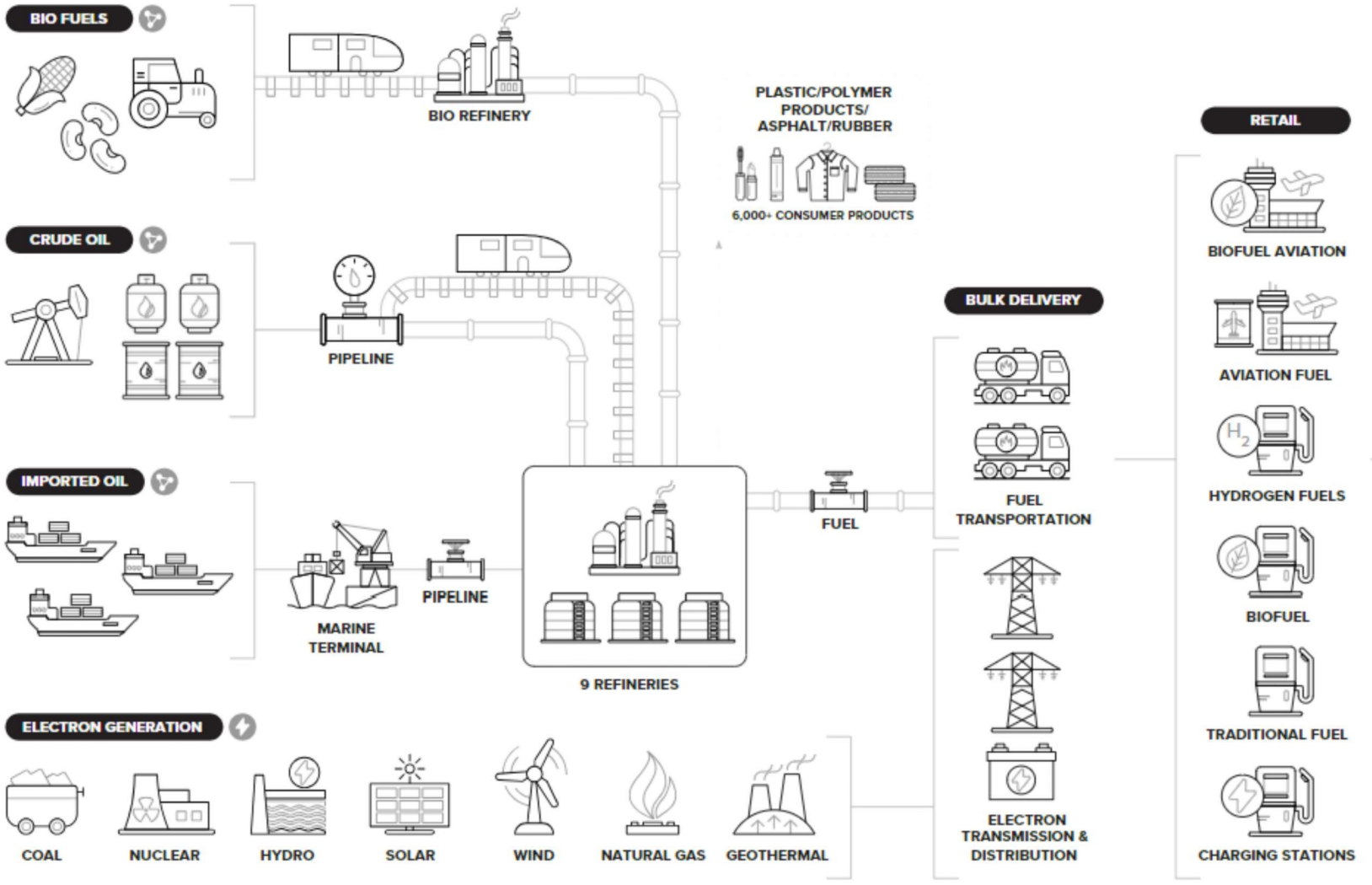
Transportation Energy Supply Chain Infrastructure & Investment (TESCII) Study Summary

For: Petroleum and Gasoline Supply Committee –September 19, 2024
By: Dr. Mark Nechodom, Senior Director for Science & Technology, WSPA

Transportation Energy System

SUPPLY

SCAN TO LEARN MORE



WSPA

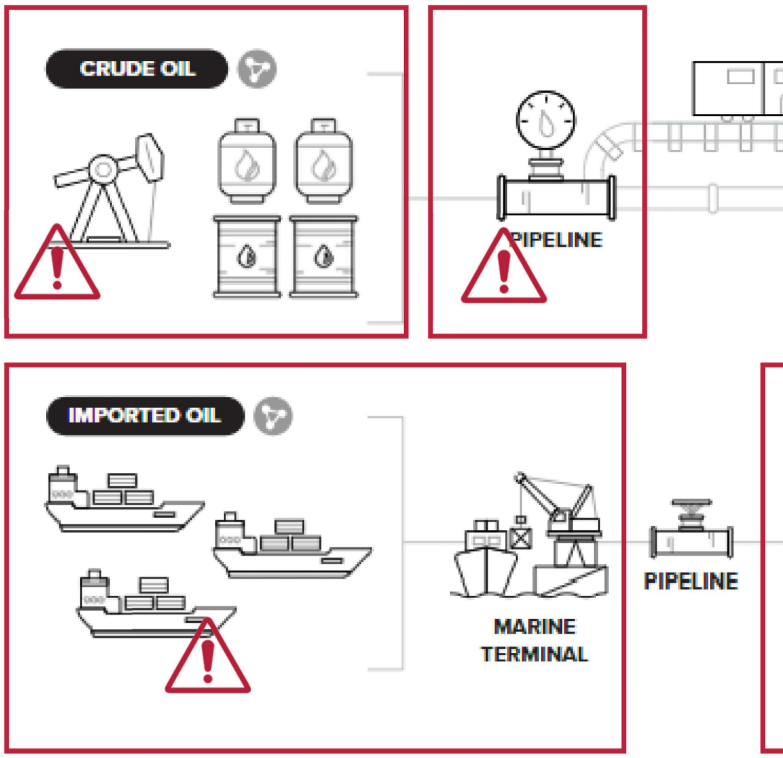
Background & Approach

- California's transportation fuel supply chain is at risk of unprecedented disruption, primarily due to the culmination of tightening state policies and regulations. To better understand the complete impact, WSPA enlisted Turner, Mason & Company (TM&C) to carry out the Transportation Energy Supply Chain Infrastructure and Investment (TESCII) study.

- TM&C conducted a study of the California transportation fuel system (upstream, downstream, logistics, refining, regulatory) with a focus on identifying potential “pinch-points” that could significantly impact the ability of the system to meet the state’s future transportation fuel demands.

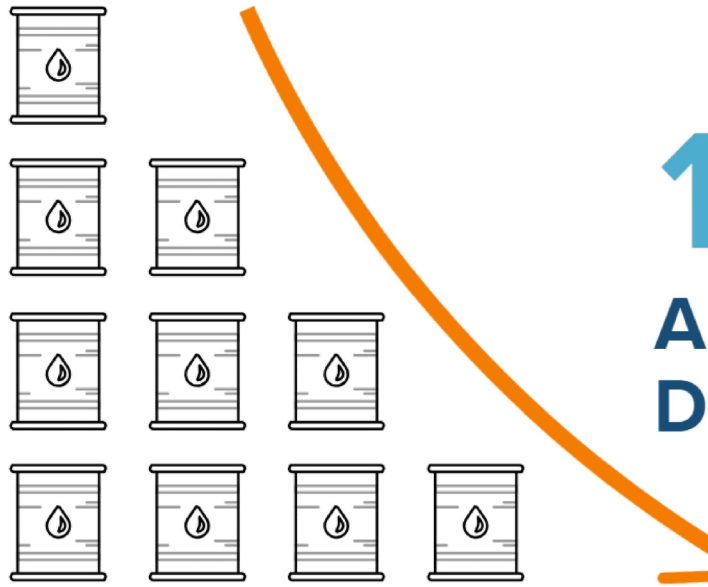
Concerns & Urgent Takeaways

- California crude oil production is in terminal decline, despite ample reserves.
- Pipelines are increasingly at risk of shutdown.
- Marine facilities face increased congestion and dramatic vessel limits.
- It's not a matter of "if" but "when" refiners and oil producers will face tough decisions.
- Without major investments, refiners' ability to adapt to shifts in supply or demand will be constrained.



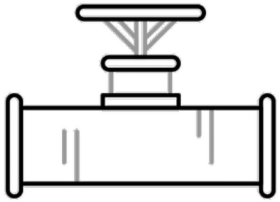
Production of Crude Oil is in Terminal Decline

- California's crude oil production is experiencing a sharp annual decline rate of ~15%, which is about 50% faster than gasoline demand declines in the state's Transportation Fuels Assessment "Rapid" case.
- This rapid decline is driven by the lack of drilling permits, NOT lack of resources.
- Setback law (SB 1137) could result in a ~20% decrease of production per year.



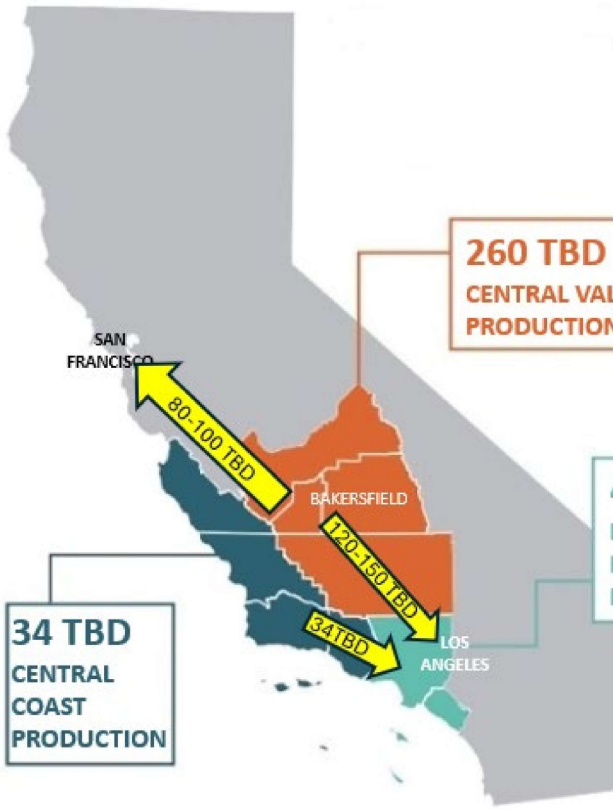
Pipelines Are Approaching Minimum Volume

- California crude oil pipelines are nearing critical minimum throughput levels, requiring at least 30% capacity to maintain safe flow.
- In all scenarios, it's assumed that once a pipeline shuts down, it will not return to service.
- Pipelines serving Northern California are at the greatest risk.
- If pipelines close, refineries become more dependent on waterborne crude oil imports but in some cases lack sufficient marine capacity to fully compensate.



Pipelines Are Approaching Minimum Volume

Regional Movement	Pipeline Name	Current Capacity (TBD)	Estimated Minimum Throughput (TBD)	Current Throughput (TBD)	
Central Valley to San Francisco	KLM Pipeline	90	30-35	80-100	~ 30%
	San Pablo Bay Pipeline	210	60-65		
Central Valley to Los Angeles	Line 63	60	20-25	120-150	~ 44%
	Line 2000	110	30-35		
	M-70 Pipeline	110	30-35		
	Chevron	30	10-15		
Central Coast to Los Angeles	Texaco	28	10-15	34	~ 40%
	Southern California Pipeline System	55	20-25		

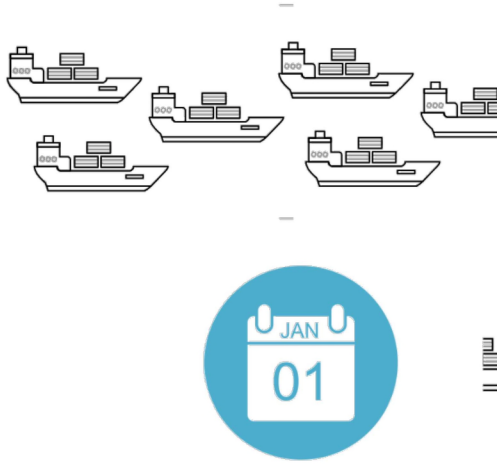


WSPA

Source: CalGEM, CEC, California State Lands Commission, TM&C analysis

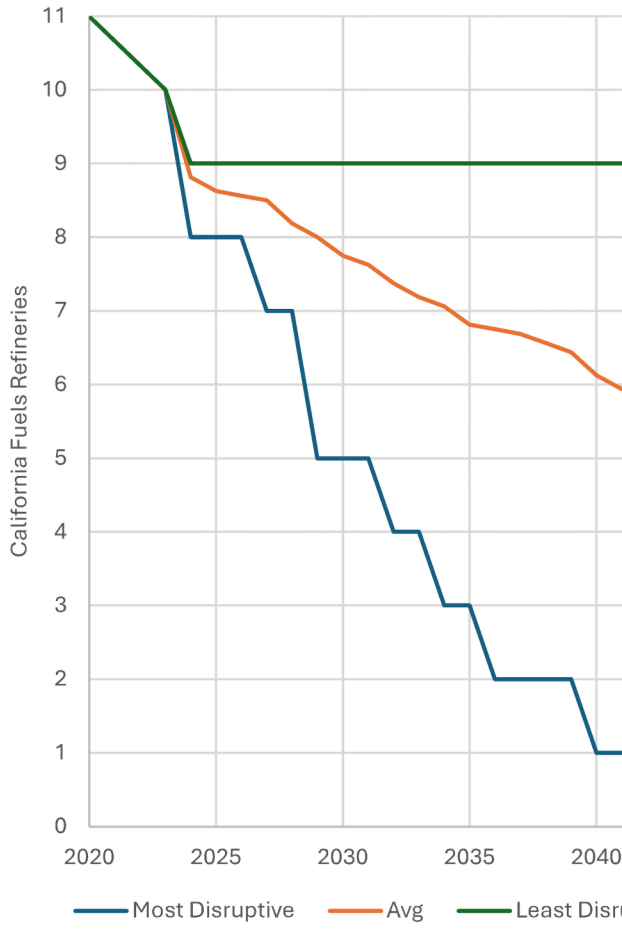
Ports Face Congestion & Vessel Limits

- Starting January 1, 2025, the California Air Resources Board (CARB) will implement “At-Berth” regulations that require ocean-going tanker vessels in Southern California ports to cut emissions using shore power or CARB-approved technologies:
  - The California tanker fleet, as a whole, is NOT currently equipped to use shore power;
  - Sufficient infrastructure is NOT in place to supply the needed electricity;
  - Stack emissions control systems are still in the testing phase, and likely a long way from full deployment at scale.
- Economic decisions may lead to a significant decline in supply of crude and other transportation fuel products needed to meet the state’s energy demand.



Refinery Shutdowns Loom in All Scenarios

- TM&C evaluated potential refinery closures across 16 scenarios covering combinations of:
  - Transportation fuel demand cases
  - Crude oil production profiles
  - Logistics constraints
  - Refining operating environments
- In all scenarios, up to half of California's fuel refineries could shut down by 2045. In the worst-case scenario, only one refinery may be left by 2040.
- "At-Berth" restrictions could quickly shutdown 3-4 refineries.
- None of these scenarios take into account the proposed gasoline margin cap penalty.

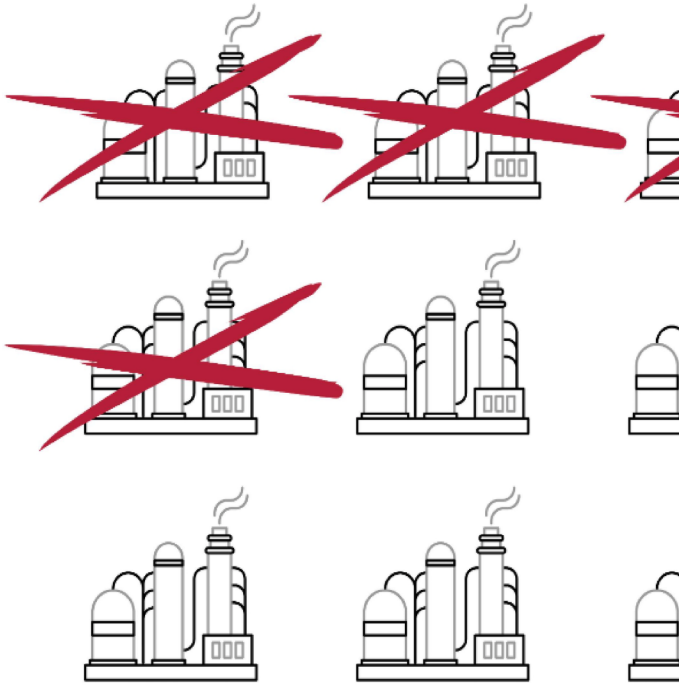


Note: Refinery utilization falls to 65% before shu

WSPA

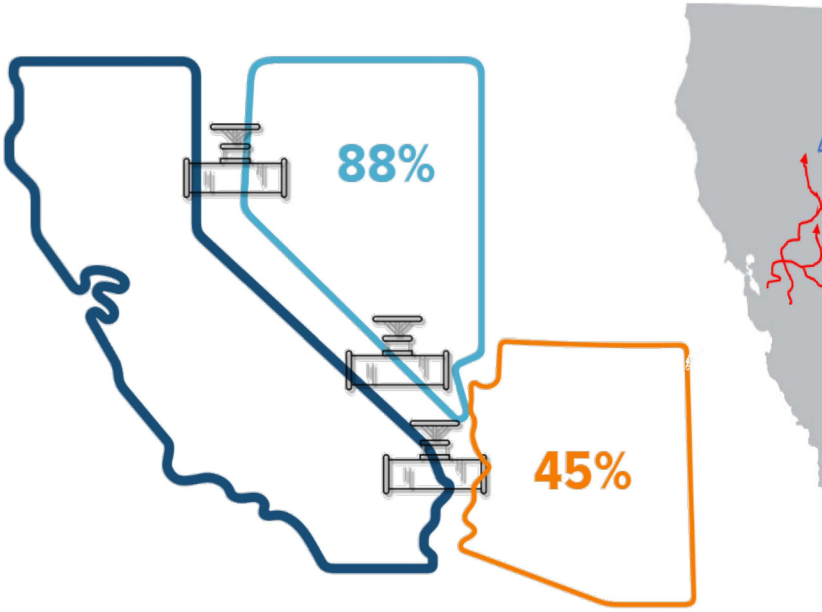
Refinery Shutdowns Loom in All Scenarios

- If onshore power is unavailable or on-ship capture is infeasible, full enforcement of “At-Berth” restrictions could close 3-4 refineries almost immediately
- Refineries may close faster than demand declines, which could put pressure on marine logistics and vessel traffic limits.
- Reality usually strikes faster and harder than models.



Arizona and Nevada Depend on California

- California refineries supply 45% of Arizona's and 88% of Nevada's transportation fuels, so any disruption in California impacts all three states.
- California's northern and southern fuel supply systems are not connected, requiring ocean-going vessels to transport fuel between them.





Discussion

Please direct inquiries to:

Dr. Mark Nechodom
Senior Director for Scienc
Western States Petroleum
mnechodom@wspa.org
916-591-1444

Fugitive Emissions from Natural Seeps and Orphaned Wells are Orders of Magnitude Greater than Fugitive Emissions from Production Equipment in Southern California

James W. Rector[1], Joseph Silvi[1], Jagger Mattox[2], Addison Yeh[2], James Li[1], Satya Weir[1], Brandon Crawford[1]

[1]Department of Civil and Environmental Engineering, University of California, Berkeley
[2]Department of Chemical & Biomolecular Engineering, University of California, Berkeley
[*]To whom correspondence should be addressed

Abstract

Parts of Southern California hold more recoverable oil per acre than anywhere else in the world. However, over the past 50 years, there has been a groundswell of opposition to continued domestic oil and gas development in Southern California, in part based on studies that have identified environmental, safety, global warming, and social justice issues associated with fugitive emissions from active oil and gas production. Discussions of emissions from oil and gas production in Southern California often overlook natural hydrocarbon seeps. However, Southern California hosts some of the largest, most emissive natural seeps in the world (e.g., Coal Oil Point in the Santa Barbara Channel and the La Brea Tar Pits in Beverly Hills). These surface seeps are associated with large oil and gas fields and are linked via fluid-transmissive faults to deeper oil and gas reservoirs. In many of these Southern Californian oil fields, drilling began over a century ago, with some fields containing dozens of improperly constructed orphaned wells that could act as additional leak pathways to the surface. Beyond emitting climate-warming greenhouse gases and reactive organic gasses, emissions from natural seeps can negatively impact the environment by polluting the ocean, contaminating waterways, and enhancing wildfires. Based on a top-down and a bottom-up meta-analysis from existing studies, we estimate that emissions from natural seeps and orphaned well seepage are currently one to two orders of magnitude greater than fugitive emissions from production equipment leaks in Southern California. Reducing the volume of hydrocarbons in the reservoirs feeding these seeps is the only method shown to markedly decrease their occurrence and emission rates.

Introduction: Seeps and Historical Oil Production in Southern California

Southern California–defined in this paper to be Los Angeles, Orange, as well as offshore and onshore Santa Barbara and Ventura counties–hosts some of the most prolific oil and gas fields in the world. In the first half of the 20th century, oil derricks lined Southern California's beaches and covered much of downtown Los Angeles (Figure 1). A USGS study (Gautier et al., 2012) indicated that there are between 1.4 and 5.6 billion barrels of recoverable oil within the Los Angeles Basin's 10 largest fields, and that many older fields still have considerable reserves.

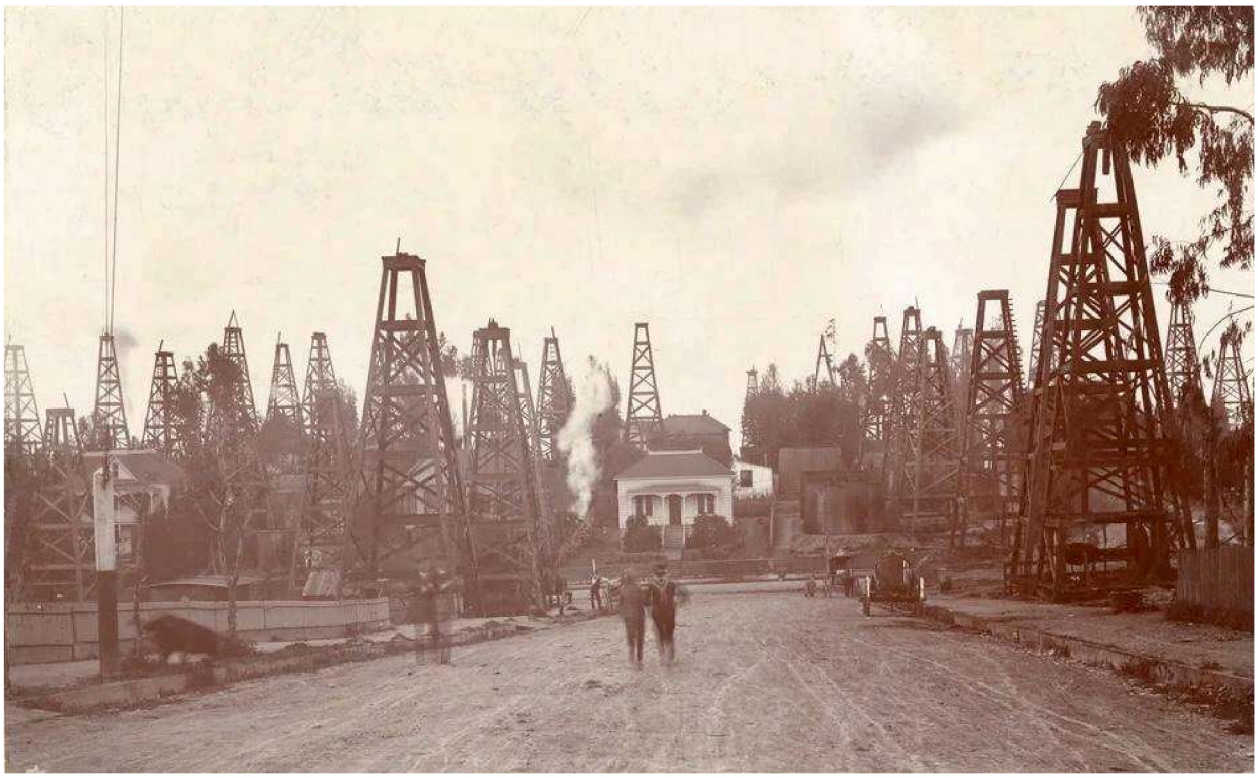


Figure 1: The Los Angeles City Oil Field near Echo Park circa 1895. Photo courtesy of California History Room, California State Library, Sacramento.

Many early California oil and gas fields were discovered based on natural tar seeps. The first successful oil well in Los Angeles was "dug" in 1892 by Edward Doheny in the Echo Park District using a whittled eucalyptus trunk as a drill bit. Doheny had been directed to the area by a man driving a cart with tar on its wheels as it drove through seeps. This well produced 45 barrels of low gravity oil and set off development of the Los Angeles City Oil Field (Franks and Lambert, 1985).

In early California oil fields such as Salt Lake, Santa Fe Springs, Los Angeles City, and Beverly Hills, hundreds of undocumented wells were drilled haphazardly prior to the implementation of a state well-record keeping system in 1915. These early wells were constructed without surface casing and were typically abandoned without plugging prior to the implementation of stricter statewide regulations in 1929. Many of these old, orphaned, and often undocumented wells are substantial contributors to methane emissions (Boutot et al., 2022). Today, many of these wells cannot be located, let alone remediated, and they function as anthropogenic seeps.

Natural seeps have impacted humans in Southern California since the last ice age. The Chumash tribe historically used natural bitumen to waterproof their boats over 10,000 years ago, enabling them to navigate to the Channel Islands, and later to line water bottles and other items. Episodic seep-generated hydrocarbons in the environment may also have contributed to negative health outcomes among the Chumash, potentially leading to loss of stature and population decline at certain points in history (Leifer, 2019; Wärmländer et al., 2011).

Seeps were noted during Portola's 1769 expedition in Southern California. (Van Blossom, 2016). Portola's fellow explorer Juan Crespi remarked that

> *"the explorers saw some large marshes of a certain substance like pitch; they were boiling and bubbling, and the pitch came out mixed with an abundance of water. They noticed that the water runs to one side and the pitch to the other, and that there is such an abundance of it that it would serve to caulk many ships"*

Offshore oil slicks in the Santa Barbara Channel were seen by Admiral Vancouver (Vancouver, 1801) in his 1790 exploration of the California coast:

"the surface of the sea, which was perfectly smooth and tranquil, was covered with a thick, slimy substance, which when separated or disturbed by a little agitation, became very luminous, whilst the light breeze, which came principally from the shore, brought with it a strong smell of tar, or some such resinous substance"

Flammable methane vents have historically posed safety hazards. The father of Ralph Lloyd–the geologist who discovered the giant Ventura Avenue Field–was nearly killed when he sought refuge from a brush fire that was ignited by a lightning bolt. He ran to a patch of ground devoid of vegetation—caused by one of many methane vents in the area—which then burst into flames. He barely escaped with his own life while his horse unfortunately burned to death (Franks and Lambert, 1985). During the Thomas fire in 2017, smoldering seeps were difficult for firefighters to extinguish (Martinez 2017). Natural seeps in Upper Ojai have also been associated with significant streambed contamination (Figure 2) as dozens of seeps in this region flow into Sisar Creek and its tributaries (California Department of Fish and Game, 2008).



Figure 2: Streambed contaminated with natural seep oil in the Upper Ojai region of Ventura County. Photo courtesy of Joseph Silvi.

Oil seeps and methane vents continue to persist in urban Southern California, largely because only a fraction of the region's underground oil and gas has been extracted. These natural methane vents can be dangerous and are often misinterpreted as infrastructure leaks. In 1985, more than 20 people were injured in an explosion in the basement of a department store in the Fairfax District west of Downtown Los Angeles and was attributed to methane gas which accumulated under the department store. It was determined that the likely cause was a combination of natural seeps and orphaned wells venting methane into the store's basement area(California Curated, 2023). A study by the Environmental Defense Fund (EDF) identified numerous methane leaks throughout Los Angeles; however, when SoCal Gas investigated, they found that many were not due to any infrastructure or distribution line leaks but rather were natural in origin (Newton, 2016).

In this paper we investigate the relative contribution of fugitive emissions from natural seeps and orphaned well seepage to present day fugitive emissions from oil and gas production equipment in Southern California.

Geology of Oil and Gas Generation, Migration, and Seeps in Southern California

Southern California is geologically unique in both structure and composition. Active tectonics combined with Miocene deposition of organic-rich sediments has produced source rocks that, upon burial and lithification, generate hydrocarbons. These hydrocarbons underpin world-class petroleum accumulations and drive the extensive natural seepage and hydrocarbon

venting observed at the surface. The Monterey Formation is the predominant source for California's abundant oil and gas resources as well as its seeps (Beckwith, 2013).

Figure 3 depicts the generation, migration, reservoir trapping and partial leaking of oil and gas to the surface in Southern California. The Monterey Formation–including its Nodular Shale unit–was deposited as organic-rich marine shales and siliceous facies throughout the middle to late Miocene (approximately 17 to 5 Ma), during which time the Pacific–North American plate boundary evolved from subduction to strike-slip motion. Upwelling along the California margin and sediment-starved deep basins promoted exceptionally high total organic carbon (TOC) in fine-grained sediments that, upon burial and lithification, serve as the principal source rocks for Southern California's petroleum accumulations (Behl, 1999). Notably, those same siliceous shales and cherts of the Monterey Formation are often the producing reservoir–making it one of the few formations globally to act as both source rock and productive reservoir (Popov et al., 2001).

Total organic carbon (TOC) in the Monterey Formation can be as high as 23% (34% organic matter by weight), more than ten times the TOC of most source rocks (Popov, et al., 2001). Oil generation extends from burial depths between 3 km and 6 km and cracking into lighter hydrocarbons starts at about 5 km (Popov, et al., 2001). Kerogens in the Monterey Formation are sulfur-rich, oil-prone and relatively immature. Oil dated as young as 0.5 Mya has been produced, and hydrocarbon generation is ongoing. Reservoir filling occurred over the past 200,000 years (Jung, et al., 2015). As an active petroleum generation province, Southern California has high heat flow and the subsurface often exhibits high pore pressures which do not decline with production as rapidly as other more mature basins (Jung, et al., 2015). These high pore pressures may enhance fluid migration and seep rates.

As shown in Figure 3 and 4, oil and gas fields in Southern California are often found along major fault systems and associated with fault flower structures, which also serve as leak pathways for surface seeps. Flower structures often have a main surface fault trace with macro-seeps along it, although macro-seeps can also be found at other faults intersecting the surface within the flower structure. Mini- and micro-seeps (Etiope, et al., 2019) are also likely to occur between the faults. Flower structures typically coalesce into a main fault zone beneath the surface which is often associated with major earthquakes. The Newport-Inglewood and Whittier Faults have experienced major earthquakes in the past century at depths between 5 km to 10 km.

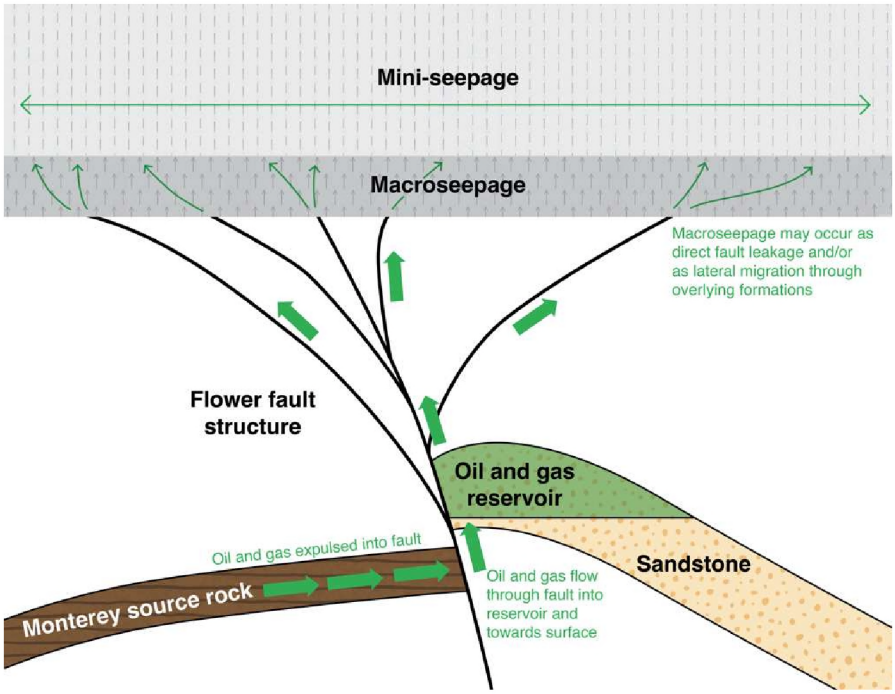


Figure 3: Hydrocarbon generation in the Monterey Formation and subsequent migration via faults into oil and gas reservoirs. In many cases, these reservoirs are bounded by faults and/or internally faulted, which may provide a leak path to the surface.

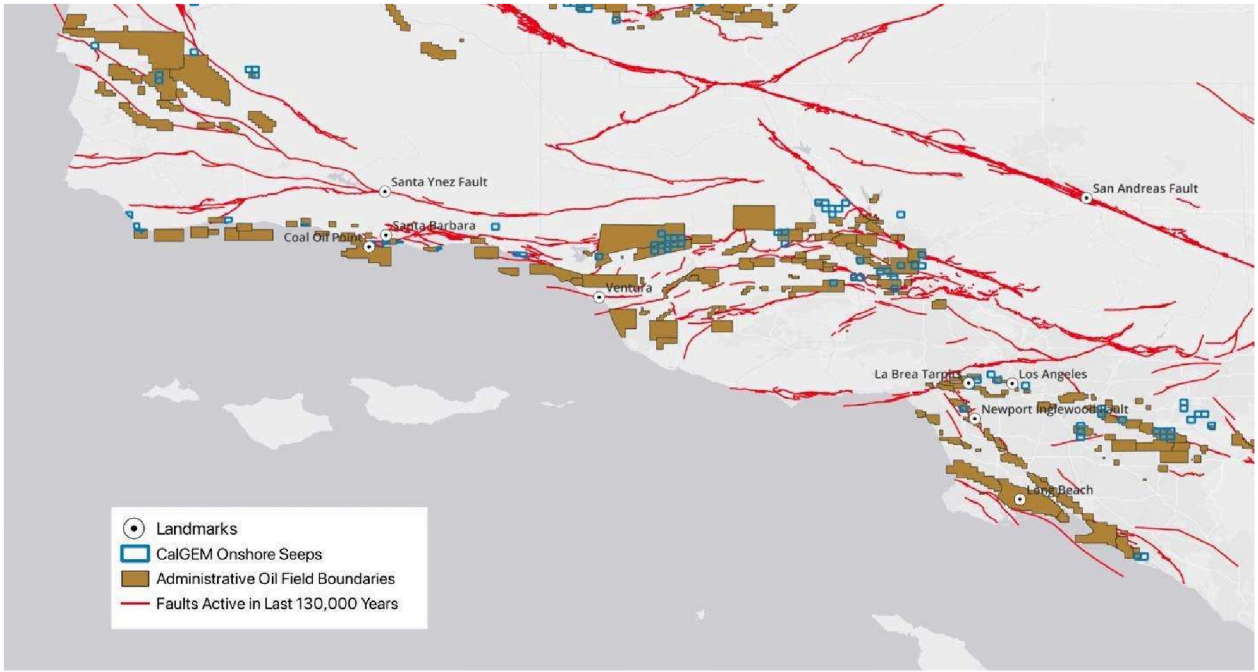


Figure 4: Oil seeps, surface fault traces and oil and gas fields in Southern California.

Studies of Methane Emissions from Seeps in Southern California

Natural hydrocarbon seeps typically occur above faulted oil and gas fields (Leifer, 2019). Local macro-seeps (e.g. Etiope, et al., 2019) can emit methane at rates exceeding 1kg/hr. Macro-seeps are infrequently found in nature, with fewer than 4,000 identified worldwide (Etiope, et al, 2019). By contrast, individual mini-seeps (Etiope, et al., 2017) emit several orders of magnitude less methane into the atmosphere, but contribute three times more than macro-seeps to global emissions (Etiope, 2019), due to the large surface area from which they can originate. Along with methane, seeps often emit light alkanes–such as ethane, propane, *i*-butane, *n*-butane, *i*-pentane, and *n*-pentane. These non-methane hydrocarbons are chemically reactive and contribute to urban and regional ozone formation (Weed, et al., 2020).

Extremely large, short-duration hydrocarbon 'eruptions' have also been documented in the geologic record. Foschi, et al. (2020), combined 3D seismic data and fluid flow modeling to identify one such 'eruption' above a North Sea gas field that emitted an estimated 39-241 teragrams (Tg) of methane in less than 1 year during the Pliocene Epoch. Offshore 3D seismic data suggest that historical seeps like this are often present above oil and gas fields (Jablonski, et al., 2013).

La Brea Tar Pits

The La Brea Tar Pits (LBTP) in Beverly Hills, California, are a well-known tourist attraction with extensive tar, asphaltum, oil, methane and other reactive organic gas seepage that has been extensively studied. Hydrocarbons emitted by the seeps there originate from deeper reservoirs within the Salt Lake Oil Field that underlie the LBTP and migrate upwards to the surface along the 6th Street Fault. (Farrell, et al., 2013; Weber, et al., 2017; Etiope, et al., 2017).



Figure 5: Methane bubbles and oil from a natural seep along a fault system in one of the many McKittrick Brea Pits of Kern County, California. Photo courtesy of Joseph Silvi.

The LBTP have the highest methane flux measured onshore in North America, with cumulative methane emissions rates around 1,600±500 kg/day from the tar pits and surrounding park (Etiope, et al., 2017). The emissions from the LBTP and seeps in the surrounding area account for a considerable amount of Los Angeles Basin seep emissions. Farrell et al. (2013) estimated methane emissions of around 167,000-250,000 kg/day from a ~95 km^2 area centered on the LBTP and extending from Downtown Los Angeles toward the Los Angeles International Airport (LAX).

The LBTP sit at the southwestern edge of the Salt Lake Oil Field which was discovered in 1906 and developed with dozens of undocumented and unplugged wells. Consequently, the seepage from areas around the LBTP are likely to be a combination of natural seeps and orphaned wells seeping. One method to distinguish anthropogenic seeps from natural seeps is by using the isotopic ratio of methane and other heavier alkanes such as ethane and propane (Molofsky, et al., 2025). In general, natural seep gas is expected to take longer to travel to the surface, allowing more chemical alteration, and resulting in more variability in surface chemistry. In addition, natural seeps typically have higher proportions of lighter hydrocarbons. While this observation appears to be true at many locations in the park around the Tar Pits proper, seep samples taken outside the park at the corner of Wilshire Boulevard and Curson Avenue exhibited methane/(ethane+propane) and propane/ethane ratios that were comparable to samples taken from the reservoir. The chemical similarities between this surface seep and the deep reservoir, suggest that this location may be the site of an undocumented orphaned well from early drilling at the Salt Lake Field (Etiope, et al, 2017).

Coal Oil Point

The Coal Oil Point Field (Figure 7) located offshore in the Santa Barbara Channel may be the most studied seep system in the world (Hornafius, et al., 1999; Leifer, 2019; Leifer, et al., 2021; Leifer, 2023; and Boles, et al., 2023). Coal Oil Point (COP) has some of the highest seep rates in the world–two orders of magnitude greater than the largest Gulf of Mexico rates (Leifer, 2019). The seeps in this area emit around 40,000 kg/day of methane, 19,000 kg/day of reactive organic gasses (ROGs) and several hundreds of barrels of oil per day (Hornafius, et al., 1999).



Figure 6: Oil and gas seeping onto the beach from the Monterey Formation at Tar Pits Park in Carpinteria along the Santa Barbara Coast. Long term production of oil and gas from reservoirs underneath the Santa Barbara Channel has slowed seepage. Photo courtesy of Joseph Silvi

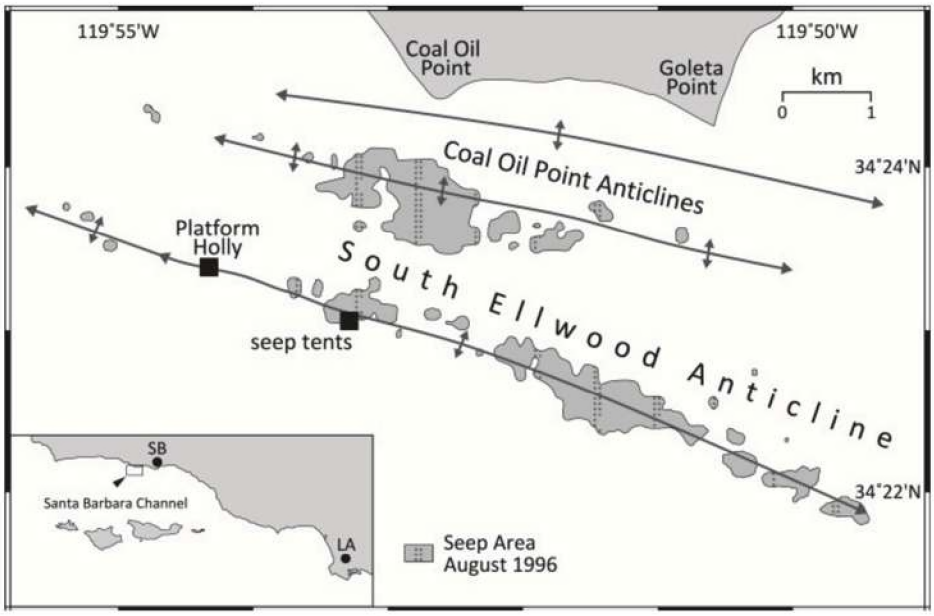


Figure 7: Map of Coal Oil Point and South Ellwood Anticlines along with seep tent locations (taken from Boles, et al., 2023).

Decades of study about seep rates at Coal Oil Point (COP) (see Quigley et al, 1999; Leifer, 2019, and Boles et al., 2023 for a far more in-depth summary) have led to several important conclusions about seep behavior and variability:

1. Very high levels of ROGs are present in the seeps, suggesting high permeability fault paths from the reservoir to the surface.

2. Regional seep rates can vary by an order of magnitude over multi-decade timescales.

3. Seep rates are affected by a wide range of factors including but not limited to oceanic conditions (i.e. tides and currents) and subsurface geological parameters such as pressure, temperature, fluid saturation, formation stress, permeability, and porosity.

4. Oil and gas production can cause short-term increases or decreases in seep rates locally, typically over periods of less than a decade and in localized areas.

5. Over longer timescales (decades), hydrocarbon production has significantly reduced seep rates. Hydrocarbon withdrawal at rates far greater than recharge is the primary reason for long term seep rate reduction rather than pressure depletion.

The last observation is consistent with other studies in Southern California. In the Santa Maria Basin, historical records indicate that seep activity near the Orcutt oil field declined following decades of production, likely due to subsurface pressure drawdown (Fischer, 1977). Similar patterns were inferred in the Ventura Basin, where local observations suggest diminished oil and gas seepage in mature fields such as Ventura Avenue and Torrey Canyon.

Other Seep Studies in California

Some California oil fields do not have high natural methane emission rates. Mellqvist, et al., (2022), made individual wellhead emissions measurements in Kern County's Lost Hills Field, finding an average wellhead emission rate of 0.008 kg/day/wellhead for alkanes and methane combined. This was confirmed by atmospheric emissions measured above the field at roughly 35 kg/day, which would require around 4,000 wells, roughly-matching the number that were operating at the time of the study.

In contrast, parts of the Upper Ojai region in northern Ventura County, which has been producing oil for over 160 years, historically exhibited more visible natural seepage; however, the 103 individual macro-seeps identified here only emit around 10 kg/day of methane within the Upper Ojai region (Duffy, et al., 2007) versus around 40,000 kg/day at Coal Oil Point. Presumably, rates were significantly higher in the 19th century prior to oil extraction as the volume and pressure of hydrocarbons in the subsurface was greater.

Equipment-Related Methane Emissions from Current Oil and Gas Production in the South Coast Air Basin

The South Coast Air Basin (SoCAB), managed by the South Coast Air Quality Management District (SCAQMD), includes Los Angeles, Orange, and the non-desert parts of Riverside and San Bernardino Counties. In 2022, SCAQMD reported that oil and gas production facilities in the SoCAB emitted about 3,300 kg/day of methane, based on quarterly inspections identifying equipment leaks exceeding 500 ppm (SCAQMD, 2022).

To better estimate total emissions from production equipment in the SoCAB, we considered threshold updates in SCAQMD's 2024 amendments. If all minor leaks were reported, SCAQMD's assessments suggest that approximately 80% more emissions would be detected. This implies that current emissions from production equipment in the SoCAB may be around 6,000 kg/day of methane.

Top-Down and Bottom-Up Estimates of Natural Seep and Orphaned Well Emissions in SoCAB

Top-Down

Peischl, et al., 2013, calculated around 1,120,000±110,000 kg/day in overall methane emissions within the SoCAB, of which 498,000±147,000 kg/day came from landfill, wastewater treatment, and dairy emissions. A large portion of the emissions (526,000±148,000 kg/day) were attributed to the combination of natural seeps and natural gas distribution/storage system leaks. Separate studies by Washington State University and SoCal Gas estimated leak rates between 0.05% and 0.12% for SoCal Gas storage and distribution infrastructure (SoCal Gas, 2025). Approximately 60% of SoCal Gas' 21.8 million customers reside within the Los Angeles Basin (SoCal Gas, 2024) resulting in approximately 12,950 kg/day to 31,100 kg/day of methane leaks

with a mean estimate of 22,000 kg/day for natural gas distribution and storage leaks from SoCal Gas's infrastructure in the Los Angeles Basin. Subtracting this from the total estimate of methane emissions for natural seeps and natural gas infrastructure leaks, since Peischl, et al., 2013, did not differentiate these two emissions sources, we estimate that natural seeps and orphaned well seepage currently contribute 504,000±148,000 kg/day of methane emissions in the LA Basin. These emissions are shown in Figure 8.

Bottom-Up

Overall macro-seep methane emissions from the La Brea Tar Pits (LBTP) and nearby environs were estimated to be 1,600±500 kg/day (Etiope, et al., 2017). Scaling this value by a factor of three (Etiope, et al., 2019) to approximately reflect emissions from mini- and micro-seeps in the area results in an estimated 4,800±1,500 kg/day from an area of about 0.04 km^2. Farrell, et al., 2013, estimated methane emissions in a 95 km^2 area around the LBTP, extending from Downtown Los Angeles toward LAX at 167,000 kg/day to 250,000 kg/day with an average of 208,500 kg/day. This area encompasses several old oil fields (Los Angeles City, Salt Lake, Beverly Hills, Cheviot Hills, and Inglewood) many of which were discovered based on natural seeps. These fields were drilled over 100 years ago and contain hundreds of historic orphaned wells that could act as anthropogenic macro seeps (Boutot et al., 2022).

While this region is a seep and emission hotspot, it is a small fraction of the overall Los Angeles Basin which has many other oil fields. For example, the Brea-Olinda and Santa Fe Springs fields, (Figure 4) also have known seeps and dozens of orphaned wells. Emissions and seep rates from these areas have not been quantified as they have been near LBTP, but the sheer area encompassed suggests that overall Los Angeles Basin emissions from natural seeps and historic orphaned wells are substantially larger than the 167,000 kg/day to 250,000 kg/day measured in Northwestern Los Angeles by Farrell, et al., 2013. Using the top-down estimate of 504,000±148,000 kg/day for total emissions from natural seeps and orphan well seepage would indicate that the Northwestern Los Angeles Basin emissions represent around a third of the overall Los Angeles Basin emissions from natural seeps and historic orphaned wells. This is depicted in Figure 8 below.

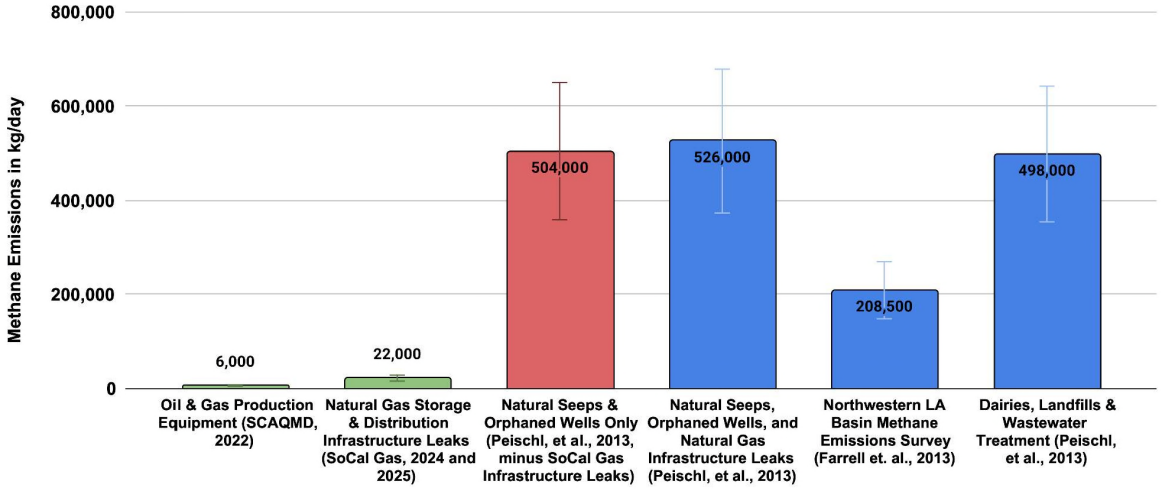


Figure 8: Estimated methane emissions from different sources within the Los Angeles Basin.

Conclusions

Equipment-related methane leaks from production facilities are estimated to be between 0.92% to 1.69% of natural seep and historic orphaned well methane emissions in the SoCAB (that is 6,000 kg/day versus 504,000±148,000 kg/day of methane emissions). It is probable that Ventura and Santa Barbara counties exhibit a similar ratio, since these counties have similar emissions standards and oil and gas development history to the Los Angeles Basin.

Our estimates extend and update the work of Peischl, et al., 2013 by quantifying present-day production equipment-related emissions and natural gas distribution emissions, thereby providing better estimates of seep and historic orphaned well emissions. To our knowledge, this study is the first to directly compare natural seep emissions to production equipment emissions since more stringent regulations for fugitive methane emissions from oil and gas equipment went into effect in the past decade. Luckily, these regulations have resulted in a substantial decline in equipment emissions. Our study suggests that equipment-related emissions are now negligible when compared to emissions from natural seeps and historic orphaned wells in Southern California.

Seep emissions, whether natural or due to orphaned well leaks, are related to the volume of hydrocarbons in the underlying oil and gas reservoir, which is influenced by reservoir depletion. Oil fields with less depletion will tend to have higher seep rates. The only demonstrated way to reduce seep emissions over time is by producing and depleting the underlying oil and gas field. In specific areas such as near the La Brea Tar Pits or near Coal Oil Point, restarting oil and gas production and depleting the reservoirs may benefit the local environment alongside reducing greenhouse and reactive organic gas emissions.

Conflict of Interest

The authors declare that they have no competing interests.

Acknowledgements

The authors thank Robert A. Harley, Giuseppe Etiope, John Harris, and Michael Mische for their informal review of the manuscript and for providing helpful comments that improved the clarity and quality of this work.

Data Availability

No new data were created or analyzed in this study. All data used were derived from existing, publicly available sources, as cited in the References. The data that support the findings of this study are available from the corresponding author upon reasonable request.

Funding

No external funding was received for this study.

References

Beckwith, R., 2013. Mighty Monterey: California's primary petroleum source rock. Journal of Petroleum Technology, 13 April. https://jpt.spe.org/mighty-monterey-californias-primary-petroleum-source-rock

Behl, R.J. (1999) 'Since Bramlette (1946): The Miocene Monterey Formation of California revisited', in Moores, E.M., Sloan, D. & Stout, D.L. (eds.) Classic Cordilleran Concepts: A View from California. Boulder, Colorado: Geological Society of America Special Paper 338, pp. 301–313. doi:10.1130/0-8137-2338-8.301. https://www.researchgate.net/publication/284977415_Since_Bramlette_1946_The_Miocene_Monterey_Formation_of_California_revisited

Boles, J.R., Garven, G. and Peltonen, C., 2023. Hydrocarbon production reduces natural methane seeps in the Santa Barbara Channel. *Marine and Petroleum Geology*, 151, p.106187. https://doi.org/10.1016/j.marpetgeo.2023.106187

Boutot, J., Peltz, A.S., McVay, R. and Kang, M., 2022. Documented orphaned oil and gas wells across the United States. Environmental Science & Technology, 56(20), pp.14228-14236.

California Curated, 2023. Underground fury: The 1985 methane blast that rocked Los Angeles and rerouted its subways, 3 November. https://californiacurated.com/2023/11/03/underground-fury-the-1985-methane-blast-that-rocked-los-angeles-and-rerouted-its-subways/

California Department of Fish and Game, 2008. *Investigation and risk assessment of significant natural seeps in Santa Paula Creek (SSEP 2008-09).* https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=193852&inline

Caplan, M., Kretzmann, H., Aguirre, C. and Naseck, K., 2022. *Oil wells leaking dangerous amounts of methane found in northeast Bakersfield near homes and elementary schools.* https://www.sierraclub.org/press-releases/2022/05/oil-wells-leaking-dangerous-amounts-methane-found-northeast-bakersfield-near

Duffy, M., Kinnaman, F., Valentine, D., Keller, E. and Clark, J., 2007. Gaseous emission rates from natural petroleum seeps in the Upper Ojai Valley, California. *Environmental Geosciences*, 14(4), pp.197–207. https://doi.org/10.1306/eg.07110707010

Duren, R., Thorpe, A. and McCubbin, I., 2020. *The California methane survey.* California Energy Commission. Report No. CEC-500-2020-047. https://www.energy.ca.gov/sites/default/files/2021-05/CEC-500-2020-047.pdf

Etiope, G., et al., 2017, Emission of Methane and Heavier Alkanes from the La Brea Tar Pits Seepage Area Los Angeles, Journal of Geophysical Research: Atmospheres. https://doi.org/10.1002/2017JD027675

Etiope, G., Ciotoli, G., Schwietzke, S., Schoell, M., 2019, Gridded maps of geological methane emissions and their isotopic signature. Earth Syst. Sci. Data, 11, 1-22, https://doi.org/10.5194/essd-11-1-2019

Farrell, P., Culling, D. and Leifer, I., 2013, Transcontinental methane measurements: Part 1. A mobile surface platform for source investigations, Atmospheric Environment, 74, pp. 422–431. https://doi.org/10.1016/j.atmosenv.2013.02.014

Fischer, D.W. (1977) Subsurface and surface oil seepage, Orcutt oil field, Santa Maria Basin, California. USGS Open-File Report.

Foschi, M., Cartwright, J.A., MacMinn, C.W. and Etiope, G., 2020. Evidence for massive emission of methane from a deep-water gas field during the Pliocene. *Proceedings of the National Academy of Sciences of the United States of America*, 117(45), pp.27869–27876. https://doi.org/10.1073/pnas.2001904117

Franks, K. A. and Lambert, P. F. (1985) Early California Oil: A Photographic History, 1865-1940. Texas A & M University Press. ISBN: 978-0890962060

Gautier, D.L., Tennyson, M.E., Cook, T.A., Charpentier, R.R., and Klett, T.R., 2012, revised 2013, Remaining recoverable petroleum in ten giant oil fields of the Los Angeles Basin, southern California: U.S. Geological Survey Fact Sheet 2012–3120, v. 1.1, 2 p.

Hornafius, J. S., Quigley, D. C. and Luyendyk, B. P., 1999, The world's most spectacular marine hydrocarbon seeps (Coal Oil Point, Santa Barbara Channel, California): Quantification of emissions, Journal of Geophysical Research, 104(C9), pp. 20703–20711. https://doi.org/10.1029/1999JC900148

Jablonski, D., Preston, J., Westlake, S. and Gumley, C.M., 2013. Unlocking the origin of hydrocarbons in the central part of the Rankin Trend, Northern Carnarvon Basin, Australia. In: M. Kepp and S. Moss, eds. *West Australian Basins Symposium*, Perth, WA. Perth: Petroleum Society of Australia, pp.1-31. https://www.researchgate.net/publication/325439220_Unlocking_the_Origin_of_Hydrocarbons_in_the_Central_Part_of_the_Rankin_Trend_Northern_Carnarvon_Basin_Australia

Jung, B., Garven, G. and Boles, J.R., 2015. The geodynamics of faults and petroleum migration in the Los Angeles basin, California. American Journal of Science, 315(5), pp.412-459. https://doi.org/10.2475/05.2015.02

Leifer, I., 2019, A Synthesis review of emissions and fates for the Coal Oil Point marine hydrocarbon seep field and California marine seepage, Geofluids, 4724587. https://doi.org/10.1155/2019/4724587

Leifer, I., Melton, C. and Blake, D.R., 2021. Long-term atmospheric emissions for the Coal Oil Point natural marine hydrocarbon seep field, offshore California. *Atmospheric Chemistry and Physics*, 21(23), pp.17607–17629. https://doi.org/10.5194/acp-21-17607-2021

Leifer, I., 2023. Decadal cyclical geological atmospheric emissions for a major marine seep field, offshore Coal Oil Point, Southern California. *Scientific Reports*, 13, p.3035. https://doi.org/10.1038/s41598-023-28067-4

Lloyd, R. B., "Father Saves Life In Brush Fire By Leap Into Canyon," California Oil World, 21 Jan. 1926

Martinez, C., 2017. *Smoldering oil in Upper Ojai a focus of fire crews fighting Thomas Fire*. Ventura County Star, 28 December. https://www.vcstar.com/story/news/2017/12/28/smoldering-oil-upper-ojai-focus-fire-crews-fighting-thomas-fire/987165001/

Mellqvist, J., Samuelsson, J., Offerle, B., Johansson, J., Brohede, S., Andersson, P., Babore, A., Ruiz, D. and Ericsson, M., 2022. *Toxic air contaminant and greenhouse gas measurements near oil and gas operations and proximate communities*. CARB Contract 18ISD023. California: California Air Resources

Board. https://ww2.arb.ca.gov/sites/default/files/2022-09/CARB_contract_18ISD023_FinalReport_ADA.pdf

Molofsky, L.J., Etiope, G., Segal, D.C., Baldassare, F.J., Christman, M. and Roehm, P.E., 2025. Methane-rich gas emissions from natural geologic seeps can be chemically distinguished from anthropogenic leaks. *Communications Earth & Environment*, 6, p.11. https://doi.org/10.1038/s43247-024-01990-8

Newton, E., 2016. *Verification study of the methane mapping of four California cities by the Environmental Defense Fund and Colorado State University.* Southern California Gas Company, 19 August. https://www.socalgas.com/regulatory/documents/r-15-01-008/EDF_4-Cities_Methane_Mapping_Report_Final_081916.pdf

Paul, D.L., Asaithambi, R., Ershaghi, I., Crompton, J. and Gautier, D., 2015. Energy security in the Los Angeles Basin: A new look at an old treasure. Paper presented at the *SPE Western Regional Meeting*, Garden Grove, California, April 2015. https://doi.org/10.2118/174029-MS

Peischl, J. et al., 2013, Quantifying sources of methane using light alkanes in the Los Angeles basin, California, Journal of Geophysical Research: Atmospheres, 118, pp. 4974–4990. https://doi.org/10.1002/jgrd.50413

Popov, M.A., Nuccio, V.F., Dyman, T.S., Gognat, T.A., Johnson, R.C., Schmoker, J.W., Wilson, M.S. & Bartberger, C., 2001, Basin-centered gas systems of the U.S., Open-File Report 01–135 Version 1.0. Denver, Colorado: U.S. Geological Survey, U.S. Department of the Interior. https://doi.org/10.3133/ofr2001135

Quigley, D., Hornafius, J.S., and Luyendyk, B.P. (1999) 'Decrease in Natural Marine Hydrocarbon Seepage near Coal Oil Point, California, Associated with Offshore Oil Production', Geology (1999) 27 (11): pp. 1047–1050 https://doi.org/10.1130/0091-7613(1999)027<1047:DINMHS>2.3.CO;2

SoCal Gas (2025). About Us. https://www.socalgas.com/about-us/mission

SoCal Gas (2024). Methane Emissions Map FAQ. https://www.socalgas.com/safety/methane-emissions/methane-emissions-map-faq#:~:text

=SoCalGas%20has%20worked%20hard%20over,scientific%20journal%20in%20March%202015.

South Coast Air Quality Management District (SCAQMD), 2022, Air Quality Management Plan. Detailed Emission Inventory. https://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2022-air-quality-management-plan/final-2022-aqmp/final-2022-aqmp.pdf?sfvrsn=edcebd61_16

South Coast Air Quality Management District (SCAQMD), 2024, Proposed Amended Rule 1173 - Control of Volatile Organic Compound Leaks and Releases from Components at Petroleum Facilities and Chemical Plants WORKING GROUP MEETING #3 JUNE 12, 2024 – 9:00. https://www.aqmd.gov/docs/default-source/rule-book/Proposed-Rules/par-1173/final-par-1173-wgm3.pdf?sfvrsn=731b8a61_8

Van Blossom, H. (2016) Honey talks about where Los Angeles began: Part 3. Boryanabooks. Available at: https://boryanabooks.com/honey-talks-about-where-los-angeles-began-part-3/.

Vancouver, G. (1801) A Voyage of Discovery to the North Pacific Ocean, and Round the World, Vol. 4, pp. 293–370. London: John Stockdale. (Online edition) Available at: https://www.americanjourneys.org/aj-134/.

Wärmländer, S.K.T.S., Sholts, S.B., Erlandson, J.M., Gjerdrum, T. & Westerholm, R. (2011). Could the health decline of prehistoric California Indians be related to exposure to polycyclic aromatic hydrocarbons (PAHs) from natural bitumen? Environmental Health Perspectives, 119(9), 1203–1207. https://doi.org/10.1289/ehp.1103478

Weber, D., Marquez, B.A., Taylor, C., Raya, P., Contreras, P., Howard, D., Nwachuku, I., Fusco, K., Morales, F. and Doezema, L.A., 2016. Macroseepage of methane and light alkanes at the La Brea tar pits in Los Angeles. *Journal of Atmospheric Chemistry*, 74, pp.339–356. https://doi.org/10.1007/s10874-016-9346-4

Weed, B.M., Brambila, G.D. and Doezema, L.A., 2020. Natural seepage of methane and light alkanes at three locations in Southern California. *Atmosphere*, 11(9), p.979. https://doi.org/10.3390/atmos11090979

A STUDY OF CALIFORNIA GASOLINE PRICES

Michael A. Mische
University of Southern California
Marshall School of Business

Business of Energy Transition **Initiative**
March 16, 2025
(Released March 16, 2025, 1800 hours, PST)

Disclaimer & Statement of Independence

This paper solely represents the author's independent work, analysis, perspectives, and opinions. It does not, in any manner, explicitly or implicitly, reflect, represent, or describe the views, opinions, and positions of the University of Southern California, the Marshall School of Business and its faculty, employees, administration, or students, or the USC *Business of Energy Transition Initiative.*

In creating and presenting this work, the author has made all reasonable attempts to ensure the accuracy and consistency of the data, attribution to data sources, analysis, and calculations. Nonetheless, variances in data and presentation may exist to some degree. In the author's opinion, such variances do not materially change the tenor, trajectories, impressions, interpretations, conclusions, or possible implications associated with the data, data sources, and related analysis.

The work presented herein is provided for informational, research, discussion, policy, and educational purposes. In performing this work, the author has not received any special compensation and has no promise or anticipation of any future compensation for the work presented herein. This work and the author are entirely independent and not affiliated with, in any form, and are not advocating on behalf of or representing any petroleum company, organization, or foreign entity.

ABSTRACT
The "Golden State" consistently ranks among the highest retail gasoline prices in the U.S. and, for most of 2024, held the #1 ranking for the highest taxes and regulatory mandated taxes and fees per gallon of gasoline in the U.S.[1] [2]

Californians are no strangers to paying some of the highest retail gasoline prices in the nation. Since January 1995 through January 20, 2025, Californians have been paying, on average, 13.1% more for their gasoline than the rest of the nation. Not surprisingly, the average price of retail gasoline in California on March 11, 2025, was $4.694 a gallon, or 52.35% higher per gallon for all formulations than the national average price for gasoline at $3.081, according to AAA.[3] Within California, retail gasoline prices vary considerably. For example, on the same day (03/11/25), the retail price for reformulated gasoline in Mono County was $5.82 a gallon, or 88.89% higher than the national average and 23.98% higher than the average for all California counties.[4]

It's not just gasoline that Californians pay a premium for. According to California's own Legislative Analyst's Office (LAO), greenhouse emissions policies have contributed to the second highest monthly electricity rates for residential service in the U.S.[5] For the 2019 to 2024 period, the LAO reports that residential electrical utility rates in California increased by 47%. In the Golden State, Californians monthly utility bills average $438.[6] [7]

California is the second largest consumer of petroleum in the U.S. Notwithstanding its proven crude oil reserves which are the 5th largest in the U.S., California represents less than 3% of all U.S. oil production.[8] While overall U.S. oil imports from foreign sources have declined considerably, California oil imports from petrostates such as Saudi Arabia and Iraq have increased significantly. As a consequence of declining in-state oil production, California is highly dependent on oil imports from petrostates such as Iraq (21.26%), as well as South American sources such as Brazil (20.41%), Guyana (15.80%), and Ecuador (13.60%). In 1982, California imported 5.6% its crude oil from foreign sources. In 2024, the Golden State imported 60.7% of its oil from foreign sources. As a consequence, California is highly vulnerable than the U.S. to geopolitical situations that effect crude prices.

As in other jurisdictions, the sentiment of California's state and local government, policies, elections, and regulations affecting the oil and gas industry have consequences that influence gasoline production and prices. Within 72 hours of passing ABX-1-2, which required California refiners to hold additional inventories of finished gasoline stock, Phillips 66 announced the closing of its Los Angeles refinery

[1] Stinson, R. V., & updated, D. M. last. (2021, August 9). *10 States with the Highest Gas Taxes*. Kiplinger.com. https://www.kiplinger.com/taxes/state-tax/603259/states-with-the-highest-gas-taxes
[2] *Gas Tax Rates by State, 2024*. (2024, September 3). Tax Foundation. https://taxfoundation.org/data/all/state/state-gas-tax-rates-2024/
[3] *AAA fuel prices*. (n.d.). https://gasprices.aaa.com/?state=CA
[4] *AAA fuel prices*. (n.d.). https://gasprices.aaa.com/?state=CA
[5] Spady, A. (2025, January 8). California's "ambitious" policies to reduce greenhouse gases drive surge in electricity costs: report. *Fox Business*. https://www.foxbusiness.com/fox-news-politics/californias-policies-greenhouse-gases-electricity-surge
[6] https://www.foxbusiness.com/fox-news-politics/californias-policies-greenhouse-gases-electricity-surge
[7] Carey, R. (n.d.). *How much does it cost to live in California? Housing, utilities, and more*. Unbiased. https://www.unbiased.com/discover/banking/what-is-the-cost-of-living-in-california#:~:text=California's%20average%20cost%20of%20living,on%20top%20of%20your%20finances.
[8] https://constructioncoverage.com/research/states-with-the-most-oil-reserves

by the end of 2025.[9] [10] The Phillips 66 refinery that is slated to close represents 8.13% of California's refining capacity. It's doubtful that demand will drop commensurate with the closing of the refinery, and simple economics states that when supply drops more than demand, prices will rise. To compensate for the closure of the Phillips 66 refinery, California will most likely have to increase its imports of California-compliant gasoline, which is costly, and surviving refineries may have to increase capacity utilization.[11]

Additional considerations related to importing California compliant gasoline involve the security of sources, travel distances, transit times, and mode of transportation, all of which influence and increase consumer prices and impact greenhouse gas (GHG) emissions and California's "well to wheel" carbon footprint. For example, if California compliant gasoline is imported to meet demand, it will most likely come from the Gulf Coast refineries requiring transit via maritime tankers in large quantities through the Panama Canal to Los Angeles or from Washington state which also contributes to additional greenhouse gas emissions and more costs leading to higher retail prices for the public at the pump.

The 2024 passage of SBX2-1, mandating California refineries to switch to producing a lower carbon fuel, will, most likely, according to the CARB, University of Pennsylvania, and USC studies, increase the retail price of gasoline at the pump from $0.47 to over $1.15 a gallon for Californians.[12] [13] Furthermore, price increases in California will mostly likely also be reflected in retail prices in Nevada, which is almost entirely dependent on California refineries for its gasoline, and to a lesser extent Arizona.[14] Nevada and Arizona have no gasoline refinery capacity and limited inbound gasoline pipelines. Consequently, Nevada imports 88% of its gasoline from California, while Arizona relies on California for 48% to meet its gasoline needs.[15] California production and prices have a direct influence on consumer prices in Nevada and Arizona. The long-term correlation for the period of January 1983 to March 2022 between Nevada gasoline prices and California gasoline wholesale prices is .995, in absolute terms, and .905 for monthly percentage changes in wholesale prices. Stated differently, what happens in California to the oil and gasoline industry regarding gasoline prices will happen to Nevada and, to a lesser extent, Arizona. In response to California's recent regulatory actions, both Governor Joe Lombardo of Nevada and Katie Holmes of Arizona documented their concerns to California's Governor Newsom in a letter dated September 10, 2024.[16] Notwithstanding, both states have exposure to California's actions and, as such, should anticipate increasing in retail gasoline prices for their consumers.

---

[9] *Phillips 66 provides notice of its plan to cease operations at Los Angeles-area refinery.* (2022). Phillips66.com. https://investor.phillips66.com/financial-information/news-releases/news-release-details/2024/Phillips-66-provides-notice-of-its-plan-to-cease-operations-at-Los-Angeles-area-refinery/default.aspx

[10] Zavala, A. (2024, October 16). *Days after Newsom signs bill aimed at "big oil," Phillips 66 says it plans to stop operating refinery.* KCRA. https://www.kcra.com/article/phillips-66-california-refinery-announcement-gas-prices/62629019

[11] *California law and refinery closure reflect ongoing challenges for the state's fuel market - U.S. Energy Information Administration (EIA).* (n.d.). https://www.eia.gov/todayinenergy/detail.php?id=63944

[12] Lazo, A. (2024, November 9). *California enacts new climate rules — which could boost gas prices.* CalMatters. https://calmatters.org/environment/climate-change/2024/11/california-fuels-standard-gas-prices-climate-change/

[13] *California's Low Carbon Fuel Standard.* (2024, October 14). Kleinman Center for Energy Policy. https://kleinmanenergy.upenn.edu/research/publications/californias-low-carbon-fuel-standard/

[14] California supplies between 84% to 88% of Nevada's gasoline.

[15] https://www.wsj.com/opinion/california-oil-refinery-tax-nevada-arizona-gavin-newsom-katie-hobbs-joe-lombardo-4aaf3553#

[16] *2024-09-10_governor-lombardo-and-hobbs-urge-governor-newsom-to-halt-legislation.* (2024, September 10). https://gov.nv.gov/Newsroom/PRs/2024/2024-09-10_governor-lombardo-and-hobbs-urge-governor-newsom-to-halt-legislation/

OBJECTIVES

The primary objective of this research is to address the issue of *"Why are retail gasoline prices in California so high?"* Secondary and complementary objectives include:

(1) Contributing to the body of research related to California oil and retail gasoline prices,
(2) Providing additional data-driven insights as to California retail gasoline prices and the determinants of retail gasoline prices,
(3) Identifying the factors contributing to California's high retail gasoline prices.

FOUR ESSENTIAL QUESTIONS

California's persistent and historically high retail gasoline prices and price differentials compared to the U.S. average represent an exceedingly complex series of questions involving the interactions between public and private sectors, as well as individual consumers. This study has endeavored to address four essential questions:

(1) "Why are retail gasoline prices in California so high?"
(2) What factors contribute to gasoline production and distribution costs in California, and to what extent do those factors influence retail gasoline prices?
(3) To what extent, if any, is there price gouging, profiteering, and or a 'mystery surcharge' placed on the California consumer by the refiner?
(4) To what extent have legislation and regulation influenced the gasoline retail prices in California?

This paper addresses those questions and offers data-driven insights into California gasoline prices.

METHODOLGY

Addressing the above research objectives required extensive analysis of data and comparative analytical methods. For this research effort, a series of critical questions were developed, and data related to addressing those critical questions was identified, obtained, organized, and analyzed. The research involved 10 to 50 years of data. The research involved in this work is widely available and includes but is not limited to verifiable sources such the California Energy Commission, U.S. Energy Information Agency, Bloomberg, U.S. Department of Energy, SEC filings, International Energy Agency, Oil & Gas Journal, American Petroleum Institute, the California Department of Tax and Fee Administration, the U.S. EPA, California Air Resources Board, Statista, The Federal Reserve Bank, the California Attorney General's Office, the California Legislative Analyst's Office, U.S. Department of Interior, Bureau of Labor Statistics, California DMV, and the U.S. Oil and Gas Association. Readers are strongly encouraged to avail themselves to over 350 sources and authorities footnoted herein. In instances where research and data were derived from proprietary sources, appropriate annotations have been provided.

In performing quantitative analysis, applied several different methods, including simple regression analysis, z-scores, percentage change analysis, comparative analysis, ratio analysis, and other techniques that, in the professional judgment of the author, were appropriate and reasonable.

ACKNOWLEDGEMENTS

The author wishes to extend a very and sincere "Thank you" to Graduate Assistants Mark Duling (USC-Marshall MS, 2025) and D. J. Nielsen (USC-Marshall MBA, 2024) for their research, dedication, and various contributions to this work. Both of you worked hard and your efforts are greatly appreciated. Additionally, the author wishes to extend acknowledgement to Professor Shon Hiatt, Director, USC *Business of Energy Transition Initiative.* To all, thank you.

Information and inquiries related to this work may be directed to:

Professor Michael A. Mische
Marshall School of Business
University of Southern California
Email: mische@marshall.usc.edu

Released
March 16, 2025
1800 Hours, PDT
Los Angeles, California

A STUDY OF CALIFORNIA GASOLINE PRICES
TABLE OF CONTENTS

Section	Topic	Page
0.0	**Executive Summary and Conclusions**	**16**
1.0	**Understanding Global & U.S. Petroleum**	**25**
1.1	Introduction	
1.2	U.S. & World Petroleum Reserves	
1.3	Product Yields & Composition	
1.4	Crude Oil & Gasoline Prices	
1.5	Pricing Components: Crude Oil & Gasoline	
1.6	Brief History of Petroleum in California	
2.0	**California Gasoline Consumption**	**44**
2.1	California Gasoline Consumption	
2.2	Factors Contributing to the Reduction in Gasoline Consumption	
2.3	Octanes and Brands	
2.4	California Retail Distribution Models	
3.0	**California Oil & Gasoline Production & Movement**	**65**
3.1	Introduction	
3.2	Petroleum and the California Economy	
3.3	California Oil Production	
3.4	California & PADD 5 Production	
3.5	California Refineries	
3.6	Gasoline Production	
3.6.1	Refiner Retail Sales to Retailers	
3.6.2.	Finished Gasoline Stocks	
3.7	Gasoline Blends	
3.7.1	Seasonal Blends	
3.7.2	California Seasonal Blends	
3.7.3	Special Blend	
3.7.4	California Octanes	
3.7.5	Branded and Unbranded	
3.8	Gasoline Storage and Days Inventory	
3.9	California Oil Transportation: Pipelines, Marine Vessels, Rail & Truck	
3.9.1	Crude & Gas Movement	
3.9.2	Maritime Vessels	
3.9.3	Pipelines	
3.9.4	Rail Tankers	
3.9.5	Tanker Trucks	

4.0 CA Oil Imports & Foreign Oil Sources **117**
4.1 California Sources of Foreign Imports
4.2 California Compared to U.S. Oil Imports
4.3 Greenhouse Gas Emissions- Imports
4.3.1 Production Emissions
4.3.2 Maritime Tanker Movement & GHG & Routes

5.0 Refinery Operations & Margins **140**
5.1 Introduction
5.2 Basic Refinery Economics
5.3 Business Operating Environment Costs
5.4 Refinery Capacity Utilization
5.5 Refinery Margins
5.5.1 Crude Costs and Margins
5.5.2 California Margins
5.5.3 Crack Spreads
5.5.4 California Crack Spreads

6.0 California Gas Pricing **166**
6.1 Introduction
6.2 California Gasoline Prices
6.3 California Gasoline Taxes, Fees and Costs
6.3.1 Excise Tax
6.3.2 California Cap and Trade & Environmental Costs
6.3.3 Local Sales Tax
6.4 California Consumer Price Inflation & Gasoline Prices
6.5 California Revenue from the Sale of Gasoline
6.6 Analysis of California Gasoline Price Movements

A STUDY OF CALIFORNIA GASOLINE PRICES
List of Exhibits by Section

1.0 Understanding Global & U.S. Petroleum

Number	Exhibit
1.1	2022/23- Global Production & Consumption – Top 10 Nations
1.2	Comparison: Percentage Change in U.S. Oil Field Production to Percentage Change in U.S. GDP 1991 to 2022
1.3	Comparison: Correlation Coefficients Between U.S. Oil Field Production & U.S. GDP for Selected Periods
1.4	Comparison: Crude Oil Prices to Food Price Index 1990 to 2015
1.5	Comparison: US & CA Average Retail Gas Prices 2019-2023 to Increase of Price of Food, Dairy, & Entertainment 2019-2023
1.6	Top 10 Proven Oil Reserves by Nation; U.S. Crude Oil and Lease Condensate
1.7	U.S. Petroleum Consumption, Production, Imports, Exports, and Net Imports, 1950-2022
1.8	Typical Distribution of Petroleum Product Yields by Barrel
1.9	World Crude Oil Prices
1.10	Crude Oil Prices and Key Geopolitical & Economic Events
1.11	U.S. Oil Shocks: Production, Consumption, Exports & Imports
1.12	Comparison Price per Barrel of Crude Oil to U.S. Price per Gallon of Retail Gasoline (Monthly for 1993 to 2024)
1.13	Comparison: Percentage Change in Crude Oil Prices to Percentage Change in U.S. Gasoline Prices

2.0 California Gasoline Consumption

Number	Exhibit
2.1	CDTFA Net Taxable Gasoline Sales by Calendar Year 2001 to 2024(e)
2.2	DOT-FHA California Gasoline Consumption 1971 to 2022
2.3	Annual Percentage Change in CDTFA Reported Gasoline Consumption to Annual Percentage Change of DOT-FHA Gasoline Consumption 2002 to 2022
2.4	Annual Percentage Change in CA. Gasoline Consumption as Compared to Annual Percentage Change in Total U.S. Gasoline Consumption (DOT-FHA-MF-226 Data) 1971 to 2022
2.5	California CDFTA Annual Percentage Change in Gasoline Sales (Consumption) by Calendar Year 2001 to 2024e
2.6	Percentage Change in California GDP to Percentage Change in CA Gasoline Consumption 2002 to 2023 (CY)
2.7	CDTFA Net Taxable Gasoline Sales Net of Aviation Fuel Sales- CY 2001 to 2024(e)
2.8	California Aviation Fuel Consumption as a Percent of Gasoline- CY
2.9	Comparison: Annual Percent Change in Gasoline Consumption- California to U.S.

2.10	2023 California Retail Gasoline Sales by County (Millions of Gallons)
2.11	Electric Vehicle Market Share in California
2.12	Electric Vehicle Projected Market Share
2.13	California: Distribution of Motor Vehicle Registrations by Fuel Type 2023
2.14	Annual Vehicle Miles Traveled in the United States
2.15	U.S. Average Miles per Gallon for Light Vehicles 1975 to 2020
2.16	Comparison: CA Percent of Premium Gasoline Sales to All U.S. Premium Sales 2020
2.17	Comparative Analysis of Octane on the Performance of Selected Cars
2.18	California Percentage Growth in Category Sales by Octane Grade 2010 to 2020
2.19	California: Percentage Distribution of Gasoline Sales by Grade 2010 to 2020
2.20	California: Percentage Change in the Composition of Retail Gasoline Sales by Grade 2010 to 2020
2.21	Distribution of California Retail Gasoline Sales: Branded vs. Unbranded 2022
2.22	California Annual Percentage Composition of Retail Gasoline Sales for Branded, Unbranded & Hypermarts Formats
2.23	Some Attributes of Gas Station Owners & Operators
2.24	California Gasoline Market Share by Brand 2010 to 2022

3.0 California Oil & Gasoline Production

Number	Exhibit
3.1	Percentage Change in California GDP to Percentage Change in U.S. GDP (current) 1982 to 2023
3.2	California's GDP Per Capita Vs Other States
3.3	California: Gross Domestic Product from Oil & Gas Extraction
3.4	Percent Change in California's GDP to % Change in CA. Oil Field Production 1998 to 2022
3.5	California In-State Oil Field Production 1981 to 2023
3.6	California Imports of Non- U.S. Oil 1982 to 2023
3.7	California Sources, Grades & Transportation Methods for Crude Oil 2018 to 2024
3.8	Comparison: Percent Change in U.S. Oil Field Production to Percent Change in California Oil Field Production
3.9	Percent of Oil Production by Top Producing U.S. State – 2023
3.10	Comparison: Percent Change in U.S. Oil Field Production to % Change in California Oil Field Production 1990 to 2022
3.11	California: Percent of In-state Oil Field Production Meeting In-state Needs 1982 to 2022
3.12	Key Indicators Related to California's Oil Production, Consumption, and other Factors
3.13	California Percent Change in Selected Indicators 1990 to 2025
3.14	Comparison Average California Field Production to All States

3.15	Percentage Distribution PADD 5 Operable Refinery Capacity- 2021
3.16	Comparison: West Coast PADD 5 Oil Field Production to CA Oil Field Production 1990 to 2023
3.17	Comparison: Annual Percentage Change in Oil Field Production for PADD 5- CA and U.S. 1991 to 2022
3.18	Comparison: Percentage Composition of PADD 5 & CA Oil Field Production to Total U.S. Oil Field Production 1990 to 2022
3.19	Comparison: PADD 5 Weekly Refinery Capacity Utilization to All U.S. Refinery Capacity Utilization Rate (CUR) June 4, 2010 to October 25, 2024
3.20	PADD 5 Refining Capacity Utilization Rate June 10, 2010 to October 25, 2024
3.21	West Coast (PADD 5) Receipts by Pipeline from Gulf Coast (PADD 3) of Crude Oil and Petroleum Products
3.22	Overall U.S. Refinery Yield of Finished Motor Gasoline 1992 to 2023
3.23	California Oil Refineries, Capacity, Volumes, & CARB Capability
3.24	Percent Distribution of California Oil Refinery Processing Capacity-By Refiner in 2024
3.25	California Number of Operable Refineries as of January 1, 1982 to January 1, 2024
3.26	Comparison: % Distribution of Product "Slate" per Barrel of Oil - CA to Typical
3.27	Comparison: Product Types per Barrel - California to U.S.
3.28	California Total Gasoline Retail Sales by Refiners 1994 to 2020
3.29	Annual Percentage Change: California Total Gasoline Retail Sales by Refiners 1994 to 2020
3.30	California Total Gasoline All Sales/Deliveries by Prime Supplier 1983 to 2020
3.31	Annual Percentage Change in California Total Gasoline All Sales/Deliveries by Prime Supplier 1983 to 2020
3.32	California CDFTA Gasoline Sales (Consumption) by Calendar Year 2001 to 2024e
3.33	California Finished Motor Gasoline Stocks at Refineries, Bulk Terminals, and Natural Gas Plants
3.34	Annual Percentage Change California Finished Gasoline Stocks at Refineries (EIA)
3.35	Monthly Percentage Change in CA Gasoline Stocks to U.S. Gasoline Stocks January 1992 to August 2024
3.36	California Finished Fuel Stocks as a Weekly Percent of Total U.S. Finished Fuel Stocks
3.37	California Percentage of PADD 5 Finished Motor Gasoline Bulk Fuel Stock as a Percentage of All PADD 5
3.38	Percentage Change in Number of Refineries, Bulk Gasoline Stocks, Refiner Sales to Retailers & Sales/Deliveries by Prime Supplier 2002 to 2024
3.39	U.S. Seasonal Blend Requirements by State- Example- Summer 2025

3.40	California Has Improved Air Quality by Aggressively Addressing/Eliminating Gasoline Emissions
3.41	Atomic Composition by Mass of Gasoline
3.42	Ethanol Concentration in Gasoline Over Time
3.43	California: Percent Distribution of Storage Capacity 2024
3.44	California: Total Net Storage Usable Percent Usable Capacity Utilization by Product Type- 2024
3.45	California Estimated Days' Supply of Finished Gasoline Stocks at Useable Capacity 2021
3.46	U.S. Crude Oil Refinery Receipts by Transportation Mode 2020
3.47	U.S. Pipeline Annual Mileage - Hazardous Liquid or Carbon Dioxide Systems
3.48	Distribution of U.S. Pipeline Mileage Used by Product Type
3.49	Distribution of U.S. Pipeline Mileage Use by Product Type - 2023
3.50	Distribution of Transportation Input Methods for Crude Oil Stocks (2016 only)
3.51	Summary of Transportation Costs per Barrel of Oil by Method
3.52	Energy Use by Transportation Mode and Fuel Type

4.0 California Oil Imports & Foreign Oil Sources

Number	Exhibit
4.1	Foreign Sources of Marine Crude Oil Imports to California (2024)
4.2	Comparison: Percentage of California Crude Oil Imports by Source- 2023 to 2024
4.3	Comparison: Percent of Oil Imports by Source- California Imports to All U.S. Imports (2024)
4.4	California- Percentage Ratio Composition of Oil Supplies to In-state Refineries for Selected Years
4.5	Comparison: Selected Rankings for Social, Economic, & Corruption for California Oil Imports (2023/2024)
4.6	Fragile States Index Rating- Selected CA Sources of Foreign Imports
4.7	Comparison of Human Rights for California Oil Sources
4.8	Comparison of Percent Change in Non-domestic Oil Imports- CA to U.S. (1982 to 2024)
4.9	Comparison: Foreign Oil Imports - California to Total U.S. (1982 to 2023)
4.10	California Growing Dependency on Imports of Foreign Sourced Oil
4.11	Total U.S. Imports of Foreign Oil- Lowering Dependency (1982 to 2024)
4.12	California: Percentage Change in Domestic, In-state, & Foreign In-bound Oil Sources to CA Refineries (Imports) (1982 to 2023)
4.13	California Alaska Oil Imports (1982 to 2023)
4.14	California Imports: Percentage Composition by Source (1982-2023)
4.15	California: Changes in Foreign Oil Imports, U.S. Alaska Imports & CA Field Production (1990 to 2023)
4.16	Comparison: McKinsey Study- GHG Emissions by Regions

4.17	Total Greenhouse Gas Emissions for Selected Possible CA Oil Imports by Source Compared to Selected Possible U.S. Sources
4.18	Density & Sulfur Content of Selected Crude Oils
4.19	Comparison: Estimated Greenhouse Gas Emissions by Oil Source
4.20	Greenhouse Gas Emissions by Vehicle Type
4.21	Estimated Transit Times Between the Persian Gulf and the United States
4.22	Comparison: Maritime Vessel GHG Emissions by Source to Destination Based on % Capacity Utilization & Trade Routes
4.23	Comparison: Estimated Oil Tanker GHG Emissions & Transit Times

5.0 Refinery Operations

Number	Exhibit
5.1	NCI Ratings & Capacities of Selected California Refineries
5.2	California: Percent Change in Gasoline Production, Demand, and Retail Prices (3/20 to 5/20)
5.3	Refinery Production- Some Influencing Factors
5.4	Business Operating Environment Factor- CA Ranking Out of 50 (2023 to 2025)
5.4.1	CA Refiner's Costs are Considerably Higher than the National Averages (2017)
5.5	Comparison: Monthly Percent Refinery Capacity Utilization- Total U.S. to PADD 5 (January 1985 to July 2024)
5.6	CA Refinery Capacity Operable to Operating Capacity Utilization Ratio (1982 to 2024)
5.7	Scheduled Refinery Switching (Transition) Shutdowns
5.8	Comparison: % Net Profit Margin Selected Industries (2022/2023)
5.9	S&P 500 Quarterly Earnings (2018-2021)
5.10	Gross Margin by California Refiner (January 2023 to November 2024)
5.11	Average Net Margins for Three California Refineries (July 2023 to April 2024)
5.12	Percentage Change in Aggregate Gasoline Volume Sold to Percentage Change in Aggregate Gross Profits (February 2023 to November 2024)
5.13	Regional September Refining Margins (2020-2024)
5.14	Comparison: CA Excise Tax to Estimated Refiner & Gas Station Net Margin (in cents/gallon)
5.15	U.S.- Crack Spread vs. Oil Price
5.16	Factors Influencing Crack Spreads
5.17	RBOB- Brent Crack Spread Range
5.18	Distillate- Brent Crack Spread Range
5.19	Quarterly Average Refined Product Crack Spread vs. WTI
5.20	Cracking Profits (1986 to 2020)
5.21	Comparison of West Coast Refineries to Gulf Coast Refineries Crack Spreads (2011 to 2023)
5.22	West vs. Gulf Crack Spreads ($ per barrel | 2011– 2023

5.23	% Change in Crack Spreads: West Coast v. Gulf Coast Refineries (2012-2023)
5.24	Comparison of Chevron West Coast 5-3-2 Crack Spreads to Chevron Gulf Coast 5-3-2 Crack Spreads (Q1- 2020 to Q4- 2021)
5.25	Percentage Change in Crude Oil Prices to Percentage Change in West Coast & Gulf Coast Crack Spreads (2012 to 2022)

6.0 California Gasoline Pricing

Number	Exhibit
6.1	Supply Chain Cost Build-up for Retail Gasoline Pricing
6.1-1	Local Gas Station Cost Influences on Local Pricing
6.2	California: Crude Oil Cost as a % of Avg. Retail Gasoline Price 1999 to 2023
6.3	U.S. Retail Gasoline Price, Refiner Acquisition Cost of Crude Oil
6.4	Gasoline Spot Prices by Markets: 2008 to 2024
6.5	Distribution of Regulatorily Mandated Taxes, Fees & Costs Per Gallon
6.6	Comparison: Average Weekly Retail Gasoline Prices California to West Coast to All U.S. Regular Reformulated Retail Prices- 1/20/94 to 1/20/25
6.7	Gap Between CA & U.S. Prices by Week
6.8	California Price Difference from U.S. Average Prices by Time Period in Dollars- 01/02/1994 to 01/20/2025
6.9	California Retail Branded & Unbranded Gasoline Prices- All Formulations- 2013-2023
6.10	California Retail Gas Prices: Branded to Unbranded Comparison- 2013 to 2023
6.11	California Branded to Unbranded Price Differential- 2013 to 2023
6.12	California Branded & Unbranded Percentage Change in Price & Percentage Change Differential- 2013 to 2023
6.13	Random Sample of Retail Gasoline Prices- Southern California
6.14	California Has the Highest Tax Per Gallon on Gasoline in the U.S.
6.15	California Fuel Taxes & Fees Up 78% from 2013 to 2023
6.16	California Retail Average Gasoline Pries Trend Above U.S. Averages with Premium Gasoline Prices Increasing Substantially
6.17	Variable Excise Tax Revenue vs. Pre-2010 Tax Scheme
6.18	Percentage Distribution of All California Taxes, Fees & Cost, inclusive of Federal Excise Tax
6.19	California Regulatory Fees Increase 200%
6.20	Percentage in California Regulatorily Mandated Taxes, Fees & Costs- 1994 to 2025
6.21	California Consumer Price Index to U.S. Consumer Price Index- 1984 to 2024
6.22	Percentage Change in California Consumer Prices to Percentage Change in U.S. Consumer Prices- 1983/84
6.23	Price Adjusted Per Gallon of Regular Reformulated Gasoline in California- 1/1/1995 to 3/8/25

6.24	CA. Gasoline Revenue from State & Local Taxes- 1982 to 2025
6.25	Fuel Tax Revenues Decline as Fuel Efficiency & ZEV Adoption Increases
6.26	Comparison: Monthly Percent Change in CA. Gasoline Wholesale Prices to Monthly Change in CA. Retail Gasoline Pump Prices- 2000 to 2022
6.27	Comparison: Weekly Percentage Change in Average U.S. Gasoline Prices to Weekly Percentage Change in Average California Gasoline Prices- 1/9/1994 to 1/25/2025
6.28	Percentage Price Differential Between Average U.S. Gasoline Price and Average California Gasoline Prices- 01/02/1995 to 01/20/2025
6.29	Percentage Change in CA Gasoline Stocks Compared to Percentage Change in CA. Average Retail Gasoline Prices
6.30	Percentage Change in CA Gasoline Stocks Compared to Percentage Change in CA Average Retail Gasoline Price & U.S. Average Retail Gasoline Prices- 2002 to 2022
6.31	CA. Retail Price- All Formulations, CA. Environmental Fees in Dollars & Percentage Change Post Torrance Refinery Fire- 2/16/15 to 2/20/17
6.32	Summary of Percentage Change in Selected California Gasoline Pricing Factors: Post Torrance Refinery Fire- 2014 to 2019
6.33	L.A. & San Francisco CARBOB Sprot Price Volatility
6.34	CA. Gasoline Prices, Gallons Sold, & Refiner Margins- January 2020 to November 2024
6.35	Comparison- Apple Net Income to Chevron Net Income- 2009 to 2023

EXECUTIVE SUMMARY

Few topics in the Golden State are as contentious and perhaps as misunderstood by consumers, activists, policymakers, educators, and researchers as California gasoline prices. Depending on one's perspective, California has either an exceptionally progressive or extraordinarily repressive political policy, legislative history, and sentiment toward its oil and gas industry.

California has the highest tax, regulatory fees, and cost burden per gallon of gasoline in the U.S., and that burden is anticipated to increase in 2025 and beyond. Included in or added to the retail price of gasoline at the pump is a litany of 6 different regulatorily mandated taxes, costs, and fees such as underground tank storage fees, state and local taxes, the California special blend premium, the California Cap and Trade Program, and other California environmental taxes. Collectively, the sum of all federal, state, and local taxes and fees, as well as regulatory-mandated costs, total approximately $1.638 a gallon, as of March 10, 2025. Comparatively, at $0.596 a gallon in state excise taxes, California's "profit" on a gallon of gasoline sold is almost 4 to 5 times higher than the net profits on the same gallon sold by the gas station operator and is currently estimated to be 3 to 20 times more than that of the refiner. Recently, over a recent 9-month period, the CEC reported that California refineries were operating at a loss of $0.02 a gallon and have incurred losses of as much as $.14 a gallon.

It is uniformly acknowledged that California has the most stringent regulatory, some would argue, again, that depending on perspective, either a toxic or visionary environment, for oil and gas companies in the world. In California, oil producers and refiners must navigate more than 25 federal, state, and local agencies overseeing oil and gas production. Additionally, California has some 518 state agencies, boards, and commissions regulating business practices. Regulatory oversight, irrespective of one's perspective, are layered into and accumulate throughout the supply change ultimately adding to the cost burdens of compliance for oil and gas industry operators, which, in turn, contribute to higher consumer prices at the pump.

California policy and law makers have little actual incentive for lowering consumer gasoline prices in the Golden State. In fact, their actions, such as cap and trade, have led to increases in prices. California is on a stated mission to eliminate internal combustion vehicles by 2035 and beyond, and the policy actions taken appear to be an apparent strategy to force gasoline prices higher as a means of compelling consumers to adopt EVs and ZEVs. With the 2035 elimination of internal vehicle sales in the Golden State looming, California refiners, oil producers, wholesalers, transporters, and gas station retail owners and operators are facing the sunset of their businesses and have little incentive to continue to operate. As California nears closer to 2035, it's doubtful that demand for gasoline will decline at a faster rate than the rate of decline in gasoline supplies resulting in supply stresses in the very near term. For 2023 and 2024, the adoption of EVs in California, as measured by sales, has flattened. Golden State consumers can expect higher and higher gasoline prices as production, supply, and the number of gas stations begin to exit their businesses.

To many, California has a relatively inhospitable business climate, as measured by various studies and surveys. At 5.2%, CA has the third highest unemployment rate in the nation, and with over 180,000 homeless people, California ranks #1 in the U.S. in homelessness. CNBC graded California as an "F" for business friendliness and ranked it 45th out of 50 states for the cost of doing business and 49th in

the cost of living. Since 2018, more than 360 companies, such as Oracle, Tesla, Nissan, Toyota, Nestle, and Hewlett Packard Enterprises, have exited the Golden State. Major companies such as X, Meta, Salesforce, and PayPal have fled San Francisco. More recently, Chevron and Phillips have announced plans to leave California. Under prevailing conditions, refiners and retail gasoline station operators are under constant cost and regulatory pressures, and we can expect more to exit the state.

The California Consumer Price Index (CCPI) has outpaced that of the overall U.S. (CPI) and has experienced higher inflation than the overall U.S. Higher inflation, higher refining costs, higher operating costs, higher regulatory compliance costs, and higher transportation and distribution costs have a compounding effect throughout petroleum supply chains, ultimately culminating at the local gas station owner/operator level, resulting in higher prices for the consumer. The correlations between spot oil prices through the California supply chain and the retail outlet indicate, expectedly, growing variances. The price at retail is a function of wholesale and regulatory costs but is ultimately determined by individual retailer pricing strategies and preferences that are reflected in the selling price of gasoline to the consumer.

California's policies and regulations may also have profound national security implications and extend across state lines. California is home to the U.S. Pacific and Third Fleets and multiple U.S. military, Marine, and National Guard installations.[17] California refineries provide aviation fuels to U.S. military forces based in Arizona, California, and Nevada, as well as diesel, gasoline, and propane fuels to U.S. Marine and Naval forces based in Southern California. National security interests with respect to fuel production and priorities would naturally take precedence over those of the California, Nevada, and Arizona consumers, and as California refinery production is in its legislative sunset period and is inevitably declining, consumer prices will inevitably increase, as well as national security concerns.

CONCLUSIONS

Based on 30 to 50 years of data, the primary conclusion from this study is that California's high gasoline prices and supply dilemmas are, by design, engineering or serendipitously, largely self-inflicted, and the result of directed policies and a litany of regulations, taxes, fees, and costs. The economic evidence is abundant; California refiners have not engaged in widespread price gouging, profiteering, price manipulation, "unexplained residual prices" or surcharges, magical or otherwise. The Golden State's gasoline price dilemma is the result of the complex interactions regulatory and political policies, and the subtleties of refinery operations and global crude oil prices and in-state centric supply and demand. Specifically, California's high gasoline prices can be attributed to:

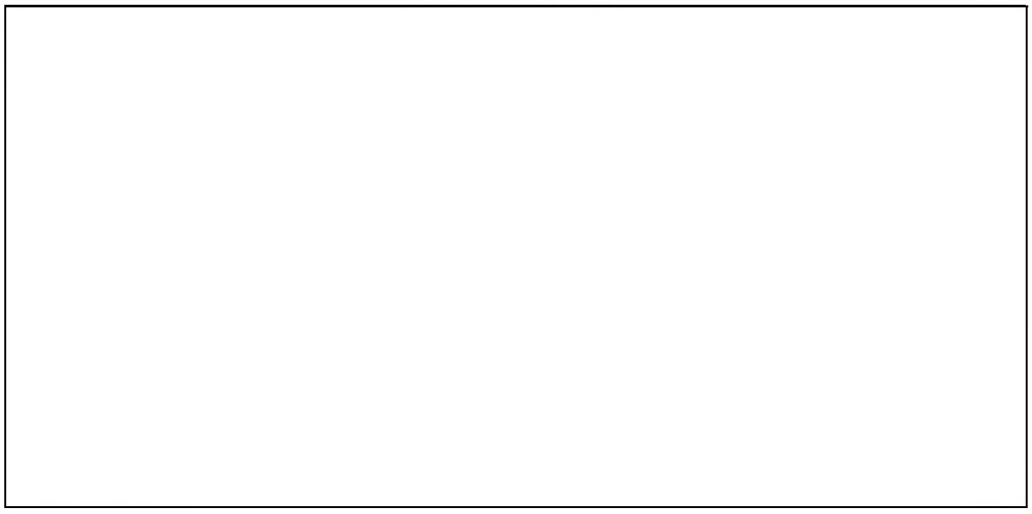
1. Aggressive environmental policies, which are layered on the oil and gas industry, add costs throughout the petroleum supply chain resulting in higher retail gasoline prices.
2. Costly reporting and compliance to regulatory and environmental mandates are added to the retail price of gasoline, including California's special blend gasoline requirements, the highest state excise tax in the U.S., as well as growing cap and trade costs, local taxes, and other environmental program costs, thereby increasing consumer prices at the pump.
3. In-state business general operating and refinery costs are which are considerably higher in California than across the U.S., are reflected in the retail price of gasoline.

[17] California, S. O. (n.d.). *California Military Bases | Military Council.* https://militarycouncil.ca.gov/s_californiamilitarybases/

4. Declining in-state oil production and increasingly greater reliance on foreign sourced imports and exposure to geopolitical conditions contribute to supply concerns and retail price volatility.
5. Refinery gasoline production, which is decreasing at a faster rate than gasoline consumption, creates stresses on supply gasoline stocks, thereby contributing to higher consumer prices.
6. Increasingly higher taxes and policy and regulatory costs, such as cap and trade, gasoline inventories, and the LCFS, which are influencing the exit of refiners from the Golden State adding to supply stresses, and price volatility, influence retailing pricing strategies by operators.
7. General disincentives associated with Governor Newsom's mandate and California Air Resource Board's (CARB) 2035 objective to eliminate internal combustion vehicles (ICV) in favor of zero-emission vehicles (ZEV) as a method to force consumer adoption of ZEVs through gasoline costs serve to dissuade new operators from entering the California market and motivate existing ones to exit.

With 2035 less than a decade away, there is no incentive for or benefit to California oil producers or refiners to invest in additional capacity or capital improvements in the Golden State. Ultimately, with the potential for the loss of two or more major refineries, combined with new special blend gasoline standards (LCFS) and the new finished gasoline stock inventory requirements, Californians are inevitably facing escalating gasoline prices at the retail pump, and most likely, increased taxes and fees to compensate for lost gasoline and cap and trade revenues.

Exhibit ES 1.0



OBSERVATIONS

State Excise Tax: California's state excise on gasoline is a direct addition to the consumer price of gasoline. Since 2003, California's state excise tax on gasoline sales has increased 200%, from $0.10 in 2003 to $0.596 in 2024. California's state excise tax on gasoline is based on and indexed to the California CPI (CCPI). Consequently, as the overall CCPI rises, so does the state excise tax on gasoline, which, in turn, increases retail gasoline prices and, ultimately, increases California state revenues. On June 14, 2022, when average gasoline prices in California hit an all-time historical high of $6.294 per gallon, or 7.02% higher than the average price in May 2022, the California state excise

tax increased by 5.48% from $0.511 to $0.539 a gallon. For the June 30, 2021, to July 21, 2024, period, while the average price of gasoline per gallon in California decreased by 27.1%, the California state excise tax on gasoline per gallon increased by 11.35%. The state excise tax is anticipated to automatically increase on July 1, 2025, from $0.61 to $0625 a gallon.

State and Local Taxes. California's local tax on gasoline is a direct addition to the consumer price of gasoline in California. In addition to the state excise tax, local taxes are also included. For 2023, the base tax is 2.27%. However, local gasoline taxes vary from county to county and municipality and collectively average 3.06% (unweighted).

California Cap and Trade Costs: California's cap-and-trade cost is a direct addition to the consumer price of gasoline in California. California mandates that refiners comply with the State's Cap and Trade program. Since taking full effect in 2015, California's Cap and Trade program cost has increased by 200% from $0.18 a gallon to $0.30 in 2024, while other environmental program costs add another $0.21 a gallon, adding $.51 to the consumer price of gasoline. From 2000 to 2025, the price differential between California's average weekly regular reformulated gasoline prices and the U.S. average for reformulated regular gasoline pre-cap and trade averaged 7.84%. After the full implementation of the cap-and-trade program in 2015, the price differential between California and the U.S. based on weekly gasoline prices for regular reformulated fuel expanded to 23.56% by March 2025. The cap-and-trade cost is anticipated to significantly increase in 2025. Initially passed in 2013 as a "backstop" for funding various environmental programs, California's cap and trade program was scheduled to phase out by 2020. The California Legislative Analyst's Office (LAO) noted in a November 2023 report, "To our knowledge, no studies have produced a reliable estimate of the emission reduction achieved by the cap-and-trade program so far." By law, 25% of the funds associated with California's cap and trade program must be directed to California's controversial High Speed Rail Project (CHSR), which is far behind its promised completion date and will now cost at least $106 billion, which over 3 times its initial budget estimate. The CHSR is currently under Federal Department of Transportation review.

California Economy and Inflation: California's higher than the U.S. average for inflation is reflected in the cost of production and distribution and retail price of gasoline and increases in the price of gasoline per gallon. Inflation, which is endemic to any economy, grew 1.13 times faster in the Golden State than in the overall U.S. Understandably, California's CCPI is highly correlated with the U.S. CPI at .998. For the 1983 to 2024 period, California's inflation, as measured by the California Consumer Price Index, was 229.4%, as compared to the overall U.S. at 202.41% (base year = 1983 = 100).

Retail Gasoline Prices: Retail gasoline prices are a function of crude oil prices, the supply of gasoline, the demand for gasoline, refinery operating efficiencies, competition, and regulatory costs. Gasoline prices in the U.S. and California are seasonal, as the price reflects the summer and winter blends, and summer blends are higher priced. Gasoline prices also reflect demand. Prices tend to drift upward during the peak driving months of the summer and drift lower after Labor Day in September. Demand tends to be at its lowest during the January to mid-March period.

Because of the decline in the number of refineries, lack of inbound pipelines, exposure to unplanned production disruptions, and heavy reliance on foreign oil sources, the Golden State is extremely sensitive to any interruptions to its foreign supply chains or discontinuities in refinery production.

When refineries shut down for planned maintenance, prices in California tend to drift up. When refineries in California switch from summer to winter and back to summer blends, production is affected, and prices drift up. When refineries have unplanned shutdowns or catastrophic events, such as fires, prices will spike. However, those conditions also exist in other markets.

From January 2, 1994, to March 10, 2025, the average weekly retail price of California gasoline has increased by 274.2%, from $1.264 a gallon to $4.73, on a non-inflation-adjusted basis. Adjusting for general and California specific inflation, the 1994 price would be $3.051 today. For the 2000 to 2022 period, the average price for gasoline in the Golden State increased by 174%. From 2/23/2015 to 3/02/2015, the average retail price of California reformulated gasoline jumped 15.5%, from $2.959 a gallon to $3.418 a gallon. For the period from July 6, 2015, to March 10, 2025, the average weekly retail price of reformulated gasoline in the Golden State increased by 38.3%, from $3.432 a gallon to $4.73. For the 1995 to 2025 period, the California weekly retail gasoline prices, as compared to the overall U.S. average weekly gasoline prices, indicate a .9786 correlation and, understandably, a .998 correlation with West Coast PADD 5 retail prices. For the 1994 to 2025 period, the weekly percentage change in California gasoline prices as compared to the overall U.S. average weekly percentage in retail gasoline prices indicates a .845 correlation. For the 1/2/24 to 1/20/25 period, the correlation between the average price for gasoline in California as compared to the average price for the U.S. indicates .9004. For the 1/2/95 to 1/20/25 period, the correlation between U.S. average weekly prices for reformulated gasoline and CA reformulated grades average weekly prices indicated .9768. With some exceptions, as described in Section 6.0, California gasoline prices, although significantly higher than the U.S., move consistently with the overall U.S. and do profile any significant long-term anomalies.

Price Gouging: There is no economic evidence of widespread price gouging, price manipulation, undefined price residuals, surcharges, or profiteering by California refiners. For the 1/2/95 to 1/20/25, California's average weekly retail reformulated gasoline prices indicate a .866 correlation with overall oil spot market prices. Investigations dating back to 2000 by the California State Attorney General have failed to prove price gouging by California refiners. Practical and academic studies were performed by the Federal Trade Commission and the Federal Reserve Bank of Dallas, and this researcher failed to discover or prove price gouging and excessive profiteering by California refiners. In fact, both the State's own California Energy Commission (CEC) and the California Attorney General have, at various times, concluded that California's chronically high retail gasoline prices are a function of the high operating costs in California, tight in-state supply due to diminishing refineries and lower gasoline stocks, the lack of secondary supplies and sources, lack of in-bound pipelines, and the high tax and regulatory cost environment imposed on oil producers, refiners, and gas station operators. The Federal Reserve of Dallas concluded that California gasoline prices are a function of "market factors" and there is no evidence as a result of this research to suggest otherwise.

California Gasoline Consumption: For the 2001 to 2024e CY period, overall CDTFA reported gasoline sales have fallen 11.12 %. California is the 2nd largest consumer of petroleum and the largest consumer of aviation fuel in the U.S. In 2023, Californians consumed 13.119 billion gallons of gasoline and over 216 million gallons of aviation fuel, based on CDTFA revenue data. The decline in gasoline consumption can be attributed to a number of factors, including the increase in EV registrations, improved miles per gallon associated with internal combustion engines, COVID-19 restrictions of 2020 and 2021, and the decline in California's population. The annual percentage change in CDTFA

gasoline sales is relatively consistent, shows a minimal annual variance of -.46%, and is highly correlated to the annual percentage change in overall U.S. gasoline consumption.

California Oil Production: Once a global leader and ranking fourth in the world in oil production, California today accounts for only around 2.7% to 3.1% of all U.S. crude production and is producing only 23.7% of its own in-state needs. For the 1982 to 2023 period, in-state oil production fell by 69% from its peak in 1985 (398,280 b/d) to a historic low in 2023 of 123,947 barrels a day. Meanwhile, as refinery production fell, California's population and number of vehicle registrations increased.

California Refineries: Since 1984, the number of oil refineries in California has decreased by nearly 70%, from 43 to 13 operable refineries. From 1984 to the present, California's oil refining capacity has decreased by 36%, from 2.5 million barrels a day to 1.7 million a day. Since 2023, the daily refining capacity for California's surviving refineries has declined 5.16%, from 1,710,371 barrels a day to 1,622,171 barrels a day. From 2023 to the end of 2025, refinery production is estimated to decline by another 8.57% to 1,483,177 barrels a day when the Phillips refinery closes down, as announced. The reduction in supply (production), which is more rapid than the decrease in consumption (demand), will result in higher gasoline prices for the California consumer. To compensate for the reduction in refinery production of California compliant gasoline, importers will have to source gasoline from alternative sources. Alternative sources for gasoline are located out of the Golden State, necessitating importers to transport it from distant suppliers. If the sources are from Gulf Coast refineries, the transit time is around 11 days. California consumers will experience higher prices at the pump as a result of out of state sources and transportation costs and may face shortages due to shipping times and the lack of out of state refineries that produce or are willing to produce California compliant gasoline (CARBOB).

California Revenues from Gasoline Sales: Gasoline sales, which drive stare excise tax revenues, as well as numerous other revenue streams, such as Cap and Trade, which, by statute, funds the California High Speed Rail Project, are estimated to range between $9.1 to $10.0 billion for 2024. For the 2000 to 2025 period, revenues from gasoline sales increased by 129%. As California pursues the transition to 2035 objectives of eliminating the sale of internal combustion vehicles, it is unclear how the State intends to replace the lost revenues attributed to gasoline sales. However, the State's own Legislative Analyst's Office (LAO) indicates that additional or increased taxes and fees are a viable means.

Consumer Preferences: On average, for the 2013 to 2023 period, the retail price differential between California branded and unbranded gasoline averages $0.284 per gallon. Californians have a distinct preference for branded gasolines. Overall, California sells more branded gasoline as a percentage of all gasoline sold than the rest of the U.S. Perhaps as a consequence of having the highest concentration of luxury and high-performance vehicles, such as Porsche, Ferrari, Bentley, Lamborghini, Mercedes Benz, and BMW in the U.S., as well as home to the third highest number of Corvettes and classic "muscle" cars in the nation, Californians, on average, consume more premium grade branded fuels, than the rest of the U.S. Premium and high octane fuels are more expensive to produce and command higher prices. Branded gasoline adds between $0.5 to $0.10 per gallon at the wholesale level. The percentage difference between California's regular and premium gasoline and the national average is 26%. Branded premium fuels command higher retail pump prices. High income individuals and owners of high-performance, classic muscle cars and high-end luxury vehicles are inelastic with respect

to gasoline prices. Owners of high-performance and luxury automobiles are highly inelastic with respect to gasoline prices and will not change fuels out of concern for performance and engine damage.

California Special Blend (CARBOB): California's CARBOB adds $0.12 to $0.17 a gallon to gasoline and is a direct addition to the consumer price of gasoline in California. The CARB requires a special gasoline blend (CARBOB) to be sold in California as part of its clean air and environmental objectives. Consequently, California gasoline is unique in its formulation and composition, which differs from the rest of the U.S. Since CARBOB is specific only to California, the California special blend gasoline is significantly more costly to produce, thus resulting in higher consumer prices at the pump. For the 2000 to 2022 period, California's GHG efforts have reduced passenger vehicle CO2 emissions by 16%, from approximately 124 million metric tons to around 105 million metric tons. CARB's intended change in the special blend for 2025 may add another $0.23 to $0.67 a gallon ($0.47 based on CARB estimates), by December 2025 and will be a direct addition to the consumer price of gasoline in California.

Seasonal Gasoline Blend: Seasonal blends add $0.13 to $0.15 to the price of a gallon of gasoline and are a direct addition to the consumer price of gasoline in California. Both the EPA and CARB require seasonal blends. The seasonal blends are intended to reduce emissions from internal combustion vehicles.

California Refinery Operating Costs: California's higher operating costs are reflected in higher consumer prices. According to the California Joint Agency Report dated May 2024, refinery operating costs in California are, on average, 128% higher (non-weighted) in the Golden State than the overall U.S. average. Likewise, California's general business operating costs incurred by businesses such as refiners, wholesalers, shippers, and gas station operators are, on average, 38% higher in California. Higher operating costs are reflected in consumer prices at the pump.

Refiner Margins and Profits: Profits and margins in the oil and gas industry are highly volatile. The CEC estimated that refinery gross profits ranged between $1.00 and $2.31 a gallon for the 2002 to 2022 period. The gross margins for three California refiners, as reported by the CEC for a 23-month period, fell by 87%, from a high of $1.64 a gallon in September 2023 to a low of $0.22 a gallon in January 2024. For all three refineries, the average gross profit per gallon was $0.84. However, gross margins are just a partial representation of refinery profitability. A more complete measure is net profit margin since net profits generate free cash flows after all costs are considered. For the 2023 to 2024 period, California refiners averaged around $0.09 a gallon in net profits. CSI Market ranks oil refineries 93rd in net profitability, 103rd in gross profits, 88th for return on assets, and 91st for return on equity. Based on CSI Market data, the gross profit margin for oil refineries averaged 4.256% and .338% for net margins for five quarters from Q4-2023 to Q4-2024. An NYU Stern study found that across all industries, the gross profit and net profit margins were 36.56% and 8.54%, respectively. As California continues to push renewable diesel fuels, refiner profitability may fall.

Revenues and profits fluctuate wildly from period to period. When the cost of crude oil is high, refinery margins improve, and profits increase. When the cost of crude oil falls, so do revenues and profits. When demand is high, profits are high. When demand is low, profits fall.

Heavy Oil: Oil refineries are highly sophisticated and are classified and rated on a standard scale known as The Nelson Complexity Index (NCI), and California has some of the most sophisticated and high NCI rated refineries. Due to the sophistication of California refineries, high NCI, and use of heavy crude oils, California's operating and profit margins are higher. Heavy oil refineries with high NCI ratings and operating at higher capacity utilization rates, such as those in California, tend to generate higher margins and crack spreads due to operation efficiencies and the diversity of products produced.

Pipelines: California has an extensive network of pipelines within the state. However, California's gasoline dilemma is further exasperated by the absence of any inbound pipelines from other states for oil or gasoline. As a result, California is isolated and has become increasingly dependent on foreign oil imported mostly by large maritime tankers and, to a lesser extent, rail and truck transports. Consequently, 98% of all foreign sourced inbound crude oil is supplied to California via maritime vessels. The lack of inbound pipelines from other states isolates California from U.S. and Canadian sources and places the State in a vulnerable position with respect to oil and gasoline supplies.

Dependency on Imports: No state in the U.S. imports more dependent on foreign sourced oil than California. While U.S. dependency on foreign oil has declined, California's dependency has increased…substantially. Consequently, California is vulnerable to price changes and supply interruptions associated with the geopolitical environment. Since 1982, California's dependency on non-U.S. oil has increased 857%. In 1982, California produced 61% of its oil needs, imported 33% from Alaska, and imported only 5.6% from foreign sources. By 2023, and based on CEC data, the composition of California in-state oil stocks reversed to 23.4% in-state sourced, Alaskan oil imports declined to 16%, and foreign sourced imports from petrostates such as Iraq and Saudi Arabia surged to 60.7%. However, in 2024, California changed its mix of non-U.S. foreign imports. Iraq, which provided 68,406 barrels of oil composed 21.26% of its non-U.S. oil imports. Brazilian oil imports increased to 20.41%, and as production scaled in Guyana, imports from that South American country increased exports to California to 50,840 barrels or 15.80% of total 321,831 barrels of non-U.S. imported oil. According to various estimates, California ranks #1 in payments to foreign sources of oil and pays more than $61.8 million per day, or $22.5 billion annually, based on Brent market prices, or $54.41 million a day, or $19.8 billion annually, based on WTI market prices, to foreign countries such as Iraq, UAE, and Saudi Arabia and others for its oil imports.

Exhibit ES 2.0

SUMMARY OF CORRELATIONS		
Summary of Selected Correlations		
Correlation Factors	**Correlation**	**Period**
Avg. CA Weekly Retail Prices to Avg. West Coast Retail Prices	0.9998	1/2/95-1/20/25
CA. Consumer Price Index to U.S. Consumer Price Index	0.9980	1984 to 2024
CA. Crude Oil Prices to U.S. Crude Oil Prices (First Purchase)	0.9904	5/2000 - 5-2022
Avg. West Coast Weekly Prices to Avg. Weekly U.S. Prices	0.9812	1/2/95-1/20/25
U.S. Avg. RF Gasoline to W.C. Avg. RF Gasoline	0.9811	1/2/95-1/20/25
Avg. CA Weekly Retail Prices to Avg. U.S. Weekly Retail Prices	0.9786	1/2/95-1/20/25
U.S. Avg. RF Gasoline to CA Avg. RF Gasoline	0.9768	1/2/95-1/20/25
CA. Avg. RF Gasoline to W.C. Avg, .RF Gasoline	0.9768	1/2/95-1/20/25
Oil Spot Prices to U.S. Avg. Retail RF Gasoline	0.9539	1/2/95-1/20/25
% Change CA Crude Prices to % Change U.S. Crude Prices	0.9190	5/200 - 5-2022
Avg. U.S. Retail Price to Avg. CA Retail Price	0.9004	1/2/24 -1/20/25
Percentage Change CA. CPI to U.S. CPI	0.8940	1984 to 2024
Oil Spot Prices to W.C. Avg. Retail RF Gasoline	0.8750	1/2/95-1/20/25
% Change CA Retail Prices to % Change CA Wholesale Prices	0.8680	5/2000 - 5-2022
Oil Spot Prices to CA. Avg. Retail RF Gasoline	0.8660	1/2/95-1/20/25
Weekly Percentage Change in CA Avg. Gasoline Prices to U.S. Weekly Percentage Change	0.8450	1994 to 2025
% Change CA Wholesale Prices to % Change U.S. Crude Prices	0.6860	5/2000 - 5-2022
Net CETA Gasoline Sales Volume to EIA Refiner Sales to Retailers	0.6338	Annual

SECTION 1.0
UNDERSTANDING GLOBAL & U.S. PETROLEUM

A STUDY OF CALIFORNIA GASOLINE PRICES
Section 1.0
Table Of Contents

1.0 Understanding Global & U.S. Petroleum
- 1.1 Introduction
- 1.2 U.S. & World Petroleum Reserves
- 1.3 Product Yields & Composition
- 1.4 Crude Oil & Gasoline Prices
- 1.5 Pricing Components: Crude Oil Prices & Gasoline
- 1.6 Brief History of Petroleum in California

1.0 UNDERSTANDING GLOBAL & U.S. PETROLEUM

1.1 Introduction

From primitive cooking and lighting to the manufacturing of cellular telephones, agricultural production, medical and pharmaceutical products, and alternative energy production, petroleum is essential to any economy and modern society. Although oil is universally known as a source of energy, petroleum is used in the manufacturing of fibers, such as polyester and nylon, certain types of medical devices, the screens that are used in monitors, televisions, cell phones, computers, cement, asphalt, wind turbines, steel, herbicides, and fertilizers.[18] Petroleum, in the form of gasoline, diesel, and aviation fuels, is essential to transportation and the movement of products. According to the U.N., in 2023, a total of 12.3 billion tons of cargo was transported using maritime vessels, which represents around 80% of all global trade.[19] [20] Maritime tankers burn diesel fuels for propulsion.

Oil is essential to any modern economy. Globally, for 2023, around 101.81 million barrels of oil were produced per day.[21] For 2024, world production is expected to increase by 1.2% to 103 million barrels a day.[22] According to the IEA, the energy sector, including the oil and gas industry, employs 65 million people worldwide (2019 est.), or about 2% of all global employment.[23] Oil represents the largest employment sector, with 8 million or 12% of total employment in the industry.[24] The five largest concentrations of energy workers are in China, followed by Asia Pacific nations, India, North America, and Europe.[25] On a comparative basis, the energy sector has more highly skilled labor as a percentage of its labor force, 45%, than the overall average of all industries, which is 25% for highly skilled labor.[26]

The U.S. leads the world in petroleum production, of which 75% is concentrated in ten nations. As indicated in the chart below, based on EIA data, the U.S. also leads in the consumption of petroleum, with The People's Republic of China a close second.

[18] IOGP. (2022, October 11). *Oil and gas in everyday life.* https://www.iogp.org/workstreams/advocacy/oil-natgas-in-everyday-life/
[19] UNCTAD. (2024, October 22). *Review of Maritime Transport 2024.* UNCTAD. https://unctad.org/publication/review-maritime-transport-2024.
[20] statista. (2017). *Topic: Ocean Shipping.* Www.statista.com; Statista. https://www.statista.com/topics/1728/ocean-shipping/
[21] *Frequently Asked Questions (FAQs) - U.S. Energy Information Administration (EIA).* (2024, April 11). Www.eia.gov. https://www.eia.gov/tools/faqs/faq.php?id=709&t=6.
[22] *Frequently Asked Questions (FAQs) - U.S. Energy Information Administration (EIA).* (2024, April 11). Www.eia.gov. https://www.eia.gov/tools/faqs/faq.php?id=709&t=6.
[23] *World Energy Employment.* (n.d.). https://iea.blob.core.windows.net/assets/a0432c97-14af-4fc7-b3bf-c409fb7e4ab8/WorldEnergyEmployment.pdf
[24] *World Energy Employment.* (n.d.). https://iea.blob.core.windows.net/assets/a0432c97-14af-4fc7-b3bf-c409fb7e4ab8/WorldEnergyEmployment.pdf
[25] *World Energy Employment.* (n.d.). https://iea.blob.core.windows.net/assets/a0432c97-14af-4fc7-b3bf-c409fb7e4ab8/WorldEnergyEmployment.pdf
[26] *World Energy Employment.* (n.d.). https://iea.blob.core.windows.net/assets/a0432c97-14af-4fc7-b3bf-c409fb7e4ab8/WorldEnergyEmployment.pdf

Exhibit 1.1

2022/23- GLOBAL PRODUCTION & CONSUMPTION- TOP 10 NATIONS					
WORLD PRODUCTION- 2023			WORLD CONSUMPTION- 2022		
Nation	Million of Barrels per day	Percent of World Total	Nation	Million of Barrels per day	Percent of World Total
United States	21.91	22%	United States	20.01	20%
Saudi Arabia	11.13	11%	China	15.15	15%
Russia	10.75	11%	India	5.05	5%
Canada	5.76	6%	Russia	3.68	4%
China	5.76	6%	Saudi Arabia	3.65	4%
Iraq	4.42	4%	Japan	3.38	3%
Brazil	4.28	4%	Brazil	3.03	3%
United Arab Emirates	4.16	4%	South Korea	2.55	3%
Iran	3.99	4%	Canada	2.41	2%
Kuwait	2.91	3%	Germany	2.18	2%
Total Top 10	74.59	73%	Total Top 10	61.08	61%
World Total-Production	**101.81**		**World Total-Consumption**	**99.95**	

(Source: EIA. https://www.eia.gov/tools/faqs/faq.php?id=709&t=6)

The U.S. oil and gas industry is a large, integral, and critical part of the U.S. economy and is vital to national and economic security. At $1.7 trillion, the oil and gas industry comprises around 8% of the U.S. GDP and employs around 11.3 million people, representing 5.6% of total U.S. employment.[27] An additional 3.4 million jobs are associated with oil and gas affiliated industries and businesses.[28] In the U.S., the oil and gas industry pays, on average, around 85% higher than the national average annually.[29] On average, the oil and gas industry accounts for around 16% of total capital expenditures annually in the U.S.[30] In contrast, the transportation and healthcare sectors account for 5.3% and 6.3% of capital expenditures, respectively.[31] In the U.S., the EIA estimates that Americans spent around $1.0 trillion on energy, of which $503 million was related to gasoline, jet fuel, and diesel fuels in 2020, which collectively accounts for 4.8% of the U.S. GDP.[32]

Illustrated in the exhibit below is the percentage change in U.S. oil field production as compared to the percentage change in U.S. GDP.

[27] https://www.api.org/-/media/Files/Policy/Taxes/DM2018-086_API_Fair_Share_OnePager_FIN3.pdf. See also, *New analysis: American-Made natural gas and oil drives U.S. economic recovery, Strengthens all industries*. (2021b, July 20). https://www.api.org/news-policy-and-issues/news/2021/07/20/2021-pwc-analysis

[28] *New analysis: American-Made natural gas and oil drives U.S. economic recovery, Strengthens all industries*. (2021, July 20). https://www.api.org/news-policy-and-issues/news/2021/07/20/2021-pwc-analysis

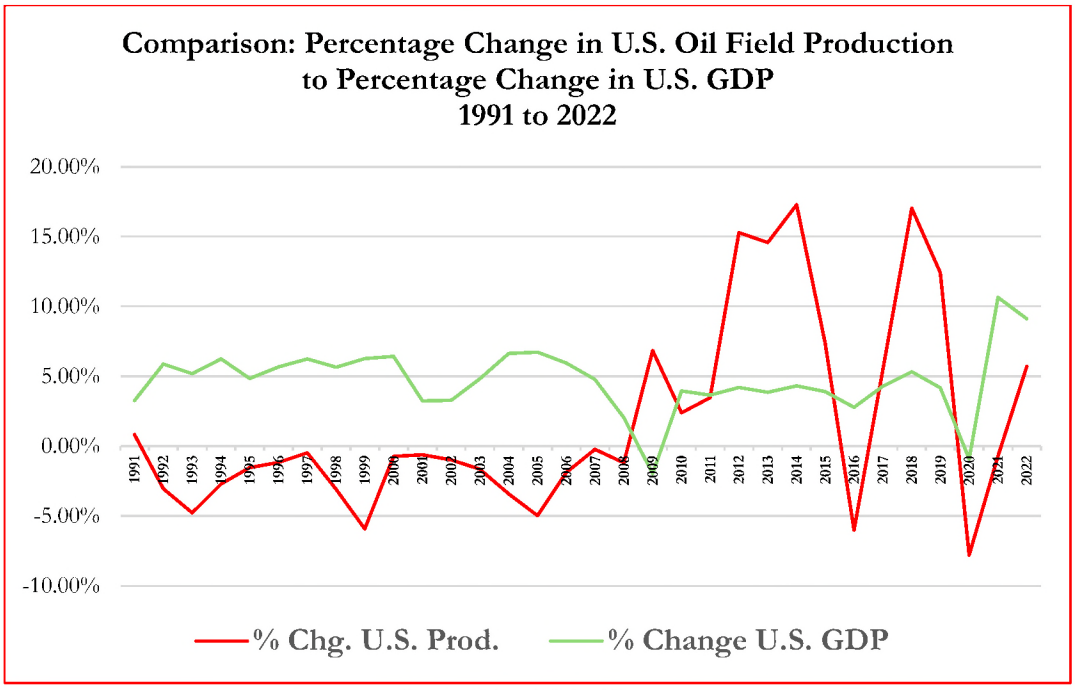
[29] American Petroleum Institute. (2019). *Oil & Natural Gas Contribution to U.S. Economy Fact Sheet*. Api.org. https://www.api.org/news-policy-and-issues/taxes/oil-and-natural-gas-contribution-to-us-economy-fact-sheet

[30] American Petroleum Institute. (2019). *Oil & Natural Gas Contribution to U.S. Economy Fact Sheet*. Api.org. https://www.api.org/news-policy-and-issues/taxes/oil-and-natural-gas-contribution-to-us-economy-fact-sheet

[31] American Petroleum Institute. (2019). *Oil & Natural Gas Contribution to U.S. Economy Fact Sheet*. Api.org. https://www.api.org/news-policy-and-issues/taxes/oil-and-natural-gas-contribution-to-us-economy-fact-sheet

[32] *2020 inflation-adjusted U.S. energy expenditures lowest since 2002*. (n.d.). Www.eia.gov. https://www.eia.gov/todayinenergy/detail.php?id=53620

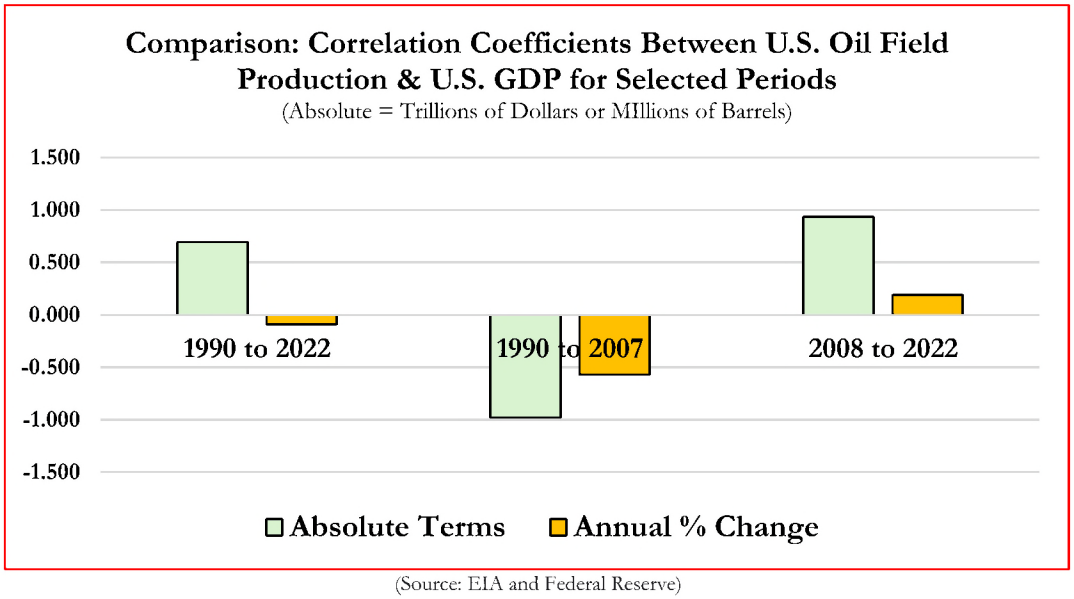
Exhibit 1.2



(Source: EIA and Federal Reserve)

On a percentage change basis, the correlation between U.S. oil field production and U.S. GDP is a negative .09, largely due to the significant variances that occurred for the 2009 to 2023 period and as imports of oil fell. For the 1990 to 2022 period, in terms of absolute U.S. oil field production, as measured in millions of barrels a day, compared to real GDP, the correlation is .69.

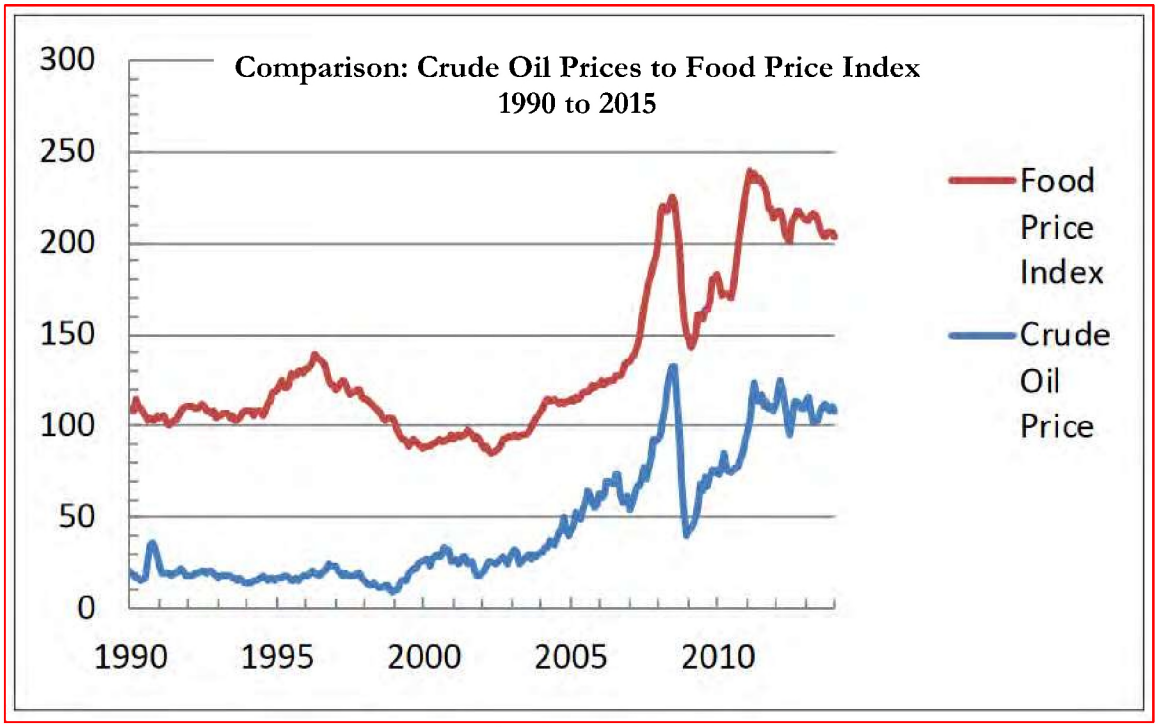
Exhibit 1.3



(Source: EIA and Federal Reserve)

Petroleum is a key component in agricultural production and, of course, is necessary to move food stocks from farm to processor, to distributor, to the retail store. Consequently, as was indicated during the inflationary period of 2021 to 2024, when general inflation outpaced real wages and peaked at 9.1%, and crude oil prices increase and subsequently stimulate increases in retail gasoline and diesel fuel prices, food prices for consumers go up.

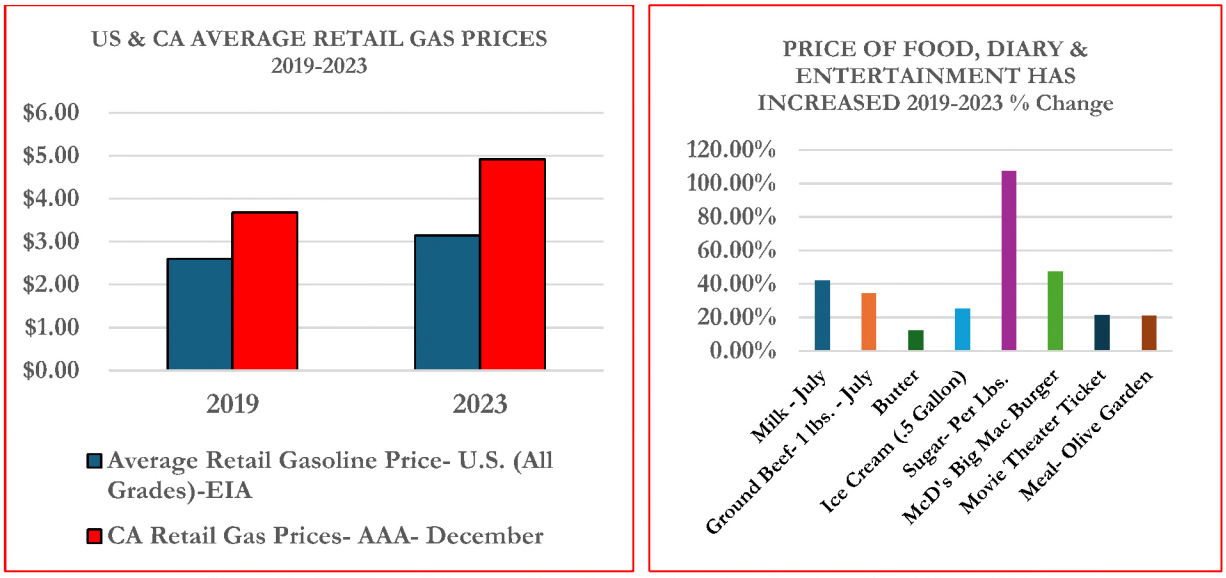
Exhibit 1.4



(Source: https://extension.psu.edu/fuel-ethanol-hero-or-villain#:~:text=Gasoline%20is%20not%20water%20soluble,performance%20if%20not%20dealt%20with)

Petroleum products, such as gasoline and diesel fuels, are significant components in the determination of the cost of food production and retail grocery prices. As indicated in the exhibit below, as gasoline prices increased, the cost of staples such as milk, ground beef, and sugar also increased.

Exhibit 1.5



(Source: Mische & Keyes, Bidenomics: Facts, Figures & Everything Americans Should Know. 2024)

Petroleum is derived from crude oil. Crude oil, or simply 'crude,' is a fossil fuel and the product of millions of years of geological activity and organic decay. Oil deposits are found in the ground, either onshore or offshore, at the bottom of an ocean, lake, or river. To locate deposits, oil producers expend considerable effort and funds to explore and "discover" petroleum deposits, which are reservoirs, pockets or patches of oil, or oil fields.

Once located, the oil must be extracted, usually via drilling.[33] The extracted oil is then refined into various products, such as gasoline, diesel fuel, aviation fuels, heating oils, and other derivatives. As described by the State of Louisiana Department of Natural Resources, gasoline is a product of oil refinement, which involves the breaking down and conversion of various liquid hydrocarbons into different products.[34] Significant economic and utilitarian value is created from crude oil through a long stream of refinement and embellishment activities. For example, both gasoline and aviation (jet) fuel are derived from petroleum, that is, crude oil that has been refined using sophisticated methods to produce a specific product to a specific standard.

There are multiple types of crude that define its quality, and no two barrels of oil are exactly identical. Petroleum is characterized by its origin and its API rating.[35] Some crude oils are "sour and heavy to extra heavy," making them more costly to produce and refine into end products. In contrast, other crudes are "sweet and light/lite," which are less expensive to refine. The quality of the crude oil is an important factor in the grade and type of gasoline produced, as well as the associated refining costs and price that is charged at the gas station. Crude oil quality is rated by various agencies using several

[33] *Petroleum*. (n.d.). https://education.nationalgeographic.org/resource/petroleum
[34] *Department of Energy and Natural Resources | State of Louisiana*. (n.d.). http://www.dnr.louisiana.gov/index.cfm?md=pagebuilder&tmp=home&pid=244
[35] API Definition: According to the American Petroleum Institute, the API rating is "An arbitrary scale expressing the gravity or density of liquid petroleum products." The higher the API gravity (rating), the lighter the oil. In general, light oil crude has an API rating of 38 degrees or more. Intermediate or medium grade oil has an API gravity rating of 22 to 38 degrees. Crude oil with API ratings of 38 and above are considered heavy and extra heavy. The characterization of oil crude as "sweet" or "sour" is related to its sulfur content. See, *Table Definitions, Sources, and Explanatory Notes*. (n.d.). Www.eia.gov. https://www.eia.gov/dnav/pet/TblDefs/pet_pnp_crq_tbldef2.asp

different scales. The predominant method for assigning a quality rating to crude oil is "gravity" (viscosity) as defined, measured, and rated using the standard established by the American Petroleum Institute (API).[36] According to McKinsey, "API gravity is a commonly used index of the density of crude oil or refined products."[37] Crude oil will typically rate between 15 to 45 on the API scale. Crude oils that rate 35-45 on the API scale are called "light crude" and are considered the highest quality and yield the highest value products from refining. Crude oils rated at 15 or lower are called "extra-heavy" and typically require more refining processes, cost more to refine, and yield lower outputs and quality used for proposes other than gasoline, diesel, and jet fuels. Crude oils with high sulfur content are generally referred to as "sour," while those with lower sulfur content are characterized as "sweet." Hence, in discussing oil, the term "Light sweet crude" would be used to describe an oil that has a high API rating and low sulfur content. The quality and origin of oil also influence the amounts of greenhouse emissions, as do extraction processes, transportation and distribution methods, and refining efficiencies associated with the oil and the production of end products, such as gasoline.

A combination of factors — including geology, location, chemistry, and climate — makes each type of oil unique, possessing specific properties that can be refined for intended uses. For example, oil found in Texas can and will be different than oil in California. Even oil derived from Texas will have unique and specific differences. West Texas oil has a different chemistry from East Texas oil. Oil found in Alaska's North Slope has a chemical profile different from that found off the Gulf Coast of the U.S. The varying chemical profiles of oil, along with its intended end use as a product, require different refining methods and different costs. Some oils are more expensive to extract, transport, and refine than others. Some oils with additives and diluents are used as feedstocks in the production of other petroleum products. Gasoline, for example, may use a blending of different oils and additives in the refinement process to comply with emissions standards and achieve desired end-market performance profiles.

1.2 U.S. & World Petroleum Reserves

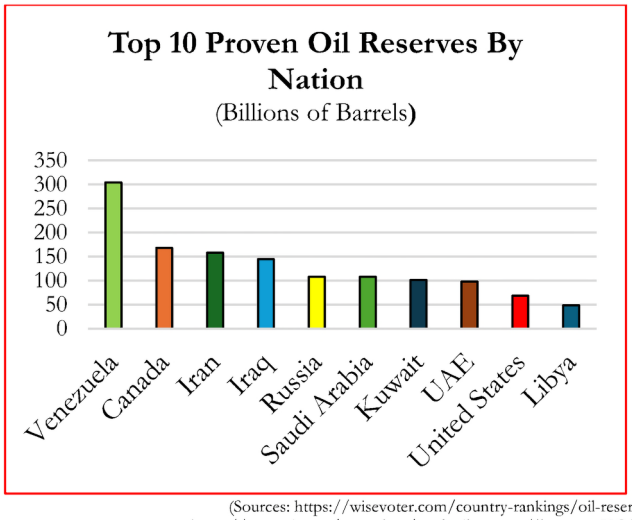
Globally, the amount of oil in the world fluctuates based on three predominant factors: (1) consumption (demand), (2) production from existing proven sources, and (3) the discovery of new oil sources (reserves). For example, in 1960, crude oil reserves were estimated to be around 291 billion barrels.[38] In 2023, world crude reserves were estimated to range between 1.5 to 1.73 trillion barrels of oil.[39] [40] [41] Reserve oil is petroleum that has been discovered and properly approximated (proven) but has not yet been harvested (produced). The majority of proven reserves, around 79%, are located in OPEC member countries.[42] Of the OPEC members, Venezuela has the largest reserves and the largest reserves in the world. Current estimates place Venezuela's proven oil reserves at around 304 billion barrels, which represents close to 18% of the world's total proven petroleum reserves, ranking Venezuela #1 globally in proven oil reserves. [43] [44]

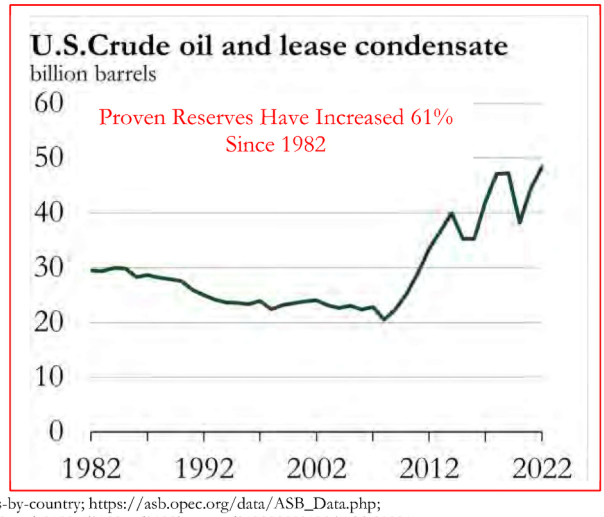
---

[36] *Oil categories.* (n.d.). https://www.api.org/products-and-services/engine-oil/eolcs-categories-and-classifications/oil-categories
[37] *API gravity.* (n.d.). Www.mckinseyenergyinsights.com. https://www.mckinseyenergyinsights.com/resources/refinery-reference-desk/api-gravity/
[38] Statista. (2024, July 23). *Global crude oil reserves 1960-2023.* https://www.statista.com/statistics/236657/global-crude-oil-reserves-since-1990/
[39] Ibid.
[40] Chen, J. (2024, July 25). *Oil reserves.* Investopedia. https://www.investopedia.com/terms/o/oil reserves.asp#:~:text=Oil%20reserves%20are%20an%20estimate,oil%20reserves%20in%20the%20world.
[41] *World Oil Statistics - Worldometer.* (n.d.). https://www.worldometers.info/oil/
[42] OPEC. (2024). *OPEC : OPEC Share of World Crude Oil Reserves.* Opec.org; Organization of the Petroleum Exporting Countries. https://www.opec.org/opec_web/en/data_graphs/330.htm
[43] *International - U.S. Energy Information Administration (EIA).* (2020, November 30). https://www.eia.gov/international/analysis/country/VEN
[44] *Data download.* (n.d.). Asb.opec.org. https://asb.opec.org/data/ASB_Data.php

For 2022, the EIA reports that the U.S. has proven reserves of at least 48.3 billion barrels of oil.[45] Comparatively, the U.S. has the 9th largest proven oil reserves in the world. However, U.S. technologies and the opening of previously closed areas could significantly increase U.S.-proven reserves. Based on current and planned consumption rates and EIA current estimates, the U.S. has about 290 years of proven and technically recoverable oil reserves.[46] The exhibit below provides an illustration of U.S. oil reserves and the top ten proven reserves by nation.

Exhibit 1.6





(Sources: https://wisevoter.com/country-rankings/oil-reserves-by-country; https://asb.opec.org/data/ASB_Data.php; https://www.eia.gov/naturalgas/crudeoilreserves/#:~:text=U.S.%20crude%20oil%20and%20lease,end%202022%20(Table%201)

When shale sources are factored in, the U.S. has considerably larger reserves than most other countries and is considered to have the largest proven reserves in the world. On a comparative basis, the U.S. currently ranks 9th in the world in proven oil reserves.[47] As of July 5, 2022, the U.S. has an estimated 264 billion barrels in total recoverable, as well as potential oil reserves (unproven), according to Norway's Rystad Energy.[48]

In response to demand and the growth of the U.S. economy, U.S. production of oil has increased significantly. The increase in oil production can be attributed to many factors, among the most prominent being new oil deposit discoveries, new discovery and production technologies, innovation in refining processes, and the growing demand of both American businesses and consumers. For example, from 1915 to 2024, the number of registered motor vehicles (all vehicles) in the U.S. grew from around 2.5 million to 297 million or 11,780%.[49] [50] Concurrently, the estimated population of the

[45] U.S. Energy Information Administration. (2017). *U.S. Crude Oil, Natural Gas, and Natural Gas Proved Reserves, Year-end 2017*. Eia.gov. https://www.eia.gov/naturalgas/crudeoilreserves/

[46] Ier. (2022, June 22). *Global Oil and Gas proved reserves increase in 2021 - IER*. IER. https://www.instituteforenergyresearch.org/fossil-fuels/gas-and-oil/global-oil-and-gas-proved-reserves-increase-in-2021/

[47] *Oil Reserves by country 2024*. (n.d.). https://worldpopulationreview.com/country-rankings/oil-reserves-by-country

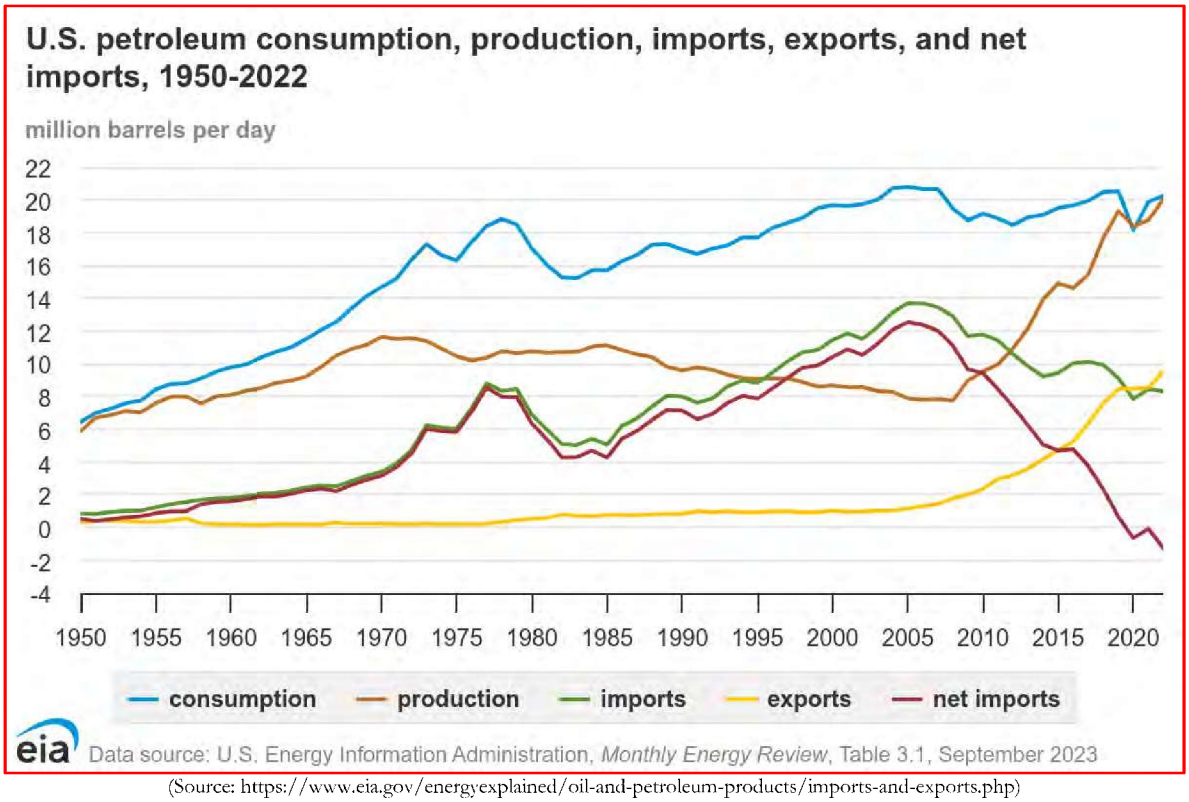
[48] Egan, M. (2016, July 5). *U.S. has more untapped oil than Saudi Arabia or Russia*. CNNMoney. https://money.cnn.com/2016/07/05/investing/us-untapped-oil/index.html

[49] Statista. (2024a, February 28). *U.S. motor vehicle registrations 1990-2022*. https://www.statista.com/statistics/183505/number-of-vehicles-in-the-united-states-since-1990/

[50] Hedges & Company. (2024, January 23). *US VIO vehicle registration statistics: How many cars in the US*. https://hedgescompany.com/automotive-market-research-statistics/auto-mailing-lists-and-marketing/

U.S. grew from 92.3 million in 1915 to over 345 million in 2024, or 273.8%.[51] [52] Correspondingly, to meet the demands of the market, industry, and consumers, oil production grew. Below is a chart comparing U.S. oil production to consumption, imports, and exports from 1950 to 2022.

Exhibit 1.7



(Source: https://www.eia.gov/energyexplained/oil-and-petroleum-products/imports-and-exports.php)

1.3 Product Yields & Composition

To better understand and unravel the pricing complexities and paradox of gasoline prices and practices, it's logical to begin with the most fundamental component: a barrel of crude oil. The standard measure for crude oil is a barrel, which contains 42 gallons or 159 liters. As a general rule and as an informal estimate, one gallon of oil produces between .47 to .67 gallons of refined gasoline, so one barrel of oil (42 gallons) yields 17-28 gallons of gasoline.

The yield rate of oil to refined gasoline varies depending on the quality of the oil crude stock used, number of refining processes required, the efficiency of refining operations, the intended end-product blends, and the seasons.[53] [54] The geological origin, source, type, and quality of crude oil significantly affect costs, yields, and the quality and price of resulting petroleum products. Certain oils, such as those that are classified as "heavy or extra-heavy, and sour," require more refining steps than oils that

[51] US Census Bureau. (2022, August 6). *Historical Population change data (1910-2020).* Census.gov. https://www.census.gov/data/tables/time-series/dec/popchange-data-text.html

[52] *United States population (2024) - Worldometer.* (n.d.). https://www.worldometers.info/world-population/us-population/#google_vignette

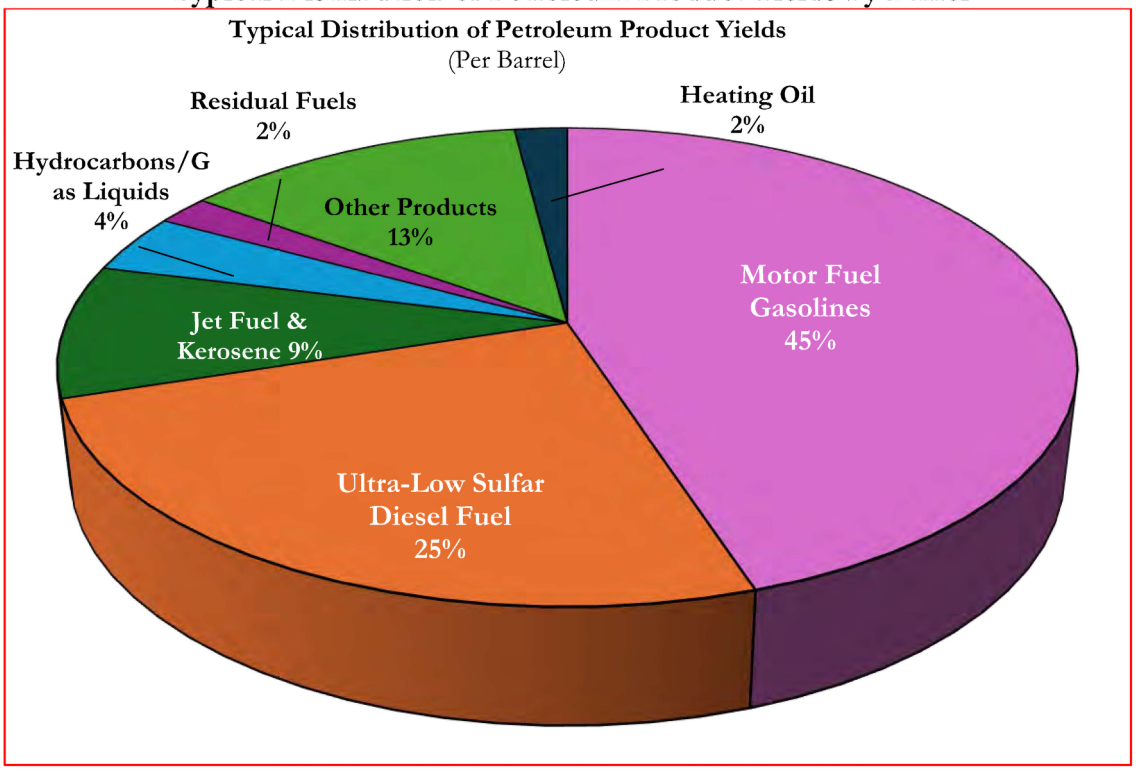
[53] Suermann, John. "Ask a Scientist." Newton. (Sept. 30, 2009) as cited in https://science.howstuffworks.com/environmental/energy/crude-oil-market.htm

[54] *How many gallons of gasoline and diesel fuel are made from one barrel of oil? - FAQ - U.S. Energy Information Administration (EIA).* (2016). Eia.gov. https://www.eia.gov/tools/faqs/faq.php?id=327&t=9

are characterized as "light, sweet." Additionally, certain types of gasolines, such as those required in California, require special refining processes and equipment, which add significantly to the cost of production, influence production yields, and are ultimately reflected in the retail pump prices paid by the public.[55]

Once oil is refined into products, the standard barrel of oil may yield far more economic value in final products than the original 42 gallons of crude oil. On average, a barrel of oil, once refined, will yield 45 gallons of total product or about 1.1 times the original volume.[56] Additionally, a single barrel of crude oil typically produces 138,095 Btu of energy.[57] Below is a chart of typical product yields from a single barrel of oil.

Exhibit 1.8
Typical Distribution of Petroleum Product Yields by Barrel



(Source: https://www.breakthroughfuel.com/blog/crude-oil-barrel/)

[55] CDTFA_CEC joint report 2024 review of the gasoline in ... (n.d.-b). https://seuc.senate.ca.gov/sites/seuc.senate.ca.gov/files/cdtfa_cec_joint_report_2024_review_of_the_gasoline_in_california_and_relate.pdf
[56] EIA, Petroleum Supply Monthly, April 2019
[57] *Facts about Oil.* (2020). Www3.Uwsp.edu. https://www3.uwsp.edu/cnr-ap/KEEP/Documents/Activities/Energy%20Fact%20Sheets/FactsAboutOil.pdf

1.4 Crude Oil & Gasoline Prices

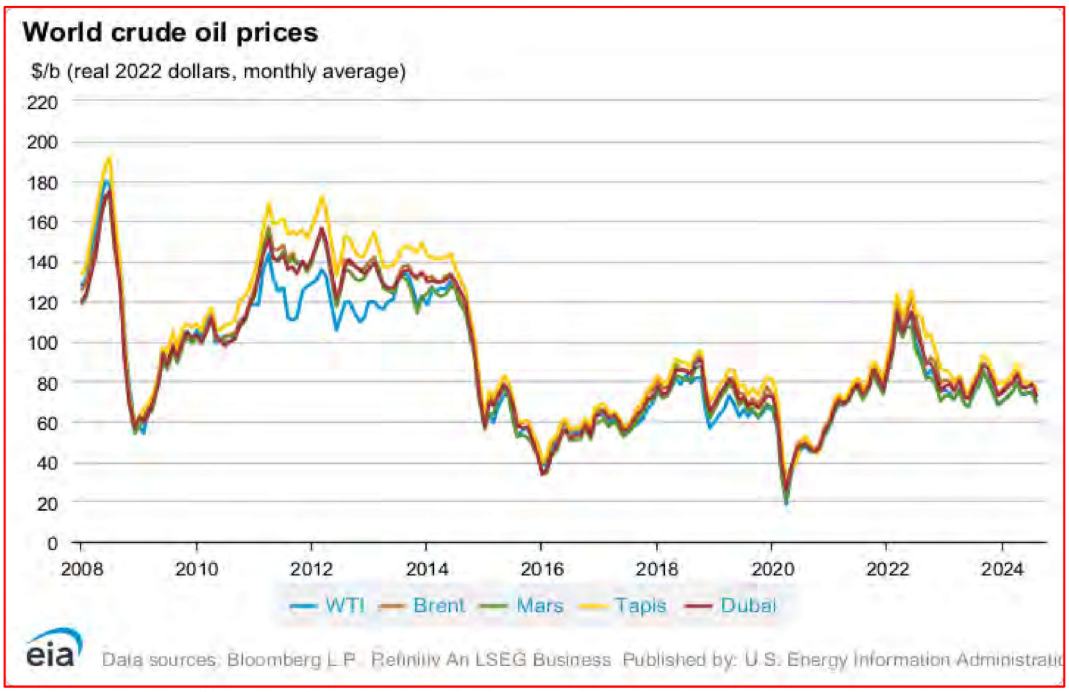
As a global commodity, crude oil prices are set and traded on various international markets. Oil and gasoline pricing are very complex and subject to wide variations from day to day, even by the hour to hour, and in some instances, by the minute. The price of crude oil is primarily driven by the basic economic laws of supply and demand. When demand is strong and supply is low, the price of oil and gasoline escalates. However, geopolitical, domestic, political, and regulatory actions conflate the basic market powers of supply and demand. Five factors influence the spot price of oil: **1-** supply, **2-** demand (consumption), **3-** geo-political events, **4-** national and local government policies and regulations, and **5-** trading/financial markets. As petroleum is a global commodity, its pricing is subject to extreme volatility. The retail price of oil and gasoline is also informed by a "build-up" of costs as the product moves through the supply chain from the well to the refinery and, finally, to the retail gasoline pump. Notably, any significant disturbance to any of these influencing factors will have an impact on the price of oil and, ultimately, the price of retail gasoline. The only issue is one of severity.

Crude oil prices, and, in turn, gasoline prices, are influenced by political policies, taxes, regulations, the origin of oil's political system (democracy vs. socialism vs. monarchy vs. dictatorship), regional conflicts, and wars (particularly in the Middle East). Oil is a global currency and a powerful economic asset (and weapon) for petrostates. Since 77% of the world's oil reserves are located in state-owned or state-controlled areas, the spot price for crude oil can be, and often is, heavily influenced and even manipulated by the state-owned producers, their governments, and cartels, such as OPEC. Prices are set for various types of crude oil grades and sources, such as WTI, Brent, Arab Light, etc., on global markets.

Oil is traded using long term contracts and spot pricing in multiple markets, with the New York Mercantile (NYMEX) and Intercontinental Exchange (ICE) being predominant. Gasoline is also traded on global markets and in California on spot markets in San Francisco and Los Angeles. The trading prices of various oil types and grades are highly correlated and generally move in the same direction with similar degrees in magnitude of movement. Future oil prices are speculative and can fluctuate wildly. For example, on April 20, 2020, the price of oil fell 306% from its May 2020 futures crude contract price to a negative price of $37.63 a barrel on the New York Mercantile Exchange.[58] Technically, this type of inversion between current and future prices meant that the seller would have to pay the buyer to purchase the seller's oil. Under those circumstances, producers have little incentive to produce more products. Illustrated on the chart below are the various crude oil prices for various grades for the 2008 to 2024 period. As indicated, prices tend to move in correlation with one another, which is not unusual for a commodity.

[58] Saefong, M. P. (2021, April 19). *Oil prices went negative a year ago: Here's what traders have learned since.* MarketWatch. https://www.marketwatch.com/story/oil-prices-went-negative-a-year-ago-heres-what-traders-have-learned-since-11618863839

Exhibit 1.9

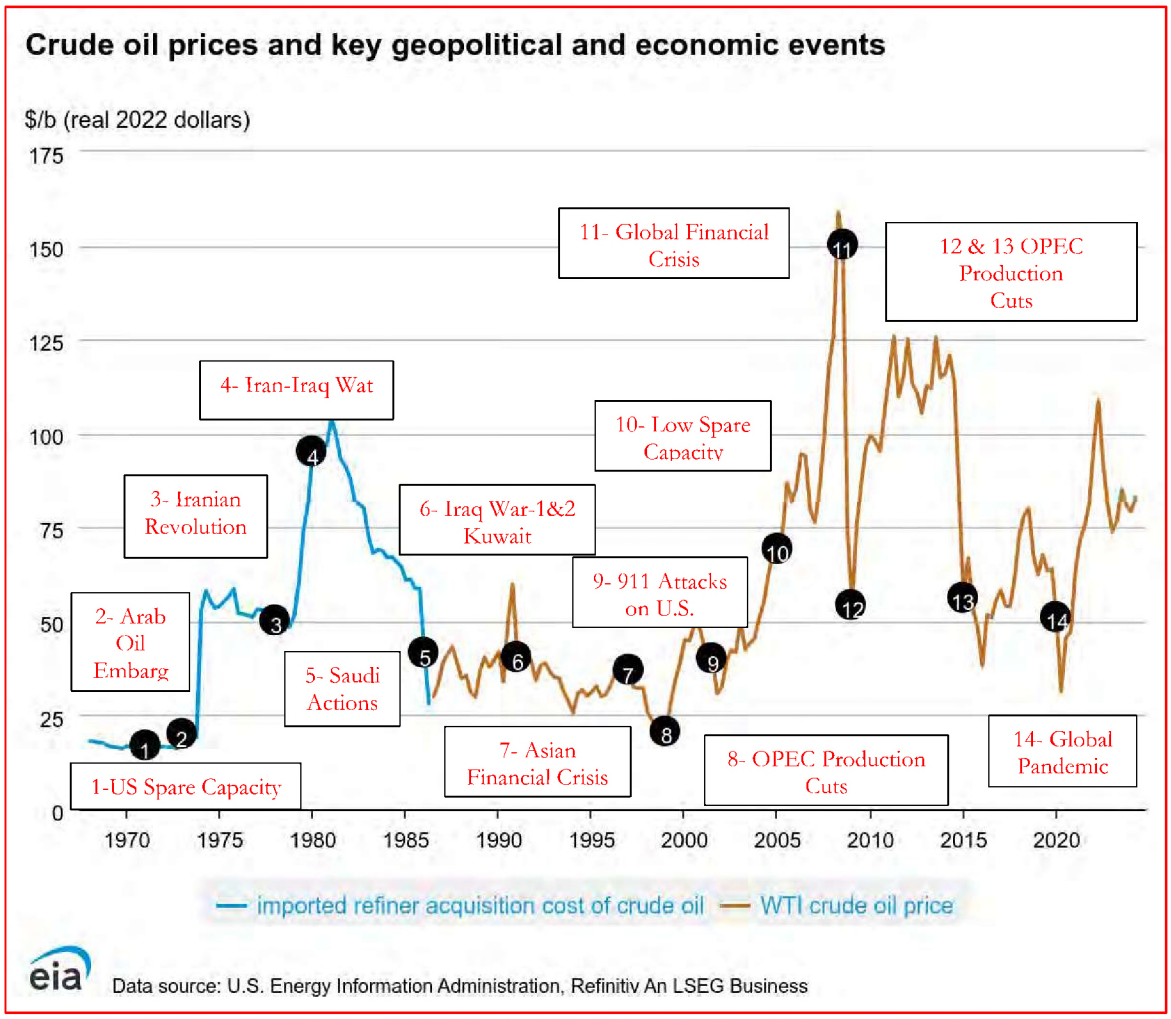


(Source:https://www.eia.gov/finance/markets/crudeoil/spot_prices.php#:~:text=Crude%20oil%20is%20traded%20in,that%20are%20lower%20in%20quality)

Notwithstanding the basic principles of economics and political events, there are many other factors that influence crude oil and gasoline prices. In California, earthquakes, fires, and flooding can cause disruptions in production and distribution (transportation). Furthermore, refinery shutdowns, transitions, and decommissions adversely affect supply and retail gasoline stocks. When those events occur, the spot prices for crude oil stock can spike and are ultimately reflected in higher prices for retail gasoline. Environmental factors such as weather and natural events (e.g., storms, hurricanes, freezes, flooding, earthquakes, etc.) also influence both crude oil and retail gasoline prices. The retail price of oil can also be further affected by other factors such as labor disputes and strikes involving rail and trucking, maritime terminal operational efficiencies, employment rates, truck and rail transport, government lockdowns, such as COVID-19, and other situations.

Illustrated below are oil price movements for the 1970 to 2023 period as related to major historical political and business events.

Exhibit 1.10



(Source: Author and https://www.cia.gov/finance/markets/crudeoil/spot_prices.php#:~:text=Crude%20oil%20is%20traded%20in,that%20are%20lower%20in%20quality)

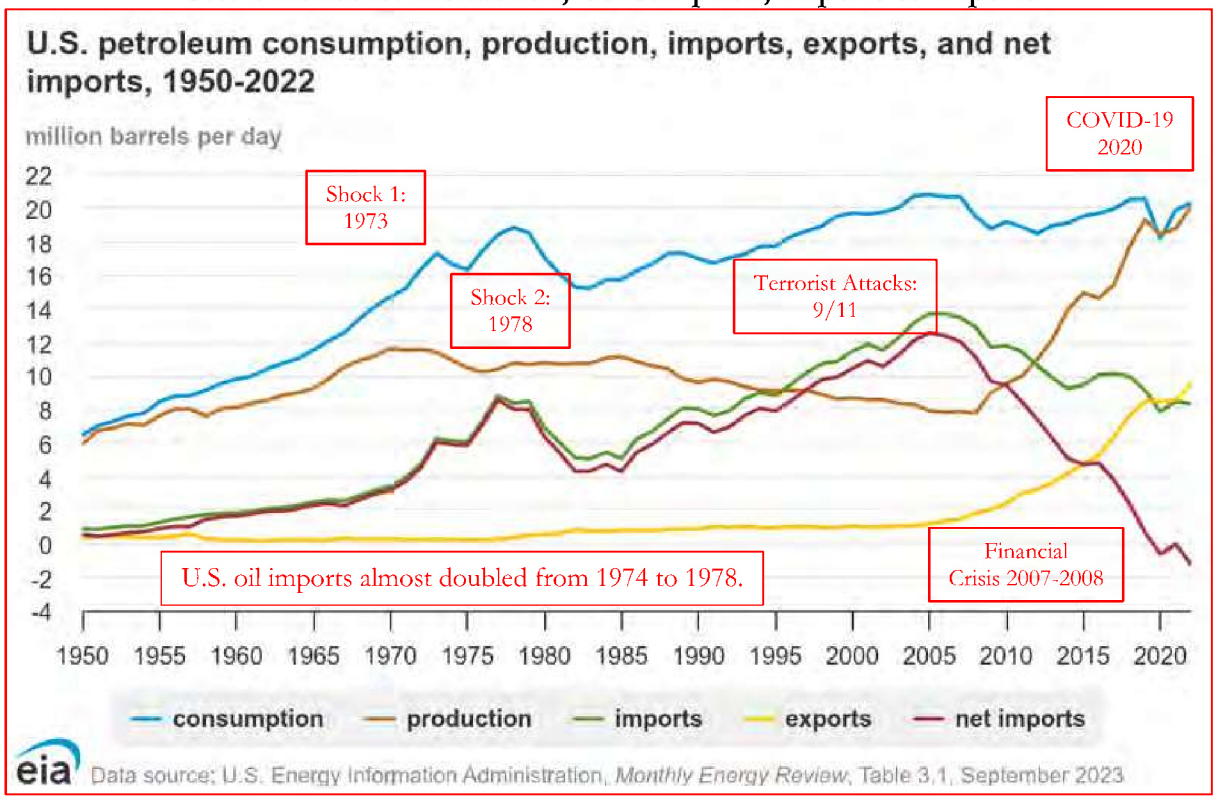
In the 1970's, the U.S. experienced two episodic events or oil "shocks." The first occurred in 1973, and the second was in 1978. On October 6, 1973, the Fourth Arab-Israeli war broke out between Israel and a collation of Arab nations, including Saudi Arabia, Egypt, and Syria.[59] [60] The U.S., which had and continues to maintain formal defense alliances with Israel, supported Israel with a $2.8 billion (equivalent to $20.2 billion in 2024) defense aid package. In retaliation to the U.S. support of Israel, the Arab members of OPEC lowered oil production by 5% and initiated an oil embargo on the U.S. Overall, global oil supplies fell by 14%. Within days of the onset of hostilities, the reduction in production, and the embargo, petroleum prices surged by 71%, rising from $3.01 to $5.12 per barrel. The rapid and unexpected surge in prices dealt a severe, almost debilitating blow to the U.S. economy. Less than three months later, in December 1973, Arab member OPEC oil producers again cut

[59] The Editors of Encyclopedia Britannica. (2018). Yom Kippur War | Summary, Causes, Combatants, & Facts. In *Encyclopædia Britannica*. https://www.britannica.com/event/Yom-Kippur-War

[60] Also known as the Yom Kippur War, or Ramadan War.

production by 25% from its September levels. In reaction, the price to the U.S. for OPEC-sourced oil rocketed to $11.65 a barrel — an increase of 287% in about 90 days. What followed were gasoline shortages, price spikes, and high inflation. By March 1974, the oil embargo was formally ended by the Arab nations, but its influence on the U.S. economy lasted well into the 1980s. Recognizing its vulnerability to foreign sources and spot market prices, the U.S. Congress established the Strategic Petroleum Reserve (SPR) in December 1975.[61]

Exhibit 1.11
U.S. Oil Shocks: Production, Consumption, Exports & Imports



With surplus oil sources and stocks, the 1980s were characterized by a worldwide collapse in oil prices. Over a six-year period, from 1980 to 1986, crude oil prices fell by 50% from their 1979 peak highs. In one year, from August 1985 to August 1986, the price of crude dropped by 71% from $28 a barrel to $8 a barrel. Led by Saudi Arabia, OPEC members agreed to lower production to pre-determined levels in order to support prices. However, despite agreements, many OPEC members produced oil in amounts far exceeding their agreements. In particular, Saudi Arabia, recognizing that adhering to its agreement to lower production was contrary to its self-interests, unilaterally removed itself from the production quotas and increased its output from 2 million barrels a day to 5 million.[62] As a result of the various actions by OPEC members, in 1986, a glut of oil was flooding into the world markets,

[61] 42 U.S. Code § 6231and 42 U.S. Code § 6234
[62] *Oil & Energy Online :: Major Oil Market Crashes in History*. (n.d.). See also, *Oil & Energy Online :: Major Oil Market Crashes in History*. (n.d.). Oilandenergyonline.com. https://oilandenergyonline.com/articles/all/major-oil-market-crashes-history/

which contributed to the collapse of oil prices.[63] Throughout much of the decade, while oil supplies were increasing, demand was moderating, placing further downward pressures on oil prices.

1.5 Pricing Components: Crude Oil Prices & Gasoline

Crude oil prices drive gasoline prices, and the largest component of gasoline prices is crude oil. Crude oil prices are the largest single determinant of retail gasoline prices. For the April 1993 to December 1, 2024, period, the correlation coefficient between monthly crude oil prices and monthly retail gasoline prices is .958, which represents an exceptionally statistically strong relationship. The other price components include transportation, storage, distribution, refining, selling costs, and taxes and fees. The U.S. government, as well as state and local governments, impose a variety of taxes and fees on the sale of gasoline to the retail consumer.

The price of crude oil is highly volatile and subject to dramatic swings and shifts, which, in turn, influence retail gasoline prices. Consequently, as the price of crude oil goes, so does the price of gasoline, and producer, refiner, and gas station retailer profits follow both. However, in oil and gasoline, as in other commodity industries, prices are quick to accelerate and slow to come down.

Exhibit 1.12



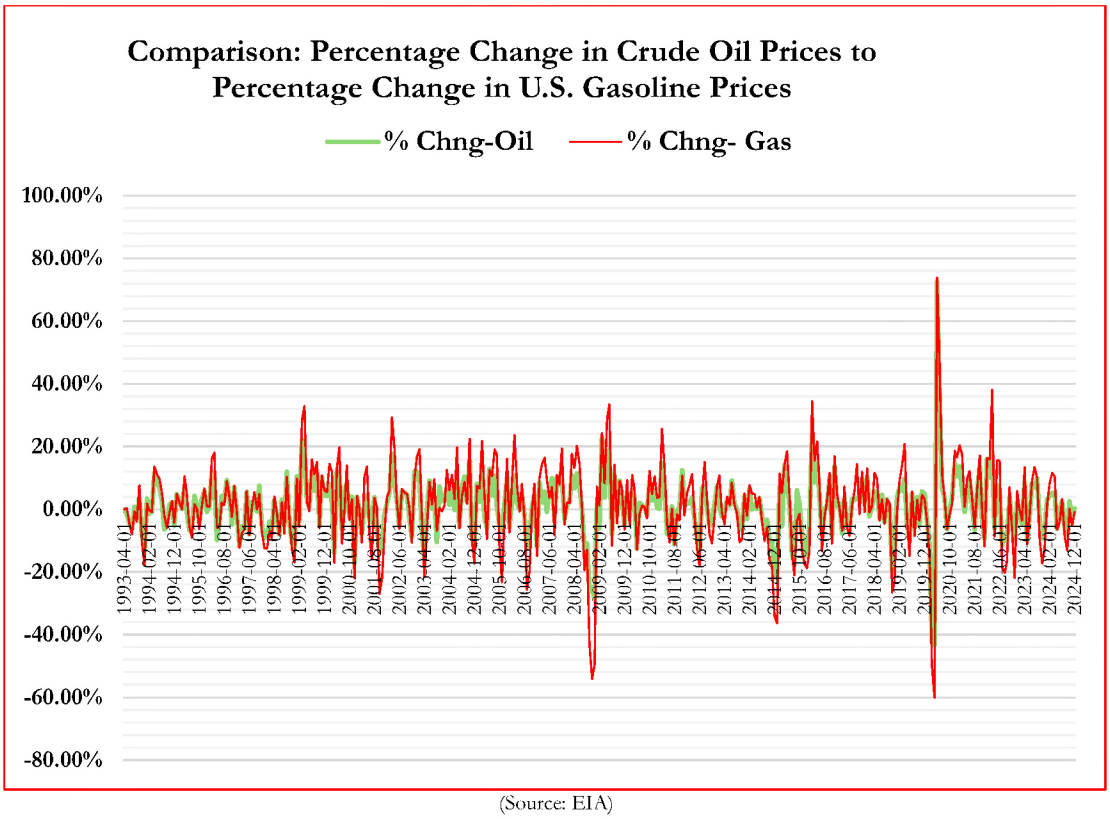
(Source: EIA https://www.eia.gov/dnav/pet/hist/leafhandler.ashx?f=m&n=pet&s=emm_epm0_pte_nus_dpg and Fed. Reserve Link: https://fred.stlouisfed.org/series/WTISPLC)

Understandably, changes in the price of gasoline closely emulate the price of crude oil, but there are many additional factors that influence the price that consumers pay at the gas pump. In addition to the volatility in global oil stock prices and federal and state excise taxes, state and local sales taxes

[63] https://www.brookings.edu/wp-content/uploads/1986/06/1986b_bpea_gately_adelman_griffin.pdf

regulatorily required special formulation blends, seasonal blends, underground storage fees, cap and trade fees, etc.

Exhibit 1.13



(Source: EIA)

For the April 1993 to December 1, 2024, period, the correlation coefficient between monthly crude oil prices and monthly retail gasoline prices is .601 and is generally considered a strong statistical relationship.[64] Section 6.0 provides a more complete description of gasoline prices in California.

1.6 Brief History of Petroleum in California

In the early 16th century, the Spanish observed California' indigenous peoples, the Tataviam and Tongva native Americans, using heavy oil (similar to tar) as waterproofing and construction material for dwellings, canoes, baskets, and weapons.[65] In the mid-1800s, settlers migrating to Southern California observed oil seeps, pools of oil oozing out of the ground. They would stop and use the seepage to lubricate their wagon wheels and most likely "refine" (distillation) it into lighting and cooking oil.[66] Other than some effort to create lighting oil for the San Fernando Mission, there was no significant commercial or economic development of the resource.

[64] In general, "for absolute values of r, 0-0.19 is regarded as very weak, 0.2-0.39 as weak, 0.40-0.59 as moderate, 0.6-0.79 as strong and 0.8-1 as very strong correlation…" For a more thorough explanation see, https://www.bmj.com/about-bmj/resources-readers/publications/statistics-square-one/11-correlation-and-regression#.

[65] "Oil and Gas Production: History in California" (PDF). *State of California*. March 18, 2013.

[66] Ibid.

On August 27, 1859, oil was formally discovered for commercial purposes in the U.S. in Titusville, Pennsylvania, by Colonel Edwin Drake. Drake struck oil at a depth of 69.5 feet.[67] In California, commercial interest in petroleum began around 1865 and after the Pennsylvania strike. Apparently, a Yale professor named Benjamin Silliman published a report in 1864 extolling the abundance of oil associated with Sulphur Mountain in Ventura County, California.[68] [69] Reports of oil seepages in Ventura County and Northern California stimulated speculators and investors. Early speculation and investment transpired in Northern California in Contra Costa, Marin, Mendocino, Santa Clara, and Santa Cruz Counties. Early efforts in Marin and Humboldt Counties would prove to be non-sustainable, but Southern and Central California would be considerably different. The growth of California's oil industry and the economic windfalls that financed much of the State's post-Civil War growth were predominantly sited in the southern and central parts of the State.

The first California commercial (production) oil well was sited in 1861 in Humboldt County. A second was drilled in Humboldt County in 1865 by the Union Mattole Oil Company.[70] However, Northern California's oil production was not scalable then, and production declined and ultimately ceased. Production setbacks notwithstanding, California's fledging petroleum industry continued to develop, especially in Southern California. In the 1860s, California achieved oil production through tunnels designed by Josiah Stanford, brother of Leyland Stanford, dug into mountains by Chinese laborers supplied by railroad and banking magnate Charles Crocker.[71] [72] Stanford's tunneling design relied on a downward slope that allowed the oil seepage to drain into collection pools and then, based on gravity, move through tunnels to collection points.[73] [74] The tunnel oil production method proved highly lucrative for Josiah and his brothers, yielding 20 barrels a day. The oil was sent to Stanford's San Francisco refinery and used until it was capped in 1998.[75]

In 1865, the Pioneer Oil Refinery, dedicated solely to refining oil, was built in Newhall, and a two-inch pipeline was installed between it and Pico Canyon.[76] On September 26, 1876, the Star Oil Works drilled the "Pico 4" well in the Santa Susana Mountains. Pico No. 4 struck oil at a depth of 370 feet and became California's first major successful oil well. Pico No. 4 produced oil for 114 years before operations ceased, and the well was capped in 1990. Today, Pico No. 4 is considered the cradle of the petroleum industry in the Golden State and is a state landmark.[77]

California's oil industry grew accelerated in Southern California and Central California. In 1890, oil was discovered in Kern and Fresno Counties (Coalinga). Although attempts were made to extract oil in the Coalinga Oil Field in 1867, the 1898 "Blue Goose" gusher solidified the area as a major oil-

---

[67] *Visit.* Carnegie Museum of Natural History. (n.d.). https://carnegiemnh.org/the-story-of-oil-in-western-pennsylvania/
[68] *Sulphur Mountain High Point - Peakbagger.com.* (2022). Peakbagger.com. https://www.peakbagger.com/peak.aspx?pid=50714
[69] Bard, T., Stanford, J., & Nelson, M. (2001). *and the 1860's Hunt for California Crude.* https://vcrma.org/wp-content/uploads/2024/04/pacific-petroleum-geologist-newsletter-california-crude.pdf
[70] Parks, C. S. (n.d.). *CALIFORNIA'S FIRST DRILLED OIL WELLS.* California State Parks. https://ohp.parks.ca.gov/ListedResources/Detail/543
[71] *The Stanfords — Camron-Stanford House.* (n.d.). Camron-Stanford House. https://www.cshouse.org/the-stanfords
[72] Wikipedia Contributors. (2023, February 21). *Charles Crocker.* Wikipedia; Wikimedia Foundation. https://en.wikipedia.org/wiki/Charles_Crocker
[73] I *The Stanfords — Camron-Stanford House.* (n.d.). Camron-Stanford House. https://www.cshouse.org/the-stanfords
[74] Bard, T., Stanford, J., & Nelson, M. (2001). *and the 1860's Hunt for California Crude.* https://vcrma.org/wp-content/uploads/2024/04/pacific-petroleum-geologist-newsletter-california-crude.pdf
[75] Bard, T., Stanford, J., & Nelson, M. (2001). *and the 1860's Hunt for California Crude.* https://vcrma.org/wp-content/uploads/2024/04/pacific-petroleum-geologist-newsletter-california-crude.pdf
[76] See, California Registered Landmark 172.
[77] See, California Registered Landmark 172.

producing region. At a depth of 1,000 feet, the Blue Goose yielded over 1,000 barrels of oil a day.[78] In 1892, California may have experienced its first oil-related environmental disaster when Union Oil Company's Well No. 28 expelled an estimated 40,000 barrels into the Santa Clara River.[79] Well, No. 28 is considered one of the first real "gusher" in California's long petroleum history. The following year, 1893, saw the first significant discovery and production of oil in Los Angeles County. Known as the Los Angeles City Field, the site produced 750,000 barrels, or around 62% of all California production.[80] In 1896, the first deep water wells were drilled off the shore of Santa Barbara. More oil was discovered between 1920 and 1930, and from 1960 to 1970, more offshore oil was discovered in the Pacific off of Carpinteria in Santa Barbara County.

By 1909, California was the leading producer of oil in the U.S. In 1900, when California's population was 1.48 million, California was producing 4.3 million barrels a day. The industrialization and post-World War I period saw California's population grow to 3.4 million while state oil production increased to 77 million barrels a day. In 1929, California oil production peaked at 292.5 million barrels annually.[81] By the end of the "Roaring '20s," California accounted for around 25% of global crude oil production and 35% of U.S. crude production.[82]

[78] Oil and Gas Production History in California Archived 2012-01-30 at Archive-It; published by California Department of Oil and Gas
[79] "Oil and Gas Production: History in California" (PDF). *State of California*. March 18, 2013.
[80] Ibid.
[81] https://www.rand.org/content/dam/rand/pubs/reports/2008/R1850.pdf
[82] Ibid.

SECTION 2.0
CALIFORNIA GASOLINE CONSUMPTION

A STUDY OF CALIFORNIA GASOLINE PRICES
Section 2.0
Table Of Contents

2.0 California Gasoline Consumption

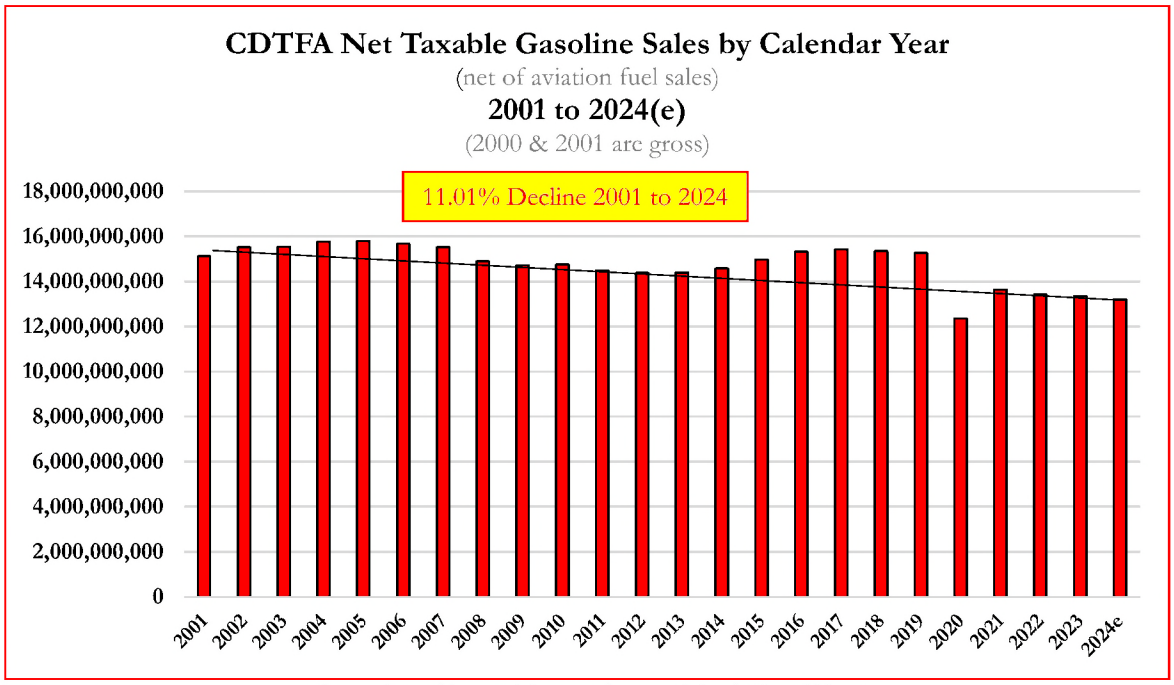
2.1 California Gasoline Consumption
2.2 Factors Contributing to the Reduction in Gasoline Consumption
2.3 Octanes and Brands
2.4 California Retail Distribution Models

2.0 CALIFORNIA CONSUMPTION

2.1 California Gasoline Consumption

California is the 2nd largest consumer of petroleum and the largest consumer of aviation fuel in the U.S.[83] In 2023, Californians consumed 13.119 billion gallons of gasoline and over 216 million gallons of aviation fuel, based on CDTFA revenue data.[84] From 2001 to 2024, overall, CDTFA reported gasoline sales had fallen 11.12 %.[85]

Exhibit 2.1



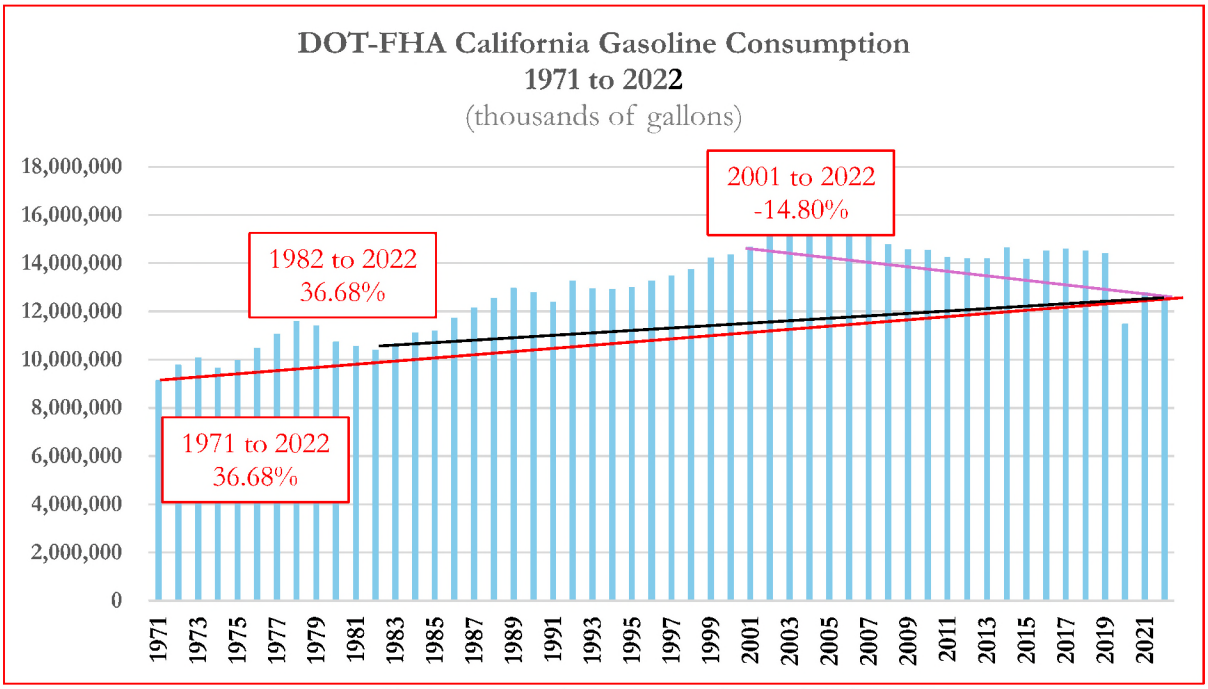
(Source: https://www.cdtfa.ca.gov/taxes-and-fees/spftrpts10.htm)

[83] U.S. EIA, Crude Oil Production, Annual, Thousand Barrels, 2023.

[84] California Department of Tax and Fee Administration. (n.d.-b). *Fuel Taxes Division Statistics & Reports – 2010.* https://www.cdtfa.ca.gov/taxes-and-fees/spftrpts10.htm

[85] *Fuel Taxes Division Statistics & Reports – 2020.* (2020). Ca.gov. https://www.cdtfa.ca.gov/taxes-and-fees/spftrpts20.htm

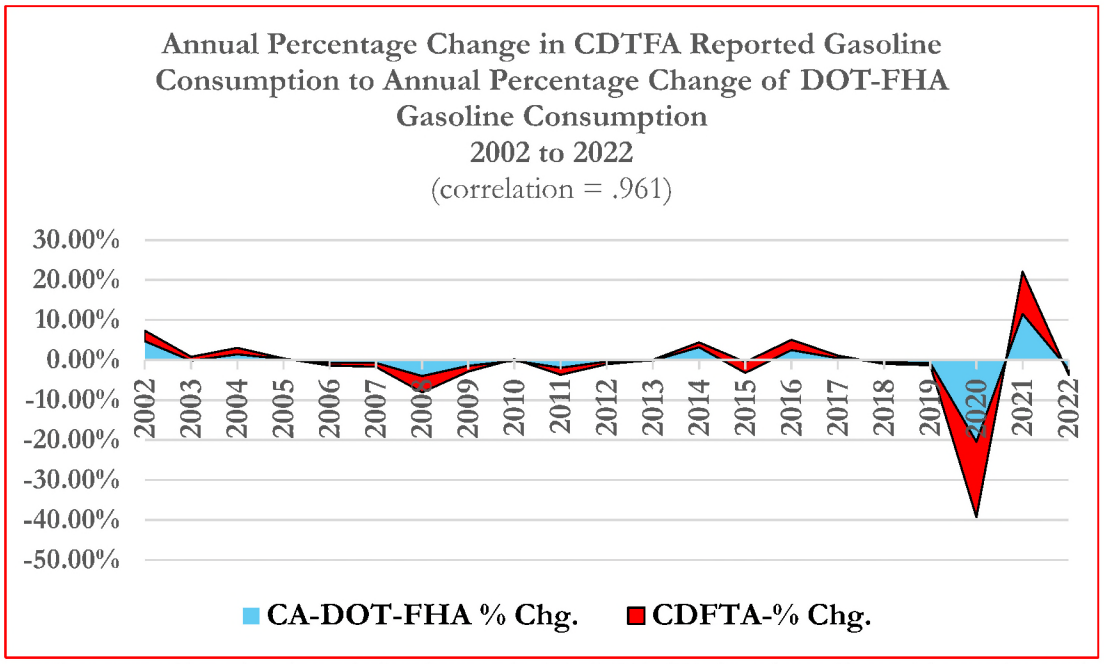
Exhibit 2.2



(Source: https://www.fhwa.dot.gov/policyinformation/statistics/2022/mf226.cfm)

On a comparative basis, the annual percentage of gasoline consumption based on CDTFA sales to U.S. DOT-FHA gasoline consumption is highly correlated.

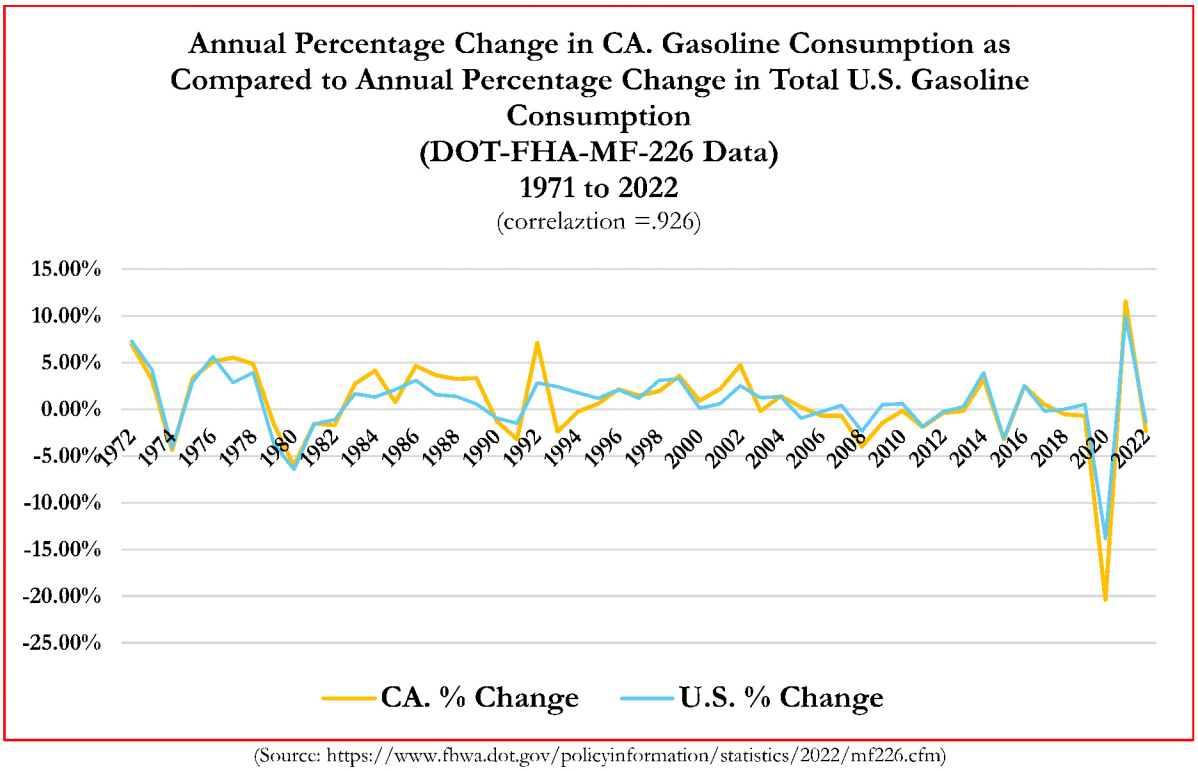
Exhibit 2.3



(Source: https://www.fhwa.dot.gov/policyinformation/statistics/2022/mf226.cfm, and https://www.cdtfa.ca.gov/taxes-and-fees/spftrpts10.htm)

The annual percentage change in CDTFA gasoline sales is relatively consistent. It shows only a modest annual variance of -.46% and is highly correlated to the annual percentage change in overall U.S. gasoline consumption.

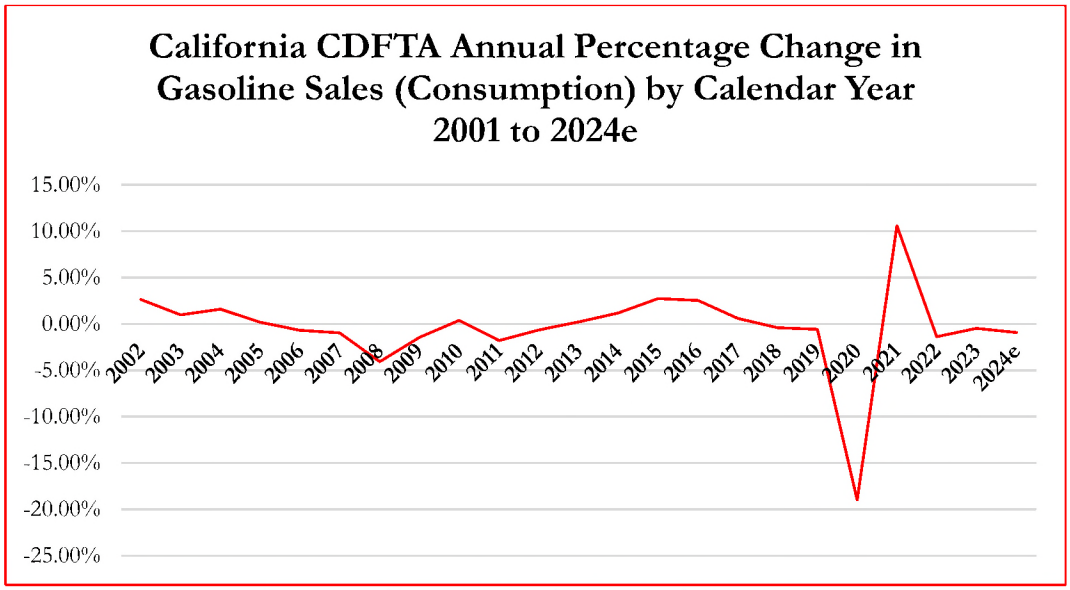
Exhibit 2.4



(Source: https://www.fhwa.dot.gov/policyinformation/statistics/2022/mf226.cfm)

With the exception of the Covid years and their related restrictions, the annual percentage change in California consumption is relatively consistent.

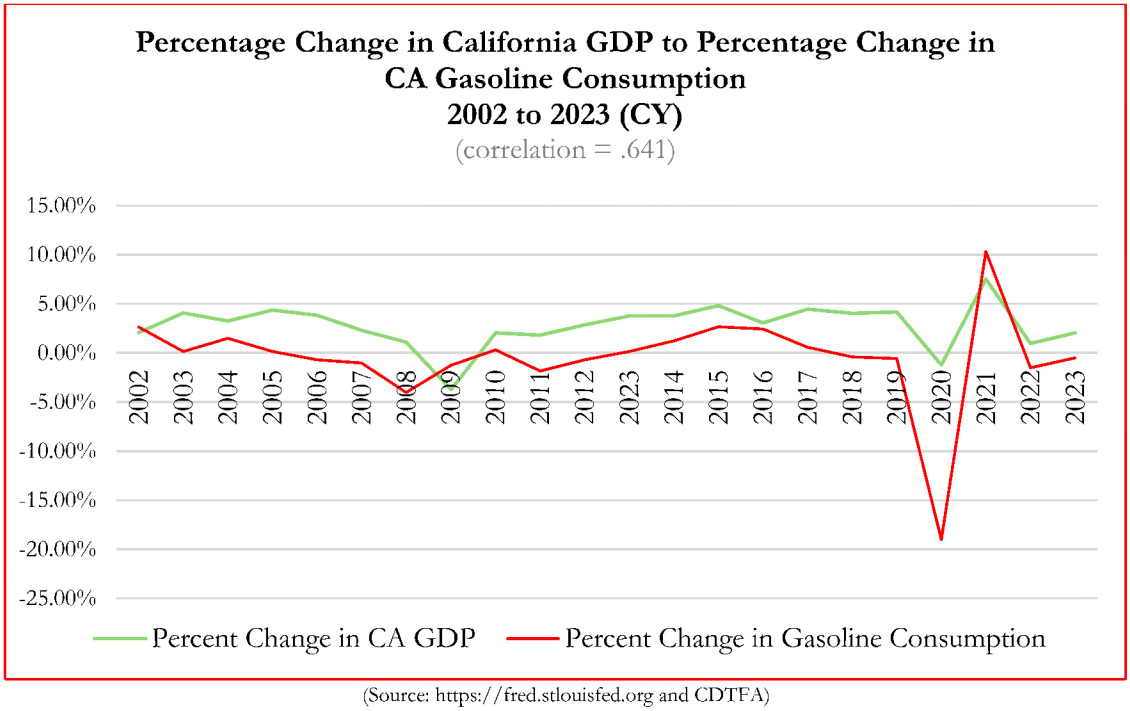
Exhibit 2.5



(Source: https://www.cdtfa.ca.gov/taxes-and-fees/spftrpts10.htm)

Notwithstanding oil shocks and geopolitical events that disrupt supply chains, gasoline consumption in California generally follows overall California GDP and economic health and growth.

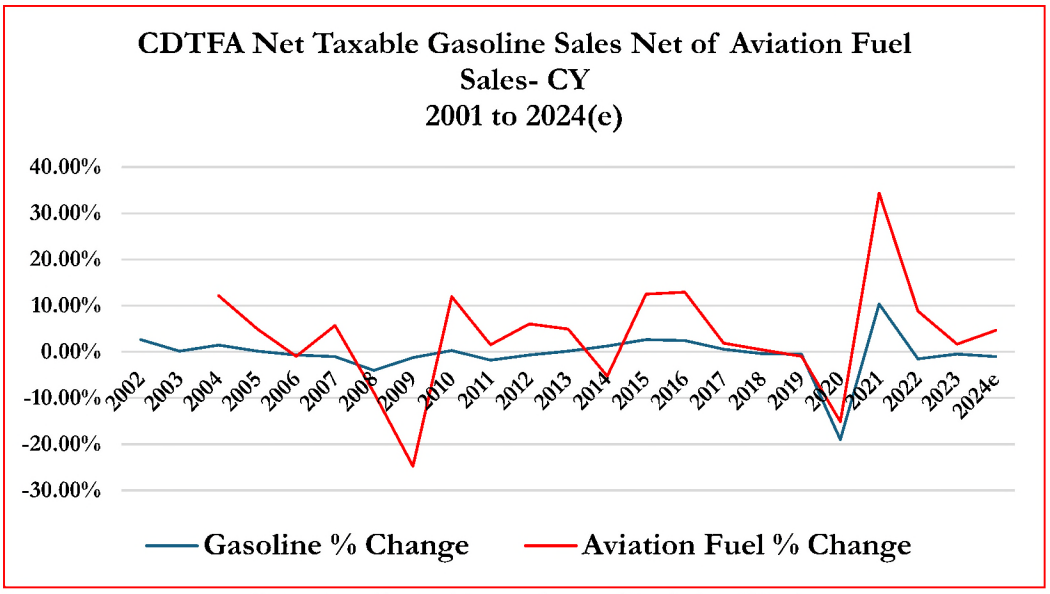
Exhibit 2.6



(Source: https://fred.stlouisfed.org and CDTFA)

Conversely, CDTFA sales of aviation (jet) fuels have increased 72.08% for the 2003 to 2024e period.[86] The largest percentage increase in aviation fuel sales occurred in 2015, 2016, and 2021, while the largest declines were in 2009 and 2020.

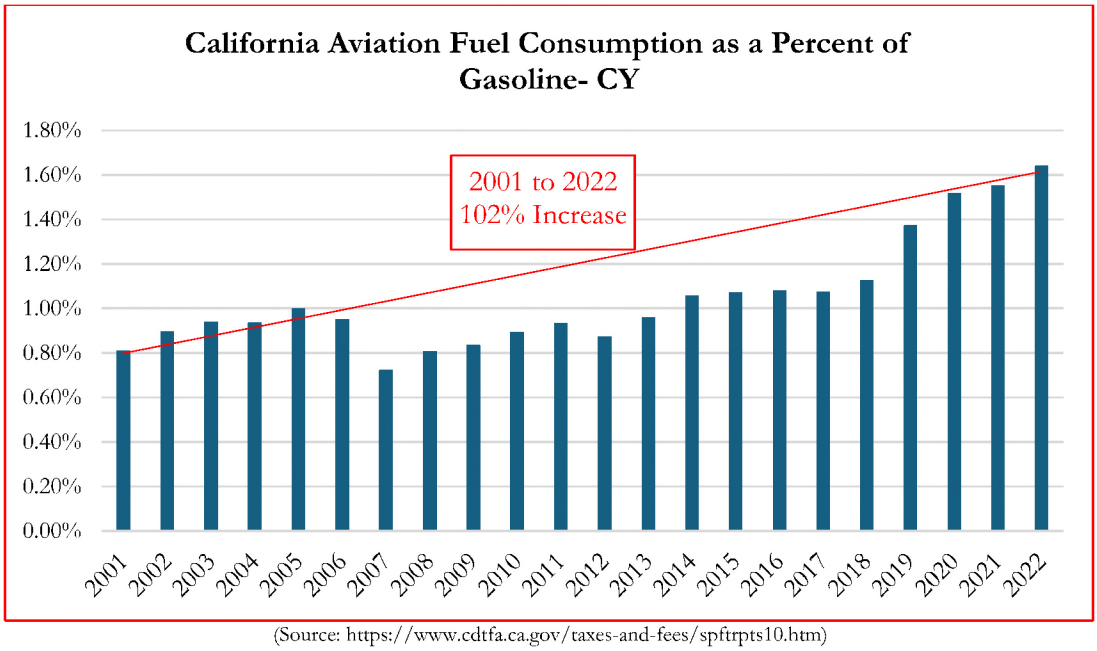
Exhibit 2.7



(Source: https://www.cdtfa.ca.gov/taxes-and-fees/spftrpts10.htm)

Aviation fuel consumption grew by 102% from 2001 to 2022.

Exhibit 2.8

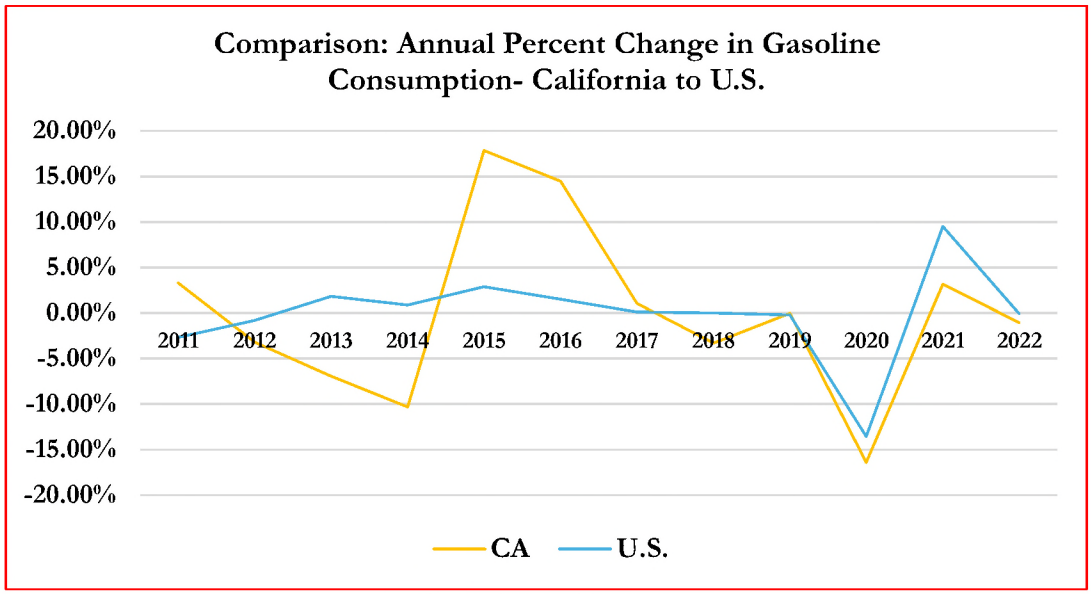


(Source: https://www.cdtfa.ca.gov/taxes-and-fees/spftrpts10.htm)

[86] *Fuel Taxes Division Statistics & Reports – 2020.* (2020). Ca.gov. https://www.cdtfa.ca.gov/taxes-and-fees/spftrpts20.htm

Gasoline consumption from 2011 to 2022 declined slightly by 6%. Since 2017, California's gasoline consumption pattern, as measured on a percentage change basis, closely mirrors that of the U.S.

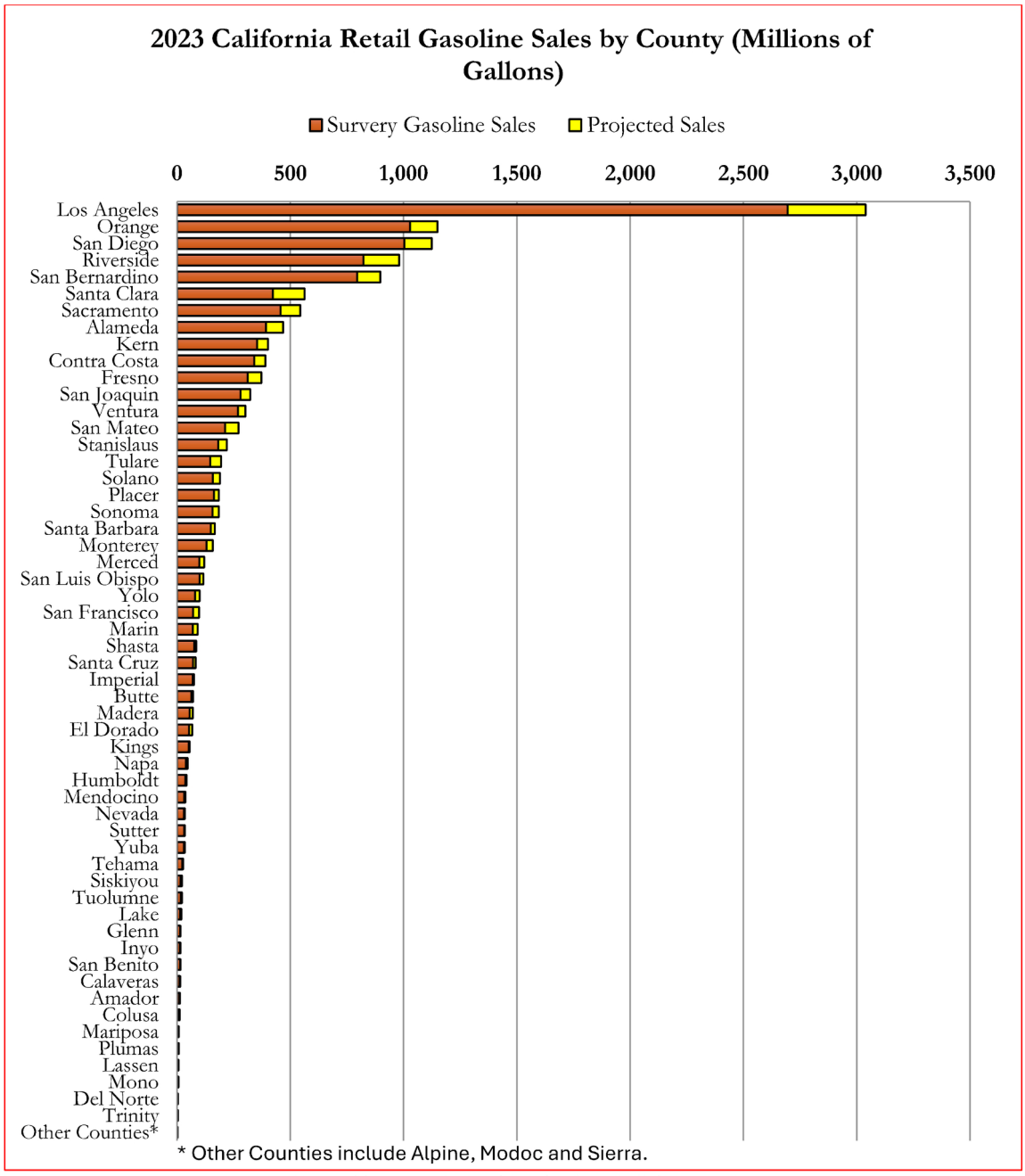
Exhibit 2.9



(Source: EIA and CEC Data)

California retail gasoline sales by county are generally informed by the population of the county.

Exhibit 2.10



(Source: Transportation Fuels Market Unit CEC-A15 report)

2.2 Factors Contributing to the Reduction in Gasoline Consumption

The decline in gasoline consumption can be attributed to a number of factors, including the increase in EV registrations, improved miles per gallon in internal combustion engines, COVID-19 restrictions of 2020 and 2021, and the decline in California's population. Some specific factors include:

- **Population Decline.** Since 2016, California has experienced a net reduction in population of -.47%. Since 2020, California's population has declined by 1.362%, resulting in a loss of one seat in the U.S. House of Representatives.[87]

- **Work at Home and Tele-commuting.** In 2005, California, along with the rest of the U.S., averaged about 5% of its labor workforce working from home.[88] California's work at home percentage of its labor force increased to 7% in 2019. Commencing with the outbreak of Covid and the California "stay-at-home" mandates, the percentage of at-home work increased and peaked at 22% in 2021, as compared to the overall U.S. at 18%.[89] [90] By 2022, the percentage of the California workforce that stayed at home had fallen to 17%, which was still higher than the overall U.S. at 15%.[91] Work at home, telecommuting, and hybrid work modes (in-office and home) reduce the number of miles associated with commuting to work. A 2024 MIT study indicates that, in general, a "1 percent decrease in onsite workers leads to a roughly 1 percent reduction in [automobile] vehicle miles driven, but a 2.3 percent reduction in mass transit ridership."[92] [93]

- **Increase in EV, Hybrid, and Hydrogen Vehicles.** California has the most aggressive policy in the U.S. with respect to zero emission vehicles (ZEV). Illustrated in the exhibit below are the projected adaptation rates for California's ZEV aspirations. As indicated in the comparative exhibits below, ZEVs, or more especially, EVs were projected to achieve a 35% market share by 2026, which will be challenging and optimistic given the 25.31% share in 2025.

---

[87] US Census Bureau. (2021, April 26). *Historical Population Change Data (1910-2020).* Census.gov. https://www.census.gov/data/tables/time-series/dec/popchange-data-text.html

[88] Bohn, S., Johnson, H., & McGhee, E. (2024, June 4). *Remote Work Is Reshaping the California Labor Market.* Public Policy Institute of California. https://www.ppic.org/blog/remote-work-is-reshaping-the-california-labor-market/

[89] *Limited Stay At Home Order November 2020.* (n.d.). Www.cdph.ca.gov. https://www.cdph.ca.gov/Programs/CID/DCDC/Pages/COVID-19/limited-stay-at-home-order.aspx

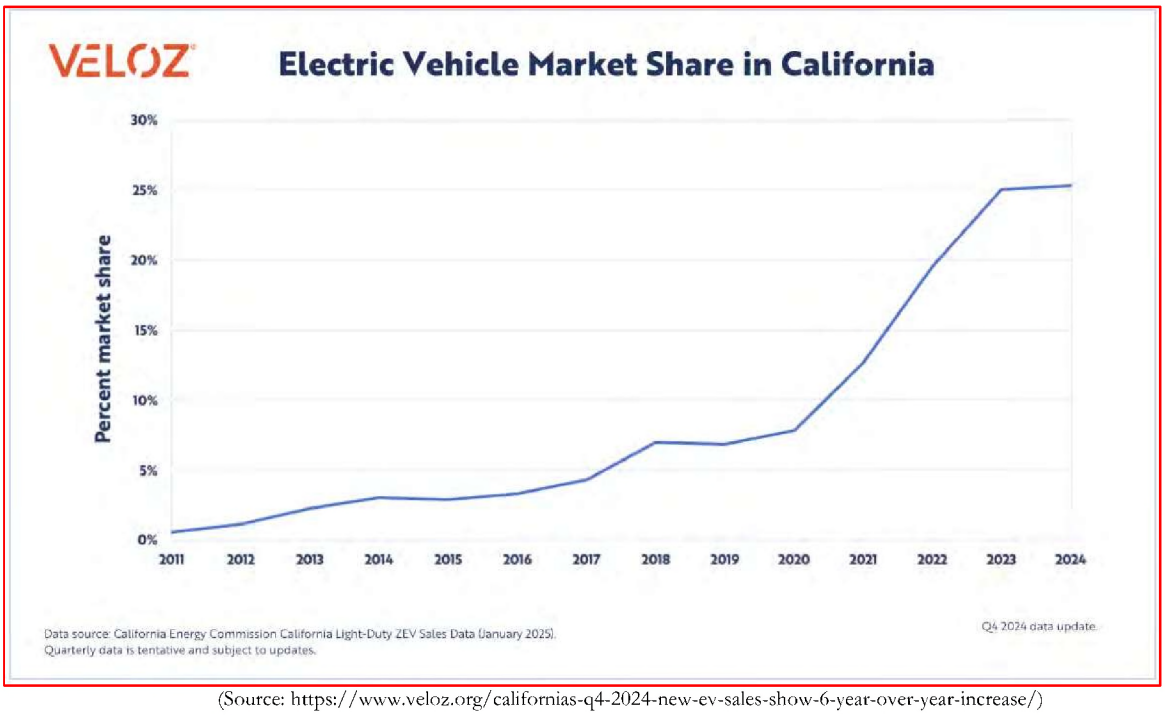
[90] Bohn, S., Johnson, H., & McGhee, E. (2024, June 4). *Remote Work Is Reshaping the California Labor Market.* Public Policy Institute of California. https://www.ppic.org/blog/remote-work-is-reshaping-the-california-labor-market/

[91] Bohn, S., Johnson, H., & McGhee, E. (2024, June 4). *Remote Work Is Reshaping the California Labor Market.* Public Policy Institute of California. https://www.ppic.org/blog/remote-work-is-reshaping-the-california-labor-market/

[92] *Has remote work changed how people travel in the U.S? | MIT Sustainability.* (2024, April 9). Mit.edu. https://sustainability.mit.edu/article/has-remote-work-changed-how-people-travel-us

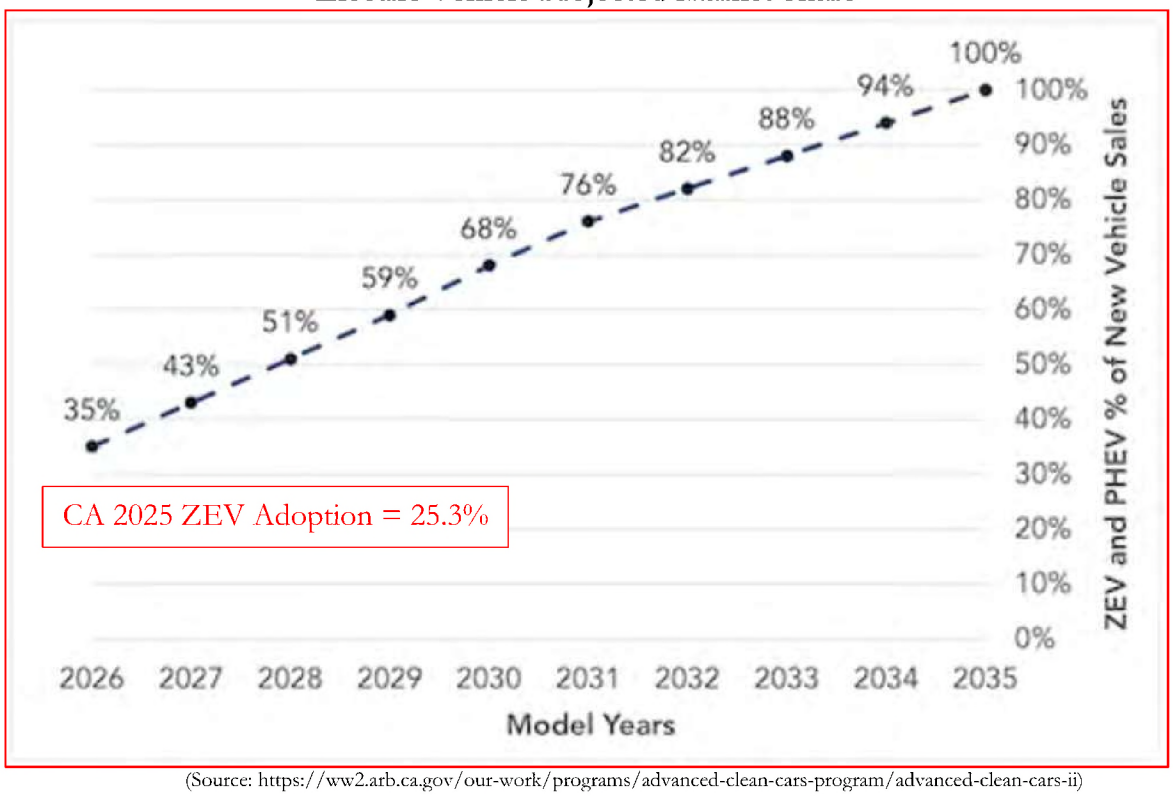
[93] See also, Hassan Obeid, Michael L. Anderson, Mohamed Amine Bouzaghrane, Joan Walker, Does telecommuting reduce trip-making? Evidence from a U.S. panel during the COVID-19 pandemic, Transportation Research Part A: Policy and Practice, Volume 180, 2024.

Exhibit 2.11



(Source: https://www.veloz.org/californias-q4-2024-new-ev-sales-show-6-year-over-year-increase/)

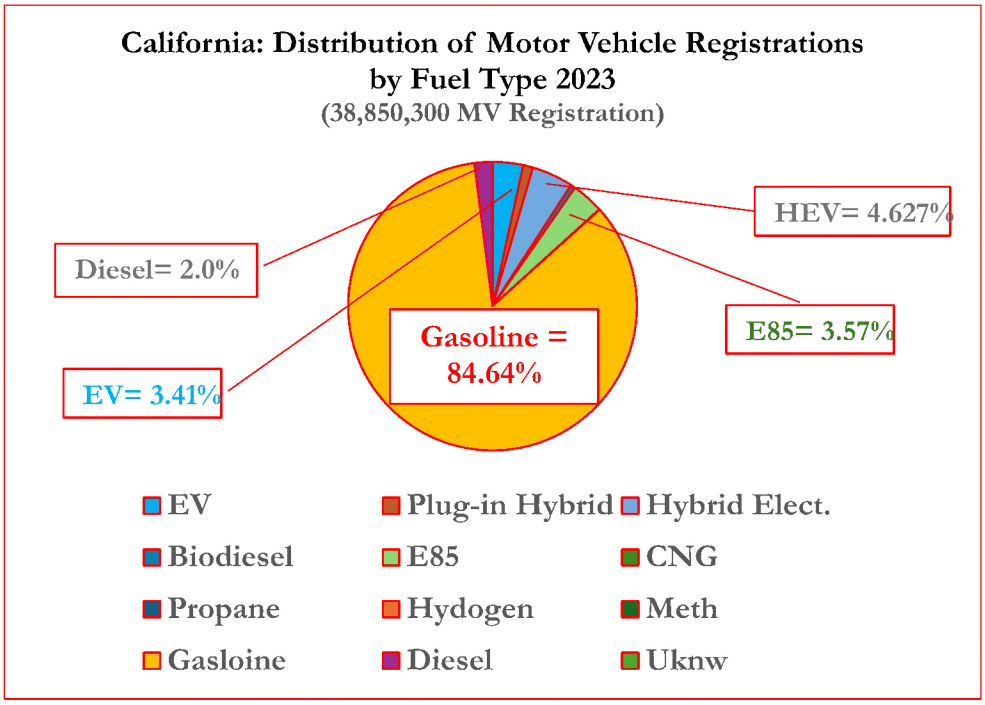
Exhibit 2.12
Electric Vehicle Projected Market Share



(Source: https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/advanced-clean-cars-ii)

In California, 25.3% of all registered cars (excludes light and heavy-duty trucks) are ZEV.[94] Understandably, California has the largest share of ZEV in the U.S. at 14.4%.[95] However, consistent with early adopter behavior, after a period of rapid adoption by the "passionate and the curious," sales of zero emissions vehicles for 2024 and early 2025 have slowed down considerably. Additionally, consumers' analysis indicates that the majority of EVs are bought by white or Asian higher income Californians living in affluent areas such as Atherton, Palo Alto, Sunnyvale, and Mountain View.[96] Nonetheless, as compared to the overall U.S. average of around 9%, California has more registered zero emission vehicles.[97]

Exhibit 2.13



(Source: https://afdc.energy.gov/vehicle-registration)

- **Annual Miles Driven and Gasoline Prices.** California gasoline prices peaked at an all-time historical high in June 2022, when they averaged $6.294 per gallon, and higher in counties such as Humboldt, Mendocino, and Mono.[98] [99] Spikes in gasoline prices, if protracted, can modify lifestyle choices and mileage driven.

---

[94] Lazo, A. (2025, February 6). *California's surge in EV sales has stalled — so what happens to its landmark mandate?* CalMatters. https://calmatters.org/environment/climate-change/2025/02/electric-car-sales-stall-california/

[95] Understanding MPG trends across states. (n.d.-k). https://www.wjbf.com/automotive/understanding-mpg-trends-across-states/

[96] Lopez, N., & Yee, E. (2023, March 22). *Who buys electric cars in California - and who doesn't?* CalMatters. https://calmatters.org/environment/2023/03/california-electric-cars-demographics/?series=california-electric-vehicles

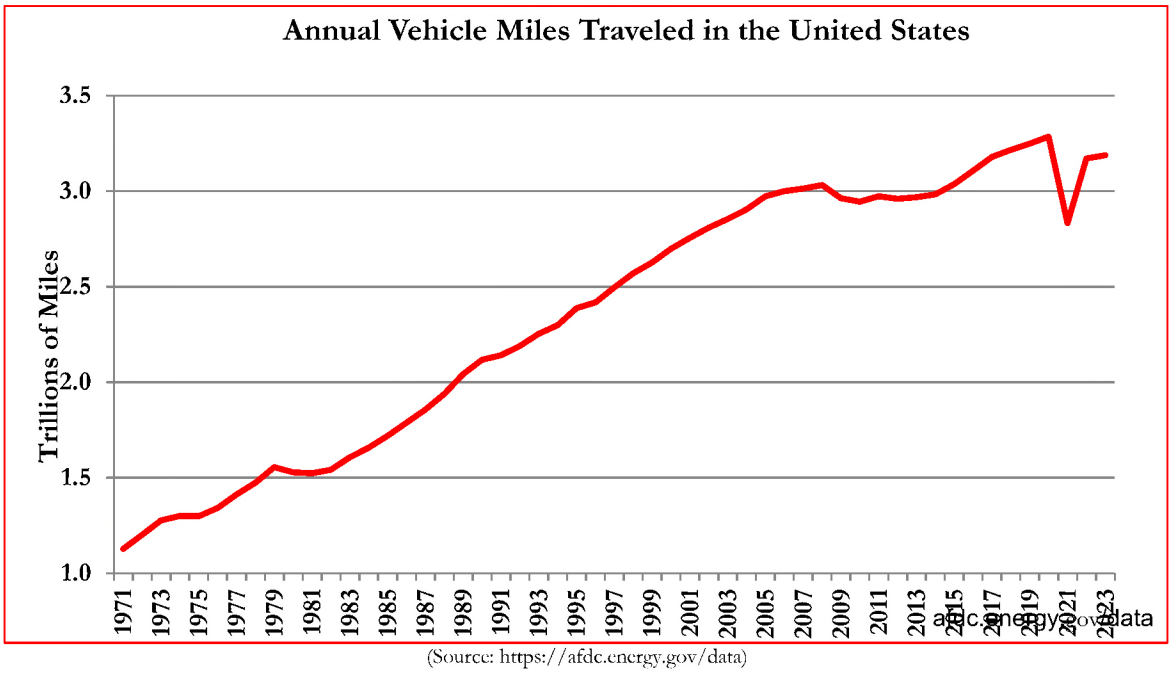
[97] Montoya, R. (2024, January 12). *What Is the Percentage of Electric Cars in the U.S.?* Edmunds. https://www.edmunds.com/electric-car/articles/percentage-of-electric-cars-in-us.html.

[98] *California All Grades All Formulations Retail Gasoline Prices (Dollars per Gallon).* (2010). Eia.gov. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=emm_epm0_pte_sca_dpg&f=m

[99] Harper, L. (2023, December 19). Gas hit nearly $10 per gallon in this California city — the most expensive in the nation. *Deseret News.* https://www.deseret.com/u-s-world/2022/6/9/23161559/gas-prices-california-most-expensive-in-nation-where-is-cheapest-gas/#:~:text=Gas%20prices%20keep%20increasing%20with%20no%20end%20in%20sight&text=Mendocino%2C%20California%2C%20has%20taken%20the,a%20whopping%20$9.60%20per%20gallon.&text=Driving%20the%20news:%20A%20northern,average%2C%20according%20to%20ABC%2030.

Covid lockdowns and restrictions notwithstanding, since 1971, the total annual miles driven in the U.S. has increased 182% from 1.13 trillion miles to 3.19 trillion miles.[100] On an average annual miles driven basis, California drivers incurred 16% less miles than the overall U.S. average. On average, a U.S. driver drove 13,596 miles in 2022 as compared to 11,409 miles for a California driver.[101] Overall, for the 2010 to 2022 period, although the number of licensed drivers increased by approximately 12%, the average annual miles driven per driver declined by 3.7%.[102]

Exhibit 2.14

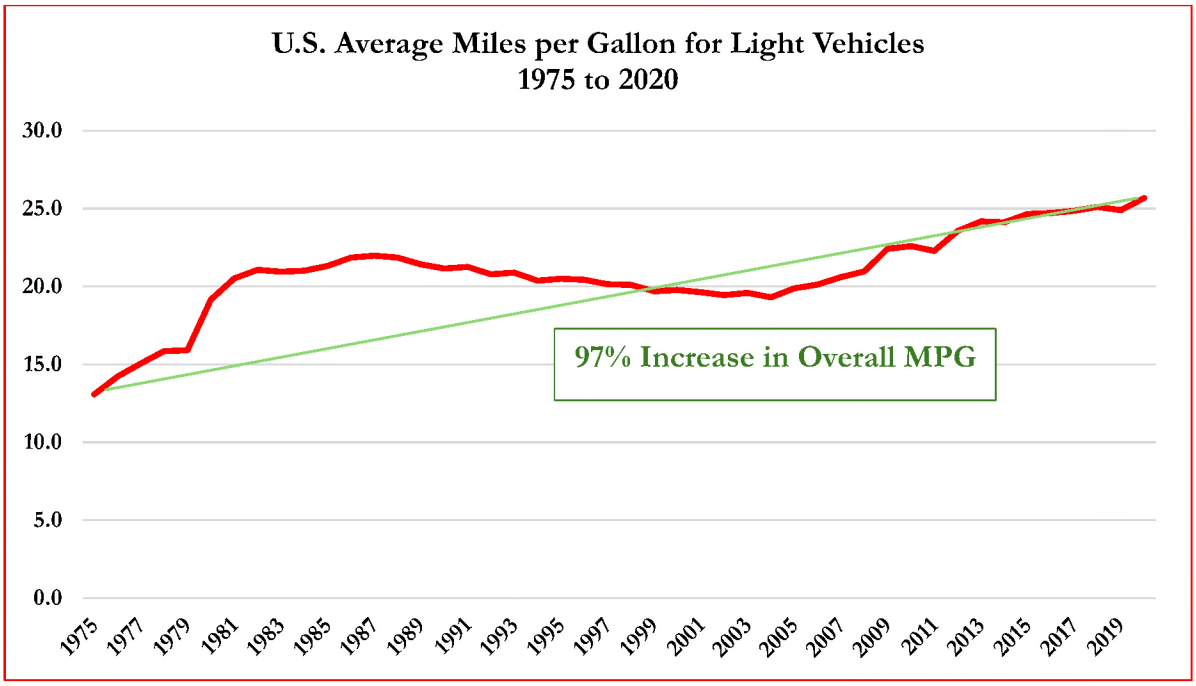


(Source: https://afdc.energy.gov/data)

- **Engine and Drivetrain Efficiency.** Over the last 40 years, automotive engines and drivetrains have become more efficient, resulting in improved miles per gallon. In 2024, California ranked first in the U.S. for average miles per gallon at 33.5 as compared to the national average of 27.5 mpg.[103]

[100] ConsumerAffairs. "How many miles does the average person drive a year? 2025 [2024]" ConsumerAffairs.com. Apr. 03, 2024, https://www.consumeraffairs.com/automotive/how-many-miles-does-the-average-person-drive-a-year.html
[101] ConsumerAffairs. "How many miles does the average person drive a year? 2025 [2024]" ConsumerAffairs.com. Apr. 03, 2024, https://www.consumeraffairs.com/automotive/how-many-miles-does-the-average-person-drive-a-year.html
[102] ConsumerAffairs. "How many miles does the average person drive a year? 2025 [2024]" ConsumerAffairs.com. Apr. 03, 2024, https://www.consumeraffairs.com/automotive/how-many-miles-does-the-average-person-drive-a-year.html
[103] Understanding MPG trends across states. (n.d.-k). https://www.wjbf.com/automotive/understanding-mpg-trends-across-states/

Exhibit 2.15



(Source: https://www.epa.gov/automotive-trends)

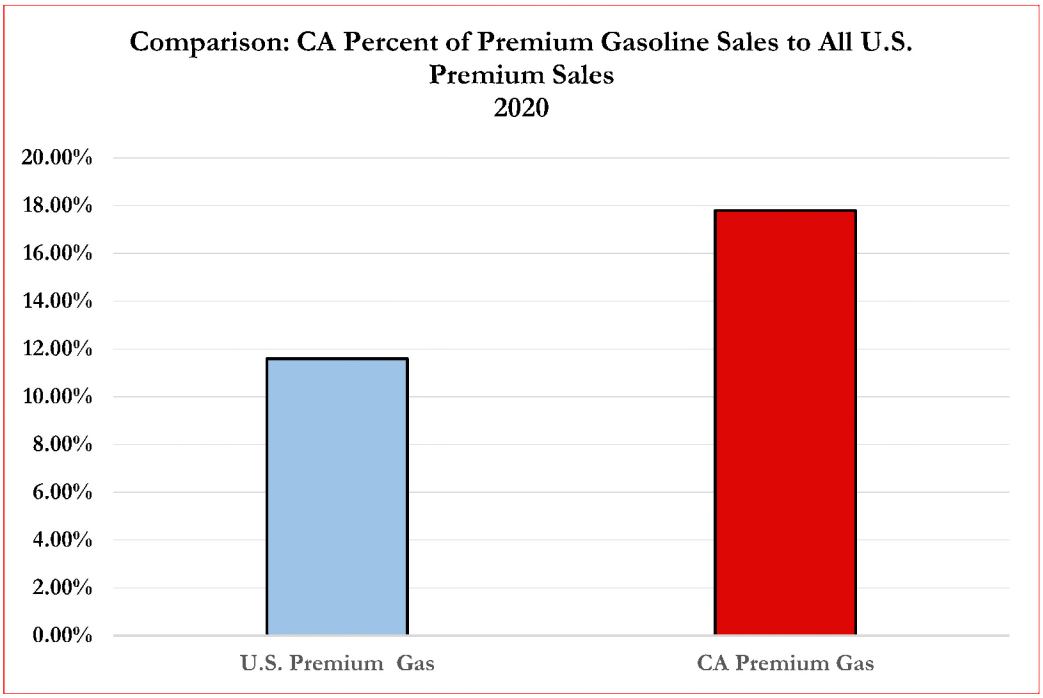
2.3 Octanes and Brands

According to CEC data, Californians favor branded gasoline products and consume more premium (higher octane) gasoline than the rest of the U.S. The choice of which octane to purchase is a consumer's choice, and refiners and retailers will respond to consumer demands. On average, Californians consume more higher-octane grades than the rest of the U.S.[104] Based on CEC and EIA, the consumption of premium grade gasoline represented 17.8% of gasoline sales in 2020, as compared to around 11% for the U.S.[105]

[104] October. (2021). *Gasoline Retail Prices by Brand Diesel Retail Prices by Region NACS Store Counts 2020 Gasoline Sales by County Top California Cities by Gasoline Sales in 2020 Total Station Counts by Ownership Total Gasoline Sales by Fuel Grade Featured Topic: Retail Fuel Outlet Annual Report PETROLEUM WATCH REFINERY NEWS INSIDE CALIFORNIA DIESEL RETAIL PRICES BY REGION CALIFORNIA GASOLINE RETAIL PRICES BY BRAND.* https://www.energy.ca.gov/sites/default/files/2021-11/2021-10_Petroleum_Watch.pdf?utm_source=chatgpt.com

[105] October. (2021). *Gasoline Retail Prices by Brand Diesel Retail Prices by Region NACS Store Counts 2020 Gasoline Sales by County Top California Cities by Gasoline Sales in 2020 Total Station Counts by Ownership Total Gasoline Sales by Fuel Grade Featured Topic: Retail Fuel Outlet Annual Report PETROLEUM WATCH REFINERY NEWS INSIDE CALIFORNIA DIESEL RETAIL PRICES BY REGION CALIFORNIA GASOLINE RETAIL PRICES BY BRAND.* https://www.energy.ca.gov/sites/default/files/2021-11/2021-10_Petroleum_Watch.pdf

Exhibit 2.16



(Source: CEC and EIA)

Notwithstanding consumer preferences, automobile manufacturers recommend octanes to owners of their vehicles. Certain engines, such as those in high performance cars, engines with high compression ratios, and or engines with turbochargers, operate more efficiently with higher octane rated fuels.[106] A 2019 *Car and Driver* magazine test found distinct differences in horsepower and engine performance in four high performance cars based on the octane used.[107] Below is a chart summarizing the *Car and Driver* test results.

Exhibit 2.17
Comparative Analysis of Octane on the Performance of Selected Cars

All Cars are 2019	FORD F-150 Pickup Truck		HONDA CR-V-Touring		DODGE Charger R/T	
Metric	**87 Octane**	**93 Octane**	**87 Octane**	**93 Octane**	**87 Octane**	**93 Octane**
Measured Horsepower	360	380	164	172	318	332
Measured Torque- lb-ft.	463	475	168	168	364	387
0-100 MPH Time	16.0 sec.	14.2 sec.	20.4 sec.	20.2 sec.	11.9 sec.	11.7 sec.
75- MPH Fuel Economy	17.0 mpg	17.6 mpg	27.3 mpg	27.6 mpg	23.2 mpg	23.5 mpg

(Source: https://www.caranddriver.com/features/a28565486/honda-cr-v-vs-bmw-m5-ford-f-150-dodge-charger/)

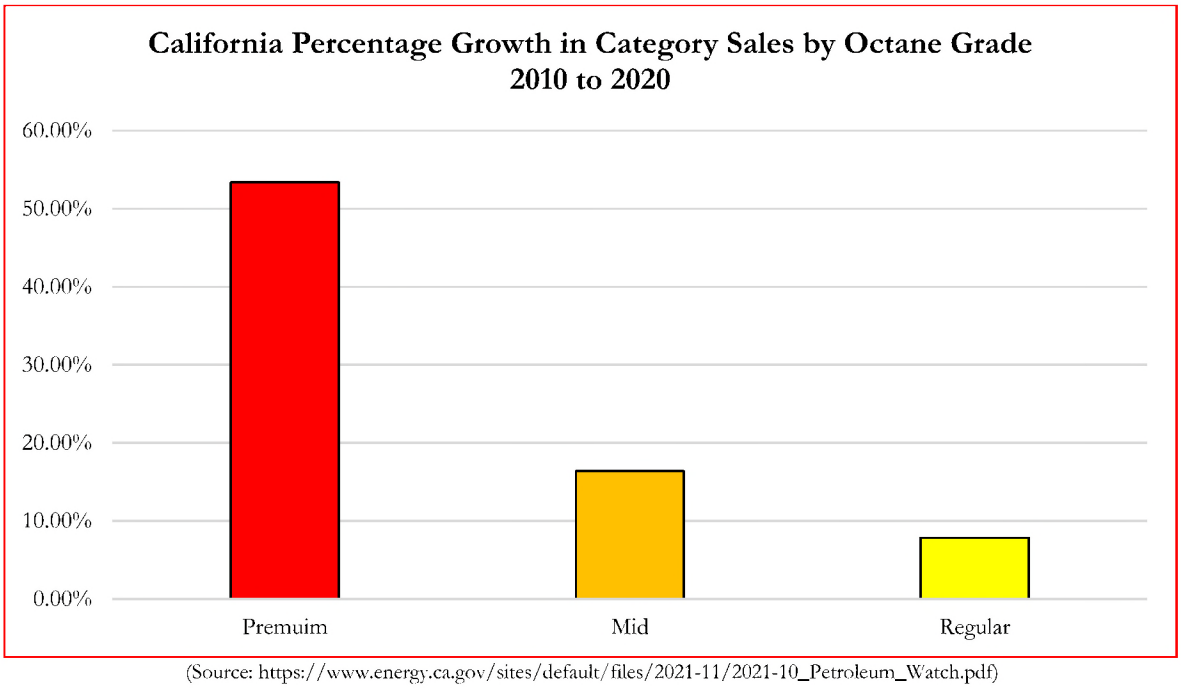
General tests conducted by AAA also indicate that, on the whole, there was some improvement in performance metrics, such as hauling, towing, and rapid acceleration associated with premium grades. However, vehicles not designed to run on premium fuels generally do not experience advantages using

[106] *Should You Use Premium Gas?* (2022, December 12). Kelley Blue Book. https://www.kbb.com/car-advice/should-you-use-premium-gas/
[107] Tingwall, E. (2019, August 4). *Is Premium Gas Worth It? We Test High Octane on 4 Popular Vehicles*. Car and Driver. https://www.caranddriver.com/features/a28565486/honda-cr-v-vs-bmw-m5-ford-f-150-dodge-charger/

higher octane ratings.[108] AAA data also indicates that the price differential between premium and lower grades has widened since 2010.[109]

As indicated in the exhibit below, the fastest growing octane segment in California since 2010 is the premium grade. A number of factors may explain this. California is home to the largest number of registered BMW, Corvettes, Jaguar, Land Rover, Mercedes Benz, and Porsche automobiles in the U.S., all of which recommend premium fuel usage. At 27.9%, California also ranks third in the U.S. for the highest share of the luxury car market.[110] Luxury car manufacturers, such as BMW, typically recommend premium fuels. California also ranks above the all-U.S. average in consumer brand loyalty scores.[111] Additional factors may include individual brand preference for a particular grade, convenience, proximity to retail outlet, attractiveness and safety of retail outlet, and other factors that influence and shape consumer behavior. Of the three octane grades sold in California, and based on CEC reporting, premium fuels have grown the fastest in terms of percentage of total gallons sold for the 2010 to 2020 period.

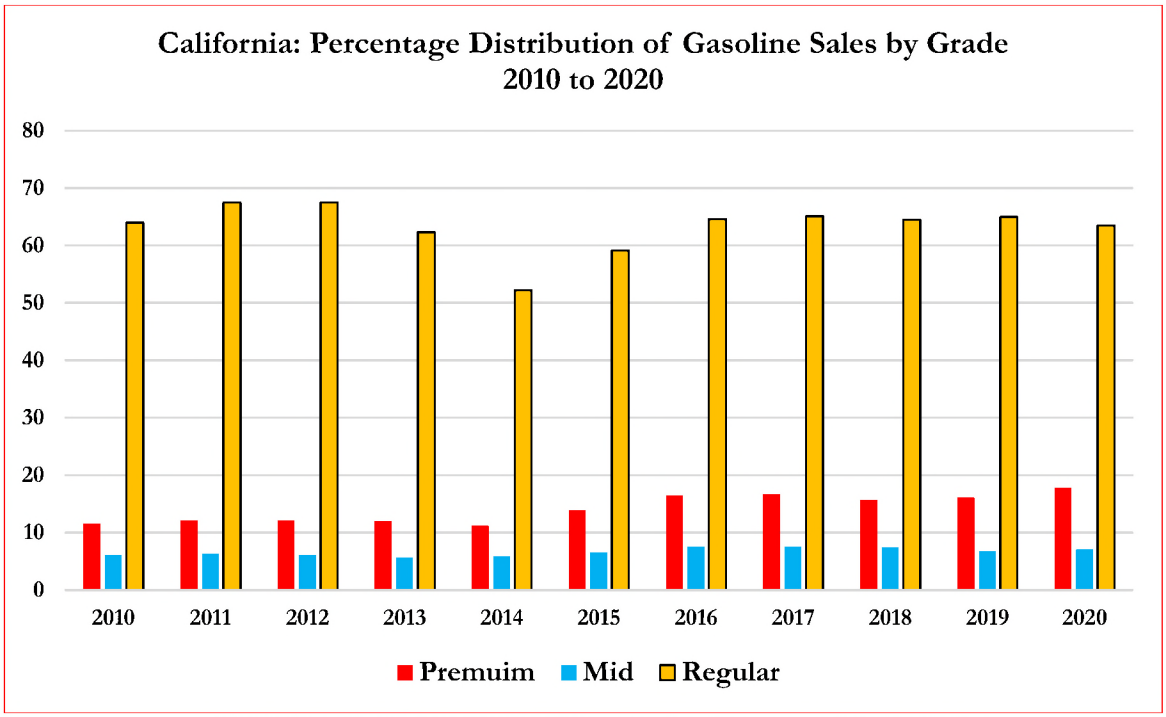
Exhibit 2.18



(Source: https://www.energy.ca.gov/sites/default/files/2021-11/2021-10_Petroleum_Watch.pdf)

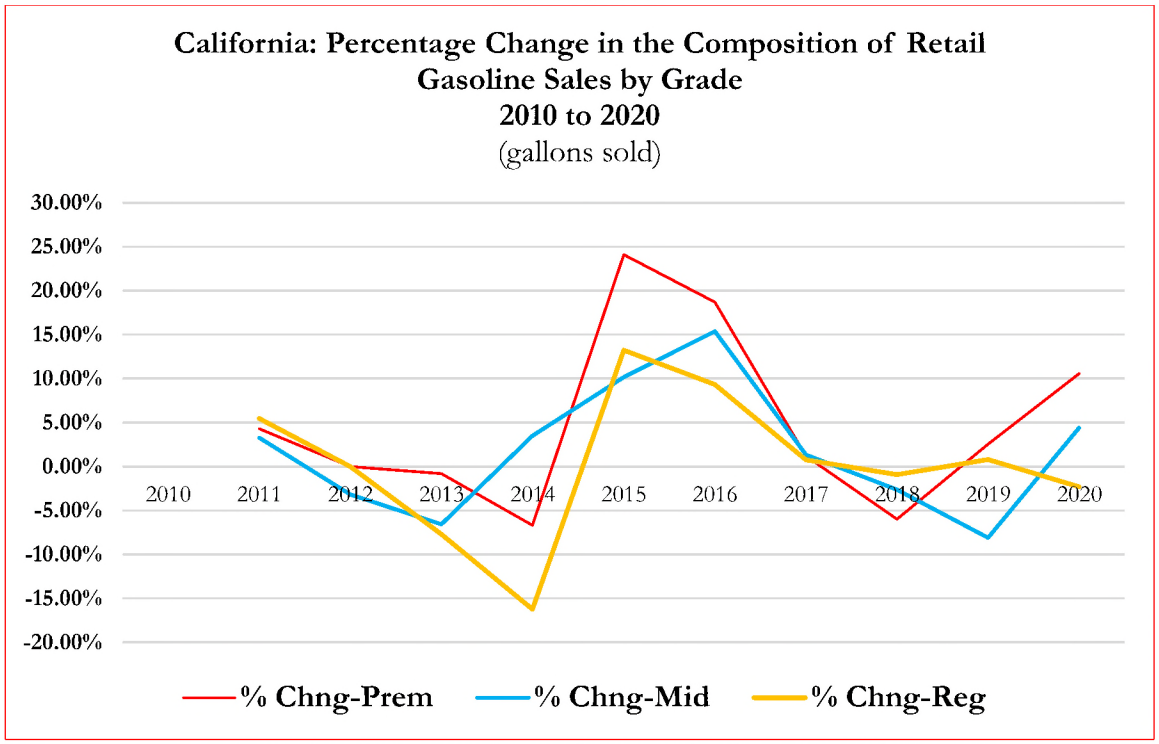
[108] *AAA Gas Prices*. (2024). Aaa.com. https://gasprices.aaa.com/premium-fuel-research/
[109] *AAA Gas Prices*. (2024). Aaa.com. https://gasprices.aaa.com/premium-fuel-research/
[110] iSeeCars. (2024, February 11). *Which states have the most luxury cars?* FOX 2. https://fox2now.com/automotive/which-states-have-the-most-luxury-cars-2/
[111] Small, A. (2025, February 6). *The 2025 Brand Loyalty Index - Go Fish Digital.* Go Fish Digital. https://gofishdigital.com/blog/2025-brand-loyalty-index/

Exhibit 2.19



(Source: https://www.eia.gov/dnav/pet/pet_cons_refmg_d_nus_vtr_mgalpd_a.htm, and https://www.energy.ca.gov/sites/default/files/2021-11/2021-10_Petroleum_Watch.pdf)

Exhibit 2.20



(Source: https://www.eia.gov/dnav/pet/pet_cons_refmg_d_nus_vtr_mgalpd_a.htm, and https://www.energy.ca.gov/sites/default/files/2021-11/2021-10_Petroleum_Watch.pdf)

2.4 California Retail Distribution Models

Retail gasoline is sold to Californians through three types of outlets: 1- branded fuel stations, 2- unbranded fuel stations, and 3- hypermarkets (see also Section 3.0). Since 2012, the number of gas stations in California has remained relatively consistent; however, that is changing. Bans and moratoriums on gasoline station construction have been enacted by many California cities and counties, including San Anselmo, Calistoga, and Novato. Los Angeles County is also considering a range of bans on retail gasoline stations.[112] Furthermore, with California's 2035 mandate eliminating the sale of internal combustion vehicles, California does not present an attractive environment for new operators to enter the market or for existing operators to invest in established operations.

In 2023, California had 10,957 gas stations.[113] Of that total, 8,435 stations, or 77%, sell California compliant gasoline for motor vehicles. Most stations (stores or outlets) are also engaged as convenience stores, which generate the preponderance of the operator's profits. The majority of gasoline stations, around 4,500 stores, are located in close proximity to freeways (less than .25 miles) and in higher populated counties.[114] The greatest concentration of gasoline stations is in Los Angeles County, which also accounts for the highest volume of gasoline sold in the Golden State in terms of gallons. Collectively, California's gasoline stations crate and support, directly or indirectly, around 125,400 jobs.[115]

Over 95% of fueling stations in California are operated by small business owners, and 60% are operated by owners of a single business.[116] Furthermore, approximately 43% of gasoline stations in California are minority-owned, while 61% of owners are foreign born.[117] Gas stations in California generate around $2.8 billion in wage income.[118]

[112] Anguiano, D. (2022, June 22). Los Angeles may ban new gas stations to help combat climate emergency. *The Guardian*. https://www.theguardian.com/us-news/2022/jun/22/los-angeles-ban-new-gas-stations-climate

[113] California Energy Commission. (n.d.-b). *California Retail Fuel Outlet Annual Reporting (CEC-A15) results*. https://www.energy.ca.gov/data-reports/energy-almanac/transportation-energy/california-retail-fuel-outlet-annual-reporting

[114] *REFINING NEWS*. (n.d.). Retrieved March 1, 2025, from https://www.energy.ca.gov/sites/default/files/2020-02/2020-01_Petroleum_Watch.pdf

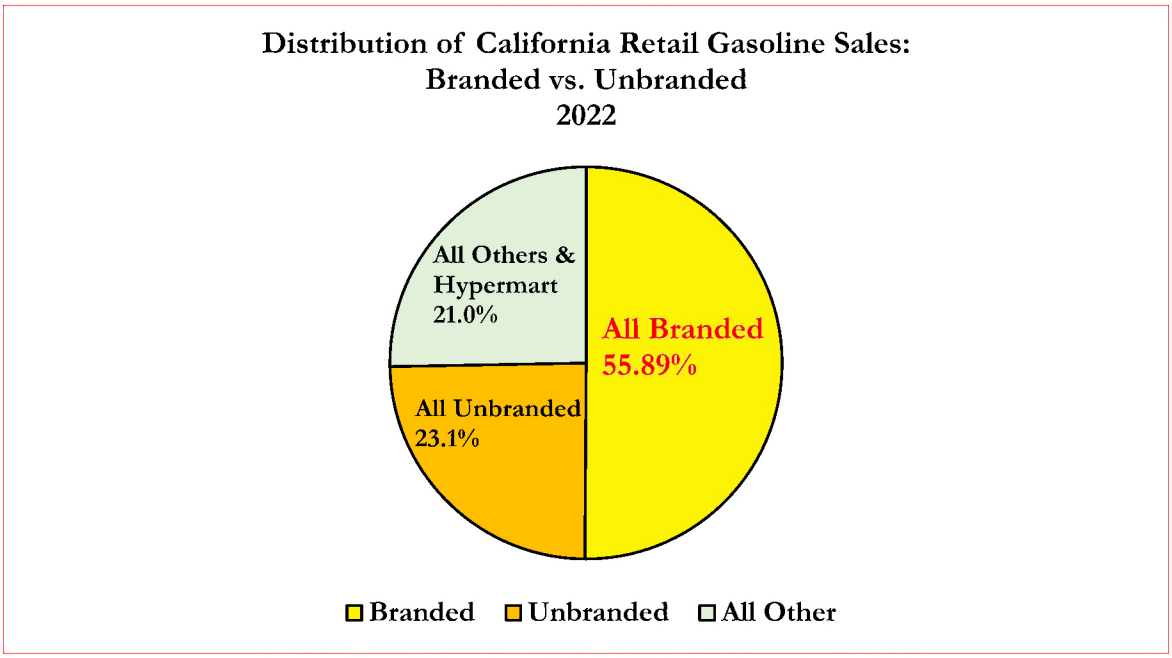
[115] https://californiafuelsconvenienceallianceefca.growthzoneapp.com/ap/CloudFile/Download/p0w84k4r

[116] https://californiafuelsconvenienceallianceefca.growthzoneapp.com/ap/CloudFile/Download/p0w84k4r

[117] https://californiafuelsconvenienceallianceefca.growthzoneapp.com/ap/CloudFile/Download/p0w84k4r

[118] https://californiafuelsconvenienceallianceefca.growthzoneapp.com/ap/CloudFile/Download/p0w84k4r

Exhibit 2.21

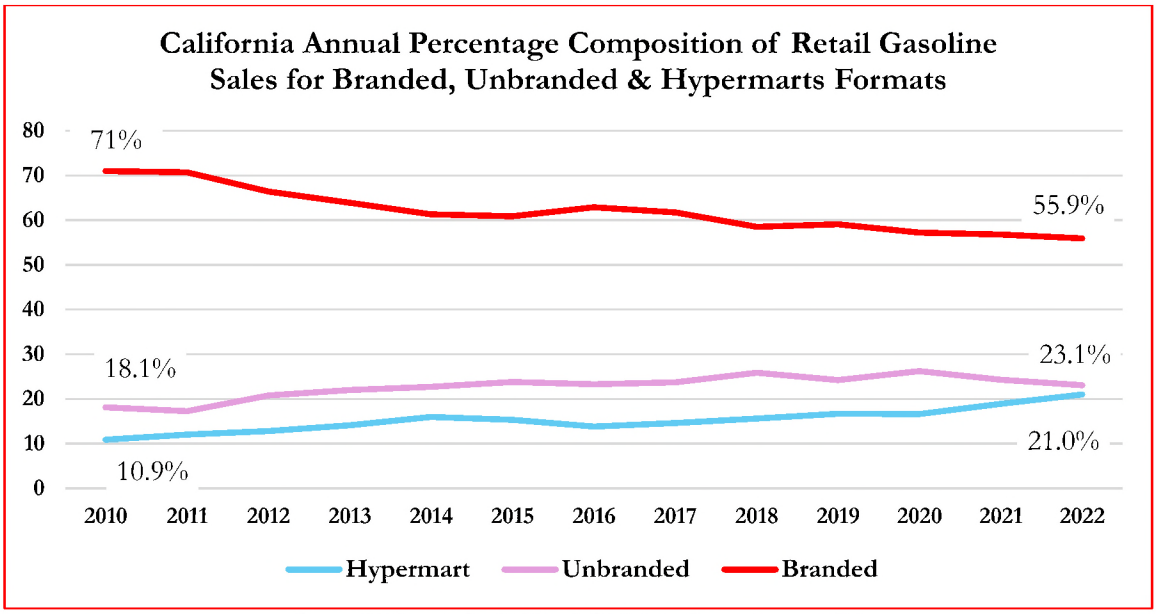


(Source: (Source: CEC as cited in CEC & CDTFA Joint Agency Report, 5/24)

Although hypermarts have a smaller share of the market in terms of the absolute number of outlets (units), hypermarts represent the fastest growing distribution segment in the Golden State as measured by sales volume. According to CEC data, in 2020, hypermarts sold, on average, 760,000 gallons of gasoline per month, or around eight times more gasoline than nonhypermarts which sold on average 96,000 gallons per month.[119] Based on the percentage composition of total gallons sold, since 2010, the selling of gasoline through "hypermarts," such as Costco and Safeway, has increased while sales of branded gasolines through flagged retailers have declined.

[119] Droboniku, G., Johnsen, R., Maduros, N., Mason, J., Neff, B., California Energy Commission, & California Department of Tax and Fee Administration. (2024). CDTFA_CEC Joint Report 2024 Review of the gasoline in California and related impact on state revenues. In *California Energy Commission and California Department of Tax and Fee Administration* (Report CEC-200-2024-007). https://seuc.senate.ca.gov/sites/seuc.senate.ca.gov/files/cdtfa_cec_joint_report_2024_review_of_the_gasoline_in_california_and_relate.pdf

Exhibit 2.22[120]



(Source: CEC as cited in CEC & CDTFA Joint Agency Report, 5/24)

The election as to whether to make and sell gasoline as branded or unbranded is contingent on the distributor's business model and any contractual relationships with branded refiners. Some of the various factors related to gas station ownership and operations are summarized in the exhibit below.

Exhibit 2.23

Some Attributes of Gas Station Owner & Operators				
Attribute	**Company**	**Lessee**	**Independent**	**Hypermarket**
Owns the Business	Yes	No	Yes	-
Owns the Assets, Land, Buildings, etc.	Yes	No	Yes	-
Leases the Land, Building, Assets*	-	Yes	-	-
Operates all Facets of the Business	Yes	Yes	Yes	Yes
Sells Only Branded Gasoline *	Yes	Yes	Yes	Yes
Can Sell Multiple Gasoline Brands*	No	No	Yes	Yes
Can Sell Unbranded Gasoline*	No	No	Yes	Yes
Benefits from National Marketing	Yes	Yes	No	
Commits to Minimum Volumes		Yes		Yes
* = Subject to contract conditions				

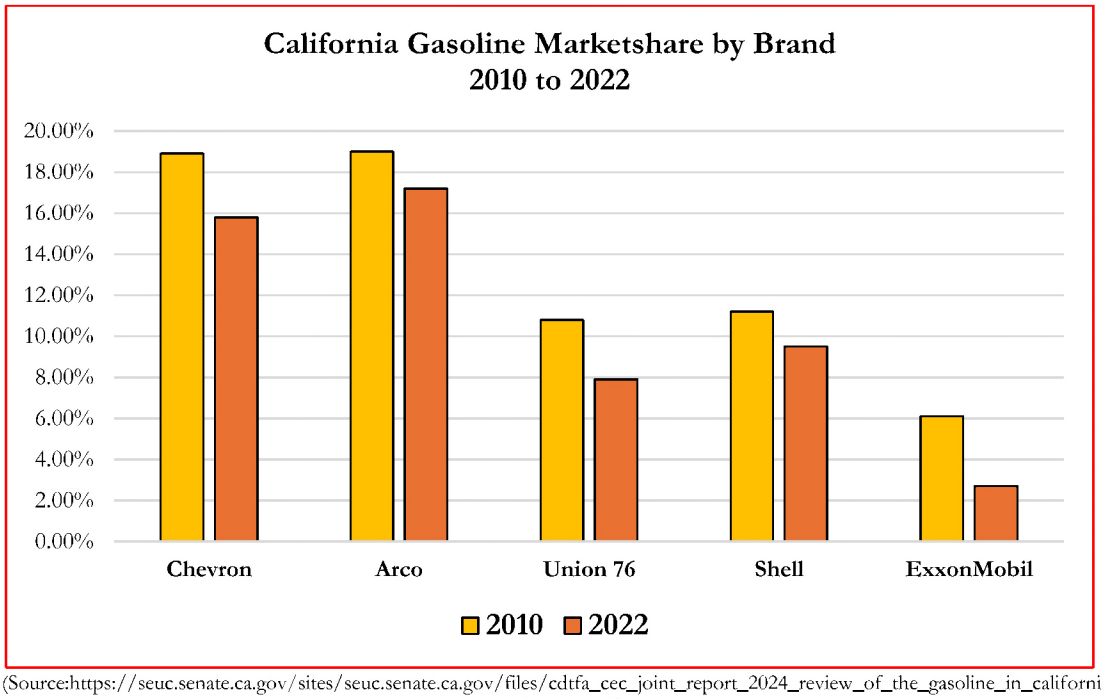
For the 2013 to 2023 period, average prices for branded gasoline formulations increased by 26.35%, while unbranded average prices increased by 18.32%. For the 2013 to 2023 period, the average price

[120] Droboniku, G., Johnsen, R., Maduros, N., Mason, J., Neff, B., California Energy Commission, & California Department of Tax and Fee Administration. (2024). CDTFA_CEC Joint Report 2024 Review of the gasoline in California and related impact on state revenues. In *California Energy Commission and California Department of Tax and Fee Administration* (Report CEC-200-2024-007). https://seuc.senate.ca.gov/sites/seuc.senate.ca.gov/files/cdtfa_cec_joint_report_2024_review_of_the_gasoline_in_california_and_relate.pdf

differential per gallon was $0.2836, with an average differential of 6.97% per gallon. For 2023, the price differential between branded and unbranded gasoline was $0.48, or 9.36%.

In California, Shell, ARCO, and Chevron are the dominant brands.

Exhibit 2.24[121]



(Source:https://seuc.senate.ca.gov/sites/seuc.senate.ca.gov/files/cdtfa_cec_joint_report_2024_review_of_the_gasoline_in_californi a_and_relate.pdf)

[121] Droboniku, G., Johnsen, R., Maduros, N., Mason, J., Neff, B., California Energy Commission, & California Department of Tax and Fee Administration. (2024). CDTFA_CEC Joint Report 2024 Review of the gasoline in California and related impact on state revenues. In *California Energy Commission and California Department of Tax and Fee Administration* (Report CEC-200-2024-007). https://seuc.senate.ca.gov/sites/seuc.senate.ca.gov/files/cdtfa_cec_joint_report_2024_review_of_the_gasoline_in_california_and_relate.pdf

SECTION 3.0
CALIFORNIA OIL & GASOLINE PRODUCTION

A STUDY OF CALIFORNIA GASOLINE PRICES
Section 3.0
Table Of Contents

3.0 California Oil & Gasoline Production

3.1 Introduction
3.2 Petroleum and the California Economy
3.3 California Oil Production
3.4 California & PADD 5 Production
3.5 California Refineries
3.6 Gasoline Production
- 3.6.1 Refiner Retail Sales to Retailers
- 3.6.2. Finished Gasoline Stocks

3.7 Gasoline Blends
- 3.7.1 Seasonal Blends
- 3.7.2 California Seasonal Blends
- 3.7.3 Special Blend
- 3.7.4 California Octanes
- 3.7.5 Branded and Unbranded

3.8 Gasoline Storage and Days Inventory
3.9 California Oil Transportation: Pipelines, Marine Vessels, Rail & Truck
- 3.9.1 Crude & Gas Movement
- 3.9.2 Maritime Vessels
- 3.9.3 Pipelines
- 3.9.4 Rail Tankers
- 3.9.5 Tanker Trucks

3.0 CALIFORNIA OIL & GASOLINE PRODUCTION

3.1 Introduction

Petroleum has always been one of California's most abundant natural resources and essential economic assets. The California oil industry enabled the industrial base and wealth of Southern California, provided the foundation for statewide economic growth, and created oil barons and philanthropists such as Alphonzo Bell, J. Paul Getty, Josiah Stanford, Demetrius Scofield, and Edward L. Doheny.

The petroleum industry in California has had a long and fascinating history. After the gold rush, it was oil that fueled much of California's economic and industrial growth for the latter part of the nineteenth and much of the twentieth century. During World War II, California oil supplied the U.S. naval, air, and land military forces with fuel to win the war in the Pacific. During the great expansion of California in the 1950s and 1960s, petroleum was essential to constructing freeway systems, and the gasoline that fueled the surge in California's population and car culture.

Oil has also played an important role in funding research and sponsoring higher education in the Golden State. According to Data for Progress, which describes itself as a "Think tank for the future of progressivism," between 2010 and 2020, oil companies (for example, BP, Chevron, and ExxonMobil) provided UC Berkeley, a State funded institution, with $154 million in research funds, and Stanford University, a private institution, with $56 million in research funds.[122] Additionally, investment in oil companies has also supported California's retirement system. The California state retirement system, CalPERS, which at $462 billion, is the largest retirement system in the U.S., reportedly holds around $9.2 billion of stock in both private and state-owned oil companies such as Chevron, ExxonMobil, Phillips 66, Marathon Oil and pipeline companies such as Energy Transfer and Kinder Morgan. CalPERS has also invested in Chinese state-owned oil companies such as Chinese Offshore Oil Corporation (CHOOC) and Chinese Oilfield Services, as well as the Russian energy company Gazprom.[123] [124] [125] [126] According to the Washington Free Beacon, in 2020, CalPERS had invested around $3.0 billion in Chinese companies, of which around $457 million were associated with companies that had been "blacklisted" by the first Trump Administration.[127]

In California, the Department of Conservation's Geologic Energy Management Division (CalGEM) has primary statutory authority for the oversight and regulation of oil production in the state and its oil and gas pipelines. There are, in total, over 25 individual federal, state, and local agencies in California that regulate, to some extent, the oil and gas industry.[128] Some of the California agencies that are involved in the regulation and oversight of oil and gas production in the state include, for

---

[122] Krieger, L. (2024, July 16). Stanford keeps oil company financial ties, despite push for divestment. *Silicon Valley*. https://www.siliconvalley.com/2024/07/13/stanford-keeps-oil-company-financial-ties-despite-push-for-divestment/#

[123] *Board of Administration Agenda Item 8c*. (2023). https://www.calpers.ca.gov/docs/board-agendas/202303/full/item8c-00_a.pdf

[124] Gilmore, A. (2024, January 8). CalPERS' CEO pushes back on fossil fuel divestment calls. *Netzeroinvestor*. https://www.netzeroinvestor.net/news-and-views/calpers-ceo-pushes-back-on-fossil-fuel-divestment-calls#:~:text=Currently%2C%20CalPERS%20holds%20investments%20with,in%20China%20and%20Saudi%20Arabia.

[125] *California Public Employees' Retirement System 2023 California Public Divest from Iran Act Legislative Report CalPERS 2023 California Public Divest from Iran Act Legislative Report*. (n.d.). Retrieved January 27, 2025, from https://www.calpers.ca.gov/docs/forms-publications/iran-sudan-divestment-2023.pdf

[126] *CalPERS 13F filings and top holdings and stakes - stockzoa*. (2024). Stockzoa.com. https://stockzoa.com/fund/calpers/

[127] Ross, C. (2021, September 2). *California's State Pension Invests Millions in Chinese State-Owned Companies*. Freebeacon.com. https://freebeacon.com/national-security/californias-state-pension-invests-millions-in-chinese-state-owned-companies/

[128] https://laedc.org/research/reports/oil-and-gas-industry-in-california-2019-report/

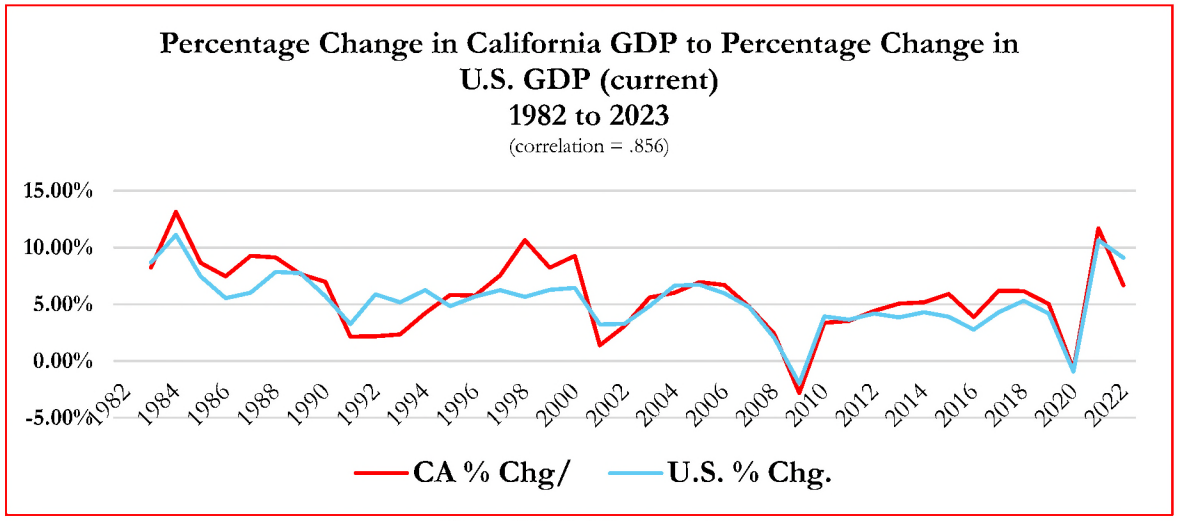
example, CARB, California Coastal Commission, Department of Toxic Substances Control, and California Energy Commission, to list a few.

3.2 Petroleum and the California Economy

With a $3.9 trillion economy (GDP), California comprises 14% of the U.S. GDP, is the nation's largest state economy, and ranks 5th as the largest economy globally.[129] On a per capita basis, California would be the second-largest economy in the world.[130] In dollar terms, California's GDP exceeds the GDPs of Italy, the U.K., Canada, and France.[131] For the 1982 to 2023 period, and on a percentage change basis, California's GDP outgrew that of the overall U.S. by 1.06 times.[132]

As California is the largest state economy in the nation, it stands to reason that the behavior of California's state economy is highly correlated with that of the overall U.S. GDP (.856 correlation) on an annual percentage change basis. For the 1982 to 2023 period, the annual percentage in California's GDP is highly correlated (.865) to the annual percentage change in the overall U.S. GDP.[133]

Exhibit 3.1



(Source: EIA, Fed. Reserve, author)

California has 39 million people, over 31.1 million motor vehicle registrations representing around 11% of all registrations nationally, and over 315,244 million miles of vehicle miles traveled in 2023.[134] [135] Although California also has one of the fastest growing economies in the U.S., based on per capita income, it has also experienced a net migration of population leaving the State. Since 2020, California's

[129] Duan, J., & Bohn, S. (2024, October 14). *California's Economy*. Public Policy Institute of California. https://www.ppic.org/publication/californias-economy/

[130] Duan, J., & Bohn, S. (2024, October 14). *California's Economy*. Public Policy Institute of California. https://www.ppic.org/publication/californias-economy/

[131] Hughes, R. A. (2025, January 6). *If California were a country*. Bull Oak. https://bulloak.com/blog/if-california-were-a-country/

[132] Author calculation.

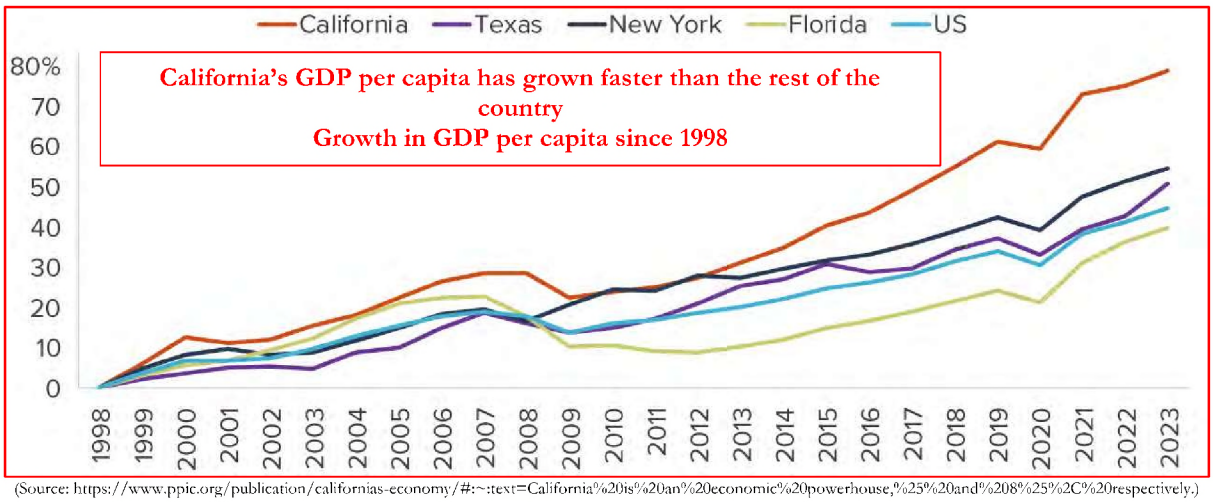
[133] Author calculation.

[134] *California State Energy Profile*. California Profile. (n.d.). https://www.eia.gov/state/print.php?sid=CA#89

[135] Carlier, M. (2024, December 5). *U.S: Motor vehicle registrations by State*. Statista. https://www.statista.com/statistics/196505/total-number-of-registered-motor-vehicles-in-the-us-by state/#:~:text=In%202022%2C%20California%20was%20the,over%20283.4%20million%20vehicle%20registrations.

population has declined by slightly over one percent, resulting in the loss of one seat in the U.S. House of Representatives.[136]

Exhibit 3.2



(Source: https://www.ppic.org/publication/californias-economy/#:~:text=California%20is%20an%20economic%20powerhouse,%25%20and%208%25%2C%20respectively.)

Along with its weather, environmental diversity, and abundance of natural resources, California is a petroleum-rich state. For 2022, the oil and gas industry comprised around 8% of the Golden State's GDP, with professional, financial, and information services at $520 billion being the largest.[137] As of December 2023, California holds around 1.5 million barrels of oil in proven reserves or around 3.1% of all U.S. proven reserves, ranks fifth largest oil reserves in the U.S., ranks 7th in oil production among 32 oil-producing states, and is home to the Monterey shale reserve.[138] Spanning across five counties and over 1,750 square miles, the Monterey Shale deposit is estimated to contain up to 300 million barrels of oil.[139] It is one of the largest deposits of shale oil in the U.S.[140] [141] At $70 a barrel and 300 million barrels, the Monterey Shale reserve potentially represents around $21.0 billion in raw crude deposits and perhaps over $100 billion of economic value in refined products.[142] For perspective, California's Legislative Analyst Office (LAO) estimates the State's budget deficit to be $55 billion in the fiscal year 2024-2025, with projected revenues to grow slower than expenditures, thus contributing to growing deficits in the future.[143] For further comparison, UCLA Anderson School of Management estimates the losses from the LA wildfires to range between $95 billion and $164 billion.[144]

---

[136] Walters, D. (2024, November 20). California's political clout will fade as long as population growth remains slow. *CalMatters*. https://calmatters.org/commentary/2024/11/california-political-clout-population-growth/

[137] *What is the gross domestic product (GDP) in California? | USAFacts*. (n.d.). USAFacts. https://usafacts.org/answers/what-is-the-gross-domestic-product-gdp/state/california/

[138] *California State Energy Profile*. California Profile. (n.d.). https://www.eia.gov/state/print.php?sid=CA#89

[139] Early estimates wee up to 15.44 billion barrels of crude. See, Garthwaite, J. (2013, May 30). *Monterey Shale Shakes Up California's Energy Future*. Science. https://www.nationalgeographic.com/science/article/130528-monterey-shale-california-fracking

[140] Global Energy Monitor. (2021, April 30). *Monterey Shale*. https://www.gem.wiki/Monterey_Shale#:~:text=Fracturing%20in%20Inglewood-,Shale%20makeup,shale%20play%20in%20the%20US.%22

[141] Onishi, N. (2013, February 4). *Vast oil reserve may now be within reach, and Battle Heats up (published 2013)*. The New York Times. http://www.nytimes.com/2013/02/04/us/vast-oil-reserve-may-now-be-within-reach-and-battle-heats-up.html?pagewanted=all&_r=1&

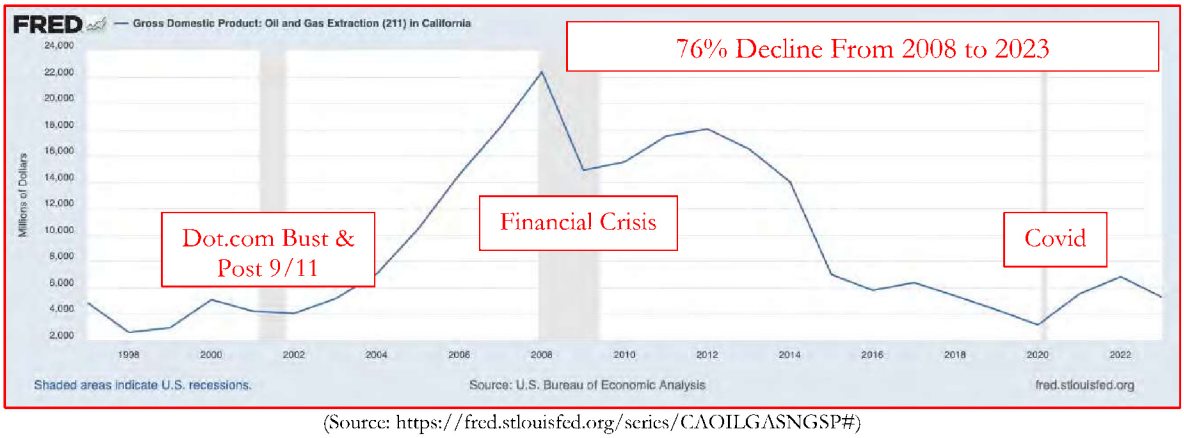
[142] Author estimate.

[143] *The 2025-26 Budget: California's Fiscal Outlook*. (2024, November 20). Ca.gov. https://lao.ca.gov/Publications/Report/4939

[144] UCLA Anderson School of Management. (2025, February 17). *Economic impact of the Los Angeles wildfires*. https://www.anderson.ucla.edu/about/centers/ucla-anderson-forecast/economic-impact-los-angeles-wildfires#:~:text=In%20summary%2C%20the%20total%20property,from%20a%20series%20of%20assumptions.

Notwithstanding its proven reserves and established oil and refining infrastructure, California is highly dependent on foreign oil imports supplied by petrostates, such as Iraq and Saudi Arabia, to supply crude oil to meet its everyday gasoline and petroleum products demands. As such, if any significant disruptions occurred with these foreign oil sources, California could not make up for oil stock deficiencies with either in-state production or imports of U.S. domestically provided oil stocks in the short term. (See Section 4.0 for a more thorough discussion of California oil imports and sources.)
Crude oil production in California has always contributed to the State's GDP. As indicated in the chart below, oil production contribution to California's GDP reached a historical peak, in absolute dollars, in 2008. Since the 2008 peak, oil production's contribution to California's GDP, in absolute dollar terms, has declined by 76%, indicating a lesser role in the State's overall economy.[145]

Exhibit 3.3
California: Gross Domestic Product from Oil & Gas Extraction

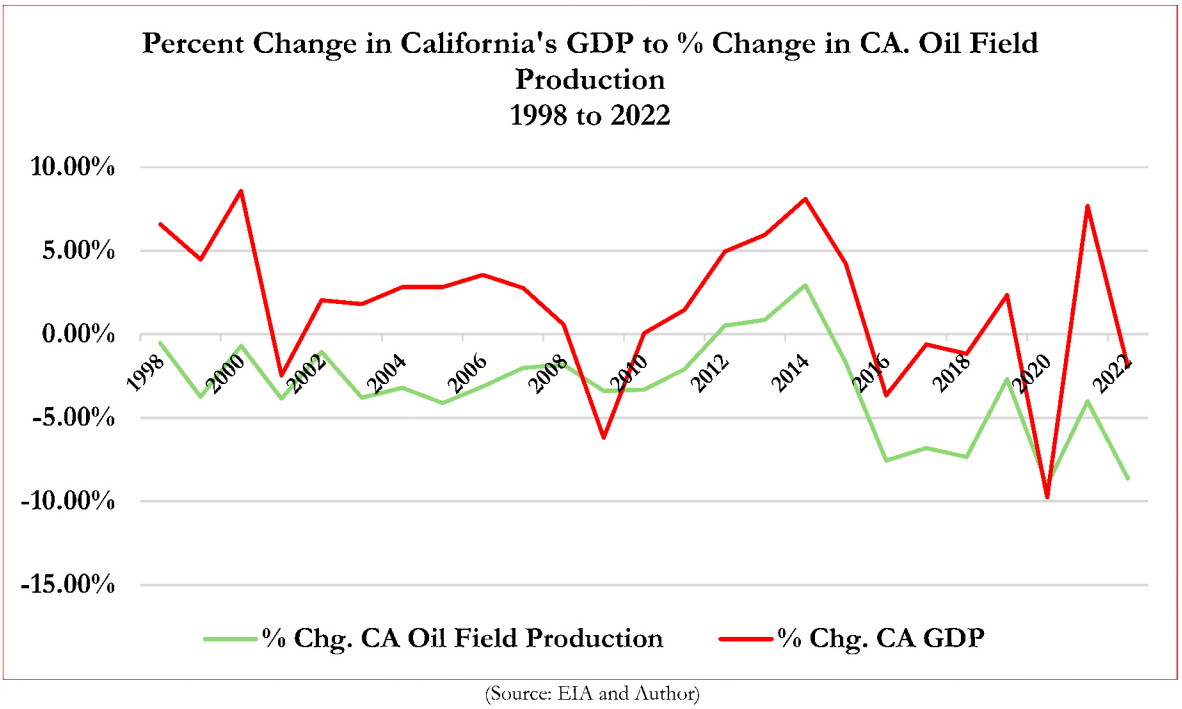


(Source: https://fred.stlouisfed.org/series/CAOILGASNGSP#)

Over the 1998 to 2023 period, although there is some similarity in movement between California's oil field production to its GDP, based on the annual percentage change, the correlation is very low (.11). The low correlation is not unexpected, as oil and gas production has become less significant over the years in California's economy, which has become dominated by the service and technology sectors.

[145] *Gross Domestic Product: Oil and Gas Extraction (211) in California.* (2023). Stlouisfed.org. https://fred.stlouisfed.org/series/CAOILGASNGSP#

Exhibit 3.4



(Source: EIA and Author)

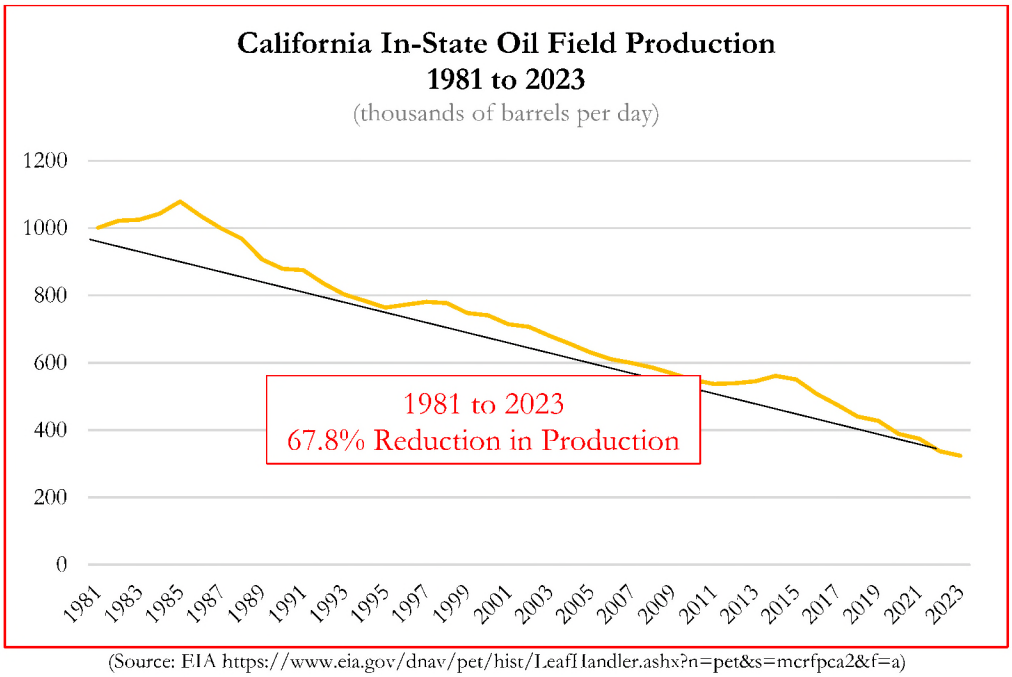
3.3 California Oil Production

Once a global leader and ranking fourth in the world in oil production, today, California accounts for only around 2.5% to 2.7% of all U.S. crude production and is producing only 23.7% of its own in-state needs. According to CEC reporting, California produced 123,947 million barrels of oil in 2023.[146] California's oil and gasoline production has consistently fallen since 1992. In 1992, California produced 320,888,000 barrels of oil.[147] In contrast, in 2022, California produced 124,727,000 million barrels of oil or only 39% of 1992 production. For the 1982 to 2023 period, in-state oil production fell by 69% from its peak high in 1985 (398,280) to a historic low in 2023 of 123,947.

[146] California Energy Commission. (n.d.-a). *Annual oil supply sources to California refineries*. https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/annual-oil-supply-sources-california

[147] California Energy Commission. (n.d.-a). *Annual oil supply sources to California refineries*. https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/annual-oil-supply-sources-california

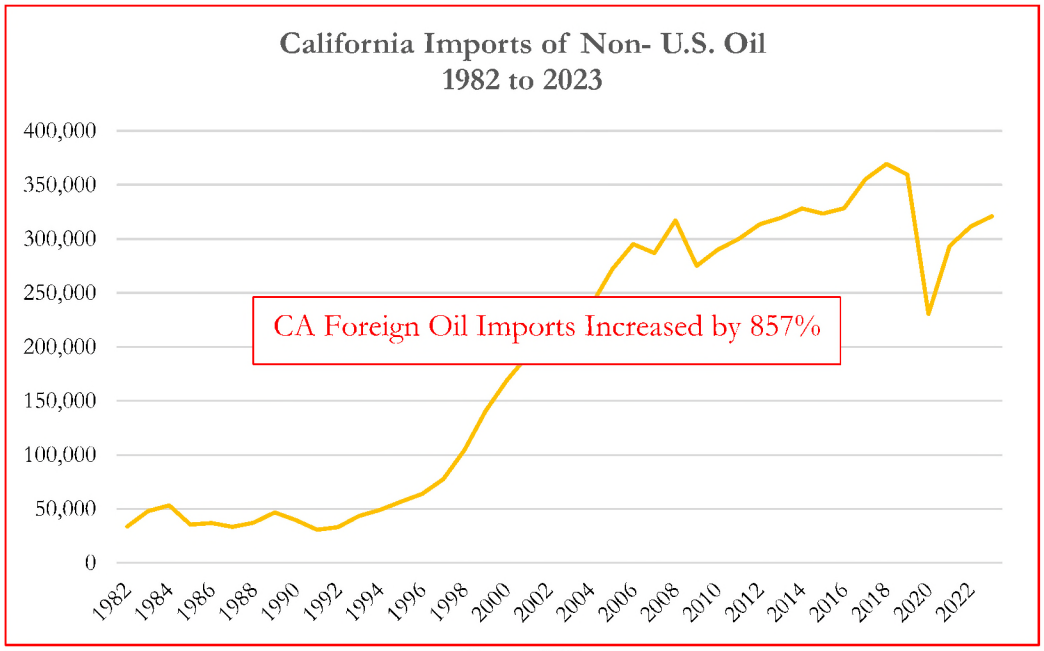
Exhibit 3.5



(Source: EIA https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mcrfpca2&f=a)

Meanwhile, California imports of non-U.S. foreign oil grew by 1,102% from its historic low in 1991 of 30,723 to 369,386, its peak high in 2018.[148] (See Section 4.0.)

Exhibit 3.6



(Source: CEC)

[148] Based on CEC data.

The exhibit below summarizes the various sources of California in-state and foreign sourced crude oil supplies by region/county, nation, or state, as well as the general grade characteristics and primary method of transportation to California refineries. As indicated, within California, pipelines are the primary mode of transportation to the refinery, and naturally, imports are transported via marine tanker vessels. The predominant crude is heavy, with a viscosity range from light heavy to very heavy. Some California compliant gasoline is imported from Washington State, as needed, but it is minimal.

Exhibit 3.7

California Sources, Grades & Transportation Methods for Crude Oil- 2018 to 2024		
Crude Oil Source	**Crude Grade Characteristic**	**Transportation Method to CA**
U.S. DOMESTIC		
CA- Kern	Very Heavy	Pipeline
CA- Midway Sunset	Very Heavy	Pipeline
CA- Belridge	Very Heavy	Pipeline
CA- San Ardo	Very Heavy	Pipeline
CA- Lost Hills	Light Heavy	Pipeline
CA- Ventura	Light Heavy	Pipeline
CA- Elk Hils	Light Heavy	Pipeline
Alaska- North Slope	Medium	Tanker
Washington State	Gasoline	Tanker
FOREIGN		
Canada	Heavy	Tanker & Rail
Ecuador	Heavy	Tanker
Guyana	Medium/Heavy	Tanker
Russia	Heavy	Tanker
Saudia Arbia	Heavy	Tanker

(Source: https://www.californiaenergyatlas.com/copy-of-crude-oil)

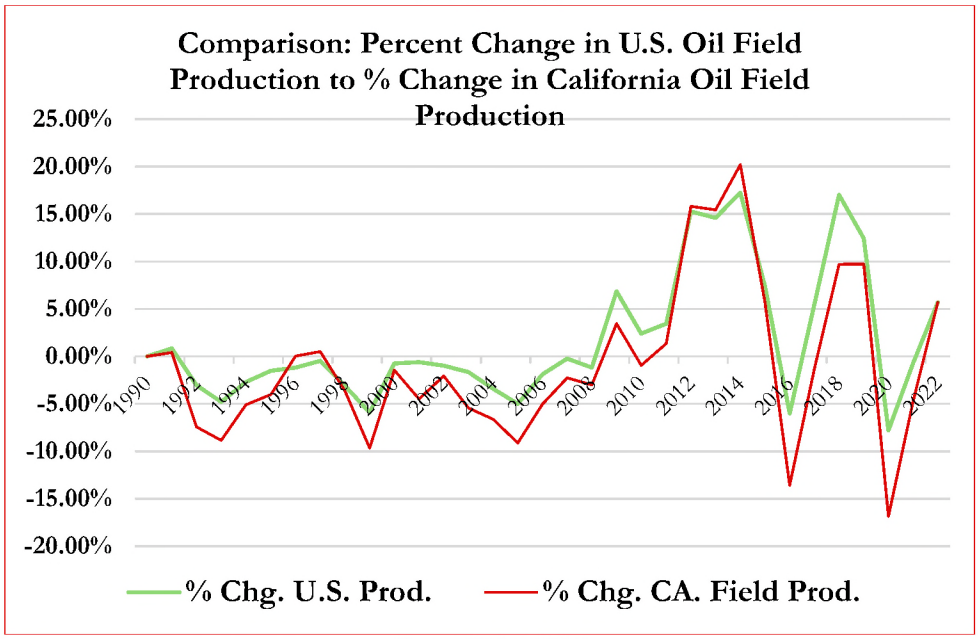
For the better part of the twentieth century, California was self-sufficient in its production of oil and was, for some years, a net exporter of oil to other states. In 1982, California produced 61% of its oil needs in the State.[149] However, since the 1980s, California's in-state oil production has fallen, and its reliance on foreign-sourced oil increased. By 2023, California's in-state oil production was only able to supply around 23% of its needs, and its dependency on foreign-sourced oil, grew. (See Section 4.0 for a discussion of imports.)

On a comparative basis for the 1990 to 2022 period, California's oil field production declined while overall U.S. oil field production grew. The overall correlation between California oil field production and U.S. oil field production in millions of barrels is -.691 in absolute terms and .337 based on annual

[149] California Energy Commission. (n.d.-a). *Annual oil supply sources to California refineries*. https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/annual-oil-supply-sources-california

percentage change. Significant variances, as measured by annual percentage change, began in 2009 and continued through 2019.

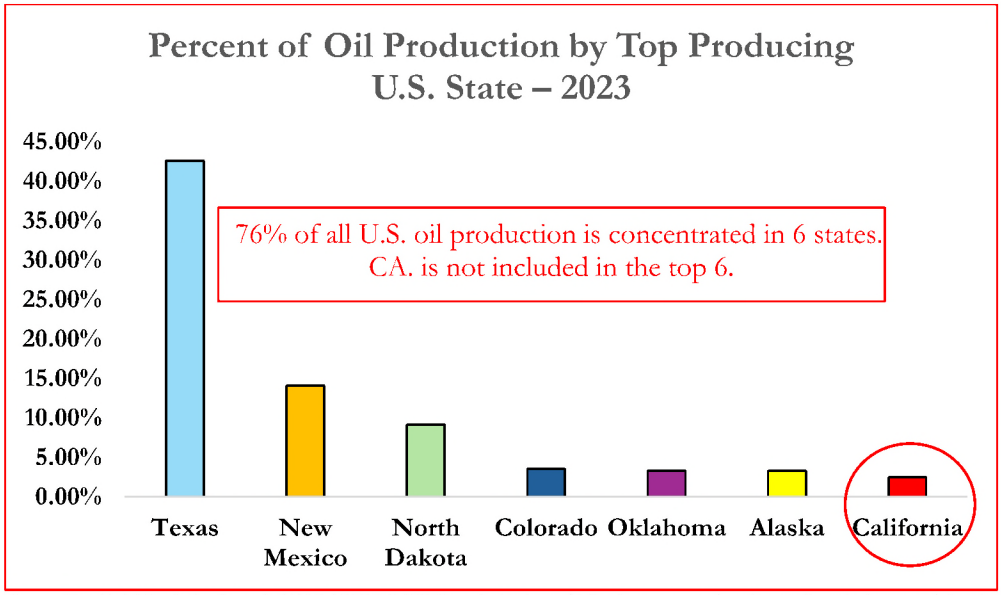
Exhibit 3.8



(Source: CEC and EIA)

Comparatively, California's in-state oil production is dwarfed by Texas, North Dakota, New Mexico, and Alaska. For perspective, Texas produced almost 18 times the amount of oil than California in 2022.

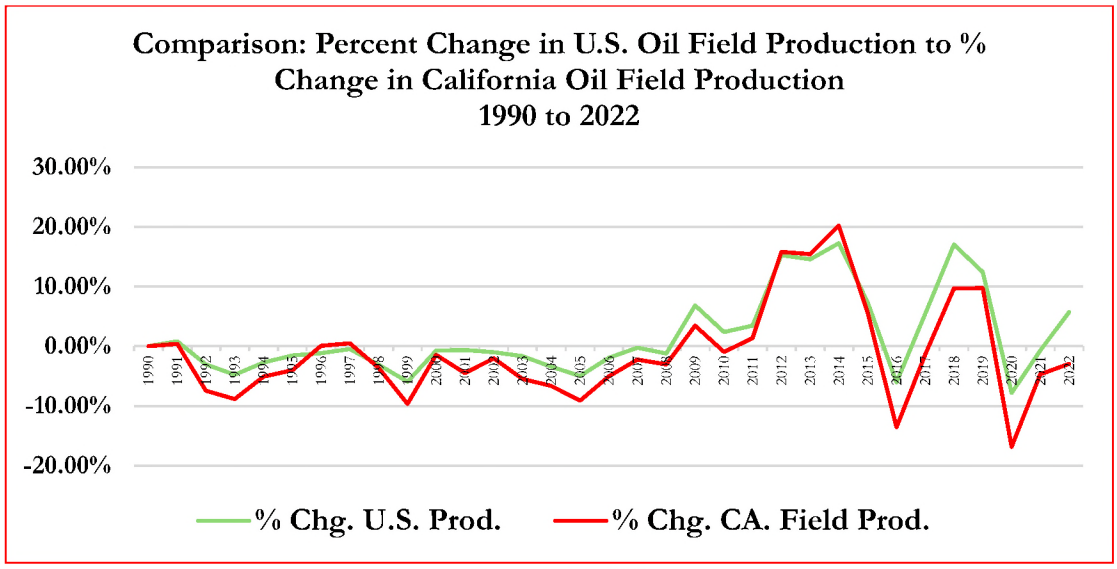
Exhibit 3.9



(Source: Top 11 Oil-Producing States in 2023 ROBERT RAPIER as cited in https://oilandgaspress.com/top-11-u-s-oil-producing-states/. See also, https://www.investopedia.com/financial-edge/0511/top-6-oil-producing-states.aspx#citation-21)

In 2012, the Golden State's in-state oil production was 197 million barrels a day, and California's population was 37.5 million. However, by 2022/23, with California's population at 38.95 million, in-state oil production had fallen by 35% to 127 million barrels. Overall, the decline in in-state production, California's field production profiles that of the overall U.S. on an annual percentage change basis.

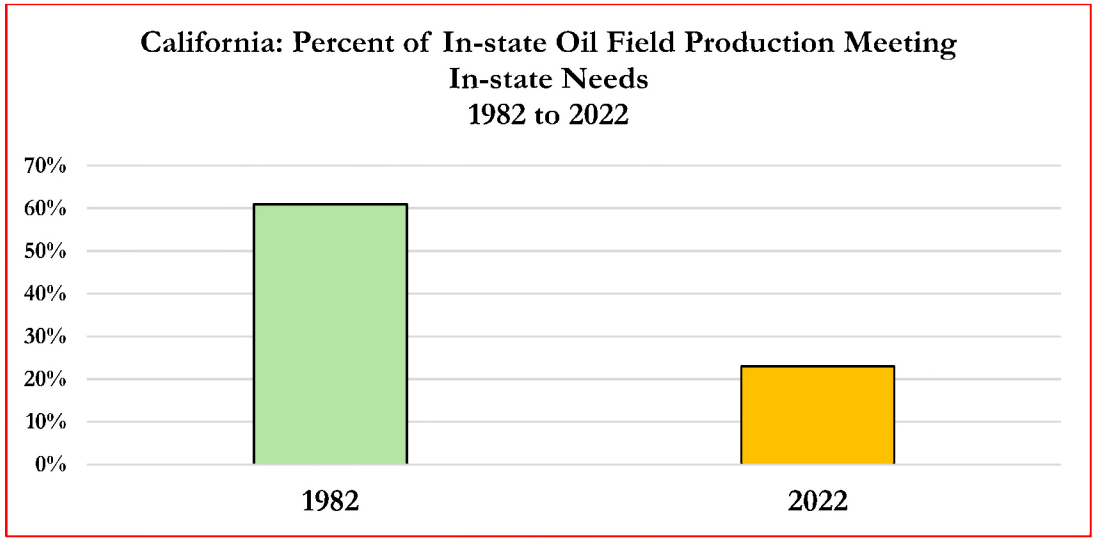
Exhibit 3.10



(Source: EIA & CEC)

Since 1990, while overall U.S. field production has increased 66%, California's field production declined 61%. Since 2018, California's field production has declined 26.4%. Since 1982, California's ability to meet its demand for petroleum through in-state production has fallen from over 60% internally sourced to about 21% in 2023.

Exhibit 3.11



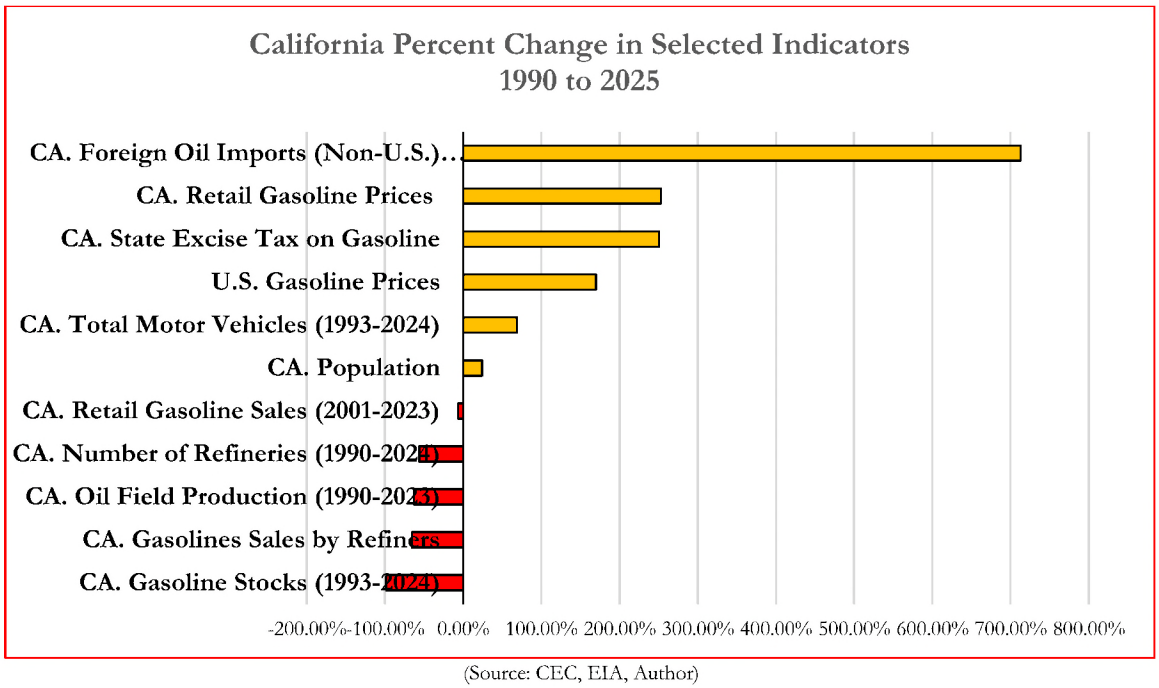
(Source: CEC & EIA)

For the 1993 to 2023 period, as California oil production and the number of refineries producing California compliant gasoline decreased, California excise taxes increased by 250%, as well as other regulatory fees, such as those associated with environmental programs, which also increased. Ultimately, excise taxes and other regulatory fees and costs are reflected in the cost of fuel sold and the retail sales price at the pump. The exhibit below summarizes some key indicators related to California's oil production (supply), consumption (demand), and other related factors.

Exhibit 3.12

(Sources: CEC, EIA, Statisica)

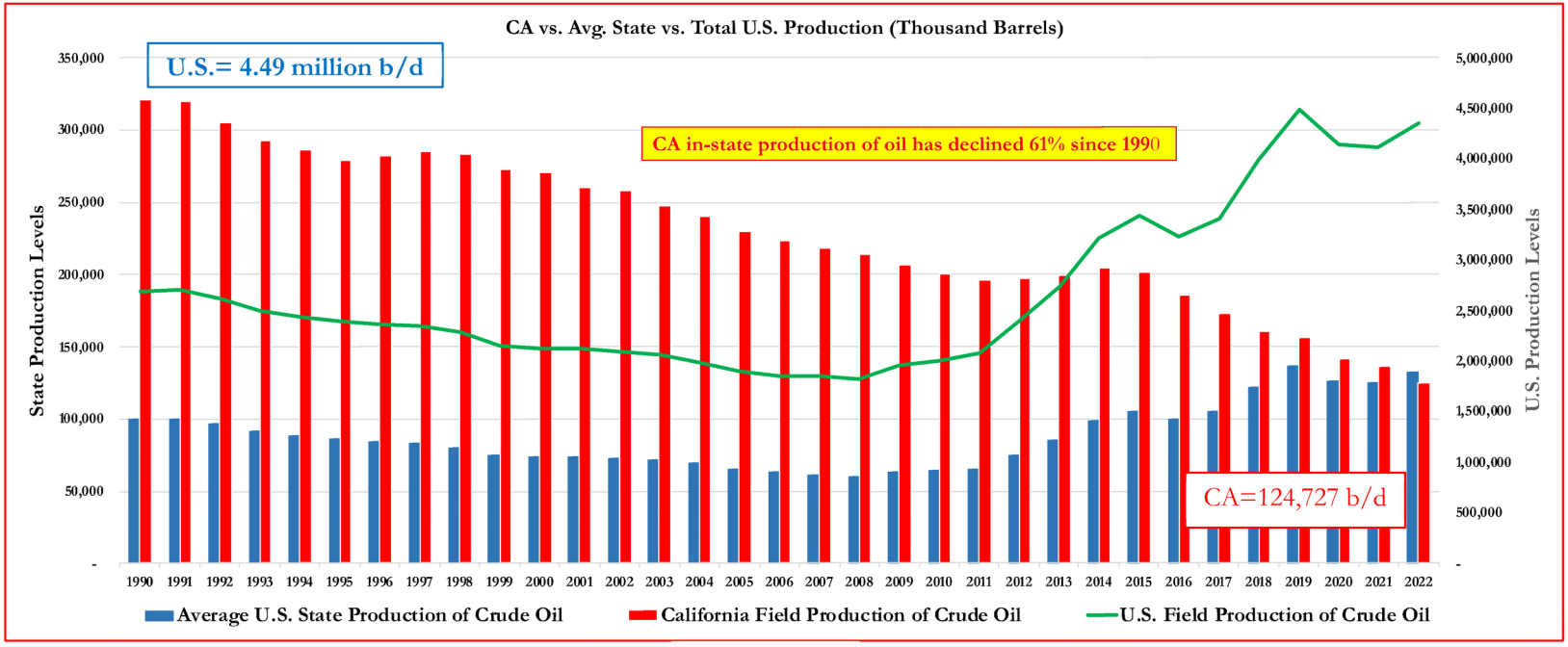
Exhibit 3.13



(Source: CEC, EIA, Author)

As illustrated in the following exhibit, California oil field production declined by over 60% from 1990 to 2022. In contrast, total U.S. oil field production and the average production by petroleum producing States increased.

Exhibit 3.14
Comparison Average California Field Production to All States

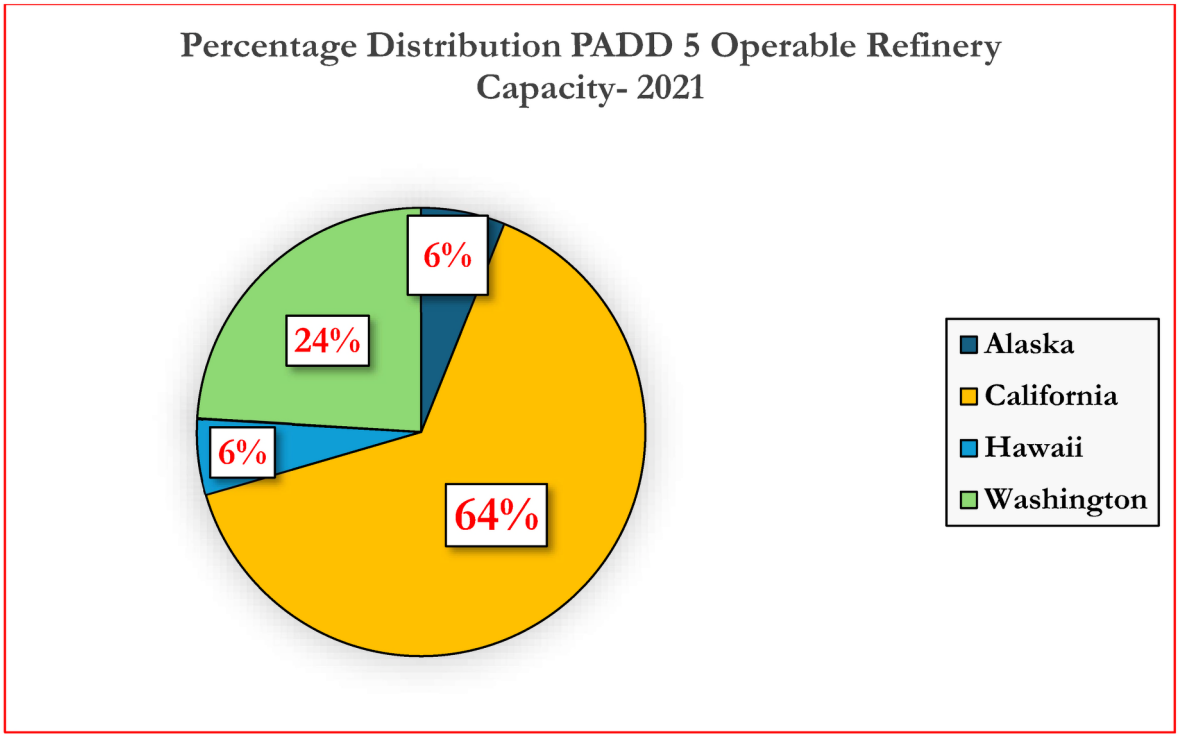


(Source: CEC, EIA)

3.4 California & PADD 5 Production

California's refineries are assigned to PADD Region 5.[150] The PADD 5 region includes Alaska, Arizona, California, Hawaii, Oregon, and Washington. As of January 1, 2021, there were 26 operating refineries in PADD 5, of which 14 are located in California.[151] Washington and Alaska have five refineries each, and Hawaii and Arizona each have one. PADD 5 has an aggregate operable capacity of 2,713,571 barrels per calendar day. Of the total PADD 5 capacity, California composes slightly over 64% with 1,748,171 million barrels of oil a day of operable capacity. Of the total 426.0 million barrels of crude oil stock held in U.S. inventory by refiners, 47.3 million or 11.1% are located in PADD 5.

Exhibit 3.15

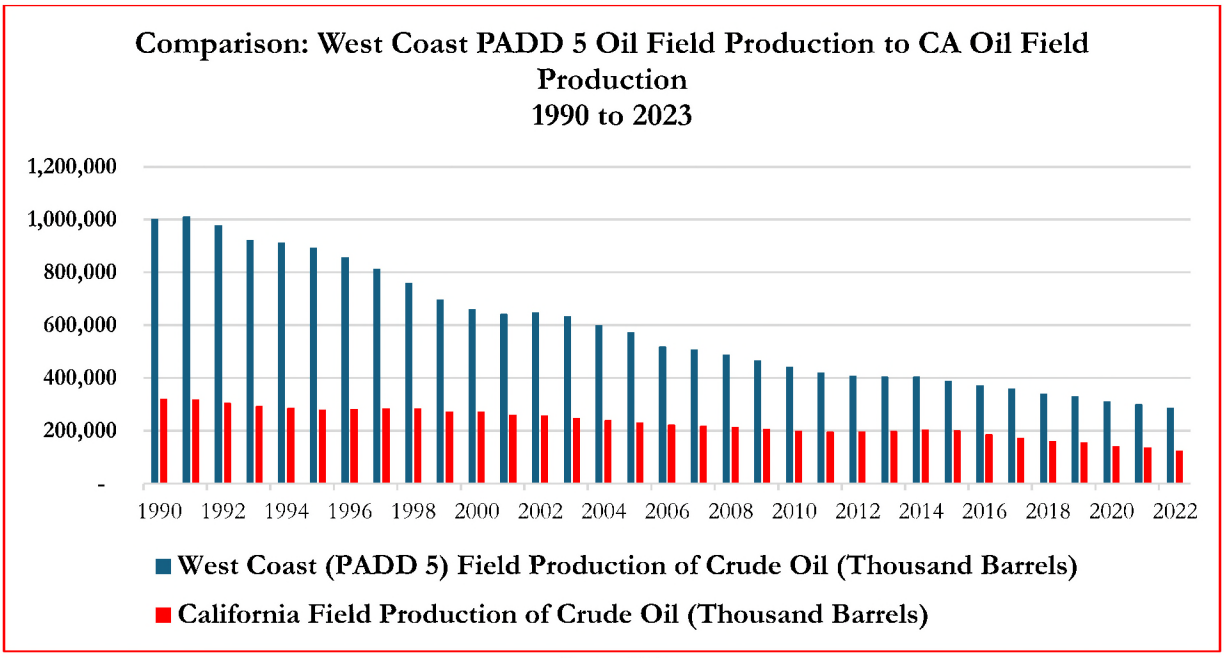


(Source: EIA)

California's percentage of PADD 5 capacity is expected to decline as refiners convert to renewables and others, such as Phillips 66 and Chevron, wind down refinery operations and exit the Golden State in anticipation of additional regulations and 2035 zero emission vehicle (ZEV) mandates.

[150] Petroleum Administration Defense District. The PADDs were created in 1942 by Presidential Executive Order during WW-II as a method for managing petroleum resources. It is currently used to collect data and for data analysis.
[151] *AFPM United States Refining Capacity Report.* (2021). https://www.afpm.org/system/files/attachments/AFPM-Capacity-Report-2021.pdf

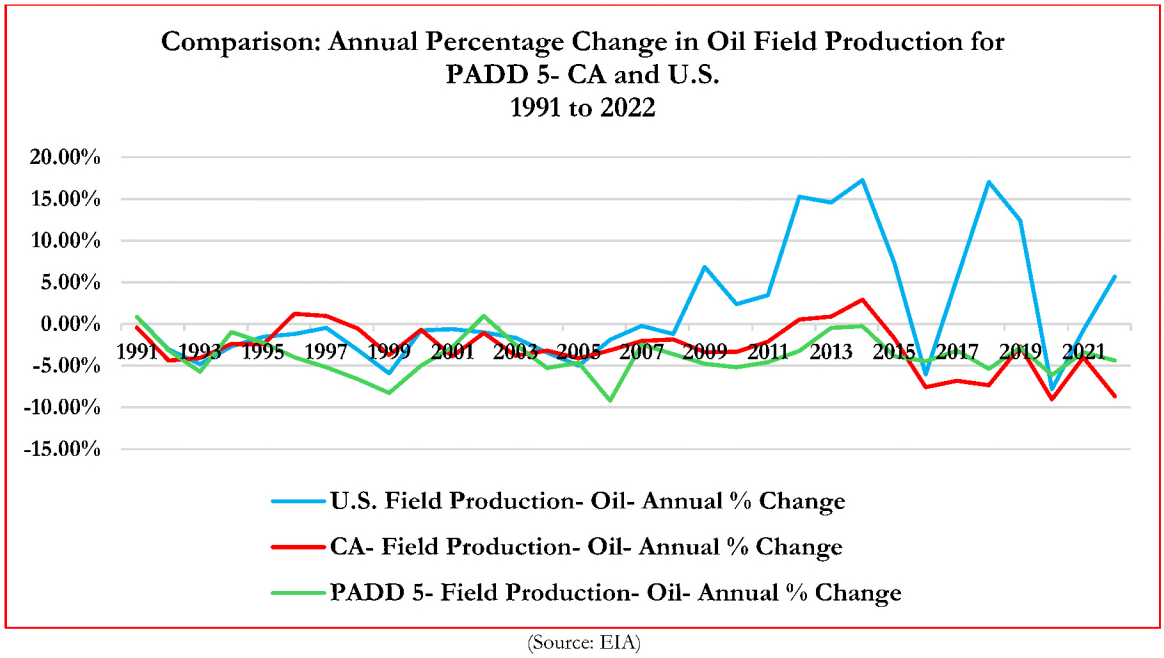
Exhibit 3.16



(Source: EIA)

On an annual percentage change basis, for the 1991 to 2022 period, while U.S. oil field production increased and overall PADD 5 production moderated, California production fell.

Exhibit 3.17

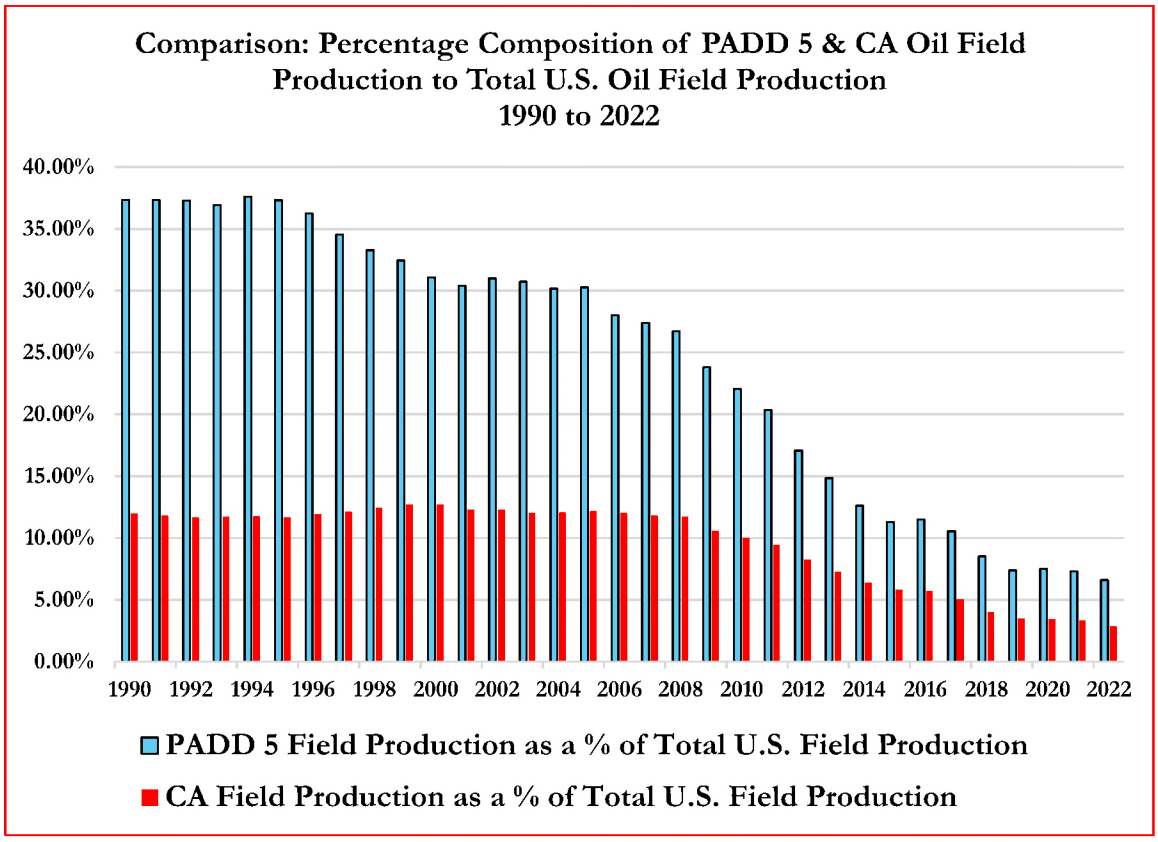


(Source: EIA)

Although refinery capacity and production for Gulf Coast refineries has increased by 27% since 2000, West Coast refinery production has fallen by 12%. Notwithstanding the growth in California's

population, GDP, and motor vehicle registrations, for the 1990 to 2022 period, PADD 5 and California oil field production as a percentage of total U.S. production has declined due to decreased in-state field production.

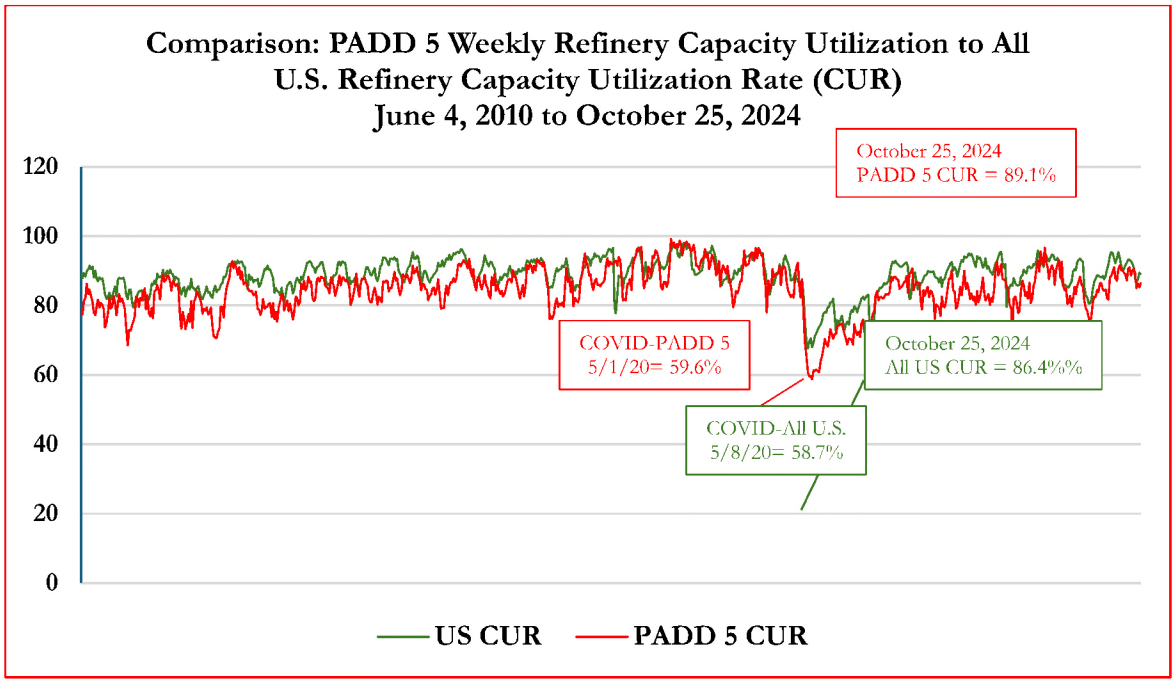
Exhibit 3.18



(Source: EIA)

PADD 5 refinery capacity utilization is consistent with all U.S. refinery capacity utilization and has a relatively high correlation of .781. California's variance of finished gasoline stocks compared to the overall PADD 5 and measured by annual percentage change for the 1993 to 2004 period was relatively consistent and exhibited a high correlation. However, commencing around April 2004 and continuing through August 2024, California's variance in finished gasoline stocks to PADD 5 stocks exhibited high variance, volatility, and a low correlation.

Exhibit 3.19

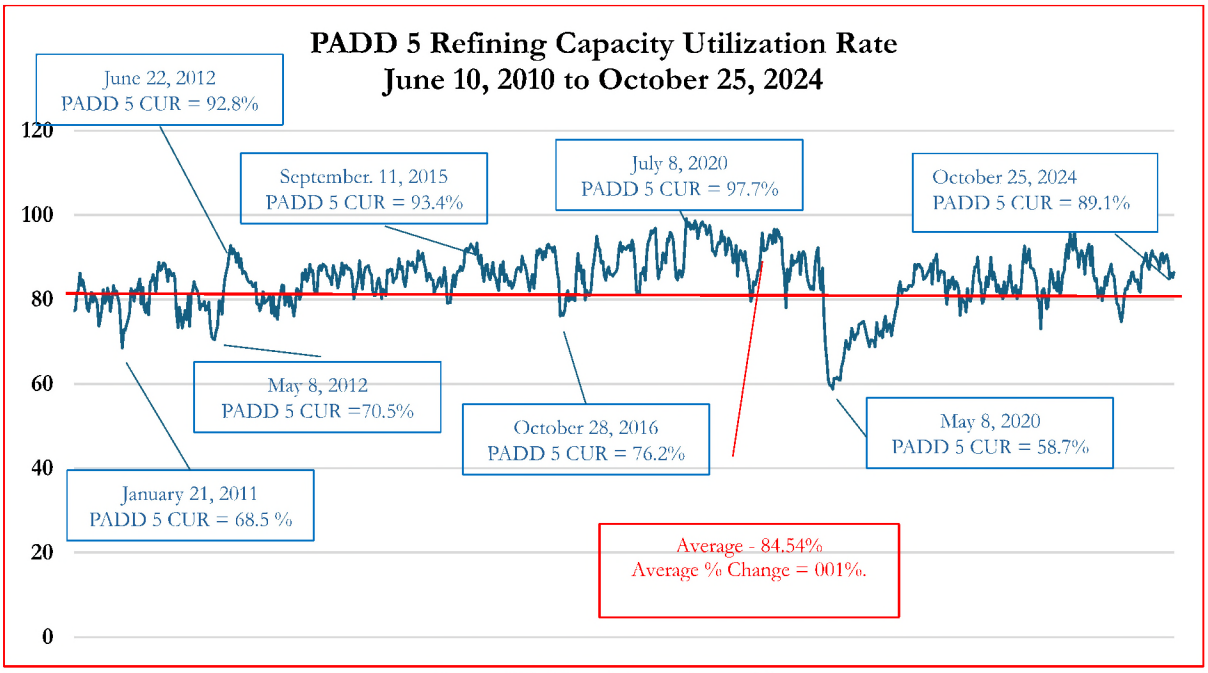


(Source: EIA. Note, dates are "week of")

From January 10, 2010, to October 25, 2024, overall PADD 5 capacity utilization averaged 84.54% and, with some exceptions, has remained consistent with U.S. refineries, with an average of .07% annual percentage change in utilization as compared to .07% for all U.S. refineries.

As the chart below indicates, overall PADD 5 capacity utilization has increased from 77.% in June 2020 to 86.4% in October 2024. Concurrently, the number of refineries declined, particularly in California.

Exhibit 3.20

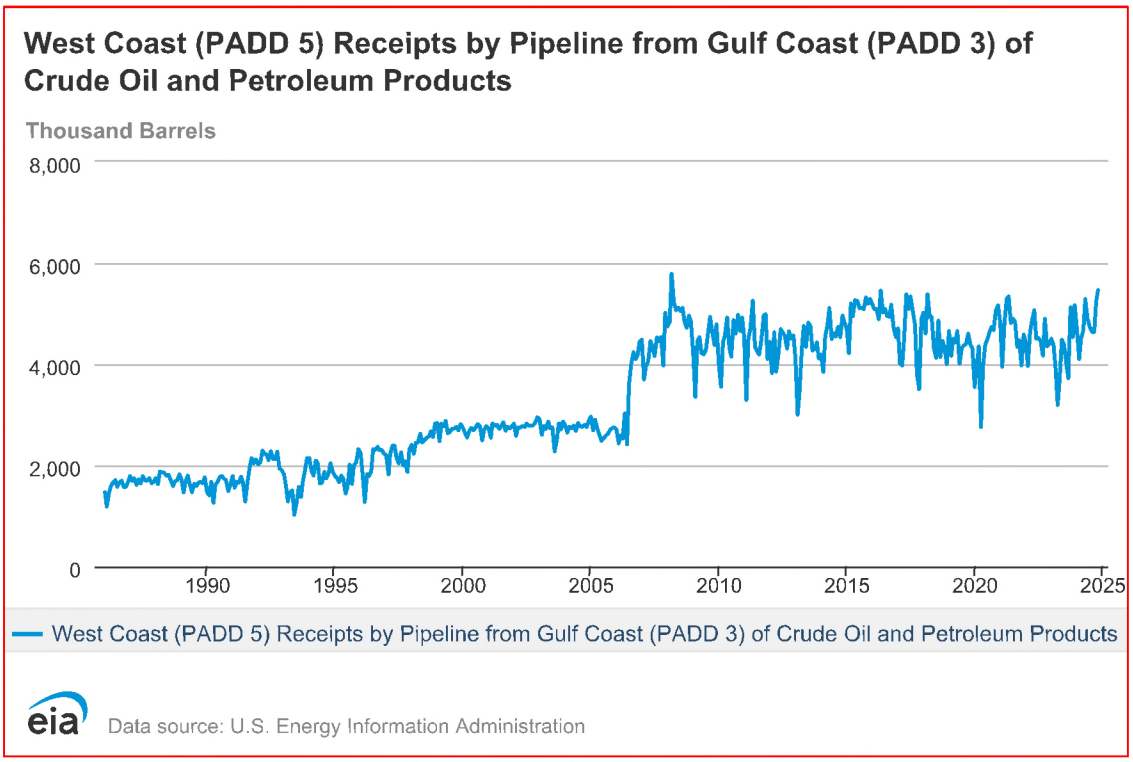


(Source: EIA. Note, dates are "week of"))

Significant variances in PADD 5 capacity utilization occurred on January 21, 2011; May 8, 2012; June 25, 2012; September 11, 2015; October 28, 2016; July 8, 2020; and May 8, 2020. Commencing the week of October 28, 2016, and running through to the week of June 22, 2018, capacity utilization of PADD 5 refineries increased from 76.2% to 96.7%, which was an all-time high for the June 10, 2010, to October 25, 2024, period. Capacity utilization for PADD 5 oil refineries reached its lowest rate on May 8, 2022, at 58.7%, compared to 56.0% for all U.S. refineries on February 26, 2021.

California is isolated from both product and supply perspectives. In the event of shortages, some CaRFG (CARFG) blend stock could be supplied by PADD 5 refineries in Washington State and also by PADD 3 Gulf Coast refineries. However, transferring or 'importing' PADD 3 stocks and gasoline at scale requires 11 to 12 days of transit time and use of the Panama Canal. The exhibit below from the EIA summarizes the oil pipeline transfers from PADD 3 refineries to PADD 5 refineries for the 1986 to November 2024 period.

Exhibit 3.21



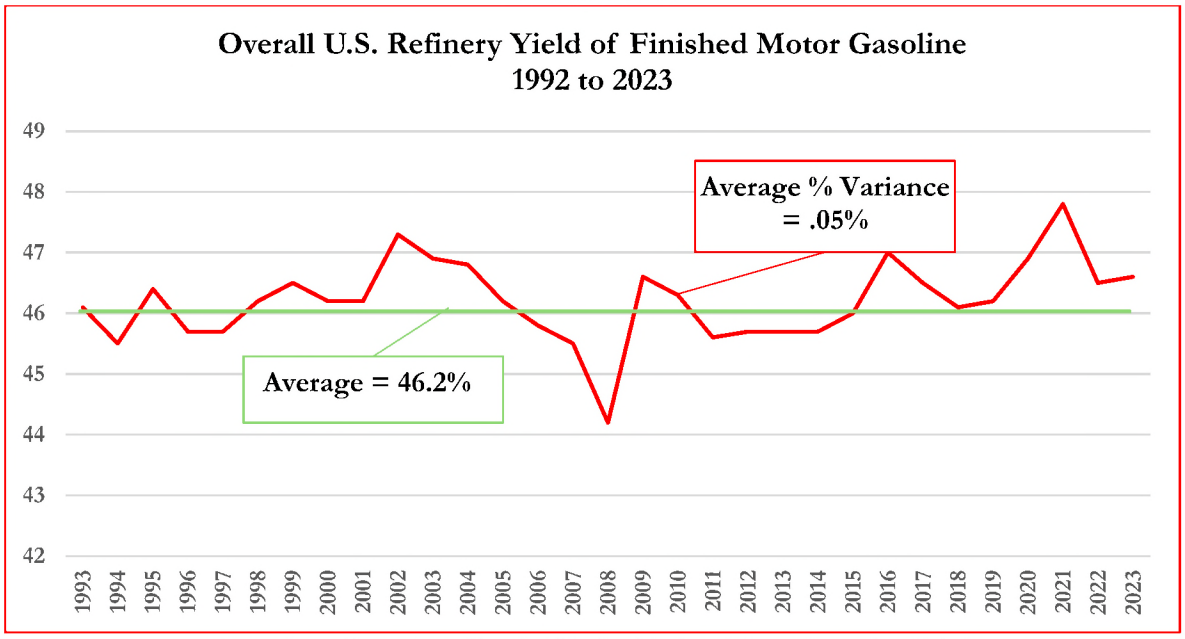
(Source: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MTTMPP5P31&f=M)

Since 1986, pipeline shipments from PADD 3 to PADD 5 have increased by 206.62%; however, since California has no inbound pipelines, the shipments are pipelined to non-California refiners. The greatest annual percentage change in transfers occurred in 2007 when transfers jumped 28.33%.

3.5 California Refineries

The largest refinery in the world is the Jamnagar Refinery complex located in India, which can process 1.2 million barrels of crude oil daily.[152] The largest refinery in the U.S. is Marathon Oil's Galveston Bay Refinery, located in Texas, with a refining capacity of 631,000 barrels of crude oil a day. In the U.S., there are 132 refineries with a combined refining capacity of over 18.4 million barrels of oil a day as of January 1, 2024.[153]

Exhibit 3.22



(Source: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mgfryus3&f=a)

According to the CEC, in 2024, California had an aggregate refinery processing capacity of 1,622,171 barrels of crude oil per day which a 5% reduction from 2023 levels of 1,710,371.[154] A further reduction in refining capacity of 9.3% to 1,483,171 barrels a day is anticipated for 2025, as associated with legislative moves and the announced closure of Phillips refinery in Los Angeles representing 139,000 barrels a day. Supply appears to be falling faster than demand, which, if materialized, generally stimulates price increases.

Collectively, California has the third largest refinery capacity in the U.S.[155] California gasoline refinery capacity is heavily concentrated in three refiners: Chevron, Marathon Oil, and PBF. These refiners collectively represent almost 70% of California's refinery capacity.

[152] Wikipedia contributors. (2024b, November 4). *List of oil refineries*. Wikipedia. https://en.wikipedia.org/wiki/List_of_oil_refineries
[153] *U.S. Number and Capacity of Petroleum Refineries*. (n.d.). Www.eia.gov. https://www.eia.gov/dnav/pet/pet_pnp_cap1_dcu_nus_a.htm
[154] California Energy Commission. (n.d.-b). *California's oil refineries*. https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/californias-oil-refineries
[155] Riedl, D., & Saha, D. (2024). In a Clean Energy Future, What Happens to California's Thousands of Oil Refinery Workers? *Www.wri.org*. https://www.wri.org/insights/ca-oil-refineries-just-transition

Exhibit 3.23[156]

California Oil Refineries, Capacity, Volumes & CARB Capability				
California Refineries As of 10/24/2024	**Barrels Per Day**	**% of California**	**CARB Diesel**	**CARB Gasoline**
Marathon Petroleum Corp., Los Angeles Refinery*	365,000	22.50%	Yes	Yes
Chevron U.S.A. Inc., El Segundo Refinery	269,000	16.58%	Yes	Yes
Chevron U.S.A. Inc., Richmond Refinery	245,271	15.12%	Yes	Yes
PBF Energy, Torrance Refinery	160,000	9.86%	Yes	Yes
PBF Energy, Martinez Refinery	156,400	9.64%	Yes	Yes
Valero Energy, Benicia Refinery	145,000	8.94%	Yes	Yes
Phillips 66, Los Angeles Refinery**	139,000	8.57%	Yes	Yes
Valero Energy, Wilmington Refinery	85,000	5.24%	Yes	Yes
Kern Energy, Bakersfield Refinery	26,000	1.60%	Yes	Yes
Sub-total CARB Capable	**1,590,671**	**98.05%**		
San Joaquin Refining Company Inc., Bakersfield Refine	15,000	0.92%	Yes	No
Lunday Thagard, South Gate Refinery	8,500	0.52%	No	No
Valero Wilmington Asphalt Refinery	6,300	0.39%	No	No
Talley Asphalt Inc., Kern Refinery	1,700	0.10%	No	No
Sub-total Non-CARB Capable	**31,500**	**1.93%**		
Grand Total	**1,622,171**	**99.98%**		

(Source: https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/californias-oil-refineries)

Since capacity is related to capital expenditures and permitting, zoning, environmental, and regulatory restrictions, physical capacity in terms of size and volume doesn't vary much from year to year. However, capacity utilization and output (production) do vary considerably from year to year and within a year.

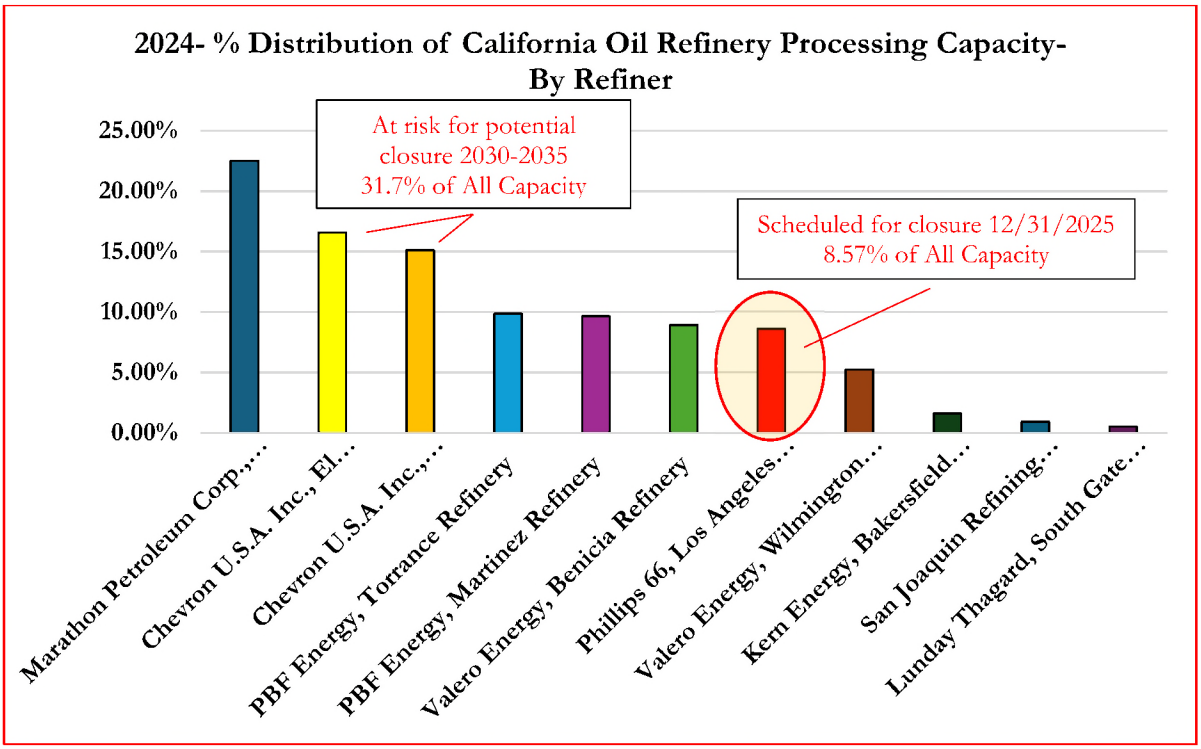
Of California's 13 refineries, 54% of capacity is concentrated in the top 3 refineries, and over 73% is concentrated in the top 5. The largest oil refinery in California is owned and operated by Marathon Oil. Located in Los Angeles, the Marathon complex has a processing capacity of 365,000 barrels of crude oil a day, which represents 22.5% of California's crude oil refinery processing capacity for 2024.[157] With two refineries, Chevron collectively represents 32% of California's refinery capacity. However, California only constitutes 3% of Chevron's sales. As noted, after some 140 years in California, Chevron is following a long list of companies, such as Oracle, Toyota, Honda, Tesla, and Charles Schwab, exiting the Golden State. Four refineries produce 90% of California's compliant gasoline.[158]

[156] California Energy Commission. (n.d.). *California's oil refineries.* https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/californias-oil-refineries

[157] California Energy Commission. (n.d.-c). *California's oil refineries.* https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/californias-oil-refineries

[158] CEC data.

Exhibit 3.24



(Source: https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/californias-oil-refineries)

On October 17, 2024, and after the passing of legislation requiring refiners to hold extensive inventories of finished gasoline products and vesting the CEC with more regulatory and discretionary powers over refinery operations, Phillips 66 announced that it is closing its Wilmington refinery by yearend 2025.[159] The Wilmington refinery constitutes 8.13% of California's 2023 refining capacity. Meanwhile, Chevron and ExxonMobil have written down between $4.5 to $5.0 billion in refinery and other California-based asset impairments. Chevron announced its planned departure from California by 2030/31.[160] [161] As of October 2024, California's 13 refiners have a combined refining capacity of around 1,622,171 barrels of oil a day.[162] With 13 operable atmospheric refineries, California represents 9.1% of all U.S. refining capacity. However, California's oil refining capacity could drop by 8.57% to 1,574,371 million barrels a day in 2025 due to the planned closure of the Phillips 66 complex in Los Angeles.[163] The recent announcement by Phillips 66 is another closure in a long history of refineries either ceasing petroleum refining operations in California or pivoting to other products, such as renewable fuels.[164]

---

[159] Briscoe, T. (2024, October 19). Phillips 66 refinery closure a welcome surprise to activists - Los Angeles Times. *Los Angeles Times*. https://www.latimes.com/environment/story/2024-10-17/phillips-66-refinery-closure-a-welcome-surprise-to-activists

[160] CrowleyBloomberg, J. R. (2024, January 2). *Chevron blames a $4 billion writedown mostly on California's regulations as its war with the state's Democratic-led government heats ups*. Fortune. https://fortune.com/2024/01/02/chevron-4-billion-writedown-california-regulations-democratic-led-government/

[161] Chevron Policy, Government and Public Affairs. (2024, August 2). *Chevron announces headquarters relocation and senior leadership changes*. chevron.com. https://www.chevron.com/newsroom/2024/q3/chevron-announces-headquarters-relocation-and-senior-leadership-changes

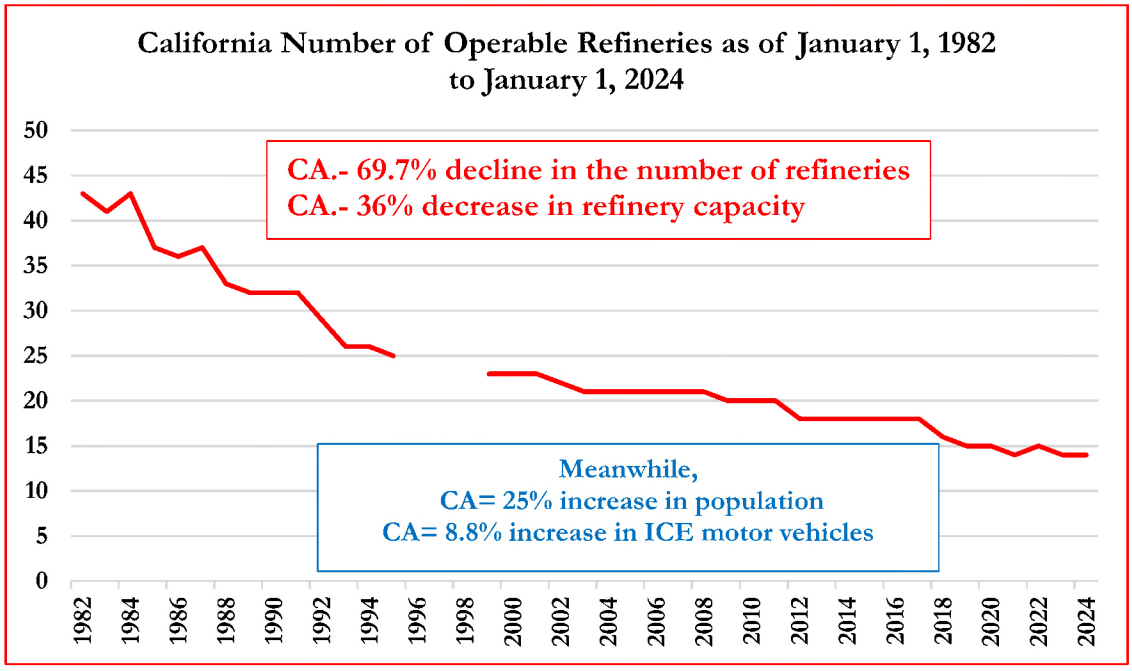
[162] Commission, C. E. (n.d.). *California's Oil Refineries*. California Energy Commission. https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/californias-oil-refineries

[163] Brelsford, R. (2024, October 17). *Phillips 66 to permanently shutter Los Angeles refinery*. Ogj.com; Oil & Gas Journal. https://www.ogj.com/refining-processing/article/55236329/phillips-66-to-permanently-shutter-los-angeles-refinery

[164] Need conversions here

Since 1984, the number of oil refineries in California has decreased by nearly 70%, from 43 to 13 operable refineries. Of the 13 remaining refineries, 9 produce California compliant reformulated gasoline (CaRFG/CARFG).[165] From 1990 to 2024, California permanent refinery shutdowns represent 74% of PADD 5 shuttered refinery capacity.[166] Over 100 years, more than 60% of California's refineries have closed.[167] Since 1982, the number of operable refineries in California has declined by 69%. From 1984 to present, California's oil refining capacity has decreased by 36%, from 2.5 million barrels a day to 1.7 million a day. Since 2023, the daily refining capacity for California surviving refineries has declined 5.16%, from 1,710,371 barrels a day to 1,622,171 barrels a day. From 2023 to the end of 2025, refinery production is estimated to decline by another 8.57%, to 1,483,177 barrels a day.

Exhibit 3.25



(Source: CEC, DMV, Bureau of Census)

With the planned closure of the Phillips 66 complex, California will only have nine refineries producing CaRFG-compliant gasoline. However, the formula for CaRFG-compliant gasoline is slated to change, which, most likely, will necessitate refiners changing processes and equipment, which could influence supply and according to CEC estimates, will most likely increase retail pump prices by $0.47.[168] [169]

[165] *California Reformulated Gasoline | California Air Resources Board.* (n.d.). Ww2.Arb.ca.gov. https://ww2.arb.ca.gov/our-work/programs/fuels-enforcment-program/california-reformulated-gasoline

[166] *PAD District / Refinery Location Total Atmospheric Distillation.* (n.d.). https://www.eia.gov/petroleum/refinerycapacity/table13.pdf

[167] California Energy Commission. (n.d.-a). *California Oil Refinery history.* https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/californias-oil-refineries/california-oil

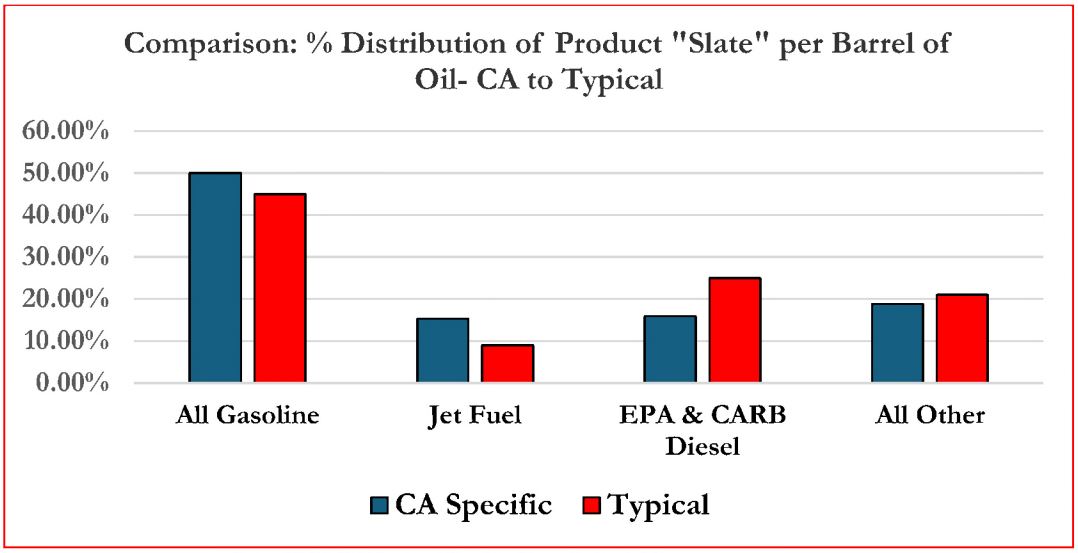
[168] Willis, B. (2024, November 9). *California Air Resources Board approves new fuel standards that could increase gas prices.* ABC30 Fresno. https://abc30.com/post/california-regulators-vote-fuel-standard/15528908/

[169] Lazo, A. (2024, November 9). *California enacts new climate rules — which could boost gas prices.* CalMatters. https://calmatters.org/environment/climate-change/2024/11/california-fuels-standard-gas-prices-climate-change/

Despite its population and vehicle growth, no new refineries have been opened in California for over 60 years.[170] Since 2017, California has lost 12% of its refining capacity and could lose at least another 8.57% with the planned closing of the Phillips 66 refinery by year end 2025. In 2024, ExxonMobil terminated its onshore production and ceased oil field operations in the Golden State.[171] In 2022, California restricted drilling permits.[172] Refinery conversions to renewable fuels have also reduced the capacity to produce gasoline by around 11%.[173] Consequently, only nine refineries survive today, producing about 90% of California's compliant gasoline.[174]

California refineries produce a slightly different product mix than the "typical" barrel. California has a slightly different product mix and yields on a barrel-to-barrel basis and compared to a "typical" barrel of oil products. Below is a chart comparing the "typical" barrel product mix to the California product mix per barrel based on the published CEC product slate for California 2024.

Exhibit 3.26



(Source: CDTFA_CEC joint report 2024 review of the gasoline in ... (n.d.-b). https://seuc.senate.ca.gov/sites/seuc.senate.ca.gov/files/cdtfa_cec_joint_report_2024_review_of_the_gasoline_in_california_and_relate.pdf)

The sheer geographical size of California and its role as an entry and exit portal for global travel (California has abundant long-haul international and domestic flights and high-traffic airports) require that its refiners produce more jet fuels than the national average. For 2020, over 54.3 million

[170] Policy, C. (2024, May 22). *California regulations could cut supply, raise gasoline prices says chevron exec*. Chevron.com; Chevron. https://www.chevron.com/newsroom/2024/q2/california-regulations-could-cut-supply-raise-gasoline-prices-says-chevron-exec
[171] Valle, S. (2022, September 1). Exxon, Shell sell California oil assets for $4 billion to IKAV. *Reuters*. https://www.reuters.com/business/energy/exxon-shell-sell-california-oil-joint-venture-asset-manager-ikav-2022-09-01/
[172] Marissasaldivar. (2024, September 26). *Governor Newsom signs legislation to restrict polluting oil & gas operations near schools, daycares, and across communities | Governor of California*. Governor of California. https://www.gov.ca.gov/2024/09/25/governor-newsom-signs-legislation-to-restrict-polluting-oil-gas-operations-near-schools-daycares-and-across-communities/#:~:text=This%20allowed%20California's%20law%20requiring%20setbacks%20%E2%80%93,crucial%20protection%20for%20public%20health%20and%20safety.
[173] *MSN*. (2025). Msn.com. https://www.msn.com/en-us/money/companies/california-playing-dangerous-game-with-climate-policies-chevron-says/ar-BB1hmygS
[174] California Energy Commission. (n.d.-e). *What drives California's gasoline prices?* https://www.energy.ca.gov/data-reports/energy-insights/what-drives-californias-gasoline-prices

passengers passed through Los Angeles (LAX) and San Francisco (SFO) international airports.[175] Jet fuel or aviation turbine fuel, produced from kerosine, requires complex refining methods, is produced to exceptionally stringent standards, and is best transported via pipelines.[176] California consumes and produces more jet fuel than any other state.[177] Below is an exhibit comparing the product yields for California to a "Typical" or average barrel of oil.

Exhibit 3.27[178]

Comparison of Product Types Per Barrel-CA. to U.S.		
Product Type	**Typical U.S. Product Types**	**California Product Types**
CA. CARB Gasoline	0.00%	42.40%
Aviation (Jet) Fuel	9.00%	15.30%
CA CARB Diesel Fuel	25.00%	10.00%
Conventional Gasoline	45.00%	5.20%
EPA Diesel Fuel	0.00%	5.80%
Other RBOB	0.00%	2.40%
Other Diesel	0.00%	0.20%
Total All Fuels	**79.00%**	**81.30%**
All Other Products	21%	18.70%
Grand Total:	**100.00%**	**100.00%**

(Source: CDTFA_CEC joint report 2024 review of the gasoline in ... (n.d.-b)

3.6 Gasoline Production

California's compliant CaRFG (CARFG) gasoline is produced by 11 refineries located in the Golden State from oil stocks largely sourced from foreign suppliers. Section 4.0 discusses California's imports and growing dependency on foreign sourced oil. The production process and economics of refinery operations are discussed in Section 5.0 of this document.

In oil refinery operations, refiners endeavor to match production to consumption as closely as possible and generally maintain only minimal levels of finished gasoline in inventory. Finished gasoline has a high-cost component and a deteriorating life span. Throughout the gasoline supply chain, various components, such as distributors, wholesalers, and retailers, also tend to keep minimal inventories of

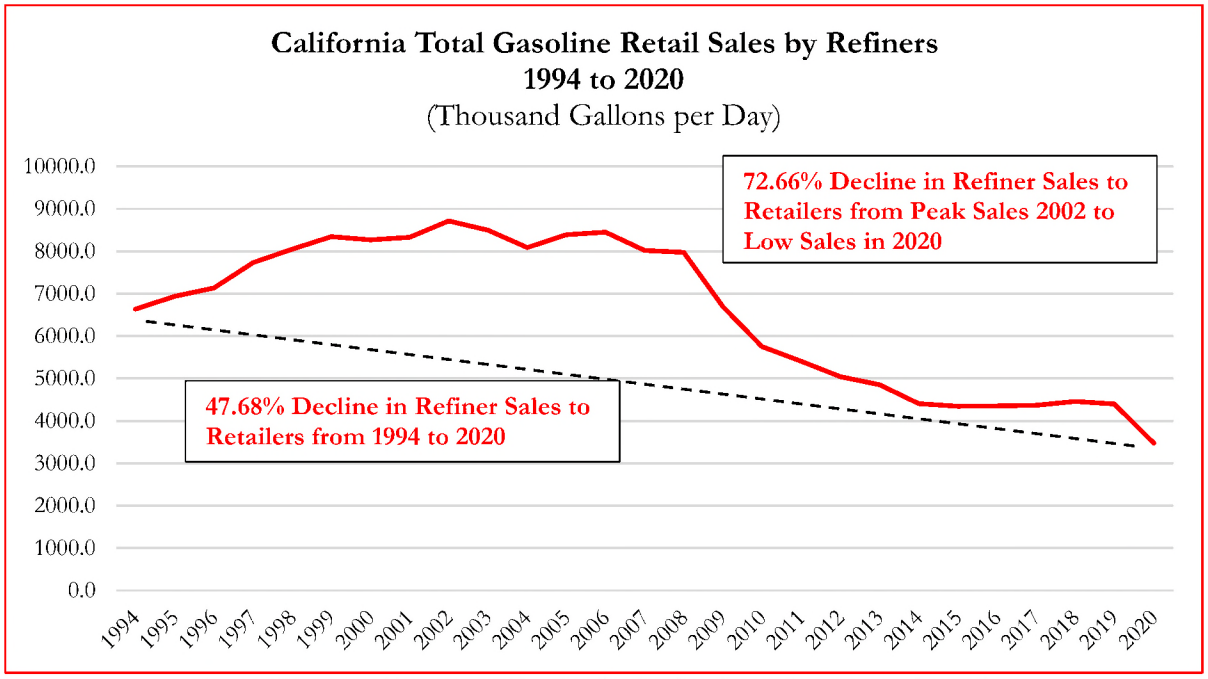
[175] Thomas, J. (2024, May 6). *The busiest & biggest airports in the US [Updated for 2024]*. Stratos Jet Charters, Inc. https://www.stratosjets.com/blog/busiest-us-airports/#:~:text=Which%20Airport%20is%20the%20Busiest,almost%201%2C000%20flights%20per%20day.
[176] *Jet Fuel: From Well to Wing JANUARY 2018*. (n.d.). https://www.airlines.org/wp-content/uploads/2018/01/jet-fuel-1.pdf
[177] *Six states accounted for more than half of U.S. jet fuel consumption in 2019 - U.S. Energy Information Administration (EIA)*. (n.d.). https://www.eia.gov/todayinenergy/detail.php?id=46556
[178] CDTFA_CEC joint report 2024 review of the gasoline in ... (n.d.-b). https://seuc.senate.ca.gov/sites/seuc.senate.ca.gov/files/cdtfa_cec_joint_report_2024_review_of_the_gasoline_in_california_and_relate.pdf

finished gasoline. Section 3.8 provides a discussion of crude and finished gasolines inventories and estimated day's supplies.

In measuring gasoline production, three important (of several metrics) measurements are (1) the sale of gasoline from the refiner to the retailer, (2) finished gasoline stocks held by refiners in bulk, and (3) the sale of gasoline from the retailer to the consumer (CDTFA sales) as discussed in Section 2.0.

3.6.1 Refiner Retail Sales to Retailers. For the 1994 to 2020 period, refiner sales to retailers declined 47.68%.[179] Since peaking in 2002, California retail sales by refiners, as reported by the EIA, have fallen 72.66% in 2021.[180] The decline in retail sales by refiners began in 2006 and accelerated through 2020.

Exhibit 3.28

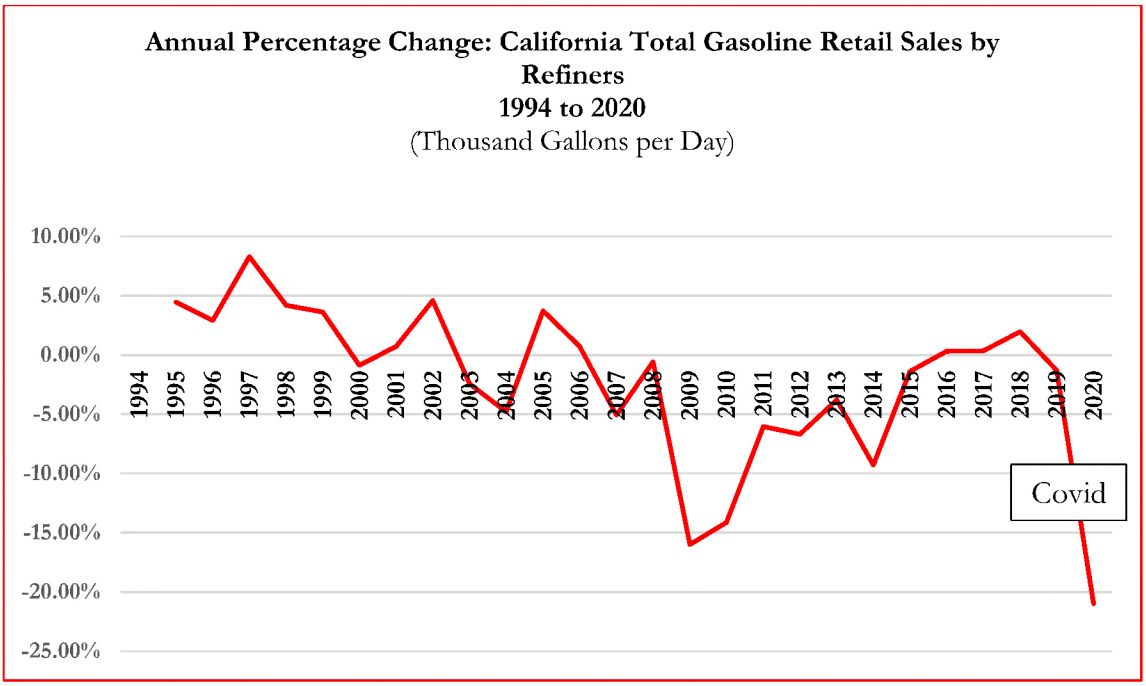


(Source: EIA at https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mgfsxca1&f=a)

Sales by refiners to retail profile significant variations on an annual basis, with 2008, 2009, and 2020 showing the greatest volatility based on double digit declines.

[179] *California Total Gasoline Retail Sales by Refiners (Thousand Gallons per Day).* (2020). Eia.gov. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=a103650061&f=a
[180] *California Total Gasoline Retail Sales by Refiners (Thousand Gallons per Day).* (2020). Eia.gov. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=a103650061&f=a

Exhibit 3.29

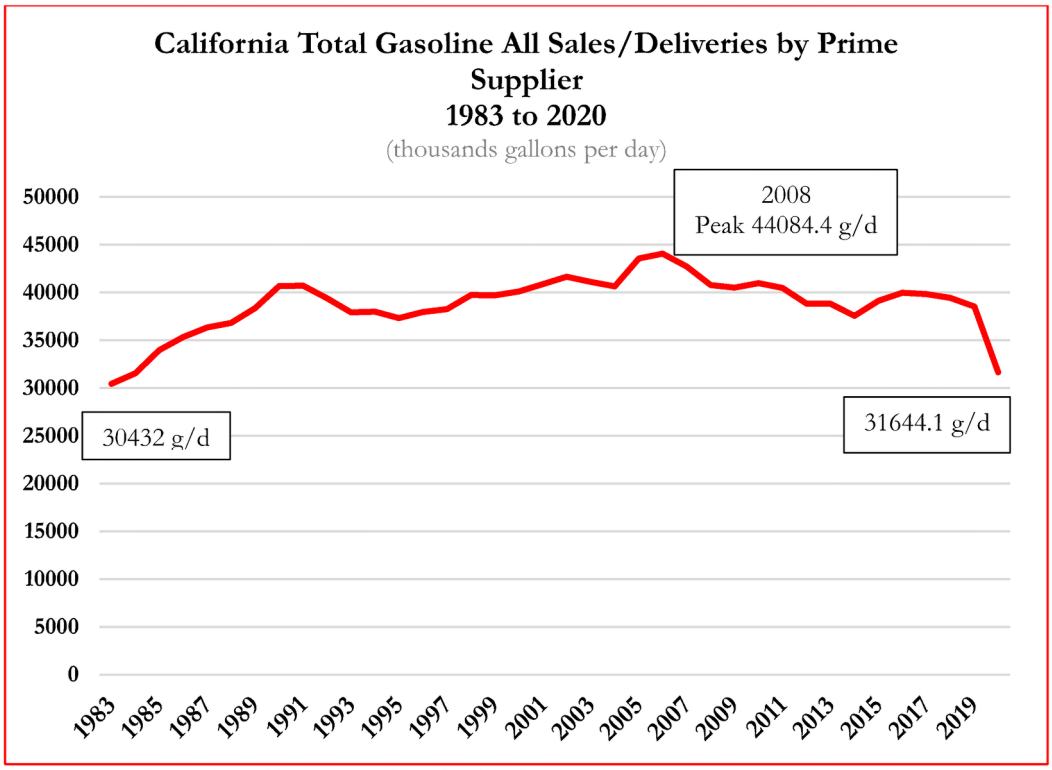


(Source: EIA at https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mgfsxca1&f=a)

Gasoline sales, as measured by sales and deliveries by prime suppliers for the 1983 to 2020 period, were relatively consistent despite significant variances on an annual basis. For 1983, 30,432 gallons a day were sold/delivered by prime suppliers, compared to 31,644 gallons a day in 2020.[181]

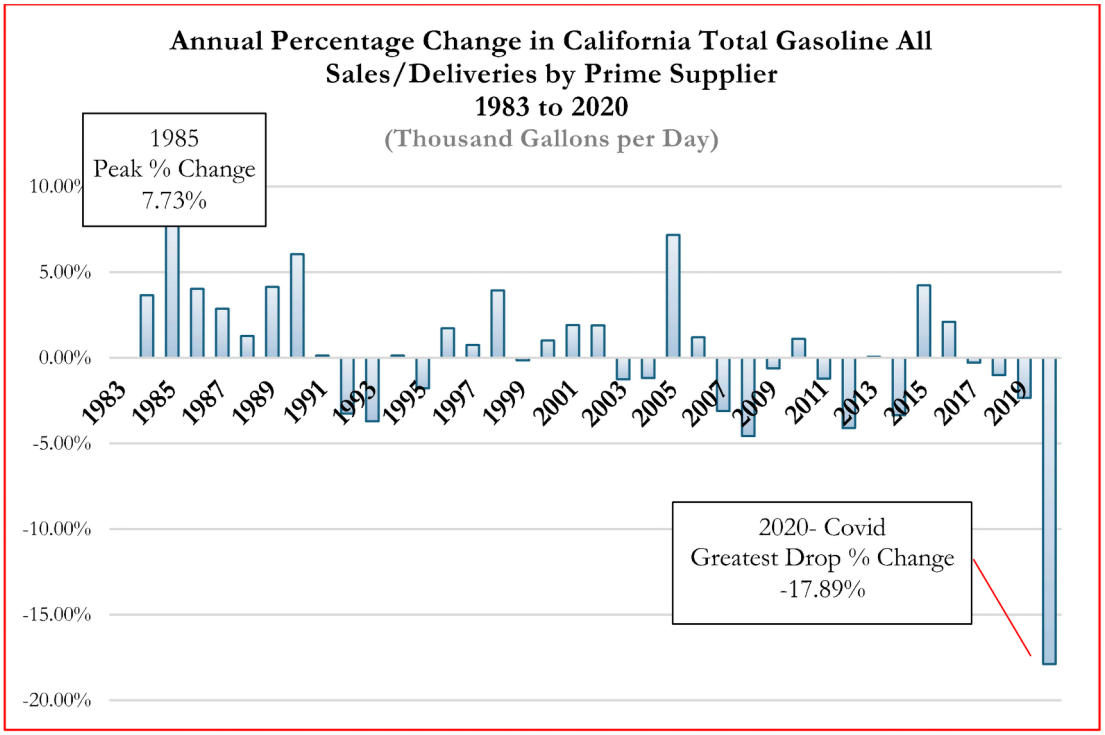
[181] All gallons are in thousands of gallons per day. Source: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=c100050061&f=a

Exhibit 3.30



(Source: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=c100050061&f=a)

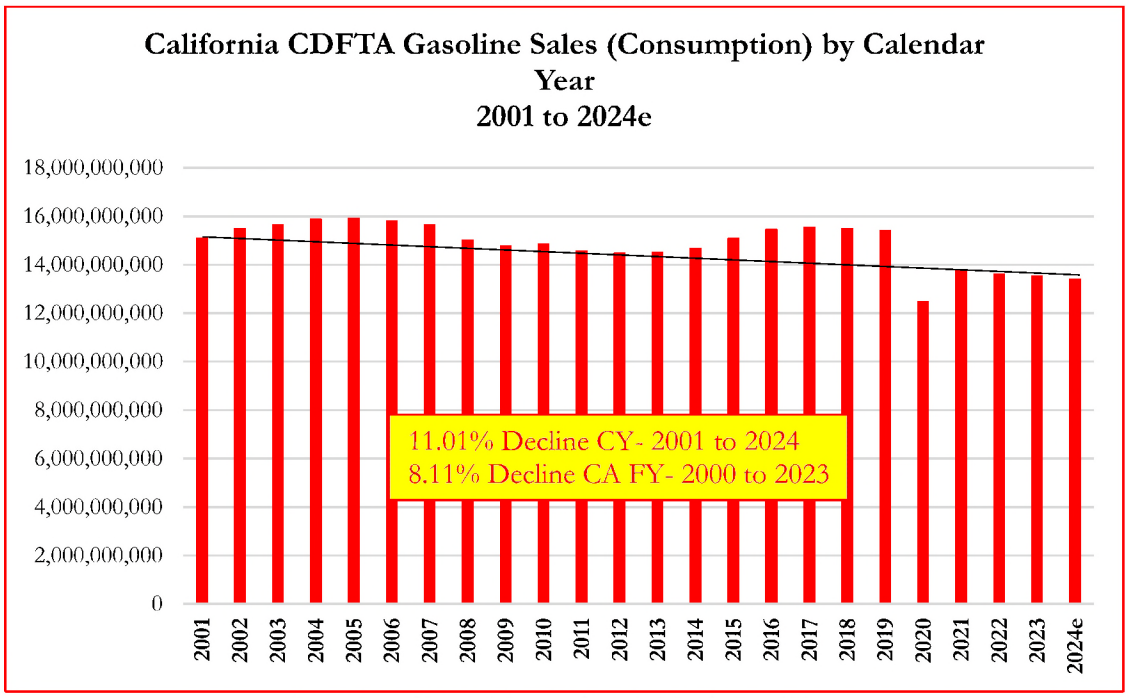
Exhibit 3.31



(Source: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=c100050061&f=a)

Based on CDFTA revenue data, California gasoline consumption, as measured in millions of gallons sold for the 2001 to 2024 period, has declined 13% (calculations are calendar year) (See Section 2.0).[182]

Exhibit 3.32



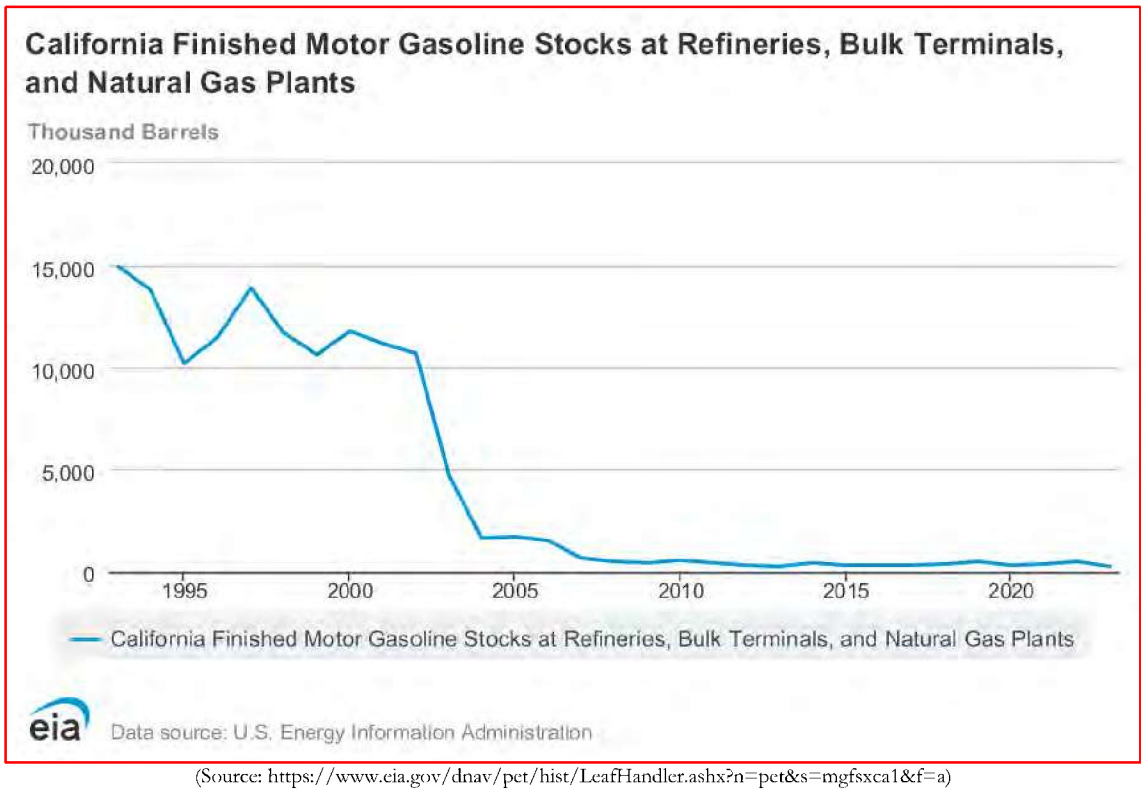
(Source: https://www.cdtfa.ca.gov/taxes-and-fees/spftrpts10.htm)

3.6.2. Finished Gasoline Stocks. Finished gasoline stocks represent the level of gasoline fuels held by refiners, bulk terminals, and natural gas plants. From 1992 through 2023, California's finished gasoline stocks have fallen from 14,966,000 to 243,000 barrels, representing a reduction of 98.36%.[183]

[182] California Department of Tax and Fee Administration. (n.d.). *Fuel Taxes Division Statistics & Reports – 2010*. https://www.cdtfa.ca.gov/taxes-and-fees/spftrpts10.htm

[183] *California Finished Motor Gasoline Stocks at Refineries, Bulk Terminals, and Natural Gas Plants (Thousand Barrels)*. (2020). Eia.gov. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mgfsxca1&f=a

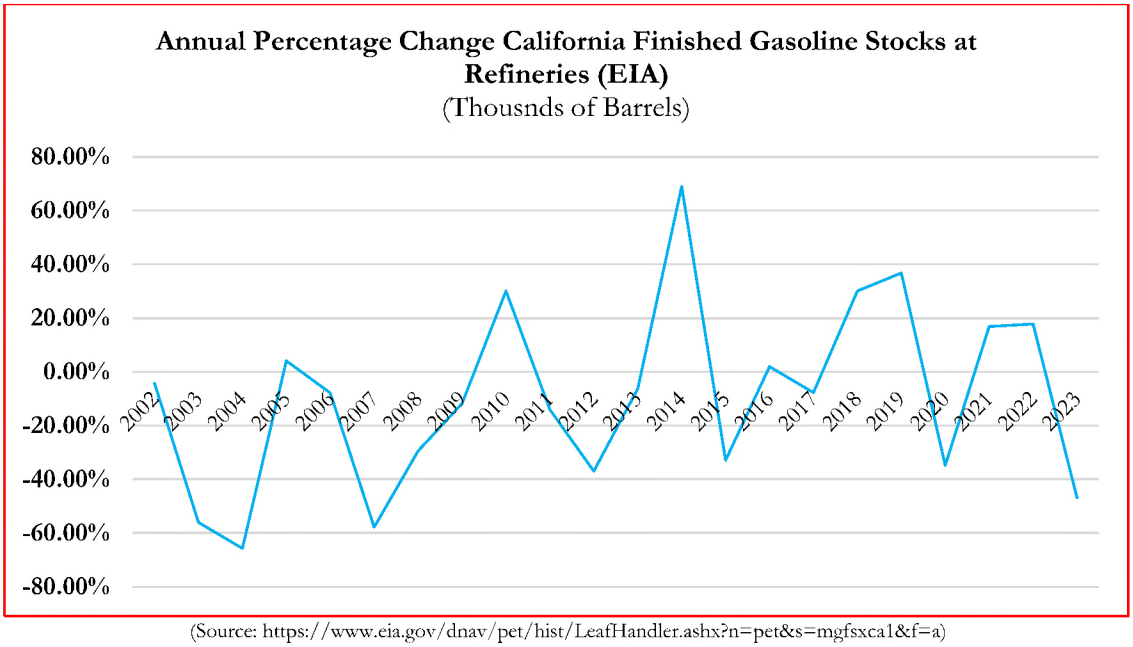
Exhibit 3.33



(Source: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mgfsxca1&f=a)

On an annual percentage basis, finished motor gasoline stocks for California vary widely from year to year and have, on average, declined 7.51% annually since 1993.

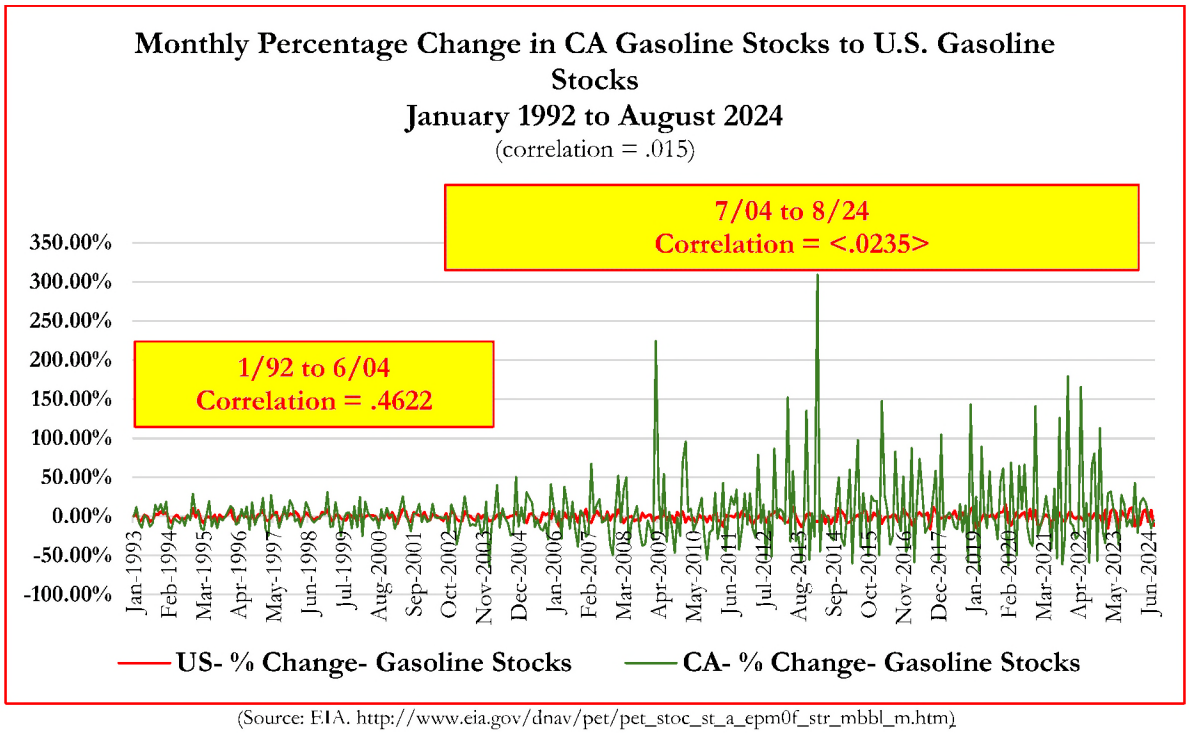
Exhibit 3.34



(Source: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mgfsxca1&f=a)

From 1993 to 2024, California's monthly variance of finished gasoline stocks compared to the overall U.S., measured by annual percentage change, was significantly greater and exhibited a very low correlation.

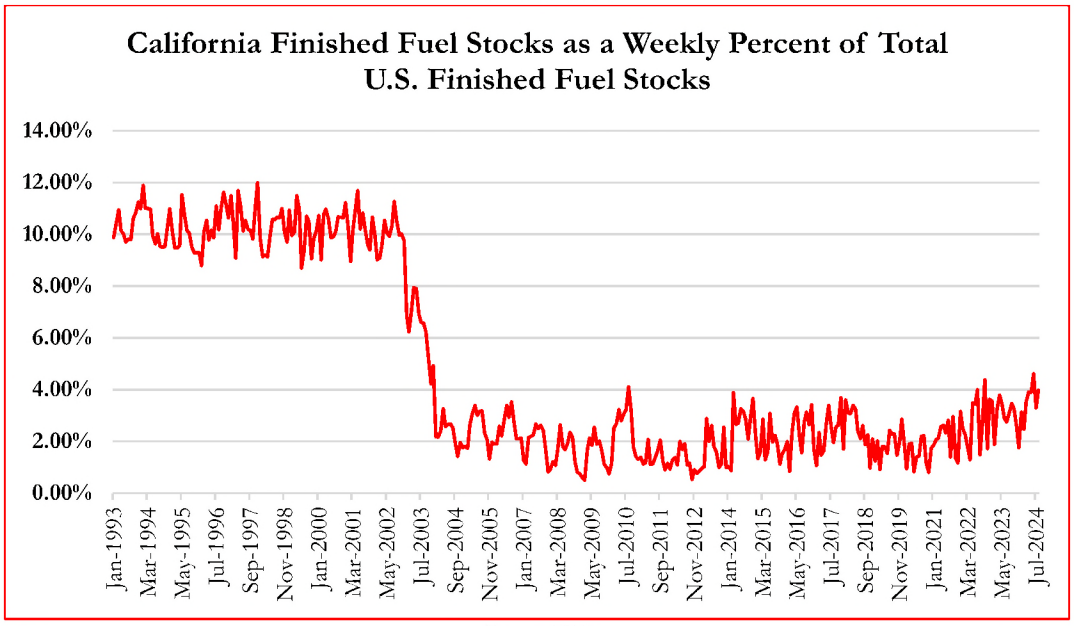
Exhibit 3.35



(Source: EIA. http://www.eia.gov/dnav/pet/pet_stoc_st_a_epm0f_str_mbbl_m.htm)

The exhibit below illustrates the weekly percentage of California bulk gasoline stocks as a percent of the total U.S. finished gasoline product stock. As a percentage of total U.S. finished fuel stocks, California has experienced a significant drop from a high of 11.99% in December 1997 to a low of .49% in February 2009. For August 2024, California bulk fuel stocks represented 3.97% of total U.S. stocks, based on EIA data.

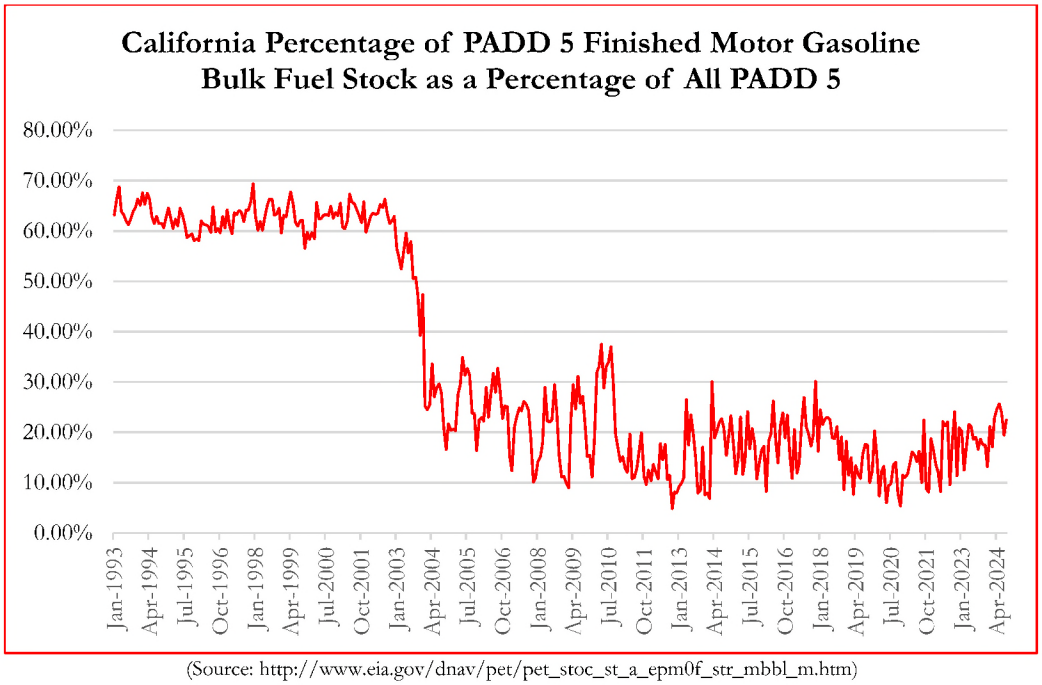
Exhibit 3.36



(Source: EIA)

A similar drop in California's percentage of total bulk fuel stocks as related to PADD 5 stocks is illustrated below.

Exhibit 3.37

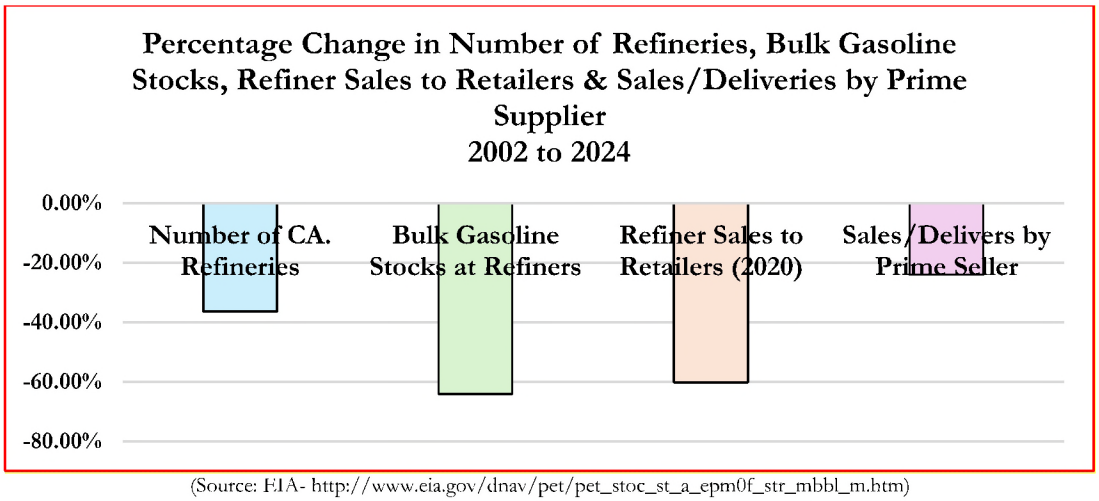


(Source: http://www.eia.gov/dnav/pet/pet_stoc_st_a_epm0f_str_mbbl_m.htm)

California's variance of finished gasoline stocks compared to the overall PADD 5 and measured by annual percentage change for the 1993 to 2004 period was relatively consistent and exhibited a high

correlation. However, commencing around April 2004 and continuing through August 2024, California's variance in finished gasoline stocks to PADD 5 stocks exhibited high variance, volatility, and a low correlation. The reduction in bulk gasoline fuel stock levels can be attributed to several factors, chief among them may be the dramatic decline in the number of California-based refineries since 1992.

Exhibit 3.38



(Source: EIA- http://www.eia.gov/dnav/pet/pet_stoc_st_a_epm0f_str_mbbl_m.htm)

Additionally, commencing in 2002, there was a significant shift and increase in the price of gasoline sold in California through company outlets. Section 7.0 provides a discussion of pricing in California.

3.7 Gasoline Blends

Gasoline in California is refined, as it is across the U.S., into various blends and octane grades. Essentially, there are three dominant octane grades: regular, mid, and premium. Additionally, a "super" premium octane grade refined as "racing" fuel is also available in limited quantities. In the U.S., there are two federally required seasonal blends. The various octane grades are refined and consistent with the regulatory requirements for the seasonal blends. California maintains the federal standards the federal standards for the season but has a slightly different seasonal schedule. However, California goes several steps beyond the federally mandated standards by requiring a California special blend that is specific only to the Golden State.

3.7.1 Seasonal Blends. Refiners across the U.S. and in California are required to produce gasoline that meets regulatory mandates based on the summer or winter season. These are referred to as "seasonal blends." Under a complex set of federal and state laws, refineries are required to produce different types of seasonal gasolines at different times of the year. Refiners across the U.S. and in California are required to produce gasoline that meets regulatory mandates based on the summer or winter season. Summer blends.

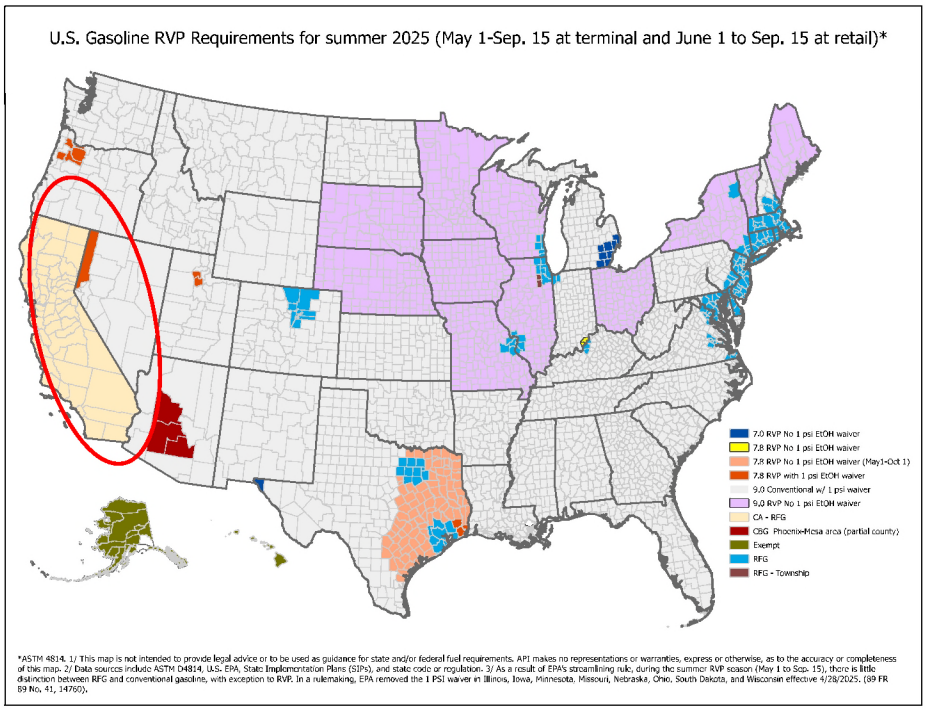
- Summer blends contain about 2% less butane than winter blends and have lower Reid Vapor Pressure (RVP) emissions than winter blends. Summer blends also have about 1.7% higher energy content per gallon, which translates into more miles per gallon.

- Winter blends have higher RVP but lower energy content per gallon. Winter blends, which contain butane and have higher RVP ratings, evaporate faster in the atmosphere. In general, the higher the RVP, the faster the evaporation.

The EPA requires the use of summer blends from June 1 to September 15. In contrast, California requires the summer blend from April 1 to October 31.

Subsequent to California's fuel initiatives and Amendments to the 1990 Clean Air Act (CAA), the U.S. Federal government, through the Environmental Protection Agency (EPA), mandated seasonal Reformulated Gasoline (RFG) blends for use throughout the U.S.[11] Beginning with Phase 1 in 1989 and latter in 1991 with Phase 2, the U.S. EPA established two other categories or types of seasonal blends, Summer and Winter. The blends are different and require different ingredients and processes, and they are produced at different times of the year. Summer blends have lower RVP qualities. Due to various state and federal regulations associated with air quality and emissions, summer blends have 14 different specifications (types) and, as such, are more costly and complex to produce.[184] Summer blends yield less per barrel of input and requires extended production times. The price increase associated with the summer blend also occurs concurrently with an increase in demand. Historically, in the U.S., gasoline consumption is lower in the first quarter of each calendar and then climbs to peak in August. Come September, demand tends to slow and drop. In contrast, winter blends have fewer specifications, are less expensive to produce, and yield higher outputs per barrel.

Exhibit 3.39
U.S. Seasonal Blend Requirements by State- Example- Summer 2025[185]



[184] *Seasonal gas prices explained*. (n.d.). https://www.convenience.org/Topics/Fuels/Changing-Seasons-Changing-Gas-Prices
[185] *U.S. gasoline requirements*. (n.d.). https://www.api.org/oil-and-natural-gas/wells-to-consumer/fuels-and-refining/fuels/us-gasoline-requirements

3.7.2 California Seasonal Blends. Due to its microclimates, California has a different seasonality calendar than most of the U.S. California's unique geography and various climates necessitate that California maintains multiple special summer blends. In California, the summer blend season runs into mid-October, which is longer than the rest of the nation. Furthermore, in California, the schedule for the mandatory shifting to summer or winter blends varies by county.[186] The summer blends sold in California's counties are designed for a specific geographical area or air basin in the state as designated by the California Air Resources Board.[13] To meet regulatory mandates, refiners start shifting from winter to summer as early as February and to the winter blend as early as mid-September.

- Seasonal blends can add as much as $.15 to the retail price per gallon of gas.[14]

3.7.3 Special Blend. California has the strictest mandates for gasoline and emissions, so its fuel is unique and more costly to produce, which, in turn, contributes to a higher retail price. The data is undisputable as multiple studies, including those of the U.S. EPA, all conclude that California's special blend has reduced smog, carcinogens, volatile organic compounds (VOC), nitrogen oxides, and other containments. [187] Nonetheless, Los Angeles continues to be ranked the highest among all U.S. major cities as having the most polluted air in 2024.[188] The tradeoff between higher retail prices associated with the unique special California gasoline blend is significantly better air quality, lower smog and soot, lower particulate emissions, and an overall improved quality of life and health.

California was the "first in the world" to introduce regulatory standards for gasoline emissions. With the California Reformulated Gasoline" (CaRFG) program, California set the most stringent standards in the U.S. for gasoline, which resulted in significant reductions in emissions from internal combustion vehicles and vast improvements in air quality.[189] Beginning in 1991 with Phase 1 mandates, California eliminated lead from gasoline and required Reid vapor pressure (RVP) systems.[190] In 1996, California implemented additional "Phase 2" mandates and later, in 2007, Phase 3 requirements, which legislated the use of specific gasoline blends to further lower emissions and air pollution. The exhibit below summarizes some key contaminants and components California has aggressively addressed to improve air quality through gasoline emissions.[10]

Smog and air pollution in California, particularly in Southern California, first appeared in the summer of 1943.[191] By the mid-1960s, air pollution, especially in the Los Angeles basin, was so severe that it was causing health issues. The smog was so thick and prevalent that it was the topic of comedic lines in both television and movies.[192] In response, California passed the first "tail-pipe" emissions standards

---

[186] Newsom, G., Hochschild, D., & California Energy Commission. (2020). *California Energy Commission Petroleum Watch Refinery News*. https://www.energy.ca.gov/sites/default/files/2020-09/2020-09_Petroleum_Watch_ADA.pdf

[187] GAO. (2005). *GASOLINE MARKETS special gasoline blends reduce emissions and improve air quality, but complicate supply and contribute to higher prices* |Report|. https://www.gao.gov/assets/gao-05-421.pdf

[188] Shafiq, S. (2025, March 12). *Report reveals 2024's most polluted cities, countries: Which US cities made the list?* USA TODAY. https://www.usatoday.com/story/news/world/2025/03/12/most-polluted-countries-cities-iqair-2024/82306911007/

[189] *California Reformulated Gasoline | California Air Resources Board.* (n.d.). Ww2.Arb.ca.gov. https://ww2.arb.ca.gov/our-work/programs/fuels-enforcment-program/california-reformulated-gasoline. See also, *Gasoline | California Air Resources Board.* (2025). Ca.gov. https://ww2.arb.ca.gov/our-work/programs/gasoline/about

[190] "RVP is an abbreviation for "Reid vapor pressure," which is a common measure of and generic term for gasoline volatility. "See, https://www.epa.gov/gasoline-standards/gasoline-reid-vapor-pressure.

[191] California Air Resources Board. (2012). *History | California Air Resources Board.* Ca.gov. https://ww2.arb.ca.gov/about/history

[192] *Jed in Politics.* (1966, November 2). Rotten Tomatoes. https://www.rottentomatoes.com/tv/the_beverly_hillbillies/s05/e08

in the U.S. In 1967, California, under then-Governor Ronald Reagan, created the California State Air Resources Board to improve California's air quality by reducing gasoline engine emissions.[193]

To reduce and eliminate Methyl Tertiary Butyl Ether (MTBE), which, at high levels, can cause adverse health effects and is a potential human carcinogen, as well as other harmful components, California enacted the strictest laws in the U.S. and the world which require that all gasoline sold contain at least 10% ethanol with the remaining 90% as petroleum.[194] [195] Currently, E10 is available for sale in California, but E15 is not sold in the state.[196] Some of the components that California law has eliminated or significantly mitigated are summarized in the exhibit below.

Exhibit 3.40



(Source: https://ww2.arb.ca.gov/our-work/programs/gasoline/about)

As a result of California's CaRFG (CARFG) requirements and other regulatory mandates, California oil refineries produce special gasoline blends that are specific only to California's requirements. The unique California blends require specialized refinery equipment and processes, which contribute to additional costs, increased prices, and sales taxes at the retail pump.

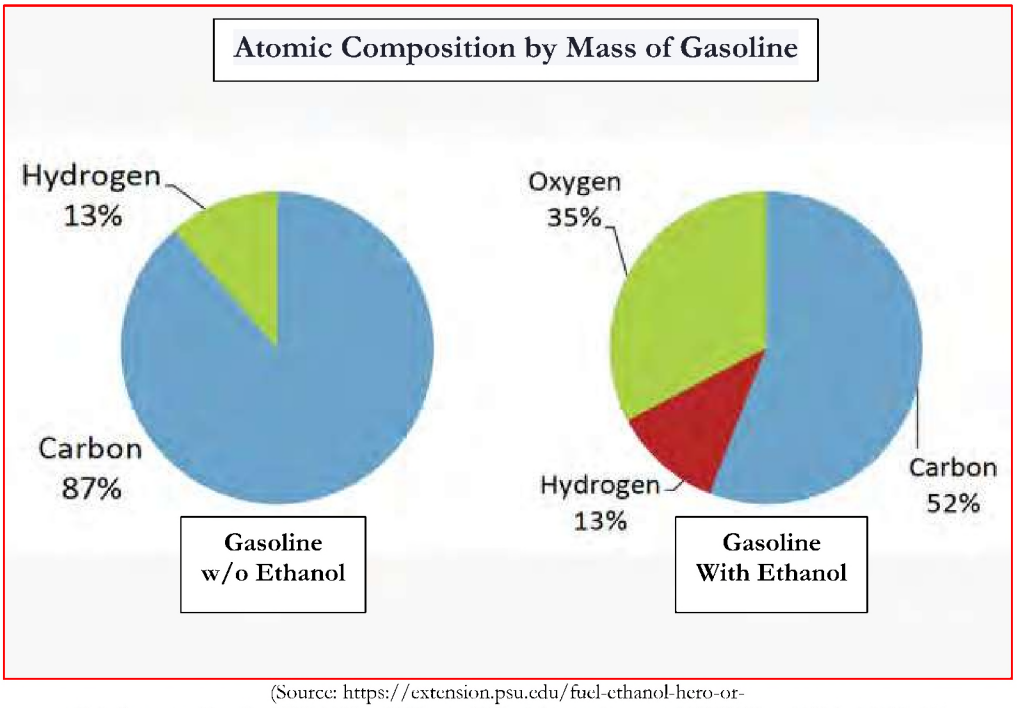
- California special blends add between $0.12 to $0.15 to the retail price of gasoline.[12]

[193] California Air Resources Board. (2012). *History | California Air Resources Board*. Ca.gov. https://ww2.arb.ca.gov/about/history
[194] *Overview | Methyl Tertiary Butyl Ether (MTBE) | US EPA*. (2025). Epa.gov. https://archive.epa.gov/mtbe/web/html/faq.html#concerns
[195] Commission, C. E. (n.d.). *California Gasoline Data, Facts, and Statistics*. California Energy Commission. https://www.energy.ca.gov/data-reports/energy-almanac/transportation-energy/california-gasoline-data-facts-and-statistics
[196] Danelladebel. (2024, October 25). *Governor Newsom urges accelerated action on new gas blend to lower prices | Governor of California*. Governor of California. https://www.gov.ca.gov/2024/10/25/governor-newsom-urges-accelerated-action-on-new-gas-blend-to-lower-prices/#:~:text=What%20you%20need%20to%20know:%20Governor%20Newsom,little%20to%20no%20impact%20on%20the%20environment.&text=As%20of%202023%2C%20E15%20was%20sold%20at%20more%20than%203%2C000%20stations%20in%2031%20states.

- California's new LCFS special blend mandate is expected to add $0.47 to $0.67 a gallon of gasoline in 2025.[197]

In addition to California CaRFG regulations, there are U.S. Federal mandates. According to federal law, U.S. refiners are required to blend 15.0 billion gallons of corn-based ethanol in gasoline stocks annually.[198] The Energy Policy Act of 2005, the 2007 Energy Independence and Security Act, and later the U.S. Renewable Fuel Standard (versions 1 and 23) further require U.S. refiners to increase their use of ethanol to an average content of 10% by volume.[199] Ethanol is an alcohol derived from biomass sources, such as corn (starch), sugar cane (sugars), or cellulosic derivatives, such as wood chips. It is used in gasoline to increase oxygenation and reduce emissions.[200] Below is an exhibit developed by Professor Daniel Ciolkosz, P.E. of Pennsylvania State University, showing the differences in the atomic content between gasoline with and without ethanol.

Exhibit 3.41



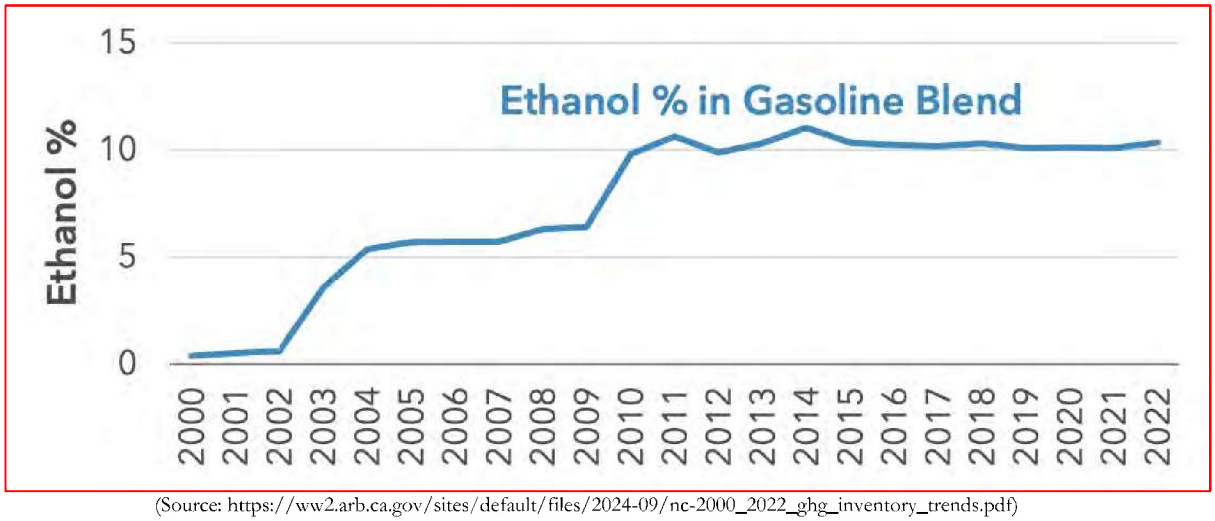
(Source: https://extension.psu.edu/fuel-ethanol-hero-or-villain#:~:text=Gasoline%20is%20not%20water%20soluble,performance%20if%20not%20dealt%20with)

In gasoline, ethanol is designated with the letter "E," followed by the percentage of ethanol contained in the gasoline. Thus, E10 means that the gasoline is composed of 10% of ethanol. There are also some E15 blends that contain 15% of ethanol. According to the U.S. Dept. of Energy, ethanol can increase the octane rating of gasoline, but there is a potential tradeoff in engine

[197] Cullenward, D. (n.d.). *California's Low Carbon Fuel Standard 2*. https://kleinmanenergy.upenn.edu/wp-content/uploads/2024/10/KC-Paper-16-Californias-Low-Carbon-Fuel-Standard.pdf
[198] See, Energy Policy Act of 2005 (PL 109–58). See also, US EPA, O. (2015, July 13). *Statutes for Renewable Fuel Standard Program*. Www.epa.gov. https://www.epa.gov/renewable-fuel-standard-program/statutes-renewable-fuel-standard-program
[199] *ENERGY INDEPENDENCE AND SECURITY ACT OF 2007*. (2005). https://www.govinfo.gov/content/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf
[200] In the U.S. about 93% of ethanol is produced from corn starch. (US Department of Energy. (2024). *Alternative Fuels Data Center: Ethanol Fuel Basics*. Afdc.energy.gov. https://afdc.energy.gov/fuels/ethanol-fuel-basics)

performance/efficiency and miles per gallon.[201] Modern engines, designed to perform using newer fuel combinations and standards, generally perform better on ethanol blends than older engines. Engine condition, maintenance, and design also influence performance. Although ethanol produces increased octane ratings, it generates up to 30% less energy per gallon of gasoline and can reduce miles per gallon by 3% or more.[202] At 30% content, ethanol fuels produce 3% less horsepower than gasoline.[203] Unlike gasoline, ethanol is water soluble and can attract and retain impurities which may impede engine performance. The use of ethanol in California is summarized in the exhibit below.

Exhibit 3.42
Ethanol Concentration in Gasoline Over Time



(Source: https://ww2.arb.ca.gov/sites/default/files/2024-09/nc-2000_2022_ghg_inventory_trends.pdf)

In the U.S., most ethanol is produced from corn which consumes up to 40% of U.S. corn production.[204] However, a 2022 study indicates that the use of ethanol, on a net basis, may have contributed to increases in greenhouse gas emissions due to changes in agricultural production and land use.[205] According to various studies performed by researchers T. J. Lark, T. Searchinger, H. K. Gibbs, J. Fargione, J. Hill, D. Tilman, S. Polasky, and P. Hawthorne, GHG emissions from land clearing and the increased use of fertilizers and production of corn, could result and have resulted in unintentional increases in GHG emissions.[206]

---

[201] US Department of Energy. (2024). *Alternative Fuels Data Center: Ethanol Fuel Basics.* Afdc.energy.gov. https://afdc.energy.gov/fuels/ethanol-fuel-basics

[202] *How much ethanol is in gasoline, and how does it affect fuel economy? - FAQ - U.S. Energy Information Administration (EIA).* (2016). Eia.gov. https://www.eia.gov/tools/faqs/faq.php?id=27&t=10

[203] Penn State Extension. (2014, May 8). *Fuel Ethanol: Hero or Villain?* Penn State Extension. https://extension.psu.edu/fuel-ethanol-hero-or-villain

[204] Penn State Extension. (2014, May 8). *Fuel Ethanol: Hero or Villain?* Penn State Extension. https://extension.psu.edu/fuel-ethanol-hero-or-villain

[205] Douglas, L. (2022, February 14). U.S. corn-based ethanol worse for the climate than gasoline, study finds. *Reuters.* https://www.reuters.com/business/environment/us-corn-based-ethanol-worse-climate-than-gasoline-study-finds-2022-02-14/

[206] Hill, J. (2022). The sobering truth about corn ethanol. *Proceedings of the National Academy of Sciences*, *119*(11). https://doi.org/10.1073/pnas.2200997119. See also, T. J. Lark et al., Environmental outcomes of the US Renewable Fuel Standard. *Proc. Natl. Acad. Sci. U.S.A.*, https://doi.org/10.1073/pnas.2101084119. (2022); T. Searchinger et al., Use of U.S. croplands for biofuels increases greenhouse gases through emissions from land-use change. *Science* **319**, 1238–1240 (2008); H. K. Gibbs et al., Carbon payback times for crop-based biofuel expansion in the tropics: The effects of changing yield and technology. *Environ. Res. Lett.* **3**, 034001 (2008), and J. Fargione, J. Hill, D. Tilman, S. Polasky, P. Hawthorne, Land clearing and the biofuel carbon debt. *Science* **319**, 1235–1238 (2008).

- Lark's study indicates that models such as the Global Trade Analysis Project (GTAP), used by the California Air Resources Board, tend to underestimate the GHG emissions from crop-based GHG mitigation efforts and overestimate the environmental benefits.[207]

3.7.4 California Octanes. As a final consumer product, gasoline is produced and sold in multiple octane grades. Octane measures the fuel's stability, anti-knock, and combustion rating.[208] Octane ratings are determined using two measurement methods: research octane rating (RON) and motor octane rating (MOR). The higher the octane rating, such as 94, the higher the stability of the fuel.[209] For automobiles, there are three basic grades and specialized "racing" fuels (higher octane) sold in some locations. In California, the octane ratings are 87- regular, 89- mid range, and 91- high. Specialized racing octanes usually range from 97 to 100+. The availability of a particular octane varies by the state (and local levels. For example, 100 octane is rarely available in California but is available in other states. Colorado's regular octane is rated at 85, while 93- high octane is available in Florida.[210] As discussed in Section 2.0, around 50% of all retail gasoline sales in California are branded.

The price spread between premium and regular gasoline varies considerably. Premium branded fuels carry a higher price as compared to unbranded premium products. In California, the variance between premium and regular ranges between $0.30 to $0.50 a gallon.

3.7.5 Branded and Unbranded. The final gasoline product produced by California refineries is a standard, generic gasoline product offered for sale to distributors and wholesalers. As a generic product, it is unbranded, and standard gasoline is offered in three different octanes. All octanes (grades) must meet both federal and California minimum regulatory standards and mandates for quality, emissions, and combustion.

Once refined and produced, the generic gasoline is stored shortly by the refinery or third-party intermediaries in tank farms before delivering to a distribution point or "racks" where the distributors purchase the fuel. Delivery from the refinery to short-term shortage tanks and then onto rack points is accomplished using pipelines, tanker trucks, and, to a more limited extent, rail tankers, which run from the refinery storage tank farms to the distribution and rack points. At the rack, the distributor purchases the generic gasoline. Once the distributor purchases the fuel from the rack, they may blend it with proprietary ingredients to create a specialized **branded** blend or leave it as a generic product to be sold as an **unbranded** product.

- To create a proprietary branded blend, the distributor adds special ingredients and formulations to create branded products such as Chevron's Techron[211] or Shell's V-Power.[212]

---

[207] Hill, J. (2022). The sobering truth about corn ethanol. *Proceedings of the National Academy of Sciences*, *119*(11). https://doi.org/10.1073/pnas.2200997119. See also, U. Lee, H. Kwon, M. Wu, M. Wang, Retrospective analysis of the U.S. corn ethanol industry for 2005–2019: Implications for greenhouse gas emission reductions. *Biofuels Bioprod. Biorefin.* **15**, 1318–1331 (2021); J. Lewandrowski et al., The greenhouse gas benefits of corn ethanol—assessing recent evidence. *Biofuels* **11**, 361–375 (2020); and M. J. Scully, G. A. Norris, T. M. Alarcon Falconi, D. L. MacIntosh, Carbon intensity of corn ethanol in the United States: State of the science. *Environ. Res. Lett.* **16**, 043001 (2021).

[208] U.S. Energy Information Administration. (2020, November 18). *Gasoline explained - octane in depth - U.S. Energy Information Administration (EIA).* Www.eia.gov. https://www.eia.gov/energyexplained/gasoline/octane-in-depth.php

[209] Ibid.

[210] Wikipedia Contributors. (2024, March 29). *List of U.S. states by standard octane ratings.* Wikipedia; Wikimedia Foundation.

[211] *Chevron with Techron | Chevron With Techron (US).* (n.d.). https://www.chevronwithtechron.com

[212] *Shell V-Power® NiTRO+ Premium Gasoline.* (n.d.). Www.shell.us. https://www.shell.us/motorist/shell-fuels/shell-v-power-nitro-plus-premium-gasoline.html

In general, branded products contain cleaning additives that help improve engine performance and longevity. However, the overall engine performance of the additives is also influenced by the particular engine, including its purpose and manufacturer. Branded products are sold to the public through gas stations that are either privately owned, leased, or operated by the brand that flags the station. Due to the additives and their special chemistries, branded gasoline commands a price premium.

- Branded gasoline costs $.05 to $.10 more per gallon at wholesale.[213]

- Unbranded gasoline products are as named. They are unbranded. Unbranded gasoline is sold to independent retail gasoline dealers without affiliation or contractual obligation with a branded product or special blend. Typically, unbranded gasoline is sold by independent dealers and retailers and at prices that are often less than branded on a per gallon basis.

3.8 Gasoline Storage and Days Inventory

Refined gasoline has unique qualities. One of which is that gasoline is a deteriorating asset. That is, gasoline, in its final form, has a short shelf life. As many farmers and collectors of antique vehicles know, if left untreated, gasoline begins to degrade and, after about six months, can relinquish much of its quality as a fuel.[214] As a product, refined gasoline will begin to degrade and lose its qualities as quickly as thirty (30) days (depending on conditions) and continues to do so until it reaches a varnish or tar-type state, making it entirely unsuitable for sale or use.[215] Stale or varnished gasoline contains contaminants and forfeits much of its detergent and intended combustible qualities. The use of degraded gasoline can also cause considerable damage to internal combustion engines. The degradation process, combined with the volatility of its combustible and flammable qualities, makes storing gasoline for long periods difficult, costly, and potentially hazardous.

Likewise, gasoline that contains ethanol (E10 and E15 blends), such as those mandated by California and Federal regulations, also has a shelf life. Ethanol blended gasoline can begin to break down and lose its properties in as little as three (3) days, with a typical range of 3 to 39 days.[216] However, if stored properly with the correct stabilizers, gasoline can be stored for prolonged periods, but its chemistry may be changed, making it potentially inconsistent with regulatory formula requirements.[217]

In its final form, gasoline represents a finished product with all the acquisition, transportation, production, and holding costs embedded in it. Refinery petroleum inventory is stored onsite in large tanks or storage depots near refineries.[218] As with any final product, holding costs exceed raw material costs, impacting free cash flows and profitability. Due to petroleum products' costs and inherent decay properties, refiners tend to produce gasoline to match the demand as closely as possible. Consequently,

---

[213] Gabe Wateski. (2023, July 21). *Difference Between Branded and Unbranded Fuel | Venture Fuels.* Venture Fuels. https://www.venturefuels.com/venture-fuels-content/branded-vs-unbranded-fuel/

[214] *How Long Can Gas Sit in a Car Before it Goes Bad?* (n.d.). J.D. Power. https://www.jdpower.com/cars/shopping-guides/how-long-can-gas-sit-in-a-car-before-it-goes-bad

[215] Moore, T. (2023, February 28). *How Long Can Fuel Really Be Stored For?* AXI International. https://axi-international.com/the-shelf-life-of-fuel-how-long-can-gasoline-and-diesel-be-stored/

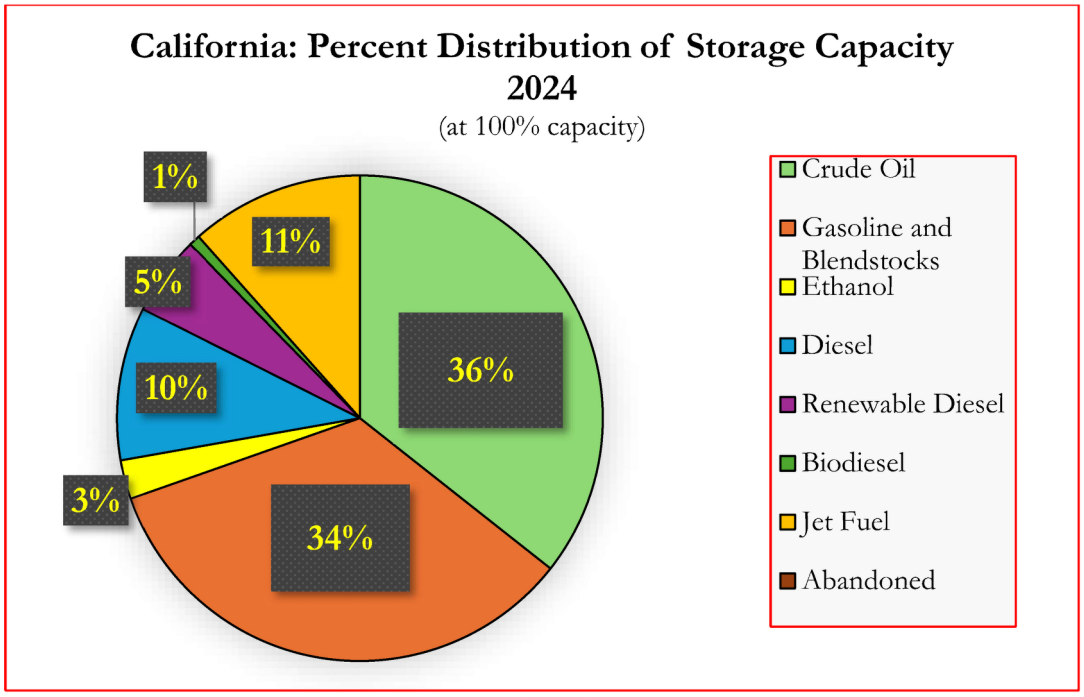
[216] *ContentKeeper Content Filtering.* (2024). Mass.gov. https://www.mass.gov/doc/large-volume-ethanol-spills-environmental-impacts-response-options/download

[217] insideout. (2020, February 1). *Does Gasoline Go Bad?* Rislone. https://rislone.com/blog/fuel-system/does-gasoline-go-bad/

[218] *Weekly Petroleum Status Report/Energy Information Administration 1.* (n.d.). https://www.eia.gov/petroleum/supply/weekly/pdf/table1.pdf

refiners tend to hold minimal inventories of finished gasoline products. In total, U.S. refiners collectively maintain around 426 million barrels of crude oil or 21.03 days' supply.[219] According to the CEC, California refiners have a maximum crude oil and gasoline and gasoline blendstocks of 13.3 and 12.7 million barrels of oil and gasoline, respectively, for 2024. This equates to approximately 558.6 and 533.4 million gallons of oil and gasoline, respectively, held as "inventory" stock. Refinery petroleum inventory is stored either onsite in large tanks or in storage depots located near refineries.[220]

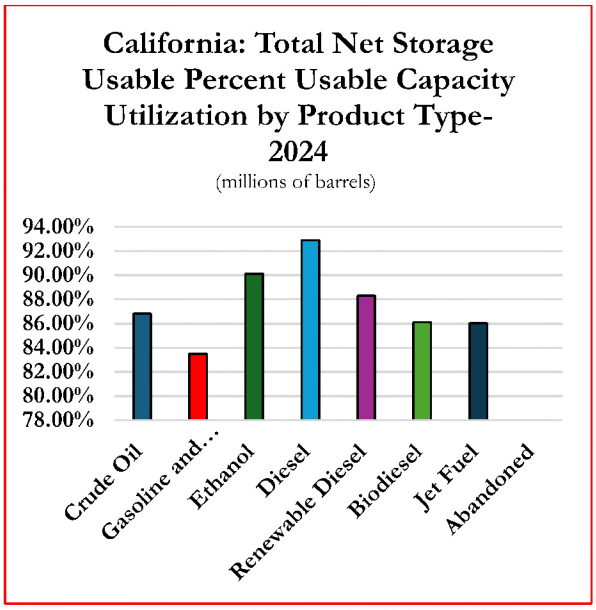
Exhibit 3.43



(Source: https://www.energy.ca.gov/sites/default/files/2024-06/CEC-200-2024-010.pdf))

[219] *Weekly Petroleum Status Report/Energy Information Administration 1*. (n.d.). https://www.eia.gov/petroleum/supply/weekly/pdf/table1.pdf
[220] Energy Information Administration. (2025). Weekly Petroleum status report. In *Energy Information Administration*. https://www.eia.gov/petroleum/supply/weekly/pdf/table1.pdf

Exhibit 3.44



California: Total Net Storage Usable Percent Usable Capacity

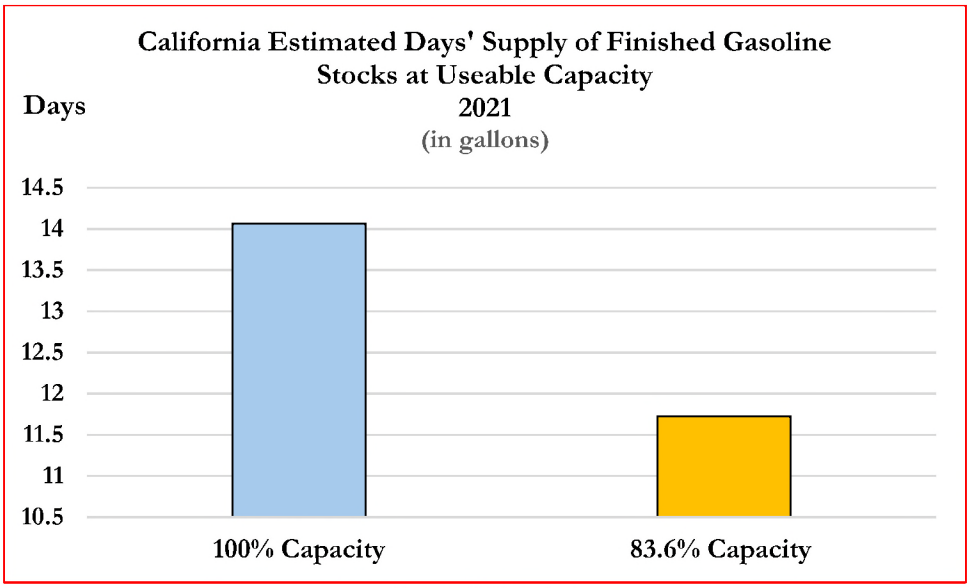
Product	Utilization
Crude Oil	86.80%
Gasoline and Blendstocks	83.50%
Ethanol	90.10%
Diesel	92.90%
Renewable Diesel	88.30%
Biodiesel	86.10%
Jet Fuel	86.00%
Abandoned	

(Source: https://www.energy.ca.gov/sites/default/files/2024-06/CEC-200-2024-010.pdf)

Based on CEC capacity utilization data and the 2024 average daily consumption rate for gasoline, California's estimated days' supply of gasoline ranges from a maximum capacity of 534,427,362 gallons or 14.7 days' supply to 445,539,486 gallons or 11.74 days' supply at 83.6% capacity utilization (see, Section 2.0).[221] As a comparison, in addition to the crude oil inventories maintained by refiners, the U.S. has its Strategic Petroleum Reserve (SPR) which was established by Congress in response to the Arab Oil Embargo of 1973.[222] Under the Biden Administration, the SPR inventory declined by 38.5% from 638.08 million barrels of oil on January 29, 2021, to 391.81 million barrels as of January 31, 2025.[223] Based on the current consumption of 20.25 million barrels of oil per day, the U.S. has about 19.3 days of supply in the SPR, down from 31.5 days in January 2021.[224]

[221] According to the CEC, for 2021, California consumed 13.82 billion gallons of gasoline or 38 millions gallons of gasoline per day.
[222] *SPR Origins*. (n.d.). Energy.gov. https://www.energy.gov/ceser/spr-origins
[223] W*eekly U.S. ending stocks of crude oil in SPR (Thousand barrels).* (n.d.). https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=WCSSTUS1&f=W
[224] https://www.eia.gov/tools/faqs/faq.php?id=33&t=6

Exhibit 3.45



(Source: CEC, Author)

Depending on conditions, location, regulations, restrictions, and contractual arrangements, retail gas stations typically replenish their inventories every 3 to 5 days.[225] The gasoline sold by a retail station is retained in underground storage tanks (UST) and represents their "inventory," which is composed of premium, mid, and regular fuel grades. Based on various sources, the capacity of the UTS generally ranges from 5,000 to 35,000 gallons. For example, the API reports that the average retail station maintains between 30,000 to 40,000[226] gallons, while the Oil and Gas Blog estimates 12,000 to 24,000 gallons.[227] The amount of gas that any station can maintain as inventory in their USTs varies considerably and is determined by factors such as the physical size of the gas station, including location, work bays, convenience store and number of pumps, lot size, set-back and depth restrictions, geology, and, most importantly, zoning regulations, and local and state laws, as well as the EPA.

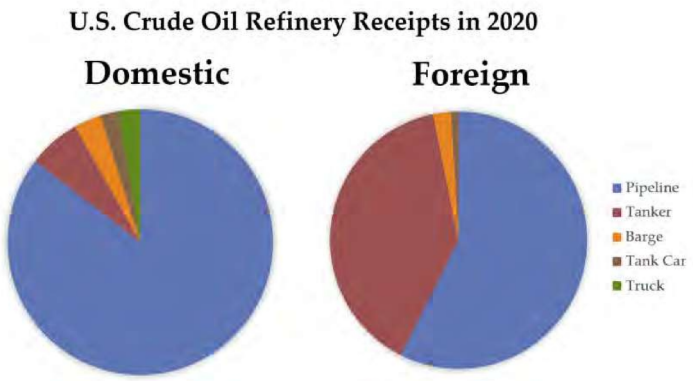
- In California, there is a $0.02 a gallon UST fee/tax on every gallon of gasoline sold.

3.9 California Oil Transportation: Pipelines, Marine Vessels, Rail & Truck

3.9.1 Crude & Gas Movement. Petroleum products, such as oil and gasoline, are moved from point to point using various transportation methods, including marine vessels, barges, pipelines, rail tankers, and truck tankers. The movement of gasoline and oil is supported by storage tanks for short-term product storage. Each method of movement has its unique qualities, mission purpose, environmental impact, convenience, risks, and costs. Below is an exhibit summarizing all U.S. refinery oil receiving by transportation mode for 2020. (Note: as U.S. domestic oil production increased, ocean imports via tankers declined. Domestically produced U.S. oil is moved via pipelines.)

[225] Various including: Sheets, C. (2022, March 15). *Why California gas prices vary: "Mystery surcharge" and more.* Los Angeles Times. https://www.latimes.com/california/story/2022-03-14/gas-prices-vary-from-place-to-place
[226] *Gas Stations.* (2024). Oilspillprevention.org. https://www.oilspillprevention.org/oil-spill-sources/gas-stations
[227] *(2025). Nipexnig.com. http://nipexnig.com/technologies/how-many-gallons-are-in-a-gas-station.html*

Exhibit 3.46
U.S. Crude Oil Refinery Receipts by Transportation Mode 2020[228]

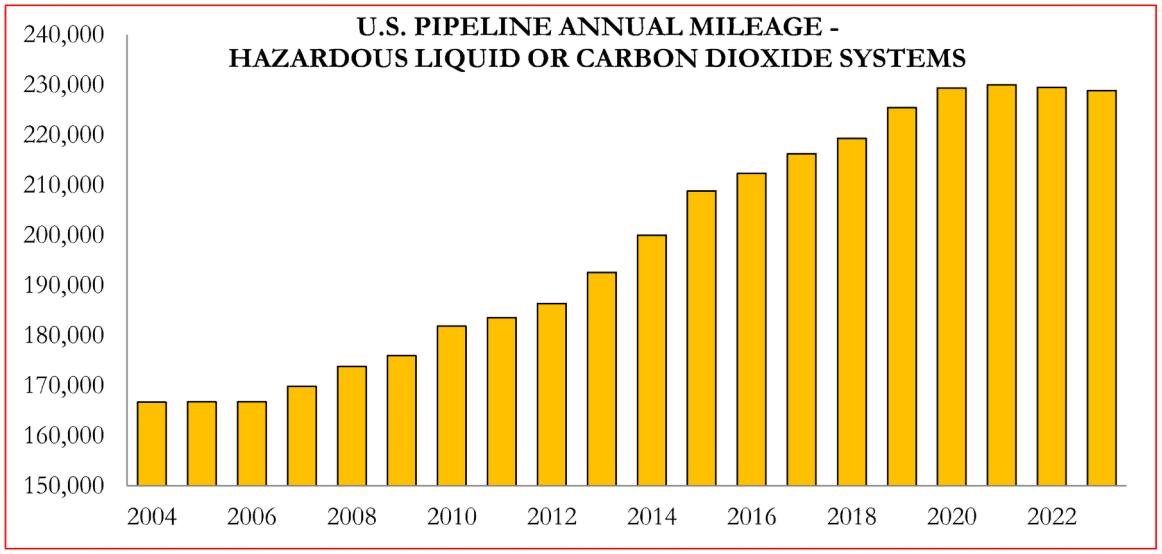


Percent of Receipts	Domestic	Foreign
Pipeline	85%	56%
Tanker	6%	39%
Barge	4%	2%
Tank Car	2%	1%
Truck	3%	0%

(Source: EIA)

The U.S. has over 3.0 million miles of pipelines, of which 684 individual lines representing 228,881 miles were used for gasoline and oil movement in 2023.[229] From 2004 to 2020, the total miles of U.S. pipelines increased 38%. However, commencing in 2021, total miles declined somewhat.

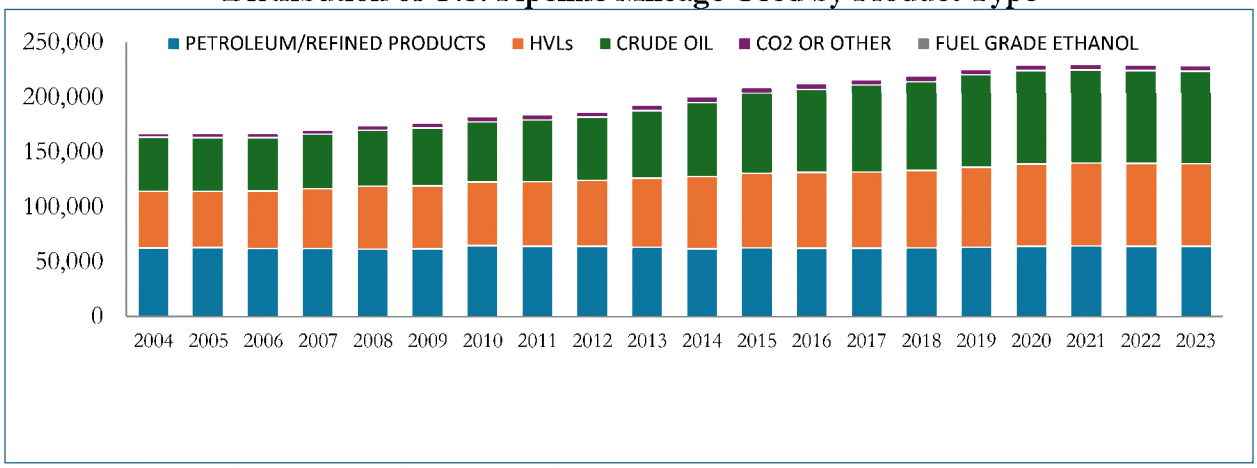
Exhibit 3.47



(Source: https://www.phmsa.dot.gov/data-and-statistics/pipeline/annual-report-mileage-hazardous-liquid-or-carbon-dioxide-systems

[228] *U.S. Total Refinery Receipts of Crude Oil by Method of Transportation*. (2018). Eia.gov. https://www.eia.gov/dnav/pet/pet_pnp_caprec_dcu_nus_a.htm
[229] *Annual Report Mileage for Hazardous Liquid or Carbon Dioxide Systems | PHMSA*. (n.d.). Www.phmsa.dot.gov. https://www.phmsa.dot.gov/data-and-statistics/pipeline/annual-report-mileage-hazardous-liquid-or-carbon-dioxide-systems

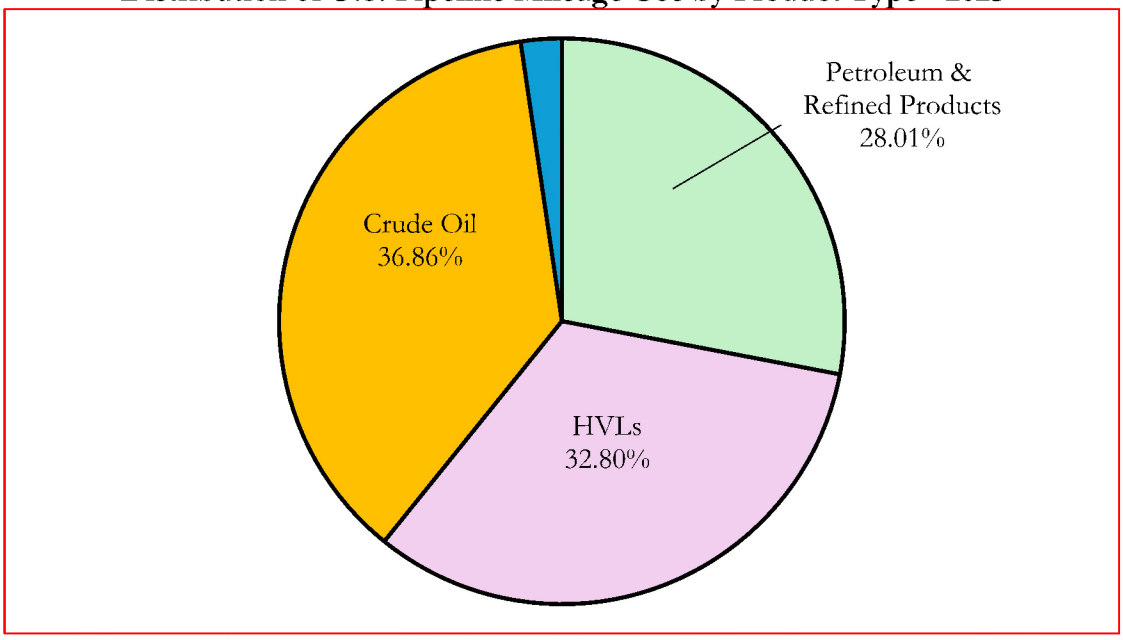
Exhibit 3.48
Distribution of U.S. Pipeline Mileage Used by Product Type



(Source: https://www.phmsa.dot.gov/data-and-statistics/pipeline/annual-report-mileage-hazardous-liquid-or-carbon-dioxide-systems)

As indicated in the exhibit above, the movement of crude oil and HVLs occupy the majority use of U.S. total pipeline mileage.

Exhibit 3.49
Distribution of U.S. Pipeline Mileage Use by Product Type - 2023



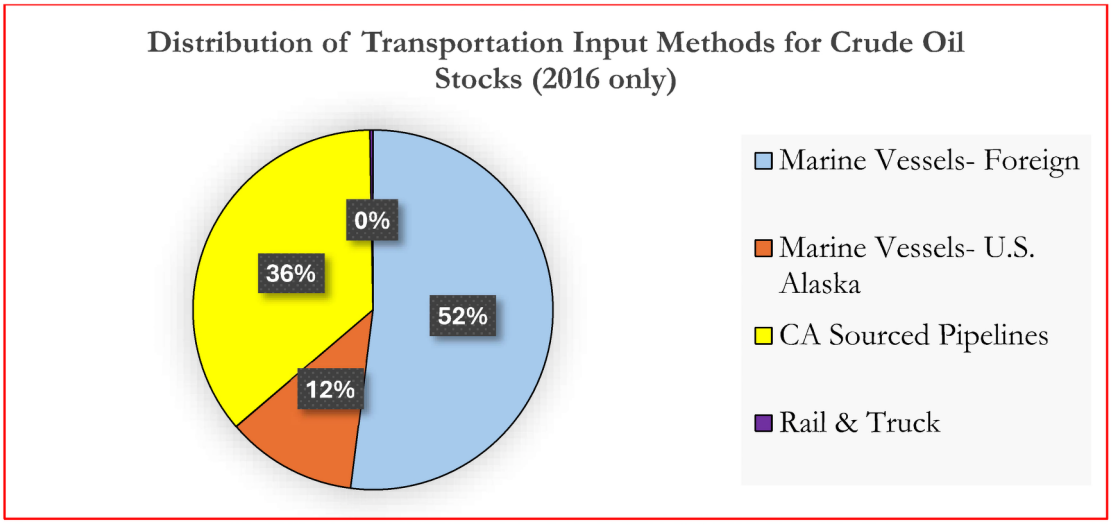
(Source: https://www.phmsa.dot.gov/data-and-statistics/pipeline/annual-report-mileage-hazardous-liquid-or-carbon-dioxide-systems)

Moving oil from field production to U.S. refineries through pipelines is the least expensive and safest of movement modes. According to the U.S. Department of Transportation, "It would take a constant line of tanker trucks, about 750 per day, loading up and moving out every two minutes, 24 hours a

day, seven days a week, to move the volume of even a modest pipeline. The railroad equivalent of this single pipeline would be a train of 225, 28,000-gallon tank cars."[230]

California has several aspects of its petroleum transportation network that combine to make it a unique and challenging environment. California is large. Its coastline is 163,696 square miles, 840 miles long, 350 miles wide, stretching 900 miles from its southern to northern tips.[231] California's sheer size and incredibly varied terrain and climates necessitate multiple transportation methods that can move vast distances while navigating elevations from 286 below sea level to over 14,000 above sea level, as well as desert and arctic climates. Around 85% of California's approximately 39 million residents live in "coastal counties" on or near the Pacific Ocean.[232] The majority of California's gasoline states are located near major freeways and its coastal population centers. California has no inbound pipelines for oil or gasoline. Therefore, California is isolated and "on its own" as it does not share any inbound pipelines with other states.[233] California supplies between 80% to 88% of Nevada's gasoline needs through two outbound pipelines and 45% to 48% of Arizona's gasoline.[234] The exhibit below summarizes the primary distribution transportation methods for California's crude oil.

Exhibit 3.50



(Source: https://www.naseo.org/Data/Sites/1/schremp-1.pdf)

[230] *General Pipeline FAQs | PHMSA*. (2019). Dot.gov. https://www.phmsa.dot.gov/faqs/general-pipeline-faqs
[231] *California Geography Essentials | Visit California*. (2019, November 13). Www.visitcalifornia.com. https://www.visitcalifornia.com/experience/california-geography-essentials/
[232] Bonta, R. (2017, July 20). *Climate Change Impacts in California*. State of California - Department of Justice - Office of the Attorney General. https://oag.ca.gov/environment/impact
[233] *Project Title: SB X1-2 Implementation*. (n.d.). https://seuc.senate.ca.gov/sites/seuc.senate.ca.gov/files/cdtfa_cec_joint_report_2024_review_of_the_gasoline_in_california_and_relate.pdf
[234] *Crude Oil | The California Energy Atlas*. (2016). CA Energy Atlas. https://www.californiaenergyatlas.com/copy-of-crude-oil

3.9.2 Maritime Vessels. Over 98% of California's non-U.S. sourced imported oil is delivered to its refineries via maritime vessels.[235] For 2023, California received 61% of its crude oil stocks from foreign sources and 16% from Alaska. Oil imports from these sources are delivered to California using maritime oil tanker vessels (limited barge).[236] Maritime vessels (oil tankers) are the most cost effective and most commonly used transportation method to move massive amounts of crude oil across long distances, typically from the point of production to a marine terminal. Tankers that move oil among and between U.S. ports must comply with the Jones Act.[237]

Refineries in California are located in close proximity to the marine terminals near San Francisco and Los Angeles. California has 12 ports, and very large crude carriers (VLCCs) oil tankers generally use California's largest ports, which are the ports of Long Beach and Los Angeles, for the importation of crude oil. However, VLCC may also be able to use the Ports of Oakland, San Diego, and Hueneme under certain specific conditions.[238]

3.9.3 Pipelines. California has no inbound pipelines but has an extensive in-state (intrastate) network of pipelines for moving oil and gasoline from refineries to distribution points (racks), as well as end-users such as airports. California also has two major outbound pipelines to supply gasoline to Nevada and Arizona. California's pipeline network is composed of common carrier arteries that transport products from multiple producers and proprietary pipelines. Proprietary pipelines are owned and operated by companies such as Chevron and ExxonMobil. The sole private common carrier in California is Kinder Morgan.[239]Kinder Morgan owns, has an interest in, and operates over 79,000 miles of pipelines and 139 terminals throughout the U.S.[240] For perspective, according to the U.S. Department of Transportation, the U.S. has over 2.6 million miles of installed petroleum and petroleum-related pipelines.[241] Pipelines carry fuels to 60 distribution points in the state.

Modern pipelines are the most efficient and effective method for moving petroleum, gasoline, and natural gas. According to the U.S. Department of Transportation, the U.S. is the safest method to transport petroleum products.[242] A modern pipeline integrates advanced technologies with continuous operations to monitor safety and environmental impacts. In the U.S., pipelines and pipeline operations are highly regulated and fall under the purview of various federal, state, and local agencies, including the Pipeline and Hazardous Materials Safety Administration. In California, the California Department of Conservation's Geologic Energy Management Division (CalGEM) and the California Office of the State Fire Marshall (OSFM) oversee oil and gas pipelines.[243] As codified in California Regulations sections 1774, 1774.1, and 1774.2, California has the strictest standards for oil and gasoline pipeline construction, testing, and maintenance in the world. California Regulations 1722, 1722.9, 1773.1, and

[235] https://www.energy.ca.gov/sites/default/files/2022-07/2022-07_Petroleum_Watch_ADA.pdf
[236] Commission, C. E. (n.d.). *Foreign Sources of Crude Oil Imports to California 2020*. California Energy Commission. https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/foreign-sources-crude-oil-imports
[237] Section 27 of the Merchant Marine Act of 1920 (P.L. 66-261). See, also: https://crsreports.congress.gov/product/pdf/R/R45725
[238] *Overview of California's Ports*. (n.d.). Lao.ca.gov. https://lao.ca.gov/Publications/Report/4618
[239] Schremp, G. (2016). *PADD 5 & California Transportation Fuel Overview Western Regional Emergency Fuel Coordination Meeting California Energy Commission Sacramento, CA*. https://www.naseo.org/Data/Sites/1/schremp-1.pdf
[240] *Home - Kinder Morgan*. (n.d.). Www.kindermorgan.com. https://www.kindermorgan.com
[241] *General Pipeline FAQs*. (n.d.). PHMSA. https://www.phmsa.dot.gov/faqs/general-pipeline-faqs
[242] *General Pipeline FAQs*. (n.d.). PHMSA. https://www.phmsa.dot.gov/faqs/general-pipeline-faqs
[243] California Department of Conservation. (n.d.). *Pipelines and facilities*. https://www.conservation.ca.gov/calgem/for_operators/Pages/Facilities.aspx#:~:text=Generally%2C%20CalGEM%20regulates%20all%20pipelines,used%20for%20transportation%20to%20refineries.

1775 provide for some of the most rigorous environmental protection standards in the world as related to oil and gas production.

Moving oil safely and efficiently through a pipeline requires sophisticated technologies involving collecting areas, pipes, pump stations, and temperature control. Heavy and extra heavy oils, as well as oils and pipelines in colder climates, require insulation and heating. In colder climates or when moving extra heavy crudes, as the temperature drops, oil becomes more viscous; that is, it becomes thicker and flows slower.[244] As a result of slower oil movement, pipelines will experience wax build-up on their internal surfaces, which must be cleaned periodically. A gasoline or pipeline can range from 4 to 48 inches in diameter.[245]

In addition to crude oil, the same pipelines may also be configured to move multiple fuel types, such as all grades of conventional gasoline, jet fuel and kerosene, heating oils, multiple grades of CARFG, and ultra-low sulfur diesel fuels. Moving different fuels through the same pipeline is accomplished in large batches, with extensive "clean-outs" occurring between each batch of products. As clean-outs are mandatory and essential to the proper and safe operation of the pipelines, they must be carefully scheduled and coordinated.

Construction costs for modern oil or gasoline pipelines can cost between $4.7 to over $10.4 million per mile, depending on geography, climate, distance, engineering, type of pipe, and other costs.[246] Generally, pipelines are buried 3 to 6 feet below ground surface. However, in some instances, geology, regulations, and engineering may require surface structures. For perspective, below is a summary of the estimated various construction costs for a modern oil and gas pipeline:

- "Oil & Gas Journal 2015-2016: $4.75 million/km (U.S. onshore gas),
- Oil & Gas Journal 2014-2015: $3.23 million/km (U.S. onshore gas),
- American Petroleum Institute 2017: $3.32 million/km (U.S. onshore gas, national average),
- Global Fossil Infrastructure Tracker median for 64 onshore and offshore projects: $2.34 million/km (date unspecified, worldwide)."[247]

Pipelines are the most cost-efficient and safest methods of moving gasoline and crude oil. The cost of transporting a single barrel of oil via pipelines ranges between $0.50 to $5.00 depending on distances, volumes, carriers, and other factors. Pipeline owners and/or operators establish the rate (cost) for transporting crude oil or gasoline as per regulatory guidance or requirements. Typically, producers (shippers) of crude or gasoline who use the pipeline enter into long-term contracts ranging from 10 to 20 years with the owner/operator. As the oil or gasoline travels through the pipeline, various costs, fees, tolls, royalties, and tariffs will be incurred, which the shipper incurs.

---

[244] The. (2025). *The Effect of Temperature on Lubricant Viscosity | Business*. Shell.us; Business. https://www.shell.us/business/fuels-and-lubricants/lubricants-for-business/lubricants-services/industry-articles/the-effect-of-temperature-on-lubricant-viscosity.html. See also, Mathura, S. (2023, March 26). *Oil Viscosity: A Practical Guide*. Precision Lubrication. https://precisionlubrication.com/articles/oil-viscosity/

[245] https://www.onesteppower.com/post/how-is-oil-transported

[246] *Rail deliveries of oil and petroleum products up 38% in first half of 2012 - U.S. Energy Information Administration (EIA)*. (n.d.). https://www.eia.gov/todayinenergy/detail.php?id=7270#:~:text=Shipping%20oil%20by%20rail%20costs,focuses%20on%20freight%20transportation%20costs.

[247] Global Energy Monitor. (2021, May 1). *Oil and Gas Pipeline Construction Costs - Global Energy Monitor*. https://www.gem.wiki/Oil_and_Gas_Pipeline_Construction_Costs

3.9.4 Rail Tankers. California received less than one percent of crude oil shipments to its refineries in 2021. California uses rail for moving propane, sulfuric acids, and butane, as opposed to finished gasoline or crude oil.[248] California has only a minimal amount (less than 1% in 2015) of inbound oil transported using rail tankers, most of which was sourced from Canada (4.27%).[249] [250] In 2024, California received no inbound crude from Canada via rail but did import 468,000 barrels from North Dakota by rail tanker.[251] In the U.S., a DOT-117 certified rail tanker can hold up to 286,000 gallons of product and must be designated with NA1993 identification.[252] [253] However, in rail transport, one of the controlling factors is the capacity of the rail track. Rail tracks are rated for speed and weight and, therefore, have restrictions. Similar restrictions are associated with tunnels, bridges, curves, incline grades, declines, and urban areas. The cost of transporting a barrel of oil via rail tanker ranges between $10 to $20.00.[254] [255] In California, the major rail carriers include BNSF, Union Pacific, and other operators. The CEC provides maps of the various California rail lines and rail tanker routes used in the State.[256]

Using tanker cars to transport crude oil usually requires the leasing of the rail tanker from 1 to 7 years, with lease payments paid monthly. The calculated cost to transport a barrel of oil via a rail tanker will depend on a number of factors, such as the load capacity (volumetric capacity), density of oil, ambient temperature at the time of loading, and track weight ratings and limitations. In general, rail tankers are loaded to 94% of their volumetric limits and 98% of their load capacities.[257] Other costs include terminal fees, loading and unloading costs, and rail rates.

3.9.5 Tanker Trucks. Of the estimated 166.1 million commercial and private trucks registered in the U.S., California is home to 9.6%, or 15.9 million.[258] Tanker trucks are used for the local delivery of crude oil and gasoline and, as such, have significant variability in cost. Distance from the tanker rack to the end user, typically a gas station, is a factor in transportation costs, which are reflected in the retail pump prices. Additionally, as fuel costs increase for the trucker, so do delivery costs, which, in turn, are reflected at the retail gasoline pump.

California relies extensively on tanker trucks for the shipping of finished gasoline products from refineries to distributors (racks) and onward to retail gasoline stations. In 2015, tanker trucks averaged

---

[248] https://calepa.ca.gov/wp-content/uploads/sites/6/2016/10/Refinery-Documents-2015yr-Petroleum.pdf
[249] Schremp, G. & California Energy Commission. (2016). California transportation fuel overview. In *Western Regional Emergency Fuel Coordination Meeting*. https://www.nasco.org/Data/Sites/1/schremp-1.pdf
[250]Commission, C. E. (n.d.). *Foreign Sources of Crude Oil Imports to California 2020*. California Energy Commission. https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/foreign-sources-crude-oil-imports
[251] California Energy Commission. (2024). *Crude Oil Imports By Rail*. California Energy Commission. https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/annual-oil-supply-sources-california/crude
[252] *More Rail Tank Cars Meet DOT-117 Safety Standards in 2022 | Bureau of Transportation Statistics*. (2022). Bts.gov. https://www.bts.gov/newsroom/more-rail-tank-cars-meet-dot-117-safety-standards-2022
[253] *Economics of Rail versus Pipeline*. (n.d.-b). Welcome to Altex Energy. https://www.altex-energy.com/economics-of-rail-versus-pipeline/#1501828266955-2913a69d-c276
[254] *Shipping Petroleum Products*. (2023, May 30). Www.freightcenter.com. https://www.freightcenter.com/shipping/petroleum-products/
[255] *Rail deliveries of oil and petroleum products up 38% in first half of 2012 - U.S. Energy Information Administration (EIA)*. (2025). Eia.gov. https://www.eia.gov/todayinenergy/detail.php?id=7270
[256] *Department of Conservation Map Server*. (2025). Ca.gov. https://maps.conservation.ca.gov/oilgas/
[257] *Economics of Rail versus Pipeline*. (n.d.). Welcome to Altex Energy. https://www.altex-energy.com/economics-of-rail-versus-pipeline/#1501828266955-2913a69d-c276
[258] *Registered U.S. private and commercial trucks by state*. (n.d.). Statista. https://www.statista.com/statistics/191023/registered-private-and-commercial-trucks-in-the-us-by-state/

approximately 4,980 deliveries per day, representing 39.84 million gallons of gasoline.[259] In California, 94% of all trucks are fueled by either diesel (67%) or gasoline (25%).[260]

The shipping of oil and gasoline using trucks is the most expensive and least efficient mass volume transportation method based on cost per barrel or gallon. Tanker trucks come in various sizes and configurations, including high-pressurized bulk, low-pressurized bulk compressed gas, and others. Fuel tanker trucks are usually non- or low-pressure liquid bulk carriers. In contrast to the massive volumes of barrels or gallons that are carried by rail tankers and maritime vessels, tanker trucks carry between 200 to 250 barrels of oil, or 8,400 to 10,500 gallons, depending on configuration and DOT rating. In California, as well as other states, tanker trucks are heavily regulated and require special licenses to operate. The cost of transporting a barrel of oil via tanker truck is roughly double that of rail or ranges between $20 to $40.00, depending on multiple factors such as distance, tolls, terrain, and the condition and mechanics of the truck.[261] Summarized below are the estimated ranges for the cost of shipping/transporting a barrel of oil from its source to Los Angeles by method.

Exhibit 3.51

SUMMARY OF TRANSPORTATION COSTS PER BARREL OF OIL BY METHOD

From to Los Angeles	Pipeline	Tanker	Rail	Truck
San Joaquin Valley	$0.50-$5.00			
Alaska North Slope		$5.00		
Brazil		$5.00		
Middle East		$6.00		
Canada			$10-$20	
U.S. (Gasoline)			$5-$20	$20 -$40

(Source: Source: https://www.wspa.org/wp-content/uploads/CA-Gas-Receipts-Feb-2024-v2-1.pdf & various)

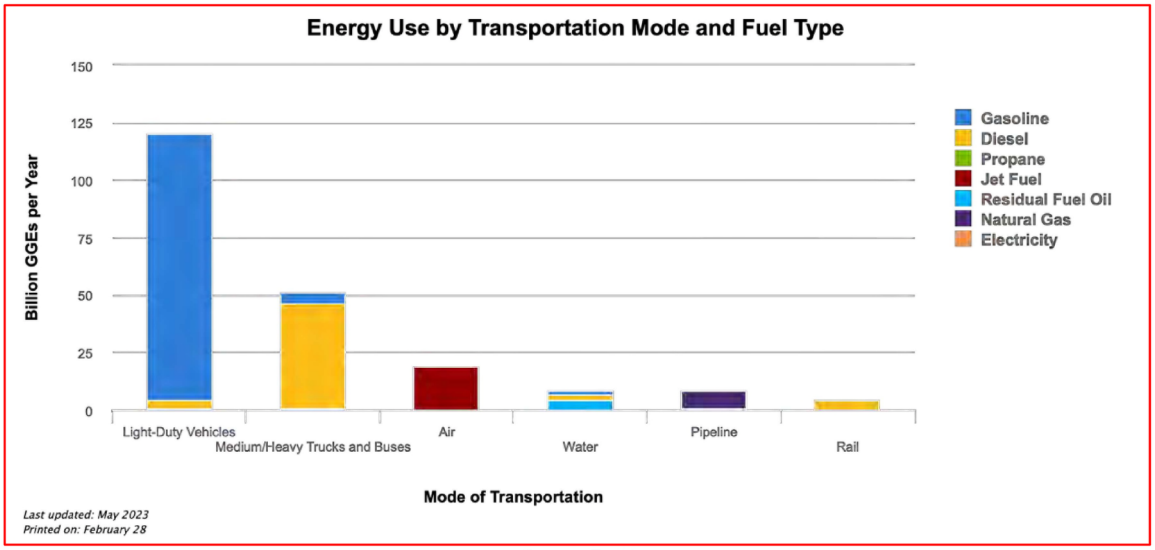
Summarized in the exhibit below is the energy use (consumption) associated with modes of transportation.

[259] Crockett, & Schremp, G. (2015). *California Transportation of Petroleum Second Northern California Refinery Safety Forum.* https://calepa.ca.gov/wp-content/uploads/sites/6/2016/10/Refinery-Documents-2015yr-Petroleum.pdf

[260] California. (n.d.). *Large Entity Fleet Reporting STATEWIDE AGGREGATED DATA.* Retrieved February 23, 2025, from https://ww2.arb.ca.gov/sites/default/files/2022-02/Large_Entity_Reporting_Aggregated_Data_ADA.pdf

[261] Green, K. P. (2018). *Pipeline crunch sending crude to markets—by truck.* Fraser Institute. https://www.fraserinstitute.org/commentary/pipeline-crunch-sending-crude-markets-truck

Exhibit 3.52



(Source: DoE)

SECTION 4.0
CALIFORNIA OIL IMPORTS & FOREIGN OIL SOURCES

A STUDY OF CALIFORNIA GASOLINE PRICES
Section 4.0
Table Of Contents

4.0 CA Oil Imports & Foreign Oil Sources

4.1 California Sources of Foreign Imports

4.2 California Compared to U.S. Oil Imports

4.3 Greenhouse Gas Emissions- Imports

4.3.1 Production Emissions

4.3.2 Maritime Tanker Movement & GHG & Routes

4.0 CA OIL IMPORTS & FOREIGN OIL SOURCES

4.1 California Sources of Foreign Imports

No state in the U.S. imports more foreign sourced oil for its use than California. In 2023, California imported 321.153 million barrels of oil from non-U.S. sources. Since 1982, California imports of foreign oil have increased by 857%. In 2024, California imports increased slightly to 321.831 million barrels of oil, or .21%. In 2024, as U.S. imports of foreign oil hit a thirty-year low, California imports of crude came within 13% of its thirty-year high (2018).[262] California holds around 3% of U.S. oil reserves and ranks 5th in the nation in proven reserves.[263] [264] Nonetheless, California is virtually wholly dependent on foreign oil sources to meet its gasoline production demands.

For 2023, 60.7% of California's oil was imported from foreign sources, including the petrostates of Iraq (21.7%) and Saudi Arabia (15.7%). South America's Brazil and Ecuador represented the third and fourth largest sources of California import sources at 15.1% and 14.6%, respectively. Collectively, and based on CEC data, the three largest sources (Iraq, Saudi Arabia, and Brazil) represented 52.4% of all California foreign imports.[265] Middle Eastern oil from OPEC members Saudi Arabia, Iraq, and the U.A.E. collectively represented 39.25% of all California oil imports for 2023.

However, in 2024, California changed its mix of non-U.S. foreign imports. Iraq, which provided 68,406 barrels of oil composed 21.26% of its non-U.S. oil imports. Brazilian oil imports increased to 20.41%, and as production scaled in Guyana, imports from that South American country increased exports to California to 50,840 barrels or 15.80% of total 321,831 barrels of non-U.S. imported oil.[266] California has also imported oil from Russia, Angola, Oman, and other national providers.[267] Depicted below is a representation of major sources of California oil for 2024 as provided by the CEC.

---

[262] Roberts, K. (2024, August 19). *2024 U.S. oil imports from Middle East hit new record low*. Forbes. https://www.forbes.com/sites/kenroberts/2024/08/16/2024-us-oil-imports-from-middle-east-hit-new-record-low/. See also, EIA and CEC import data.

[263] *California State Energy Profile*. California Profile. (n.d.-a). https://www.eia.gov/state/print.php?sid=CA

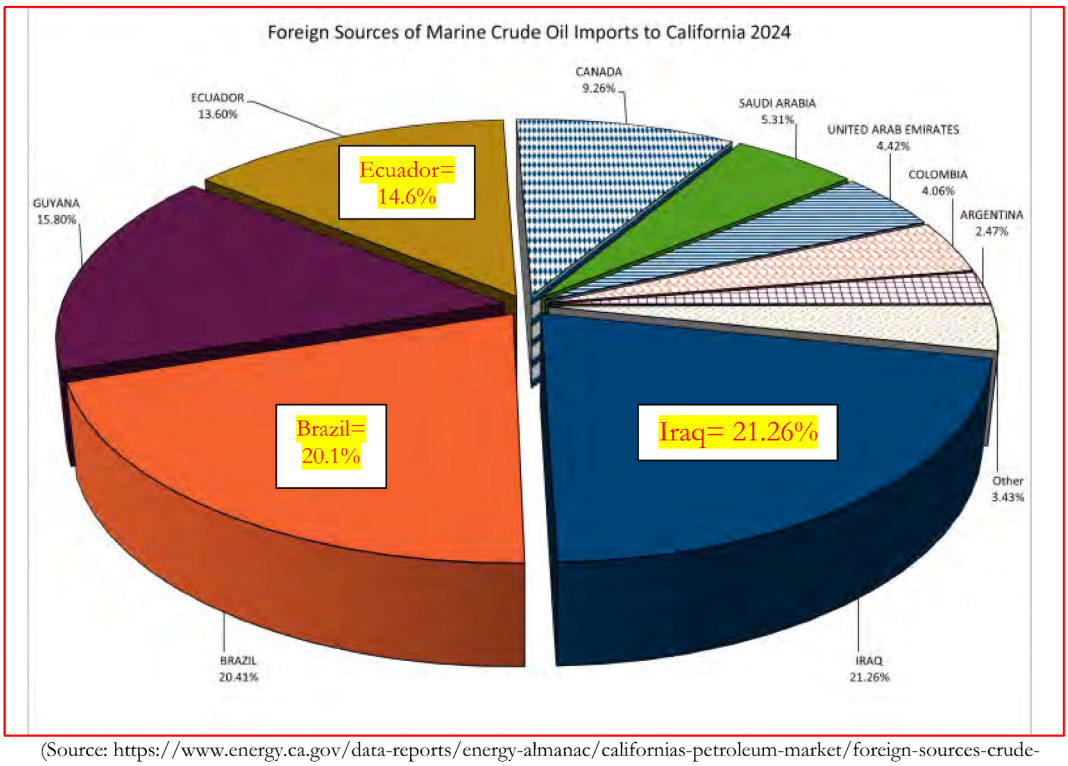
[264] Jones, J. (2024a, June 29). *States with the most oil reserves [2024]*. Construction Coverage. https://constructioncoverage.com/research/states-with-the-most-oil-reserves

[265] California Energy Commission. (n.d.-h). *Foreign sources of crude oil imports to California*. https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/foreign-sources-crude-oil-imports

[266] California Energy Commission. (n.d.-d). *Foreign sources of crude oil imports to California*. https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/foreign-sources-crude-oil-imports

[267] *California 2019 crude average carbon intensity up*. (2019). Green Car Congress. https://www.greencarcongress.com/2020/06/20200616-carbci.html

Exhibit 4.1



(Source: https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/foreign-sources-crude-oil-imports)

Depicted below is a comparison of California imported oil sources for the years 2023 and 2024.

Exhibit 4.2

Comparison: Percent of Oil Imports by Source- California 2023 vs 2024		
Source	**California 2023**	**California 2024**
Iraq	21.70%	21.26%
Saudi Arabia	15.70%	5.31%
Brazil	15.10%	20.41%
Ecuador	14.60%	13.60%
Mexico	4.15%	<2%
Guyana	9.73%	15.80%
Canada	4.27%	9.26%

(Source: https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/foreign-sources-crude-oil-imports)

Compared to all U.S. oil imports, for 2024, California has a significantly greater dependency on and a higher percentage of foreign oil from petrostate Iraq, and South America's Brazil and Ecuador than the overall U.S.

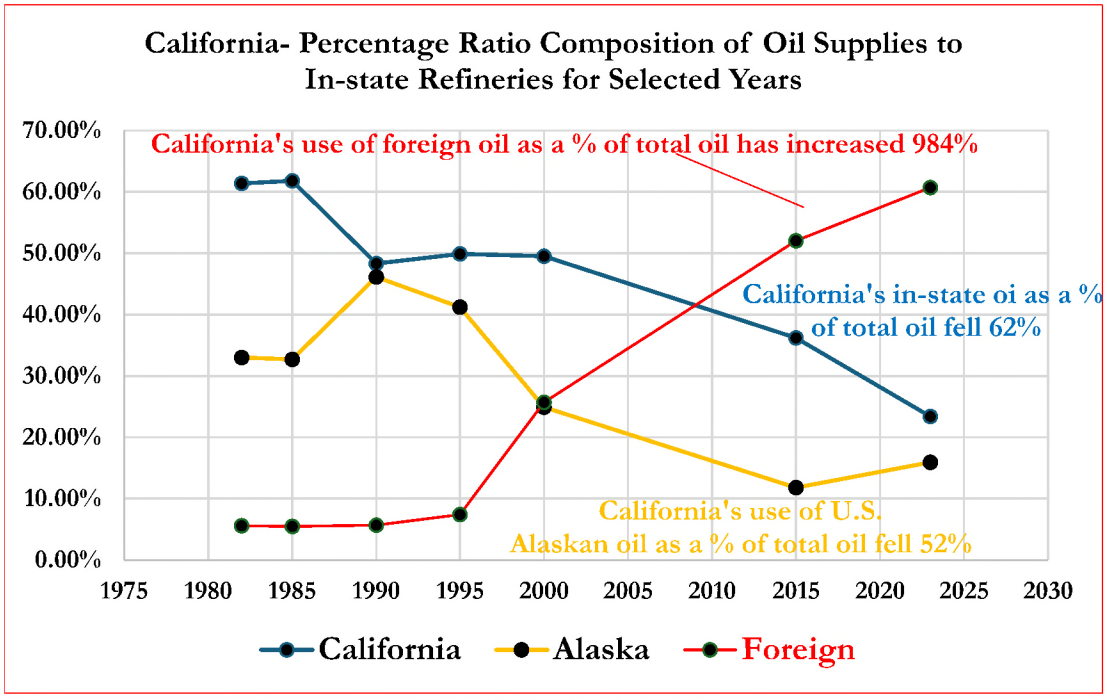
Exhibit 4.3

Comparison: Percent of Oil Imports by Source-CA. to U.S.- 2024		
Source	**California 2024**	**U.S. 2024**
Iraq	21.26%	3.43%
Brazil	20.41%	3.45%
Canada	9.26%	66.00%
Saudi Arabia	5.31%	2.82%
Colombia	2.67%	3.06%
Mexico	2.00%	7.03%
Venezuela	0.00%	4.61%

(Source: https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/foreign-sources-crude-oil-imports and https://www.eia.gov/petroleum/imports/companylevel/)

For 2023, on a percentage composition basis, California imports 6.8 times and 2.9 times more oil from Iraq and Saudi Arabia, respectively, and 5.2 times and 7.3 times more from Brazil and Ecuador than the overall U.S. Since the mid-1990s, California's ratio of foreign sourced oil to in-state production has shifted from .92 in 1982 to 2.59 in 2023 (indicating a significantly greater reliance on foreign oil as feeder stock to California's refineries).[268] [269]

Exhibit 4.4



(Source, CEC, EIA, and Author)

[268] *U.S. Energy Information Administration - EIA - Independent Statistics and Analysis.* (n.d.). https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_sum/html/rank_use_pet_capita.html&sid=US

[269] *U.S. Crude Oil Production by State | Bureau of Transportation Statistics.* (2024). Bts.gov. https://www.bts.gov/browse-statistical-products-and-data/freight-facts-and-figures/us-crude-oil-production-state

According to various estimates, California ranks #1 in payments to foreign sources of oil and pays more than $61.8 million per day, or $22.5 billion annually, based on Brent market prices, or $54.41 million a day, or $19.8 billion annually, based on WTI market prices, to foreign countries such as Iraq, U.A.E., and Saudi Arabia and others for its oil imports.[270] California's oil imports from various petrostates, such as Iraq and Saudi Arabia, as well as various other Middle Eastern sources have both intended and unintended economic consequences and directly and indirectly support the sourcing countries' economies, governing policies and structures, political agendas, and societal initiatives. Summarized in the exhibit below are some of pertinent social, political, and human freedom rankings for various sources such as Transparency International and Global Finance of California crude oil imports.[271] The U.S. is provided for a comparative perspective.

Exhibit 4.5

Comparison: Selected Rankings for Social, Economic & Corruption for California Oil Imports (2023/2024)					
	Iraq	**Saudia Arabia**	**Brazil**	**Ecuador**	**United States**
Percent of California Total Imports	21.70%	15.70%	15.10%	14.60%	NA
Corruption Perception Ranking	154	53	104	115	24
Human Freedom Ranking	156	157	70	72	17
Media/Press Freedom Ranking	169	166	82	110	55
Democracy Ranking	128	150	51	85	29
Economic Freedom Ranking/Score	Not Ranked	61.9	53.2	55	70.1
Poorest County Ranking	71	173	107	79	182
Government Integrity	18.3	43.9	36.9	34.9	76.4

(Source: Various. See footnote below.)

Iraq, which is California's largest provider of foreign in 2023, is ranked 27th out of 179 as a "Fragile/Failed State Index" by the Fund for Peace. For perspective, North Korea, Rwanda, and Venezuela rank "better." The U.S. is ranked 141st.[272]

[270] Based on WTI and Brent crude prices as of 3/14/25, and CA. imports are reported by CEC. See also, Ed, C. (2018, October 9). *California ranks #1 in sending dollars abroad for Energy*. https://www.cfact.org/2018/10/09/california-ranks-1-in-sending-dollars-abroad-for-energy/ . See also, *FACTS - Californians for energy independence*. (2023, July 31). Californians for Energy Independence. https://www.energyindependenceca.com/facts/#:~:text=California%20now%20imports%2075%25%20of,use%2C%20mostly%20from%20foreign%20countries.&text=California%20spends%20$25%20Billion%20dollars,to%20meet%20our%20energy%20needs.

[271] Sources include Transparency International. (2024, September 12). *2023 Corruption Perceptions Index: Explore the results.* Transparency.org. https://www.transparency.org/en/cpi/2023; Vásquez, I., Mcmahon, F., Murphy, R., & Schneider, G. (2023). *HUMAN FREEDOM INDEX 2023 A Global Measurement of Personal, Civil, and Economic Freedom*. https://www.cato.org/sites/cato.org/files/2023-12/human-freedom-index-2023-full-revised.pdf; *Age of conflict*. (n.d.). https://pages.eiu.com/rs/753-RIQ-438/images/Democracy-Index-2023-Final-report.pdf?version=0; Ventura, L. (2024, October 20). *Poorest Countries in the world 2024*. Global Finance Magazine. https://gfmag.com/data/economic-data/poorest-country-in-the-world/;*Human rights index*. (2024, March 7). Our World in Data. https://ourworldindata.org/grapher/human-rights-index-vdem?tab=chart&country=BRA~ECU~IRQ~SAU~USA; and The Heritage Foundation. (n.d.). *Index of Economic Freedom: All Country Scores | The Heritage Foundation*. Index of Economic Freedom | the Heritage Foundation. https://www.heritage.org/index/pages/all-country-scores.

[272] Energyskeptic. (n.d.). *Peak everything, overshoot, & collapse - preservation of knowlege*. Peak Everything, Overshoot, & Collapse - Preservation of Knowlege. https://energyskeptic.com/

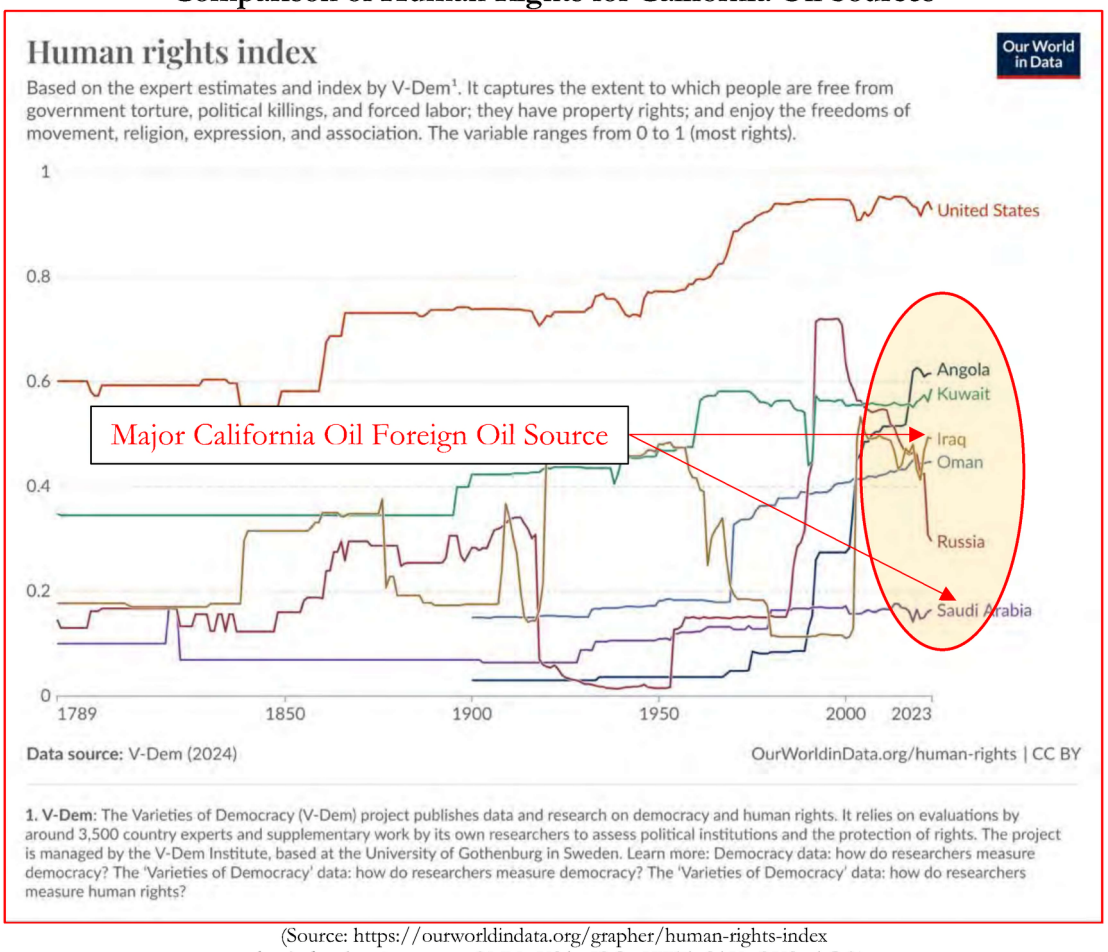
Exhibit 4.6

FRAGILE STATES INDEX RANKING Selected CA Sources of Foreign Imports	
California Oil Source	**Overall Ranking Out of 179**
Iraq	27
Brazil	71
Ecuador	87
Saudi Arabia	100
U.S.A.	141
Note: Lower number = more unfavorable.	

(Source: https://fragilestatesindex.org/excel/)

As summarized in the chart below, California's sources of foreign oil rank considerably lower in terms of human rights compared to domestically available sources from the U.S., including California.

Exhibit 4.7
Comparison of Human Rights for California Oil Sources



(Source: https://ourworldindata.org/grapher/human-rights-index vdem?tab=chart&country=OMN~USA~IRQ~KWT~SAU~RUS~AGO)

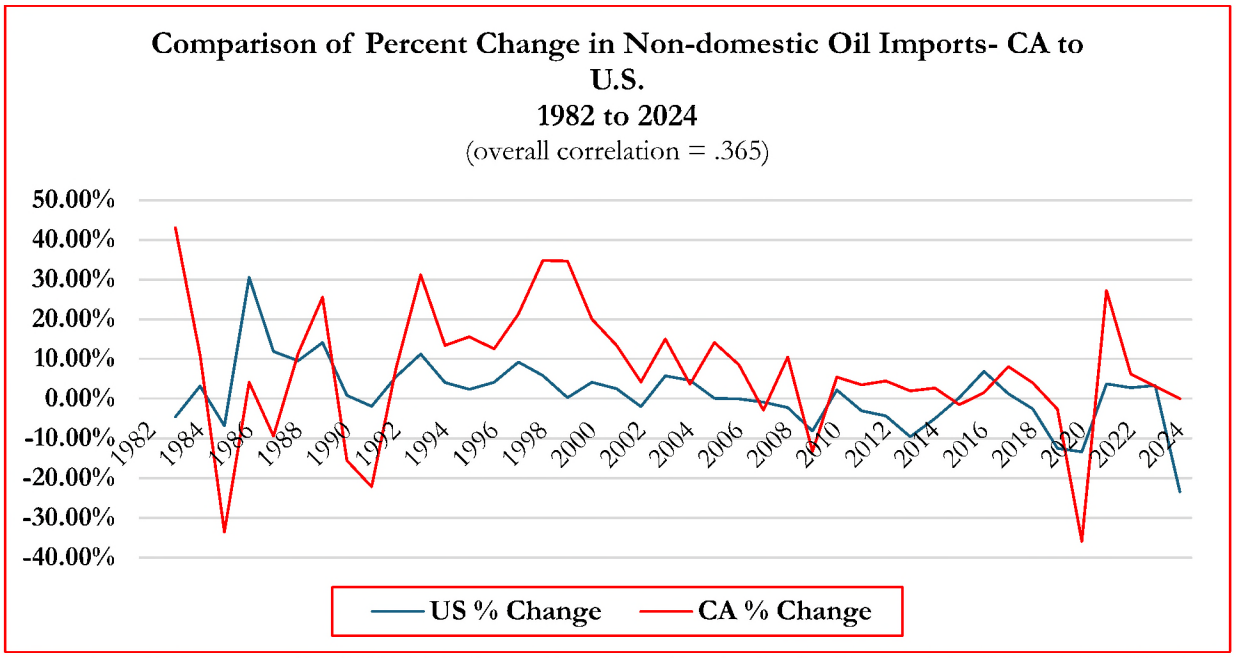
4.2 California Compared to U.S. Oil Imports

Although both California and the overall U.S. grew substantially over forty years, California's dependency on foreign sourced oil grew faster and moved contradictorily to that of the overall U.S. Consequently, on an annual percentage change basis, California has a low correlation (.365) for oil imports as compared to the overall U.S. oil imports. From 1982 to 2017, California exhibited wide disparities in oil imports between itself and the overall U.S. However, in 2017, California began to present smaller deviations in the annual percentage change in non-domestic oil imports to that of the overall U.S.

As California's in-state oil field production declined, the Golden State turned to foreign petrostates such as Iraq, Saudi Arabia, and the U.A.E., as well as South American sources such as Brazil, Guyana, and former OPEC member Ecuador, to produce gasoline, diesel, and jet fuels, and other petroleum

derivative products.[273] [274] As California is highly dependent on foreign oil, it is also highly vulnerable to geopolitical events, natural and force majeure events, and a host of other activities that can cause supply disruptions and spot and long-term contract pricing variations in world oil markets.

Exhibit 4.8



(Sources: https://afdc.energy.gov/data/10324. CA CEC, https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MCRIMUS1&f=M)

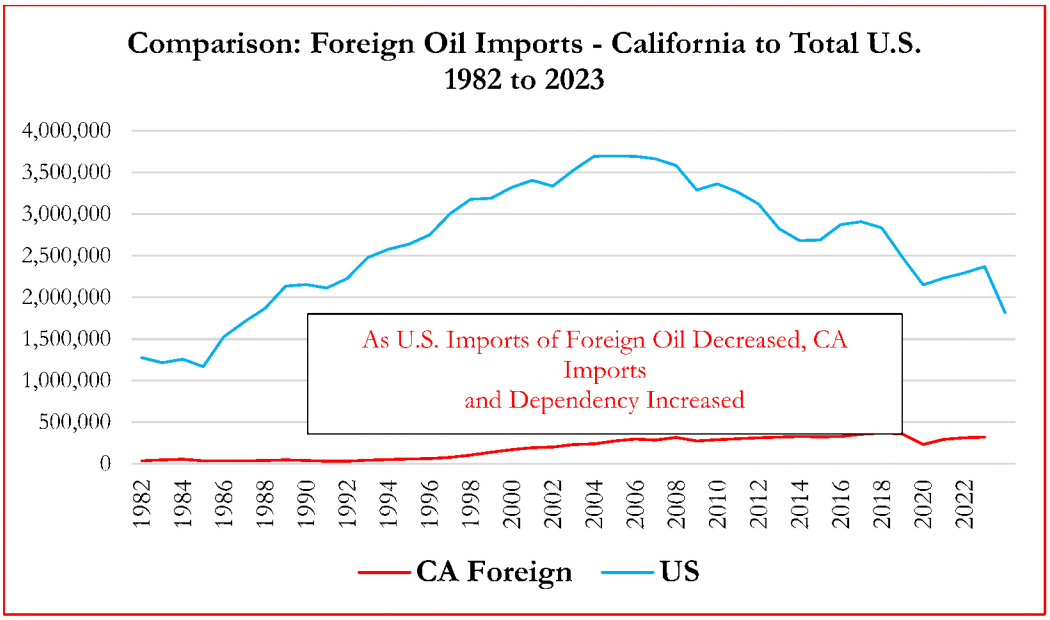
Since 1982, California's reliance on foreign oil imports has increased by 858%, or 20 times greater than that of the overall U.S. importing of foreign oil.[275]

[273] Fox News. (2015, December 21). *Shale oil deposit a possible boon to struggling California, but state wary, enviros opposed.* https://www.foxnews.com/politics/shale-oil-deposit-a-possible-boon-to-struggling-california-but-state-wary-enviros-opposed

[274] Jones, J. (2024, March). *States With the Most Oil Reserves [2024] - Construction Coverage.* Construction Coverage. https://constructioncoverage.com/research/states-with-the-most-oil-reserves

[275] *Alternative Fuels Data Center: Maps and Data - U.S. Production, Consumption, and Trade of Petroleum Products.* (n.d.). Afdc.energy.gov. https://afdc.energy.gov/data/10324

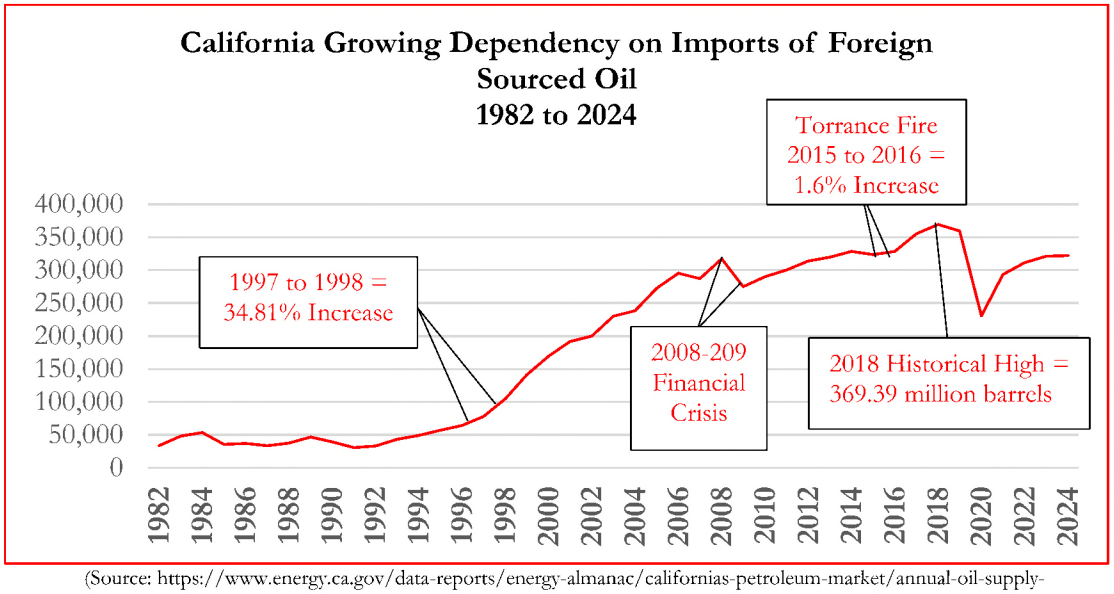
Exhibit 4.9



(Source: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MCRIMUS1&f=M)

In 1982, California produced 61% of its oil needs, imported 33% from Alaska, and imported only 5.6% from foreign sources. By 2023, and based on CEC data, the composition of California in-state oil stocks reversed to 23.4% in-state sourced, Alaskan oil imports declined to 16%, and foreign sourced moved to 60.7%. The exhibit below illustrates California's growing dependency on non-U.S. foreign oil sources. Since 1982, California's dependency on foreign oil has grown by 859%.

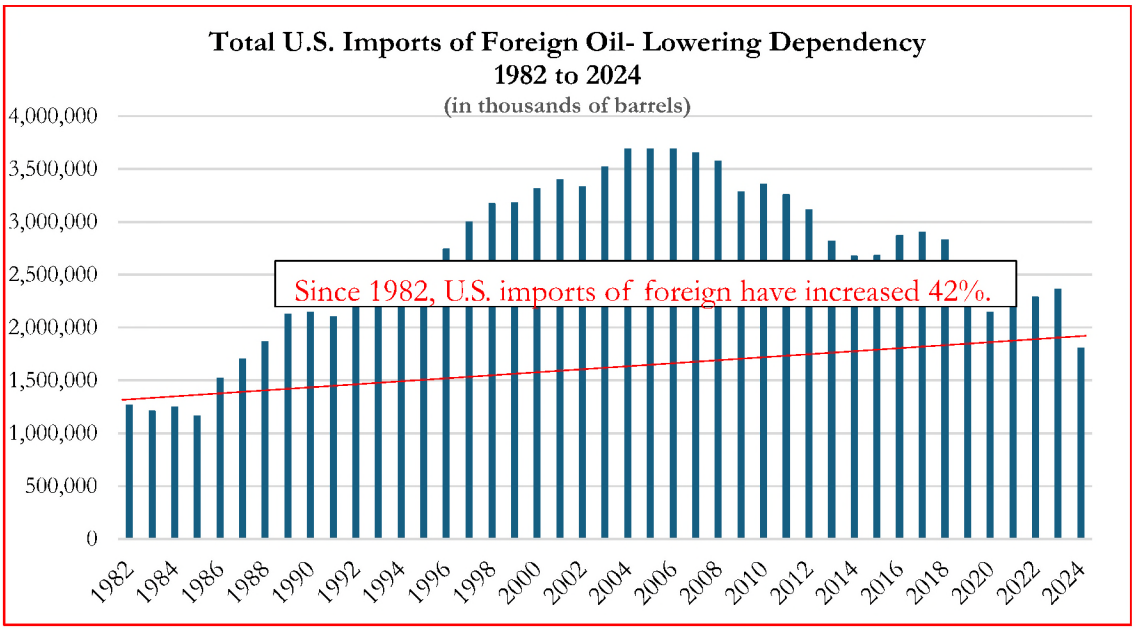
Exhibit 4.10



(Source: https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/annual-oil-supply-sources-california)

In contrast, while California's in-state production declined, and its dependency on foreign oil increased, U.S. imports and dependency on foreign sourced oil decreased, and domestic U.S. oil production increased.

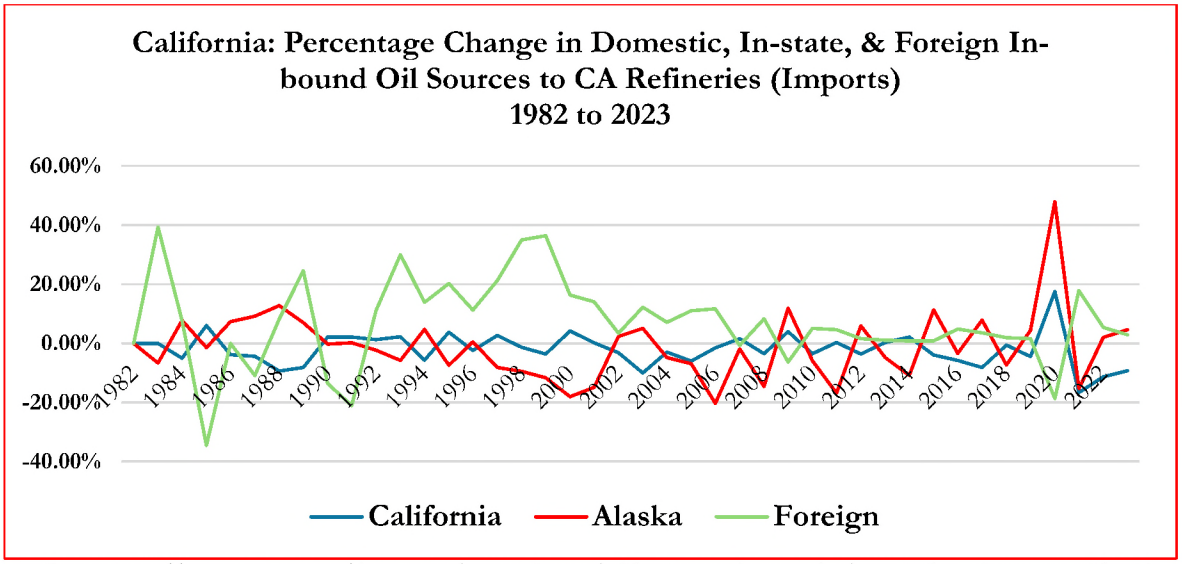
Exhibit 4.11



(Source: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MCRIMUS1&f=M)

The composition of California's inbound oil stocks by source, as measured by annual percentage change, is depicted below. Note the declines in Alaskan oil imports and the increase in foreign stock dependency. The 2020 spike is attributed to Covid-19.

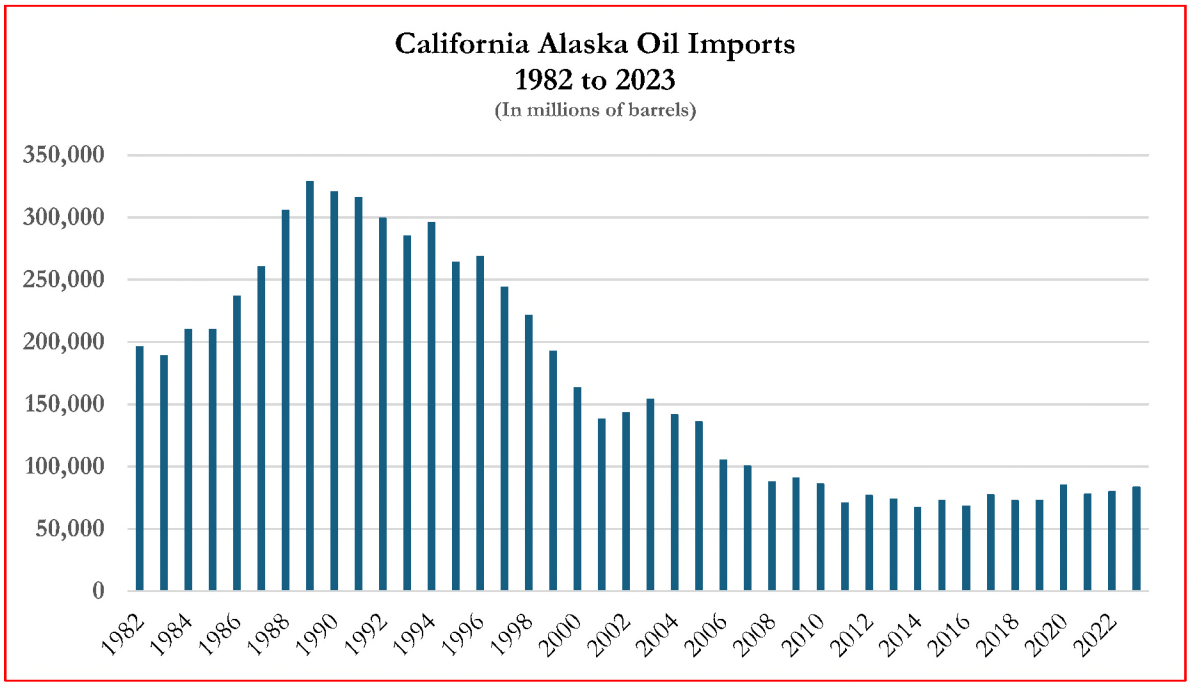
Exhibit 4.12



(Source: https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/annual-oil-supply-sources-california)

Commencing in the mid-1990s, as California's imports of domestically produced oil from Alaska and in-state oil production began a long-term decline, its need for foreign produced oil began to accelerate. While imports of non-U.S. domestically sourced oil from OPEC and other states increased by 857%, California imports of U.S. domestically produced oil from Alaska plummeted by 57.32%.[276]

Exhibit 4.13

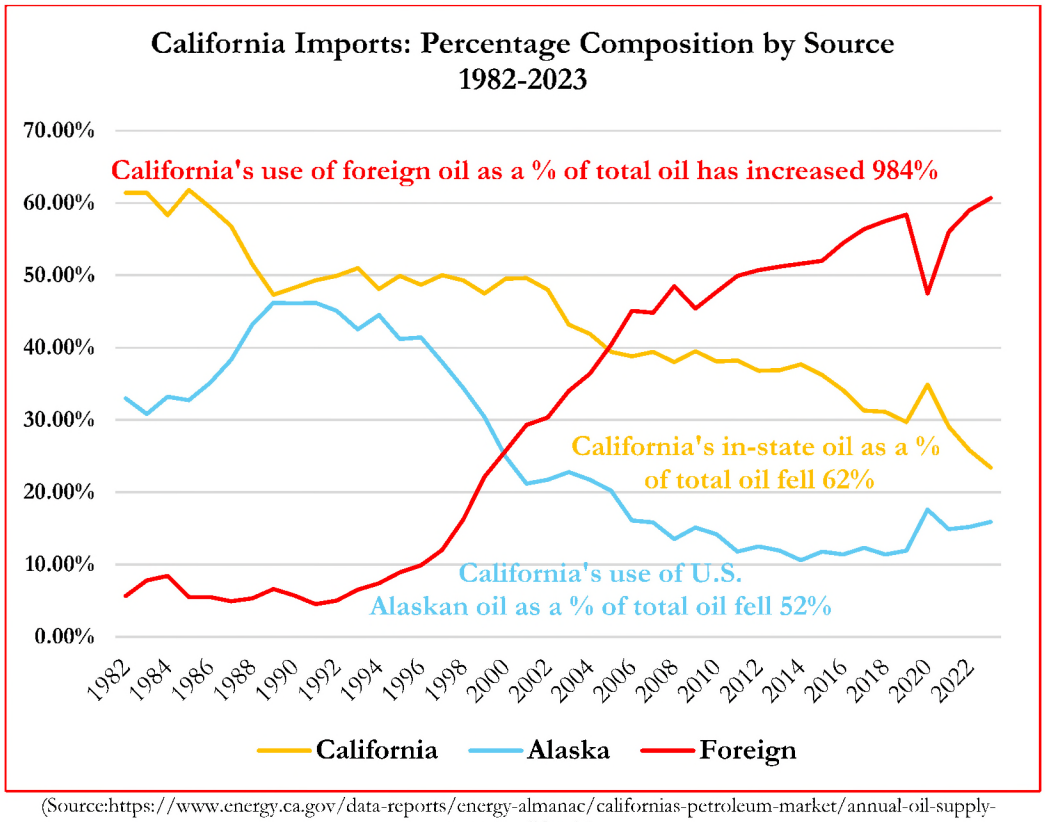


(Source: https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/annual-oil-supply-sources-california)

The chart below depicts the percentage composition of California oil stocks for the 1982 to 2023 period. As indicated, California oil imports' composition changed significantly between 1982 and 2023. Specifically, there is a decline in the importing of U.S. Alaskan sourced oil, a drop in in-state production, and a dramatic increase in the use of foreign sourced oil.

[276] Alaska North Slope oil field production declined but accounted for 15% of California's oil in 2021. Today, the Alaskan Pipeline operates at 20-25% of its original capacity due to lower field production. However, both field production and pipeline capacity utilization are expected to increase in 2025. See, https://www.californiaenergyatlas.com/crude-oil

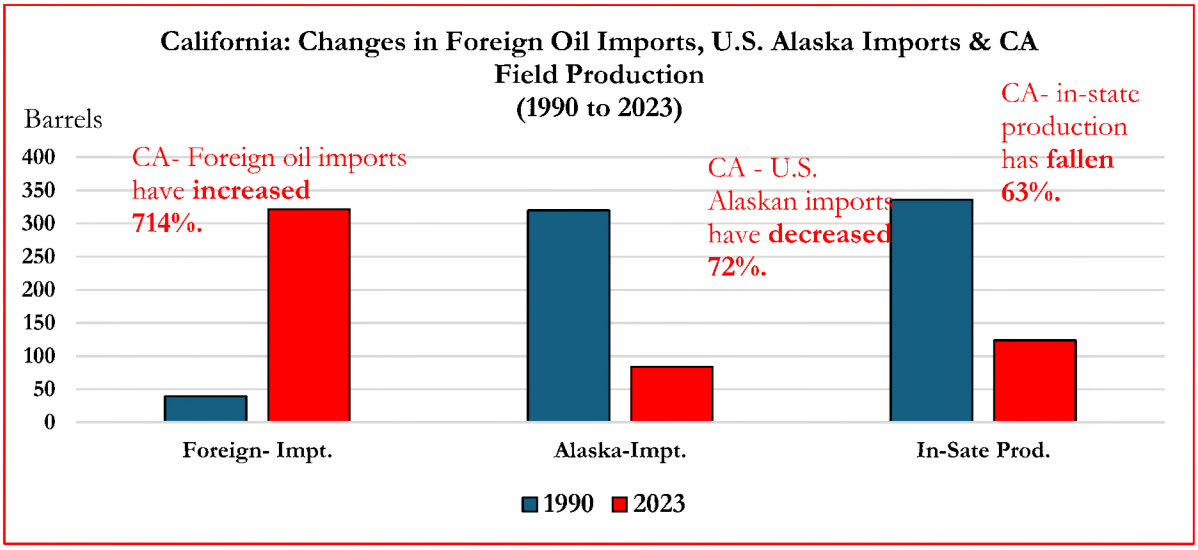
Exhibit 4.14



(Source:https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/annual-oil-supply-sources-california)

While imports from foreign sources increased, domestically sourced 'imports' from other U.S. petroleum producing states, Alaska and California's in-state production have declined.

Exhibit 4.15



(Source: CEC)

4.3 Greenhouse Gas Emissions- Imports

4.3.1 Production Emissions. Measuring and comparing greenhouse emissions is a complex process in the petroleum industry, and methods and reporting standards vary. The U.S. Environmental Protection Agency (EPA), U.S. Department of Energy (DoE), California Air Resources Board (CARB), and International Standards Organization (ISO), for example, all have various standards and measurement methods. The ISO standards for measuring complete "well to tank," or what is more formally termed the Life Cycle Assessment (LCA) Sections 14040 and 14044, provide a standardized method for evaluating environmental impacts.[277]

Extracting and shipping oil creates multiple levels of greenhouse gas (GHG) emissions. As crude petroleum has unique chemistries, "no two barrels of oil are alike." Oil sourced in Texas can and will differ from oil produced in California. Even oil derived from Texas will have unique and specific differences. West Texas oil has a different chemistry from East Texas oil. Oil found in Alaska's North Slope has a chemical profile distinct from that found off the Gulf Coast of the U.S. Accordingly, where the oil is sourced, how it is sourced, how it is refined and stored, and how it is transported will create unique carbon footprints and GHG emissions.

GHG emissions are gases that are released into the atmosphere. Higher atmospheric temperatures are created as a result of gases that absorb longer wavelength radiation.[278] GHG emissions include a number of different components: HFC- hydrofluorocarbons, N_2O- nitrous oxide, CO_2 – carbon dioxide, CH_4 - methane, PFCs- perfluorocarbons, H_2O- in the form of water vapor, and SF_6- sulfur hexafluoride.[279] The most abundant of these components are carbon dioxide and methane, which compose between 80% to 90% and 5% to 10%, respectively, of human related (anthropogenic) GHG. Although it is a less abundant contributor to GHG, methane is far more potent than carbon dioxide as it is far more effective at trapping heat (about 80 times more than carbon dioxide). However, carbon dioxide has a much longer lifespan in the atmosphere, lasting for hundreds of years.[280]

At each stage of the "well to tank" oil production, refinement, and distribution process, GHG is created and emitted. Recent research has placed increasing emphasis on understanding the entire carbon and environmental footprint created by the complete well to tank life cycle.

Generally, crude oil production GHG emissions are measured in CO_2 equivalents per barrel of oil, or $kgCO_2$ eq./barrel (kilograms of carbon dioxide equivalent per barrel).[281] The carbon intensity of producing and consuming combustible transportation fuels is measured as CO_2e/MJ (megajoule of energy). In oil production, as well as in the production of liquefied natural gas, most methane GHG emissions are generated through a process known as "venting and flaring, and leaks."

---

[277] International Organization for Standardization. (2014, August 12). *ISO 14044:2006*. ISO. https://www.iso.org/standard/38498.html and International Organization for Standardization. (2006, August 12). *ISO 14040:2006*. ISO. https://www.iso.org/standard/37456.html.

[278] *Greenhouse Gas Emission - an overview | ScienceDirect Topics*. (n.d.). Www.sciencedirect.com. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/greenhouse-gas-emission

[279] *Greenhouse Gas Emission - an overview | ScienceDirect Topics*. (n.d.). Www.sciencedirect.com. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/greenhouse-gas-emission

[280] *The Natural Gas Industry Has a Methane Problem*. (2019, June 7). Nrdc.org. https://www.nrdc.org/stories/natural-gas-industry-has-methane-problem

[281] EPA. (2022, June 23). *Greenhouse Gases Equivalencies Calculator - Calculations and References | US EPA*. US EPA. https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references. See also, Netherlands, S. (2024). *CO2 equivalents*. Statistics Netherlands. https://www.cbs.nl/en-gb/news/2019/37/greenhouse-gas-emissions-down/co2-equivalents#:~:text=One20kg20of20CO2

- Flaring is the process of releasing gases directly into the atmosphere and/or igniting released gases to combust in the atmosphere at the point of production or refinement.

- Venting results from the intentional release of gases associated with pneumatic equipment, pipelines, tanks, etc., associated with the production and movement of petroleum products. Venting can also occur from fugitive emissions or leaks in pipelines, valves, pumps, vessels, and equipment throughout the production infrastructure.

- Methane leaks from storage tanks, pipelines, and collectors at terminals.[282]

The U.S. and California, as well as the U.S. petroleum industry and operators, have the world's most stringent production, health & safety, operational, and environmental standards for petroleum production and movement. Other crude sources, including OPEC members such as Iraq and Venezuela, do not have as stringent safety and environmental protection and enforcement standards, nor do Ecuador and Columbia. Consequently, the GHG created at production and refinery points tends to be greater in countries with lower standards.

According to a 2013 study performed by H.M. El-Houjeiri, A.R. Brandt, and J.E. Duffy, as cited by the CARB, [283] crude oil field production emissions of carbon dioxide average between 3 to 30 g CO_2/MJ. The range of emissions is contingent on processing methods and practices, rates of production, and flaring rates at a particular point of production. In California, the CARB assessment concluded that the range for California oil field production was 1.5 to 47 g CO_2/MJ.[284]

According to a McKinsey study, GHG emissions intensity for heavy oil such as that imported by California refiners ranges from 30 to 120 of CO_2 e/barrel per barrel. In general, and for example purposes only, California foreign oil sources averaging 70 kg of CO_2 e/barrel do not compare as favorably to domestically produced oil from the U.S. Permian Basin, which ranges from 20 to 40 and averages 20 kilograms of CO_2 e/barrel.[285] Below is a summary prepared by the management consulting firm McKinsey & Co., incorporative of other sources, of the estimated greenhouse gas emission intensity by various oil-producing areas, including the U.S. Gulf of Mexico. (Note: grades of oil sweet to extra heavy vary considerably.)

---

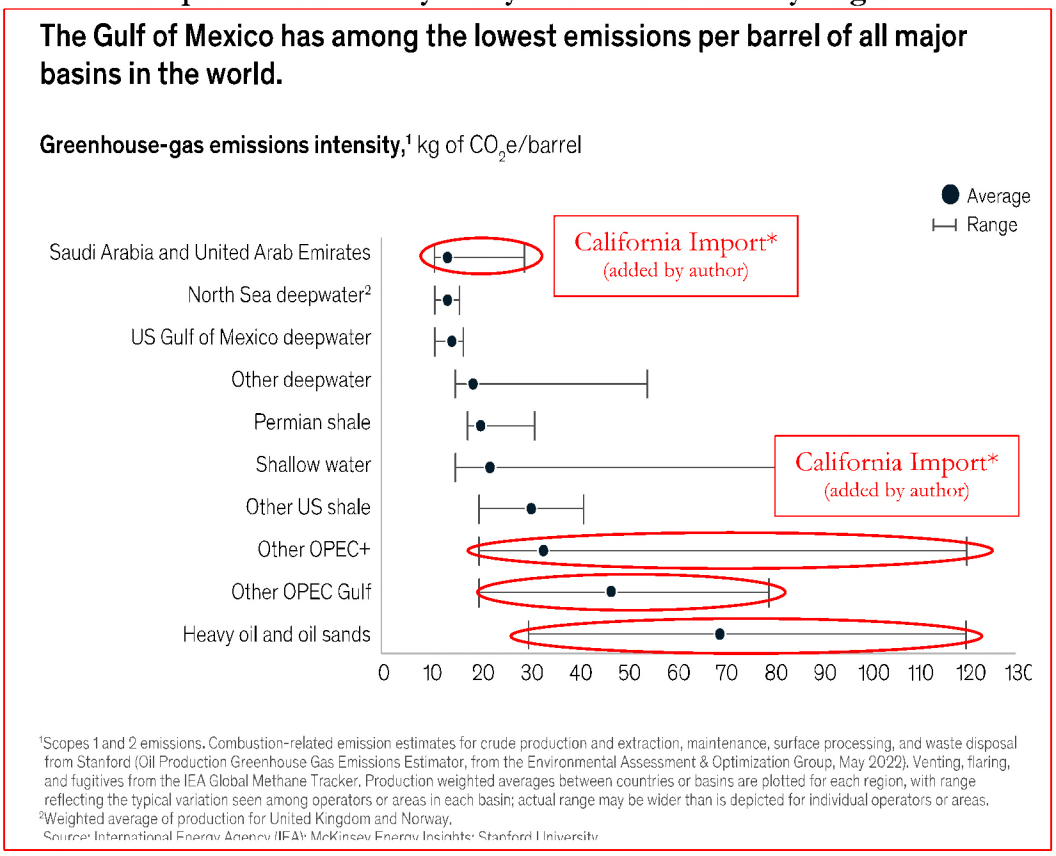
[282] Mandel, J., & Zou, J. J. (2019, May 30). *Leaks threaten safety — and success — of America's top natural gas exporter.* Center for Public Integrity. https://publicintegrity.org/environment/leaks-threaten-safety-and-success-of-americas-top-natural-gas-exporter/

[283] El-Houjeiri, H.M., Brandt, A.R., Duffy, J.E., 2013. Open-Source LCA Tool for Estimating Greenhouse Gas Emissions from Crude Oil Production Using Field Characteristics. Environ. Sci. Technol. 47, 5998–6006. El-Houjeiri, H.M., Brandt, A.R., Duffy, J.E., 2013. Open-Source LCA Tool for Estimating Greenhouse Gas Emissions from Crude Oil Production Using Field Characteristics. Environ. Sci. Technol. 47, 5998–6006.

[284] CARB (2019). California Air Resources Board. Calculation of 2019 Crude Average Carbon Intensity Value. https://www.greencarcongress.com/2020/06/20200616- carbci.html

[285] Brown, J., Luciano Di Fiori, Smith, M., & Kassia Yanosek. (2022, September 21). *How the Gulf of Mexico can further the energy transition.* McKinsey & Company; McKinsey & Company. https://www.mckinsey.com/industries/oil-and-gas/our-insights/how-the-gulf-of-mexico-can-further-the-energy-transition

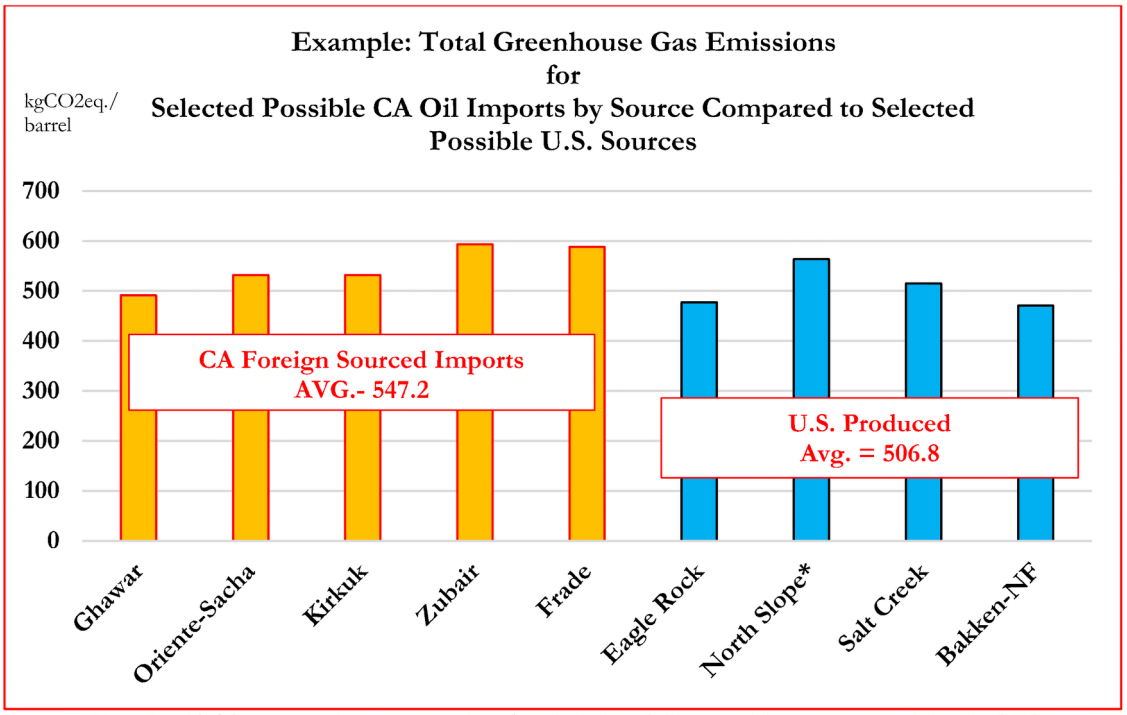
Exhibit 4.16
Comparison: McKinsey Study- GHG Emissions by Regions



(Source: McKinsey & Co.)

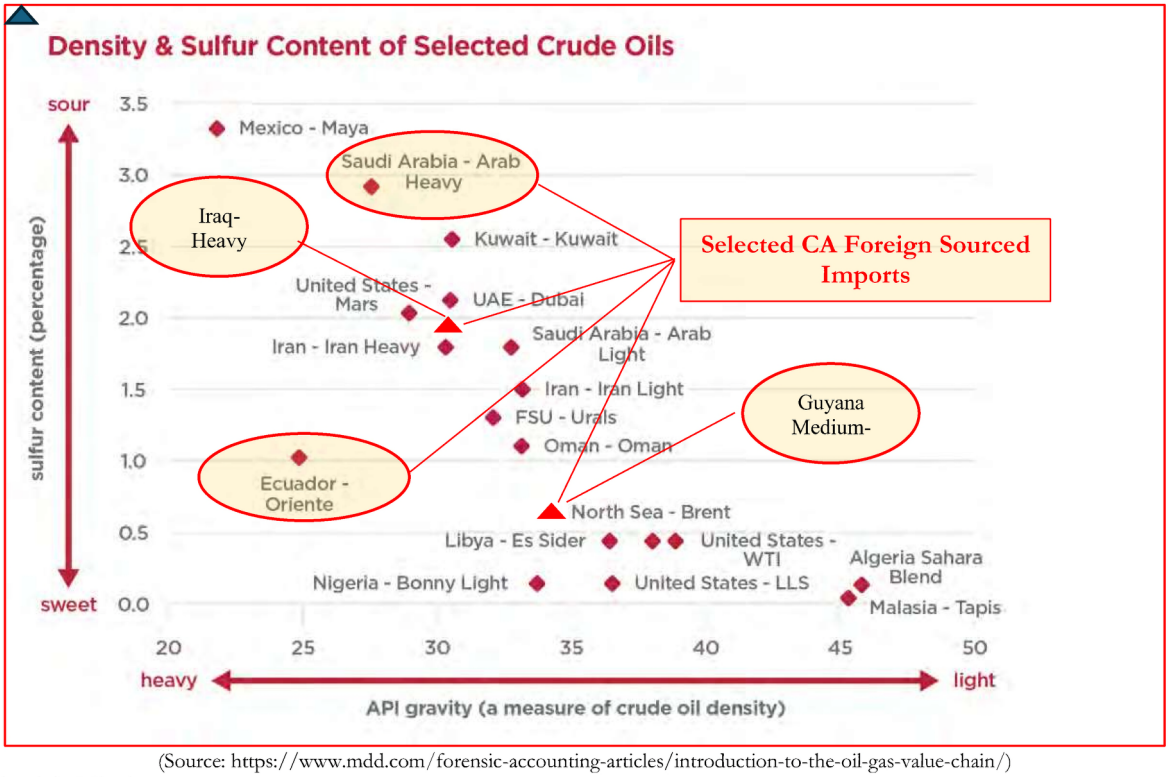
California imports oil from various wells in Saudia Arabia, Iraq, the U.A.E., Brazil, Ecuador, and several other sources. Oil field production GHG emissions vary considerably by source and production methods. Below is an example of the typical GHG emissions by oil fields from foreign sources compared to U.S. sources. (Note, provided for example purposes only. The actual GHG emissions for California's oil sources will vary.)

Exhibit 4.17



(Note: Provided for comparative purposes only and not inclusive of all sources. There are many variations in GHG emissions based on the exact source of oil and upstream production methods. Source: http://oci.carnegieendowment.org/#compare/iraq-kirkuk/iraq-zubair.)

Exhibit 4.18



(Source: https://www.mdd.com/forensic-accounting-articles/introduction-to-the-oil-gas-value-chain/)

Below is a summary based on the Carnegie Endowment for International Peace Oil-Climate Index of the total GHG emissions associated with various California heavy crude oil foreign sources as compared to selected U.S. light crude oil sources.[286] Significantly, since California refineries were and are currently configured for the refinement of California in-state sourced heavy crude oils, they currently use foreign sourced heavy crudes for refinement into gasoline and other products. The use of light crudes would require retooling and significant capital investment and given the mandates to eliminate both gasoline and diesel fueled vehicles, there is no incentive to invest on behalf of the refiners in light crude refinement. Nonetheless, the comparison is interesting since the U.S. is a major producer of light, and California has an abundance of heavy crudes in proven reserves.

[286] *Assessing global oils — Carnegie Endowment for International Peace.* (n.d.). Assessing Global Oils — Carnegie Endowment for International Peace. http://oci.carnegieendowment.org/#compare/iraq-kirkuk/iraq-zubair

Exhibit 4.19
Comparison: Estimated Greenhouse Gas Emissions by Oil Source

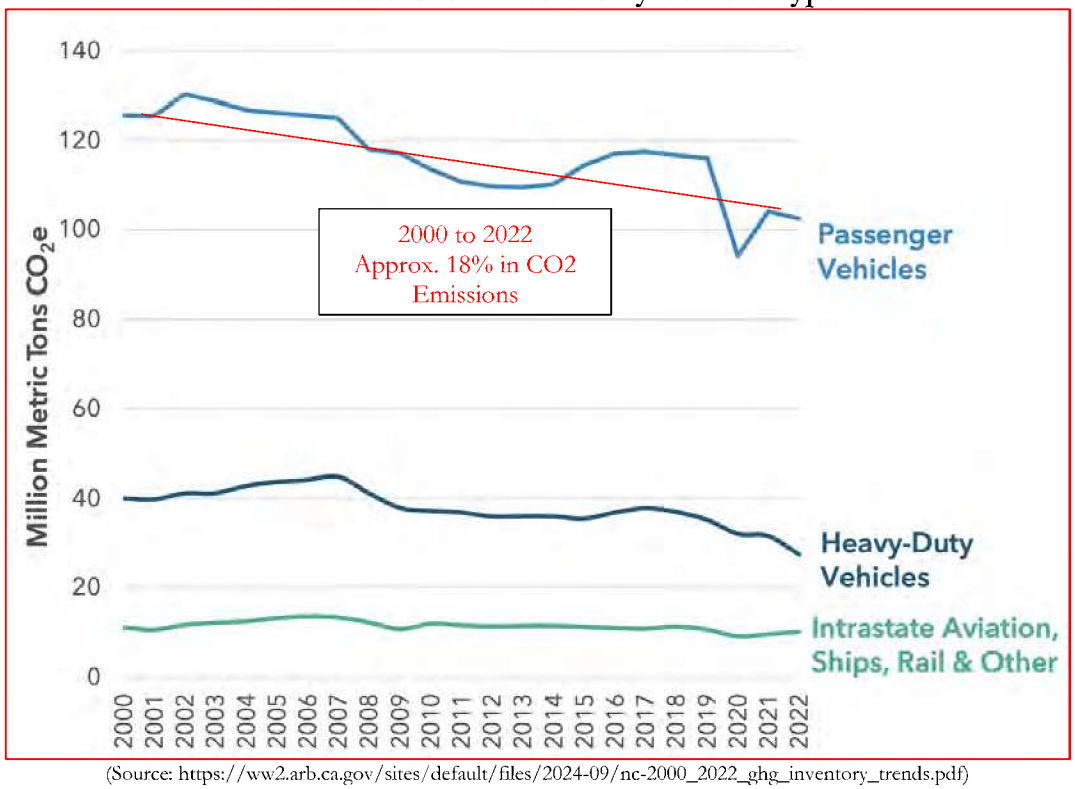
GREENHOUSE GAS EMISSIONS-COMPARISON: SELECTED CALIFORNIA CRUDE OIL IMPORTS TO U.S. SOURCES

COUNTRY OF ORIGIN	CA. TOP FOREIGN SOURCES					UNTIED STATES			
Region	Saudi Arabia	Ecuador	Iraq	Iraq	Brazil	Texas	Alaska	Wyoming	U.S.
	Ghawar	Oriente-Sacha	Kirkuk	Zubair	Frade	Eagle Rock	North Slope*	Salt Creek	Bakken-NF
Total GHG Emissions	491	532	532	593	588	477	564	515	471
GHG From Upstream Production	34	60	71	130	34	41	102	68	24
GHG From Transportation to Customers	11	11	11	11	11	10	11	11	10
API Gravity Weighting	33	29	39	30	20	41	31-32.1	37	38
Sulfur Content %	1.63%	0.95%	1.97%	2.66%	0.80%	0.31%	0.85-.98%	0.30%	0.07%
Classification	Light	Medium	Light	Deep	Heavy	Light	Medium	Light	Light
Sulfur Content Classification	Sour	Sour	Sour	Sour	Sour	Sweet	Sour	Sweet	Sweet
Percentage of Total GHG Due to Production	6.92%	11.28%	13.35%	21.92%	5.78%	8.60%	18.09%	13.20%	5.10%

Provide for comparative purposes only. There are many variations in GHG emissions based on the exact source of oil and upstream production methods. Source: http://oci.carnegieendowment.org/#compare/iraq-kirkuk/iraq- zubair.)

GHG and CO_2 emissions at the wellhead and refinery are important measurements but are incomplete. The totality of GHG emissions, or what is generally referred to as "well to wheel" emissions, which include transportation, must also be considered. Because California has limited in-state oil production and no in-bound pipelines from oil-producing states of any significance, the Golden State must import over 321,153,000 barrels of crude oil for gasoline production using maritime ocean tankers of various sizes which contribute to GHG emissions.[287]

Exhibit 4.20
Greenhouse Gas Emissions by Vehicle Type



(Source: https://ww2.arb.ca.gov/sites/default/files/2024-09/nc-2000_2022_ghg_inventory_trends.pdf)

4.3.2 Maritime Tanker Movement & GHG & Routes. According to CEC data, over 98% of California's non-U.S. sourced imported oil is delivered to its refineries via maritime vessels.[288] Since California imports over 50% of its oil from Middle Eastern sources, the GHG emissions generated in transit to California maritime terminals are higher due to the distance, time, and speed required to transport the oil stock.

Over 12 billion barrels of crude oil are moved using maritime tankers.[289] Ocean tankers produce GHG and CO_2 emissions and, based on an International Transport Forum (ITF) study, account for 3% of

[287] Various including CEC, EIA and others.
[288] Commission, C. E. (n.d.). *Foreign Sources of Crude Oil Imports to California 2020*. California Energy Commission. https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/foreign-sources-crude-oil-imports
[289] ETC Energy Transitions Commission (2018), Reaching zero carbon emissions from shipping. https://www.ieta.org/resources/COP24/Misc%20Media%20Files/Dec7/SE16%20(3).pdf

global emissions.[290] According to a 2015 study, oil tankers produced 114 million tons of CO_2, which accounted for 13% of all maritime CO_2 emissions.[291] Many factors, such as the age of the tanker, the propulsion technology of the tanker, load capacity, percent utilization of load capacity, speed of travel, as well as distance and trading lanes used, are just a few factors that impact total GHG emissions as related to oil production, transportation, and gasoline production. Other factors, including weather, geopolitical events, and destination port, can increase GHG emissions. The longer that the tanker is "anchor hoteling" and waiting for a berth and (idling) for lading and unlading its cargo, the greater the level of GHG emissions created.

Ocean tanker vessels come in various sizes and off-load at maritime terminals located in northern and southern California. Maritime transportation of foreign petroleum costs a barrel of oil and travel time to delivery and contributes to greenhouse emissions. However, due to economies of scale, ocean vessel transportation is one of the least costly and most efficient methods of moving vast amounts of petroleum. On average, it can cost between $30,000 to $70,000 a day to operate a very large crude carrier (VLCC) tanker, depending on fuel costs, port congestion, the size and age of the vessel, and the time of year.[292] Since Oil tankers burn diesel and heavy oil fuels, they produce greenhouse gas emissions.[293] In general, older oil tankers tend to be less efficient than newer ones, emitting more greenhouse gases than the newer VLCC tankers.

The distance and transit routes (trade lanes) a tanker uses to move from a source terminal, such as in Saudia Arabia or Iraq, to California has an enormous impact on emissions. Other factors include ocean tanker load factor, the percentage of tanker capacity utilization for its crude cargo, speed, routes, weather, etc. According to the EIA, the typical transit time for a VLCC class oil tanker to travel from Jeddah, Saudi Arabia, to Los Angeles is about 42-43 days (6 weeks).[294] Transit times from the U.S. Gulf Coast refineries to Los Angeles are about 11-13 days.

---

[290] Greene, S., Jia, H., & Rubio-Domingo, G. (2020). Well-to-tank carbon emissions from crude oil maritime transportation. *Transportation Research Part D: Transport and Environment*, *88*, 102587. https://doi.org/10.1016/j.trd.2020.102587

[291] Olmer, N., Comer, B., Roy, B., Mao, X. and Rutherford, D. Greenhouse Gas Emissions from Global Shipping, 2013-2015. (2017), https://theicct.org/publications/GHG-emissions-global-shipping-2013-2015

[292] VLCC oil tankers have a capacity to carry up to 2.0 million barrels of oil. See, Gunvor Group. (2024, January 22). *Very large crude carrier - Gunvor Group*. https://gunvorgroup.com/glossary/very-large-crude-carrier/#:~:text=A%20Very%20Large%20Crude%20Carrier,extraction%20locations%20to%20refineries%20worldwide.

[293]

[294] *U.S. crude oil imports from Saudi Arabia and Iraq recently increased, but may decline soon - U.S. Energy Information Administration (EIA)*. (n.d.). https://www.eia.gov/todayinenergy/detail.php?id=30092#:~:text=Although%20crude%20oil%20exports%20from,the%20southern%20tip%20of%20Africa.

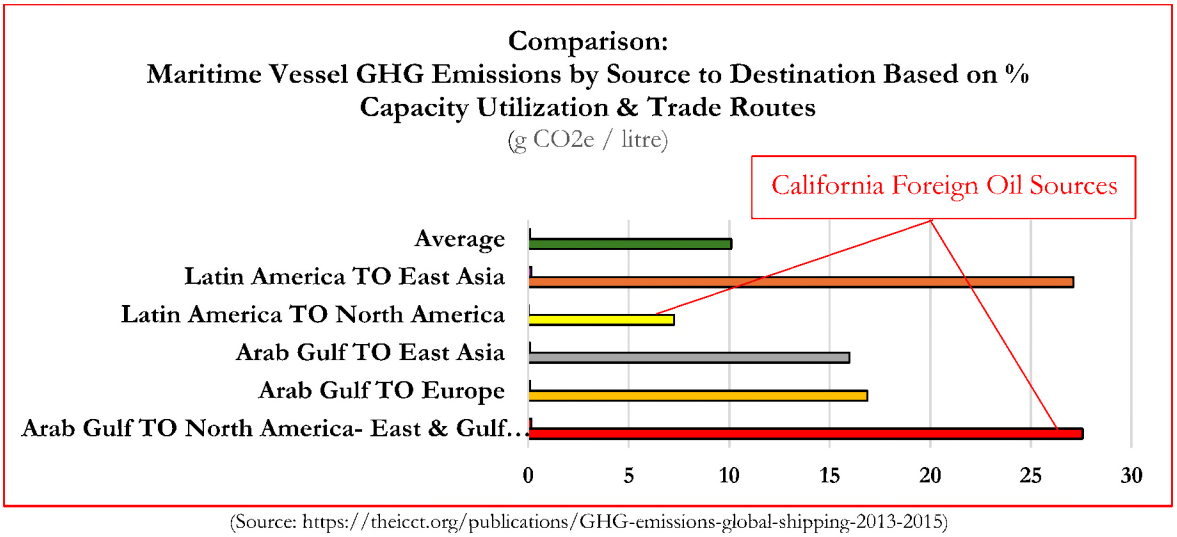
Exhibit 4.21



(Source:https://www.eia.gov/todayinenergy/detail.php?id=30092#:~:text=Although%20crude%20oil%20exports%20from,the%20southern%20tip%20of%20Africa)

Oil tankers, such as those used to transport crude oil to California, generate over 114 million tons of CO_2 annually.[295] Approximately 109 million metric tons of greenhouse gas emissions were associated with maritime oil vessel transportation in 2018.[296] Total greenhouse gas emissions related to transportation average around 11-12 kg CO_2 eq/barrel, according to Carnegie Endowment OCI data.[297]

Exhibit 4.22



(Source: https://theicct.org/publications/GHG-emissions-global-shipping-2013-2015)

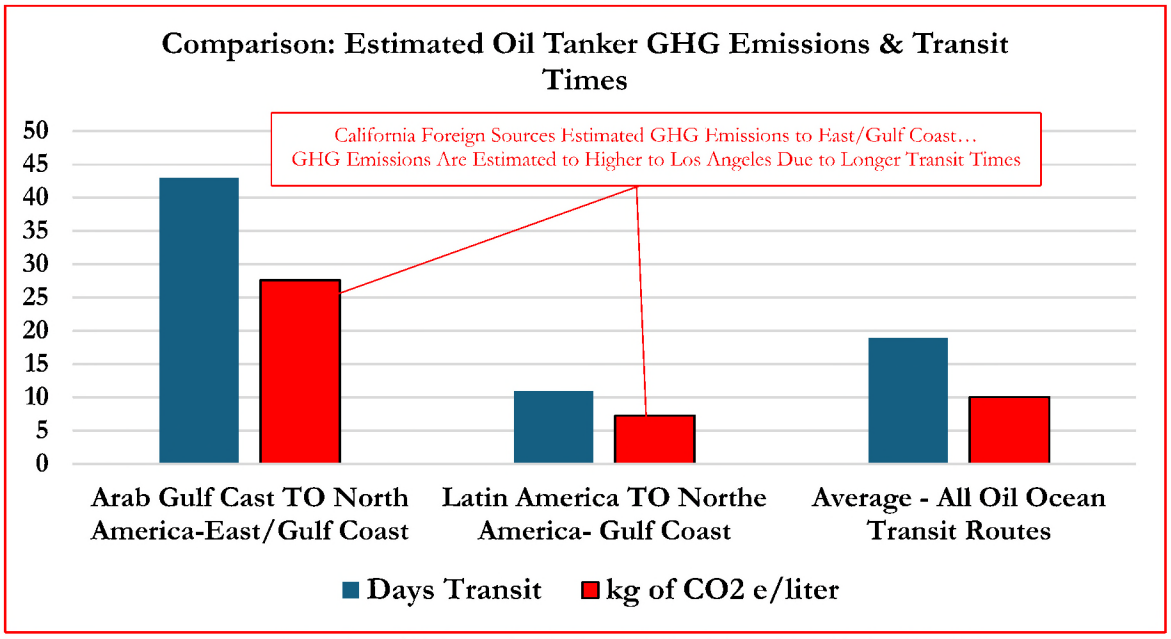
[295] Olmer, N., Comer, B., Roy, B., Mao, X. and Rutherford, D. Greenhouse Gas Emissions from Global Shipping, 2013-2015. (2017), https://theicct.org/publications/GHG-emissions-global-shipping-2013-2015

[296] Ankathi, S., Lu, Z., Zaimes, G. G., Hawkins, T., Gan, Y., & Wang, M. (2022). Greenhouse gas emissions from the global transportation of crude oil: Current status and mitigation potential. *Journal of Industrial Ecology*, *26*(6), 2045–2056. https://doi.org/10.1111/jiec.13262

[297] *Assessing Global Oils — Carnegie Endowment for International Peace.* (n.d.). Assessing Global Oils — Carnegie Endowment for International Peace. https://oci.carnegieendowment.org/#total-emissions

Most of California's crude oil imports in 2023 came from Iraq, Saudi Arabia, and Brazil. Although transit times and distances vary for oil imports from these sources, they all contribute to GHG emissions when measured as "well to tank."

Exhibit 4.23



(Source: https://theicct.org/publications/GHG-emissions-global-shipping-2013-2015)

SECTION 5.0
REFINERY OPERATIONS & MARGINS

A STUDY OF CALIFORNIA GASOLINE PRICES
Section 5.0
Table Of Contents

5.0 Refinery Operations & Margins

5.1 Introduction
5.2 Basic Refinery Economics
5.3 Business Operating Environment Costs
5.4 Refinery Capacity Utilization
5.5 Refinery Margins
5.5.1 Crude Costs and Margins
5.5.2 California Margins
5.5.3 Crack Spreads
5.5.4 California Crack Spreads

5.0 REFINERY OPERATIONS

5.1 Introduction

The first oil finery was established in Pittsburgh, Pennsylvania, in 1850. In 1855, a refiner in Connecticut produced gasoline. In 1862, John D. Rockefeller committed to building his first refinery, and by 1880, Rockefeller had created the Standard Oil Company, which produced petroleum products, predominantly kerosene, to a relatively consistent quality standard.[298]

Refineries are essential to the production of gasoline, jet fuels, heating oils, and bulk distillates, such as diesel fuels for trucks, railroad locomotives, maritime vessels, and agricultural machinery. Refineries are extraordinarily complex, and there are many different types of refineries with different production capacities and processes that produce specialized products. Some refineries are highly diverse and can produce a variety of products, and others are limited to only a few products. Irrespective of specialization, refineries are necessary to process crude petroleum molecules to produce fuels, plastics, concrete, asphalts, fertilizers, and many other products. Some of the more common of the 6,000 by-products of petroleum production include everyday items such as perfume, floor coverings, soap, paints, caulking, golf balls, drinking cups, blush, eyeliner, dialysis machines, medical gloves, birth control pills, insulin, and vitamins.[299] [300]

Oil refineries are highly sophisticated and are classified and rated on a standard scale known as The Nelson Complexity Index (NCI).[301] The NCI indicates the levels of operational and technical sophistication of a specific refinery and its operations. The NCI rates refinery capacity and sophistication on a scale of 1 to 20, with 20 being the most complex. Refineries with high NCI ratings are more sophisticated and capital intensive and are, therefore, inherently more complex and expensive to operate. However, high NCI-rated refineries generally have higher gross profit margins than less complex and lower NCI-rated refineries, assuming higher utilization rates.[302]

California has some of the most complex, sophisticated, and highest NCI-rated refineries in the U.S. and the world. For example, PBF's Torrance refinery, with 166,000 barrels per day throughput, and its Martinez refinery, at 157,000 barrels a day capacity, have NCI ratings of 13.8 and 16.1, respectively.[303] Chevron's El Segundo coking refinery has an NCI rating of 12.62 and 9.62 in its Northern California Richmond cracking complex.[304] [305] The Phillips 66 refinery that is slated to close by year-end 2025 has an NCI rating of 14.1.[306] By comparison, Marathon Petroleum, which operates

---

[298] *The refining and petrochemical industries: 170 years of innovation.* (n.d.). Www.afpm.org. https://www.afpm.org/newsroom/blog/refining-and-petrochemical-industries-170-years-innovation

[299] Paul. (2023, March 18). *List of 365 Products Made from Oil / Petroleum.* Bad Ass Work Gear. https://badassworkgear.com/list-of-products-made-from-oil-petroleum/

[300] Bruzek, A. (2020, November 25). *Making the Pill from Yams to Fish.* Living on Earth; World Media Foundation. https://www.loe.org/shows/segments.html?programID=20-P13-00048&segmentID=4

[301] *Refining Report Complexity index indicates refinery capability, value.* (1996, March 18). Ogj.com; Oil & Gas Journal. https://www.ogj.com/home/article/17234421/refining-report-complexity-index-indicates-refinery-capability-value

[302] Hafner, M., & Luciani, G. (2022). *The Palgrave handbook of international energy economics.* Chapter 3, Jean-Pierre Favennec. Palgrave Macmillan.

[303] *Refineries – PBF Energy.* (n.d.). https://www.pbfenergy.com/refineries/

[304] kgi-admin. (2021, October 27). *Refinery profile: El Segundo coking refinery, US.* Offshore Technology. https://www.offshore-technology.com/marketdata/el-segundo-refinery-coking-the-us/?cf-view

[305] kgi-admin. (2021, October 27). *Refinery profile: Richmond cracking refinery, US.* Offshore Technology. https://www.offshore-technology.com/data-insights/richmond-refinery-cracking-the-us/

[306] *Petroleum refineries vary by level of complexity - Today in Energy - U.S. Energy Information Administration (EIA).* (n.d.). Www.eia.gov. https://www.eia.gov/todayinenergy/detail.php?id=8330

the largest refinery in California, has its most sophisticated and highest NCI-rated refinery in Galveston, Texas, which is rated at 15.3, and the Jurong Island I refinery in Singapore has an NCI rating of 5.8.[307] [308] Overall, and based on the available data, the average for U.S. refineries is 9.5, while European refineries have a lower average of approximately 6.5.[309]

Exhibit 5.1[310]

NCI RATINGS & CAPACITIES OF SELECTED CALIFORNIA REFINERIES		
California Refinery	Capacity (barrels per day)	NCI Rating
GCEH-Benicia	145,000	16.1
Marathon - LA	365,000	12.07
Phillips 66- LA (slated for closure)	139,000	14.3
PBF- Martinez	156,400	16.1
PBF- Torrance	160,000	13.8
Valero- Wilmington	85,000	15.9
CA. Total (selected refineries only)	175,067	
CA. NCI Average		**14.43**
U.S. NCI Average		**9.5**
EU NCI Average		**6.5**

(Source: see footnote below)

Operationally, refineries share three basic processes: **1-** Separation, **2-** Conversion, and **3-** Treatment.

- 1- Separation involves the atmospheric distillation of crude oil into various fractions or components (fracking).
- 2- Conversion involves the "cracking" of the various components into various product type streams.
- 3- Treatment creates the final petroleum product, such as gasoline. Treatment involves blending separated products with various additives to derive a gasoline product and grade compliant with federal and State mandates.

---

[307] *What is the Nelson Complexity Index? Oil 101 Podcast.* (2021, September 28). EKT Interactive. https://ektinteractive.com/podcast/oil-101-podcast/oil-101-nelson-complexity-index/

[308] sarikabandari. (2023, May 4). *Top ten active oil refineries in Asia*. Offshore Technology. https://www.offshore-technology.com/data-insights/top-ten-active-oil-refineries-asia/?cf-view

[309] Maples, R. E. (2006). *Petroleum refinery process economics*. Pennwell Corp.

[310] *List of oil refineries.* (2020, April 24). Wikipedia. https://en.wikipedia.org/wiki/List_of_oil_refineries

Refineries are capital intensive operational assets that require an extensive and sophisticated supporting infrastructure, highly trained workers, constant maintenance, and technical and innovative upgrades. Under the most favorable conditions, an oil refinery will cost between $5.0 to $15.0 billion (or about $46 per person in the U.S.) and years to build. In California, it is essentially impossible to build a new refinery or to significantly expand an existing refinery due to zoning, permitting, regulatory, and environmental restrictions, as well as the prevailing political policies and sentiment.[311] California's Advanced Clean Cars Acts I and II mandate the elimination of internal combustion engine (ICE) cars and light truck and SUV sales by 2035. Consequently, there is no incentive for a refiner to expand or incur significant investments in refinery operations, for new gas station retailers to enter the market, or for current refiners to even stay in the California market space.[312]

5.2 Basic Refinery Economics

Refinery economics are as complex as the engineering of a refinery and its related operations. Refineries are extraordinarily expensive to maintain and operate, which contributes to the challenges of operating a refinery profitably. Refineries operate on crude oil, which is the primary input for the creation of other products, such as gasoline. The key operating characteristics of an oil refinery reflect traditional economic theory. Oil refineries operate best when:

(1) there is a stable and certain stream in inbound oil stocks from which to make products,
(2) they operate within a capacity utilization range of 88% to 94% and achieve and sustain economies of scale in production,
(3) their operating equipment is well-maintained pursuant to a planned maintenance schedule,
(4) they are operated with a highly skilled and trained labor force,
(5) they are producing relatively homogeneous products, and
(6) they utilize advanced production methods and innovations.

Refineries are most efficient and productive when they achieve economies of scale and when the costs of production are optimized. Economies of scale vary based on a number of factors, of which engineering, capacity, labor competency, and quality of raw material inputs, processes, and products produced are central. Typically, the larger the refinery volume and the higher its capacity utilization rate, the more efficient and profitable the refinery will be, ceteris paribus. Stated differently, the cost of refining a barrel of crude decreases as more crude is refined. The more crude oil that is refined creates a larger numerator from which to allocate and spread both variable and fixed costs, thereby lowering cost per unit and improving both operating (gross) and net margins. Typically, the complexity of the refining methods and technologies is associated with higher production costs. Conversely, complex refineries also generate higher margins than less complex ones since complex refineries are adaptable and efficient at cracking and the conversion of heavier crudes into high value products, such as gasoline.

The type of oil stocks that a refinery uses to produce gasoline and other fuels largely determines the manufacturing methods and technologies that it uses to produce the fuels. In general, the costs of

[311] *The Cost of Building a Refinery in 2021*. (2021, November 5). Tiger General. https://www.tigergeneral.com/the-cost-of-building-a-refinery-in-2021/
[312] California Air Resources Board. (2024). *Cars and Light-Trucks Are Going Zero - Frequently Asked Questions | California Air Resources Board.* Ww2.Arb.ca.gov. https://ww2.arb.ca.gov/resources/documents/cars-and-light-trucks-are-going-zero-frequently-asked-questions

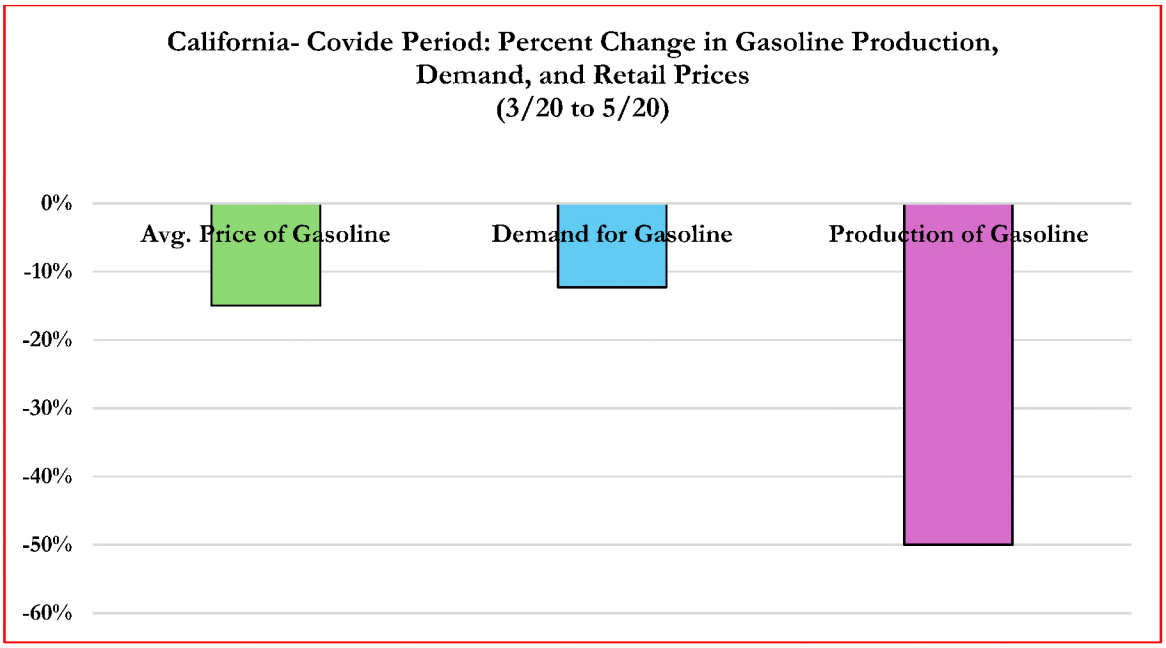
processing crude oils are influenced by not only production methods but the quality of the crude oil itself. Refineries, such as those in California, are configured to process light heavy to extra heavy crude oils from California and foreign sources (see Section 3.0). To process lighter sweet crudes would require a massive investment in equipment and changes to manufacturing processing flows. Thus, in California, with a legislative mandate looming to end internal combustion vehicles and high structural and embedded costs, it is not practical or economically prudent to apply funds for California refiners to engage in switching to different, lighter crude oil stocks.

Refiners are completely reliant on a consistent and steady supply of crude oil stock to produce gasoline, jet fuel, and derivative products. Refineries are designed for throughput, and to help maintain economies of scale, refiners hold a certain amount of crude oil as raw material inventory. The crude oil is inventoried (stored) in large tanks. Relative to PADD 5, where California's refineries are located, of the total 426.0 million barrels of crude oil stock held in U.S. inventory by refiners, 47.3 million or 11.1% are located in PADD 5. As described in Section 3.0, California refineries hold between 11.74 to 14.7 days of finished gasoline inventories and around 13.3 million barrels of oil as inventory stock.

To achieve profitability, refiners must refine at high volumes of throughput, which creates economies of scale. Refinery throughput (production) is measured in barrels or gallons a day and as a percentage of the refinery's maximum capacity utilization. Like any other business, refiners are highly sensitive to changes in the price of raw materials, which, in this case, are global crude oil prices. This is particularly the issue with California refineries, which are heavily dependent on foreign sourced oil, especially oil from the Middle East. Refiners are also obviously sensitive to end-user demands, which, although they have certainty, also fluctuate and can be highly elastic to external stimuli, such as government mandated shutdowns, as was the case throughout 2020 and into 2022. During the COVID-19 pandemic, when governments such as California implemented mass restrictions and mandatory shutdowns of businesses, schools, and retail establishments, the demand for gasoline fell from 32.4 million gallons a day in March 2020 to 28.6 million barrels a day in May 2020, or roughly 12.3%.[313] Correspondingly, from March 2020 to May 2020, California gasoline production fell by 50%, and the average retail selling price for all formulations fell 15% from $3.262 to $2.771 per gallon.[314]

[313] *California Total Gasoline Retail Sales by Refiners (Thousand Gallons per Day).* (2014). Eia.gov. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=A103650061&f=M
[314] *California All Grades All Formulations Retail Gasoline Prices (Dollars per Gallon).* (2010). Eia.gov. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=emm_epm0_pte_sca_dpg&f=m

Exhibit 5.2



(Source: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMM_EPM0_PTE_SCA_DPG&f=M)

Many factors influence refinery operations and, ultimately, refiner profitability. Some of the most severe situations, such as weather, accidents, equipment malfunctions, and war, can cause unplanned production outages or reductions of significant duration, which, in turn, influence the supply of fuels and end-user prices. The chart below summarizes just a few of the many exposures and risks that influence refinery production.

Exhibit 5.3

REFINERY PRODUCTION- SOME INFLUENCING FACTORS		
Influence on Production	**Predictable**	**Non-predictable**
Product Demand	☑	
Refinery- Planned Maintenance	☑	
Refinery- Unplanned Maintenance		☑
Force Majeure		☑
Weather		☑
Political Events- War		☑
Shipping Lane Disruption		☑
Seasonal Blend Change	☑	
CA Special Blend	☑	
Processing & Equipment Malfunctions	☑	☑
Accidents		☑
Regulatory Requirements	☑	
Labor Disputes		☑
Marine Terminal Disruptions		☑

(Source: Author)

Due to their technical configurations, processes, and refinement capacities, refinery economics and operations are highly sensitive to changes in the price of crude oil, the source of crude oil, and the quality of crude oils used to refine crude petroleum into gasoline. Refineries in California specialize in complex processes. To meet demand, and with no inbound pipelines, California refineries are almost entirely dependent on foreign crude oil and maritime transportation for consistent crude stocks. Any disruptions to foreign sources or in the inbound transportation of crude oil will disrupt refinery operations and could stimulate an increase in retail prices. Such was the situation in the 1970s with the Arab Oil Embargo of the U.S. Any disruptions, whether planned, unplanned, unforeseen, foreseen, or by force majeure, etc., affect both oil and gasoline supply and demand. When a refinery shuts down or is forced to shut down due to some event, supply is stressed throughout the distribution and supply chain model, and retail prices usually spike in the short term. When capacity and supply are restored, prices moderate.

In California, as well as in other states, refineries must schedule production switchovers to comply with EPA mandates. In California, refiners must also produce California's special CaRFG (reformulated) gasoline grades and blends as mandated by California law. California, as discussed in Section 3.0, requires a special blend of gasoline, which is unique to the Golden State and not required in other states. Thus, California is an isolated market and highly vulnerable to supply dynamics.

Refinery economics requires that refineries constantly plan and strive to achieve a sense of equilibrium between the amount of crude oil stock inputs (supply) and the amount of gasoline output needed to satisfy the consumer market (demand). Because of their high-capacity utilization, high capital costs, product shelf life, and regulatory costs, refiners have a minimal surplus inventory of finished products. For example, according to EIA data for 2024, the world production of petroleum was estimated at 102.5 million barrels a day, and world consumption was 102.77 million barrels a day…virtually equilibrium.[315] As discussed in Section 3.0, gasoline is an unstable liquid in that, once refined, it is vulnerable to oxidation, heat, humidity, moisture, and other contaminants. In final product form, finished gasoline has a diminishing shelf-life because it degrades over time.

5.3 Business Operating Environment Costs

California is one of the costliest states in the U.S. in which to operate a business. According to CNBC, California ranks 23rd in the U.S. as a "Top Business State," is ranked 45th for cost of doing business, and holds the 47th rank for business friendliness in the U.S.[316] For site selection and locating a business, while Texas ranks as #1, California is ranked #15.[317] Furthermore, in 2018, 68% of major highways and roads in California were ranked by the National Transportation Research Group as poor or mediocre, resulting in an additional $843.00 annually in individual vehicle operating costs.[318] Below is an exhibit summarizing some of the common ranking factors for business environments as related to the Golden State.

---

[315] https://www.eia.gov/outlooks/steo/tables/pdf/3atab.pdf

[316] Danelladebel. (2024, June 28). *Governor Newsom Announces California Will Phase Out Gasoline-Powered Cars & Drastically Reduce Demand for Fossil Fuel in California's Fight Against Climate Change | Governor of California*. Governor of California. https://www.gov.ca.gov/2020/09/23/governor-newsom-announces-california-will-phase-out-gasoline-powered-cars-drastically-reduce-demand-for-fossil-fuel-in-californias-fight-against-climate-change/

[317] Monaghan, D. (2024, November). *2024 Business Climate Rankings: Growth Mindset*. Site Selection Magazine. https://siteselection.com/2024-business-climate-rankings/

[318] TRIP. (2018). *California transportation by the numbers*. https://tripnet.org/wp-content/uploads/2018/08/CA_Transportation_by_the_Numbers_TRIP_Report_Aug_2018.pdf

Exhibit 5.4[319]

Business Operating Environment Factor	2023 to 2025 CA. Ranking Out of 50
Cost of Living	**50**
Best State to Do Business In	**50**
Commercial Insurance Rates	**50**
State Financial Liability & Unfunded Liabilities	**50**
Retail Gasoline Prices	**49**
College Readiness	**49**
Unemployment Rate	**49**
Favorable Tax Climate	**48**
Workers Compensation Rates ($100/PR)	**47**
Most Likihood of Business Insurance Lawsuits	**46**
Cost of Doing Business	**45**
Education: K to 12	**37**
Economy	**32**
Overall Business Friendliness & Climate	**23**
(Scale: 1 = Best or First, 50 = Worst or Last)	

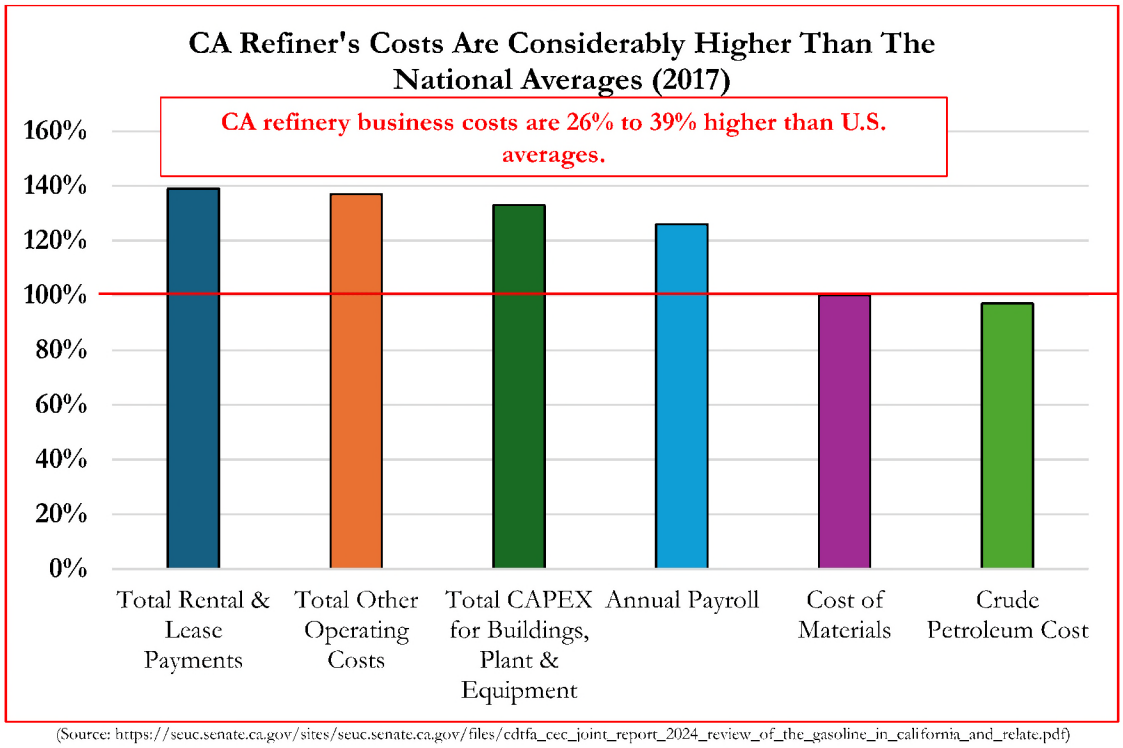
(Source: Multiple, See footnote below)

Not surprisingly, the high cost of doing business in California carries over to refinery operations and costs. According to the October 2024 CEC and CDTFA Joint Agency Report, California refinery costs are considerably higher than the averages for the U.S.[320] Specifically, the Joint Agency Report concluded that California refinery operating costs range between 26% to 37% higher than the U.S. average for refineries. Summarized in the exhibit below are the findings from the CEC and CDTFA Joint Agency Report.

[319] Various including, but not limited to: staff, CNBC. com. (2024, July 11). *23. California.* CNBC. https://www.cnbc.com/2024/07/11/top-states-for-business-california.html; *California.* (2025, February 12). ChiefExecutive.net. https://chiefexecutive.net/best-worst-states-business/California/;Reason Foundation. (2024, December 19). *State debt: California, Illinois, New York, New Jersey and Texas each have over $200 billion in total liabilities.* Reason Foundation. https://reason.org/transparency-project/debt-trends-state-local/state/#;Hallo, S. (2024). *States with the highest workers' comp rates.* Propertycasualty360.com; Property Casualty 360. https://www.propertycasualty360.com/2024/06/03/states-with-the-highest-workers-comp-rates/?slreturn=2025020300429;Meenasian, S. (2025, January 21). *Which States Top the Charts for business Insurance Lawsuits? A Look at the Numbers.* USA Business Insurance Services, Inc. https://www.businessinsuranceusa.com/news/insurance/states-highest-business-insurance-lawsuits/;U.S. Bureau of Labor Statistics. (2024). *Unemployment Rates for States.* Bls.gov. https://www.bls.gov/web/laus/laumstrk.htm; https://www.usnews.com/news/best-states/rankings/education/prek-12.

[320] CDTFA_CEC joint report 2024 review of the gasoline in ... (n.d.-b). https://seuc.senate.ca.gov/sites/seuc.senate.ca.gov/files/cdtfa_cec_joint_report_2024_review_of_the_gasoline_in_california_and_relate.pdf

Exhibit 5.4.1

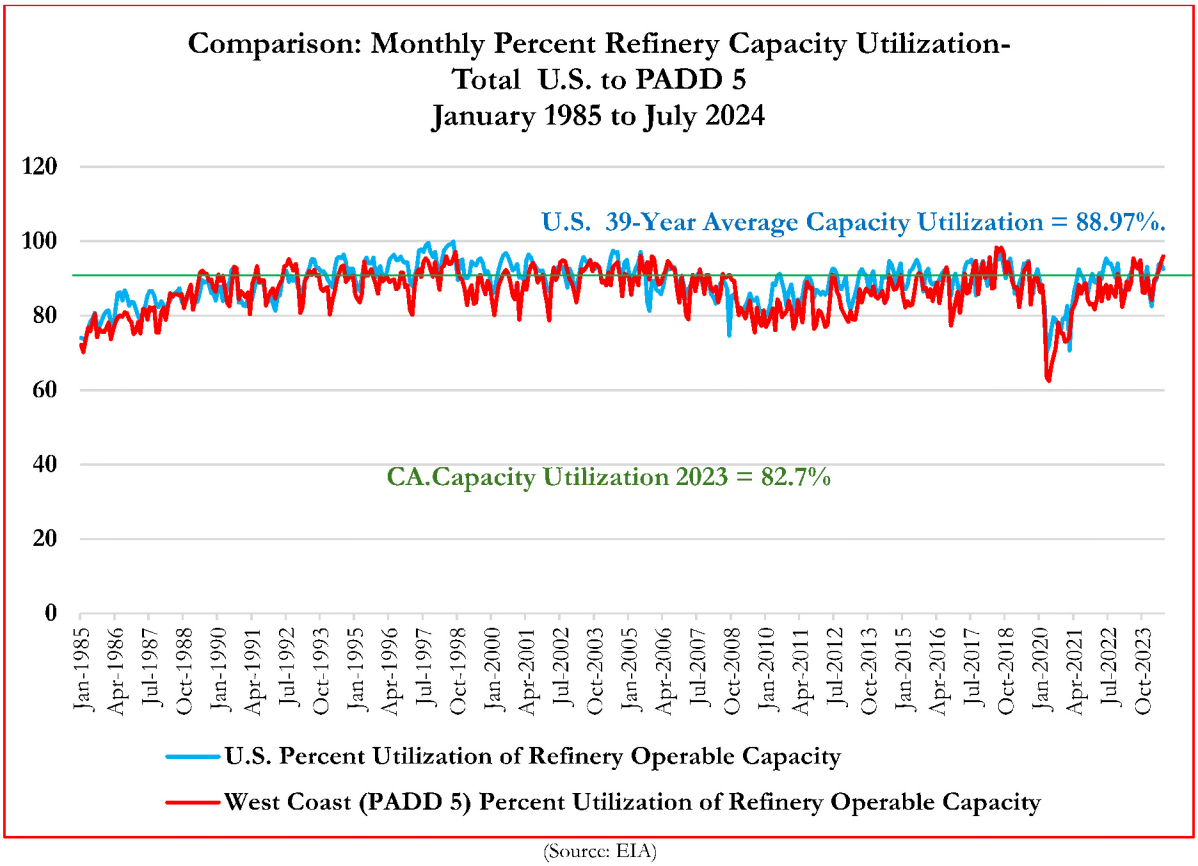


(Source: https://seuc.senate.ca.gov/sites/seuc.senate.ca.gov/files/cdtfa_cec_joint_report_2024_review_of_the_gasoline_in_california_and_relate.pdf)

5.4 Refinery Capacity Utilization

Refining capacity utilization is a key component and metric in operational efficiencies and economies of scale. Below is a chart summarizing the monthly percent of capacity utilization of all U.S. oil refineries compared to PADD 5 refineries from 1985 to 2024. As indicated, the correlation between the overall U.S. and PADD 5 is relatively strong, with a correlation coefficient of .773.

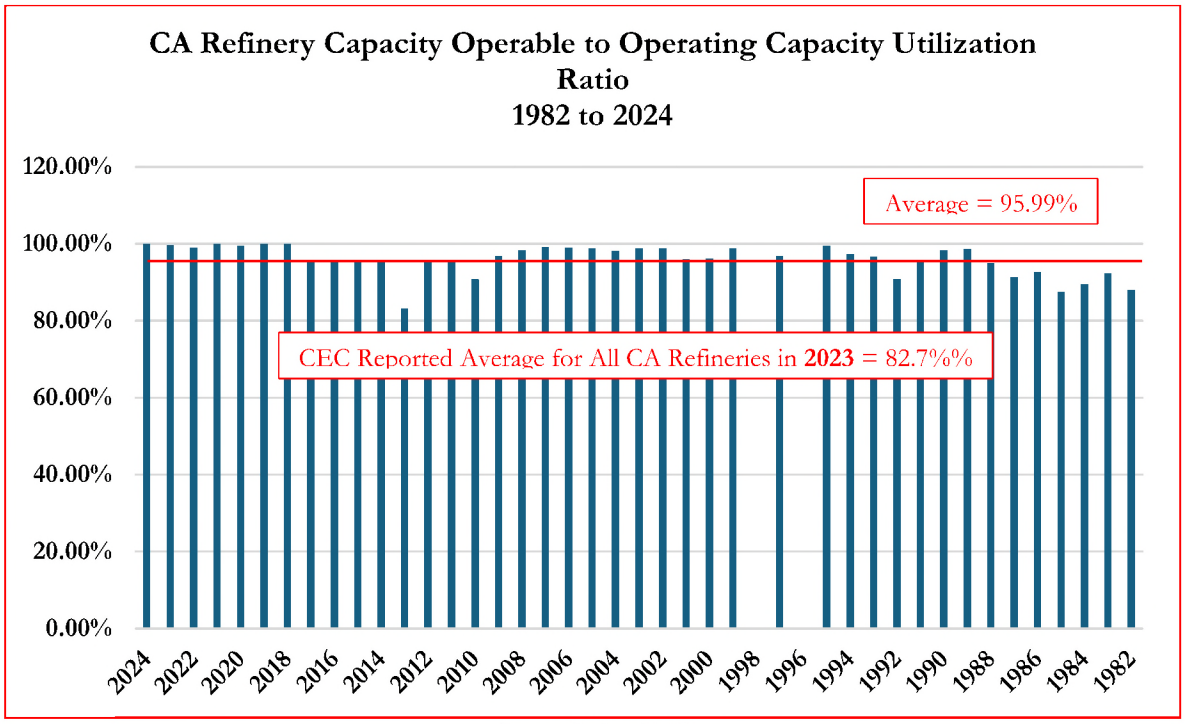
Exhibit 5.5



(Source: EIA)

Refineries adjust their capacity utilization rates based on several factors, foremost the estimated demand for products. When demand is high, refiners increase capacity utilization; when it is low, they adjust utilization downward. Thus, refiners constantly try to achieve a sense of equilibrium between production (supply) and demand (consumption).

Exhibit 5.6



(Source: CEC and EIA)

To maintain operational capacity, produce various octanes, and adhere to the regulatory requirements of specialized and seasonal blends and grades, refineries must switch or transition from one blend and one season to another. The switchovers typically involve a shutdown or slowdown in production and a reduction in capacity utilization and output. The switchovers not only impact refinery operations but also oil and gasoline transportation. Gasoline pipelines, which move finished products from refiners to distribution points, must be evacuated and cleaned so as not to mix seasonal blends and conventional gasoline with reformulated special blended gasoline. When planned switchovers and shutdowns occur, retail prices usually experience a "seasonal" increase due to inventory levels and the general uncertainties surrounding refinery reopening and resumption of full production. In general, refinery operations are stopped, suspended, or interrupted based on three primary reasons:

- **Scheduled Technical or "Turnaround" Shutdowns.** As operational assets, refineries schedule (plan) periodic shutdowns for inspection, testing, maintenance, re-certifications, repairs, upgrades, and the installation of new technologies. Scheduled shutdowns are known in advance and are usually public knowledge. California refineries, as well as those in other countries and states, practice scheduled shutdowns.
  - In the U.S., major technical or "Turnaround" shutdowns are performed about every four years for refineries in January and February (the first calendar quarter) when the demand for gasoline is usually at its lowest. Historically, the demand for gasoline has been the lowest during the first week of February and is highest in August through mid-September.
  - Based on a four-year schedule, about 25% (one in four) of refineries undergo turnaround or scheduled (planned) shutdowns about once every four years.

- **Scheduled Switching (Transition) Shutdowns.** Because refineries make a number of different products and gasoline grades, they schedule periods of time in which they can switch their operational profiles over to the planned product. Switchovers can take as little as a few days or run several weeks. In the U.S., as well as California, refineries schedule "switchovers" or transition shutdowns to produce seasonal blends.
  - California refineries have several periods of required switchovers due to the mandatory seasonal blends.[5]
  - Generally, a switchover to seasonal blends causes short-term retail price increases.
  - California gasoline pipelines are also affected by seasonal switches as they must also be cleaned and purged as a precondition to switching out blends.
  - Below is an exhibit summarizing key refinery shutdown and changeover periods.

Exhibit 5.7

Event	Timing		Regulatory Required	Comments
Scheduled/Planned	January	February	Partial	Low Demand- Turnaround
US- Summer Blend Switch	March	April	Yes	EPA- Transition Season; price increases common
Terminal/Retail Purge	May	June	Yes	Can result in lower short term inventories & price spikes
Driving Season- Summer	March	August	No	Generally higher demand & higher prices
US- Winter Blend	September	February	Yes	Can result in lower short term inventories & price spikes
Driving Season- Winter	September	February	No	Generally lower demand & lower prices
CA- Summer Blend	April	October	Yes	Generally higher demand & higher prices
CA- Winter Blend	November	Marach	Yes	Generally lower demand & lower prices

(Sources: AAA, and https://www.convenience.org/Topics/Fuels/Changing-Seasons-Changing-Gas-Prices)

- **Unplanned Shutdowns.** Unplanned shutdowns occur due to mechanical or equipment failures, malfunctions, and/or safety needs, as well as refinery mishaps and acts of nature and force majeure. Unplanned shutdowns include non-controllable events such as weather-related, natural events (e.g., earthquakes), and mechanical/technical (e.g., breakdowns, equipment failures, etc.) that can disrupt production and supply chains. Likewise, labor and transportation disruptions, wars and terrorism, and other geopolitical events can force unscheduled shutdowns or production rollbacks, which, in turn, influence increases in retail prices. Some examples:
  - In 2020, a major fire occurred in Marathon's Carson refinery, resulting in flaring and atmospheric contamination.[321]
  - In 2015, the Exxon Mobil Torrance Refinery sustained an explosion, shutting down production.[322]
  - In 2015, a ruptured oil pipeline emptied 140,000 gallons of crude oil into the Pacific Ocean offshore of Santa Barbara (Refugio), disrupting refinery supplies and causing considerable environmental damage.[323]

[321] *Communities for a Better Environment 6325 Pacific*. (n.d.). Retrieved March 6, 2025, from https://www.cbecal.org/wp-content/uploads/2020/02/CBE-2020-Factsheet-MarathonTesoro-explosion-Refinery-Fires.pdf
[322] *ExxonMobil Torrance Refinery Explosion | CSB*. (n.d.). Www.csb.gov. https://www.csb.gov/exxonmobil-torrance-refinery-explosion-/
[323] *Following Santa Barbara Oil Spill, New Analysis, Video Reveal Devastating Toll of California Pipelines*. (2015). Biologicaldiversity.org. https://www.biologicaldiversity.org/news/press_releases/2015/california-pipelines-05-22-2015.html

- In 2012, Chevron's Richmond Refinery, which began operating in 1902, experienced a pipe explosion that shut down production for almost a year.[324]

As indicated in Section 3.0, refiners in the U.S. are required by the EPA to produce various octanes in **seasonal** blends. In California, refiners are required to produce **both** seasonal and California **special** blends, which make California gasoline unique. The production of both blends requires special tooling (equipment) and processes that yield a final product that is compliant with the regulatory mandates. The costs of producing a compliant product are considerably higher.

5.5 Refinery Margins

5.5.1 Crude Costs and Margins.

Oil refinery gross and net margins are some of the most volatile of all industries. As crude oil is a commodity, refinery profits are highly correlated with global oil prices. Crude oil represents 45% to 60% of the price of gasoline and has a direct influence on retail prices at the pump.[325]In California, crude oil has historically represented 48.25% of the price of gasoline.

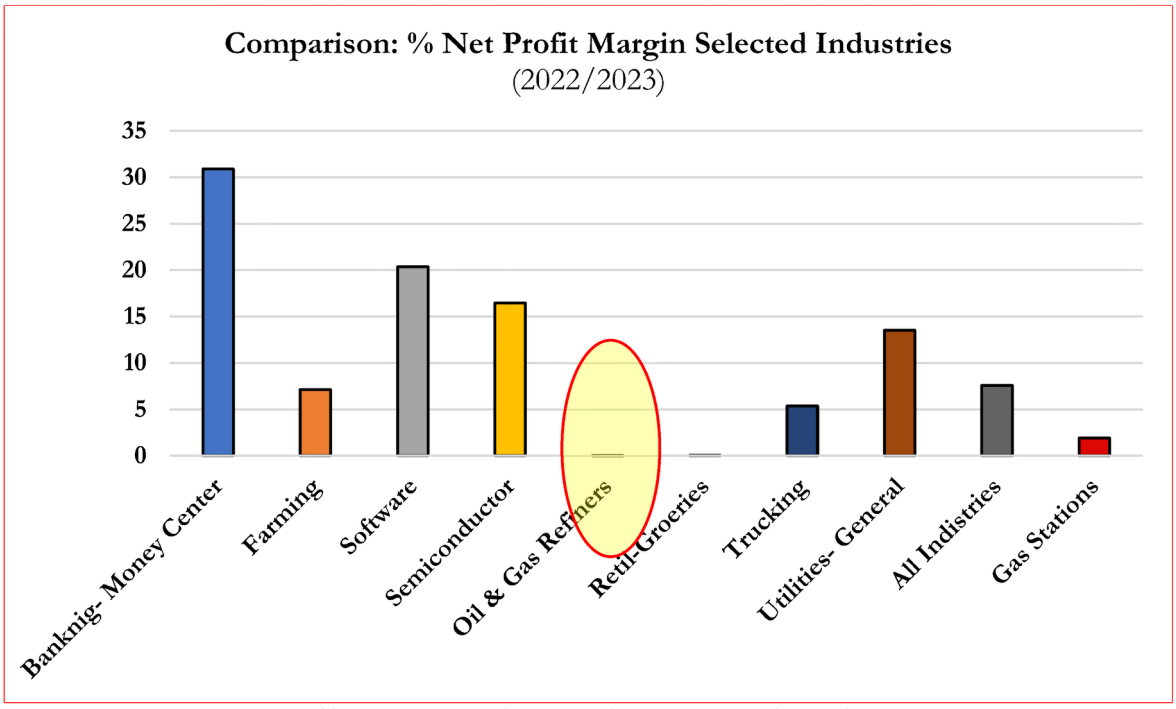
As crude oil is a commodity, oil refinery margins follow the basic laws of supply, demand, and prices. When crude oil prices are high, refineries benefit, and their margins expand. Conversely, when crude oil prices are low, refinery margins contract. Therefore, refinery profits and margins can be high or low at any point in time. Refineries, like any business, can operate with profits or losses, depending on costs and efficiencies, but unlike many other businesses, they are at risk with respect to crude oil prices. Special seasonal blends yield different profit margins, as well. Winter blends are more expensive to refine and also have higher margins than summer blends. Strong macroeconomics are also correlated to higher crack spreads and margins. In addition to the impact of crude oil prices are the operating behaviors of a refinery and the products that they make, which influence profitability.)

5.5.2 California Refinery Margins. Across multiple industries, the CSI Market ranks oil refineries 93rd in net profitability, 103rd in gross profits, 88th for return on assets, and 91st for return on equity.[326] Based on CSI Market data, the gross profit margin for oil refineries averaged 4.256% and .338% for net margins for five quarters from Q4-2023 to Q4-2024.[327] For perspective, an NYU Stern study found that across all industries, the gross profit and net profit margins were 36.56% and 8.54%, respectively.[328] On a comparative basis, oil refinery net profits are among the lowest among various industries and rank low, along with grocery stores.

---

[324] *"Kristin J. Bender and Daniel M. Jimenez, "Massive fire at Chevron refinery in Richmond fully contained; shelter in place lifted", Contra Costa Times (August 6, 2012)"*
[325] EIA. Also, *Gas Prices Explained – US Oil & Gas Association.* (2024, August 8). Usoga.org. https://usoga.org/gas-prices-explained/.
[326] *Oil Refineries Industry Profitability by quarter, Gross, Operating and Net Margin from 1 Q 2022.* (n.d.). Csimarket.com. https://csimarket.com/Industry/industry_Profitability_Ratios.php?ind=606
[327] *Oil Refineries Industry Profitability by quarter, Gross, Operating and Net Margin from 1 Q 2022.* (n.d.). Csimarket.com. https://csimarket.com/Industry/industry_Profitability_Ratios.php?ind=606
[328] Damodaran, A. (2024, January 5). *Useful Data Sets.* Nyu.edu. https://pages.stern.nyu.edu/~adamodar/New_Home_Page/data.html

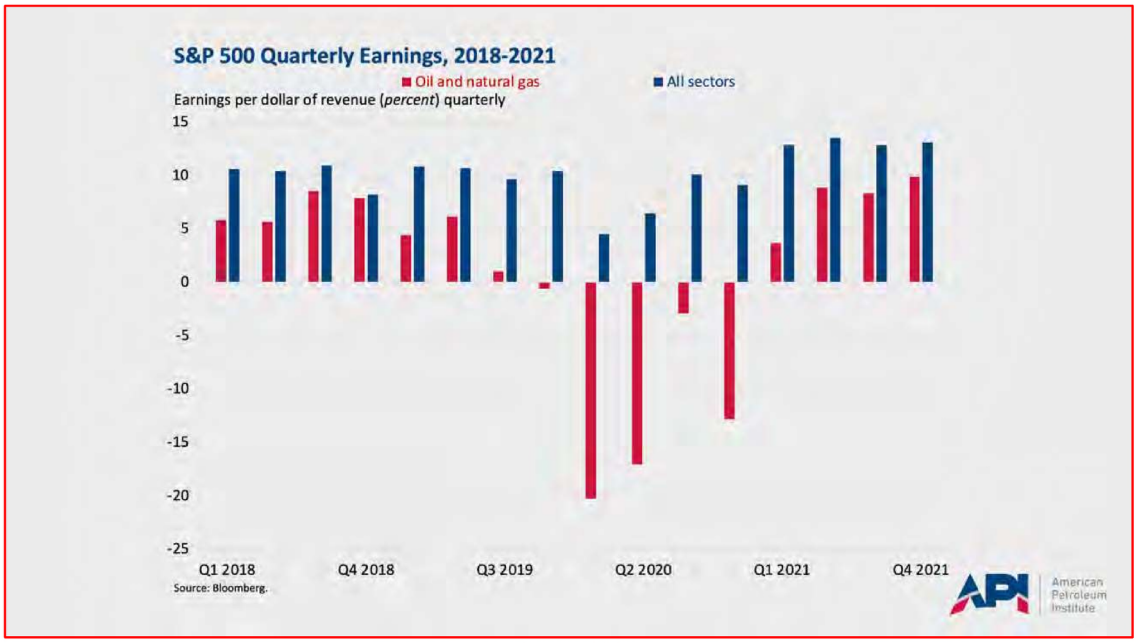
Exhibit 5.8



(Source: https://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/margin.html and https://csimarket.com/Industry/industry_Profitability_Ratios.php?ind=606)

As indicated in the exhibit below, refinery earnings and margins fluctuate daily, weekly, quarterly, and annually.

Exhibit 5.9

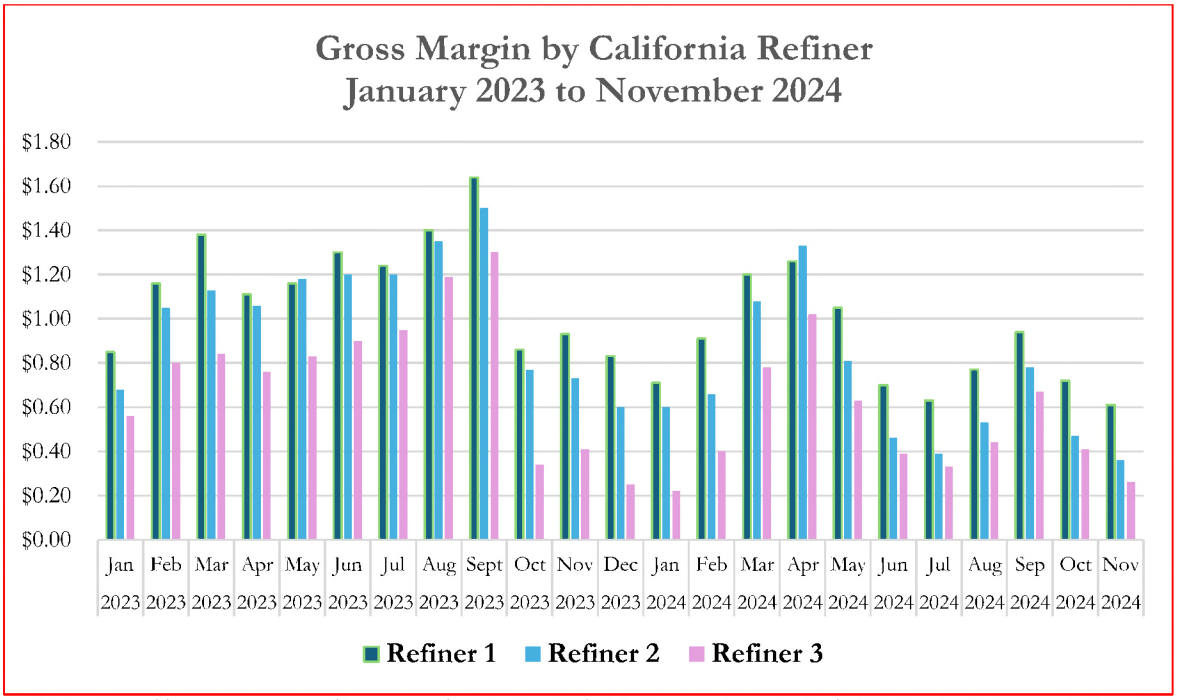


(Source: API)

Based on its internal analysis, the CEC estimated that refinery gross profits ranged between $1.00 and $2.31 a gallon for the 2002 to 2022 period. However, that was gross profit margins only and not net profits. To derive gross profits, the CEC uses the wholesale price of gasoline minus the cost of crude oil. Such representation is accurate but not necessarily completely accurate. It is common for refineries to include in the calculation of gross profits the cost of crude oil stock plus regulatory costs. A more thorough measure is net profit margin and dollars since net profits generate free cash flows after all costs are considered. Net profits include all operational costs, which, in 2023, averaged around $1.00 a gallon. For perspective, California taxes, fees, and regulatory mandates total around $1.42 a gallon. Taken as a whole, for the 2023 to 2024 period, California refiners averaged around $0.09 a gallon. 2022 was also reflective of Biden's economic policies and a period of high inflation, with gasoline prices hitting a historical high in June 2022 and inflation peaking at 9.1%. From December 2019 to December 2023, overall percentage change in retail gasoline prices in the U.S. increased by 21%, while the percentage change in California gasoline prices increased by 34%.

As indicated below, the gross margins for three California refiners, as reported by the CEC for a 23-month period, fluctuated from a high of $1.64 a gallon in September 2023 to a low of $0.22 a gallon in January 2024. For all three refineries, the average gross profit per gallon was $0.84.

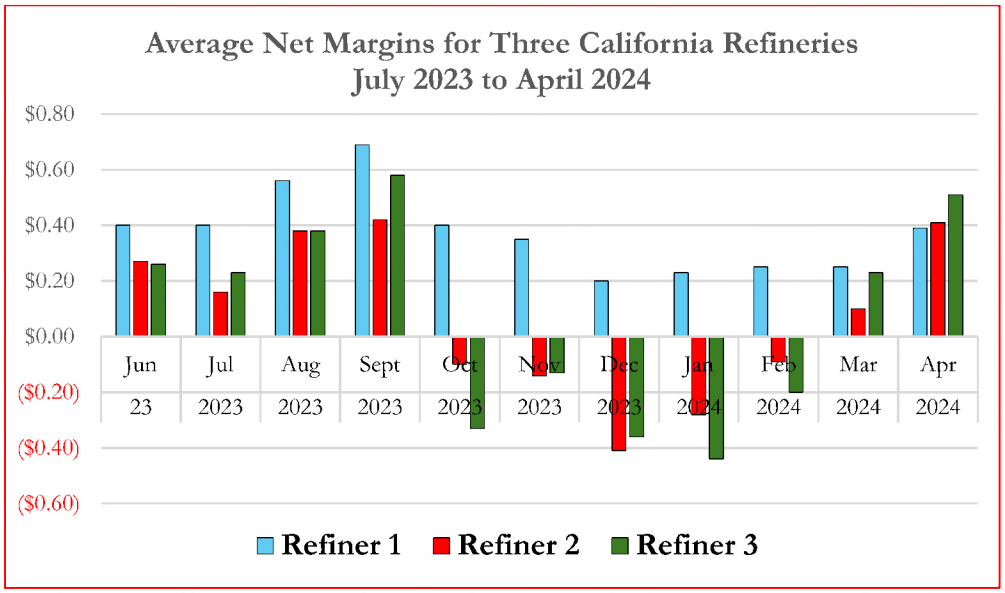
Exhibit 5.10



(Source: https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/california-oil-refinery-cost-disclosure)

Summarized below is the average net margin for three California refiners for an 11-month period. Of the 11 months, five months, or 45.5%, indicated negative profitability.

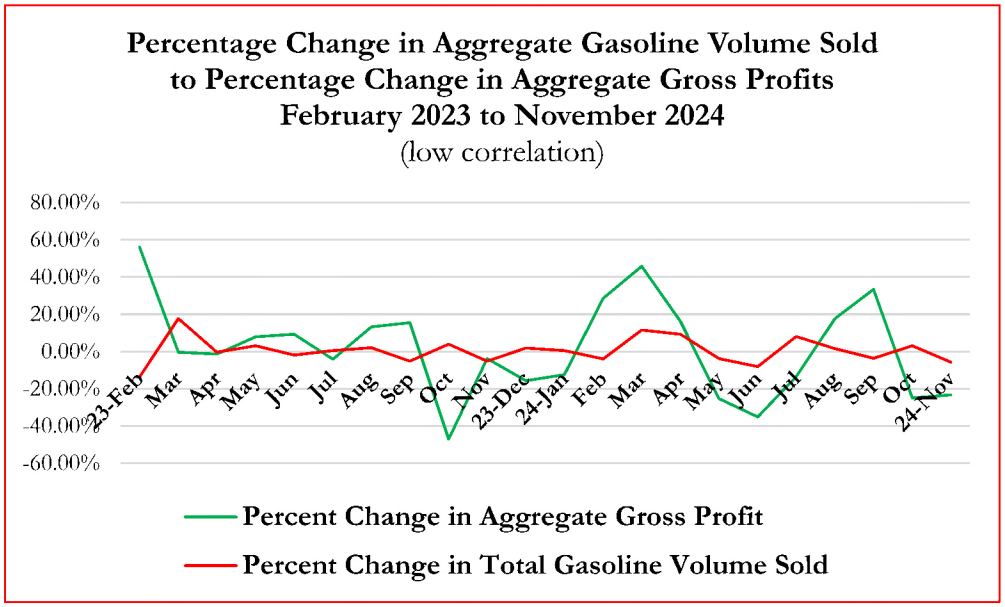
Exhibit 5.11



(Source: https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/california-oil-refinery-cost-disclosure)

Summarized in the exhibit below is the percentage of gasoline volume sold in California and aggregate gross profits for a 22-month period commencing February 2023 and ending November 24, 2024. As indicated, gasoline sales fluctuated, as measured by percentage change, ranging from 17.89% to -13.60% with an average variance of .50%. Conversely, the average fluctuation in aggregate gross profits for the same period ranged from 58.06% to -48.98%, with an average variance of 1.62%.

Exhibit 5.12



(Source: https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/california-oil-refinery-cost-disclosure)

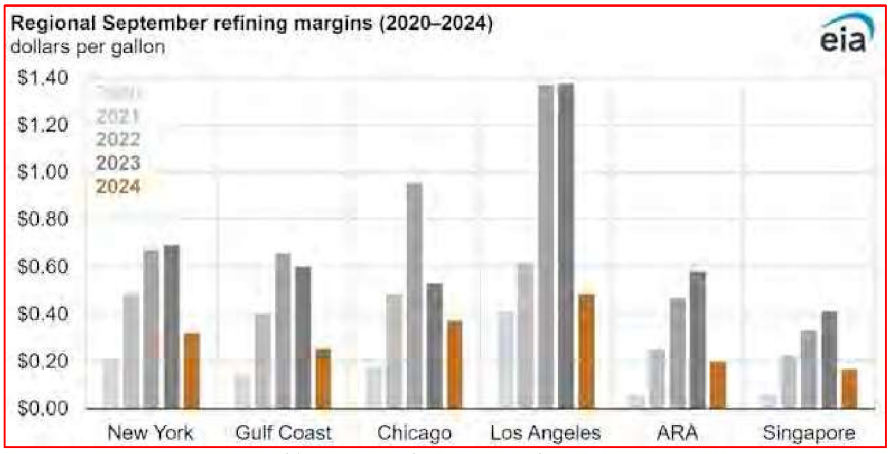
On a five-year basis, comparing the various refining margins for six U.S. regions, the refining margins, as measured in dollars, show extreme variability. As indicated in the exhibit below, refiner margins rebounded and increased from mid-2020, the end of Covid, through 2023. The margins reflect not only operating efficiencies and the price of crude oil but also the speed at which various regions recovered from government mandated Covid lockdowns. California was the first state to issue 'shelter in place" lockdowns, which began on March 19 and ran through to August 28, 2020, or 162 days. California's lockdown was the second longest, and New Mexico was the longest in the U.S.[329] For perspective, Florida's lockdown period was 31 days, spanning the April 2 to May 2, 2020, period.[330]

When the lockdowns were lifted, demand recovered and snapped back. In California, which had comparatively protracted lockdowns, as demand for gasoline recovered, refiner margins substantially increased, in part due to the rate of recovery and a reduction in refinery capacity due to closures or conversions. In simple economic terms, refiner margins increased as demand accelerated at faster rates than supply due to reductions in supply attributed to refinery closures and/or conversions.[331] As demand stabilized in late 2023 and slowed throughout 2024, and the global price of crude oil modulated, refiner margins began to fall. Contributing to the decline in refinery margins was the drop in distillate fuels used in manufacturing. During the Biden years, U.S. industrial manufacturing increased less than one percent from 102.02% in 2019 to 102.90% in 2023.[332]

Additional factors that contributed to higher crack spreads and, thereby, higher refiner margins and profits and retail gasoline prices during the 2020 to 2023 period were high U.S. inflation, lower global refinery capacity, and the Russian invasion of Ukraine.

Since peaking in 2023, refiner margins across the U.S., including California, are falling. As indicated, the refinery margins, as measured in dollars per barrel in California, fell further and faster than any other part of the U.S. from 2023 to 2024.

Exhibit 5.13

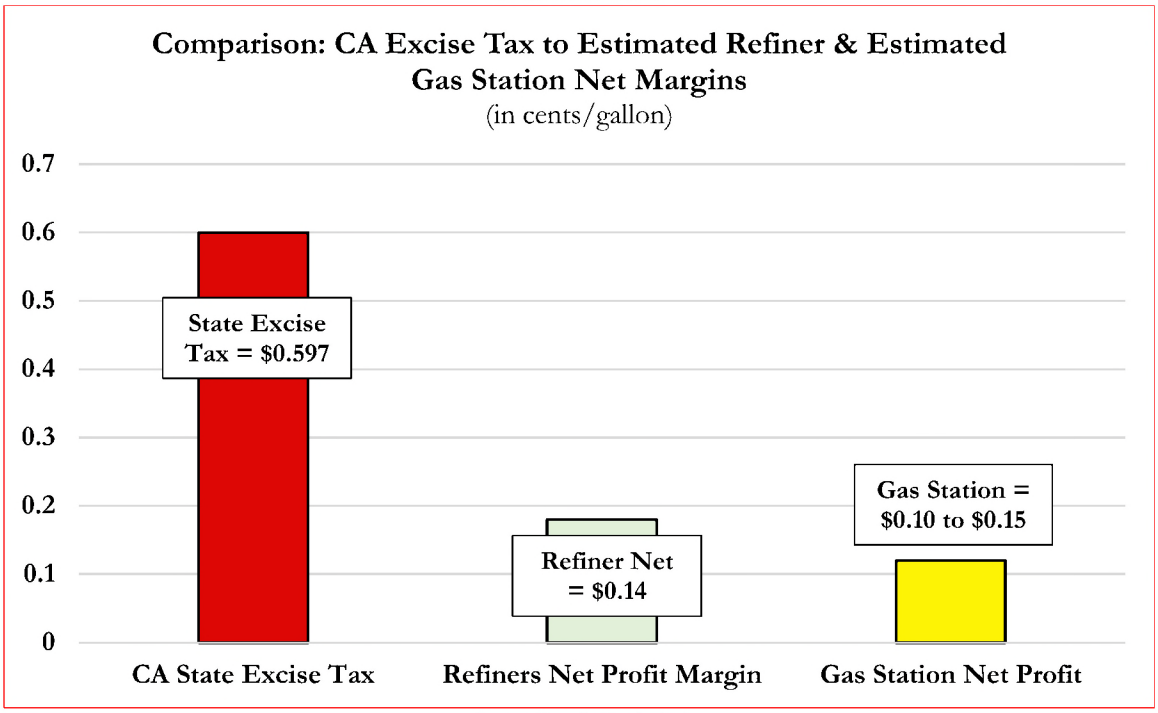


(Source: https://www.eia.gov/todayinenergy/detail.php?id=63447#)

[329] https://ballotpedia.org/States_that_issued_lockdown_and_stay-at-home_orders_in_response_to_the_coronavirus_(COVID-19)_pandemic,_2020
[330] https://ballotpedia.org/States_that_issued_lockdown_and_stay-at-home_orders_in_response_to_the_coronavirus_(COVID-19)_pandemic,_2020
[331] *Global refinery margins fall to multiyear seasonal lows in September - U.S. Energy Information Administration (EIA).* (2025). Eia.gov. https://www.eia.gov/todayinenergy/detail.php?id=63447#
[332] FRED. (2019). *Industrial Production Index*. Stlouisfed.org. https://fred.stlouisfed.org/series/INDPRO

In California, on a comparative basis, the State generates over 3 times as much in excise taxes per gallon of gasoline sold than the average refinery makes at around $0.08 to $0.18 in net profits, subject to crude oil prices and seasonality, and over 5 times as much as the retail gasoline station operator makes in net profits from the sale of gasoline to the public.

Exhibit 5.14



(Source: Compiled by Author)

5.5.3 Crack Spreads. A common measure of refinery efficiency and profitability is the crack spread. Crack spreads have long been used in the oil industry as a measure of profitability. Crack spreads represent the "profit" in both dollars and percentages, between the cost of crude oil inputs and the selling price of the resulting products, such as gasoline, aviation fuels, and distillates, from the refining of crude oil. There are three basic methods for calculating the crack spread. Each method has a preferred application as related to a refinery and the products that it produces. Two of the predominant measures for crack spreads are the 3-2-1 and 5-3-2 calculations.

- 3-2-1. The 3-2-1 crack spread is the most commonly used for multiple products. The EIA defines the crack spread as "an indicator of refining margins, the short-term profit margin for oil refineries, which generally produce about 2 barrels of gasoline for every 1 barrel of distillate fuel oil. To estimate the refinery crack spreads, regional crude oil benchmarks were used (Brent for New York, Los Angeles, and ARA; Light Louisiana Sweet for the U.S. Gulf Coast; West Texas Intermediate for Chicago; and Dubai for Singapore). ARA=Amsterdam-Rotterdam-

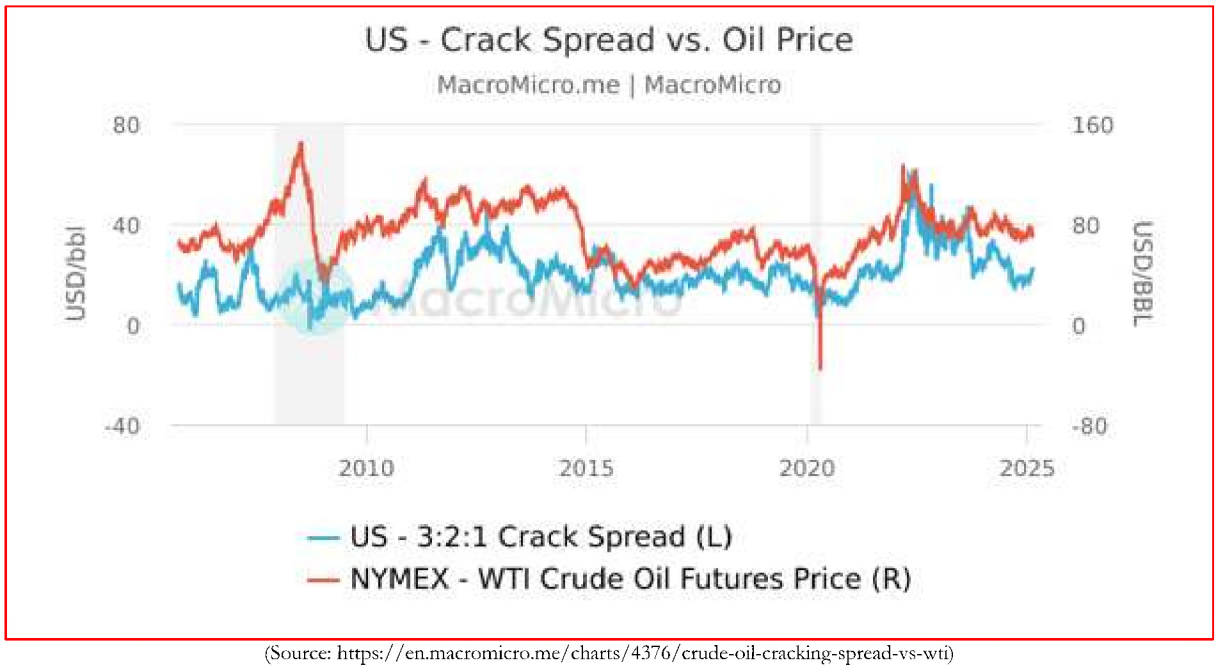
Antwerp."[333] The crack spread is a calculation that is determined by subtracting 3 barrels of oil from the price of 1 barrel of distillate plus 2 barrels of gasoline and is expressed as:

Crack Spread = (2 barrels of gasoline + 1 barrel of distillate) – 3 barrels of oil

- 5-3-2. The 5-3-2 crack spread is also a measure of refinery profitability and efficiency. The 5-3-2 method is generally used by a refiner when there are lower yields of retail gasoline relative to other products, such as jet fuel and distillates. The calculation involves 5 barrels of oil to produce 3 barrels of gasoline and 2 barrels of distillates, such as heating oil.

Understandably, since crude is the primary input to the refinery, the resulting crack spread is highly correlated to the crude price of oil.

Exhibit 5.15



(Source: https://en.macromicro.me/charts/4376/crude-oil-cracking-spread-vs-wti)

As indicated in the exhibit below, a number of other factors also have a significant influence on the crack spread.

[333] *Global refinery margins fall to multiyear seasonal lows in September - U.S. Energy Information Administration (EIA).* (2025). Eia.gov. https://www.eia.gov/todayinenergy/detail.php?id=63447#

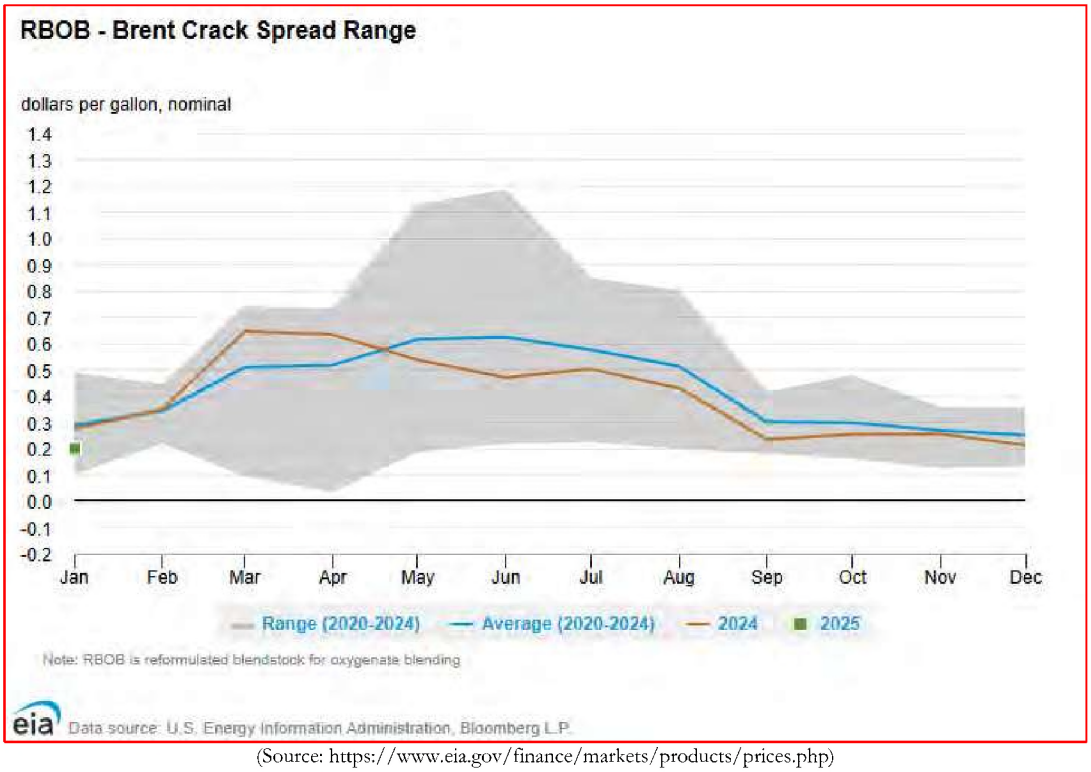
Exhibit 5.16

FACTORS INFLUENCING CRACK SPREADS	
FACTOR	**IMPACT ON CRACK SPREAD**
Crude Prices	Higher crude prices are associated with higher crack spreads.
Seasonality	California has a longer summer season which is associated with higher crack spreads.
Refinery Capacity Utilization	Refineries operate best when they achieve economies of scale and operate at higher capacity utilization levels. Higher utilization levels, such as those of California refineries, typically generate higher crack spreads.
Geographical Location of Refinery	Refineries that are concentrated near high population areas, such as those in Southern and Northern California.
Refinery Nelson Rating & Complex	Advanced refineries, such as those with hydrocrackers, deep conversion units, and fluid catalytic cracking and higher rated NCI typically generate higher crack spreads. California refineries, on average, have higher NCI ratings than the U.S. and Europe.
Quality of Crude Grades Imports	Refineries, such as those of California, process heavy crudes. Refineries that process heavier crudes typically have higher crack spreads due to their ability to produce a wider range of products.
Demand	Demand for gasoline and distillates influence crack spreads. In California, the demand for gasoline is second only to Texas in volume consumed. California also produces more aviation fuel per barrel of oil than the U.S.. Both the demand for gasoline and aviation fuels positively influence and increase crack spreads of California refineries.

(Source: Various and Author)

Crack spreads are reflective of demand, supply, product mix, and seasonality. During the summer months, demand for gasoline is higher than in winter, and crack spreads tend to be higher. Likewise, when manufacturing and commercial transportation are robust, crack spreads reflect that activity.

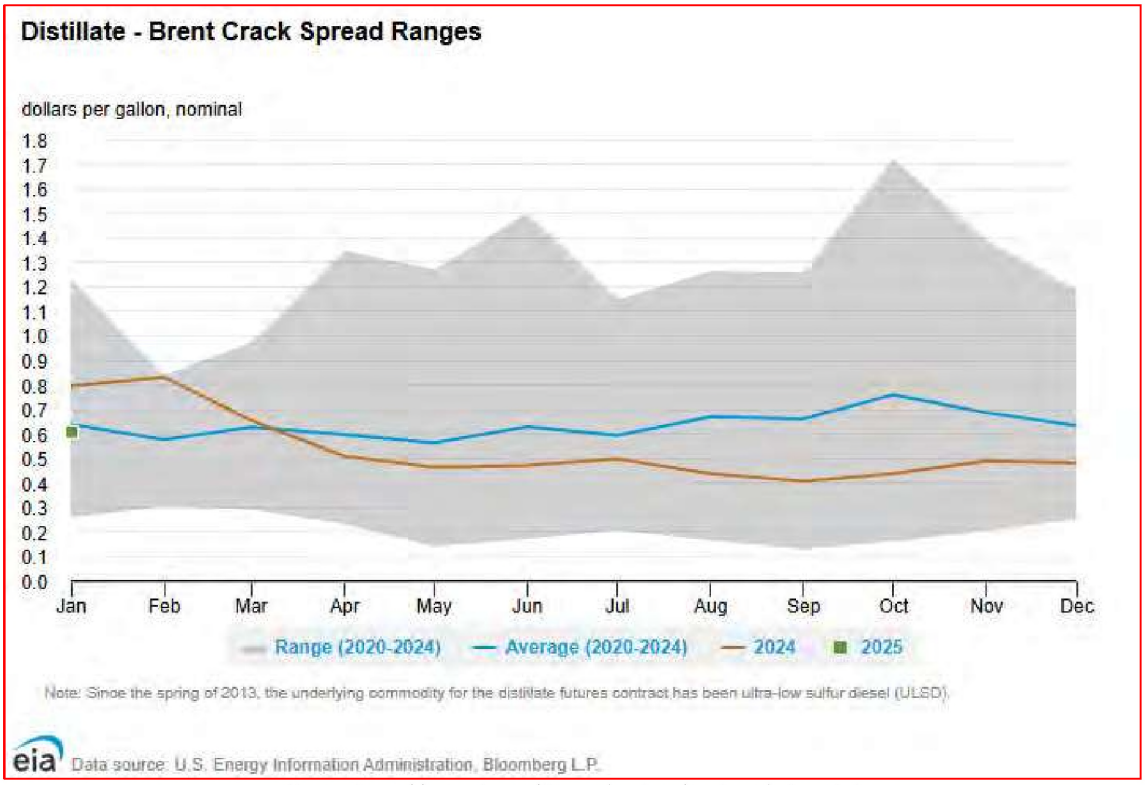
Exhibit 5.17



(Source: https://www.eia.gov/finance/markets/products/prices.php)

During winter, driving time is lower, and the demand for gasoline is lower, but the demand for heating fuels increases.

Exhibit 5.18



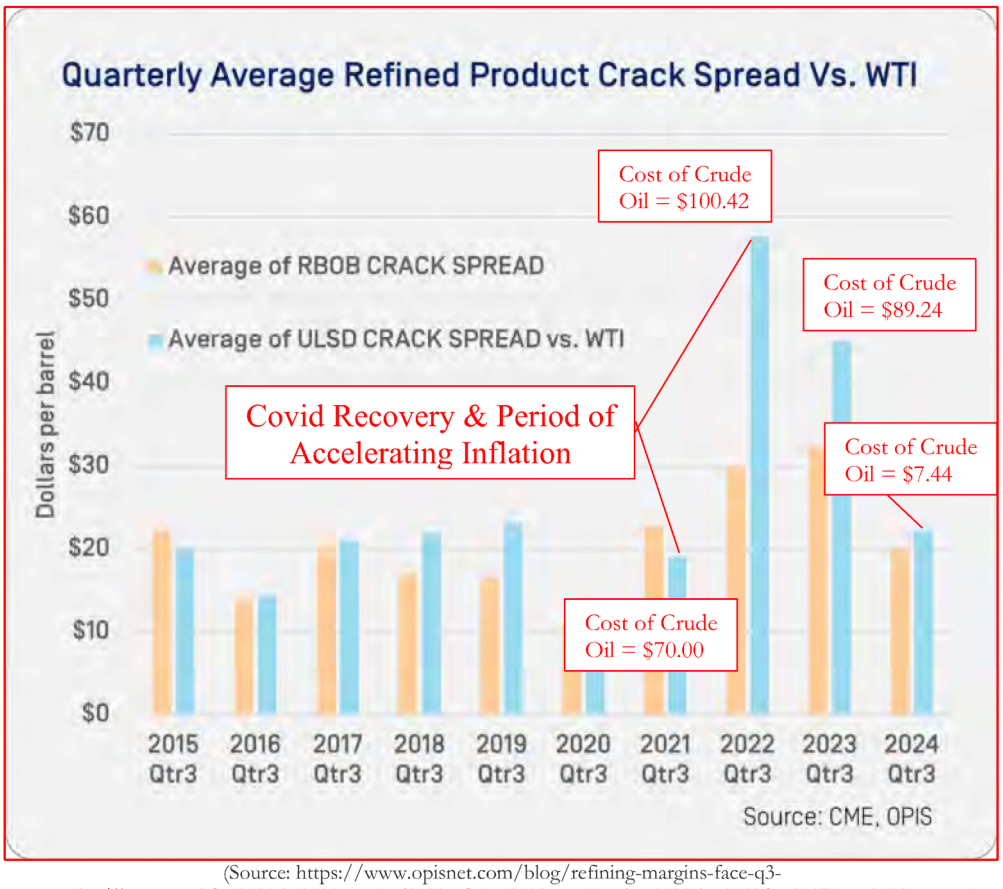
(Source: https://www.eia.gov/finance/markets/products/prices.php)

In general, historically, crack spreads, as presented in dollars, ranged between:

- $10 to $25 a barrel for the 2014 to 2020 period.
- $5 to $20 a barrel per-2008.
- $20 to $30 a barrel for the 2009 to 2014 period.
- $40 to $63 a barrel for the 2021 to 2022 period.[334]
- OPIS data indicates that crack spreads increased 159.1% between Q3- 2019 from around $22 a barrel to $57 a barrel in Q3- 2022.[335]
- According to OPIS, crack spreads were around $57 a barrel in Q3-2022, and crack spreads fell by 61% to approximately $23 a barrel in Q3-2024.[336]

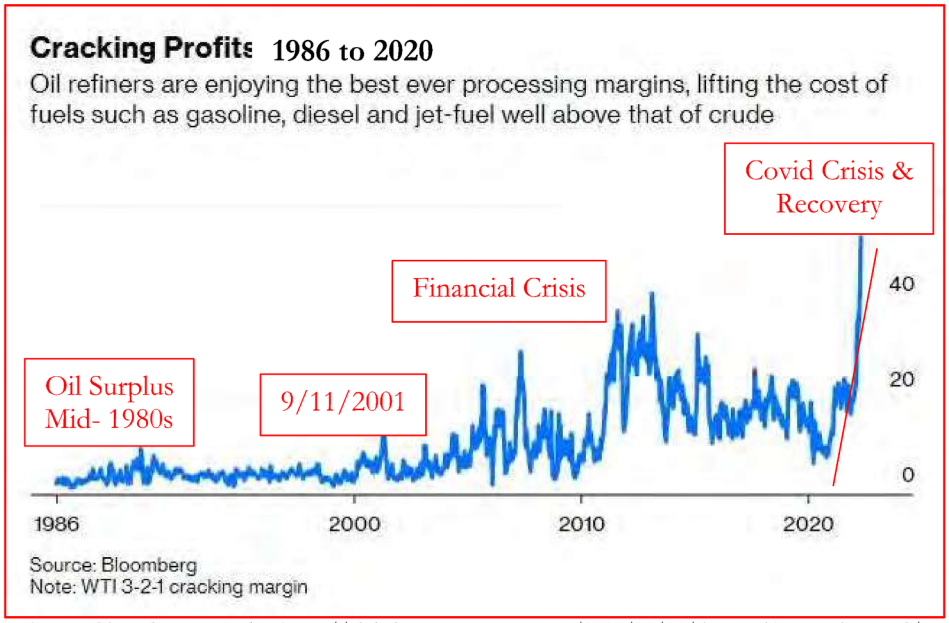
[334] Apthorp, A., & Apthorp, A. (2022, July 20). *What Is It Wednesday – 3:2:1 Crack Spread - Mansfield Energy*. Mansfield Energy. https://mansfield.energy/2022/07/20/what-is-it-wednesday-321-crack-spread/
[335] cmoore. (2024, October 16). *Refining Margins Face Third-Quarter Struggles - OPIS, A Dow Jones Company*. OPIS, a Dow Jones Company. https://www.opisnet.com/blog/refining-margins-face-q3-struggles/
[336] cmoore. (2024, October 16). *Refining Margins Face Third-Quarter Struggles - OPIS, A Dow Jones Company*. OPIS, a Dow Jones Company. https://www.opisnet.com/blog/refining-margins-face-q3-struggles/

Exhibit 5.19



(Source: https://www.opisnet.com/blog/refining-margins-face-q3-struggles/#:~:text=After%20the%20outsized%20refining%20margins,than%20that%20five%2Dyear%20average)

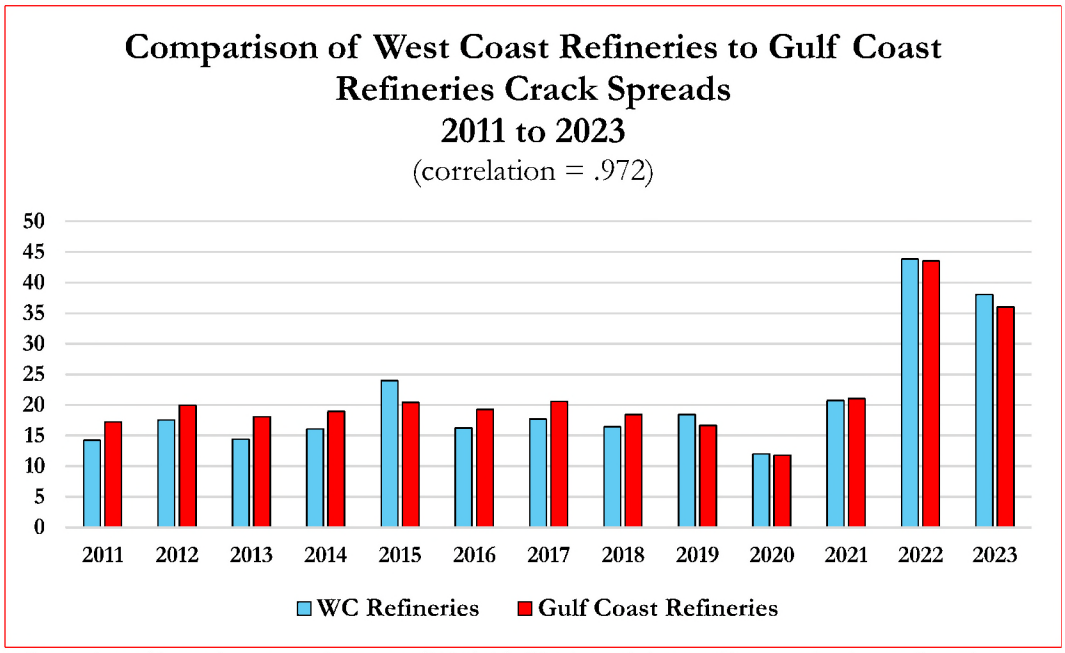
Exhibit 5.20



(Source: Bloomberg as cited in https://global-macro-monitor.com/2022/05/26/the-smoking-crack-spread/)

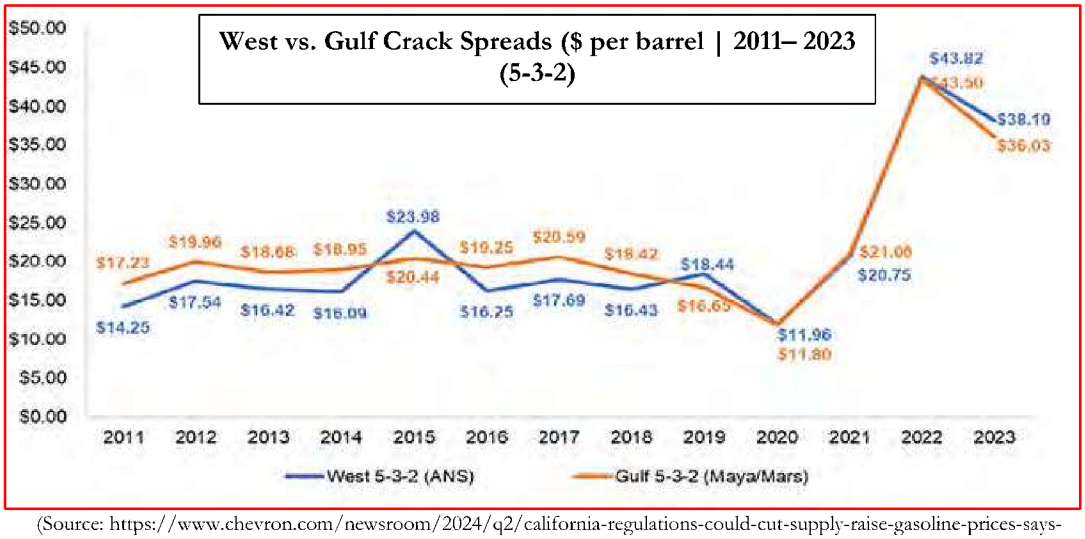
5.5.4 California Crack Spreads. Both Governor Newsom and members of the California Legislature have asserted that California oil refineries have engaged in price gouging, excessive pricing, and/or profiteering. However, analysis of oil refinery data obtained under SB 1322 and SBX1-2 indicates otherwise. Analysis of West Coast refineries to Gulf Coast refineries indicates a very high correlation between the two and no significant anomalies between the two for the 2011 to 2023 period. If there were significant margin anomalies associated with pricing and profiteering, the crack spreads would most likely show lower correlations and considerable variations would exist.

Exhibit 5.21



(Source: https://www.chevron.com/newsroom/2024/q2/california-regulations-could-cut-supply-raise-gasoline-prices-says-chevron-exec)

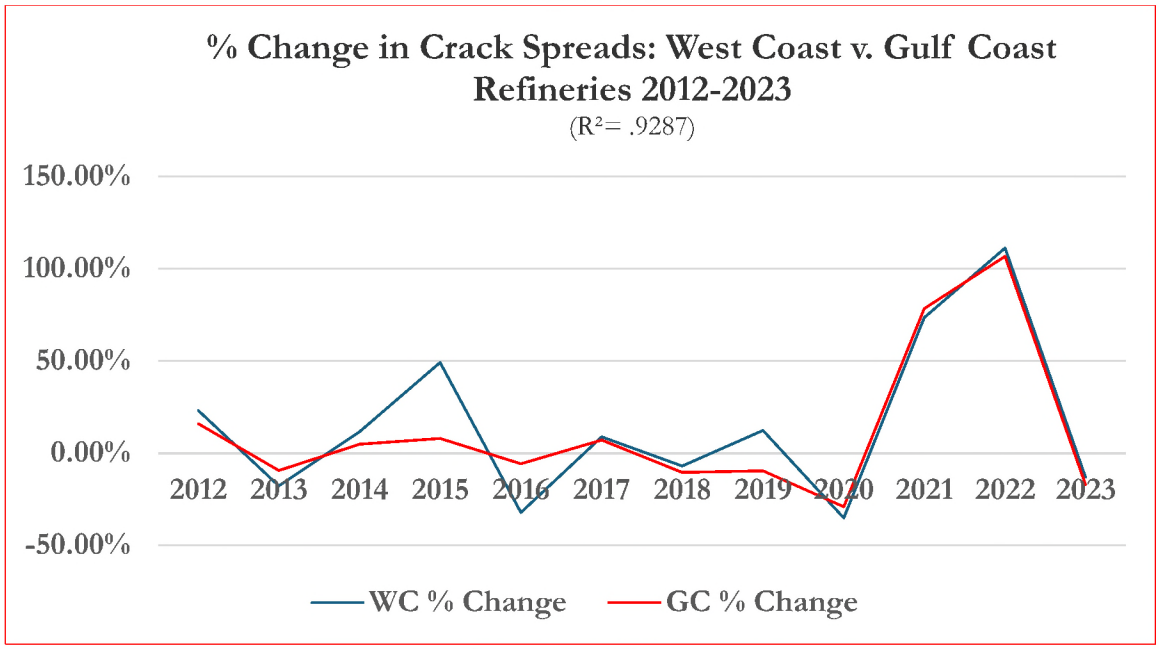
Exhibit 5.22



(Source: https://www.chevron.com/newsroom/2024/q2/california-regulations-could-cut-supply-raise-gasoline-prices-says-chevron-exec)

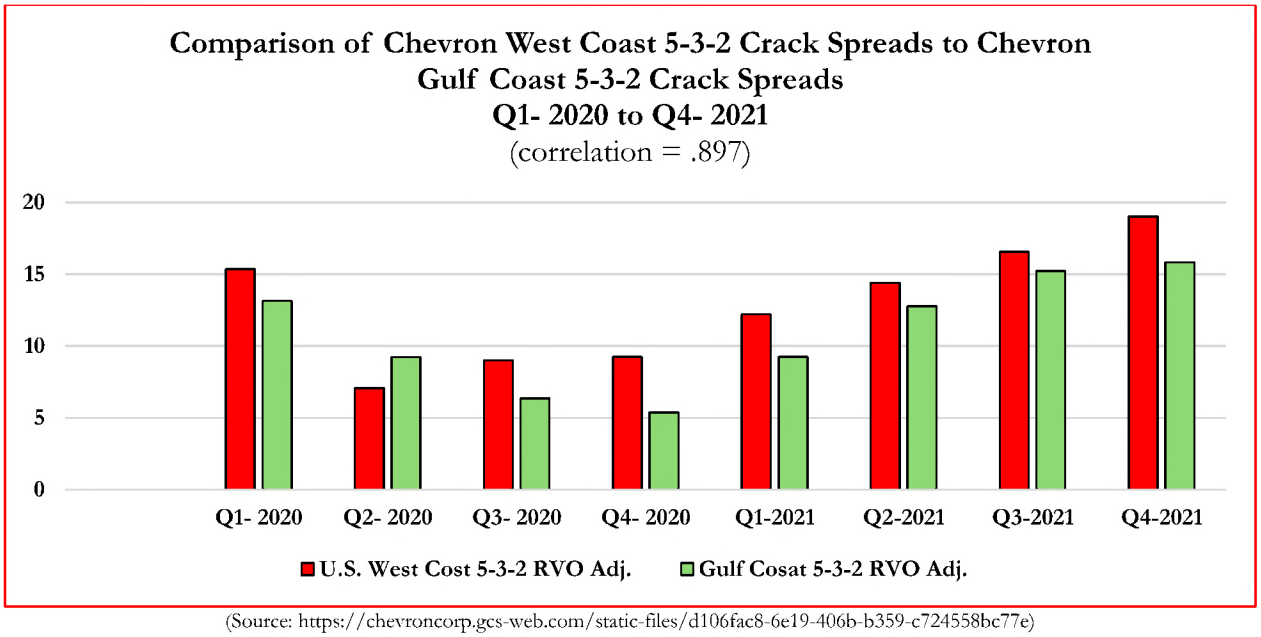
On an annual percentage basis, the crack spreads between West Coast refineries and Gulf Coast refineries also present a high correlation of .928 and no anomalies.

Exhibit 5.23



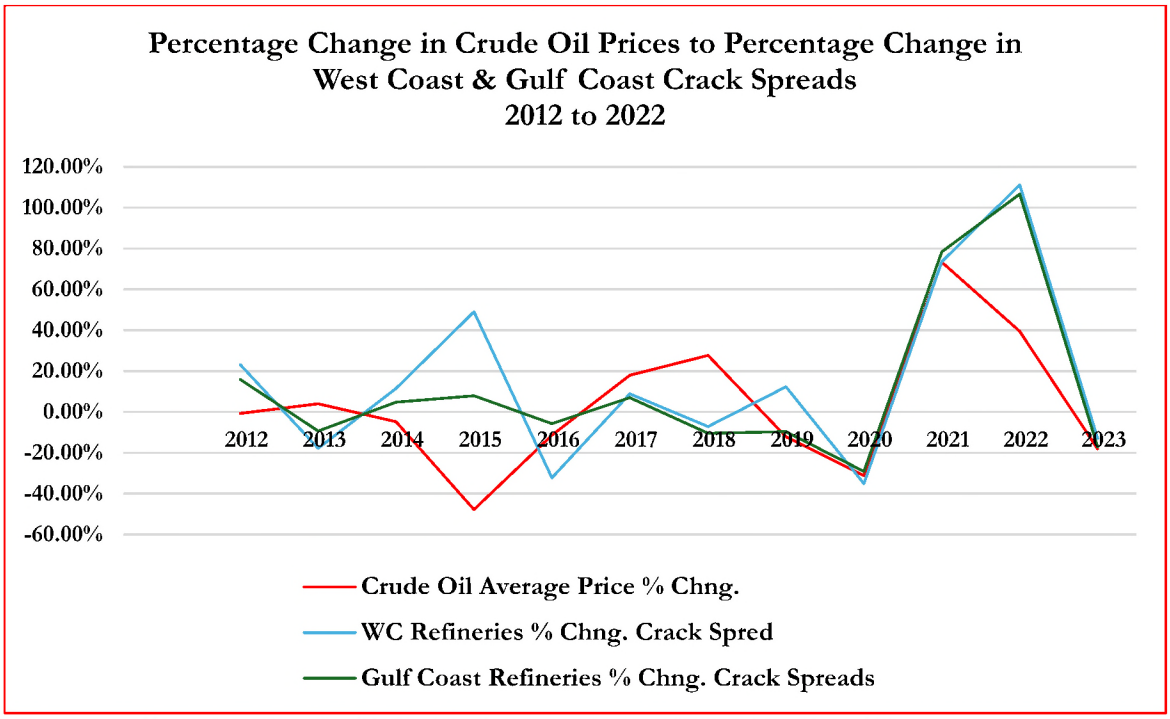
(Source: EIA and Chevron)

Exhibit 5.24



(Source: https://chevroncorp.gcs-web.com/static-files/d106fac8-6e19-406b-b359-c724558bc77e)

Exhibit 5.25



(Source: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RWTC&f=M and https://chevroncorp.gcs-web.com/static-files/d106fac8-6e19-406b-b359-c724558bc77e

One of the cost factors effecting crack spreads is the price of crude that the refiner pays. On the west coast, and particularly in California, refiners tend to pay a slightly higher for 'first purchase' crude oil than the rest of the U.S. due to low in-state production, and the need to import oil from distant sources such as the Middle East. The higher acquisition cost generally does not directly affect the crack spread but it will be reflected in the overall price of gasoline. However, crack spreads alone are very useful, they are incomplete with respect to refinery profits. A higher crack spread may not necessarily indicate higher net profits. Ironically, California's cap and trade program, which requires refiners to incur considerable compliance costs in the purchase of carbon credits, are reflected in the crack spreads. Consequently, as a result of inclusion of cap-and-trade costs, profits may not improve but the crack spread will widen.[337]

[337] *California law and refinery closure reflect ongoing challenges for the state's fuel market - U.S. Energy Information Administration (EIA).* (n.d.). https://www.eia.gov/todayinenergy/detail.php?id=63944

SECTION 6.0
CALIFORNIA GASOLINE PRICING

A STUDY OF CALIFORNIA GASOLINE PRICES
Section 6.0
Table Of Contents

6.0 CALIFORNIA GASOLINE PRICING

6.1 Introduction
6.2 California Gasoline Prices
6.3 California Gasoline Taxes, Fees and Costs
- 6.3.1 Excise Tax
- 6.3.2 California Cap and Trade & Environmental Costs
- 6.3.3 Local Sales Tax

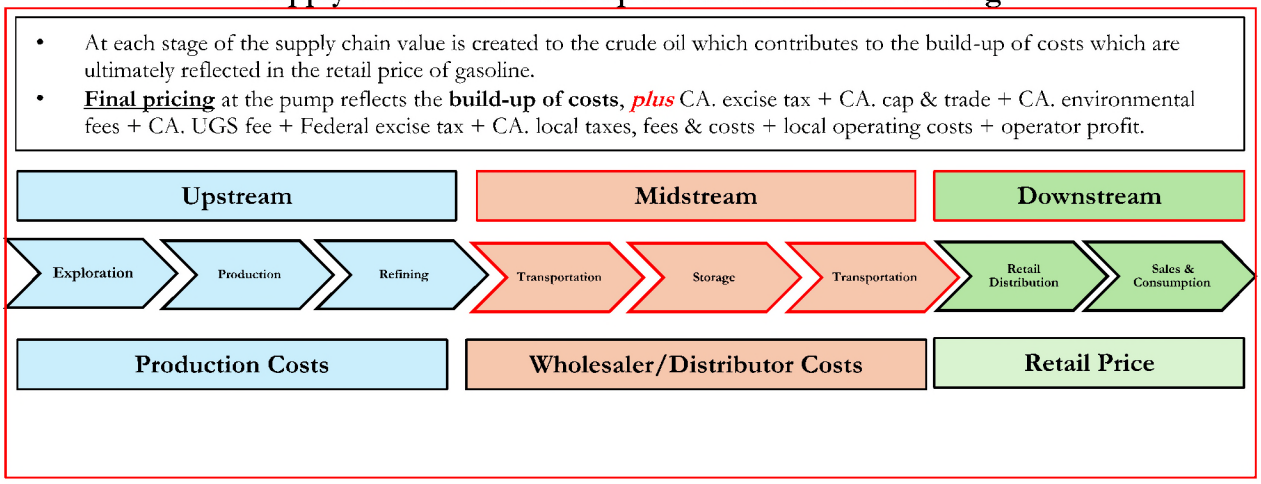
6.4 California Consumer Price Inflation & Gasoline Prices
6.5 California Revenue from the Sale of Gasoline
6.6 Analysis of California Gasoline Price Movements

6.0 CALIFORNIA GASOLINE PRICING

6.1 Introduction

The final retail pump price is reflective and is a product of many costs that are incurred and built up throughout the petroleum to gasoline supply chain. The price for gasoline that the station pays is based on the wholesale contract for the purchase of gas that supplies the gas station. The retail pump price that the consumer pays is a function of the cost build-up created by the combination of upstream, midstream, and downstream activities associated with the supply, production, refinement, transportation, and distribution of petroleum to arrive at a final pump price. At each point in the supply chain, costs are incurred and accumulated to arrive at the final consumer price.

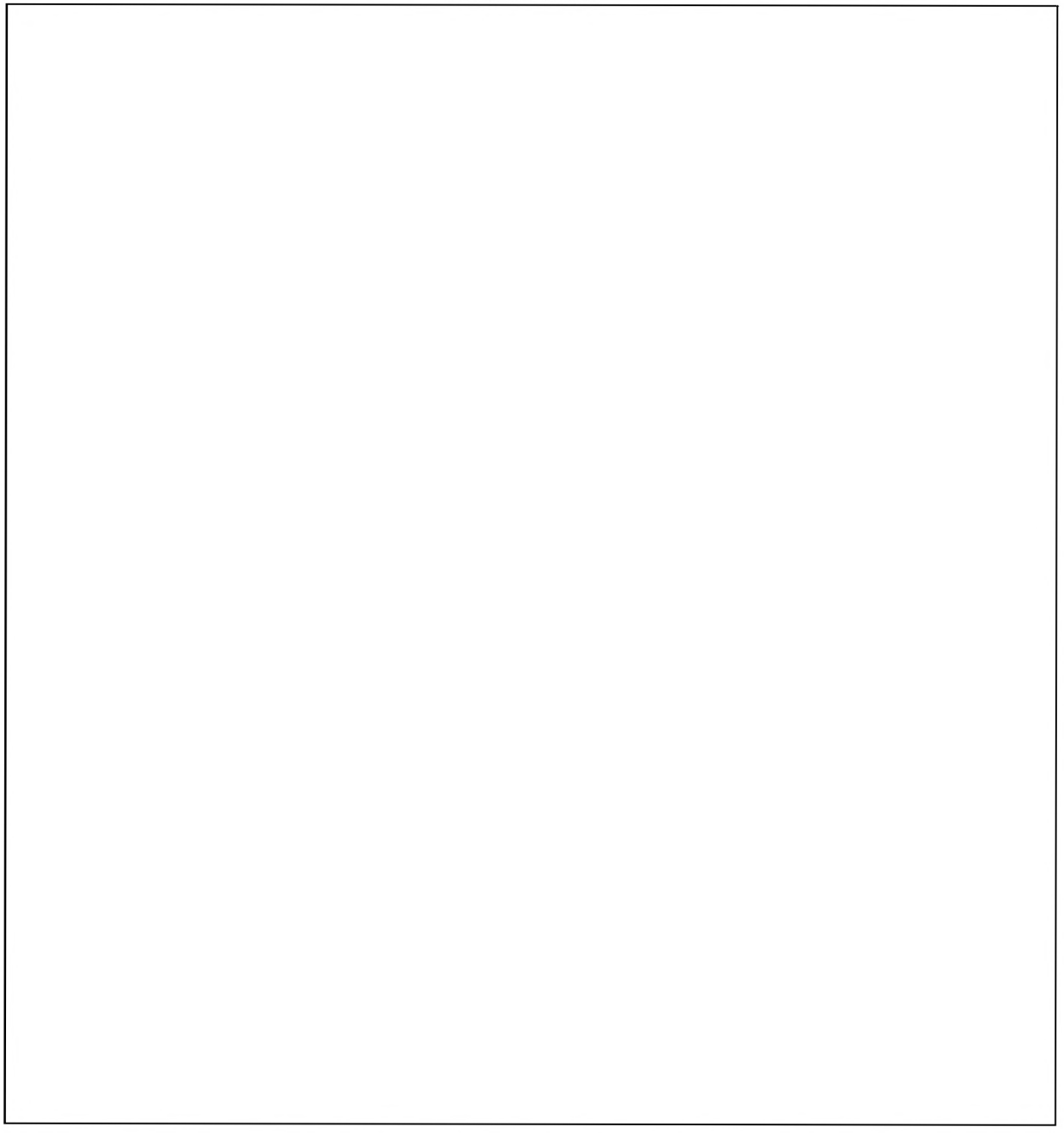
Exhibit 6.1
Supply Chain Cost Build-up for Retail Gasoline Pricing



In addition to the wholesale price, the final local gas pump prices that the consumer pays are a function of many other variables that comprise the "cost build-up." Since the majority of gas stations in California and the U.S. are independently owned and operated by individuals and small businesses, gas stations are generally free to set their own prices. A gas station is a business and, as such, must generate profits in order to sustain itself and remain in business. Local prices, which are set by the owner/operator (dealer) of the station, vary considerably by state, county, city, and specific physical location. Here are some of the major components of the cost build-up for retail pricing of gasoline: level of competition, location, age of station, traffic volumes, size of gas storage and number of underground tanks, ease of ingress and egress, just to note a few.

Some of the other factors that inform operating costs and, in turn, influence final retail pump prices include:

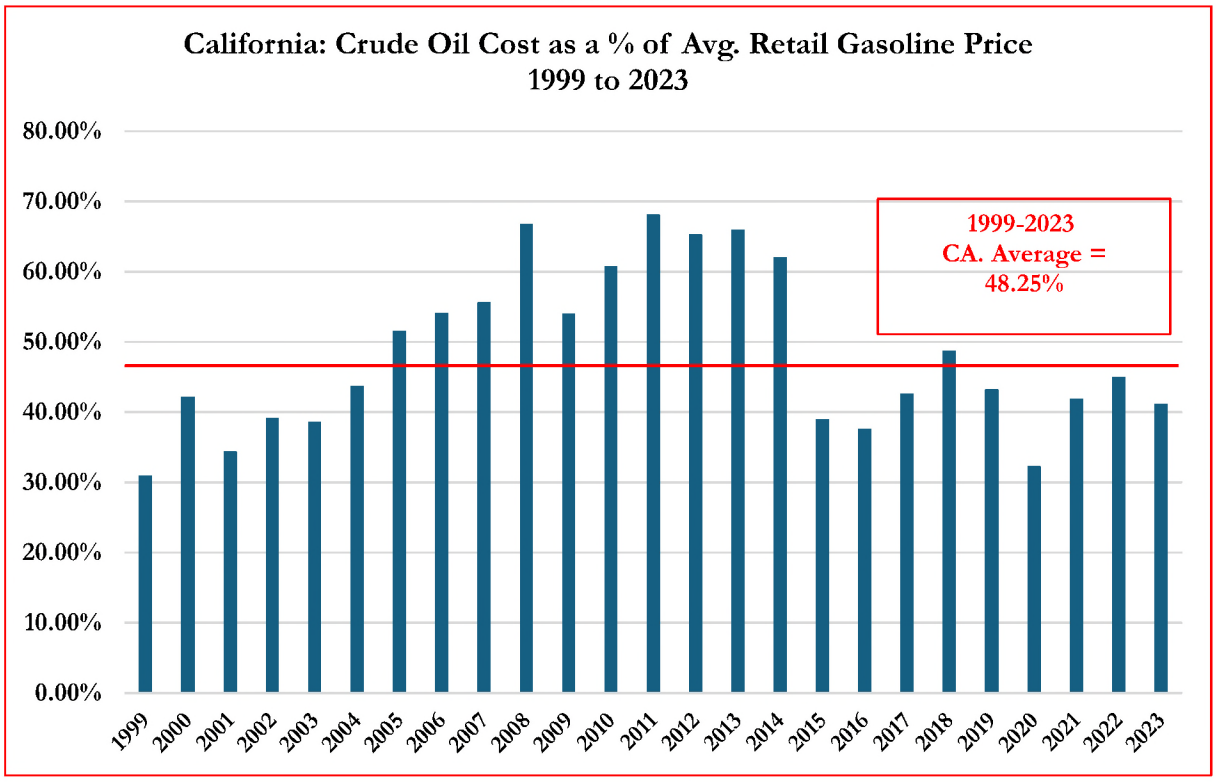
Exhibit 6.1-1



6.2 Oil & Gasoline Spot Prices. Final retail prices, which are reflective of the refiner's taxes, fees, and costs, plus the "build-up" of costs throughout the supply chain to the local gas station operator cost. The local operator then sets their retail selling prices based on local demand and volumes, operating costs including local taxes and fees, local pricing, individual sentiment as to future gasoline supplies and costs, and competitive influences, just to list a few.

The majority of raw material costs are in the production of gasoline, and the largest single component of wholesale gasoline prices is in crude oil, which in California have historically averaged 48.25%.

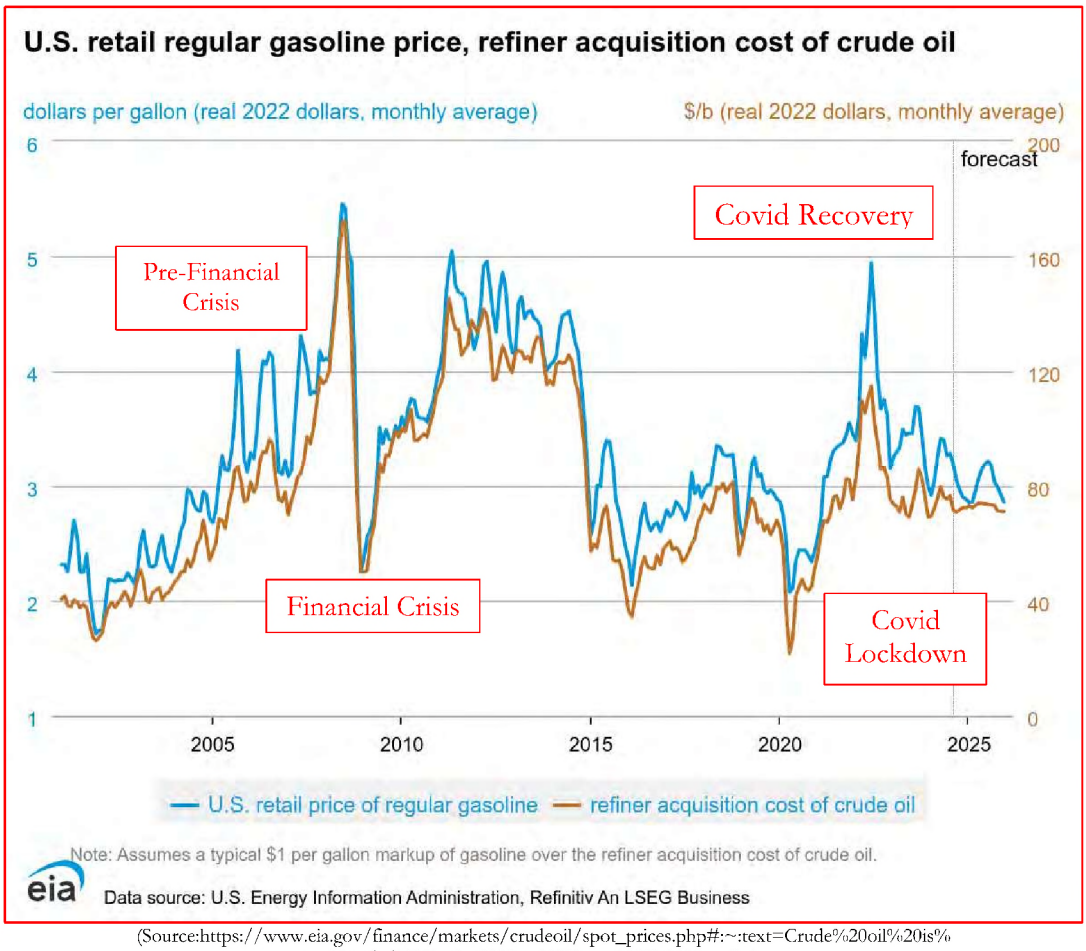
Exhibit 6.2



(Source: EIA and CEC)

For the 30-year period, oil spot prices to average U.S. reformulated gasoline prices indicate a high correlation of .9539, with minimal deviations with exception of extraordinary events.

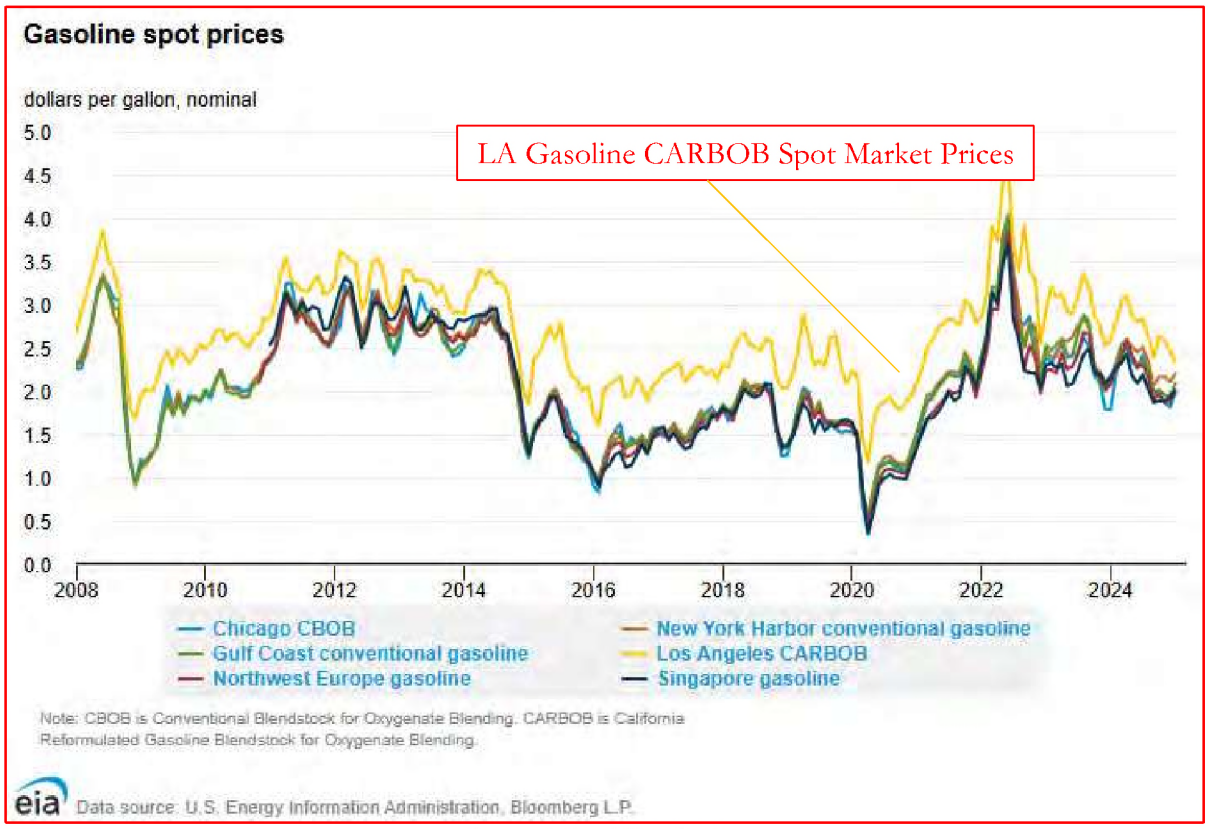
Exhibit 6.3



(Source:https://www.eia.gov/finance/markets/crudeoil/spot_prices.php#:~:text=Crude%20oil%20is%20traded%20in,that%20are%20lower%20in%20quality)

The spot price for gasoline across various U.S. markets, including Los Angeles, tends to move collectively and in a relatively consistent manner and this is true for California. Overall, for the January 1, 1995, to January 20, 2025, period, the 30-year correlation is indicated to be .9539.

Exhibit 6.4



(Sources: EIA and Bloomberg)

California spot and retail gasoline prices partially reflect the layering of regulatory costs, fees, and taxes, onto already high operating costs, and greater than average CPI. The total of all California regulatorily mandated taxes, fees and costs as of March 10, 2025, is calculated to be $$1.458 per gallon, plus federal excise tax of $0.18 a gallon for a grand total of $1.638 a gallon. California taxes, costs and fees represent 89% of total regulatory costs superimposed on the consumer. Based on a layering of costs, the higher cost of California CARBOB over others such as Gulf Coast, and NY Harbor conventional is expected. When combined with demand swings, and especially tightening supplies, prices will, understandably, profile a greater and sometimes widening gap between California CARBOB and other markets.

Exhibit 6.5[338]



(Source: CEC, EIA, https://www.congress.gov/crs-product/R48314 & Author)

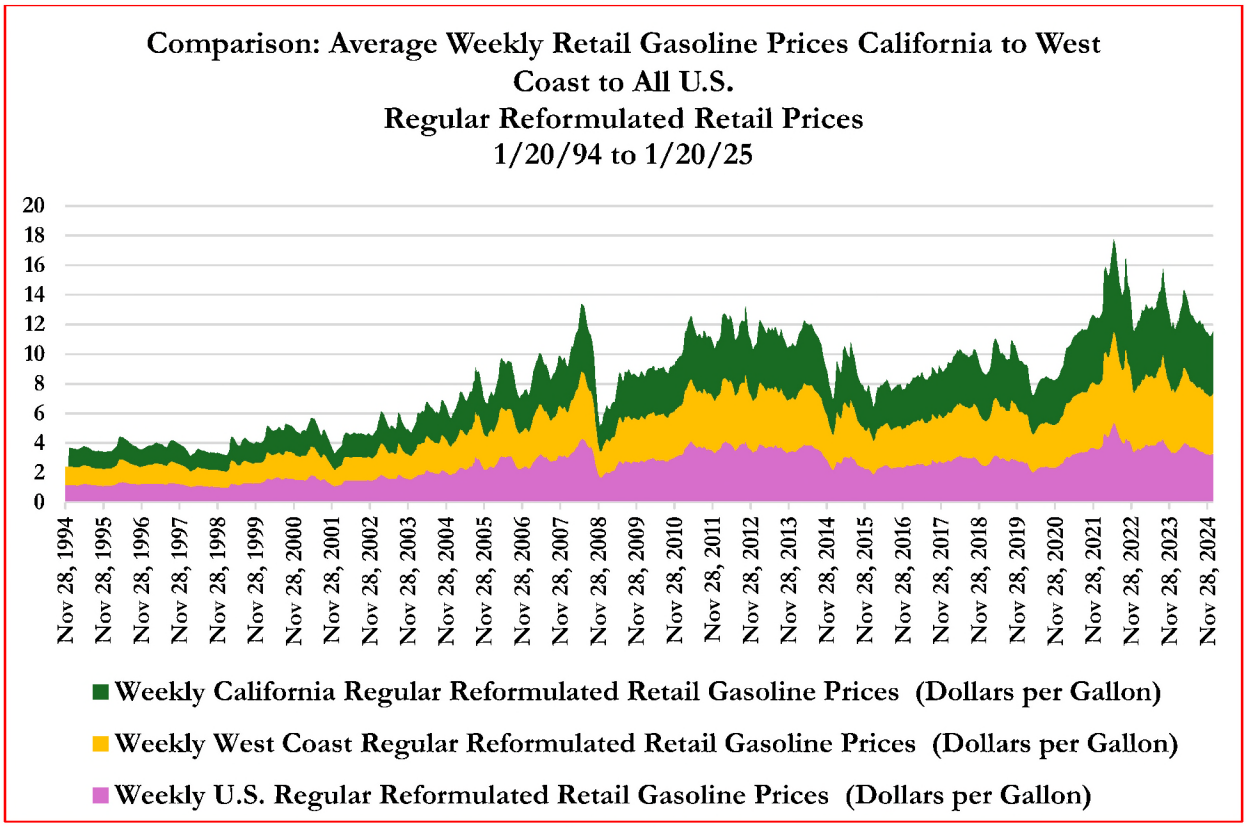
6.2 California Gasoline Prices

California gasoline prices behave, with some exceptions, in a manner consistent with overall U.S. market. For the January 2, 1995, to January 20, 2025, period, the correlation between oil spot prices to the California retail price for reformulated gasoline was high indicating .8660. and a correlation of .8750 between oil spot prices and California average weekly prices for reformulated gasoline. Furthermore, although California gasoline is more expensive, the correlation between U.S. average weekly gasoline prices for reformulated regular and California reformulated regular prices for the January 1, 1995, to January 20, 2025, period is indicated at .9768.

The exhibit below summarizes the weekly average dollar differences in California retail gasoline as compared to the West Coast and all of the U.S. For the 1994 to 2025 period, Californians have paid, on average, 13.01% per gallon of gasoline in the Golden State as compared to the overall average for the U.S.

[338] *The California Cap-and-Trade Program: Overview and Considerations for Congress.* (2025). Congress.gov. https://www.congress.gov/crs-product/R48314, Cornett, S. (2023, October 24). *California's Cap-and-Trade Program: Frequently Asked Questions.* Lao.ca.gov. https://lao.ca.gov/Publications/Report/4811, *California's Climate Programs – Facts per Gallon.* (2023). Factspergallon.com. https://factspergallon.com/californias-climate-programs/, https://www.wspa.org/wp-content/uploads/CA-Gas-Receipts-Feb-2024-v2-1.pdf

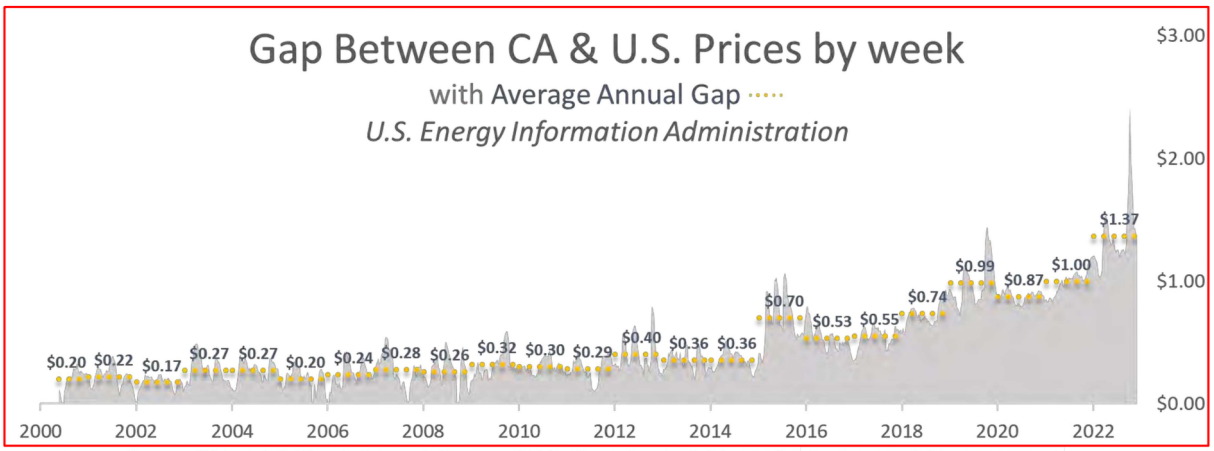
Exhibit 6.6



(Source: EIA)

For the January 2, 1994, to January 20, 2025, period, the average price differential for regular reformulated gasoline between the overall U.S. and California averaged $0.355 a gallon. Between January 2, 1994. Since 2015, when California's Cap and Trade programs took full effect, the number of refineries fell, and a major fire broke out in one of the Los Angeles area refineries, the gap between average U.S. gasoline prices and gasoline prices in the Golden State has widen. From 2000 to 2025, the price differential between California average weekly regular reformulated gasoline prices and the U.S. average for reformulated regular gasoline pre-cap and trade averaged 7.84%. Post full implementation of the cap-and-trade program in 2015, the price differential between California and the U.S. based on weekly gasoline prices for regular reformulated fuel expanded to 23.56% by March 2025.

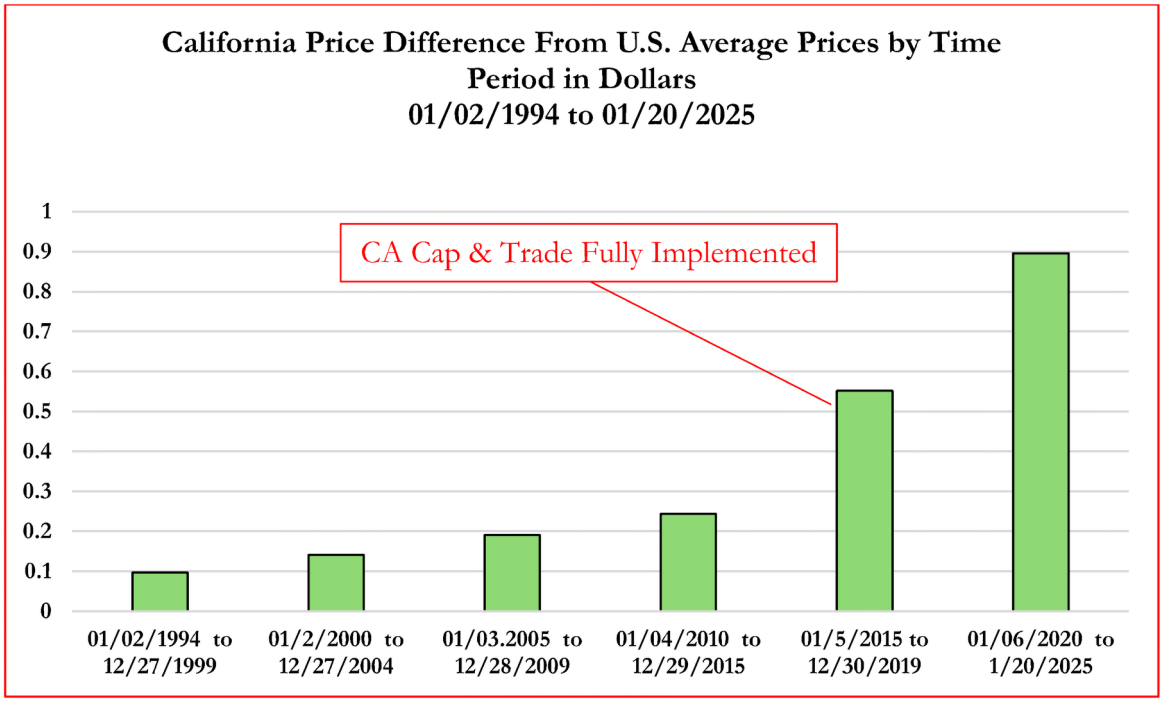
Exhibit 6.7



(Source: EIA and California Research Bureau. (2022). Gas prices in California. In *Gas Prices in California: History & Policy*. https://www.library.ca.gov/wp-content/uploads/crb-reports/CRB_Gas_Prices_in_California.pdf)

Illustrated in the exhibit below is the absolute dollar difference in the average retail price of regular reformulated gasoline between California and the U.S. for selected time periods.

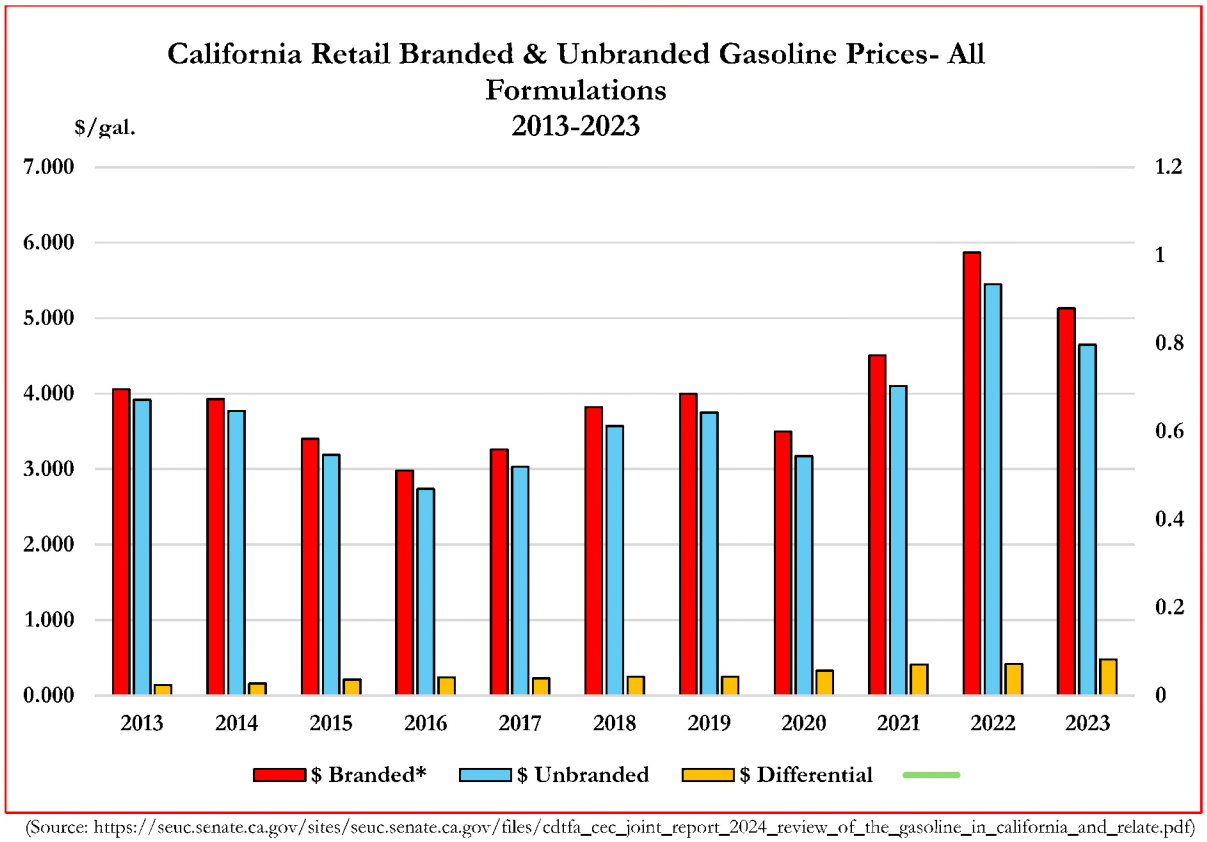
Exhibit 6.8



(Source: EIA & Author)

As illustrated in the exhibit below, the price of regular gasoline in California on January 2, 1995, was $1.264 a gallon.[339] Adjusting for inflation, the equivalent price of gasoline on March 8, 2025, would be $2.72 a gallon or 115% more. Correspondingly, for the same period, California State Revenue from the sale of gasoline increased 324%. For the same period, the California State Excise Tax on gasoline sales increased 233%, while the price of gasoline increased 274%.

Exhibit 6.9



(Source: https://seuc.senate.ca.gov/sites/seuc.senate.ca.gov/files/cdtfa_cec_joint_report_2024_review_of_the_gasoline_in_california_and_relate.pdf)

[339] *U.S. Regular Reformulated Retail Gasoline Prices (Dollars per Gallon).* (2020). Eia.gov. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=emm_epmrr_pte_nus_dpg&f=a

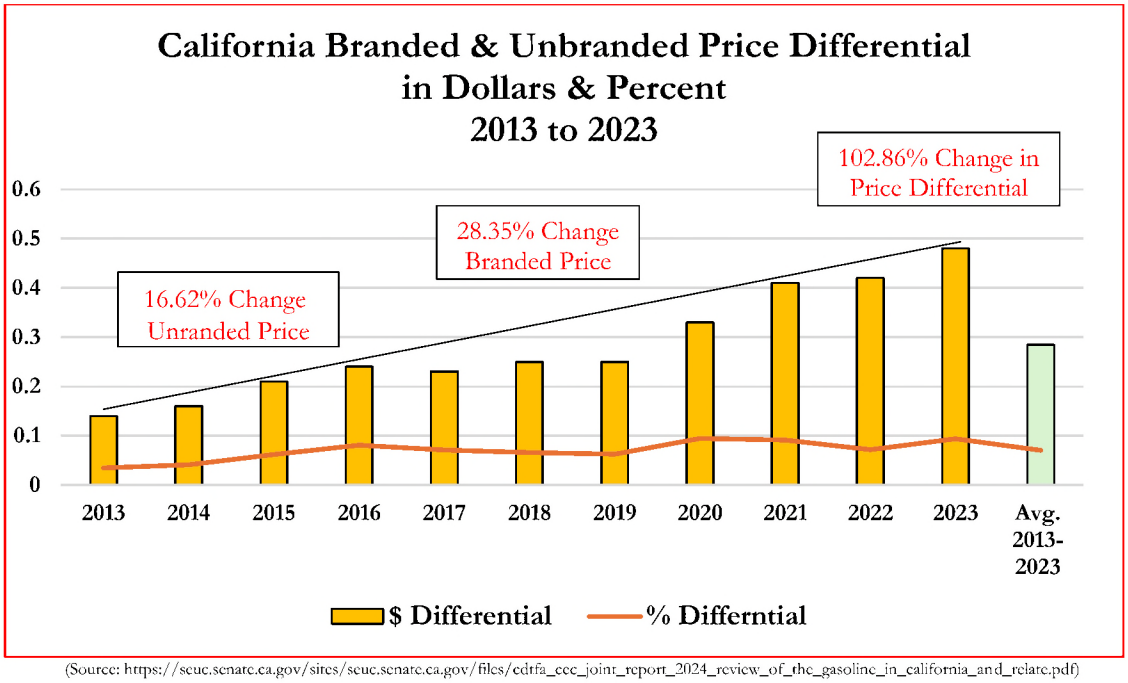
Exhibit 6.10

Price Differential CA Gasoine All Formulations 2013 to 2023				
Year	Branded	Unbranded	$ Differential	% Differntial
2013	4.06	3.92	0.14	3.45%
2014	3.93	3.77	0.16	4.07%
2015	3.4	3.19	0.21	6.18%
2016	2.98	2.74	0.24	8.05%
2017	3.26	3.03	0.23	7.06%
2018	3.82	3.57	0.25	6.54%
2019	4	3.75	0.25	6.25%
2020	3.5	3.17	0.33	9.43%
2021	4.51	4.1	0.41	9.09%
2022	5.87	5.45	0.42	7.16%
2023	5.13	4.65	0.48	9.36%
Avg. 2013- 2023	4.042	3.758	0.284	7.026%
% Chg. 2013-2023	26.35%	18.62%		1.415 x

(Source: https://scuc.senate.ca.gov/sites/scuc.senate.ca.gov/files/cdtfa_cec_joint_report_2024_review_of_the_gasoline_in_california_and_relate.pdf)

Based on CEC data, for the 2013 to 2023 period, the average price of branded gasoline in California was $4.042, as compared to the average price of unbranded at $3.758 a gallon. For the same period, the price of branded gasoline increased 26.35%, as compared to the price of unbranded, which increased by 18.64%. The absolute price differential from 2013 to 2023, grew from $0.14 to $0.48, a gallon or 102.86%.

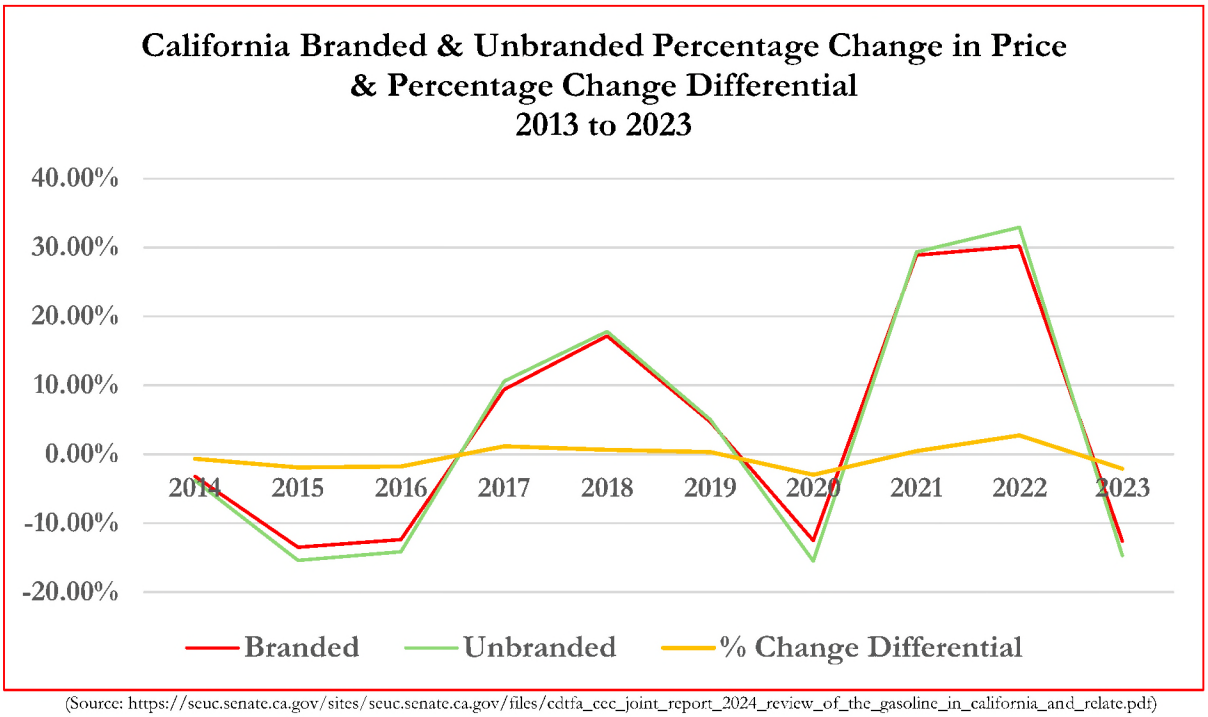
Exhibit 6.11



(Source: https://scuc.senate.ca.gov/sites/scuc.senate.ca.gov/files/cdtfa_cec_joint_report_2024_review_of_the_gasoline_in_california_and_relate.pdf)

Not surprisingly, the percentage in branded and unbranded gasoline prices move consistently and indicate a correlation of .999. Individually, branded gasoline prices present a slightly greater variance than unbranded, however, unbranded prices tended to demonstrate higher peak and lower trough variances than branded for the 2014 to 2023 period.

Exhibit 6.12



(Source: https://seuc.senate.ca.gov/sites/seuc.senate.ca.gov/files/cdtfa_cec_joint_report_2024_review_of_the_gasoline_in_california_and_relate.pdf)

California has a higher percentage of premium gasoline sales than the rest of the U.S. In California, 17.8% of all gasoline retail sales in 2020 were premium octane, compared to 11.6%, according to the EIA.[340] [341] Consumers' preference for premium fuels, as expressed by California's higher percentage of premium gasoline sales compared to the overall U.S., contributes to higher retail pump prices and margins. For the 2010 to 2020 period, retail gasoline sales volume of regular octane in California as a percentage of all gasoline octanes volumes sold have remained relatively stable, growing only by 1.5%; meanwhile, premium octane sales as a percentage of all gasoline sales have grown 53.45%.

In California, as in common throughout markets in the U.S., it is not unique to see considerable variances in retail prices for the same brand and grade of gasoline. Even in areas where only a few miles or blocks separate stations, prices may vary by considerable amounts.[342] For example, on 9/25 and 9/25, prices for a random sample varied by as much as 10% for Chevron's regular blend and 5%

[340] CALIFORNIA ENERGY COMMISSION. (2021). *CALIFORNIA ENERGY COMMISSION PETROLEUM WATCH 2021*. https://www.energy.ca.gov/sites/default/files/2021-11/2021-10_Petroleum_Watch.pdf
[341] Mitchell, R. (2022, June 2). Paying extra for premium gas? You should probably stop - Los Angeles Times. *Los Angeles Times*. https://www.latimes.com/business/story/2022-06-01/midgrade-premium-regular-gasoline-damage-money#:~:text=Midgrade%20makes%20up%20a%20tiny,pump%20provides%20fatter%20profit%20margins
[342] Sheets, C. (2022, March 15). Why California gas prices vary: 'Mystery surcharge' and more - Los Angeles Times. *Los Angeles Times*. https://www.latimes.com/california/story/2022-03-14/gas-prices-vary-from-place-to-place

for Shell. Retail pump prices for unbranded gasoline are usually lower and have greater variability than the example below.

Exhibit 6.13

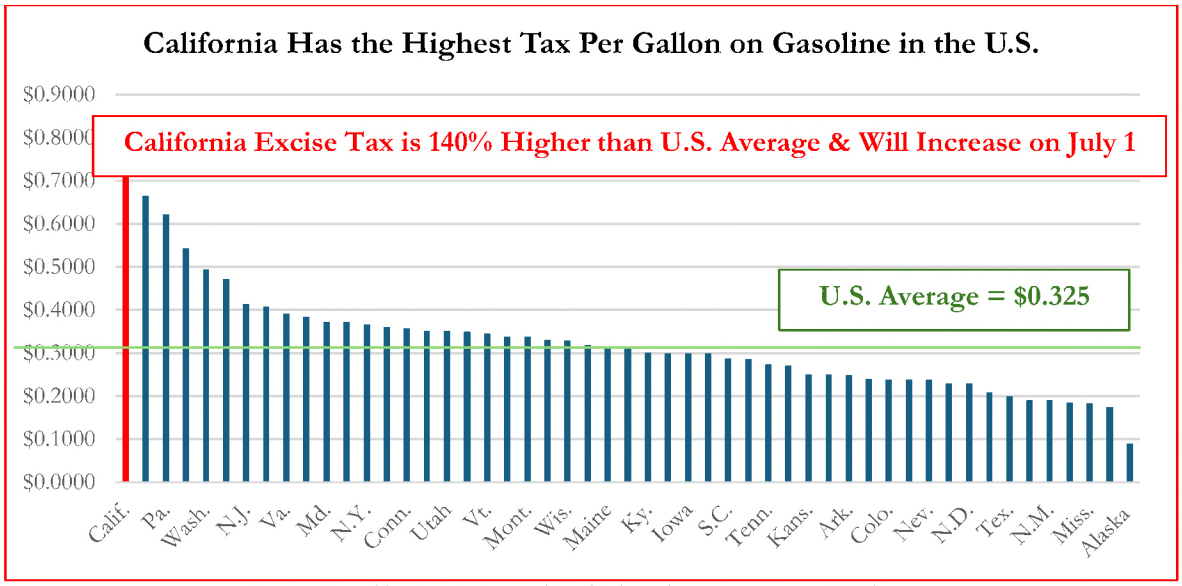


(Source: Direct Observation)

6.3 California Gasoline Taxes, Fees and Costs

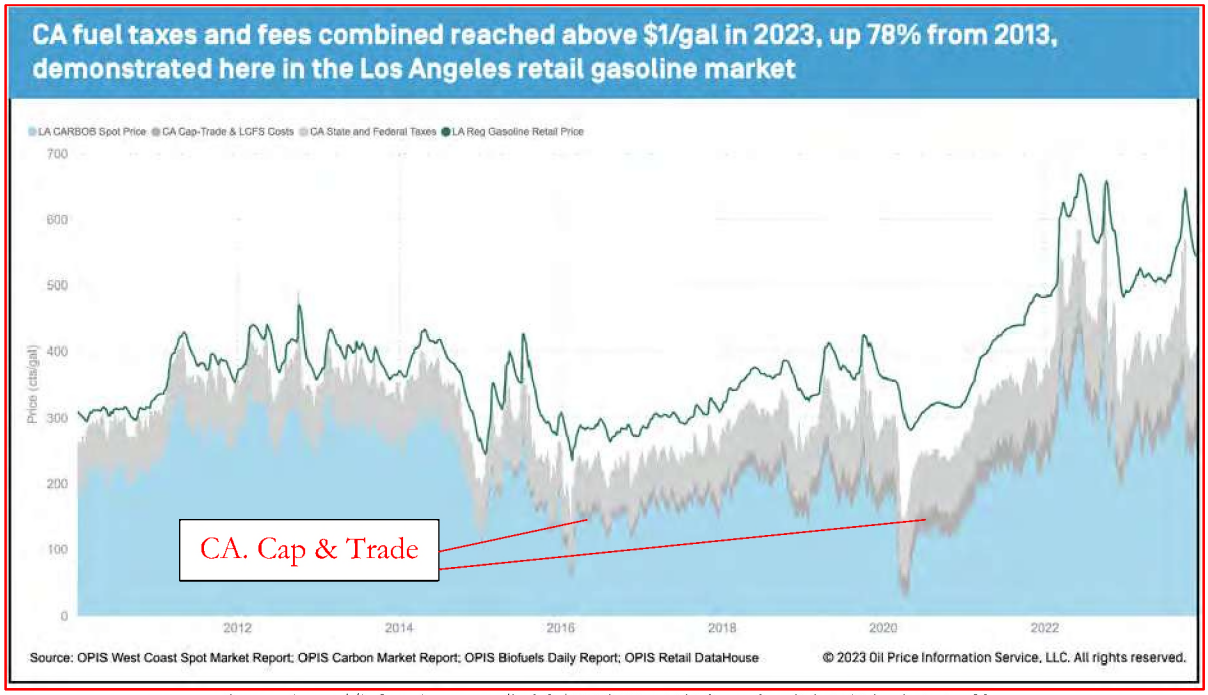
Retail gasoline prices are a function of the interactions among many variables and components. Factors such as supply, demand, seasonality, taxes, fees, costs, refinery operations, and individual gas station (outlet) owners/operators. In the Golden State, regulatory fees, taxes, and costs are second only to the cost of the crude oil needed to produce gasoline.

Exhibit 6.14



(Source: https://taxfoundation.org/data/all/state/state-gas-tax-rates-2023/)

Exhibit 6.15



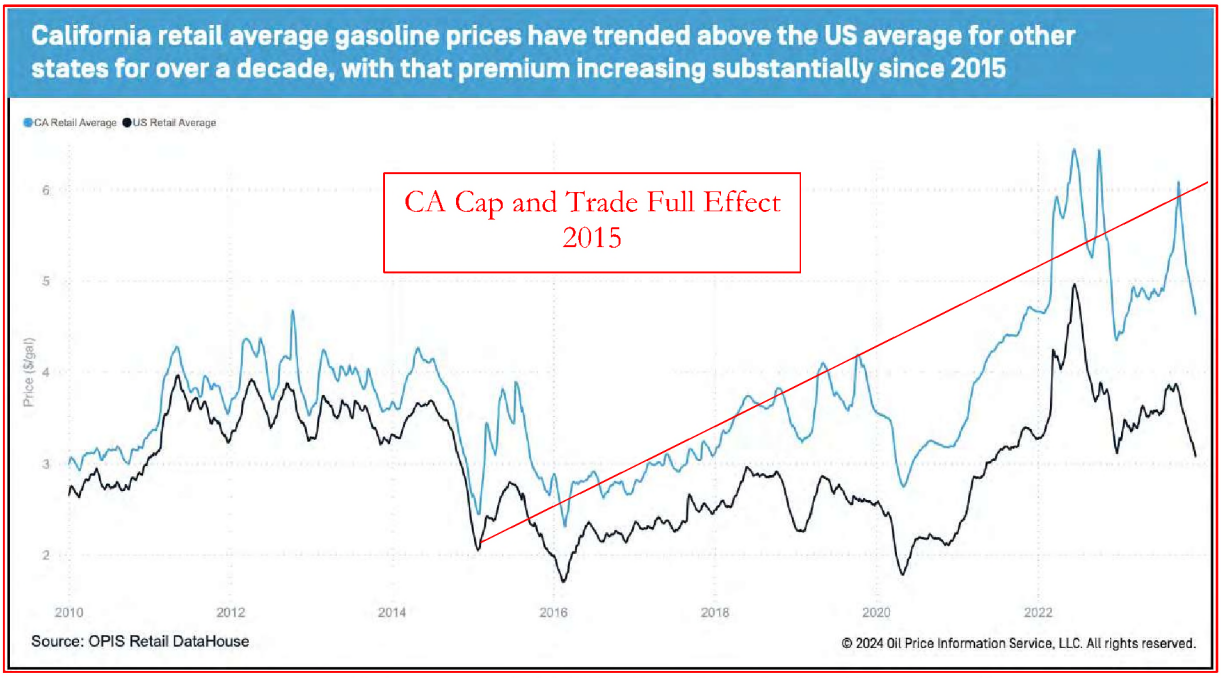
(Source: https://info.opisnet.com/hubfs/OPIS-West%20Coast-Spotlight%20Analysis-1.pdf)

Analysis of OPIS data highlights a growing disparity between West Coast crude oil prices, gasoline spot prices, and fuel costs at both the wholesale and retail levels since 2015—the year when wholesale fuel sellers were required to adhere to cap-and-trade policies.[343]

[343] *California's Gasoline Market: How the State's Unique Structure Impacts Pricing at the Pump*. (n.d.). Retrieved March 11, 2025, from https://info.opisnet.com/hubfs/OPIS-West%20Coast-Spotlight%20Analysis-1.pdf

For the 2003 to 2025 period, California's gas tax has also increased by 231.1%. It was $0.18 cents per gallon in 2003, $0.39.5 per gallon in 2013, and has now risen to $0.596 per gallon, according to figures from the California Department of Tax and Fee Administration (CDTFA).[344] Indexed to the CCPI, the California excise tax is scheduled to automatically change on July 1 of each year and is estimated to increase from $0.613 to $0.625 per gallon in 2025, depending on California's Consumer Price Index.[345] As of December 11, 2023, taxes and regulatory fees added $1.386 per gallon to the price of gasoline in the state.[346] This research estimates all taxes, regulatory costs, and fees have risen faster than the annual inflation by 9.52% to $1.518 a gallon as of March 2025. The largest components of the increase are California's cap and trade costs, which are passed on to the consumer, and the LCFS premium.[347]

Exhibit 6.16



(Source: https://info.opisnet.com/hubfs/OPIS-West%20Coast-Spotlight%20Analysis-1.pdf)

6.3.1 Excise Tax. The state excise tax on gasoline, which is indexed to the California Consumer Price Index, is legislatively engineered to change on July 1 of every year. Since California has, dating back to 1955, an inflation rate in excess of that of the overall U.S., the excise tax on gasoline sales is virtually guaranteed to increase each year.

---

[344] *Tax Rates — Special Taxes and Fees.* (2022). Ca.gov. https://www.cdtfa.ca.gov/taxes-and-fees/special-taxes-and-fees-tax-rates/

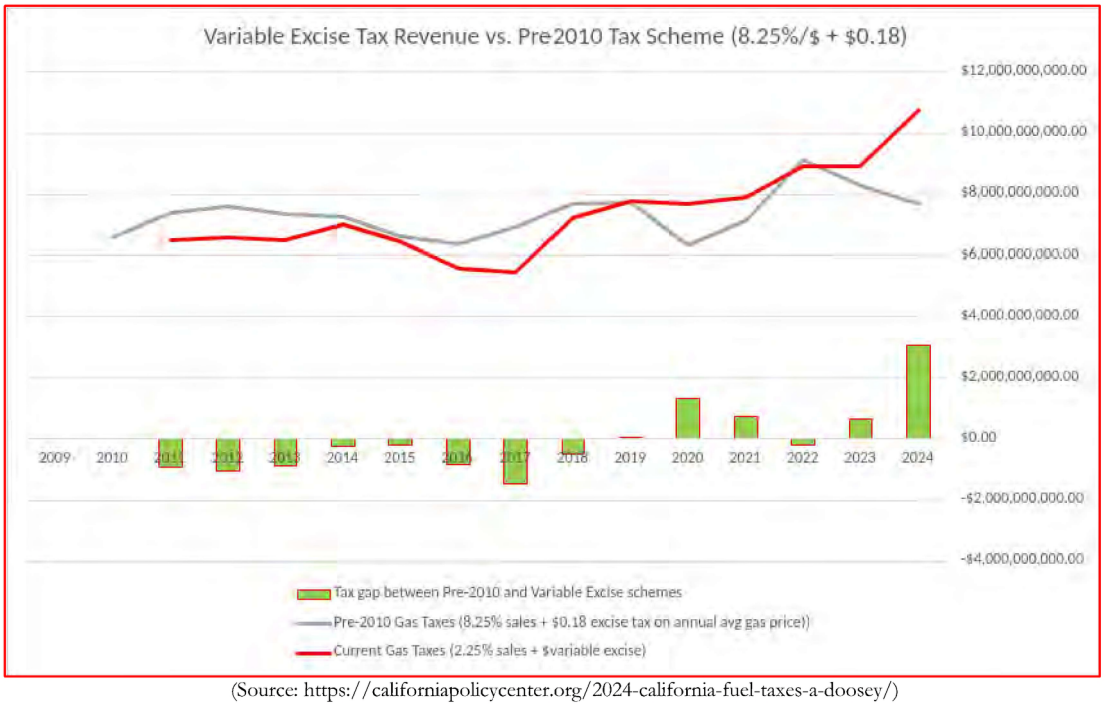
[345] *California's Gasoline Market: How the State's Unique Structure Impacts Pricing at the Pump.* (n.d.). Retrieved March 11, 2025, from https://info.opisnet.com/hubfs/OPIS-West%20Coast-Spotlight%20Analysis-1.pdf

[346] Commission, C. E. (n.d.). *Estimated Gasoline Price Breakdown and Margins.* California Energy Commission. https://www.energy.ca.gov/estimated-gasoline-price-breakdown-and-margins

[347] *California's Gasoline Market: How the State's Unique Structure Impacts Pricing at the Pump.* (n.d.). Retrieved March 11, 2025, from https://info.opisnet.com/hubfs/OPIS-West%20Coast-Spotlight%20Analysis-1.pdf

California's state excise tax, which was supposed to eliminate state sales taxes in 2010, has grown from around $0.07 a gallon in 1971 to almost $0.60 a gallon in 2025. California changed in 2010 to variable excise tax (indexed) with the objective of raising more revenue and equalizing taxes for both the state and local governments. Although the Legislature "assured voters that the scheme would be equalized to the pre-2010 sales tax method," the net effect between the pre-2010 tax and post-2010 tax indicates significant divergence, as illustrated in the exhibit below by the California Policy Center. As indicated in the exhibit below, the switch to the variable excise tax has increased gasoline revenues to the State by almost $2.0 billion or $0.147, a gallon based on 13.6 billion gallons of gasoline consumed in 2023.[348] [349]

Exhibit 6.17



(Source: https://californiapolicycenter.org/2024-california-fuel-taxes-a-doosey/)

6.3.2 California Cap and Trade & Environmental Costs. California's cap and trade program adds $0.30 to $0.33, to the price o a gallon to gas. Additionally, California's other environment initiatives add another $0.21 to consumer prices at the gas pump. California mandates that refiners comply with the State's Cap and Trade program. The program requires that refiners bid on allowances for emissions and the state's unique LCFS. The cap-and-trade cost is anticipated to significantly increase in 2025. Twenty-five percent (25%) of California's cap and trade regulatory fees generated by gasoline sales are statutorily allocated to California's High Speed Rail project (CHSR).[350] Originally scheduled for completion in 2020 at a cost of $33 billion, the CHSR is years behind schedule and billions of dollars over budget. Current estimates place the completion of the high-speed rail project

[348] *2024 California Fuel taxes… A DOOSEY | California Policy Center.* (2025, January 15). California Policy Center |. https://californiapolicycenter.org/2024-california-fuel-taxes-a-doosey/

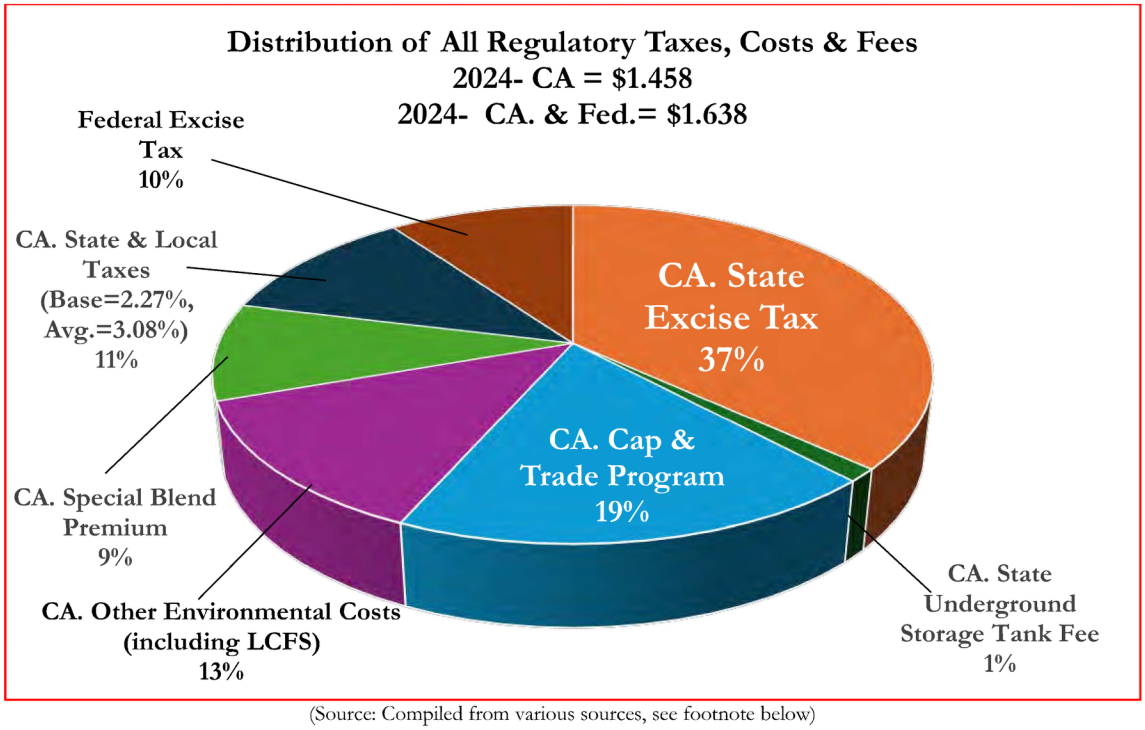
[349] Commission, C. E. (n.d.). *California Gasoline Data, Facts, and Statistics.* California Energy Commission. https://www.energy.ca.gov/data-reports/energy-almanac/transportation-energy/california-gasoline-data-facts-and-statistics

[350] *Cap and Trade Funding.* (2021, May 19). Metropolitan Transportation Commission. https://mtc.ca.gov/funding/state-funding/cap-and-trade-funding

between 2030 and 2035, with a projected cost of $106 billion, or three times its original estimate.[351] As noted by the California Legislative Analyst's Office (LAO) in a November 2023 report, "To our knowledge, no studies have produced a reliable estimate of the emission reduction achieved by the cap-and-trade program so far."[352]

Two of largest revenue generators for the Golden State are its excise tax, which is the highest in the U.S., and its environmental program fees, which represent 42% and 36% of revenues, respectively. Of the environmental program fees generated, California's cap and trade mandate is 24%, while other environmental programs are 12%.

Exhibit 6.18[353]



(Source: Compiled from various sources, see footnote below)

The expenses tied to both cap-and-trade and the Low Carbon Fuel Standard (LCFS) directly influence and increase gasoline prices for consumers. Over time, the costs associated with complying with these regulations have risen and tend to cumulate. Data from the OPIS Carbon Market Report indicates that compliance costs for CARB reformulated gasoline (RFG) at the wholesale level in California increased by 200%, from about $0.10 per gallon in 2015 to over $0.30 per gallon by the end of 2023.[354] The recently established LCFS standard in late 2024 by the CARB, which was delayed pending further

---

[351] *U.S. Transportation Secretary Duffy Announces Review of California High-Speed Rail Project | US Department of Transportation*. (2025). Transportation.gov. https://www.transportation.gov/briefing-room/us-transportation-secretary-duffy-announces-review-california-high-speed-rail-project

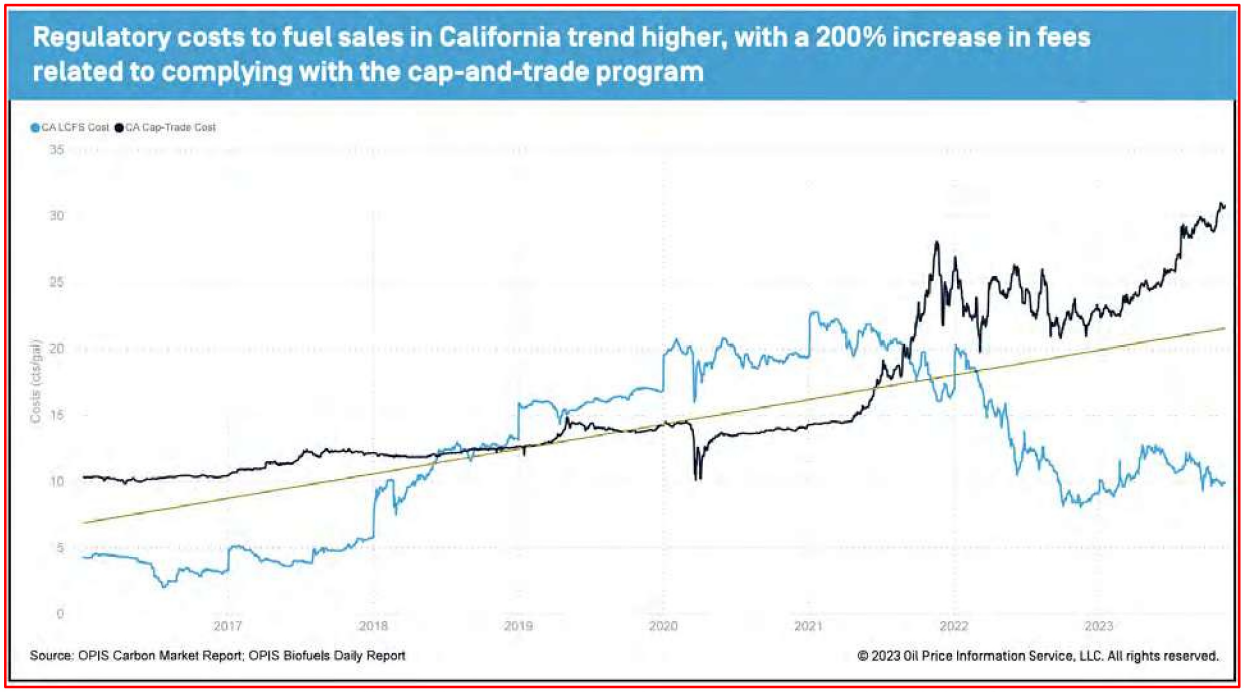
[352] *California's Cap-and-Trade program: Frequently asked questions*. (2023, October 24). https://lao.ca.gov/Publications/Report/4811#:~:text=As%20noted%20above%2C%20cap-and,their%20income%20towards%20transportation%20costs.

[353] *The California Cap-and-Trade Program: Overview and Considerations for Congress*. (2025). Congress.gov. https://www.congress.gov/crs-product/R48314

[354] *California's Gasoline Market: How the State's Unique Structure Impacts Pricing at the Pump*. (n.d.). Retrieved March 11, 2025, from https://info.opisnet.com/hubfs/OPIS-West%20Coast-Spotlight%20Analysis-1.pdf

disclosure and transparency regarding the cost to the consumer, was estimated by the CARB to add another $0.47 a gallon by year-end 2025.[355]

Exhibit 6.19



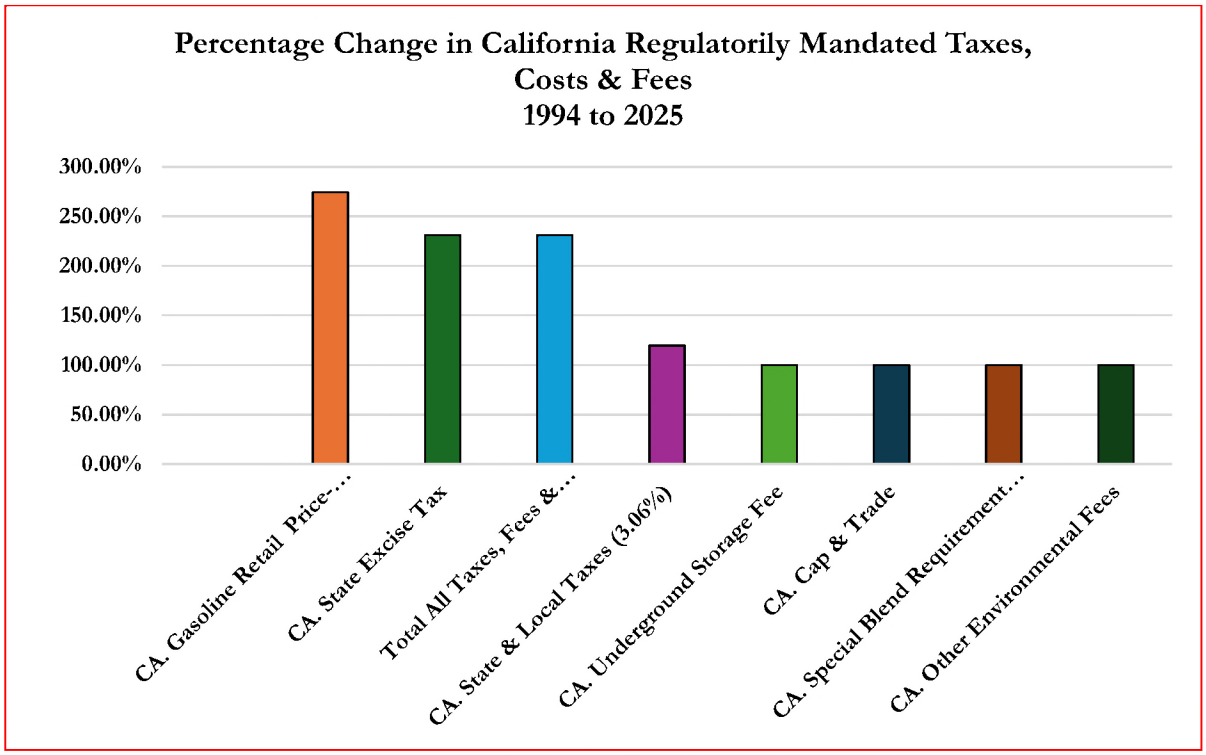
(Source: https://info.opisnet.com/hubfs/OPIS-West%20Coast-Spotlight%20Analysis-1.pdf)

6.3.3 Local Sales Tax. In addition to the highest state excise tax in the nation, California also imposes a 2.25% base sales tax for local districts. However, an analysis of cities located in California's 58 counties indicates that, on average, the effective tax rate at the local level on gasoline sales is 3.06% (non-weighted for sales and city size).[356] While the retail price of gasoline has increased by 274% since 1994, the state excise tax and local sales tax have increased by 231.1%, and 119.7%, respectively. The three significant cost burdens that have been added through regulations since 1994, are the California cap and trade program, the special blend, and other environmental costs.

[355] IER. (2025, March 4). *California's Plan to Tighten Its Fuel Standard Hits a Setback*. IER. https://www.instituteforenergyresearch.org/regulation/californias-plan-to-tighten-its-fuel-standard-hits-a-setback/?amp=1

[356] County, A. (n.d.). *District Taxes, Rates, and Effective Dates DISTRICT SALES AND USE TAX RATES Tax Area District Name and Acronym Rate Effective Date End Date Newark (City) City of Newark Transactions and Use Tax (NEGT)*. Retrieved March 10, 2025, from https://www.cdtfa.ca.gov/formspubs/cdtfa105.pdf

Exhibit 6.20

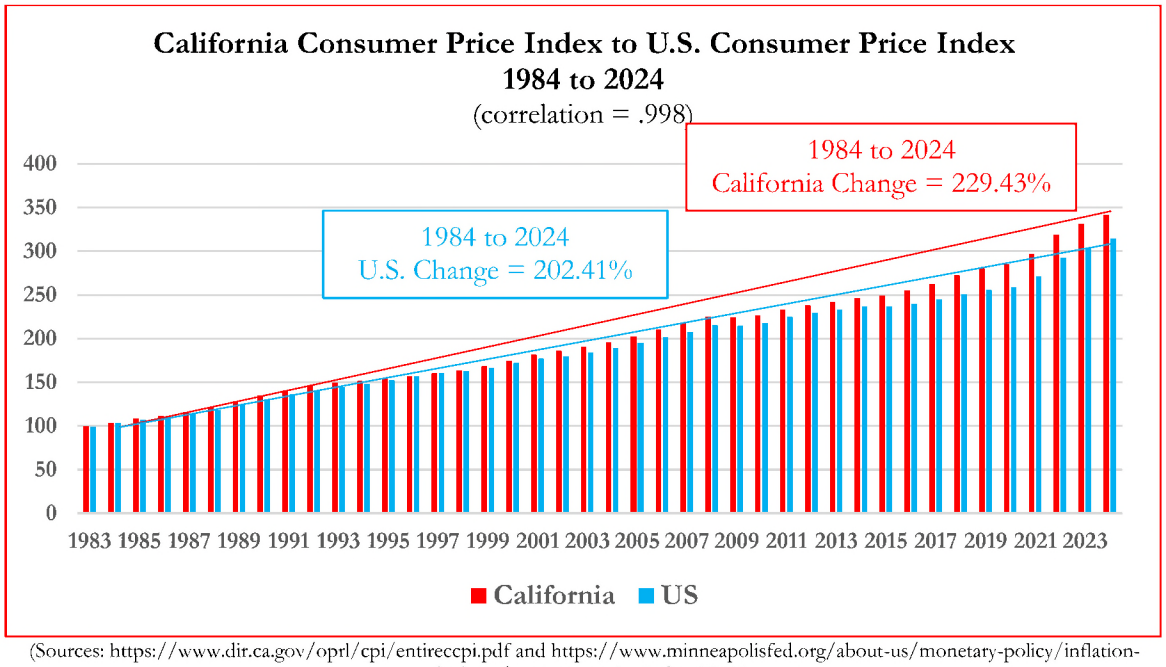


(Source: Compilation)

6.4 California Consumer Price Inflation & Gasoline Prices

Inflation is a common phenomenon in any economy. Since 1985, California's rate of inflation, as measured by the California Consumer Price Index, has increased faster than that of the overall U.S. For the 1984 to 2024 time period, California's CCPI increased by 229.43%, while the overall U.S. Consumer Price Index (CPI) increased by 202.41%. California's CPI, which is the basis for the California state excise tax on gasoline, is 1.13 times higher than that of the overall U.S. Not surprisingly, at .998, California's CPI is highly correlated to the overall U.S. CPI.

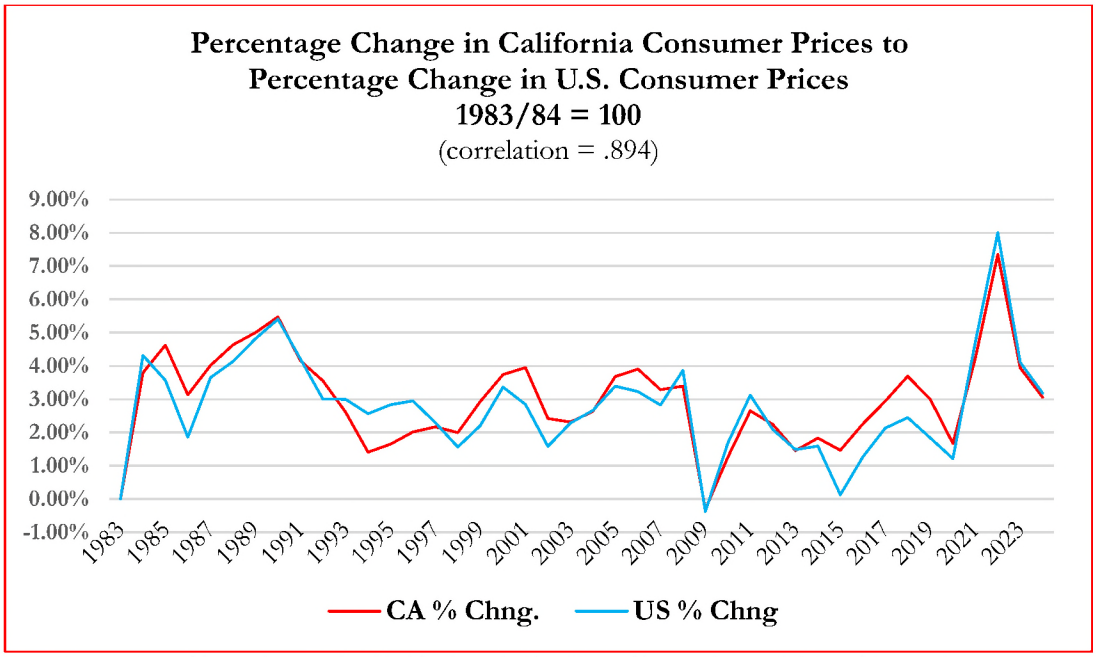
Exhibit 6.21



(Sources: https://www.dir.ca.gov/oprl/cpi/entireccpi.pdf and https://www.minneapolisfed.org/about-us/monetary-policy/inflation-calculator/consumer-price-index-1913-)

For the 1984 to 2024 period, California's CPI is highly correlated with that of the overall U.S. CPI (.894).

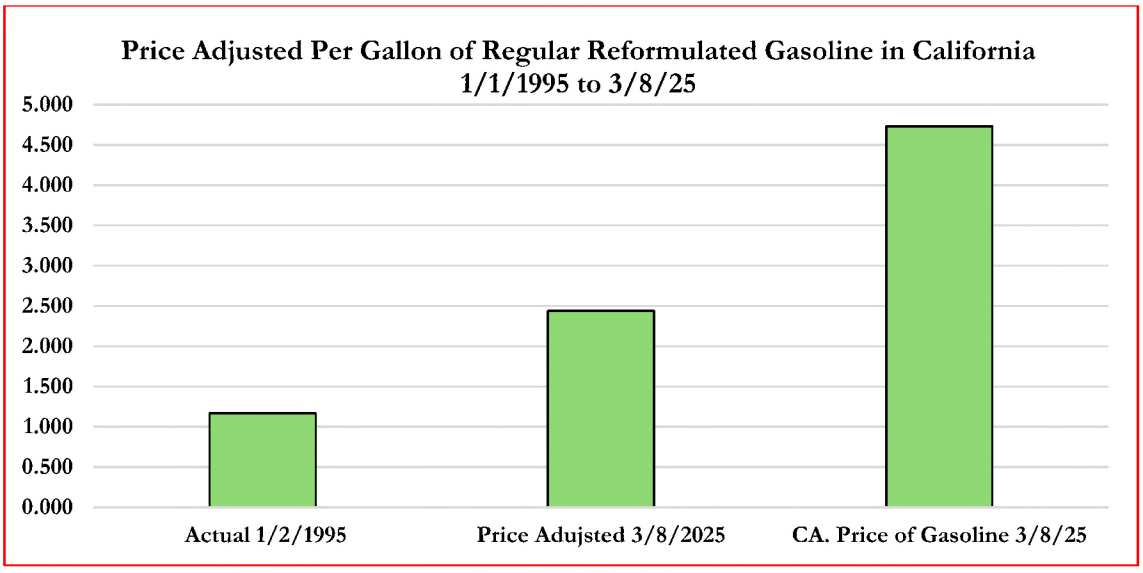
Exhibit 6.22



(Sources: https://www.dir.ca.gov/oprl/cpi/entireccpi.pdf and https://www.minneapolisfed.org/about-us/monetary-policy/inflation-calculator/consumer-price-index-1913-

Adjusting for general and California specific inflation, the 1994 price of California reformulated regular gasoline would be $3.051, today. Adding the 2024, total regulatory cost of $1.638, to the inflation adjusted price, brings the price adjusted cost to $4.734, which is within one percent of the actual price.

Exhibit 6.23



(Source: EIA & Author)

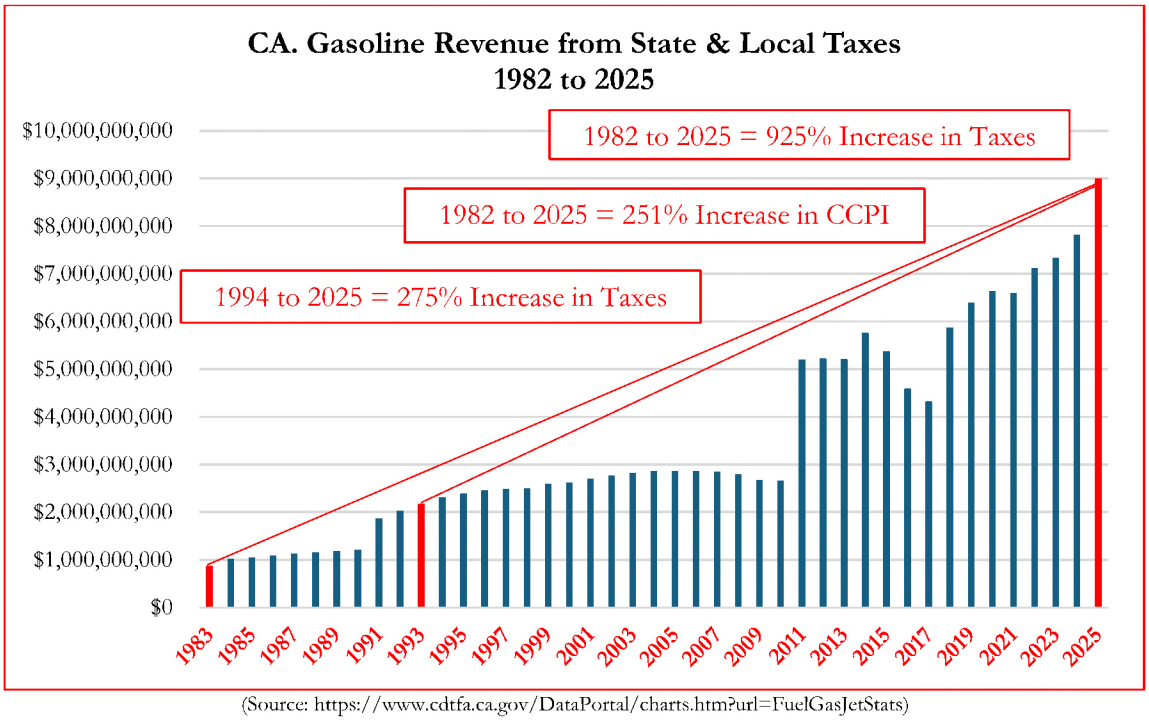
6.5 California Revenue from the Sale of Gasoline

Gasoline sales are BIG business for the Golden State, which will generate between $9.5 and $10.0 billion in income from gasoline taxes and fees to the State for its 2024/2025 fiscal year. The majority of California's gasoline revenues are allocated to the support of highways, local streets and roads, and multimodal programs.[357]

Since 1983, California's gasoline sales revenues have increased by 925%. For the 1994 to 2025 period, California revenues from gasoline sales have increased 275%. Correspondingly, the average retail price for regular gasoline increased by 274% for the same period. For the 1982 to 2025 period, increases in California taxes outpaced the CCPI by 3.8 times or 957% to 251%.

[357] *Assessing California's Climate Policies—Implications for State Transportation Funding and Programs.* (2023, December 13). Ca.gov. https://lao.ca.gov/Publications/Report/4821

Exhibit 6.24



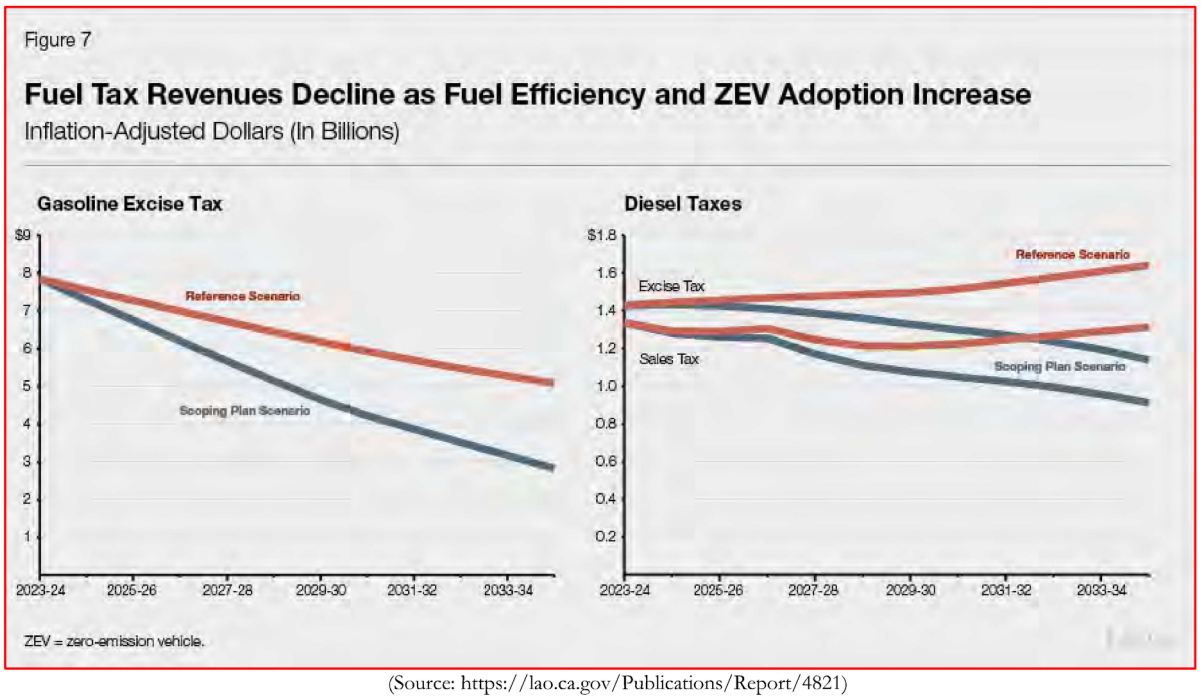
(Source: https://www.cdtfa.ca.gov/DataPortal/charts.htm?url=FuelGasJetStats)

California's Legislative Analyst's Office (LAO) predicts that as a consequence of California's zero emissions policies and the 2035 mandates to eliminate the selling of new internal combustion engine cars, revenues for the Golden State may fall by at least $5.0 billion over a ten-year period.[358] As of this time, it is unclear how California will compensate for the pending loss of gasoline sale revenues. As provided in the LAO report, California may have to increase taxes on gasoline and or increase motor vehicle registration fees to compensate for the shortfall associated with its zero emissions vehicle mandates.[359]

[358] *Assessing California's Climate Policies—Implications for State Transportation Funding and Programs.* (2023, December 13). Ca.gov. https://lao.ca.gov/Publications/Report/4821

[359] *Assessing California's Climate Policies—Implications for State Transportation Funding and Programs.* (2023, December 13). Ca.gov. https://lao.ca.gov/Publications/Report/4821

Exhibit 6.25



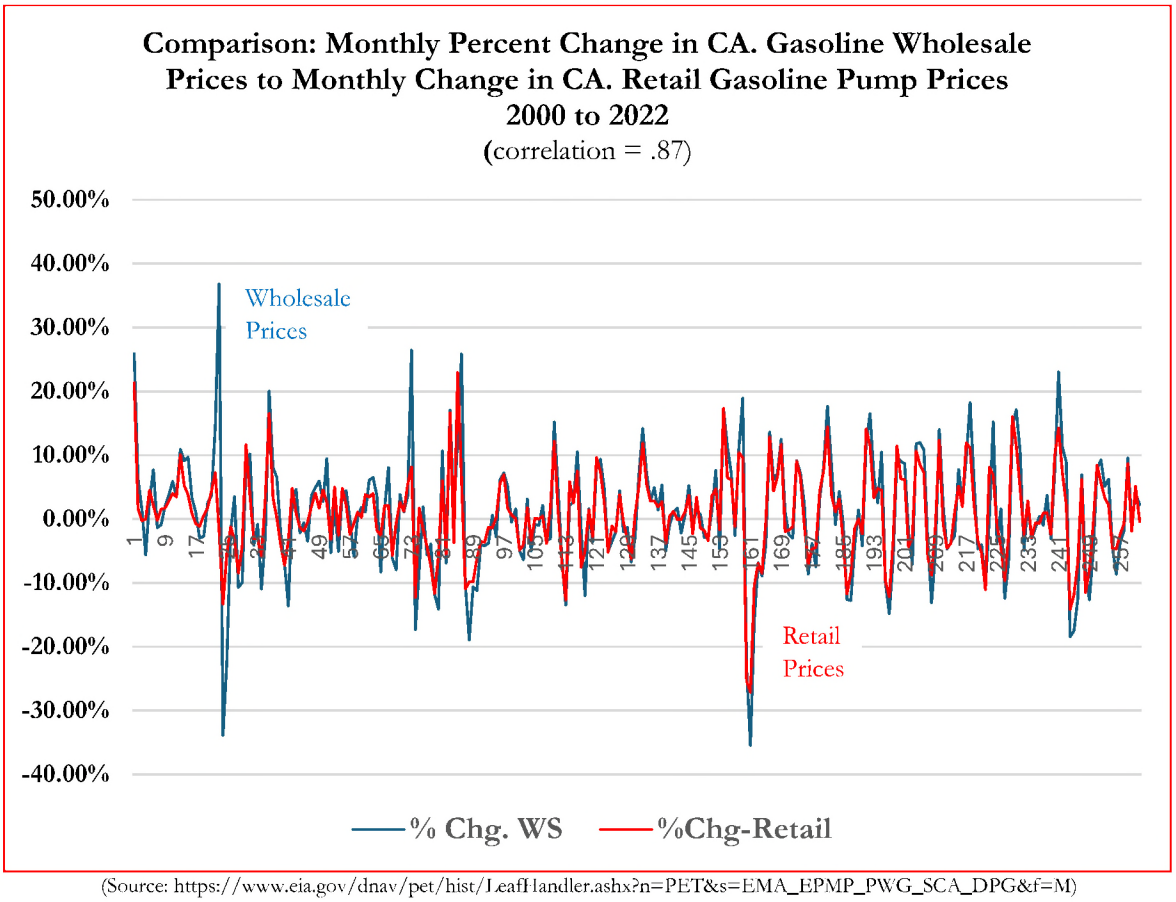
(Source: https://lao.ca.gov/Publications/Report/4821)

6.6 Analysis of California Gasoline Price Movements

The cost of crude oil to the refiner and the wholesale price (rack price) at which the refiner sells the refined gasoline to the distributor represent two of the most significant components of the retail price.[360] In California, changes in wholesale gasoline prices are correlated to changes in retail gasoline pump prices. For the 2000 to 2022 period, the monthly percent change in wholesale and retail prices averaged .94% and .89%, respectively, and have a correlation coefficient of .87.

[360] Rack Price or Rate Defined. "The rack price includes the cost of the gas itself, as well as transportation, overhead, and profit costs. The price can vary from terminal to terminal and depends on the cost of crude oil and related refining costs. The rack price also depends upon the distance between the fuel retailer and wholesaler terminal. A gas station located far from a terminal is going to pay a higher fuel rack price than one located just down the street." See, https://kendrickoil.com/what-is-a-fuel-rack-price/

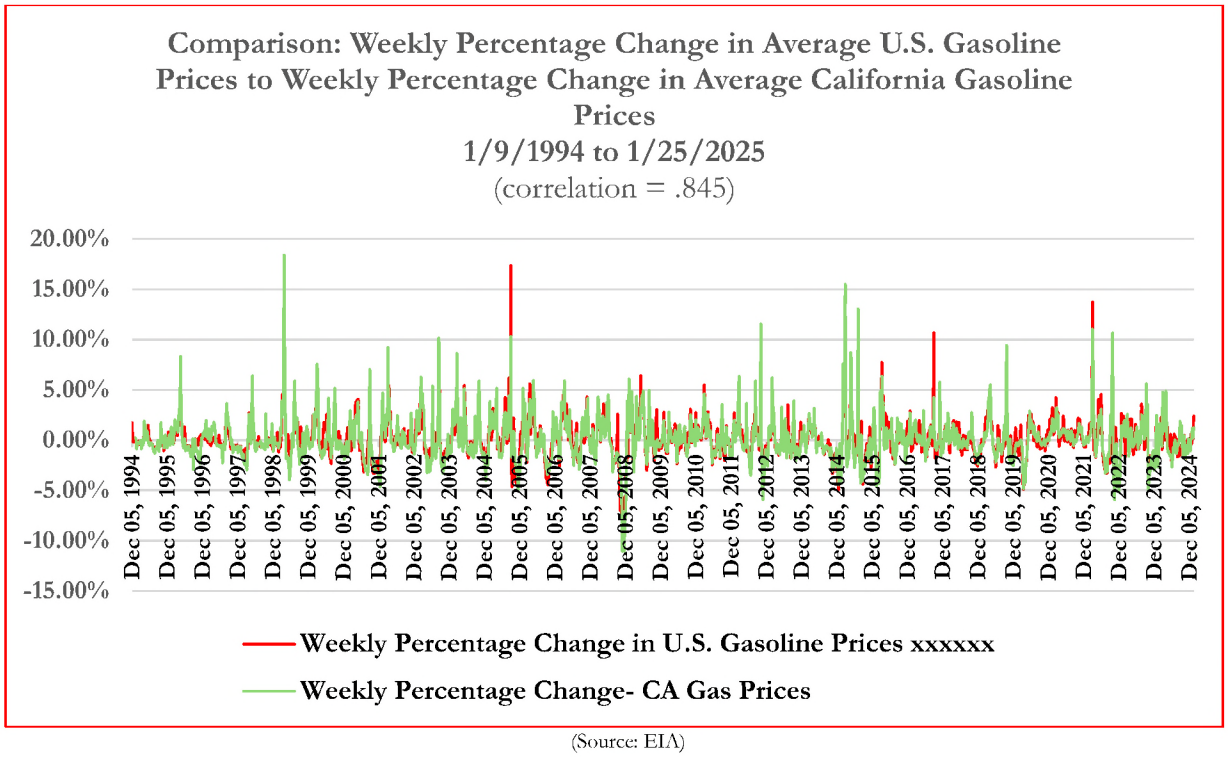
Exhibit 6.26



(Source: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMA_EPMP_PWG_SCA_DPG&f=M)

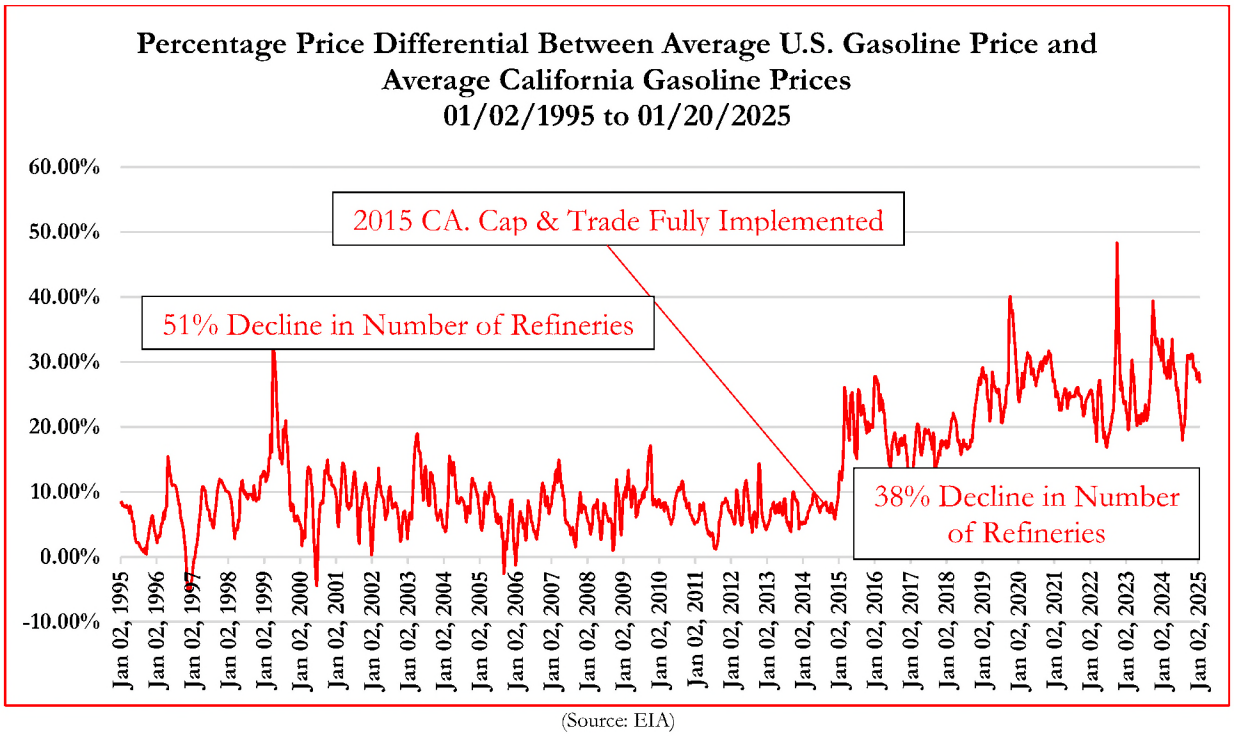
The weekly percentage in California average gasoline prices are also have a relatively high correlation with the weekly change in the average price of gasoline in the U.S.

Exhibit 6.27



(Source: EIA)

Exhibit 6.28



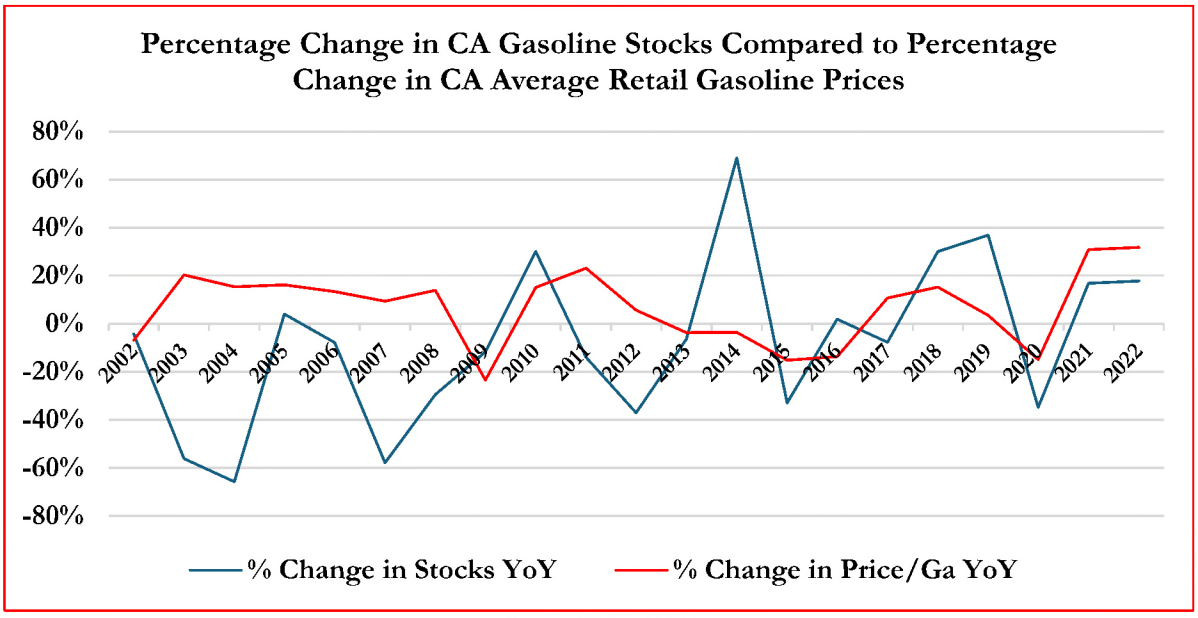
(Source: EIA)

In 2010, gasoline prices in California were approximately $0.31 per gallon higher than the national average outside the state, representing an 11% price gap. By 2022, this difference had widened significantly, with California drivers paying $1.55 per gallon more, or roughly 39% above the rest of the U.S. In 2023, the price gap remained elevated, with California's retail gasoline prices averaging $1.46 per gallon higher, translating to a 41% premium compared to other states.[361]

In spring 2022, gasoline prices in California experienced a sharp increase in retail gasoline prices to $5.91 per gallon on March 29, according to OPIS retail pricing data. This surge was largely driven by supply constraints, including maintenance work and unexpected disruptions at refineries, and the continued recovery in demand post-Covid lockdowns. Notably, PBF's Torrance refinery struggled to restart its fluid catalytic cracking unit, a key component in gasoline production, while Valero Energy's Wilmington refinery was undergoing scheduled (planned) maintenance.[362]

Adding to the supply stress, gasoline inventories had plummeted to 24.675 million barrels by the end of September 2022, the lowest level in a decade and well below the 30-million-barrel benchmark considered a stable supply See Section 3.0).[363] At the same time, gasoline imports into the West Coast were slow to react to the Covid-rebound and dwindled to just 1,000 barrels per day, worsening the shortage.[364]

Exhibit 6.29



(Source: CEC and EIA)

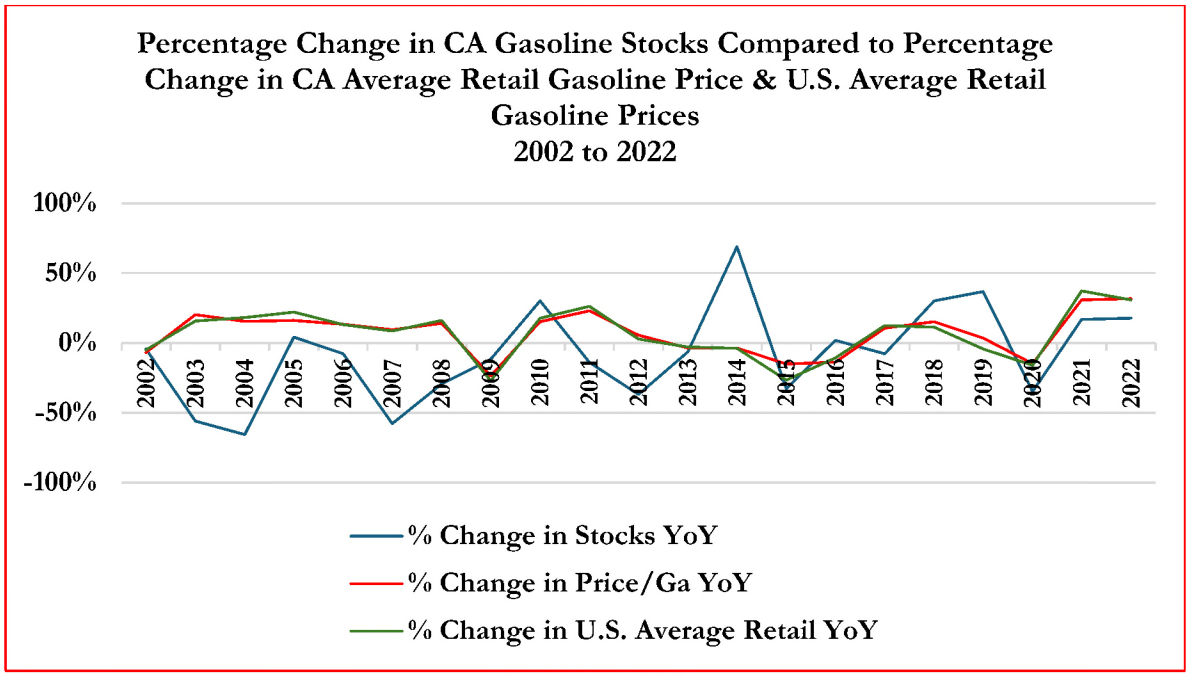
[361] *California's Gasoline Market: How the State's Unique Structure Impacts Pricing at the Pump.* (n.d.). Retrieved March 11, 2025, from https://info.opisnet.com/hubfs/OPIS-West%20Coast-Spotlight%20Analysis-1.pdf

[362] *California's Gasoline Market: How the State's Unique Structure Impacts Pricing at the Pump.* (n.d.). Retrieved March 11, 2025, from https://info.opisnet.com/hubfs/OPIS-West%20Coast-Spotlight%20Analysis-1.pdf

[363] *Weekly West Coast (PADD 5) Ending Stocks of Total Gasoline (Thousand Barrels).* (2015). Eia.gov. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=WGTSTP51&f=W

[364] *Weekly West Coast (PADD 5) Imports of Total Gasoline (Thousand Barrels per Day).* (2015). Eia.gov. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=WGTIM_R50-Z00_2&f=W

Exhibit 6.30



(Source: CEC and EIA)

Operational issues at refineries also played a role in driving prices higher. In 2015, a fire in the Torrence refinery disrupted gasoline production while the extra costs of the California cap and trade program became fully effective. On February 18, 2015, ExxonMobil's Torrance, California refinery sustained a catastrophic malfunction resulting in an explosion equal to a 1.7 tremor.[365] The explosion resulted in the refinery being shut down for over a year and being sold to PBF, reopening in May 2016.[366] The February explosion occurred in a month when demand is lower, and refiners are performing planned maintenance and reduced production. During the week of February 16, 2015, the explosion the average retail price for all formulations for California was $2.847. Following the explosion, the average retail price of gasoline jumped 5.38%, for the week of February 23, 2015, and then by 13.24% the week of March 2, 2015. The average price of gasoline spiked a second time during the week of July 13, 2015, during the prime driving season, by 11.55%, from the prior week, on a percentage change basis.

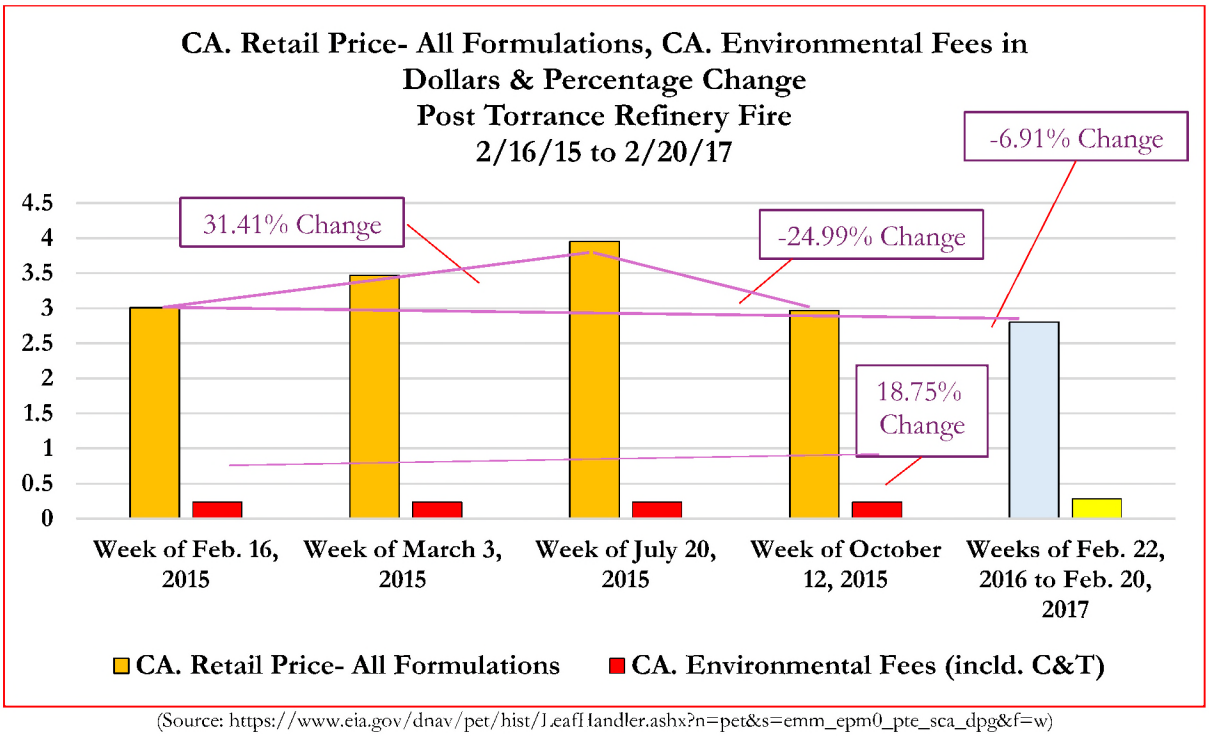
From the week of February 23, 2015, to the week of October 5, 2015, the average weekly retail price of all formulations of gasoline in California ranged between $3.009 to $3.954, a gallon on July 20, 2015, the peak of the summer driving season. The week of October 12, 2016, the average price of all formulations of gasoline in the Golden State fell below $3.00 a gallon and remained below that level until February 20, 2017. On a percentage change basis, for the week of February 27, 2017, the price of gasoline increased by 2% to 3.014 a gallon from the previous week's average of $2.955 a gallon, and remined above $3.00, a gallon, with the exception of the weeks of July 24 and July 17, 2017, when the prices dropped to $2.995 and $2.988, respectively. Correspondingly, while gasoline prices declined, on

[365] Zou, J. J. (2017, February 10). *The ExxonMobil near-disaster you probably haven't heard of.* Center for Public Integrity. https://publicintegrity.org/environment/the-exxonmobil-near-disaster-you-probably-havent-heard-of/

[366] Staff Report. (2016, May 10). *ExxonMobil Restarts Torrance Refinery One Year After Explosion.* NBC Los Angeles; NBC Southern California. https://www.nbclosangeles.com/news/local/planned-restart-torrance-refinery-expected-tuesday/2004869/

a percentage change basis by average of 6.91%, California environmental fees increased by 18.75%, for the February 16, 2015, to February 20, 2017, period.

Exhibit 6.31[367]

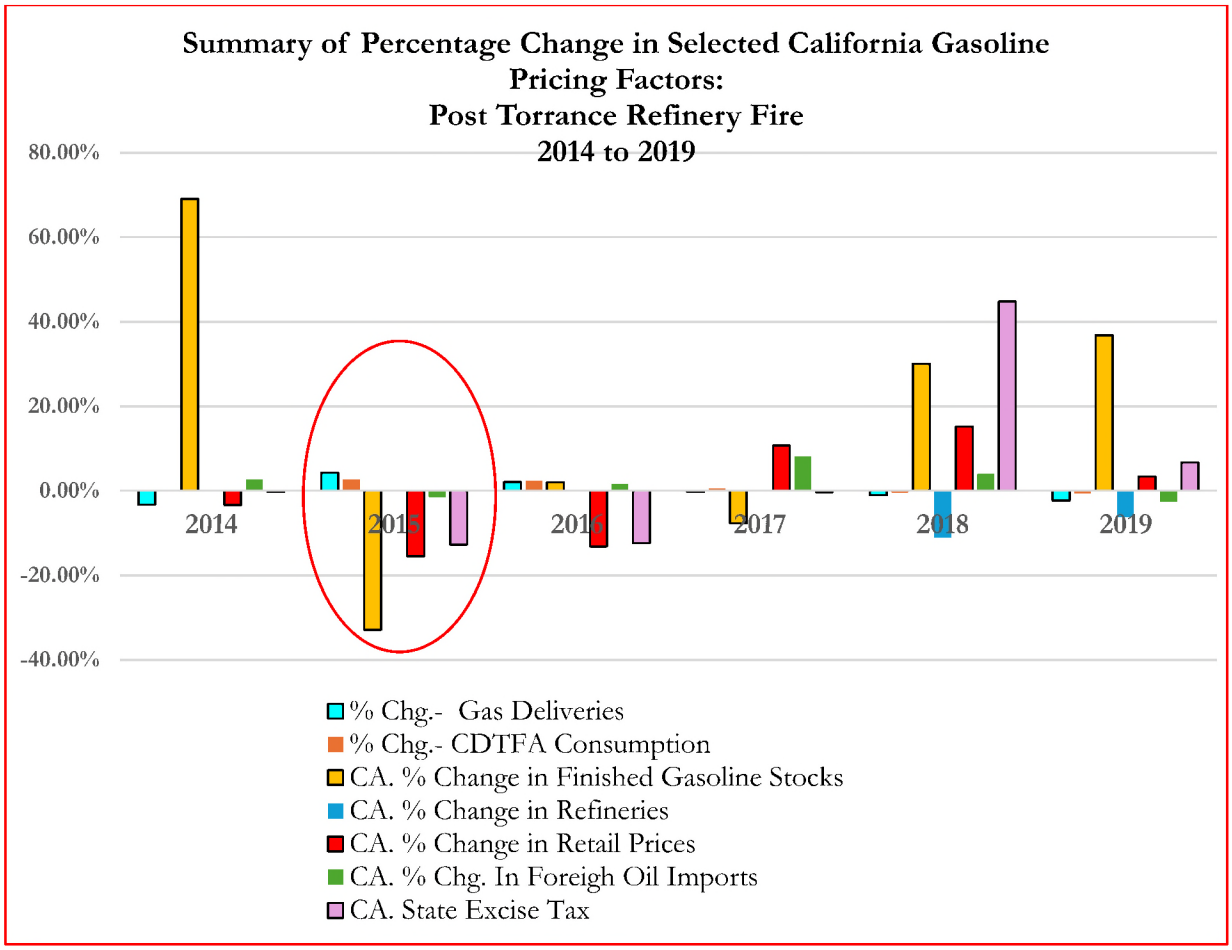


(Source: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=emm_epm0_pte_sca_dpg&f=w)

On a percentage change basis, while gasoline consumption and gasoline deliveries to retail outlets declined slightly, average retail gasoline prices increase, as did the state excise tax, oil imports, and California environmental costs on a per gallon basis.

[367] *Weekly California All Grades All Formulations Retail Gasoline Prices (Dollars per Gallon)*. (n.d.). Www.eia.gov. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMM_EPM0_PTE_SCA_DPG&f=W

Exhibit 6.32[368]



In September 2022, three major California refineries were undergoing scheduled maintenance, while an additional facility may have faced an unplanned power outage, though the company did not confirm the disruption. These refinery challenges further constrained fuel production, contributing to the state's price volatility and increased pricing.[369]

From 2000 to 2025, the price differential between California average weekly regular reformulated gasoline prices and the U.S. average for reformulated regular gasoline pre-cap and trade averaged

[368] *Sales Tax Rates for Fuels*. (2025). Ca.gov. https://www.cdtfa.ca.gov/taxes-and-fees/sales-tax-rates-for-fuels.htm#motor.Commission, C. E. (n.d. a). *Annual Oil Supply Sources To California Refineries*. California Energy Commission. https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/annual-oil-supply-sources-california; *California Total Gasoline All Sales/Deliveries by Prime Supplier (Thousand Gallons per Day)*. (2020). Eia.gov. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=c100050061&f=a; *Fuel Taxes Division Statistics & Reports – 2010*. (2025). Ca.gov. https://www.cdtfa.ca.gov/taxes-and-fees/spftrpts10.htm; *California Finished Motor Gasoline Stocks at Refineries, Bulk Terminals, and Natural Gas Plants (Thousand Barrels)*. (2020). Eia.gov. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mgfsxca1&f=a *California All Grades All Formulations Retail Gasoline Prices (Dollars per Gallon)*. (2010b). Eia.gov. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=emm_epm0_pte_sca_dpg&f=m; *California Finished Motor Gasoline Stocks at Refineries, Bulk Terminals, and Natural Gas Plants (Thousand Barrels)*. (2020b). Eia.gov. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mgfsxca1&f=a

[369] *California's Gasoline Market: How the State's Unique Structure Impacts Pricing at the Pump*. (n.d.). Retrieved March 11, 2025, from https://info.opisnet.com/hubfs/OPIS-West%20Coast-Spotlight%20Analysis-1.pdf

7.84%. Post full implementation of the cap-and-trade program in 2015, the price differential between California and the U.S. based on weekly gasoline prices for regular reformulated fuel expanded to 23.56% by March 2025.

In September 2023, retail gasoline prices in California climbed to $6.083 per gallon. The factors behind this price increase mirrored those from autumn 2022, including low fuel inventories, limited imports, and below-average refinery output.[370] In response to the price surge, the California Air Resources Board (CARB), under Governor Newsom's direction, approved an early switch to winter-blend gasoline on September 28 to help lower costs.[371] Winter-grade gasoline is less expensive to refine than its summer counterpart due to the inclusion of lower-cost fuel formulation components.

At the wholesale level, Los Angeles CARBOB spot prices peaked at $4.3866 per gallon on September 26, with a significant $1.87 per gallon cash differential over the NYMEX RBOB contract, according to OPIS data. However, just a day later, the price had dipped to $4.0501 per gallon, and by September 29, after the RVP transition, it had plunged to $2.9895 per gallon.[372]

Despite claims of gas station owner-operator price gouging, retail gasoline prices tend to be less volatile than wholesale and spot prices due to supply contract structures and station-level inventory management.[373] An OPIS analysis of gasoline price trends in Los Angeles and San Francisco following California's RVP waivers in 2022 and 2023 revealed that while spot and rack prices dropped sharply, retail price declines were more gradual and took longer to be reflected at the pump. Gas station operators generally operate with a 7 to 14 supply of gasoline and with 14-to-30-day purchase contracts from wholesalers and will also react to local competition pricing. In the absence of oil shocks, such as in the 1970s, local prices tend to move slower than either spot or rack wholesale.[374] As California has one of the highest costs of living and one of the highest costs of doing business, it only stands to reason that California gas station operators moderate their reactions to changes in spot and wholesale prices.

---

[370] *California's Gasoline Market: How the State's Unique Structure Impacts Pricing at the Pump.* (n.d.). Retrieved March 11, 2025, from https://info.opisnet.com/hubfs/OPIS-West%20Coast-Spotlight%20Analysis-1.pdf

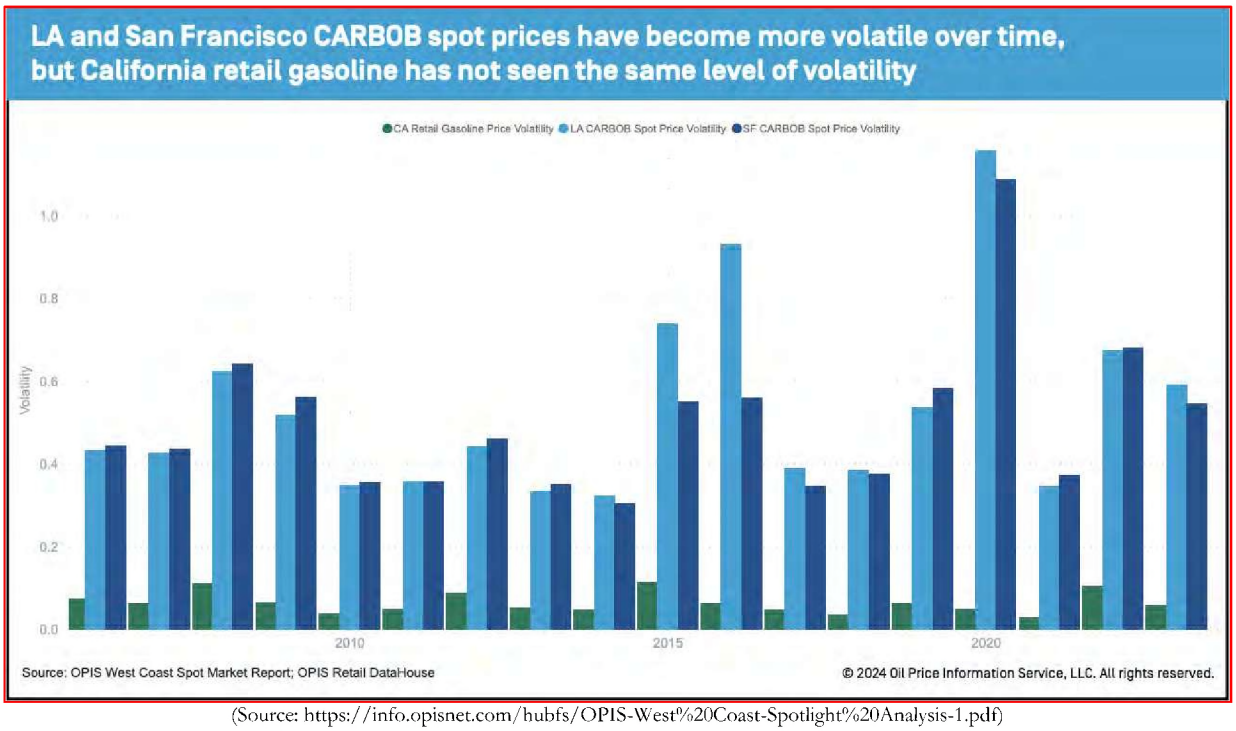
[371] https://ww2.arb.ca.gov/sites/default/files/2023-09/RVP_Advisory_2023.pdf

[372] *California's Gasoline Market: How the State's Unique Structure Impacts Pricing at the Pump.* (n.d.). Retrieved March 11, 2025, from https://info.opisnet.com/hubfs/OPIS-West%20Coast-Spotlight%20Analysis-1.pdf

[373] *California's Gasoline Market: How the State's Unique Structure Impacts Pricing at the Pump.* (n.d.). Retrieved March 11, 2025, from https://info.opisnet.com/hubfs/OPIS-West%20Coast-Spotlight%20Analysis-1.pdf

[374] *California's Gasoline Market: How the State's Unique Structure Impacts Pricing at the Pump.* (n.d.). Retrieved March 11, 2025, from https://info.opisnet.com/hubfs/OPIS-West%20Coast-Spotlight%20Analysis-1.pdf

Exhibit 6.33



(Source: https://info.opisnet.com/hubfs/OPIS-West%20Coast-Spotlight%20Analysis-1.pdf)

Although gasoline price spikes in 2022 and 2023 may give the impression of increased volatility, a deeper analysis of the data presents a more nuanced picture.

- According to OPIS data, California's retail gasoline price volatility between 2006 and 2014 averaged 21.23%, while from 2015 to 2023, it measured 20.53%.[375]

- In contrast, spot market volatility has increased significantly. Between 2006 and 2014, Los Angeles CARBOB spot prices had a volatility rate of 129.9%, but from 2015 to 2023, that figure jumped to 206.4%.[376] Similarly, San Francisco CARBOB spot price volatility rose from 134% in the 2006–2014 period to 181.5% from 2015 to 2023.[377]

The evidence of a stable retail market is further supported by analyzing the week-to-week price movements of California gasoline compared to the U.S. from November 1994 to Jan 2025. Out of the 1567 weeks, the differential widened for 765 weeks and narrowed for 802 weeks. Additionally, the average duration of the differential widening was 2.86 weeks, and the average duration of narrowing was 2.99 weeks.[378] This analysis supports the conclusion that price declines take longer to be reflected at the pump; however, on average, this disparity is very small. This is also evidence against the proposed predatory asymmetric pass-through causality in the 2024 CEC and CDFTA Joint Agency

[375] CA retail regular gasoline price data through November 15, 2023

[376] *California's Gasoline Market: How the State's Unique Structure Impacts Pricing at the Pump*. (n.d.). Retrieved March 11, 2025, from https://info.opisnet.com/hubfs/OPIS-West%20Coast-Spotlight%20Analysis-1.pdf

[377] Los Angeles CARBOB spot price data and San Francisco CARBOB spot price data through December 29, 2023

[378] Analysis conducted by author

report.[379] Additionally, there were 51 weeks where the differential had a Z-score above 2 and only 6 weeks with a Z-score below -2. In these weeks, the California to U.S. price differential reaches well above 40%. This relationship of California having a disproportionately high number of outlier weeks holds true for many relationships, including West Coast Reformulated gasoline to California Reformulated differential (45 outliers with a Z-score above 2 and 9 outliers with a Z-score below -2) and California to WTI spot oil differential (40 outliers with a Z-score above 2, and 9 outliers with a Z-score below -2).[380] This data reveals the fact that California's supply chain is fundamentally vulnerable to price changes, leaving the consumer to pay higher prices for longer periods of time.

The 2024 Joint Agency Study also comments on refinery margins. However, this information is clouded in uncertainty given that the report focuses largely on gross margins and the fact that the CEC states that they "cannot estimate profit margins based on average retail prices and observed wholesale market prices. This is because detailed data on refining and distribution costs, costs paid by approximately 10,000 retail locations, hundreds of wholesale marketers, jobbers, and distributors, is not available."[381] Nonetheless, the joint agency report suggests that gross gasoline refining margins have increased significantly since 2022, implying perhaps that the refineries are engaging in unfair pricing strategies to exploit the consumer. However, the report also states that refining costs and profits in 2022 average 16% of the selling price of gasoline, of which 14% of the selling price of gasoline is normally associated with refining costs.[382] This implies that CEC calculates the profit margin to be just 2%, which is less than a grocery store, and providing strong evidence of fair pricing practices and lack of any malicious price manipulations or profiteering.

For the 2020 to 2024, September refining margins, as well as refiner's net profits per gallon of gasoline produced, have declined significantly across all major U.S. markets since recovering from the Covid restrictions and lockdowns and 2024 highs. The 3:2:1 crack spread also declined in the same period. California refinery margins dropped by around 85% from approximately $1.38, a gallon in September 2023 to $0.20, in September 2024.[383] Furthermore, in November 2023, refinery costs and profits decreased to 10.95% of the price of gasoline.[384] California refineries are not immune from global and U.S. macroeconomic behavior. From January 2023 to November 2024, period retail gasoline sales in California increased by 11.49% , from $4.368 to $4.925 a gallon, while refiner's gross profit margins dropped by 26.%.

---

[379] *Project Title: SB X1-2 Implementation.* (n.d.). https://seuc.senate.ca.gov/sites/seuc.senate.ca.gov/files/cdtfa_cec_joint_report_2024_review_of_the_gasoline_in_california_and_relate.pdf

[380] Analysis conducted by author

[381] Commission, C. E. (n.d.). *Estimated Gasoline Price Breakdown and Margins.* California Energy Commission. https://www.energy.ca.gov/estimated-gasoline-price-breakdown-and-margins

[382] *Project Title: SB X1-2 Implementation.* (n.d.). https://seuc.senate.ca.gov/sites/seuc.senate.ca.gov/files/cdtfa_cec_joint_report_2024_review_of_the_gasoline_in_california_and_relate.pdf

[383] *Global refinery margins fall to multiyear seasonal lows in September - U.S. Energy Information Administration (EIA).* (2025). Eia.gov. https://www.eia.gov/todayinenergy/detail.php?id=63447#

[384] *Project Title: SB X1-2 Implementation.* (n.d.). https://seuc.senate.ca.gov/sites/seuc.senate.ca.gov/files/cdtfa_cec_joint_report_2024_review_of_the_gasoline_in_california_and_relate.pdf

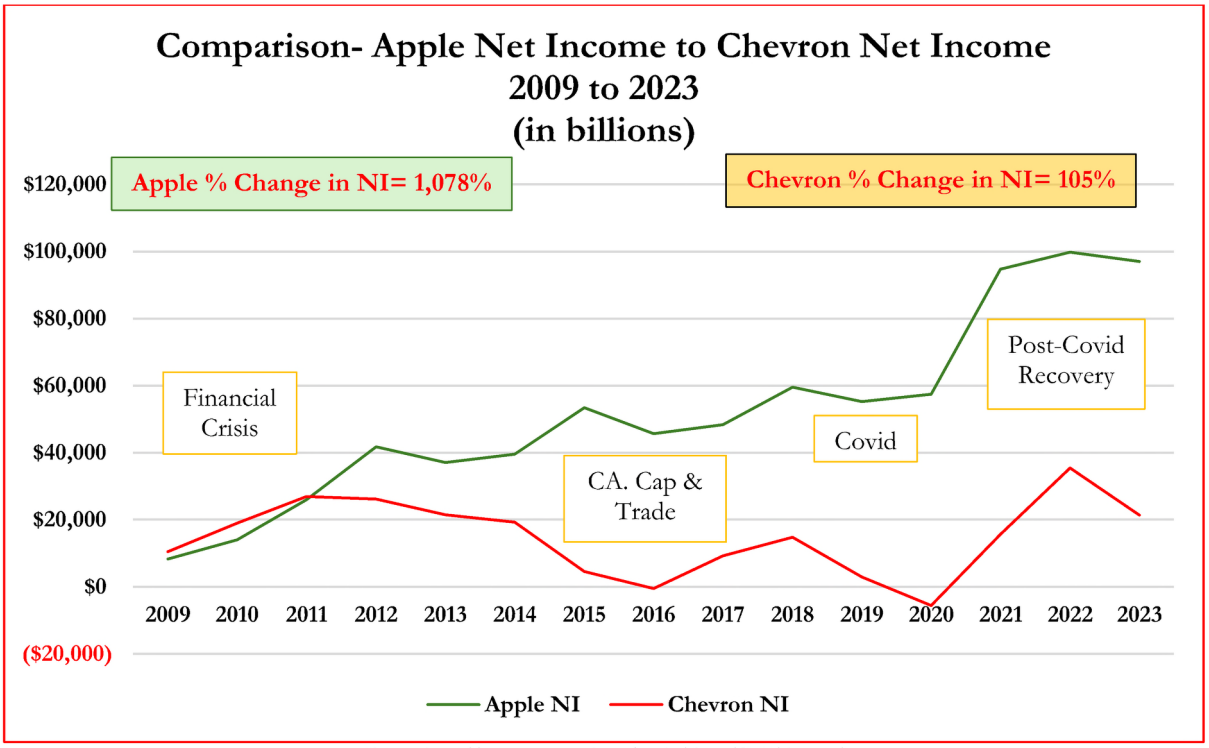
Exhibit 6.34[385]

California Gasoline Prices, Gallons Sold & Refiner Gross Margins (1/23 to 11/24)			
Indicator	**Jan. 2023**	**Nov. 2024**	**Percent Change**
CA. Avg. Retail Price of Gasoline*	4.368	4.935	12.98%
CA. Gasoline Sold **	904,596,000	960,190,000	6.15%
CA. Aggregate Gross Profits**	597,033,360	441,687,400	-26.02%
* EIA data for all formulations; ** CEC data			

Based on data provided to the CEC under SB 1322,[386] CEC analysis of recent 9 months of California refinery data, in-state net profits per gallon for refineries were negative.

For perspective, the below exhibit contrasts the percentage in net profits for California's two most highly valued companies, Chevron and Apple, both of which were headquarter in California in 2025, for the 2009 to 2023 timeframe.

Exhibit 6.35



(Source: https://www.macrotrends.net/stocks/charts/CVX/chevron/net-income#:~:text=Chevron%20annual%20net%20income%20for,a%20381.89%25%20decline%20from%202020, and https://www.macrotrends.net/stocks/charts/AAPL/apple/net-income#:~:text=Apple%20annual%20net%20income%20for,a%2064.92%25%20increase%20from%202020)

[385] https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/california-oil-refinery-cost-disclosure, and https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMM_EPM0_PTE_SCA_DPG&f=M

[386] https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB1322

Los Angeles Times

CALIFORNIA

California legislators strike last-minute deal to help oil industry but limit offshore drilling



The sun sets over Cymric oil field in McKittrick in Kern County. (Irfan Khan / Los Angeles Times)




By Laura J. Nelson and Grace Toohey

Sept. 11, 2025 3 AM PT

- California lawmakers introduced a last-minute deal that would streamline environmental approvals for up to 2,000 new wells annually in oil-rich Kern County, while tightening the regulatory requirements for offshore drilling.
- The looming closure of two California refineries has become a sore spot for Gov. Gavin Newsom and for California Democrats, pitting their longtime clean-energy goals against concerns about the rising cost of living.

SACRAMENTO — Amid concerns that refinery closures could send gas prices soaring, California legislative leaders Wednesday introduced a last-minute deal aimed at increasing oil production to shore up the struggling fossil-fuel industry while further restricting offshore drilling.

The compromise, brokered by Gov. Gavin Newsom, Assembly Speaker Robert Rivas and Senate Pro Tem Mike McGuire, would streamline environmental approvals for new wells in oil-rich Kern County and increase oil production. The bill also would make offshore drilling more difficult by tightening the safety and regulatory requirements for pipelines.

With support from Rivas and McGuire, Senate Bill 237 is expected to pass as part of a flurry of last-minute activity during the Legislature's final week. Newsom's office said the governor "looks forward to signing it when it reaches his desk."

The late introduction of the measure may force the Legislature to extend its 2025 session, set to end Friday, by another day because bills must be in print for 72 hours before they can be voted on.

The bill was introduced Wednesday as part of a package of energy policies that aims to address growing concerns about affordability and the closure of California oil refineries.

Valero and Phillips 66 plan to close plants in the San Francisco Bay Area and Los Angeles County's South Bay, which would reduce California's in-state oil refining capacity by an estimated 20%. Industry experts warn that losing refining capacity could lead to more volatile gas prices.

The closures have become a sore spot for Newsom and for state Democrats, pitting their longtime clean-energy goals against concerns about the rising cost of living — a major political liability.

The package tries to strike a balance between the oil industry and climate activists, but neither side seemed particularly pleased: Environmental groups panned the agreements, and industry groups said they were still reviewing the bill.

"I don't think what's in that legislation is going to keep refineries open," said Michael Wara, the director of Stanford University's Climate and Energy Policy Program.

Crude oil produced in California makes up a fraction of what refineries turn into gasoline, he said, so although increasing production may help stabilize the decline of local oil companies, it won't benefit the refineries.

The bill would grant statutory approval for up to 2,000 new wells per year in the oil fields of Kern County, the heart of California oil country, which produce about three-fourths of the state's crude oil. That legislative fix, effective through 2036, would in effect circumvent years of legal challenges by environmental groups seeking to stymie drilling.

The state, which has championed and pioneered progressive environmental policies to slash carbon emissions, also is home to a billion-dollar oil industry that helps power its economy and has significant political sway in Sacramento. Despite steady declines in production, California remains the eighth-largest crude oil producing state in the nation, according to the U.S. Energy Information Administration.

Hollin Kretzmann, an attorney at the Center for Biological Diversity's Climate Law Institute, said the legislation "acknowledges the harms of oil drilling yet takes radical steps to boost it."

"Removing environmental safeguards won't reverse the terminal decline of California oil production but it will allow the industry to do more damage on its way out the door," Kretzmann said, adding that it will have "no impact on refinery closures or gas prices."

Ted Cordova, a vice president of E&B Natural Resources, an oil and natural gas company with operations in Kern County, told reporters earlier this week that California needs to reverse falling oil production to keep refineries operating. He said his firm gets emails from pipeline companies saying they are operating "at dangerously low levels, can you send us more?"

The bill also has the potential to create new hurdles for Sable Offshore Corp., the Texas oil firm that is moving toward restarting offshore drilling along Santa Barbara County's coast, depending on when the company navigates through a litany of ongoing litigation and necessary state approvals.

The company has moved forward on repairs to the network of oil pipelines that burst in 2015 in one of the state's worst oil spills, despite opposition from the California Coastal Commission.

The bill, which would take effect in January, reasserts the authority of the commission to oversee pipeline repair projects and requires the "best available technology" for any pipe transporting petroleum from offshore. That could add lengthy governmental reviews for Sable if the operation isn't running by January.

The company, despite reports that it's running low on capital and has suffered repeated setbacks, continues to say it hopes to begin sales as soon as possible.

Representatives from Sable did not respond to questions Wednesday.

Mary Nichols, an attorney at UCLA Law's Emmett Institute on Climate Change and the Environment, said the bill probably wouldn't affect the ongoing project off Santa Barbara County's coast — which remains tied up in litigation — but makes clear that there's no easy path for any other company looking to take advantage of offshore oil in federal waters under the oil-friendly Trump administration.

"This was designed to send a message to anybody else who might be thinking about doing the same thing," said Nichols, a former chair of the California Air Resources Board.

Lawmakers also introduced a tentative deal on cap-and-trade, an ambitious climate program that has raised roughly $31 billion since its inception 11 years ago. The revised language would extend the program from its current 2030 deadline until 2045.

The program, last renewed in 2017, requires major polluters such as power plants and oil refineries to purchase credits for each ton of carbon dioxide they emit, and allows those companies buy or sell their unused credits at quarterly auctions.

Assemblymember Lori D. Wilson (D-Suisun City), one of the authors of SB 237, said she was glad to make progress on the push and pull between the state's fuel needs and its commitment to green energy. She said she understands there are environmental concerns, but "at the end of the day, our purpose was an issue of petroleum supply."

"We all don't want an import model," she said.

Times staff writers Melody Gutierrez and Hayley Smith contributed to this report.

More to Read

Newsom signs California climate package aimed at lowering gas and utility costs

Sept. 19, 2025



California lawmakers pass measures to expand oil production in Central Valley, restrict offshore drilling

Sept. 13, 2025



Down to the wire: California lawmakers announce last-minute climate and energy package

Sept. 11, 2025



Sign up for Essential California

The most important California stories and recommendations in your inbox every morning.

Sign Me Up



Laura J. Nelson

Laura J. Nelson is a staff writer at the Los Angeles Times covering California politics, including the 2026 governor's race and the midterm elections in the U.S. House of Representatives.



Grace Toohey

Grace Toohey is a reporter at the Los Angeles Times covering breaking news for the Fast Break Desk. Before joining the newsroom in 2022, she covered criminal justice issues at the Orlando Sentinel and the Advocate in Baton Rouge. Toohey is a Maryland native and proud Terp.

Gavin Newsom warms to Big Oil in climate reversal

CALmatters (California)

August 18, 2025 Monday

Distributed by Newsbank, Inc. All Rights Reserved
Copyright 2025 CALmatters

Section: ENVIRONMENT

Length: 2377 words

Byline: Alexei Koseff, ALEJANDRO LAZO AND MAYA C. MILLER

Body

We're keeping a close eye on your elected officials in the California Legislature. Sign up for beta access to My Legislator, your weekly report on what your representatives said, voted on, introduced and more.

The oil industry is having an I-told-you-so moment in California.

For decades, the state has raced to end its reliance on fossil fuels and prioritize clean energy. Its relationship with oil companies became particularly contentious in the past two years, as Gov. Gavin Newsom and Democratic legislators held two special sessions to crack down on alleged price gouging at the pump.

But now two of its last remaining fuel refineries are closing sooner than California expected, tossing a simmering emergency into officials' laps. With a hotly debated forecast that $8-per-gallon gasoline might be on the horizon, there has been a remarkable shift at the state Capitol. Led by Newsom, who just last fall was lambasting oil companies for "screwing" consumers, California may soon let its black gold flow again.

"We are all the beneficiaries of oil and gas. No one's naive about that," Newsom said at a press conference last month. "So it's always been about finding a just transition, a pragmatism in terms of that process."

Newsom and Democratic legislative leaders are now negotiating a plan with the industry to boost stagnating production in California's oil-drilling hub of Kern County and avert a nightmare scenario for a governor with national ambitions and a party that has promised to focus on affordability. Lawmakers could pass a measure before the end of their annual session in mid-September, though the details remain unsettled and environmental groups are raising alarms.

The headspinning realignment potentially heralds a new era in California's transition to a carbon-free future, as high costs, technological impediments and flagging political will force Democrats to recalibrate their ambitious climate goals. President Donald Trump and congressional Republicans are also taking aim at the state's vast powers to regulate its greenhouse gas

emissions and air pollution, including revoking California's mandate to phase out gas-powered vehicles and slashing renewable energy tax credits.

"We all need to kind of evolve. Maybe that's just the lesson on climate. There's not really a purity test on this. It's not like civil rights," said state Sen. Henry Stern, a Calabasas Democrat who five years ago was publicly advocating for keeping more California oil in the ground.

As both a staffer and a legislator, Stern worked on major laws to require buffer zones around oil wells in sensitive areas and restrict the well stimulation technique known as fracking. But he said he does not want California to see the same backlash to climate action as western Europe, where environmentally focused Green parties have recently been crushed electorally by far-right populists.

1. Just the right amount of news

2. Just the right amount of news

1. Get California's most essential headlines without feeling overwhelmed.

2. Get California's most essential headlines without feeling overwhelmed.

"We can perform a muscular version of climate policy that doesn't have to be so all-or-nothing," Stern said.

Oil industry forces Newsom's hand

Refinery closures are accelerating the pressure in Sacramento. Two days after Newsom signed a law increasing state oversight of maintenance, Phillips 66 announced in October that it would shut its Los Angeles facility by the end of 2025 because of concerns over the sustainability of the California market. Then in April, Valero declared it would close its Benicia refinery next year, citing a challenging regulatory environment.

That would leave only six major facilities to refine crude oil into transportation fuels in a state that remains the country's second-largest gasoline consumer after Texas, as well as a major user of jet fuel, according to the U.S. Energy Information Administration. A business professor at the University of Southern California projected the loss of refining capacity, which will be offset with more expensive imports of finished fuel, combined with additional state actions, could send gasoline prices spiraling past $8 per gallon by the end of 2026.

Republicans pounced on that figure to criticize Newsom for fomenting an energy crisis in California, sparking fierce pushback from the governor's office, which has dismissed the report as an "unscientific analysis" by a professor with close ties to the oil industry. Other experts have estimated a smaller effect on prices, which currently average about $4.49 per gallon in California, according to AAA, $1.33 higher than the national average but lower than they've been since January.

The Western States Petroleum Association the powerful Sacramento-based lobby for the oil and gas industry that has donated more than $330,000 to lawmakers in the past decade blames taxes, fees and regulations for California's high prices. Decades of state rules, including

strict emissions targets, a ban on the additive MTBE, and requirements for a special gasoline blend, traditionally make refining more expensive. Drilling in California is also in what the industry calls "terminal decline" as the Newsom administration has largely stopped issuing new permits, forcing a greater reliance on foreign countries such as Brazil, Iraq, Guyana and Ecuador with looser labor and environmental standards.

"At some point, are you going to have enough supply to meet California's demands?" said Catherine Reheis-Boyd, CEO of the petroleum association, who evoked the fuel shortages and long lines at gas stations that followed a 1973 embargo against the United States by other oil-producing nations. "People's lives were completely disrupted."

Industry leaders argue pumping more crude oil in California, particularly in Kern County, could help meet demand at a lower cost. But if the state doesn't act quickly, they warn that production could drop so low it would shut down pipelines between local oil fields and refineries, further exacerbating a crisis of California's own creation.

"For me, I don't care if the motivation is political or policy. I'm very happy that we're having a conversation about something that's really impactful to the consumers of California," Reheis-Boyd said.

Climate commitment meets reality

After years of making the oil industry into a political boogeyman, Newsom has become surprisingly receptive to its message.

Gone is the bombastic governor who declared to a United Nations summit in 2023 that "this climate crisis is a fossil fuel crisis," or strong-armed the Legislature that same year into adopting a law that could penalize oil companies for excessive profits.

In April, after Valero said it would close its Benicia refinery, Newsom directed Siva Gunda, vice chair of the California Energy Commission, to "redouble the state's efforts to work closely with refiners on short- and long-term planning" and ensure a "reliable supply of transportation fuels."

Gunda returned a series of recommendations in June that closely aligned with the industry's wishlist, including stabilizing in-state crude production, rolling back regulations that limit imports and improving investor confidence.

While the commission is exploring delaying implementation of the profit penalty and refinery maintenance oversight laws, Newsom began circulating a draft bill that would provide blanket approval for environmental reviews of Kern County wells to sidestep litigation that has stalled drilling. That proposal is now at the center of negotiations over a legislative package that could simultaneously create new standards for restarting offshore drilling, require the industry to plug more idle wells and end the use of fracking.

"We're in the 'how' business. We move to a low-carbon, green-growth future, change the way we produce and consume energy," Newsom said at the press conference last month. "At the same time, we have enough available fuel supplies, a stable fuel supply and address the anxieties around cost. Both and."

Matt Rodriguez, a longtime Democratic consultant who has worked in California and on several presidential campaigns, said Newsom is caught between a commitment to climate action that is important to the left and a substantive problem that could hurt both the economy and individual voters.

"The reality is that gas prices are higher here than the rest of the nation. That's just undeniable," he said. "If there are storm clouds on the horizon, you can't just sit there and ignore it."

The larger the gap between the price at the pump in California and in other states, Rodriguez said, the greater the liability it poses in a future presidential campaign for Newsom, who will likely also face criticism for how his own policies contributed to the problem. But Rodriguez said there is a potential upside if the governor can negotiate a solution with the oil industry, allowing him to tout himself as a pragmatist rather than an ideologue.

"Any way that he can keep gas prices from ballooning, that's his imperative," Rodriguez said.

'We didn't have a champion'

Environmental groups, meanwhile, are up in arms. More than 120 signed a letter earlier this month opposing Newsom's push, which they characterized as an industry giveaway that would "gravely harm the air we breathe and water we drink around the state, but have no impact on refinery closures or gas prices."

Hollin Kretzmann, an attorney with the Center for Biological Diversity, called the governor's proposal to streamline approval of new Kern County wells a "drill, baby, drill" plan that would "eviscerate" California's bedrock environmental review law for one of its core purposes: reining in a polluting industry.

He noted that courts already struck down earlier versions of the idea when Kern County tried it, because the environmental review was deemed insufficient. Last month, the county passed a third version of the plan, which Newsom's bill would enshrine into state law.

"It's a very misguided and ill-conceived proposal," Kretzmann said.

Martha Dina Argüello, executive director of the Physicians for Social Responsibility Los Angeles, remembers attending a press conference last September, outside the Inglewood Oil Field, where Newsom signed a trio of new laws aimed at cleaning up idle wells and restricting oil and gas operations. She said she was "stunned" by the governor's rapid reversal and warned that it would allow the oil industry to gut public health protections under the guise of affordability, passing the costs on to low-income communities near oil fields and refineries that have higher asthma and cancer risks from exposure to toxic chemicals.

"You don't often get champions who are consistent and it's very sad that we didn't have a champion that was really going to do the difficult thing and tell us the changes that we need to make to actually address climate change and air pollution," she said. "That's what our communities still need."

Landing a deal will be tricky

The governor's office is working to find an approach that can get through the Legislature in a short time frame. Lawmakers return from their summer recess on Monday for the final month of session.

That could necessitate making tradeoffs between priorities for environmentally minded lawmakers on the left, such as protecting the buffer zones around oil wells, and moderates more sympathetic to the industry's arguments. It's possible the proposal will be merged with a separate effort to extend California's cap-and-trade system for greenhouse gas emissions, because oil refiners are seeking a more gradual decline in the credits that allow them to emit carbon pollution without paying.

Stern described the mood among lawmakers as "begrudgingly practical," but also grumpy about having to take on yet another fight over oil, "so nothing feels like a win." Given the political sensitivities, he said it was possible the Legislature would pass only the provision to boost drilling in Kern County and carry over the rest of the discussion into next year.

Nevertheless, the boundaries of the debate around domestic oil production have completely shifted in Sacramento, with affordability taking on a more prominent role.

Learn more about legislators mentioned in this story.

Shannon Grove

Republican, State Senate, District 12 (Bakersfield)

Henry Stern

Democrat, State Senate, District 27 (Calabasas)

Cottie Petrie-Norris

Democrat, State Assembly, District 73 (Irvine)

Assemblymember Cottie Petrie-Norris, an Irvine Democrat who chairs the Assembly's utilities and energy committee, said the Legislature could no longer afford to treat California's energy transition like a future aspiration, as previous generations of officials have. Instead, lawmakers must be pragmatic and retain the support of everyday Californians, she said, because without their buy-in, the state will cease to be a climate leader.

"There are some advocates who continue to think that you can somehow just wave a magic wand and end oil production in California without terrible consequences," she said. "We need California to be an inspiration, and not a cautionary tale."

An agreement to expand drilling would be a hard-fought victory for Sen. Shannon Grove, a Bakersfield Republican who has spent the majority of her 10-year legislative career repeatedly warning that cutting oil production in California would only increase reliance on imports from countries with lower environmental and labor standards.

"Do I wish that companies and businesses would not have left my district and taken their jobs with them and created a vast unemployment rate? Do I wish that the people who lost their jobs still had their jobs? Do I wish it would have happened sooner?" Grove said. "Yes. But I'm grateful that it's happening."

Grove said Kern County, which also is home to some of the state's largest solar and wind projects, has the potential to be the "energy capital of the United States." She argues the county has done its due diligence with environmental reviews to ensure that future drilling projects are more climate conscious than importing oil from other countries.

"If you're going to do it, you have to do it right," she said, "and Kern County does it right."

Load-Date: August 26, 2025

End of Document

What is an Energy Island?

California is an Energy Island

A combination of geographical factors and public policy choices has led to California becoming an energy island — we are disconnected from the other lower-48 states and therefore unable to secure additional domestic crude oil sources to support our energy needs of fueling transportation, powering businesses, growing food and producing everyday products.

Unique challenges exist that create this dynamic including lack of pipeline infrastructure and little public support for oil by rail or truck. Of course, California is not an actual island, and it is blessed with abundant natural resources, but the policies it has adopted are forcing Californians to rely more and more on distant energy sources to meet our needs.

Currently, California imports more than 70% of its crude oil supplies, most of it from foreign sources. If California continues on this trajectory, it would be choosing even greater dependence on foreign oil which threatens reliability, sustainability and affordability for California's diverse communities. Instead, California's leaders can protect working families, consumers and our global environment by promoting in-state production under the world's most stringent safety, labor, and environmental standards.

Why Domestic Supplies Cannot Replace California Production

CALIFORNIA IS EXTREMELY LIMITED IN ITS ABILITY TO IMPORT CRUDE OIL FROM THE REST OF THE NATION: Within the 48 contiguous states, pipeline infrastructure, rail and truck transportation are the constraining factors. With Alaska, other existing commitments limit opportunities to increase supplies.

PIPELINE INFRASTRUCTURE: No crude oil pipelines exist from other states. Regulatory approvals make this an untenable option.

ALASKA: Alaska has been a declining source. While there has been an increase in investment that may counter that trend, it will not be enough to offset California's current production levels in the foreseeable future.

RAIL AND TRUCK TRANSPORTATION: Limited crude oil is transported by rail. Rail transport is extremely expensive, highly controversial, and would require an increase of 243,000 rail cars to meet current demands. Truck transport is unfeasible due to limited capacity.

If we want a domestic supply, we need to produce it here in California

WHAT'S AT RISK FROM CALIFORNIA'S DEPENDENCE ON FOREIGN CRUDE OIL: Reliance on foreign energy imports create risks including reliability of our energy supply, market volatility, international turmoil, global environmental quality, and increased global air emissions.

RELIABILITY AND AFFORDABILITY: Volatile Markets Volatility exists within the global oil market due to geo-political and economic reasons. This includes: unforeseen circumstances, new costly investments, needs of other foreign countries like China, India and Europe, and trade wars

Strait of Hormuz A blockage of the Strait of Hormuz, the only sea passage from the Persian Gulf, is possible due to regional skirmishes. One-third of the world's sea-borne oil passes through it every day.Unstable Foreign Countries Foreign countries may limit or shut off supplies due to embargoes or other means.

WORKER SAFETY AND ENVIRONMENTAL PROTECTIONS: Imported oil is not produced to California's stringent safety, labor, and environmental standards.

CONTROL AND SECURITY: What's our risk level for control? Is California okay handing over control of our energy needs to a remote source and putting our energy security at risk?

OUR COMMITMENT: Our industry is an active partner in helping California set an example to other states and other countries by producing the affordable, reliable energy we need in a way that safeguards public health, safety, and the environment. We share the state's commitment to a vibrant economic, energy and environmental future that strengthens California's working families, local employers, diverse communities and abiding values.

Sources:
"Sources of Crude Oil Imports to California, 2017." California Energy Commission. https://www.energy.ca.gov/almanac/petroleum_data/statistics/2017_foreign_crude_sources.html (https://www.energy.ca.gov/almanac/petroleum_data/statistics/2017_foreign_crude_sources.html)
"Oil Imports by Rail, 2017," California Energy Commission,

https://www.energy.ca.gov/almanac/petroleum_data/statistics/2017_crude_by_rail.html (https://www.energy.ca.gov/almanac/petroleum_data/statistics/2017_crude_by_rail.html)

U.S. Energy Information Administration, October 13, 2015. https://www.eia.gov/todayinenergy/detail.php?id=23312 (https://www.eia.gov/todayinenergy/detail.php?id=23312)



Download File (https://dev-ei-ca.pantheonsite.io/wp-content/uploads/2019/01/California_Energy_Island_Infographic-9-4.pdf)

Join Our Coalition

Over 200,000 Californians standing together to support safe, affordable and reliable local oil and gas production.

*First Name

*Last Name

*Email

*Zip code

Phone

By clicking "Join Us," I consent to receive autodialed calls/texts at the phone number provided about campaign updates. Message and data rates may apply. Reply "STOP" to opt out. Text HELP for help.

JOIN US

FOR

INDEPENDENCE

(https://www.energyindependenceca.com/)

About CEI:

Californians for Energy Independence is a coalition that supports state and local policies that allow for continued domestic energy production and opposes those policies - such as oil taxes and energy bans - that would hinder production and increase reliance on foreign oil.

Visit our other sites:

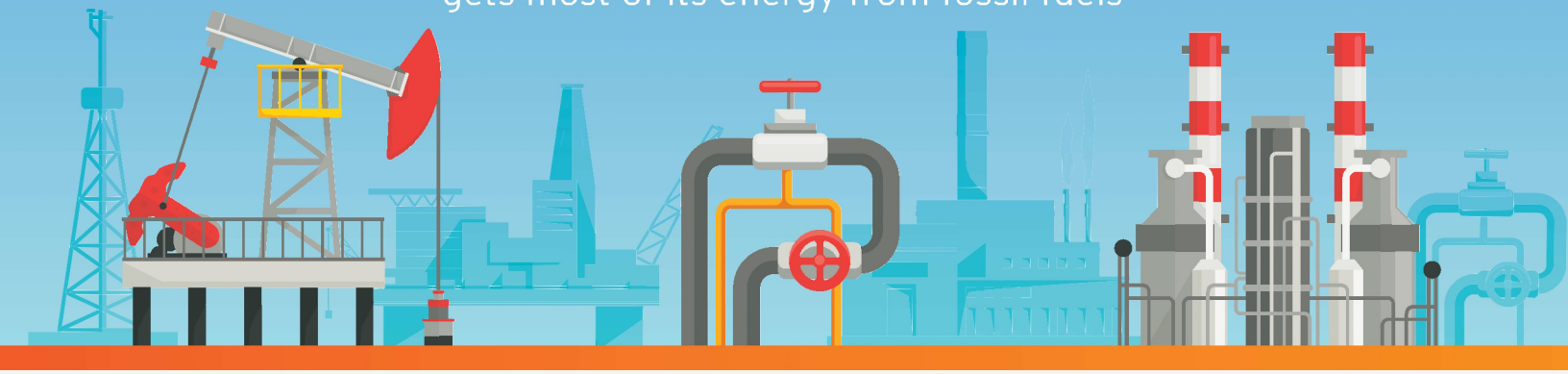
Careers In Energy (https://ceicareersinenergy.com)
California Energy Workers (https://californiaenergyworkers.com)
Extracting Fact (https://www.extractingfact.com)
Californians for Energy Independence (https://www.energyindependenceca.com)

PAID FOR BY CALIFORNIANS FOR ENERGY INDEPENDENCE

©2020 CALIFORNIANS FOR ENERGY INDEPENDENCE | PRIVACY POLICY (/PRIVACY-POLICY/)

WHERE CALIFORNIA GETS ITS ENERGY

California is the world's 5th-largest economy and gets most of its energy from fossil fuels





73% Fossil Fuel

16% Renewables

9% Other

2% Nuclear

U.S. Energy Information Administration



California Oil Production

463,000 BBL/day

California Oil Usage

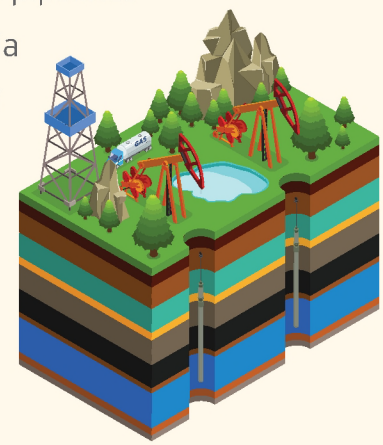
1,800,000 BBL/day

California Energy Commission

California uses almost **4x** more oil than it produces and accounts for 55% of net energy imports for the entire United States

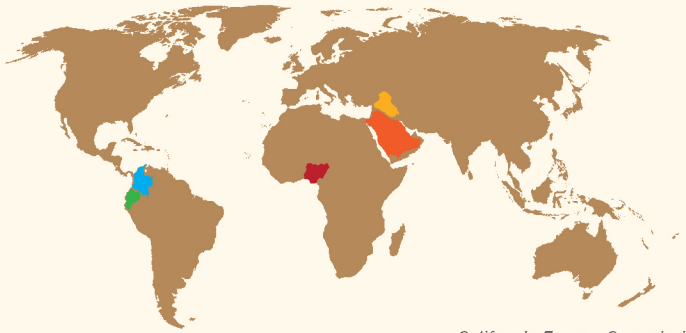
CALIFORNIA, THE "ENERGY ISLAND"

There are currently no pipelines to bring oil to California from any other part of the United States. California must rely on imported oil to make up the difference



CALIFORNIA'S TOP 5 FOREIGN OIL SOURCES (2019)

- *Saudi Arabia* **87,601,000 BBL**
- *Ecuador* **62,370,000 BBL**
- *Iraq* **58,730,000 BBL**
- *Colombia* **32,814,000 BBL**
- *Nigeria* **19,528,000 BBL**



California Energy Commission

WHY IT MATTERS

LESS ACCOUNTABILITY

Oil exporting countries do not adhere to California's safety, labor, human rights, and environmental standards

ENVIRONMENT HEALTH INDEX

U.S.	82.8
COLOMBIA	51.6
ECUADOR	50.2
SAUDI ARABIA	47.5
IRAQ	39.5
NIGERIA	31

Yale University

GLOBAL FREEDOM SCORES

U.S.	85
ECUADOR	67
COLOMBIA	65
NIGERIA	45
IRAQ	29
SAUDI ARABIA	7

Freedom House

HIGHER COSTS

Imported foreign oil costs Californians over **$25 BILLION** a year and is less reliable and less sustainable



Capitol Matrix Consulting

NEGATIVE ENVIRONMENTAL IMPACT

THE LARGEST OIL TANKERS BURN NEARLY **4 TONS** OF FUEL EVERY DAY THEY ARE ANCHORED

International Council on Clean Transportation

EACH SHIP EMITS **11+ TONS** OF CARBON DIOXIDE PER DAY

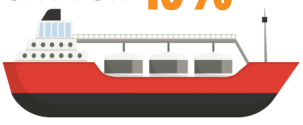


International Council on Clean Transportation

A FOREIGN OIL TANKER TRAVELS AN ESTIMATED **8,865 MILES** AND AVERAGES **0.004 MILES PER GALLON** TO CALIFORNIA'S PORTS

Energy & Infrastructure of PTS Advance

OIL TANKERS ACCOUNT FOR **13%** OF WORLD MARINE CO2 EMISSIONS



International Council on Clean Transportation



KERN EDC
ECONOMIC DEVELOPMENT CORPORATION

OFFICE OF THE GOVERNOR

October 25, 2024

Liane Randolph
Chair, California Air Resources Board
1001 I Street
Sacramento, CA 95814

Dear Chair Randolph,

Thank you for your leadership and dedication to addressing California's climate crisis, our persistent air quality challenges, and our affordability concerns. California is on the frontlines of the climate crisis – and too many Californians continue to breathe dirty air. Together we have taken bold steps to advance clean transportation options, including a world-leading clean fuels and zero-emission vehicle agenda, on our path to achieve economy-wide carbon neutrality by 2045 and to meet federal air quality mandates.

At the same time, California families have also experienced significant gasoline price spikes – particularly during Fall 2022 and Fall 2023 – costing Californians upwards of $2.2 billion. As we continue to shift away from fossil fuels, it's imperative that the state maintain a reliable and affordable supply of transportation fuels.

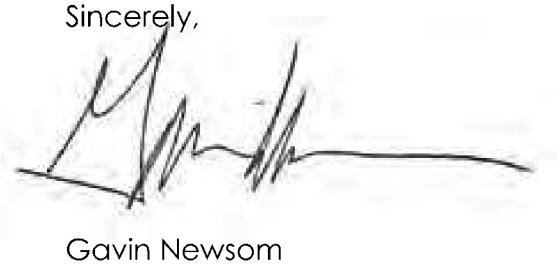
In furtherance of our work to address gasoline price spikes, the Energy Commission partnered with California regulatory agencies, including California Air Resources Board (CARB), and stakeholders to publish the Transportation Fuels Assessment. One production enhancement strategy that the Energy Commission considered is to "allow increased blending of ethanol with CARBOB from 10 percent (E10) to 15 percent (E15), effectively augmenting the existing CARBOB supply." According to a University of California, Berkeley and United States Naval Academy study, allowing E15 fuel could result in a $0.20 per gallon price decrease, saving Californians up to $2.7 billion per year. Additionally, an initial analysis commissioned by the state suggests that allowing this fuel blend would result in no additional environmental harm.

Under Senate Bill 529 (Bowen, 1999), any regulatory change to change California's gasoline blend requires a Multimedia Evaluation and approval by the Environmental Policy Council – an intensive process unique to California, which the federal government and the many other states that have already allowed use of E15 fuel have not been required to undertake.

Given the potential for allowing E15 gasoline to increase fuel supply and reduce gasoline prices, with little to no environmental harm, it is prudent for CARB to prioritize resources that would allow for the expeditious completion of this process. Therefore, I am directing CARB to accelerate its action on this critical issue. Further, I welcome partnership with the Legislature next year to consider necessary statutory changes and funding that would further expedite CARB's consideration of authorizing E15.

I look forward to working with you and the Legislature to continue to tackle these challenges in the years to come.

Sincerely,



Gavin Newsom
Governor of California

U.S. Energy Information Administration

California State Energy Profile

California Quick Facts

- In 2024, California was the fourth-largest total electricity producer in the nation. It is also the nation’s third-largest electricity consumer and imports the second-largest amount of electricity of any state.
- In 2024, California was the eighth-largest producer of crude oil among the 50 states, and the state ranked third in crude oil refining capacity.
- California is the largest consumer of jet fuel in the nation and second-largest consumer of motor gasoline after Texas.
- California is the second-largest total energy consumer among the states, after Texas, but its per capita energy consumption is the third-lowest in the nation.
- In 2024, renewable resources, including hydroelectric power and small-scale solar power, supplied 57% of California's in-state electricity generation. Natural gas fueled another 35% and nuclear power provided almost all the rest.

Last Updated: June 20, 2025

- Consumption by Source
- Consumption by Sector
- Production
- Electricity
- Prices

Data

Last Update: August 21, 2025 | **Next Update:** September 18, 2025

Energy Indicators

Demography	California	Share of U.S.	Period
Population	39.4 million	11.6%	2024
Civilian Labor Force	19.8 million	11.5%	Jun-25
Economy	**California**	**U.S. Rank**	**Period**
Gross Domestic Product	$ 4,103.1 billion	1	2024
Gross Domestic Product for the Manufacturing Sector	$ 405,643 million	1	2024
Per Capita Personal Income	$ 85,518	6	2024
Vehicle Miles Traveled	316,612 million miles	1	2023
Land in Farms	23.7 million acres	16	2024
Climate	**California**	**U.S. Rank**	**Period**
Average Temperature	60.5 degrees Fahrenheit	14	2024
Precipitation	26.1 inches	39	2024

Prices

Petroleum	California	U.S. Average	Period	find more
Domestic Crude Oil First Purchase	$ 62.41 /barrel	$ 59.94 /barrel	May-25	
Natural Gas	**California**	**U.S. Average**	**Period**	find more
City Gate	$ 2.92 /thousand cu ft	$ 4.63 /thousand cu ft	May-25	find more
Residential	$ 21.02 /thousand cu ft	$ 19.18 /thousand cu ft	May-25	find more
Coal	**California**	**U.S. Average**	**Period**	find more
Average Sales Price	--	$ 54.04 /short ton	2023	
Delivered to Electric Power Sector	--	$ 2.49 /million Btu	May-25	
Electricity	**California**	**U.S. Average**	**Period**	find more
Residential	35.03 cents/kWh	17.47 cents/kWh	May-25	find more
Commercial	22.91 cents/kWh	12.96 cents/kWh	May-25	find more
Industrial	20.17 cents/kWh	8.30 cents/kWh	May-25	find more

Reserves

Reserves	California	Share of U.S.	Period	find more
Crude Oil (as of Dec. 31)	1,492 million barrels	3.1%	2022	find more
Expected Future Production of Dry Natural Gas (as of Dec. 31)	1,070 billion cu ft	0.2%	2022	find more
Expected Future Production of Natural Gas Plant Liquids	54 million barrels	0.2%	2022	find more
Recoverable Coal at Producing Mines	--	--	2023	find more
Rotary Rigs & Wells	**California**	**Share of U.S.**	**Period**	find more
Natural Gas Producing Wells	3,583 wells	0.7%	2020	find more
Capacity	**California**	**Share of U.S.**	**Period**	
Crude Oil Refinery Capacity (as of Jan. 1)	1,680,371 barrels/calendar day	9.1%	2024	
Electric Power Industry Net Summer Capacity	98,420 MW	7.9%	May-25	

Supply & Distribution

Production	California	Share of U.S.	Period	find more
Total Energy	1,642 trillion Btu	1.6%	2023	find more
Crude Oil	262 thousand barrels per day	1.9%	May-25	find more
Natural Gas - Marketed	130,703 million cu ft	0.3%	2023	find more
Coal	--	--	2023	find more
Total Utility-Scale Net Electricity Generation	**California**	**Share of U.S.**	**Period**	find more
Total Net Electricity Generation	17,301 thousand MWh	5.0%	May-25	
Utility-Scale Net Electricity Generation (share of total)	**California**	**U.S. Average**	**Period**	
Petroleum-Fired	*	0.3 %	May-25	find more
Natural Gas-Fired	25.0 %	39.3 %	May-25	find more
Coal-Fired	0.1 %	14.2 %	May-25	find more
Nuclear	6.7 %	18.1 %	May-25	find more
Renewables	68.1 %	27.8 %	May-25	

Supply & Distribution

Stocks	California	Share of U.S.	Period	find more
Motor Gasoline (Excludes Pipelines)	176 thousand barrels	1.8%	May-25	
Distillate Fuel Oil (Excludes Pipelines)	4,097 thousand barrels	4.7%	May-25	find more
Natural Gas in Underground Storage	511,812 million cu ft	7.2%	May-25	find more
Petroleum Stocks at Electric Power Producers	159 thousand barrels	0.7%	May-25	find more
Coal Stocks at Electric Power Producers	0 thousand tons	0.0%	May-25	find more
Fueling Stations	**California**	**Share of U.S.**	**Period**	
Motor Gasoline	8,116 stations	7.4%	2023	
Propane	208 stations	7.9%	Jul-25	
Electric Vehicle Charging Locations	17,538 stations	23.9%	Jul-25	
E85	564 stations	11.9%	Jul-25	
Biodiesel, Compressed Natural Gas, and Other Alternative Fuels	1,674 stations	45.6%	Jul-25	

Consumption & Expenditures

Summary	California	U.S. Rank	Period	
Total Consumption	6,817 trillion Btu	2	2023	find more
Total Consumption per Capita	174 million Btu	50	2023	find more
Total Expenditures	$ 195,100 million	1	2023	find more
Total Expenditures per Capita	$ 4,977	21	2023	find more
by End-Use Sector	**California**	**Share of U.S.**	**Period**	
Consumption				
» Residential	1,167 trillion Btu	6.4%	2023	find more
» Commercial	1,158 trillion Btu	7.1%	2023	find more
» Industrial	1,457 trillion Btu	4.7%	2023	find more
» Transportation	3,036 trillion Btu	10.8%	2023	find more
Expenditures				
» Residential	$ 35,489 million	10.8%	2023	find more

Consumption & Expenditures

» Commercial	$ 34,515 million	14.5%	2023	find more
» Industrial	$ 20,446 million	8.6%	2023	find more
» Transportation	$ 104,649 million	13.7%	2023	find more
by Source	**California**	**Share of U.S.**	**Period**	
Consumption				
» Petroleum	648 million barrels	8.8%	2023	find more
» Natural Gas	2,085 billion cu ft	6.4%	2023	find more
» Coal	1,277 thousand short tons	0.3%	2023	find more
Expenditures				
» Petroleum	$ 113,651 million	12.4%	2023	find more
» Natural Gas	$ 27,338 million	13.5%	2023	find more
» Coal	$ 147 million	0.6%	2023	find more
Consumption for Electricity Generation	**California**	**Share of U.S.**	**Period**	find more
Petroleum	7 thousand barrels	0.5%	May-25	find more
Natural Gas	31,058 million cu ft	3.1%	May-25	find more
Coal	4 thousand tons	*	May-25	find more
Energy Source Used for Home Heating (share of households)	**California**	**U.S. Average**	**Period**	
Natural Gas	60.7 %	46.0 %	2023	
Fuel Oil	0.2 %	3.7 %	2023	
Electricity	29.6 %	41.7 %	2023	
Propane	3.6 %	5.0 %	2023	
Other/None	5.9 %	3.5 %	2023	

Environment

Renewable Energy Capacity	**California**	**Share of U.S.**	**Period**	find more
Total Renewable Energy Electricity Net Summer Capacity	42,432 MW	11.1%	May-25	
Ethanol Plant Nameplate Capacity	128 million gal/year	0.7%	2024	
Renewable Energy Production	**California**	**Share of U.S.**	**Period**	find more

Environment

Utility-Scale Hydroelectric Net Electricity Generation	3,100 thousand MWh	12.9%	May-25	
Utility-Scale Solar, Wind, and Geothermal Net Electricity Generation	8,091 thousand MWh	12.0%	May-25	
Utility-Scale Biomass Net Electricity Generation	370 thousand MWh	9.9%	May-25	
Small-Scale Solar Photovoltaic Generation	3,439 thousand MWh	36.7%	May-25	
Fuel Ethanol Production	1,506 thousand barrels	0.4%	2023	
Renewable Energy Consumption	**California**	**U.S. Rank**	**Period**	find more
Renewable Energy Consumption as a Share of State Total	15.6 %	8	2023	
Fuel Ethanol Consumption	33,628 thousand barrels	2	2023	
Total Emissions	**California**	**Share of U.S.**	**Period**	find more
Carbon Dioxide	324.3 million metric tons	6.8%	2023	
Electric Power Industry Emissions	**California**	**Share of U.S.**	**Period**	find more
Carbon Dioxide	43,360 thousand metric tons	2.8%	2023	
Sulfur Dioxide	1 thousand metric tons	0.1%	2023	
Nitrogen Oxide	59 thousand metric tons	5.3%	2023	

Analysis

Last Updated: June 20, 2025

Overview

California has the largest economy in the nation, with a $4.2 trillion GDP in 2024, overtaking Japan to become the fourth-largest economy in the world.[1,2] About one in nine U.S. residents live in California, and it is the most populous state in the nation.[3] California also uses more energy than any other state except Texas.[4] However, energy efficiency efforts have helped make California's per capita energy use the third lowest in the nation.[5,6] California has abundant renewable energy resources, including solar energy, hydroelectric power, geothermal energy, and biomass, and the state produces more electricity from renewable energy than every other state but Texas.[7] California is also rich in mineral resources. Long known for gold and other precious minerals, the state has the nation's largest rare earths mine.[8] Additionally, California has significant crude oil reserves, and the state's petroleum refineries have nearly one-tenth of the nation's total crude oil refining capacity.[9,10]

California stretches two-thirds of the way up the U.S. West Coast. At its greatest distances, it is more than 1,040 miles long and 560 miles wide.[11] With such great distances to travel, transportation accounts for the largest share of the

state's energy consumption.[12] Californians have more registered motor vehicles and travel more vehicle miles than residents in any other state.[13] California accounts for one-tenth of U.S. motor gasoline consumption and about one-seventh of the nation's jet fuel consumption.[14,15] Overall, the state's transportation sector accounts for 42% of California's total energy consumption. The industrial sector uses 22% of the state's total energy and the residential and commercial sectors each account for 17%.[16] However, per capita energy consumption in both the residential and commercial sectors is lower than in all other states except Hawaii.[17] Although California has a varied climate, most of the state's more densely populated areas are relatively mild for much of the year.[18,19] Changes in weather patterns and climate have resulted in an increased use of cooling and almost three-fourths of California households have air conditioning.[20,21]

Per capita residential and commercial sector energy use in California is lower than in all other states except Hawaii.

Electricity

In 2024, California was the nation's fourth-largest total electricity producer and accounted for about 5% of all U.S. utility-scale (1-megawatt and larger) power generation.[22] Renewable resources, including hydropower and small-scale (less than 1-megawatt) customer-sited solar photovoltaic (PV) systems, supplied 57% of California's total in-state electricity generation in 2024. Natural gas-fired power plants provided 35% of the state's total net generation. Nuclear power's share of California's total electricity generation was about 7%. The state has one operating commercial nuclear power plant—the two-reactor Diablo Canyon facility.[23,24] Coal fuels only a small amount of California's in-state net generation, all of it from one 57-megawatt industrial cogeneration plant.[25,26]

California is the nation's fourth-largest electricity producer.

In 2024, California was the nation's second-largest conventional hydroelectric power producer after Washington, and it is consistently among the nation's top four hydropower producers.[27,28] Hydropower's contribution is highly variable and is dependent on rain and snowfall.[29,30] Nonhydroelectric renewable resources, mainly solar and wind energy, provided 45% of California's total in-state electricity generation in 2024.[31]

California imports the second-largest amount of electricity, after Virginia, and typically receives between one-fifth and one-third of its electricity supply annually from outside of the state.[32,33] Wildfires in California and surrounding states threaten both imports of electricity and transmission within the state.[34,35] Although California consumes more electricity than all other states except Texas and Florida, it uses less electricity per capita than any other state except Hawaii.[36,37] In 2024, California had the nation's second-highest average price of electricity, after Hawaii.[38] The commercial sector accounted for 47% of California's electricity sales in 2024. The residential sector, where three in ten California households use electricity for home heating, accounted for 35% of sales.[39,40] About 17% of the state's electricity sales went to the industrial sector. Light rail, subways, and the iconic cable cars in California's transportation sector accounted for 0.3% of the state's electricity use.[41]

California has led the states in the most electric vehicles (EVs) and EV charging locations every year since 2016.[42] California is part of the West Coast Green Highway, an extensive network of electric vehicle DC fast charging locations located along Interstate 5. The state has about 16,800 public charging locations.[43,44] In 2023, California had about 1.2 million registered battery electric vehicles, the most of any state and more than one-third of the U.S. total.[45]

Renewable energy

California is second in the nation, after Texas, in total electricity generation from renewable resources. The state is the nation's top producer of electricity from solar energy and geothermal resources. In 2024, California was the nation's

second-largest producer of electricity from biomass, after Georgia, and also the second-largest producer of conventional hydroelectric power, after Washington.[46]

California is the nation's top producer of electricity from solar and geothermal energy.

Solar energy is the largest source of California's renewable electricity generation.[47] The state's greatest solar resources are in California's southeastern deserts, where all of its solar thermal facilities and several of its largest solar PV plants are located. However, solar PV facilities are located throughout the state.[48,49] In 2024, utility-scale solar energy supplied about 19% of the state's total electricity net generation. When small-scale solar generation is included, solar energy provided 32% of the state's total electricity generation.[50] At the beginning of 2025, California had about 22,200 megawatts of utility-scale solar power generating capacity, more than any other state. When small-scale solar panel generating systems are included, the state had about 40,000 megawatts of total solar capacity.[51]

In 2024, wind accounted for 6% of California's total in-state electricity generation, and the state ranked tenth in the nation in wind-powered generation.[52,53] California wind power potential exists at several areas around the state, both onshore and offshore.[54] The majority of the state's wind turbines are in six major wind resource areas: Altamont, East San Diego County, Pacheco, Solano, San Gorgonio, and Tehachapi.[55] At the beginning of 2025, California had 6,400 megawatts of wind capacity.[56] The first wind power farm on California's coast, with 27 turbines and 95 megawatts of capacity, came online in Santa Barbara County at the end of 2023.[57]

California is the nation's top producer of electricity from geothermal resources. In 2024, the state produced 70% of the nation's utility-scale geothermal-sourced electricity, and geothermal power accounted for about 4% of the state's total in-state generation.[58,59] The state's operating geothermal power plants have a combined total capacity of nearly 1,900 megawatts.[60] Four areas in California have substantial geothermal resources—the coastal mountain ranges north of San Francisco, volcanic areas of north-central California, areas near the Salton Sea in southern California, and areas along the state's eastern border with Nevada. The Geysers, located in the Mayacamas Mountains north of San Francisco, is the largest complex of geothermal power plants in the world and has about 725 megawatts of installed generating capacity.[61,62]

Superheated geothermal brines in the Salton Sea geothermal resource area in Southern California contain lithium, a critical mineral used to manufacture rechargeable batteries.[63,64] The state has the largest rare earth mine in the United States. The Mountain Pass mine in Southern California's Mojave Desert is the largest deposit of rare earth elements in the nation. Rare earths are used in the manufacture of electric vehicles, wind turbines, and batteries, among other applications.[65,66] In 2024, the Mountain Pass mine produced almost 45,500 metric tons of rare earth concentrate, accounting for about 12% of global rare earth production.[67,68]

California ranks second in the nation, after Georgia, in the most utility-scale electricity generation from biomass.[69] In 2024, biomass fueled 2% of the state's total net generation, and more than half of that was from wood and wood-derived fuels.[70] In early 2025, California had roughly 1,000 megawatts of utility-scale biomass generating capacity and nearly three-fifths was fueled by wood and wood waste. Landfill gas, municipal solid waste, and other biomass sources fuel the remaining biomass capacity.[71] California's biomass resources also provide feedstock to the two wood pellet manufacturing facilities in the state. Those plants can produce about 168,000 tons of pellets per year. Wood pellets are used for heating but can also be used for electricity generation.[72] About 1% of California households use wood as their primary fuel for space heating.[73]

California consumes 1.4 billion gallons of fuel ethanol annually, which is one-tenth of the nation's fuel ethanol supply and 11 times more than the 128 million gallons that the state's three fuel ethanol plants can produce annually.[74,75] Midwestern states provide most of the additional fuel ethanol California uses.[76] California can produce a combined 80 million gallons of biodiesel annually from four production plants, which is almost one-third of the nearly 269 million

gallons of biodiesel consumed in the state.[77,78] Several California petroleum refineries have added manufacturing capacity for renewable diesel production derived from biomass.[79,80,81] California accounts for 10% of U.S. renewable diesel production and 91% of the nation's renewable diesel consumption.[82,83]

California's renewable portfolio standard (RPS), enacted in 2002 and revised several times since then, required that 33% of electricity retail sales in California come from eligible renewable resources by 2020. The state met that goal three years before the target date.[84] The RPS also requires that 60% of electricity sales come from renewables by 2030 and 100% by 2045.[85] In 2022, the state legislature set intermediate targets of 90% renewable energy and zero-carbon electricity by the end of 2035 and 95% by the end of 2040 on the way to the eventual target of 100% by 2045.[86]

Petroleum

California was the eighth-largest crude oil producer among the states in 2024 and accounted for about 2% of the nation's total onshore and offshore oil production.[87] Although California's annual crude oil production has steadily declined from its peak of 394 million barrels in 1985, the state produced 104 million barrels of crude oil in 2024.[88] Reservoirs along California's Pacific Coast, including in the Los Angeles basin, and those in the state's Central Valley contain major crude oil reserves, and the state holds about 3% of the nation's total proved crude oil reserves.[89,90]

Assessments of California's offshore areas indicate the potential for large, undiscovered recoverable crude oil resources in the federally administered Outer Continental Shelf.[91] However, in 1994, concerns about the risks of offshore crude oil and natural gas development resulted in a permanent moratorium on new offshore oil and natural gas leasing in state waters.[92] Congress imposed a federal moratorium on oil and natural gas leasing in California federal waters in 1982, but it expired in 2008.[93] No new California offshore federal lease sales have occurred since then, although about two dozen older crude oil and natural gas production platforms remain active in federal waters that start three miles from the California coastline and about a dozen platforms are in state waters off the coast of California.[94,95,96] In April 2025, the Department of the Interior sought public comment on creating a new five-year offshore drilling plan for oil and natural gas in federal waters, including off California.[97,98]

Foreign suppliers provide almost two-thirds of the crude oil refined in California.

California has 9% of the nation's total crude oil refining capacity and ranks third among the states, after Texas and Louisiana, with the most refining capacity.[99] A network of pipelines connects California crude oil production to the state's 14 operating petroleum refineries, which are located primarily in the Los Angeles area, the San Francisco Bay area, and the San Joaquin Valley.[100,101,102] As crude oil production in California and Alaska declined, the state's refineries increased their supply from foreign oil imports.[103,104] Led by Iraq, Brazil, Guyana, and Ecuador, foreign suppliers provided almost two-thirds of the crude oil refined in California in 2024.[105,106] In October 2024, a new California law allowed state regulators to set minimum petroleum product inventory levels for refineries in the state to help curb gasoline and diesel fuel price volatility.[107] Shortly after the law's enactment, an oil company operating a 139,000-barrel-per-day refinery in the Los Angeles area announced it would shut down the facility by the end of 2025.[108] A separate oil company told state regulators in April 2025 that it would close its 170,000-barrel-per-day refinery in the San Francisco area by the end of April 2026.[109,110]

California requires that motorists use, at a minimum, a specific blend of motor gasoline called CaRFG (California Reformulated Gasoline) to reduce pollution from motor vehicles and improve air quality. California refineries produce cleaner fuels in order to meet state environmental regulations. Refineries in the state often operate at or near maximum capacity because of the high demand for those petroleum products and the lack of interstate pipelines that can deliver those cleaner fuels into the state. When unplanned refinery outages occur, the lack of CaRFG deliveries available from interstate pipelines means replacement supplies of CaRFG come in by marine tanker from out-of-state U.S. refineries or from other countries, such as India and South Korea. It can take several weeks to find and bring replacement motor gasoline from overseas that meets California's unique specifications.[111,112,113]

California is the nation's second-largest consumer of refined petroleum products, after Texas, and accounts for about 9% of U.S. total consumption.[114] California is the nation's largest consumer of jet fuel and the second-largest consumer of motor gasoline, after Texas.[115,116] The transportation sector uses about 86% of the petroleum consumed in the state. The industrial sector accounts for about 10% of state petroleum use, and the commercial sector consumes about 3%. The residential sector, where about 4 out of 100 California households heat with petroleum products, mostly propane, uses about 1%. A small amount of petroleum is used for electricity generation.[117,118]

Natural gas

California's natural gas output has declined steadily since 2000, and the state now accounts for less than 1% of the nation's total natural gas reserves and production.[119,120] California's natural gas production is less than one-tenth of the state's total natural gas consumption.[121,122] Several interstate natural gas pipelines enter California from Arizona, Nevada, and Oregon bringing natural gas into California from the Southwest, the Rocky Mountain region, and western Canada.[123] California consumes nearly 90% of the natural gas delivered to the state.[124] A small amount is exported to Mexico. The remaining natural gas that enters the state is placed in California's 14 underground natural gas storage fields that together can hold about 604 billion cubic feet of natural gas, about 7% of the nation's storage capacity.[125]

California is the nation's second-largest natural gas consumer. Only Texas uses more.[126] In 2024, about 31% of the natural gas delivered to California consumers went to the state's industrial sector. The electric power sector closely followed at 30%, as natural gas fueled about one-third of the state's total electricity generation.[127,128] The residential sector, where 6 in 10 California households use natural gas for home heating, accounted for 22% of natural gas use. The commercial sector consumed about 15%, and the transportation sector used about 1% as compressed natural gas vehicle fuel.[129,130]

California is the nation's second-largest natural gas consumer, after Texas.

Coal

California does not have any coal reserves or production and has very little coal-fired electricity generation. All the generation is from one industrial facility in Trona.[131,132,133] Almost all the coal consumed in California arrives by rail from mines in Colorado and Utah.[134] In 2024, some coal produced in other states was exported to other countries from California ports.[135]

Energy on tribal lands

California has the largest Native American population in the nation at about 535,000, and the state is home to nearly 100 federally recognized tribal groups.[136,137] Although tribal areas exist throughout California, they account for less than 1% of the state's land area.[138,139] Many of the state's tribal lands are small, including the nation's smallest reservation, the 1.32-acre parcel that contains the Pit River Tribe cemetery.[140] The state's largest is the forested Hoopa Valley Reservation, home of the Hupa people, in northern California's Humboldt County, with 102,000 acres.[141,142]

California's diverse climate and geography give tribes access to a variety of renewable energy resources. One of the first utility-scale wind projects on tribal land in the nation is in southern California. In 2005, the Campo Kumeyaay Nation in southern California leased some of its land in San Diego County for the development of a 50-megawatt wind project.[143,144] The Ramona Band of Cahuilla became one of the first tribes to make its reservation independent of the regional electric grid in 2009.[145] In 2015, the Bear River Band of the Rohnerville Rancheria in Northern California became the first California tribe to install a hybrid solar, wind, and advanced energy storage microgrid for power generation.[146]

Some reservations in California have abundant biomass potential. The Blue Lake Rancheria Tribe in Humboldt County has a 175-kilowatt biogas fuel cell system powered by gasified wood waste from the forestry industry.[147,148] In 2019, the Rancheria extended use of its microgrid to the broader community, about 10% of the county's population, during a

widespread wildfire-related utility power shutoff in northwest Humboldt County.[149] In 2022, the U.S. Department of Energy (DOE) awarded the Karuk Tribe almost $2 million to build a nearly 1 megawatt ground-mounted solar panel system and battery energy storage in northern California.[150] In addition to the tribes that have abundant solar, wind, and biomass resources, some California tribal lands have geothermal electricity generation potential, particularly in the Imperial Valley in southern California, the Geysers area in northern California, and along the state's eastern border.[151]

The California Energy Commission (CEC) awarded one of its largest grants, $31 million, in 2022 to the Viejas Tribe of Kumeyaay Indians for a long-duration energy storage system in San Diego County to provide renewable backup power for the tribe. The energy storage system supports statewide grid reliability in the event of an emergency.[152] The CEC awarded in 2024 a $32 million grant to the Paskenta Band of Nomlaki Indians to build a large-scale 5-megawatt solar and long-duration 15-megawatthour microgrid in northern California.[153] Since 2010, DOE has invested more than $21 million in about 40 California tribal renewable energy and energy efficiency projects.[154]

Endnotes

[1] U.S. Bureau of Economic Analysis, Regional Data, GDP and Personal Income, Annual Gross Domestic Product (GDP) by State, SAGDP2 GDP by industry in current dollars, All Areas, All industry total, 2024.

[2] Office of Governor Gavin Newsom, "California is Now the 4th Largest Economy in the World," Press Release (April 23, 2025).

[3] U.S. Census Bureau, U.S. and World Population Clock, Most Populous States, accessed May 19, 2025.

[4] U.S. Energy Information Administration (EIA), State Energy Data System, Table C11, Total Energy Consumption Estimates by End-Use Sector, Ranked by State, 2022.

[5] McCann, Adam, "Most & Least Energy-Efficient States (2025)," WalletHub (October 15, 2024).

[6] U.S. EIA, Rankings: Total Energy Consumed per Capita, 2022.

[7] U.S. EIA, Electric Power Monthly (February 2025), Tables 1.10.B, 1.11.B, 1.15.B, 1.16.B, 1.17.B, 1.18.B.

[8] MP Materials Corp., About, accessed May 19, 2025.

[9] U.S. EIA, U.S. Crude Oil and Natural Gas Proved Reserves, Year-end 2022, Table 6.

[10] U.S. EIA, Number and Capacity of Petroleum Refineries, Atmospheric Crude Oil Distillation Operable Capacity (B/CD), as of January 1, 2024.

[11] NETSTATE, California, The Geography of California, accessed May 19, 2025.

[12] U.S. EIA, State Energy Data System, Table C1, Energy Consumption Overview: Estimates by Energy Source and End-Use Sector, 2022.

[13] U.S. Department of Transportation, Federal Highway Administration, Highway Statistic Series: State Statistical Abstracts, California, 2023.

[14] U.S. EIA, State Energy Data System, Table F10, Motor Gasoline Consumption, Price, and Expenditure Estimates, 2023.

[15] U.S. EIA, State Energy Data System, Table F2, Jet Fuel Consumption, Price, and Expenditure Estimates, 2023.

[16] U.S. EIA, State Energy Data System, Table C1, Energy Consumption Overview: Estimates by Energy Source and End-Use Sector, 2022.

[17] U.S. EIA, State Energy Data System, Table C14, Total Energy Consumption Estimates per Capita by End-Use Sector, Ranked by State, 2022.

[18] U.S. Census Bureau, 2020 Census: California Profile, Population Density by Census Tract, accessed May 19, 2025.

[19] NETSTATE, Geography of California, Climate, accessed May 19, 2025.

[20] U.S. EIA, Residential Energy Consumption Survey (RECS), 2009 RECS Survey Data, Air Conditioning, in West Region, divisions, and states (HC7.11) and 2020 RECS Survey Data, State Data, Housing characteristics, Highlights for air conditioning in U.S. homes by state, 2020.

[21] Bump, Phillip, "Californians may no longer be able to avoid air conditioning," The Washington Post (September 7, 2022).

[22] U.S. EIA, Electric Power Monthly (February 2025), Table 1.3.B.

[23] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2001-24.

[24] U.S. Nuclear Regulatory Commission, California, updated February 21, 2025.

[25] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2001-24.

[26] U.S. EIA, Preliminary Monthly Electric Generator Inventory (based on Form EIA-860M as a supplement to Form EIA-860), Inventory of Operating Generators as of April 2025, Plant State: California, Technology: Conventional Steam Coal.

[27] U.S. EIA, Electric Power Monthly, (February 2025), Table 1.10.B.

[28] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, New York, Oregon, Washington, Conventional hydroelectric, Annual, 2001-24.

[29] U.S. EIA, "California's hydroelectric generation affected by historic drought," Today in Energy (July 7, 2021).

[30] U.S. EIA, "U.S. hydropower generation expected to rise in 2025 following last year's relative low," Today in Energy (May 19, 2025).

[31] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2001-24.

[32] U.S. EIA, "Virginia was the top net electricity recipient of any state in 2023," Today in Energy (December 20, 2024).

[33] U.S. EIA, California Electricity Profile 2023, Table 10, available in XLSX format.

[34] Mulkern, Anne C., "Soaring Temperatures and Wildfire Threaten California's Power Grid," Scientific American (July 12, 2021).

[35] Arbaje, Paul, "Wildfires and Power Grid Failures Continue to Fuel Each Other," Union of Concerned Scientists (May 23, 2024).

[36] U.S. EIA, Electric Power Monthly (February 2025), Table 5.4.B.

[37] U.S. EIA, State Energy Data System, Table C17, Electricity Retail Sales to Ultimate Customers, Total and Residential, Total and per Capita, Ranked by State, 2022.

[38] U.S. EIA, Electric Power Monthly (February 2025), Table 5.6.B.

[39] U.S. EIA, Electricity Data Browser, Retail sales of electricity, California, 2001-24.

[40] U.S. Census Bureau, Tables, Table B25040, House Heating Fuel, California, 2023 American Community Survey 1-Year Estimates.

[41] U.S. EIA, Electricity Data Browser, Retail sales of electricity, California, 2001-24.

[42] U.S. EIA, "California leads the United States in electric vehicles and charging locations," Today in Energy (December 14, 2023).

[43] U.S. EIA, Monthly Energy Review (May 2025), Appendix F monthly state file, XLS, Public Ports only and Public & Private Ports combined.

[44] West Coast Electric Highway, accessed May 20, 2025.

[45] U.S. EIA, State Energy Data System, Table F39, Electric Light-Duty Vehicles Overview, 2023.

[46] U.S. EIA, Electric Power Monthly, (February 2025), Tables 1.10.B, 1.11.B, 1.14.B, 1.15.B, 1.16.B, 1.17.B, 1.18.B.

[47] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2001-24.

[48] U.S. EIA, Preliminary Monthly Electric Generator Inventory (based on Form EIA-860M as a supplement to Form EIA-860), Inventory of Operating Generators as of April 2025, Plant State: California, Technology: Solar Photovoltaic, Solar Thermal without Energy Storage.

[49] National Renewable Energy Laboratory, Global Horizontal Solar Irradiance Map, February 22, 2018.

[50] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2001-24.

[51] U.S. EIA, Electric Power Monthly (February 2025), Table 6.2.B.

[52] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2001-24.

[53] U.S. EIA, Electric Power Monthly (February 2025), Table 1.14.B.

[54] U.S. Department of Energy, Energy Efficiency and Renewable Energy, WINDExchange, Wind Energy in California, Maps & Data, accessed May 21, 2025.

[55] California Energy Commission, Wind Energy in California, accessed May 21, 2025.

[56] U.S. EIA, Electric Power Monthly (February 2025), Table 6.2.B.

[57] Andre, Lisa, "Local leaders celebrate 'significance' of Strauss wind project in Lompoc with ribbon cutting," Lompoc Record (updated April 10, 2025).

[58] U.S. EIA, Electric Power Monthly (February 2025), Table 1.16.B.

[59] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2001-24.

[60] U.S. EIA, Electric Power Monthly (February 2025), Table 6.2.B.

[61] Calpine, The Geysers, About Geothermal Energy, Welcome to the Geysers, accessed May 21, 2025.

[62] California Energy Commission, Geothermal Energy, accessed May 21, 2025.

[63] California Energy Commission, Lithium Valley Commission, accessed May 21, 2025.

[64] Burton, Jason, "U.S. Geological Survey releases 2022 list of critical minerals," U.S. Geological Survey, Press Release (February 22, 2022).

[65] MP Materials Corp., About, accessed May 21, 2025.

[66] Xie, John, "California Mine Becomes Key Part of Push to Revive US Rare Earths Processing," VOA News (December 31, 2020).

[67] MP Materials Corp., "MP Materials Reports Fourth Quarter and Full Year 2024 Results," Press Release (February 20, 2025).

[68] U.S. Geological Survey, Mineral Commodity Summaries 2025, Rare Earths, World Mine Production and Reserves (January 2025), p. 144-145.

[69] U.S. EIA, Electric Power Monthly (February 2025), Table 1.15.B.

[70] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2001-24.

[71] U.S. EIA, Preliminary Monthly Electric Generator Inventory (based on Form EIA-860M as a supplement to Form EIA-860), Inventory of Operating Generators as of April 2025, Plant State: California, Technology: Wood/Wood Waste Biomass, Landfill Gas, Municipal Solid Waste, Other Waste Biomass.

[72] U.S. EIA, Monthly Densified Biomass Fuel Report, Table 1, Densified biomass fuel manufacturing facilities in the United States by state, region, and capacity, January 2025.

[73] U.S. Census Bureau, Tables, Table B25040, House Heating Fuel, California, 2023 American Community Survey 1-Year Estimates.

[74] U.S. EIA, U.S. Fuel Ethanol Plant Production Capacity (August 15, 2024), U.S. Nameplate Fuel Ethanol Plant Production Capacity as of January 1, 2024, Detailed annual production capacity by plant is available in XLSX format.

[75] U.S. EIA, State Energy Data System, Table F31, Fuel Ethanol Consumption Estimates, 2023.

[76] U.S. EIA, Movements by Pipeline, Tanker, Barge and Rail between PAD Districts, Fuel Ethanol, Annual, 2019-24.

[77] U.S. EIA, U.S. Biodiesel Plant Production Capacity (August 15, 2024), Detailed annual production capacity by plant is available in XLSX format.

[78] U.S. EIA, State Energy Data System, Table F29, Biodiesel Consumption Estimates, 2023.

[79] Bomgardner, Melody M., "California refiners shift production to renewable diesel," Chemical and Engineering News (August 19, 2020).

[80] Gerveni, Maria and Scott Irwin, "Overview of the Production Capacity of U.S. Renewable Diesel Plants through December 2022," (March 8, 2023).

[81] U.S. EIA, "Consumption of renewable diesel continues general growth trend on the U.S. West Coast," Today in Energy (February 18, 2025).

[82] U.S. EIA, State Energy Data System, Table P4B, Primary Energy Production Estimates, Biofuels, in Thousand Barrels, Ranked by State, 2022.

[83] U.S. EIA, State Energy Data System, Table F30, Renewable Diesel Consumption Estimates, 2023.

[84] California Energy Commission, California Clean Energy Almanac 2020, Chair's Message.

[85] NC Clean Energy Technology Center, DSIRE, California Renewables Portfolio Standard, updated November 26, 2024.

[86] Balaraman, Kavya, "California legislature aims for 90% clean electricity by 2035 as part of sweeping climate package," Utility Dive (September 2, 2022).

[87] U.S. EIA, Crude Oil Production, Annual, Thousand Barrels, 2019-24.

[88] U.S. EIA, California Field Production of Crude Oil, Annual, 1981-2024.

[89] U.S. EIA, U.S. Crude Oil and Natural Gas Proved Reserves, Year-end 2022, Table 6.

[90] U.S. EIA, Crude Oil Proved Reserves, Reserves Changes, and Production, California, CA-Coastal Region Onshore, CA-Los Angeles Basin Onshore, CA, San Joaquin Basin Onshore, and CA-State Offshore, 2021.

[91] U.S. Department of the Interior, Bureau of Ocean Energy Management, Assessment of Undiscovered Oil and Gas Resources of the Nation's Outer Continental Shelf, 2021, BOEM Fact Sheet RED-2021-09.

[92] Frisk, Carla, "California Coastal Sanctuary Act of 1994," Environmental Defense Center (December 22, 2017).

[93] Eversheds-Sutherland, "Congress Allows Moratorium on Offshore Drilling to Expire," Lexology (October 1, 2008).

[94] Congressional Research Service, Five-Year Offshore Oil and Gas Leasing Program: Status and Issues in Brief (October 1, 2024), p. 11.

[95] U.S. Department of the Interior, Bureau of Safety and Environmental Enforcement, Pacific OCS Platforms, accessed May 22, 2025.

[96] California State Lands Commission, Oil and Gas, Offshore Oil & Gas Located in California Waters, accessed May 22, 2025.

[97] Rivers, Kimberly, "Federal public comment period opens on oil drilling in California coastal waters," Ojai Valley News (May 1, 2025).

[98] U.S. Department of the Interior, Bureau of Ocean Energy Management, Request for Information and Comments on the Preparation of the 11th National Outer Continental Shelf Oil and Gas Leasing Program, April 30, 2025.

[99] U.S. EIA, Number and Capacity of Petroleum Refineries, Atmospheric Crude Oil Distillation Operable Capacity (B/CD), Annual, as of January 1, 2024.

[100] U.S. EIA, Number and Capacity of Petroleum Refineries, Total Number of Operable Refineries, as of January 1, 2024.

[101] U.S. EIA, Interactive GIS Data Viewer, California, Petroleum Refineries, Crude Oil Pipelines, accessed May 22, 2025.

[102] California Energy Commission, California's Oil Refineries, accessed May 22, 2025.

[103] U.S. EIA, Alaska Field Production of Crude Oil, Annual, 1981-2024.

[104] U.S. EIA, California Field Production of Crude Oil, Annual, 1981-2024.

[105] California Energy Commission, Foreign Sources of Crude Oil Imports to California 2024.

[106] California Energy Commission, Annual Oil Supply Sources to California Refineries, 2024.

[107] U.S. EIA, "California law and refinery closure reflect ongoing challenges for the state's fuel market," Today in Energy (December 9, 2024).

[108] Phillips 66 Co., "Phillips 66 provides notice of its plan to cease operations at Los Angeles-area refinery," Press Release (October 16, 2024).

[109] Jao, Nicole, "Valero to shut Benicia refinery due to tough regulatory environment, high costs," Reuters (April 24, 2025).

[110] Valero, "Valero Announces Notice to the California Energy Commission Regarding its Benicia, California, Refinery," Press Release (April 16, 2025).

[111] California Air Resources Board, Cleaner Burning Gasoline: An Update, accessed May 23, 2025.

[112] California Energy Commission, State of California Energy Assurance Plan, CEC-600-2014-006 (June 2014), p. 64.

[113] U.S. EIA, "Why California usually pays more at the pump for gasoline," Today in Energy (May 5, 2025).

[114] U.S. EIA, State Energy Data System, Table F16, Total Petroleum Consumption Estimates, 2023.

[115] U.S. EIA, State Energy Data System, Table F2, Jet Fuel Consumption, Price, and Expenditure Estimates, 2023.

[116] U.S. EIA, State Energy Data System, Table F10, Motor Gasoline Consumption, Price, and Expenditure Estimates, 2023.

[117] U.S. EIA, State Energy Data System, Table F16, Total Petroleum Consumption Estimates, 2023.

[118] U.S. Census Bureau, Tables, Table B25040, House Heating Fuel, California, 2023 American Community Survey 1-Year Estimates.

[119] U.S. EIA, California Natural Gas Gross Withdrawals, Annual, 1967-2024.

[120] U.S. EIA, U.S. Crude Oil and Natural Gas Proved Reserves, Year-end 2022, Table 8.

[121] U.S. EIA, Natural Gas Gross Withdrawals and Production, Gross Withdrawals, Annual, 2019-24.

[122] U.S. EIA, Natural Gas Consumption by End Use, Total Consumption, Annual, 2019-24.

[123] California Public Utilities Commission, Natural Gas and California, Supplies, accessed May 23, 2025.

[124] U.S. EIA, International and Interstate Movements of Natural Gas by State, California, Annual, 2018-23.

[125] U.S. EIA, Underground Natural Gas Storage Capacity, Total Number of Existing Fields and Total Storage Capacity, Annual, 2018-23.

[126] U.S. EIA, Natural Gas Consumption by End Use, Total Consumption, Annual, 2019-24.

[127] U.S. EIA, Natural Gas Consumption by End Use, California, Annual, 2019-24.

[128] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2024.

[129] U.S. Census Bureau, Tables, Table B25040, House Heating Fuel, California, 2023 American Community Survey 1-Year Estimates.

[130] U.S. EIA, Natural Gas Consumption by End Use, California, Annual, 2019-24.

[131] U.S. EIA, Annual Coal Report (October 30, 2024), Tables 7, 14, 15.

[132] U.S. EIA, Preliminary Monthly Electric Generator Inventory (based on Form EIA-860M as a supplement to Form EIA-860), Inventory of Operating Generators as of April 2025, Plant State: California, Technology: Conventional Steam Coal.

[133] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2001-24.

[134] U.S. EIA, Annual Coal Distribution Report (October 30, 2024), By Coal Destination State, California, Table DS-5, Domestic Coal Distribution, by Destination State, 2023.

[135] U.S. EIA, Quarterly Coal Report, 4th Quarter 2024, Table 13, Western Total.

[136] "States with the biggest Native American populations," KRQE (October 18, 2023).

[137] U.S. Department of the Interior, Bureau of Indian Affairs, Tribal Leaders Directory, "Indian Entities Recognized and Eligible to Receive Services from the United States Bureau of Indian Affairs," Federal Register, Vol. 89, No. 238, December 11, 2024, Notices, p. 99,899-99,903.

[138] U.S. Environmental Protection Agency, California Tribal Lands and Reservations, updated May 2, 2025.

[139] U.S. Forest Service, Forest Service National Resource Guide to American Indian and Alaska Native Relations, Appendix D: Indian Nations, The American Indian Digest (April 1997), p. D-3.

[140] U.S. Department of the Interior, Bureau of Indian Affairs, What is a federal Indian reservation?, FAQ Category, accessed May 27, 2025.

[141] K'ima:w Medical Center, Hoopa Valley Tribe, accessed May 27, 2025.

[142] The Conservation Fund, "Hoopa Valley Tribe Regains Major Tract of Ancestral Land," Press Release (December 20, 2023).

[143] Standen, Amy, "Tribal Lands Struggle to Bring Clean Power Online," National Public Radio (August 20, 2010).

[144] U.S. EIA, Preliminary Monthly Electric Generator Inventory (based on Form EIA-860M as a supplement to Form EIA-860), Inventory of Operating Generators as of April 2025, Plant State: California, Technology: Onshore Wind Turbine.

[145] Gomez, John Jr., Ramona Band of Cahuilla Indians (November 17, 2009).

[146] Froese, Michelle, "California Tribe Installs First Renewable Hybrid Microgrid," Windpower Energy & Development (April 27, 2015).

[147] Clarke, Chris, "Tribe to Launch Biomass-Fueled Fuel Cell Plant in Northern California," KCET Redefine (February 28, 2013).

[148] Petersen, Karen, "Blue Lake Rancheria's Bold Action on the Climate Front Pays Dividends," U.S. Department of Energy, Office of Indian Energy Policy and Programs (February 27, 2015).

[149] Maloney, Peter, "Life Won Thanks to the Blue Lake Rancheria Microgrid," Microgrid Knowledge (November 11, 2019).

[150] U.S. Department of Energy, Office of Indian Energy, Karuk Tribe-2020 Project, accessed May 27, 2025.

[151] U.S. Department of Energy, Office of Indian Energy, Developing Clean Energy Projects on Tribal Lands, DOE/IE-0012 (December 2012), p. 45.

[152] California Energy Commission, "California Energy Commission Approves $31 Million for Tribal Long-Duration Energy Storage Project," Press Release (November 3, 2022).

[153] Paskenta Band of Nomlaki Indians, "Paskenta Band of Nomlaki Indians Breaks Ground on Historic Solar Plus Storage Microgrid," Press Release (April 11, 2024).

[154] U.S. Department of Energy, Office of Indian Energy Policy and Programs, Tribal Energy Projects Database, California, accessed May 27, 2025.

Other Resources

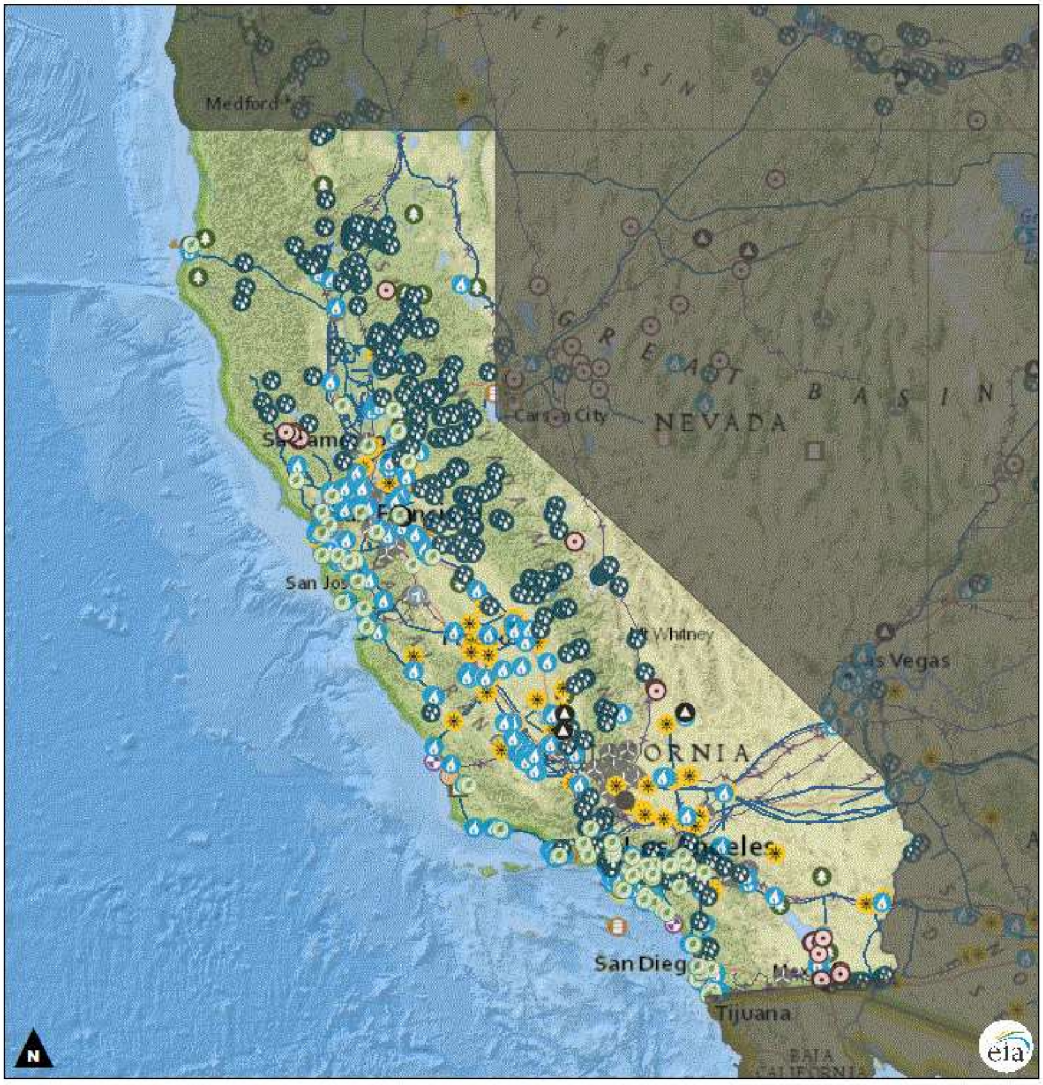
Energy-Related Regions and Organizations

- Petroleum Administration for Defense District (PADD): 5
- Regional Transmission Organization (RTO) and Independent System Operator (ISO): California Independent System Operator (CAISO)
- North American Electric Reliability Corporation (NERC) ERO Enterprise: Regional Entities: Western Electricity Coordinating Council (WECC)

Other Websites

- California Energy Commission
- California Public Utilities Commission (CPUC), Energy
- California Department of Community Services and Development
- California Department of Conservation, Geologic Energy Management Division
- California Air Resources Board
- Energy Upgrade California
- California Energy Commission, Clean Transportation Program
- California ISO (Independent System Operator)
- California Energy Commission, California Energy Planning Library
- California Energy Commission, Energy Almanac
- California Energy Commission, Energy Maps and Spatial Data
- EIA Southern California Daily Energy Report
- California Department of Water Resources
- California Office of Energy Infrastructure Safety
- U.S. Nuclear Regulatory Commission, California
- EIA California Flickr Album
- Western Regional Partnership (WRP)
- Alternative Fuels Data Center, Federal and State Laws and Incentives
- West Coast Green Highway
- USA.Gov, Get help with energy bills
- NC Clean Energy Technology Center, Database of State Incentives for Renewables and Efficiency (DSIRE)
- National Association of Regulatory Utility Commissioners (NARUC)
- National Association of State Energy Officials (NASEO)
- National Conference of State Legislatures (NCSL), Energy
- National Renewable Energy Laboratory (NREL), Geospatial Data Science, Data and Tools
- U.S. Geological Survey (USGS), Publications

- Interstate Oil and Gas Compact Commission (IOGCC)
- U.S. Department of the Interior, Bureau of Ocean Energy Management (BOEM)
- Western Governors Association
- Western Interstate Energy Board (WIEB)
- Western Area Power Administration (WAPA)
- Bonneville Power Administration (BPA)
- U.S. Department of Health & Human Services, Office of Community Services, An Office of the Administration for Children & Families, Low Income Home Energy Assistance Program (LIHEAP)
- U.S. Department of Energy, Office of Indian Energy Policy and Programs
- U.S. Geological Survey (USGS), Maps
- Lawrence Livermore National Laboratory (LLNL), Energy Flow Charts
- National Renewable Energy Laboratory (NREL), SLOPE: State and Local Planning for Energy
- National Renewable Energy Laboratory (NREL), Tribal Energy Atlas
- EIA Status of U.S. Nuclear Outages
- EIA Natural Gas Storage Dashboard
- EIA Energy Disruptions Maps
- U.S. Department of Agriculture (USDA), Rural Development Energy Programs



States:Electricity Transmission Lines - Ventyx, Velocity Suite;Grey Base:National

0 45 90 180 Miles

Mask	Hydroelectric Power Plant	Pumped Storage Power Plant
Surface Coal Mine	Natural Gas Power Plant	Solar Power Plant
Underground Coal Mine	Nuclear Power Plant	Wind Power Plant
Biomass Power Plant	Other Power Plant	Wood Power Plant
Coal Power Plant	Other Fossil Gases Power Plant	Petroleum Refinery
Geothermal Power Plant	Petroleum Power Plant	Strategic Petroleum Reserve

http://www.eia.gov/state/

U.S. Energy Information Administration

Skip to sub-navigation

California

State Profile and Energy Estimates

Profile Analysis

Print State Energy Profile

(overview, data, & analysis)

Last Updated: June 20, 2025

Overview

California has the largest economy in the nation, with a $4.2 trillion GDP in 2024, overtaking Japan to become the fourth-largest economy in the world.[1,2] About one in nine U.S. residents live in California, and it is the most populous state in the nation.[3] California also uses more energy than any other state except Texas.[4] However, energy efficiency efforts have helped make California's per capita energy use the third lowest in the nation.[5,6] California has abundant renewable energy resources, including solar energy, hydroelectric power, geothermal energy, and biomass, and the state produces more electricity from renewable energy than every other state but Texas.[7] California is also rich in mineral resources. Long known for gold and other precious minerals, the state has the nation's largest rare earths mine.[8] Additionally, California has significant crude oil reserves, and the state's petroleum refineries have nearly one-tenth of the nation's total crude oil refining capacity.[9,10]

Per capita residential and commercial sector energy use in California is lower than in all other states except Hawaii.

California stretches two-thirds of the way up the U.S. West Coast. At its greatest distances, it is more than 1,040 miles long and 560 miles wide.[11] With such great distances to travel, transportation accounts for the largest share of the state's energy consumption.[12] Californians have more registered motor vehicles and travel more vehicle miles than residents in any other state.[13] California accounts for one-tenth of U.S. motor gasoline consumption and about one-seventh of the nation's jet fuel consumption.[14,15] Overall, the state's transportation sector accounts for 42% of California's total energy consumption. The industrial sector uses 22% of the state's total energy and the residential and commercial sectors each account for 17%.[16] However, per capita energy consumption in both the residential and commercial sectors is lower than in all other states except Hawaii.[17] Although California has a varied climate, most of the state's more densely populated areas are relatively mild for much of the year.[18,19] Changes in weather patterns and climate have resulted in an increased use of cooling and almost three-fourths of California households have air conditioning.[20,21]

Electricity

California is the nation's fourth-largest electricity producer.

In 2024, California was the nation's fourth-largest total electricity producer and accounted for about 5% of all U.S. utility-scale (1-megawatt and larger) power generation.[22] Renewable resources, including hydropower and small-scale (less than 1-megawatt) customer-sited solar photovoltaic (PV) systems, supplied 57% of California's total in-state electricity generation in 2024. Natural gas-fired power plants provided 35% of the state's total net generation. Nuclear power's share of California's total electricity generation was about 7%. The state has one operating commercial nuclear power plant—the

two-reactor Diablo Canyon facility.[23,24] Coal fuels only a small amount of California's in-state net generation, all of it from one 57-megawatt industrial cogeneration plant.[25,26]

In 2024, California was the nation's second-largest conventional hydroelectric power producer after Washington, and it is consistently among the nation's top four hydropower producers.[27,28] Hydropower's contribution is highly variable and is dependent on rain and snowfall.[29,30] Nonhydroelectric renewable resources, mainly solar and wind energy, provided 45% of California's total in-state electricity generation in 2024.[31]

California imports the second-largest amount of electricity, after Virginia, and typically receives between one-fifth and one-third of its electricity supply annually from outside of the state.[32,33] Wildfires in California and surrounding states threaten both imports of electricity and transmission within the state.[34,35] Although California consumes more electricity than all other states except Texas and Florida, it uses less electricity per capita than any other state except Hawaii.[36,37] In 2024, California had the nation's second-highest average price of electricity, after Hawaii.[38] The commercial sector accounted for 47% of California's electricity sales in 2024. The residential sector, where three in ten California households use electricity for home heating, accounted for 35% of sales.[39,40] About 17% of the state's electricity sales went to the industrial sector. Light rail, subways, and the iconic cable cars in California's transportation sector accounted for 0.3% of the state's electricity use.[41]

California has led the states in the most electric vehicles (EVs) and EV charging locations every year since 2016.[42] California is part of the West Coast Green Highway, an extensive network of electric vehicle DC fast charging locations located along Interstate 5. The state has about 16,800 public charging locations.[43,44] In 2023, California had about 1.2 million registered battery electric vehicles, the most of any state and more than one-third of the U.S. total.[45]

Renewable energy

California is second in the nation, after Texas, in total electricity generation from renewable resources. The state is the nation's top producer of electricity from solar energy and geothermal resources. In 2024, California was the nation's second-largest producer of electricity from biomass, after Georgia, and also the second-largest producer of conventional hydroelectric power, after Washington.[46]

California is the nation's top producer of electricity from solar and geothermal energy.

Solar energy is the largest source of California's renewable electricity generation.[47] The state's greatest solar resources are in California's southeastern deserts, where all of its solar thermal facilities and several of its largest solar PV plants are located. However, solar PV facilities are located throughout the state.[48,49] In 2024, utility-scale solar energy supplied about 19% of the state's total electricity net generation. When small-scale solar generation is included, solar energy provided 32% of the state's total electricity generation.[50] At the beginning of 2025, California had about 22,200 megawatts of utility-scale solar power generating capacity, more than any other state. When small-scale solar panel generating systems are included, the state had about 40,000 megawatts of total solar capacity.[51]

In 2024, wind accounted for 6% of California's total in-state electricity generation, and the state ranked tenth in the nation in wind-powered generation.[52,53] California wind power potential exists at several areas around the state, both onshore and offshore.[54] The majority of the state's wind turbines are in six major wind resource areas: Altamont, East San Diego County, Pacheco, Solano, San Gorgonio, and Tehachapi.[55] At the beginning of 2025, California had 6,400 megawatts of wind capacity.[56] The first wind power farm on California's coast, with 27 turbines and 95 megawatts of capacity, came online in Santa Barbara County at the end of 2023.[57]

California is the nation's top producer of electricity from geothermal resources. In 2024, the state produced 70% of the nation's utility-scale geothermal-sourced electricity, and geothermal power accounted for about 4% of the state's total in-state generation.[58,59] The state's operating geothermal power plants have a combined total capacity of nearly 1,900 megawatts.[60] Four areas in California have substantial geothermal resources—the coastal mountain ranges north of San Francisco, volcanic areas of north-central California, areas near the Salton Sea in southern California, and areas along the state's eastern border with Nevada. The Geysers, located in the

Mayacamas Mountains north of San Francisco, is the largest complex of geothermal power plants in the world and has about 725 megawatts of installed generating capacity.[61,62]

Superheated geothermal brines in the Salton Sea geothermal resource area in Southern California contain lithium, a critical mineral used to manufacture rechargeable batteries.[63,64] The state has the largest rare earth mine in the United States. The Mountain Pass mine in Southern California's Mojave Desert is the largest deposit of rare earth elements in the nation. Rare earths are used in the manufacture of electric vehicles, wind turbines, and batteries, among other applications.[65,66] In 2024, the Mountain Pass mine produced almost 45,500 metric tons of rare earth concentrate, accounting for about 12% of global rare earth production.[67,68]

California ranks second in the nation, after Georgia, in the most utility-scale electricity generation from biomass.[69] In 2024, biomass fueled 2% of the state's total net generation, and more than half of that was from wood and wood-derived fuels.[70] In early 2025, California had roughly 1,000 megawatts of utility-scale biomass generating capacity and nearly three-fifths was fueled by wood and wood waste. Landfill gas, municipal solid waste, and other biomass sources fuel the remaining biomass capacity.[71] California's biomass resources also provide feedstock to the two wood pellet manufacturing facilities in the state. Those plants can produce about 168,000 tons of pellets per year. Wood pellets are used for heating but can also be used for electricity generation.[72] About 1% of California households use wood as their primary fuel for space heating.[73]

California consumes 1.4 billion gallons of fuel ethanol annually, which is one-tenth of the nation's fuel ethanol supply and 11 times more than the 128 million gallons that the state's three fuel ethanol plants can produce annually.[74,75] Midwestern states provide most of the additional fuel ethanol California uses.[76] California can produce a combined 80 million gallons of biodiesel annually from four production plants, which is almost one-third of the nearly 269 million gallons of biodiesel consumed in the state.[77,78] Several California petroleum refineries have added manufacturing capacity for renewable diesel production derived from biomass.[79,80,81] California accounts for 10% of U.S. renewable diesel production and 91% of the nation's renewable diesel consumption.[82,83]

California's renewable portfolio standard (RPS), enacted in 2002 and revised several times since then, required that 33% of electricity retail sales in California come from eligible renewable resources by 2020. The state met that goal three years before the target date.[84] The RPS also requires that 60% of electricity sales come from renewables by 2030 and 100% by 2045.[85] In 2022, the state legislature set intermediate targets of 90% renewable energy and zero-carbon electricity by the end of 2035 and 95% by the end of 2040 on the way to the eventual target of 100% by 2045.[86]

Petroleum

California was the eighth-largest crude oil producer among the states in 2024 and accounted for about 2% of the nation's total onshore and offshore oil production.[87] Although California's annual crude oil production has steadily declined from its peak of 394 million barrels in 1985, the state produced 104 million barrels of crude oil in 2024.[88] Reservoirs along California's Pacific Coast, including in the Los Angeles basin, and those in the state's Central Valley contain major crude oil reserves, and the state holds about 3% of the nation's total proved crude oil reserves.[89,90]

Assessments of California's offshore areas indicate the potential for large, undiscovered recoverable crude oil resources in the federally administered Outer Continental Shelf.[91] However, in 1994, concerns about the risks of offshore crude oil and natural gas development resulted in a permanent moratorium on new offshore oil and natural gas leasing in state waters.[92] Congress imposed a federal moratorium on oil and natural gas leasing in California federal waters in 1982, but it expired in 2008.[93] No new California offshore federal lease sales have occurred since then, although about two dozen older crude oil and natural gas production platforms remain active in federal waters that start three miles from the California coastline and about a dozen platforms are in state waters off the coast of California.[94,95,96] In April 2025, the Department of the Interior sought public comment on creating a new five-year offshore drilling plan for oil and natural gas in federal waters, including off California.[97,98]

California has 9% of the nation's total crude oil refining capacity and ranks third among the states, after Texas and Louisiana, with the most refining capacity.[99] A network of pipelines

Foreign suppliers provide almost two-

connects California crude oil production to the state's 14 operating petroleum refineries, which are located primarily in the Los Angeles area, the San Francisco Bay area, and the San Joaquin Valley.[100,101,102] As crude oil production in California and Alaska declined, the state's refineries increased their supply from foreign oil imports.[103,104] Led by Iraq, Brazil, Guyana, and Ecuador, foreign suppliers provided almost two-thirds of the crude oil refined in California in 2024.[105,106] In October 2024, a new California law allowed state regulators to set minimum petroleum product inventory levels for refineries in the state to help curb gasoline and diesel fuel price volatility.[107] Shortly after the law's enactment, an oil company operating a 139,000-barrel-per-day refinery in the Los Angeles area announced it would shut down the facility by the end of 2025.[108] A separate oil company told state regulators in April 2025 that it would close its 170,000-barrel-per-day refinery in the San Francisco area by the end of April 2026.[109,110]

thirds of the crude oil refined in California.

California requires that motorists use, at a minimum, a specific blend of motor gasoline called CaRFG (California Reformulated Gasoline) to reduce pollution from motor vehicles and improve air quality. California refineries produce cleaner fuels in order to meet state environmental regulations. Refineries in the state often operate at or near maximum capacity because of the high demand for those petroleum products and the lack of interstate pipelines that can deliver those cleaner fuels into the state. When unplanned refinery outages occur, the lack of CaRFG deliveries available from interstate pipelines means replacement supplies of CaRFG come in by marine tanker from out-of-state U.S. refineries or from other countries, such as India and South Korea. It can take several weeks to find and bring replacement motor gasoline from overseas that meets California's unique specifications.[111,112,113]

California is the nation's second-largest consumer of refined petroleum products, after Texas, and accounts for about 9% of U.S. total consumption.[114] California is the nation's largest consumer of jet fuel and the second-largest consumer of motor gasoline, after Texas.[115,116] The transportation sector uses about 86% of the petroleum consumed in the state. The industrial sector accounts for about 10% of state petroleum use, and the commercial sector consumes about 3%. The residential sector, where about 4 out of 100 California households heat with petroleum products, mostly propane, uses about 1%. A small amount of petroleum is used for electricity generation.[117,118]

Natural gas

California's natural gas output has declined steadily since 2000, and the state now accounts for less than 1% of the nation's total natural gas reserves and production.[119,120] California's natural gas production is less than one-tenth of the state's total natural gas consumption.[121,122] Several interstate natural gas pipelines enter California from Arizona, Nevada, and Oregon bringing natural gas into California from the Southwest, the Rocky Mountain region, and western Canada.[123] California consumes nearly 90% of the natural gas delivered to the state.[124] A small amount is exported to Mexico. The remaining natural gas that enters the state is placed in California's 14 underground natural gas storage fields that together can hold about 604 billion cubic feet of natural gas, about 7% of the nation's storage capacity.[125]

California is the nation's second-largest natural gas consumer. Only Texas uses more.[126] In 2024, about 31% of the natural gas delivered to California consumers went to the state's industrial sector. The electric power sector closely followed at 30%, as natural gas fueled about one-third of the state's total electricity generation.[127,128] The residential sector, where 6 in 10 California households use natural gas for home heating, accounted for 22% of natural gas use. The commercial sector consumed about 15%, and the transportation sector used about 1% as compressed natural gas vehicle fuel.[129,130]

California is the nation's second-largest natural gas consumer, after Texas.

Coal

California does not have any coal reserves or production and has very little coal-fired electricity generation. All the generation is from one industrial facility in Trona.[131,132,133] Almost all the coal consumed in California arrives by rail from mines in Colorado and Utah.[134] In 2024, some coal produced in other states was exported to other countries from California ports.[135]

Energy on tribal lands

California has the largest Native American population in the nation at about 535,000, and the state is home to nearly 100 federally recognized tribal groups.[136,137] Although tribal areas exist throughout California, they account for less than 1% of the state's land area.[138,139] Many of the state's tribal lands are small, including the nation's smallest reservation, the 1.32-acre parcel that contains the Pit River Tribe cemetery.[140] The state's largest is the forested Hoopa Valley Reservation, home of the Hupa people, in northern California's Humboldt County, with 102,000 acres.[141,142]

California's diverse climate and geography give tribes access to a variety of renewable energy resources. One of the first utility-scale wind projects on tribal land in the nation is in southern California. In 2005, the Campo Kumeyaay Nation in southern California leased some of its land in San Diego County for the development of a 50-megawatt wind project.[143,144] The Ramona Band of Cahuilla became one of the first tribes to make its reservation independent of the regional electric grid in 2009.[145] In 2015, the Bear River Band of the Rohnerville Rancheria in Northern California became the first California tribe to install a hybrid solar, wind, and advanced energy storage microgrid for power generation.[146]

Some reservations in California have abundant biomass potential. The Blue Lake Rancheria Tribe in Humboldt County has a 175-kilowatt biogas fuel cell system powered by gasified wood waste from the forestry industry.[147,148] In 2019, the Rancheria extended use of its microgrid to the broader community, about 10% of the county's population, during a widespread wildfire-related utility power shutoff in northwest Humboldt County.[149] In 2022, the U.S. Department of Energy (DOE) awarded the Karuk Tribe almost $2 million to build a nearly 1 megawatt ground-mounted solar panel system and battery energy storage in northern California.[150] In addition to the tribes that have abundant solar, wind, and biomass resources, some California tribal lands have geothermal electricity generation potential, particularly in the Imperial Valley in southern California, the Geysers area in northern California, and along the state's eastern border.[151]

The California Energy Commission (CEC) awarded one of its largest grants, $31 million, in 2022 to the Viejas Tribe of Kumeyaay Indians for a long-duration energy storage system in San Diego County to provide renewable backup power for the tribe. The energy storage system supports statewide grid reliability in the event of an emergency.[152] The CEC awarded in 2024 a $32 million grant to the Paskenta Band of Nomlaki Indians to build a large-scale 5-megawatt solar and long-duration 15-megawatthour microgrid in northern California.[153] Since 2010, DOE has invested more than $21 million in about 40 California tribal renewable energy and energy efficiency projects.[154]

Endnotes

[1] U.S. Bureau of Economic Analysis, Regional Data, GDP and Personal Income, Annual Gross Domestic Product (GDP) by State, SAGDP2 GDP by industry in current dollars, All Areas, All industry total, 2024.

[2] Office of Governor Gavin Newsom, "California is Now the 4th Largest Economy in the World," Press Release (April 23, 2025).

[3] U.S. Census Bureau, U.S. and World Population Clock, Most Populous States, accessed May 19, 2025.

[4] U.S. Energy Information Administration (EIA), State Energy Data System, Table C11, Total Energy Consumption Estimates by End-Use Sector, Ranked by State, 2022.

[5] McCann, Adam, "Most & Least Energy-Efficient States (2025)," WalletHub (October 15, 2024).

[6] U.S. EIA, Rankings: Total Energy Consumed per Capita, 2022.

[7] U.S. EIA, Electric Power Monthly (February 2025), Tables 1.10.B, 1.11.B, 1.15.B, 1.16.B, 1.17.B, 1.18.B.

[8] MP Materials Corp., About, accessed May 19, 2025.

[9] U.S. EIA, U.S. Crude Oil and Natural Gas Proved Reserves, Year-end 2022, Table 6.

[10] U.S. EIA, Number and Capacity of Petroleum Refineries, Atmospheric Crude Oil Distillation Operable Capacity (B/CD), as of January 1, 2024.

[11] NETSTATE, California, The Geography of California, accessed May 19, 2025.

[12] U.S. EIA, State Energy Data System, Table C1, Energy Consumption Overview: Estimates by Energy Source and End-Use Sector, 2022.

[13] U.S. Department of Transportation, Federal Highway Administration, Highway Statistic Series: State Statistical Abstracts, California, 2023.

[14] U.S. EIA, State Energy Data System, Table F10, Motor Gasoline Consumption, Price, and Expenditure Estimates, 2023.

[15] U.S. EIA, State Energy Data System, Table F2, Jet Fuel Consumption, Price, and Expenditure Estimates, 2023.

[16] U.S. EIA, State Energy Data System, Table C1, Energy Consumption Overview: Estimates by Energy Source and End-Use Sector, 2022.

[17] U.S. EIA, State Energy Data System, Table C14, Total Energy Consumption Estimates per Capita by End-Use Sector, Ranked by State, 2022.

[18] U.S. Census Bureau, 2020 Census: California Profile, Population Density by Census Tract, accessed May 19, 2025.

[19] NETSTATE, Geography of California, Climate, accessed May 19, 2025.

[20] U.S. EIA, Residential Energy Consumption Survey (RECS), 2009 RECS Survey Data, Air Conditioning, in West Region, divisions, and states (HC7.11) and 2020 RECS Survey Data, State Data, Housing characteristics, Highlights for air conditioning in U.S. homes by state, 2020.

[21] Bump, Phillip, "Californians may no longer be able to avoid air conditioning," The Washington Post (September 7, 2022).

[22] U.S. EIA, Electric Power Monthly (February 2025), Table 1.3.B.

[23] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2001-24.

[24] U.S. Nuclear Regulatory Commission, California, updated February 21, 2025.

[25] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2001-24.

[26] U.S. EIA, Preliminary Monthly Electric Generator Inventory (based on Form EIA-860M as a supplement to Form EIA-860), Inventory of Operating Generators as of April 2025, Plant State: California, Technology: Conventional Steam Coal.

[27] U.S. EIA, Electric Power Monthly, (February 2025), Table 1.10.B.

[28] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, New York, Oregon, Washington, Conventional hydroelectric, Annual, 2001-24.

[29] U.S. EIA, "California's hydroelectric generation affected by historic drought," Today in Energy (July 7, 2021).

[30] U.S. EIA, "U.S. hydropower generation expected to rise in 2025 following last year's relative low," Today in Energy (May 19, 2025).

[31] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2001-24.

[32] U.S. EIA, "Virginia was the top net electricity recipient of any state in 2023," Today in Energy (December 20, 2024).

[33] U.S. EIA, California Electricity Profile 2023, Table 10, available in XLSX format.

[34] Mulkern, Anne C., "Soaring Temperatures and Wildfire Threaten California's Power Grid," Scientific American (July 12, 2021).

[35] Arbaje, Paul, "Wildfires and Power Grid Failures Continue to Fuel Each Other," Union of Concerned Scientists (May 23, 2024).

[36] U.S. EIA, Electric Power Monthly (February 2025), Table 5.4.B.

[37] U.S. EIA, State Energy Data System, Table C17, Electricity Retail Sales to Ultimate Customers, Total and Residential, Total and per Capita, Ranked by State, 2022.

[38] U.S. EIA, Electric Power Monthly (February 2025), Table 5.6.B.

[39] U.S. EIA, Electricity Data Browser, Retail sales of electricity, California, 2001-24.

[40] U.S. Census Bureau, Tables, Table B25040, House Heating Fuel, California, 2023 American Community Survey 1-Year Estimates.

[41] U.S. EIA, Electricity Data Browser, Retail sales of electricity, California, 2001-24.

[42] U.S. EIA, "California leads the United States in electric vehicles and charging locations," Today in Energy (December 14, 2023).

[43] U.S. EIA, Monthly Energy Review (May 2025), Appendix F monthly state file, XLS, Public Ports only and Public & Private Ports combined.

[44] West Coast Electric Highway, accessed May 20, 2025.

[45] U.S. EIA, State Energy Data System, Table F39, Electric Light-Duty Vehicles Overview, 2023.

[46] U.S. EIA, Electric Power Monthly, (February 2025), Tables 1.10.B, 1.11.B, 1.14.B, 1.15.B, 1.16.B, 1.17.B, 1.18.B.

[47] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2001-24.

[48] U.S. EIA, Preliminary Monthly Electric Generator Inventory (based on Form EIA-860M as a supplement to Form EIA-860), Inventory of Operating Generators as of April 2025, Plant State: California, Technology: Solar Photovoltaic, Solar Thermal without Energy Storage.

[49] National Renewable Energy Laboratory, Global Horizontal Solar Irradiance Map, February 22, 2018.

[50] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2001-24.

[51] U.S. EIA, Electric Power Monthly (February 2025), Table 6.2.B.

[52] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2001-24.

[53] U.S. EIA, Electric Power Monthly (February 2025), Table 1.14.B.

[54] U.S. Department of Energy, Energy Efficiency and Renewable Energy, WINDExchange, Wind Energy in California, Maps & Data, accessed May 21, 2025.

[55] California Energy Commission, Wind Energy in California, accessed May 21, 2025.

[56] U.S. EIA, Electric Power Monthly (February 2025), Table 6.2.B.

[57] Andre, Lisa, "Local leaders celebrate 'significance' of Strauss wind project in Lompoc with ribbon cutting," Lompoc Record (updated April 10, 2025).

[58] U.S. EIA, Electric Power Monthly (February 2025), Table 1.16.B.

[59] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2001-24.

[60] U.S. EIA, Electric Power Monthly (February 2025), Table 6.2.B.

[61] Calpine, The Geysers, About Geothermal Energy, Welcome to the Geysers, accessed May 21, 2025.

[62] California Energy Commission, Geothermal Energy, accessed May 21, 2025.

[63] California Energy Commission, Lithium Valley Commission, accessed May 21, 2025.

[64] Burton, Jason, "U.S. Geological Survey releases 2022 list of critical minerals," U.S. Geological Survey, Press Release (February 22, 2022).

[65] MP Materials Corp., About, accessed May 21, 2025.

[66] Xie, John, "California Mine Becomes Key Part of Push to Revive US Rare Earths Processing," VOA News (December 31, 2020).

[67] MP Materials Corp., "MP Materials Reports Fourth Quarter and Full Year 2024 Results," Press Release (February 20, 2025).

[68] U.S. Geological Survey, Mineral Commodity Summaries 2025, Rare Earths, World Mine Production and Reserves (January 2025), p. 144-145.

[69] U.S. EIA, Electric Power Monthly (February 2025), Table 1.15.B.

[70] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2001-24.

[71] U.S. EIA, Preliminary Monthly Electric Generator Inventory (based on Form EIA-860M as a supplement to Form EIA-860), Inventory of Operating Generators as of April 2025, Plant State: California, Technology: Wood/Wood Waste Biomass, Landfill Gas, Municipal Solid Waste, Other Waste Biomass.

[72] U.S. EIA, Monthly Densified Biomass Fuel Report, Table 1, Densified biomass fuel manufacturing facilities in the United States by state, region, and capacity, January 2025.

[73] U.S. Census Bureau, Tables, Table B25040, House Heating Fuel, California, 2023 American Community Survey 1-Year Estimates.

[74] U.S. EIA, U.S. Fuel Ethanol Plant Production Capacity (August 15, 2024), U.S. Nameplate Fuel Ethanol Plant Production Capacity as of January 1, 2024, Detailed annual production capacity by plant is available in XLSX format.

[75] U.S. EIA, State Energy Data System, Table F31, Fuel Ethanol Consumption Estimates, 2023.

[76] U.S. EIA, Movements by Pipeline, Tanker, Barge and Rail between PAD Districts, Fuel Ethanol, Annual, 2019-24.

[77] U.S. EIA, U.S. Biodiesel Plant Production Capacity (August 15, 2024), Detailed annual production capacity by plant is available in XLSX format.

[78] U.S. EIA, State Energy Data System, Table F29, Biodiesel Consumption Estimates, 2023.

[79] Bomgardner, Melody M., "California refiners shift production to renewable diesel," Chemical and Engineering News (August 19, 2020).

[80] Gerveni, Maria and Scott Irwin, "Overview of the Production Capacity of U.S. Renewable Diesel Plants through December 2022," (March 8, 2023).

[81] U.S. EIA, "Consumption of renewable diesel continues general growth trend on the U.S. West Coast," Today in Energy (February 18, 2025).

[82] U.S. EIA, State Energy Data System, Table P4B, Primary Energy Production Estimates, Biofuels, in Thousand Barrels, Ranked by State, 2022.

[83] U.S. EIA, State Energy Data System, Table F30, Renewable Diesel Consumption Estimates, 2023.

[84] California Energy Commission, California Clean Energy Almanac 2020, Chair's Message.

[85] NC Clean Energy Technology Center, DSIRE, California Renewables Portfolio Standard, updated November 26, 2024.

[86] Balaraman, Kavya, "California legislature aims for 90% clean electricity by 2035 as part of sweeping climate package," Utility Dive (September 2, 2022).

[87] U.S. EIA, Crude Oil Production, Annual, Thousand Barrels, 2019-24.

[88] U.S. EIA, California Field Production of Crude Oil, Annual, 1981-2024.

[89] U.S. EIA, U.S. Crude Oil and Natural Gas Proved Reserves, Year-end 2022, Table 6.

[90] U.S. EIA, Crude Oil Proved Reserves, Reserves Changes, and Production, California, CA-Coastal Region Onshore, CA-Los Angeles Basin Onshore, CA, San Joaquin Basin Onshore, and CA-State Offshore, 2021.

[91] U.S. Department of the Interior, Bureau of Ocean Energy Management, Assessment of Undiscovered Oil and Gas Resources of the Nation's Outer Continental Shelf, 2021, BOEM Fact Sheet RED-2021-09.

[92] Frisk, Carla, "California Coastal Sanctuary Act of 1994," Environmental Defense Center (December 22, 2017).

[93] Eversheds-Sutherland, "Congress Allows Moratorium on Offshore Drilling to Expire," Lexology (October 1, 2008).

[94] Congressional Research Service, Five-Year Offshore Oil and Gas Leasing Program: Status and Issues in Brief (October 1, 2024), p. 11.

[95] U.S. Department of the Interior, Bureau of Safety and Environmental Enforcement, Pacific OCS Platforms, accessed May 22, 2025.

[96] California State Lands Commission, Oil and Gas, Offshore Oil & Gas Located in California Waters, accessed May 22, 2025.

[97] Rivers, Kimberly, "Federal public comment period opens on oil drilling in California coastal waters," Ojai Valley News (May 1, 2025).

[98] U.S. Department of the Interior, Bureau of Ocean Energy Management, Request for Information and Comments on the Preparation of the 11th National Outer Continental Shelf Oil and Gas Leasing Program, April 30, 2025.

[99] U.S. EIA, Number and Capacity of Petroleum Refineries, Atmospheric Crude Oil Distillation Operable Capacity (B/CD), Annual, as of January 1, 2024.

[100] U.S. EIA, Number and Capacity of Petroleum Refineries, Total Number of Operable Refineries, as of January 1, 2024.

[101] U.S. EIA, Interactive GIS Data Viewer, California, Petroleum Refineries, Crude Oil Pipelines, accessed May 22, 2025.

[102] California Energy Commission, California's Oil Refineries, accessed May 22, 2025.

[103] U.S. EIA, Alaska Field Production of Crude Oil, Annual, 1981-2024.

[104] U.S. EIA, California Field Production of Crude Oil, Annual, 1981-2024.

[105] California Energy Commission, Foreign Sources of Crude Oil Imports to California 2024.

[106] California Energy Commission, Annual Oil Supply Sources to California Refineries, 2024.

[107] U.S. EIA, "California law and refinery closure reflect ongoing challenges for the state's fuel market," Today in Energy (December 9, 2024).

[108] Phillips 66 Co., "Phillips 66 provides notice of its plan to cease operations at Los Angeles-area refinery," Press Release (October 16, 2024).

[109] Jao, Nicole, "Valero to shut Benicia refinery due to tough regulatory environment, high costs," Reuters (April 24, 2025).

[110] Valero, "Valero Announces Notice to the California Energy Commission Regarding its Benicia, California, Refinery," Press Release (April 16, 2025).

[111] California Air Resources Board, Cleaner Burning Gasoline: An Update, accessed May 23, 2025.

[112] California Energy Commission, State of California Energy Assurance Plan, CEC-600-2014-006 (June 2014), p. 64.

[113] U.S. EIA, "Why California usually pays more at the pump for gasoline," Today in Energy (May 5, 2025).

[114] U.S. EIA, State Energy Data System, Table F16, Total Petroleum Consumption Estimates, 2023.

[115] U.S. EIA, State Energy Data System, Table F2, Jet Fuel Consumption, Price, and Expenditure Estimates, 2023.

[116] U.S. EIA, State Energy Data System, Table F10, Motor Gasoline Consumption, Price, and Expenditure Estimates, 2023.

[117] U.S. EIA, State Energy Data System, Table F16, Total Petroleum Consumption Estimates, 2023.

[118] U.S. Census Bureau, Tables, Table B25040, House Heating Fuel, California, 2023 American Community Survey 1-Year Estimates.

[119] U.S. EIA, California Natural Gas Gross Withdrawals, Annual, 1967-2024.

[120] U.S. EIA, U.S. Crude Oil and Natural Gas Proved Reserves, Year-end 2022, Table 8.

[121] U.S. EIA, Natural Gas Gross Withdrawals and Production, Gross Withdrawals, Annual, 2019-24.

[122] U.S. EIA, Natural Gas Consumption by End Use, Total Consumption, Annual, 2019-24.

[123] California Public Utilities Commission, Natural Gas and California, Supplies, accessed May 23, 2025.

[124] U.S. EIA, International and Interstate Movements of Natural Gas by State, California, Annual, 2018-23.

[125] U.S. EIA, Underground Natural Gas Storage Capacity, Total Number of Existing Fields and Total Storage Capacity, Annual, 2018-23.

[126] U.S. EIA, Natural Gas Consumption by End Use, Total Consumption, Annual, 2019-24.

[127] U.S. EIA, Natural Gas Consumption by End Use, California, Annual, 2019-24.

[128] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2024.

[129] U.S. Census Bureau, Tables, Table B25040, House Heating Fuel, California, 2023 American Community Survey 1-Year Estimates.

[130] U.S. EIA, Natural Gas Consumption by End Use, California, Annual, 2019-24.

[131] U.S. EIA, Annual Coal Report (October 30, 2024), Tables 7, 14, 15.

[132] U.S. EIA, Preliminary Monthly Electric Generator Inventory (based on Form EIA-860M as a supplement to Form EIA-860), Inventory of Operating Generators as of April 2025, Plant State: California, Technology: Conventional Steam Coal.

[133] U.S. EIA, Electricity Data Browser, Net generation for all sectors (thousand megawatthours), California, Annual, 2001-24.

[134] U.S. EIA, Annual Coal Distribution Report (October 30, 2024), By Coal Destination State, California, Table DS-5, Domestic Coal Distribution, by Destination State, 2023.

[135] U.S. EIA, Quarterly Coal Report, 4th Quarter 2024, Table 13, Western Total.

[136] "States with the biggest Native American populations," KRQE (October 18, 2023).

[137] U.S. Department of the Interior, Bureau of Indian Affairs, Tribal Leaders Directory, "Indian Entities Recognized and Eligible to Receive Services from the United States Bureau of Indian Affairs," Federal Register, Vol. 89, No. 238, December 11, 2024, Notices, p. 99,899-99,903.

[138] U.S. Environmental Protection Agency, California Tribal Lands and Reservations, updated May 2, 2025.

[139] U.S. Forest Service, Forest Service National Resource Guide to American Indian and Alaska Native Relations, Appendix D: Indian Nations, The American Indian Digest (April 1997), p. D-3.

[140] U.S. Department of the Interior, Bureau of Indian Affairs, What is a federal Indian reservation?, FAQ Category, accessed May 27, 2025.

[141] K'ima:w Medical Center, Hoopa Valley Tribe, accessed May 27, 2025.

[142] The Conservation Fund, "Hoopa Valley Tribe Regains Major Tract of Ancestral Land," Press Release (December 20, 2023).

[143] Standen, Amy, "Tribal Lands Struggle to Bring Clean Power Online," National Public Radio (August 20, 2010).

[144] U.S. EIA, Preliminary Monthly Electric Generator Inventory (based on Form EIA-860M as a supplement to Form EIA-860), Inventory of Operating Generators as of April 2025, Plant State: California, Technology: Onshore Wind Turbine.

[145] Gomez, John Jr., Ramona Band of Cahuilla Indians (November 17, 2009).

[146] Froese, Michelle, "California Tribe Installs First Renewable Hybrid Microgrid," Windpower Energy & Development (April 27, 2015).

[147] Clarke, Chris, "Tribe to Launch Biomass-Fueled Fuel Cell Plant in Northern California," KCET Redefine (February 28, 2013).

[148] Petersen, Karen, "Blue Lake Rancheria's Bold Action on the Climate Front Pays Dividends," U.S. Department of Energy, Office of Indian Energy Policy and Programs (February 27, 2015).

[149] Maloney, Peter, "Life Won Thanks to the Blue Lake Rancheria Microgrid," Microgrid Knowledge (November 11, 2019).

[150] U.S. Department of Energy, Office of Indian Energy, Karuk Tribe-2020 Project, accessed May 27, 2025.

[151] U.S. Department of Energy, Office of Indian Energy, Developing Clean Energy Projects on Tribal Lands, DOE/IE-0012 (December 2012), p. 45.

[152] California Energy Commission, "California Energy Commission Approves $31 Million for Tribal Long-Duration Energy Storage Project," Press Release (November 3, 2022).

[153] Paskenta Band of Nomlaki Indians, "Paskenta Band of Nomlaki Indians Breaks Ground on Historic Solar Plus Storage Microgrid," Press Release (April 11, 2024).

[154] U.S. Department of Energy, Office of Indian Energy Policy and Programs, Tribal Energy Projects Database, California, accessed May 27, 2025.

Share: Translate Settings

California Energy Commission
50 YEARS OF ENERGY LEADERSHIP

Enter keywords, e.g. Energy Code

Zero Emission Vehicle and Infrastructure Statistics

Light-Duty Vehicle Population in California

The next update is expected late-April / early-May 2026.

Light-Duty vehicle population is updated annually in April to reflect the number of vehicles "on the road" during the selected calendar year. Light-Duty zero-emission vehicle (ZEV) population is lower than new ZEV sales because of vehicle retirements, accidents, owners moving out of state, or other reasons. Dashboard is best viewed from a computer. Visit full page layout of dashboard, download data, or return to the dashboard collection page.

Other Dashboards in this Collection:

New ZEV Sales | Light-Duty Vehicle Population | Medium- & Heavy-Duty Vehicle Population | EV Chargers | Hydrogen Stations | School Buses | School Bus Chargers | MDHD ZEV Station Development in California

ZEV POPULATION

Total Light-Duty Vehicles end of 2024

1,899,831

Battery Electric (BEV)	Plug-in Hybrid (PHEV)	Fuel Cell (FCEV)
4.95%	1.47%	0.04%
1,453,994	432,880	12,957

NON-ZEV POPULATION

Total Light-Duty Vehicles end of 2024

27,472,463

Gasoline	Gasoline Hybrid	Diesel	Other
85.50%	5.99%	2.02%	0.03%
25,113,445	1,758,070	593,359	7,589



MAKE	MODEL	Number of Vehicles
Tesla	Model Y	414,659
	Model 3	376,489
	Model S	74,678
	Model X	60,377
	Cybertruck	9,313
	Roadster	379
Toyota	Prius Prime	61,147
	RAV4 Prime	28,585
	Prius Plug-In Hybrid	21,122
	Mirai	11,582
	bZ4X	9,174
	RAV4 EV	1,025
	RAV4 PHEV	76
Chevrolet	Volt	43,329
	Bolt EV	37,837
	Bolt EUV	21,898
	Equinox EV	5,081
	Blazer EV	4,217
	Silverado EV	1,987
	Spark EV	1,864
	S-10	37
BMW	i4	19,598
	X5	15,107
	i3	13,868
	5 Series	12,090
	iX	11,771
	3 Series	9,349
	i5	3,397
	i7	2,250

SELECT FILTER

Year: 2024

Map Filter: County

County: (All)

Fuel Type: (All)

Make: (All)

Expand All

Share:

Translate Settings

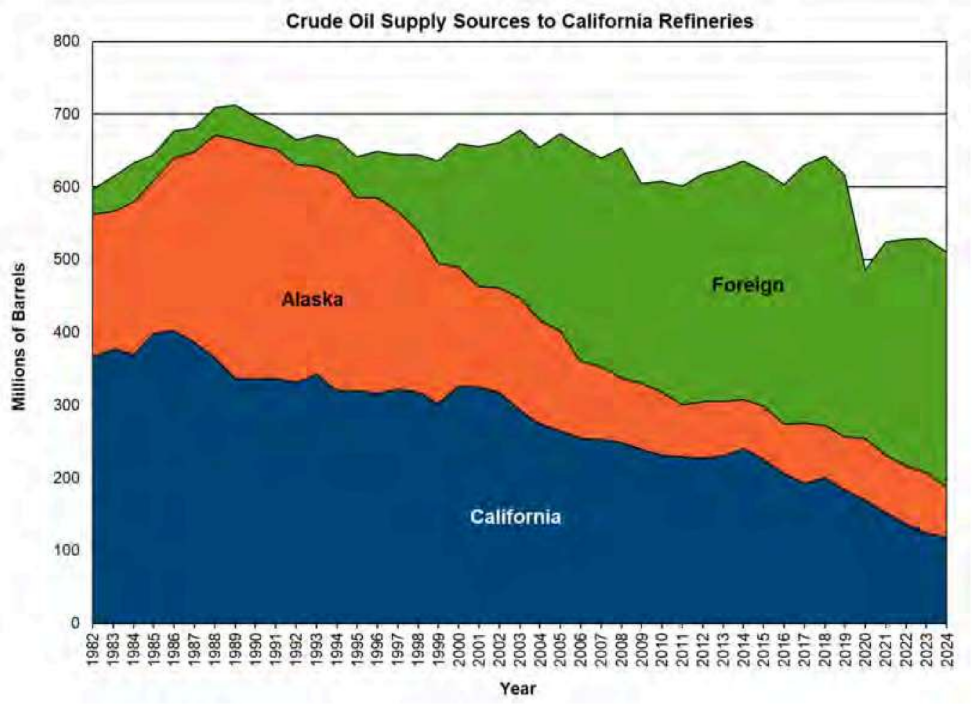
California Energy Commission
50 YEARS OF ENERGY LEADERSHIP

Enter keywords, e.g. Energy Code

California's Petroleum Market

Annual Oil Supply Sources To California Refineries

Annual Oil Supply Sources To California Refineries



Annual Oil Supply Sources to California Refineries (In Thousands of Barrels)

Year	California**	%	Alaska	%	Foreign	%	Total
2024	118,733	23.3%	67,879	13.3%	324,037	63.5%	510,649
2023	123,947	23.4%	83,842	15.9%	321,153	60.7%	528,942
2022	136,050	25.8%	80,257	15.2%	311,530	59.0%	527,837
2021	152,473	29.1%	78,145	14.9%	293,417	56.0%	524,035
2020	169,211	34.9%	85,662	17.6%	230,581	47.5%	485,454
2019	183,158	29.7%	73,252	11.9%	359,712	58.4%	616,122
2018	199,658	31.1%	72,945	11.4%	369,386	57.5%	641,989
2017	192,979	30.6%	81,769	13.0%	355,150	56.4%	629,898

Year	California**	%	Alaska	%	Foreign	%	Total
2016	205,528	34.1%	68,765	11.4%	328,513	54.5%	602,806
2015	225,435	36.2%	73,182	11.8%	323,336	52.0%	621,953
2014	240,095	37.7%	67,702	10.6%	328,245	51.6%	636,042
2013	230,357	36.9%	74,382	11.9%	319,677	51.2%	624,416
2012	227,626	36.8%	77,150	12.5%	313,530	50.7%	618,306
2011	229,556	38.2%	71,138	11.8%	300,016	49.9%	600,710
2010	231,339	38.1%	86,382	14.2%	289,797	47.7%	607,518
2009	239,070	39.5%	91,148	15.1%	274,883	45.4%	605,101
2008	248,490	38.0%	88,362	13.5%	317,136	48.5%	653,988
2007	252,125	39.4%	100,899	15.8%	286,849	44.8%	639,873
2006	254,498	38.8%	105,684	16.1%	295,306	45.1%	655,488
2005	265,050	39.4%	136,237	20.2%	272,187	40.4%	673,474
2004	274,396	41.9%	141,967	21.7%	238,484	36.4%	654,847
2003	292,899	43.2%	154,524	22.8%	230,041	34.0%	677,464
2002	317,573	48.0%	143,463	21.7%	199,964	30.3%	661,000
2001	324,723	49.6%	138,693	21.2%	191,843	29.3%	655,259
2000	325,816	49.5%	163,789	24.9%	169,105	25.7%	658,710
1999	301,966	47.5%	193,327	30.4%	140,905	22.1%	636,198
1998	317,816	49.3%	221,984	34.4%	104,650	16.2%	644,450
1997	322,242	50.0%	244,623	38.0%	77,628	12.0%	644,493
1996	316,201	48.7%	268,806	41.4%	63,996	9.9%	649,003
1995	320,372	49.9%	264,530	41.2%	56,864	8.9%	641,766
1994	320,369	48.1%	296,508	44.5%	49,192	7.4%	666,069
1993	342,762	51.0%	285,565	42.5%	43,359	6.5%	671,686
1992	331,638	49.9%	299,652	45.1%	33,056	5.0%	664,346
1991	336,931	49.3%	316,115	46.2%	30,723	4.5%	683,769
1990	336,154	48.3%	320,829	46.1%	39,454	5.7%	696,437
1989	336,876	47.3%	329,020	46.2%	46,708	6.6%	712,604

Year	California**	%	Alaska	%	Foreign	%	Total
1988	365,354	51.5%	306,247	43.2%	37,217	5.3%	708,818
1987	386,676	56.8%	260,843	38.3%	33,395	4.9%	680,914
1986	402,230	59.4%	237,508	35.1%	36,877	5.5%	676,615
1985	398,280	61.8%	210,647	32.7%	35,408	5.5%	644,335
1984	369,225	58.3%	210,450	33.2%	53,262	8.4%	632,937
1983	377,125	61.4%	189,538	30.8%	47,991	7.8%	614,654
1982	365,962	61.4%	196,462	33.0%	33,553	5.6%	595,977

** California totals may also include minor amounts from North Dakota and Gulf Coast States.

Source: California Energy Commission, aggregated from Petroleum Industry Information Reporting Act data. Please note that total of foreign oil receipts to refineries will not match that shown on other pages. The Petroleum Industry Information Reporting Act (PIIRA) data gives the breakdown by foreign, California and Alaska but not the foreign countries. The PIERS data includes the foreign breakdown by country but no domestic receipts. U.S. Dept. of Commerce, U.S. Dept. of Energy, Army Corps of Engineers, and State Lands Commission all give different totals by different breakdowns.

CONTACT

Media & Public Communications Office
mediaoffice@energy.ca.gov

CATEGORIES

Topic
Fuels

Division
Fuels and Transportation

CONTACT

California Energy Commission
715 P Street
Sacramento, CA 95814

Contact Us | Directions
Language Services

CAREERS

Come be part of creating a clean, modern and thriving California.

Learn more about Careers

CAMPAIGNS

Register to Vote

California Independent Petroleum Association
1001 K Street, 6th Floor
Sacramento, CA 95814
Phone: (916) 447-1177
Fax: (916) 447-1144

September 18, 2025

Department of Conservation
801 K Street, MS-24-02
Sacramento, CA 95814

Subject: Comments on the SB1137 First Implementation Regulations

To whom it may concern:

The California Independent Petroleum Association (CIPA) appreciates the opportunity to comment on the Department of Conservation Geologic Energy Management Division's (CalGEM) updated SB 1137 First Implementation Regulations. CIPA represents approximately 300 independent oil and gas operators, service and supply companies, as well as royalty owners throughout the State of California who supply the crude oil and natural gas necessary for California's residents to commute to work and school, repair roads and other infrastructure, heat and cool their homes, and keep the lights turned on.

CIPA is submitting this letter to provide our comments on the draft First Implementation Regulations posted for public review on August 1, 2025. Note that submission of these comments in no way indicates that CIPA or its members agree with or accept the false premises on which SB 1137 rests or the Legislature's determination of the need for designated Health Protection Zones in the first place. It is also important to recognize that the state's view of California's energy future has shifted substantially since the passage of SB 1137. It has become clear to the Governor and the Legislature, as indicated through their public statements and actions, that the policies they've adopted to curtail domestic production in the State have directly resulted in the shutdown of the State's refineries and increased the cost of petroleum products for the state's residents, businesses, and visitors – at significant negative environmental impact.

Regardless of the numerous incentives and mandates the State sets for renewable energy and EV vehicles, California's demand for crude oil has continued to climb year over year, reaching 648 million barrels in 2023. At the current rate of increase, California is on track to surpass

consumption recorded in 2004, which exceeded 681 million barrels. Meanwhile, domestic production levels have dropped precipitously to 113 million barrels (2024) and total production of crude oil is likely only to reach 106 million barrels in 2025.[1,2] Therefore, it is imperative that the State act rapidly to mitigate for future refinery closures and stabilize crude oil pipelines that deliver domestic crude to the refineries. Implementation of the proposed First Implementation Regulations under SB 1137 will have the exact opposite effect.

The following sections present our specific comments to each of the documents posted for public review related to the rulemaking process for the First Implementation Regulations.

Comments on Initial Statement of Reasons

While CalGEM's Initial Statement of Reasons about specific sections of the regulation are reasonable and practicable with regard to CalGEM's administrative mandate to implement the rulemaking, the following statements regarding the benefits and costs of the regulations are entirely inaccurate and/or false and should either be deleted or corrected:

- Page 2, *"SB 1137 is intended to assist frontline communities by cleaning up pollution, remediating negative health impacts, and addressing increasing impacts of climate change."* This is a completely false narrative. Implementation of the proposed regulations will not clean or remediate any existing conditions, and will not address any impacts of climate change at all. SB 1137's sole intent is to eliminate the production of crude oil in California. This will (and has) led to a dramatic increase of foreign imports to make up for lost in-state production. Given only California crude is under the state's cap and trade program, every imported barrel exacerbates worldwide GHG emissions.
- Page 45, *"The Department has made an initial determination that the adoption of these regulations will not have a significant statewide adverse economic impact directly affecting business."* This assertion does not align with reality. With the implementation of SB 1137, businesses with legally permitted operations will be stripped of the ability to extract the minerals within their leases making production uneconomic well in advance of the depletion of the resources. This will result in a direct economic impact to production companies as well as the companies that provide services to operators. In addition, cities and counties that rely on revenue from oil and gas production will experience significant shortfalls in their anticipated budgets, resulting in direct impacts to public services and businesses within their jurisdiction.

[1] https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_use/tx/use_tx_CA.html&sid=CA

[2] https://www.conservation.ca.gov/calgem/Online_Data/Pages/WellSTAR-Data-Dashboard.aspx

Comments on Economic Impact Assessment

The summary of potential costs of the regulations as presented in Sections 2 and 3 is inappropriately divided into two buckets – costs to the State and costs to the largest operators in the State. The economic impacts to CIPA members, many of whom operate in the Los Angeles Basin, are entirely ignored in the assessment. Moreover, fiscal costs to CalGEM are, in fact, fiscal costs to operators. CalGEM is fully funded through assessment of operators in the State. Therefore, rather than separated out and presented as if the costs to CalGEM are borne by the state or taxpayers, the analysis should present the total costs to industry. Accordingly, Table 2 should consider the estimated operator cost multiplied by the 226 active operators in the state upon which the cost to CalGEM should be added to that total. This would more actively represent the direct costs of the additional documentation and noticing that would be incurred by industry as result of the regulations (~$104 million). The analysis should be expanded to include the costs for operators to develop monitoring plans, procure and install monitoring devices, conduct gas sampling and gas testing, and complete the required reporting, all of which is currently not considered. This financial burden would obviously have a greater adverse effect on smaller operators than larger ones.

Beyond that, we wholeheartedly agree with CalGEM's note that it is entirely misleading to compare the revenue of the largest operators in the state to the costs of implementation, particularly when net income for the same operators in the same time period is readily available (and less than 10% of the revenue numbers presented). In addition, as mentioned above, CalGEM did not consider the economic impact of the regulations to CIPA members, for whom annual revenue and net income is much less than the five large operators considered in the analysis, but who would bear the same cost in complying with the new regulations.

Most importantly, the Economic Impact Analysis entirely avoids calculation of costs of the implementation of Section 1765.3(a), and the analysis must be revised to disclose these direct costs to operators. This cost is much greater than the simple calculation of how many labor hours it may take to prepare a map or submit a form which is the analysis completed for every other section of the regulation. Rather this cost represents the inability of an operator to produce from the assets for which it has legal surface and/or mineral rights. Without the ability to drill new wells or rework or sidetrack existing wells in Health Protection Zones, the decline rate of existing assets will increase significantly across the board. Section 1765.3(a) would prohibit operators from any activities to maintain or increase current production levels from wells located within Health Protection Zones, which includes nearly all wells in Los Angeles and Orange counties, and over ¼ of all wells in Ventura County. Accordingly, SB 1137 will result in decreased state production, requiring the state to increase its imports, driving up costs for consumers and shifting environmental burdens overseas. This is not speculative or in any way unknown or unable to be estimated. For example, the financial consequence of Section 1765.3(a) has been documented in publicly available documents by the City of Long Beach for the past three years, and those analyses could have easily been referenced and extrapolated

statewide in CalGEM's Economic Impact Analysis. The Economic Impact Analysis must also be expanded to evaluate the cost to the State of importing more oil from overseas to make up for the reduction in domestic production which will directly result from the implementation of Section 1765.3(a).

Comments on the Draft Regulations

Our review of the First Implementation Regulations indicates that CalGEM ignored nearly all of the prior comments CIPA submitted in March 2025, in response to the Discussion Draft Regulations. Accordingly, we are resubmitting those comments in this letter (updated to match the current section numbering in the draft regulation), along with our additional specific suggested revisions to the proposed regulatory language (Attachment A).

In addition to the specific comments included in Attachment A, CIPA notes that the regulations do not include the language requiring CalGEM to issue an NOI if a court finds that SB 1137 effects a taking, even though this requirement is specified in the legislation itself (PRC Section 3281(a)(2)). This language should be explicitly stated in the regulations.

Finally, though not specifically addressed in this proposed rule, there is a parallel process occurring at the Air Resources Board (CARB) to establish performance standards for air quality monitoring under SB 1137. Once established sometime next year via CARB rulemaking, it is imperative that implementation of the Leak Detection and Monitoring Plans be completed in a coordinated and transparent manner with the State's air quality experts, including CARB and the local air districts. CIPA is concerned that there isn't a current understanding of how the Leak Detection and Monitoring Plans will be evaluated or approved, or whom to address if a deficiency is found. Before implementation begins, these important questions need to be resolved.

Conclusion

In conclusion, CIPA remains opposed to SB 1137 and to CalGEM's rulemaking actions pursuant to it, which will further discourage and delay permitting. CIPA encourages CalGEM to revise both its Statement of Reasons and Economic Impact Analysis to provide more accurate and transparent information to the Office of Administrative Law and the public regarding the purpose, intent, and financial impacts of SB 1137, in addition to revising the draft regulations to provide a clear and defined administrative path forward to determine compliance.

Sincerely,



Rock Zierman

CEO, California Independent Petroleum Association

Attachment A - Specific Comments by Section Number

The following table presents CIPA's comments and recommended changes on each specific section of the draft rules for the Division's consideration. Proposed deletions are shown with strike-through and inserts are shown with underline.

Section Number	Proposed Revisions to the Discussion Draft Regulations	Explanation
1765.1	(c) For the purposes of this article, a "sensitive receptor" means any of the following: (1) A residence, including a private home, condominium, apartment, and living quarter. A building or structure in a location not authorized for residential use by local ordinance and zoning law is not a residence.	CIPA appreciates that CalGEM more clearly defined a business open to the public in the draft regulations. We strongly suggest that CalGEM re-include the language regarding non-authorized residences that was previously in the discussion draft. Without this clarification, illegal encampments, RVs, and trailers used as "living quarters" would qualify as a sensitive receptor.
1765.3(b)(2)	(2) ~~A New Production Facility Notice in accordance with Section 1765.5 and Section 1765.5.1 if production facilities are proposed if production facilities are proposed~~	This language does not appear to be supported by SB1137. There was no mention of needing to provide information related to facilities with a NOI. This should be struck from the regulation.
1765.3	(c) If a notice of intention submitted under Public Resources Code section 3203 is for a well with a wellhead that is within a Health Protection Zone, and the basis for approving the proposed operations is to prevent or respond to a threat to public health, safety, or the environment, then the operator shall include the following: (7) Any other information requested by the Division to evaluate the threat to public health, safety, or the environment, and the proposed operations responding to the threat. An explanation of the purpose and need for the proposed operations as it relates to prevention or response of a threat to public health, safety, or the environment (d) The Division may waive some or all requirements of subdivision (c) if the Division determines that it has information and documentation necessary to evaluate the threat and proposed operations."	The language is open-ended and needs to be well defined in order to facilitate CalGEM's ability to efficiently process the request. In 1765. 3 c (1) (2) (3) (4) the operator has to describe a threat to the public, health, safety and or the environment and the magnitude of the risk or harm and likely population to be impacted when the reality is there is no threat, short or long term. In many instances operators need to do work in order to comply with existing regulations, or address an NOV, and ensure the health and safety of the public through proper maintenance of existing wells. Regarding (d) How will this be interpreted? Many permitted operations involve repairs and testing for idle well compliance, which the Division should have all the information on these wells needed to document the threat/operations.
1765.4	(a) Except as provided in subdivisions (c) and (d), operators shall not commence any work that requires a notice of intention under Public	1. Regarding (a). The language, as written, is not clear that water sampling is not required for reworks and sidetracks. CIPA proposes language to make this clear.

Section Number	Proposed Revisions to the Discussion Draft Regulations	Explanation
	Resources Code section 3203 in a Health Protection Zone where planned work involves drilling of a new well (1) The notice required by Public Resources Code section 3284 has been provided to all property owners and tenants at least ~~thirty~~ seven days before work commences. Any new development that is approved within the HPZ after notice has been provided is not subject to this requirement and no additional noticing by operators is required prior to commencing work. (c) The Division may waive the requirements of Public Resources Code section 3284 if the operator demonstrates that the delay in well work associated with the requirements of this section is likely to result in significant damage to life, health, or natural resources and prompt work would result in improved environmental setting or natural resources. (2) The operator shall provide documentation of the benefits of proceeding with work risk associated with the delay caused by the sampling and testing process including a qualitative discussion of the probability that the harm will occur and a rough estimate of the potential magnitude of the impacts of the harm that is likely to result.	2. CIPA believes 7 days should be sufficient as with other notifications. CIPA maintains there is no associated risk. The language is open-ended and the additional clause helps to prevent repeated and unnecessary requests for sampling. Section 1765.4 imposes prescriptive requirements regarding the format, timing, and documentation of water sampling and notice submissions. In contrast, the statute (PRC Section 3281(b)) only requires that operators provide a simple certification or statement confirming compliance. These additional details extend beyond the statutory mandate and unnecessarily increase the administrative burden on operators.
1765.4.1	(a) Operators shall adhere to the following requirements when providing notice to property owners and tenants under Public Resources Code section 3284: (1) the notice shall describe the nature, location, duration, and approximate timing of the work to be performed. (2) the notice shall offer to sample and test private domestic water wells or surface water on their property that property owners have documented water rights to for the purposes of domestic use before and after drilling in accordance with the requirements of Public Resources Code section 3284.	Before commencing work in the HPZ, the operator must notify all property owners and tenants within the HPZ and offer to test wells or surface water on the property. How will operators gain access to multi-unit communities that are, for example, gated or otherwise restricted? What is the procedure if tenants do not answer the door or ignore the notice, particularly if the owner of the property signs the notice? Practically, operators may want to submit their notices at the same time they submit NOIs. But the timing of operations is subject to receiving the NOI (which is subject to CalGEM's extensive permitting review delays), and, therefore, may be difficult to estimate. The operator may only be able to give a rough estimate. We also reiterate our comment that water sampling shall be limited to only those resources for which property owners have the rights for purposes of domestic use.

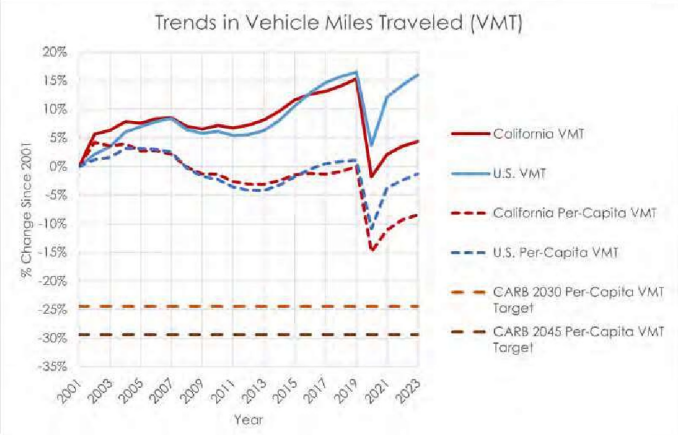
Section Number	Proposed Revisions to the Discussion Draft Regulations	Explanation
1765.5.1(a)(1)	New Production Facility Notice shall include the following information about the proposed new or newly operated production facility: (A) Production facility type. (B) Production facility purpose. (C) Production facility name. (D) Production facility size. (E) Production facility location, including latitude and longitude coordinates of the proposed production facility. If the proposed new production facility is a pipeline, then the operator shall provide the longitude and latitude coordinates for each end of the pipeline and the point location of the pipeline segment that is nearest to the sensitive receptor closest to the pipeline.	This is redundant and already covered by other regulations.
1765.5.1.	(c) If the basis for the proposed new construction or operation of a production facility is that the production facility is necessary to protect public health and safety, then the operator shall provide the following unless there is imminent danger which is communicated to the district.: ~~(7) Any other information requested by the Division to evaluate the threat to public health and safety and the proposed production facility to respond to the threat.~~	This language is open-ended and needs to be well defined in order to facilitate CalGEM's ability to efficiently process the request
1765.6.	~~Annual~~ Submission of Sensitive Receptor Inventory and Map (a) For purposes of ~~the annual~~ Notice of Intent required submission of a sensitive receptor inventory and a sensitive receptor map as required under Public Resources Code section 3285, an operator shall submit all of the following: ~~(3) For each of the operator's wellheads and production facilities determined by the operator not to be located within a Health Protection Zone, a statement to the effect and all the supporting information and explanation described in Section 1765.9 subdivision a, upon which the operator based its determination.~~	Calling for an annual inventory needs to be redefined in order to facilitate CalGEM's ability to efficiently process requests. Submissions should be limited for when an NOI is required. The sensitive receptor inventory must identify sensitive receptors based on the location of all of the operator's wellheads and production facilities. For wellheads not within the HPZ, operators must submit a statement that identifies all buildings, permanent structures, parks, or any other site identified as a potential sensitive receptor and explain why each feature does not meet the definition of a sensitive receptor. This requirement is overly burdensome. The definition of a sensitive receptor is clearly provided in the regulation and any other feature that

Section Number	Proposed Revisions to the Discussion Draft Regulations	Explanation
		does not meet that definition should not require any additional explanation.
1765.7	(a) (C) If the inventory is submitted in connection with an annual inventory submission under Public Resources Code section 3285, then the scope of the inventory shall make a determination that all of their respective wellheads and production facilities are located within a health protection zone. ~~include identification of:~~ ~~(i) Each wellhead located in a health protection zone;~~ ~~(ii) Each production facility located in a health protection zone; and~~ ~~(iii) Each wellhead and production facility identified in the inventory shall have an entry that identifies at least one sensitive receptor within 3200 feet of that wellhead or production facility based on the location of all each of the operator's wellheads and production facilities, consistent with Section 1765.6. ".~~ (a)(2)(D) ~~The distance in feet between the sensitive receptor of the operator's wellheads, proposed wellheads, production facilities, or proposed production facilities that are identified in the inventory and are within 3,200 feet of the sensitive receptor.~~	1. Sensitive Receptor (SR) Inventories/Maps for Urban Operations (all Ops in HPZ): PRC 3285 (a) (2) states "An operator who has identified sufficient sensitive receptors such that their entire operation is located within a health protection zone may cease adding new sensitive receptors to their inventory and make a determination that all of their wellheads and production facilities are located within a health protection zone." How do you handle urban operations where all facilities are in an HPZ? This requires operators to include much more information than PRC 3285 requires if all their operations are in an HPZ. The statutory language focuses on identifying sensitive receptors and then adding data relative to operations (wellheads/facilities in HPZ). On the other hand, the regulations focus on identifying all operations and then adding data for sensitive receptors. This is important when all operations are in an HPZ, no additional data is needed to be added after showing that all operations are in an HPZ.
1765.8	(b)(1) ~~The map shall be presented in a letter-sized (8.5"x11") layout.~~ The map shall be presented at a size sufficient to display all of the required information at the scale specified in the regulation. As an alternative, operators may submit the required information to CalGEM in KMZ or GIS datafiles.	There is no way we will be able to fit all the information requested onto a 8X11 map in PDF format without obscuring information. Further asking Operators to piece maps together to create a larger view is antiquated and Operators should be allowed to present information to CalGEM in a KMZ or GIS shapefile. PRC does not specify a paper size or scale requirement for sensitive receptor maps.
1765.9.	(a) Operators seeking to demonstrate that a location is not within a Health Protection Zone shall provide a statement to the Division. ~~that adheres to the following requirements:~~ ~~(1) The statement shall identify all of the following features located within 3,200 feet of the location:~~ ~~(A) All buildings, including all permanent, installed, rigid walled structures;~~	PRC Section 3281(b) requires only that an operator certify—by a simple statement—that no sensitive receptors exist within 3,200 feet of the wellhead. The current proposed requirements in §1765.9, which demand detailed inventories, including building addresses and comprehensive data, exceed the statutory mandate. The PRC does not require this additional information, which unnecessarily burdens operators.

Section Number	Proposed Revisions to the Discussion Draft Regulations	Explanation
	~~(B) All parks, including all areas open to the public for outdoor recreation; and~~ ~~(C) Any site that the Division has identified as a potential sensitive receptor.~~ ~~(2) The statement shall include the physical address of each identified feature, including the city, postal zip code, street name and number, and, if necessary to distinguish the sensitive receptor, a unit or building number.~~ ~~(3) The statement shall explain why each of the features identified do not meet the definition of a "sensitive receptor" under Section 1765.1.~~ (1~~3~~) The statement shall be submitted in .txt, .docx, or .pdf format. (b) When the Division reviews a statement provided under subdivision (a~~) and submitted in connection with a notice of intention under Public Resources Code section 3203~~, the Division will review the information provided, and any other relevant information, and determine on a case-by-case basis whether each feature identified is a sensitive receptor as defined in Section 1765.1 and consistent with the purposes of this article. If the Division agrees that the location is not within a Health Protection Zone, then the Division will provide a written verification that, as of the date of determination, the subject location is not within a Health Protection Zone. Within 30 days of the submittal of the statement, the Division shall respond either that the Division agrees or disagrees that the location is or is not within a Health Protection Zone, and within that same period then the Division will provide a written verification that, as of the date of determination, the subject location is within or not within a Health Protection Zone."	

California VMT Data

Trends in Vehicle Miles Traveled (VMT)



VMT across the U.S. and California is trending upward, undermining our policy goals around climate, equity, and safety. Before the Covid-19 pandemic, total and per-capita VMT was increasing, both in California and in the United States more broadly. While VMT decreased sharply during the pandemic, it has since rebounded with national VMT returning to pre-pandemic levels. California VMT diverged from national trends somewhat during this period, falling well below U.S. VMT during the height of the pandemic in 2020 and recovering more slowly afterwards, but it is trending upward again.

To meet the state's ambitious climate goals, daily per-capita VMT must reach 17.2 by 2045 (a 29% reduction from 2001 levels). While California may have lower per-capita VMT than the U.S., it is still far above the levels needed to reach that goal and is trending in the wrong direction. Caltrans and its partners are striving to improve these trends by working to provide better access to destinations for all modes.

Data sources:

- California Public Roads Data
- California Population Estimates
- USDOT Highway Statistics Series (2001 - 2022 national VMT data)
- December 2023 Traffic Volume Trends (2023 VMT national VMT data)
- U.S. Population Estimates
- California Air Resources Board 2022 Scoping Plan Appendix E

A note on VMT data:

This analysis utilizes state-level Highway Performance Monitoring System (HPMS) data and national-level Highway Statistics Series data, which is derived from state-level HPMS data. There are several known issues with these data sources, as discussed in CARB's 2022 SB 150 Report, Appendix A. For their analysis, CARB utilized a hybrid approach, combining HPMS data with regional vehicle registration and fuel sales data. While appropriate for state-level analysis, this methodology was not feasible as national-level datasets weren't readily available. With these limitations in mind, HPMS data is used here due to a lack of alternative data sources. If more reliable datasets become available, this analysis will be updated. It is important to note that while different VMT data sources provide different VMT estimates, the overall trends remain relatively consistent across analyses.

Menu

- Home
- Implementation Resources
- SB 743 Working Group
- California VMT Data
- Newsletter

Contact Us

SB743.Implementation@dot.ca.gov

Subscribe for updates

Statewide Campaigns

- ADA Access
- Adopt-A-Highway
- Amber Alert
- Be Work Zone Alert
- CAL FIRE
- Cal OES: Power Outage and Fire Recovery Resources
- California Climate Investments
- California Connected
- California Transportation Plan 2050
- Clean California
- Go Safely California
- HeatReadyCA.com
- REAL ID
- Save Our Water
- Stormwater Education Campaign

DAY ▪ CARTER ▪ MURPHY LLP

▪ 3620 American River Dr., Suite 205
Sacramento, CA 95864
T: 916.570.2500

▪ daycartermurphy.com

▪ Tracy K. Hunckler
thunckler@daycartermurphy.com

September 29, 2025

VIA EMAIL ONLY
cpc@lacity.org

Los Angeles City Planning Commission
c/o The Commission Executive Assistant
200 N. Spring Street, Room 763
Los Angeles, CA 90012

Re: *Case No. ZA-2025-2976-ZAI-1A – Agenda Item No. 12 (October 9, 2025 CPC Meeting)*
Warren Supplemental Submission in Support of Appeal of ZA-2025-2976-ZAI

Honorable Commissioners:

We represent Warren E&P, Inc.; Warren Resources of California, Inc.; and Warren Resources, Inc.; (collectively "Warren")[1] in its appeal of Zoning Administrator Interpretation ZA-2025-2976-ZAI, dated June 12, 2025, which purports to define "maintenance" as it is used in Los Angeles Municipal Code ("LAMC") sections 13.01-H and 13.01-I (the "ZAI"). Warren submitted a justification statement in support of its timely appeal in June of this year, which arguments are incorporated herein by reference as if stated in full, as are Warren's arguments in support of its appeal of the 2023 Zoning Administrator Interpretation ZA-2022-8997-ZAI (herein, the "2023 ZAI"). In addition to those legal arguments, Warren submits the following.

The County of Los Angeles Department of Regional Planning ("LA County Planning") has prepared an Initial Study in connection with the County's Revised Oil Well Ordinance which, like the ZAI, is designed to phase out oil production activities in the County. The County's Initial Study is attached. Therein, the County concludes that preparation of an Environmental Impact Report ("EIR") under the California Environmental Quality Act ("CEQA") is required in connection with the adoption of the County's Revised Oil Well Ordinance due to the potentially significant impacts to mineral resources. As previously explained in more detail, the City's ZAI is a de facto ban on maintenance

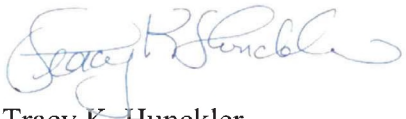
[1] Warren operates a drilling and production site and holds mineral interests within the City and would be detrimentally affected by the Project. It has a beneficial interest that would be adversely affected by the environmental impacts associated with the Project, and the Project will otherwise have a direct, substantial effect on Warren and its operations. Further, Warren makes these comments on behalf of the public interest, which interest would suffer if the City were not compelled to perform its duties under CEQA.

activities in support of the City's restriction of oil and gas operations. As with the County's ordinance, then, an EIR under CEQA is similarly necessary in connection with the City's ZAI, which will undoubtedly have an impact on mineral resources, among other potential environmental impacts that the City has failed to consider despite Warren and others urging such consideration.

Warren therefore continues to urge the City to reconsider adoption of the ZAI for all of the reasons previously expressed, and with particular attention to the need for environmental review.

Sincerely,

DAY CARTER & MURPHY LLP



Tracy K. Hunckler

Attachment

ENVIRONMENTAL CHECKLIST FORM
INITIAL STUDY

LA COUNTY PLANNING

PROJECT SUMMARY

Project Title	Revised Oil Well Ordinance
Project No./Case No.	PRJ2025-000212
Related Case No(S).	RPPL2025000276, RPPL2025000277, RPPL2025000284
Lead Agency Name & Address	County of Los Angeles Department of Regional Planning ("LA County Planning") 320 W. Temple Street, 13th Floor Los Angeles, CA 90012
Location & Custodian of Record of Proceedings	LA County Planning 320 W. Temple Street, 13th Floor Los Angeles, CA 90012
Staff Contact	Kenneth Warner
Staff Email & Phone Number	ordinance@planning.lacounty.gov (213) 974-6432
Project's Sponsor/ Project Applicant's Name & Address	LA County Planning 320 W. Temple Street, 13th Floor Los Angeles, CA 90012
Project Location	Los Angeles County (Countywide)
Assessor's Parcel Number (APN)	N/A
USGS Quad	N/A
Gross Acreage	Approximately 1,696,000 acres (approximately 2,650 square miles)
Supervisorial District	Countywide
General Plan or Community/Area Plan Designation	Implementation of the Revised Oil Well Ordinance, once approved, would occur throughout unincorporated Los Angeles County in all General Plan and Area Plan designations.
Planning Area	Implementation of the Revised Oil Well Ordinance, once approved, would occur throughout unincorporated Los Angeles County in all Planning Areas.
Zoning/Community Standards District (if applicable)	Implementation of the Revised Oil Well Ordinance, once approved, would occur throughout unincorporated Los Angeles County in all zoning designations and Community Standards Districts.

Brief Description of Project:

The project includes: i) Amendments to Title 22 – Planning & Zoning of the Los Angeles County Code to prohibit new oil wells and production facilities, designate existing oil wells and production facilities as nonconforming due to use, and modify standards for oil wells during the amortization period ii) Amendments to the Baldwin Hills Community Standards District (CSD) to be consistent with Countywide prohibition of oil wells and production facilities and standards for oil wells during the amortization period, iii) Amendments to Title 12 - Environmental Protection of the Los Angeles County Code to remove noise exemptions for oil wells, and iv) Amendments to the General Plan in support of sustainability and environmental justice goals by phasing out oil production in unincorporated Los Angeles County.

Surrounding Land Uses & Setting:

The affected areas are adjacent to open space, residential, commercial, and industrial zones in urban, suburban, and rural settings across Los Angeles County.

Native American Consultation:
Have California Native American tribes traditionally and culturally affiliated with the project area requested consultation pursuant to Public Resources Code § 21080.3.1?

☐ Yes ☒ No

If so, is there a plan for consultation that includes, for example, the determination of significance of impacts to tribal cultural resources, procedures regarding confidentiality, etc.?

LA County Planning has notified California Native American tribes pursuant to AB 52. LA County Planning will comply with all provisions of AB 52 and SB 18.

Note: Conducting consultation early in the CEQA process allows tribal governments, lead agencies, and project proponents to discuss the level of environmental review, identify and address potential adverse impacts to tribal cultural resources, and reduce the potential for delay and conflict in the environmental review process. (See Public Resources Code section 21080.3.2.) Information may also be available from the California Native American Heritage Commission's Sacred Lands File per Public Resources Code section 5097.96 and the California Historical Resources Information System administered by the California Office of Historic Preservation. Please also note that Public Resources Code section 21082.3(c) contains provisions specific to confidentiality.

Other public agencies whose approval is required (e.g. permits, financial approval, or participation agreements):

Public Agency	*Approval Required*
None	None

Concurrent projects in the area:

Project/Case No.	*Description and Status*
None	None

Reviewing Agencies:

Responsible Agencies

- ☒ None
- Regional Water Quality Control Board:
  - ☐ Los Angeles Region
  - ☐ Lahontan Region
- ☐ Coastal Commission
- ☐ Army Corps of Engineers
- ☐ LAFCO

Special Reviewing Agencies

- ☒ None
- ☐ Santa Monica Mountains Conservancy
- ☐ National Parks
- ☐ National Forest
- ☐ Edwards Air Force Base
- ☐ Resource Conservation District of Santa Monica Mountains

Regional Significance

- ☒ None
- ☐ SCAG Criteria
- ☐ Air Quality
- ☐ Water Resources
- ☐ Santa Monica Mtns. Area

Trustee Agencies

- ☒ None
- ☐ State Dept. of Fish and Wildlife
- ☐ State Dept. of Parks and Recreation
- ☐ State Lands Commission
- ☐ University of California (Natural Land and Water Reserves System)

County Reviewing Agencies

- ☒ DPW
- ☒ Fire Department
  - Forestry, Environmental Division
  - Health Hazmat
- ☐ Sanitation District
- ☒ Public Health/Environmental Health Division: Drinking Water Program (Private Wells), Toxics Epidemiology Program (Noise)
- ☐ Sheriff Department
- ☐ Parks and Recreation
- ☐ Subdivision Committee

ENVIRONMENTAL FACTORS POTENTIALLY AFFECTED

The environmental factors checked below would be potentially significant impacts affected by this project.

- ☐ Aesthetics
- ☐ Agriculture & Forestry
- ☐ Air Quality
- ☐ Biological Resources
- ☐ Cultural Resources
- ☐ Energy
- ☐ Geology & Soils
- ☐ Greenhouse Gas Emissions
- ☐ Hazards & Hazardous Materials
- ☐ Hydrology/Water Quality
- ☐ Land Use/Planning
- ☒ Mineral Resources
- ☐ Noise
- ☐ Population/Housing
- ☐ Public Services
- ☐ Recreation
- ☐ Transportation
- ☐ Tribal Cultural Resources
- ☐ Utilities/Service Systems
- ☐ Wildfire
- ☐ Mandatory Findings of Significance

DETERMINATION (To be completed by the Lead Agency)

On the basis of this initial evaluation:

☐ I find that the proposed project **COULD NOT** have a significant effect on the environment, and a **NEGATIVE DECLARATION** will be prepared.

☐ I find that although the proposed project could have a significant effect on the environment, there will not be a significant effect in this case because revisions in the project have been made by or agreed to by the project proponent. A **MITIGATED NEGATIVE DECLARATION** will be prepared.

☒ I find that the proposed project MAY have a significant effect on the environment, and an **ENVIRONMENTAL IMPACT REPORT** is required.

☐ I find that the proposed project MAY have a "potentially significant impact" or "potentially significant unless mitigated" impact on the environment, but at least one effect 1) has been adequately analyzed in an earlier document pursuant to applicable legal standards, and 2) has been addressed by mitigation measures based on the earlier analysis as described on attached sheets. An **ENVIRONMENTAL IMPACT REPORT** is required, but it must analyze only the effects that remain to be addressed.

☐ I find that although the proposed project could have a significant effect on the environment, because all potentially significant effects (a) have been analyzed adequately in an earlier **EIR** or **NEGATIVE DECLARATION** pursuant to applicable standards, and (b) have been avoided or mitigated pursuant to that earlier **EIR** or **NEGATIVE DECLARATION**, including revisions or mitigation measures that are imposed upon the proposed project, nothing further is required.

Kenneth Warner		3/27/25
Print Name (Project Planner)	Signature (Project Planner)	Date

Bruce Durbin		3/27/25
Print Name (Section Head)	Signature (Section Head)	Date

EVALUATION OF ENVIRONMENTAL IMPACTS:

1) A brief explanation is required for all answers except "No Impact" answers that are adequately supported by the information sources the lead agency cites in the parentheses following each question. A "No Impact" answer is adequately supported if the referenced information sources show that the impact simply does not apply to projects like the one involved (e.g., the project falls outside a fault rupture zone). A "No Impact" answer should be explained where it is based on project-specific factors as well as general standards (e.g., the project will not expose sensitive receptors to pollutants, based on a project-specific screening analysis).
2) All answers must take account of the whole action involved, including off-site as well as on-site, cumulative as well as project-level, indirect as well as direct, and construction as well as operational impacts.
3) Once the lead agency has determined that a particular physical impact may occur, then the checklist answers must indicate whether the impact is potentially significant, less than significant with mitigation, or less than significant. "Potentially Significant Impact" is appropriate if there is substantial evidence that an effect may be significant. If there are one or more "Potentially Significant Impact" entries when the determination is made, an EIR is required.
4) "Negative Declaration: Less Than Significant With Mitigation Incorporated" applies where the incorporation of mitigation measures has reduced an effect from "Potentially Significant Impact" to a "Less Than Significant Impact." The lead agency must describe the mitigation measures and briefly explain how they reduce the effect to a less than significant level. (Mitigation measures from Section XVII, "Earlier Analyses," may be cross-referenced.)
5) Earlier analyses may be used where, pursuant to the tiering, program EIR, or other CEQA processes, an effect has been adequately analyzed in an earlier EIR or negative declaration. (State CEQA Guidelines § 15063(c)(3)(D).) In this case, a brief discussion should identify the following:
    a) Earlier Analysis Used. Identify and state where they are available for review.
    b) Impacts Adequately Addressed. Identify which effects from the above checklist were within the scope of, and adequately analyzed in, an earlier document pursuant to applicable legal standards, and state whether such effects were addressed by mitigation measures based on the earlier analysis.
    c) Mitigation Measures. For effects that are "Less than Significant with Mitigation Measures Incorporated," describe the mitigation measures which were incorporated or refined from the earlier document and the extent to which they address site-specific conditions for the project.
6) Supporting Information Sources: A source list should be attached, and other sources used, or individuals contacted should be cited in the discussion.
7) The explanation of each issue should identify: the significance threshold, if any, used to evaluate each question, and mitigation measures identified, if any, to reduce the impact to less than significant. Sources of thresholds include the County General Plan, other County planning documents, and County ordinances. Some thresholds are unique to geographical locations.

PROJECT DESCRIPTION

Overview

The project is an ordinance amending the Los Angeles County Code and an amendment to the County of Los Angeles General Plan.

This ordinance and general plan amendment establish a regulatory framework to phase out oil production activities in unincorporated Los Angeles County. Specifically, the project includes amendments to the Los Angeles County Planning & Zoning Code (Title 22) including the Baldwin Hills Community Standards District (CSD), the County Environmental Protection Code (Title 12), and the County of Los Angeles General Plan. These updates will align County land use policies with regional sustainability and environmental justice goals, while ensuring the safe and orderly phase out of oil production activities.

1. Title 22 (Planning & Zoning) Oil Well Ordinance:

   Under the proposed ordinance, no new oil wells or production facilities may be established in any zone. Pursuant to Section 22.172 of the County Code (Nonconforming Uses, Buildings, and Structures), existing, legally established oil wells or production facilities operating without an approved Conditional Use Permit or other discretionary permit will be considered nonconforming and subject to a 20-year amortization period. In addition, the ordinance establishes performance standards addressing signage, comment and complaint logging, site maintenance, bonding, well plugging, and site abandonment and restoration. This ordinance would apply to all oil wells in unincorporated Los Angeles County, except in the Coastal Zone.

2. Baldwin Hills Community Standards District (CSD) Amendment:

   The project amends the Baldwin Hills CSD to align with and fully implement the provisions of the Title 22 Oil Well Ordinance described above, ensuring consistent application of the new regulations and standards within the Baldwin Hills CSD area.

3. Removal of Title 12 (Environmental Protection) Exemption for Oil & Gas Wells:

   The project eliminates the current exemption of oil and gas wells from the Noise Control regulations set forth in Title 12 of the County Code. Consequently, these wells will be subject to all provisions of the Noise Control chapter, ensuring better management of noise impacts related to oil and gas extraction activities.

4. General Plan Amendment:

   The project amends the General Plan. Specifically, it revises the Land Use Element, Conservation and Natural Resources Element, and Safety Element to prohibit new oil well operations and remove designations that support oil production activities.

Background

Los Angeles County has a long history of oil production, much of it occurring in densely populated and environmentally sensitive areas. Over time, concerns about oil production's potential negative impacts to public health, safety, and environmental quality—especially near homes, schools, and parks—have intensified. In response, the County of Los Angeles Board of Supervisors has prioritized environmental justice and transition away from fossil fuel dependence. Key actions informing this project include:

- A 2021 Board Motion emphasizing the protection of public health and directing the development of an Oil Well Ordinance.
- Findings from the Baldwin Hills Community Standards District (CSD) and its associated EIRs, which identified air quality degradation, potential hazards, and other risks stemming from oil production.

Building upon these initiatives, this project aligns with the County's sustainability goals by reducing stationary pollution sources and promoting healthier, more livable communities. The project will amend the General Plan and Los Angeles County Code to provide a regulatory framework for phasing out oil operations in the unincorporated areas. Although the County plays a key role, oil wells and production facilities are also regulated and permitted by a network of federal, state, regional, and local agencies. These include California Department of Transportation (Caltrans), California Water Boards (RWQCB), California Department of Conservation Geologic Energy Management Division (CalGEM), California Department of Toxic Substances Control (DTSC), California Occupational Safety and Health Administration (CalOSHA), Department of Transportation (USDOT), Environmental Protection Agency (USEPA), Governor's Office of Emergency (Cal OES), Occupational Safety and Health Administration (OSHA), South Coast Air Quality Management District (SCAQMD), and State Fire Marshall. In addition to the Department of Regional Planning (DRP), Los Angeles County agencies include the Fire Department, Department of Public Health (DPH), and Public Works (PW).

Recent statewide legislation complements the project and reinforces the County's sustainability and environmental justice efforts, including:

- Senate Bill 1137 (2022): Establishes 3,200-foot health protection zones around sensitive receptors like residences, schools, and hospitals, prohibiting new oil and gas wells within these areas and imposing stricter standards on existing operations. While SB 1137 sets state-level restrictions based on proximity to sensitive receptors, the project takes a broader approach, prohibiting new wells countywide in unincorporated areas, as well as phasing out existing oil operations.
- Assembly Bill 1866 (2024): Increases fees for idle wells statewide and requires stricter Idle Well Management Plans (IWMPs) to compel operators to properly close and remediate wells.
- Assembly Bill 2716 (2024): Targets low-production wells in the Inglewood Oil Field, requiring all such wells there to be closed and abandoned by December 31, 2030.
- Assembly Bill 3233 (2024): Strengthens local authority by confirming the power of local governments to regulate or prohibit oil and gas operations via ordinance.

Proposed Performance Standards During Amortization

During the amortization period for existing oil wells and production facilities, the Title 22 (Planning & Zoning) Oil Well Ordinance and Baldwin Hills Community Standards District (CSD) Amendment,

described above, propose a set of performance standards designed to ensure that ongoing operations are safe, orderly, and minimally impactful to surrounding communities during the phase-out process. These standards apply countywide to any oil well or production facility subject to the Title 22 Oil Well Ordinance or Baldwin Hills CSD Amendment and will be phased in according to specific timelines. Requirements for signage, complaint tracking, site maintenance, bonding, and well abandonment ensure that the eventual retirement and restoration or conversion of each site proceeds in a responsible manner.

1. Applicability and Compliance Schedule

Existing oil wells and production facilities become nonconforming uses upon the effective date of this project, unless they already operate under a discretionary permit with a defined expiration. These nonconforming wells must comply with certain provisions immediately, such as site maintenance and well abandonment requirements, while other standards take effect after one or two years. This tiered compliance schedule allows operators time to update signage, institute complaint-tracking procedures, post bonds, and address other operational details before permanently shutting down their wells.

2. Signage Requirements

To maintain orderly operations and facilitate oversight, operators must install specific signs at each well site or production facility. Sites where oil production is the sole use will display entrance identification signs that include the operator's name, the lease name, and relevant contact numbers for odor complaints (South Coast Air Quality Management District) and land-use inquiries. Wells on lots with other primary uses will also post signage at any fenced perimeter. These signage rules, along with requirements for well identification signs, ensure that members of the public and regulators can quickly identify an operator and locate the correct reporting channel for issues.

3. Complaint and Comment Log

Operators must establish a written log tracking all incoming comments and complaints about site operations, whether conveyed by phone or email. This log records the date, time, and nature of each complaint, as well as the response offered. Operators must respond within 24 hours (or the next business day), providing an update on actions taken to address the issue. The log must be available to the Director of Regional Planning upon request, promoting accountability and enabling prompt resolution of nuisance or hazard concerns.

4. Site Maintenance Provisions

Recognizing that oil production facilities can affect local aesthetics and public safety, the project imposes rigorous site maintenance rules. Operators must keep all structures, fences, walls, and equipment in good condition, free of graffiti, rust, or staining. Pools of oil, water, or debris must be removed, and any weeds or dry brush within 25 feet of wells or production facilities must be cleared to reduce fire risk. Any drilling or repair equipment that is no longer in use must be removed within 90 days. Once a well is abandoned, the site must be restored to its original condition as nearly as practicable.

5. Bonding Requirements

To safeguard against potential financial shortfalls that could leave wells improperly closed or sites unremediated, operators will be required to post indemnity bonds. The Director of Regional Planning sets the amount (no less than $152,000 per well), based on the site's complexity and operational scope. The bond ensures coverage of well plugging, reabandonment if required by the

California Geologic Energy Management Division (CalGEM), and remediation efforts if contamination is discovered. These bonds may be reassessed every five years and are released only when all wells on a site have been fully plugged and the lot restored to the Director's satisfaction.

6. Well Plugging and Abandonment

In alignment with CalGEM standards, this project confirms that wells must be properly sealed, equipment removed, and contaminated materials disposed of in an approved manner. Operators are required to clear unused pipelines and clean the well site of oil and debris. The closure process must be completed expeditiously—within 60 days following plugging—while final restoration must occur no later than one year after the last well on a lot is abandoned, unless CalGEM approves a longer timeline.

These performance standards ensure that operators fulfill all environmental and public health obligations until the completion of site restoration. Items such as signage and complaint logging address the immediate need for transparency and responsiveness, while bonding and well-abandonment provisions protect against long-term risks, including soil contamination, fire hazards, and visual blight. The project thus facilitates a responsible phase-out of oil production, striking a balance between operator feasibility and community welfare.

Plugging & Abandoning Oil Wells in California

The California Geologic Energy Management Division (CalGEM) and state legislature have established specific requirements for plugging and abandoning oil wells in California to protect public health and prevent environmental hazards. These regulations, codified under Title 14 of the California Code of Regulations and Chapter 1 of the Public Resources Code, ensure that all wells are safely decommissioned. Key requirements include:

1. Cement Plugging: Wells must be sealed with cement plugs to isolate oil and gas zones and prevent contamination of freshwater aquifers. Cement plugs are typically placed at the bottom of the well, across oil or gas zones, and at intervals to ensure complete isolation.
2. Freshwater Protection: Cement barriers are required to protect freshwater zones from potential contamination by hydrocarbons or other harmful substances. This includes placing a minimum 200-foot cement plug across fresh-saltwater interfaces.
3. Removal of Equipment: All production equipment, pipelines, and associated infrastructure must be removed from the site during abandonment. Any materials that pose contamination risks must be properly disposed of in accordance with state and federal regulations.
4. Surface Restoration: After the plugging process, the well site must be restored to its original condition or adapted for future use. This includes regrading the site, reseeding vegetation, and addressing any soil contamination.
5. Inspection and Compliance: CalGEM inspectors oversee plugging and abandonment operations to ensure compliance with applicable standards. This includes verifying the proper placement of cement plugs, the removal of equipment, and the adequacy of surface restoration efforts.
6. Idle and Hazardous Wells: Idle wells that are not currently producing oil or gas must be managed under strict guidelines to prevent them from becoming environmental hazards. Hazardous or deserted wells are prioritized for immediate abandonment and remediation.

7. Financial Assurance: Operators are required to post indemnity bonds or other financial assurances to cover the costs of plugging, abandonment, and site restoration. The amount of the bond depends on the well's depth, location, and complexity.
8. Special Requirements: In some cases, additional measures may be necessary, such as enhanced cementing techniques for fractured formations or the use of bridge plugs to secure specific zones within a well.

These regulations ensure that abandoned oil wells do not pose ongoing risks to public health, safety, or the environment. The Title 22 (Planning & Zoning) Oil Well Ordinance and Baldwin Hills Community Standards District (CSD) Amendment, described above, require that wells are plugged and abandoned in compliance with all CalGEM regulations.

ENVIRONMENTAL SETTING

Project Location

Los Angeles County spans approximately 4,083 square miles and is home to 88 cities and unincorporated areas totaling approximately 2,656 square miles. These unincorporated regions feature diverse landscapes, ranging from densely populated urban neighborhoods to rural and agricultural areas. The project applies to the unincorporated areas of Los Angeles County.

The project area hosts a broad range of land use designations, including residential, industrial, open space, and agricultural zones, many of which are directly adjacent to existing oil production activities. These oil production activities, especially concentrated in areas like the Baldwin Hills CSD area within the Inglewood Oil Field, raise concerns about land use compatibility, environmental quality, and negative impacts to public health.

Figures 1 and 2 provide maps of the unincorporated areas and the boundaries of the Baldwin Hills CSD to illustrate the project's geographic scope.

Site Background

The unincorporated areas of Los Angeles County span diverse and distinct regions. To provide a mechanism for local communities to work with the County to develop plans that respond to their unique character, the County of Los Angeles General Plan establishes 11 Planning Areas. The project specifically addresses areas where oil production activities are currently active or could potentially expand, including but not limited to the areas detailed below for each Planning Area:

1. Antelope Valley Planning Area
    a. Characterized by vast, open desert terrain and lower population densities, oil production is limited in this region but located near agricultural and rural residential uses.
2. Coastal Islands Planning Area
    a. No known major oil resources.
3. East San Gabriel Valley Planning Area
    a. The Whittier Oil Field, in the Puente Hills near the city of Whittier, was discovered in 1897 and became a significant oil producer in the early 20th century. The area has a history of oil drilling, with several companies operating in the region. The Whittier Oil Field is located near natural habitats and urban areas.
4. Gateway Planning Area
    a. While sparse oil operations exist in the unincorporated communities of the Gateway Planning Area, the Area's major oil fields—including Santa Fe Springs, Long Beach, and Seal Beach—are largely within incorporated cities.
5. Metro Planning Area
    a. Discovered in 1923, the Dominguez Oil Field is situated beneath the Dominguez Hills near Carson, California, approximately fourteen miles south of downtown Los Angeles. It became a significant oil producer from its inception through the 1960s, leading to the establishment of numerous refineries and industrial complexes in the area. The field is adjacent to urban areas, educational institutions, and residential neighborhoods.

6. San Fernando Valley Planning Area
    a. Located in the Santa Susana Mountains north of the Porter Ranch neighborhood, the Aliso Canyon Oil Field was discovered in 1938. It peaked as an oil producer in the 1950s and was later repurposed as a natural gas storage facility in the 1970s.
7. Santa Clarita Valley Planning Area
    a. Nestled between the Santa Susana, San Gabriel, and Sierra Pelona Mountains, this region encompasses active oil production areas such as Pico Canyon and Placerita Canyon. Historically significant as the site of California's first commercially successful oil well, the valley's oil activities are now located near residential areas, open space preserves, recreational, and institutional uses.
8. Santa Monica Mountains Planning Area
    a. Santa Monica Mountains North Area: Known for its scenic and ecological significance, this region has a limited number of oil production activities primarily located near the northern foothills and adjacent valleys. While extraction is less intensive here compared to other regions, operations are in proximity to protected open spaces, wildlife corridors, and recreational areas.
9. South Bay Planning Area
    a. Discovered in 1932, the Wilmington Oil Field is one of the largest in the United States, originally containing approximately three billion barrels of oil. It extends from San Pedro Bay through Long Beach and east of the Palos Verdes Peninsula, including the unincorporated community of West Carson.
10. West San Gabriel Valley Planning Area
    a. Discovered in 1917, the Montebello Oil Field is situated in the Montebello Hills, adjacent to the city of Montebello. This discovery transformed the area from its agricultural roots into a major oil-producing region. At its peak, the field contributed to approximately one-eighth of California's crude oil production. Over the years, the surrounding landscape has urbanized, with the oil field now bordered by residential neighborhoods, commercial developments, and recreational areas.
11. Westside Planning Area
    a. Baldwin Hills Community Standards District (CSD): The Baldwin Hills CSD comprises much of the Inglewood Oil Field. It is bordered by residential neighborhoods, schools, and Kenneth Hahn State Recreation Area.

Oil field operations encompass activities such as well drilling, maintenance, fluid production and processing, including temporary storage. Drilling operations typically require substantial surface grading, construction of sound suppression walls, and installation of well pads, taking 7–14 days per pad. Drilling occurs 24 hours a day over a 10-day period for each well, powered by diesel engines. Additionally, secondary containment and stormwater management systems mitigate risks from spills, leaks, and heavy rainfall.

The Inglewood Oil Field has been a center of oil production activities in Los Angeles County, producing over 368 million barrels of oil since its inception in 1924. This Oil Field lies adjacent to Kenneth Hahn State Recreation Area. Drainage from portions of the field flows into retention basins designed to contain spills and manage stormwater runoff, ultimately discharging into the Los Angeles County storm drain system and natural watercourses such as Ballona Creek.

Residents and communities surrounding the Inglewood Oil Field have long expressed concerns regarding air quality, noise, vibration, and potential health risks associated with oil production activities. The field operates amidst densely populated urban areas, including residential neighborhoods and schools. Emissions from oil production activities and drilling operations

contribute to cumulative air quality impacts, while noise from drilling rigs, trucks, and other equipment also affects nearby residents.

In recent decades, advancements in oil production technology and evolving regulatory oversight have shaped its operational landscape. However, historical practices left behind environmental contamination, including hydrocarbons in soil and localized contamination in perched groundwater zones adjacent to densely urbanized residential neighborhoods, schools, recreational areas and environmentally sensitive habitats. Modern operations are subject to stricter environmental regulations, including bioremediation programs treating hydrocarbon-impacted soil and stormwater management plans to prevent offsite contamination.

Proactive remediation programs have recently treated over 220,000 cubic yards of hydrocarbon-impacted soil using bioremediation. Retention basins and advanced spill response plans further mitigate environmental risks. However, localized contamination in soil and perched groundwater remains a legacy issue of historical operations, requiring continued oversight and management.

The project seeks to phase out oil operations in unincorporated Los Angeles County, transitioning the project sites to other uses. This transition aligns with County sustainability goals and reflects broader regional priorities for environmental protection, equitable land use planning, and a just transition to a fossil-fuel-free economy.

Existing Conditions/Site Characteristics

The project area features a broad range of urban, suburban, rural, and natural landscapes. These areas include residential neighborhoods, schools, parks, sensitive habitats, and recreational spaces, many of which are adjacent to or impacted by existing oil production facilities. The environmental setting provides the context for understanding the potential impacts of the project.

Surrounding Land Uses

The project encompasses the unincorporated communities throughout Los Angeles County. Los Angeles County is bordered by Ventura County to the west, Kern and San Bernardino Counties to the north and east, and Orange County to the southeast, with each neighboring area having distinct characteristics and land uses that influence the regional context of the project. For example:

- To the north: Kern County's oil production zones illustrate regional significance of fossil fuel operations but contrast with Los Angeles County's push toward sustainability and land use compatibility.
- To the east, west, and south: Urban and suburban neighborhoods intermingle with industrial zones, underscoring the need for careful regulation to prevent land use conflicts.

Within the unincorporated areas of Los Angeles County, significant portions of land near oil operations are designated for residential, recreational, or sensitive environmental uses.

PURPOSE OF THIS INITIAL STUDY

The purpose of this Initial Study is to evaluate the potential environmental impacts of the proposed regulatory framework to phase out oil production activities in unincorporated Los Angeles County. This study is conducted in compliance with the California Environmental Quality Act (CEQA), pursuant to the California Public Resources Code (PRC) § 21000 et seq. and the CEQA Guidelines (California Code of Regulations [CCR], Title 14, § 15000 et seq.). CEQA requires public agencies to identify and assess the environmental consequences of their actions and to adopt feasible mitigation measures where significant impacts may occur (PRC § 21002, CEQA Guidelines § 15021).

Specifically, this Initial Study aims to:

1. Determine whether the proposed project may result in significant environmental effects that necessitate the preparation of an Environmental Impact Report (EIR), or whether a Negative Declaration (ND) or Mitigated Negative Declaration (MND) may suffice (CEQA Guidelines § 15063).
2. Provide a transparent, public-facing document that outlines the environmental setting, evaluates potential impacts, and considers the project's consistency with applicable land use and environmental policies (CEQA Guidelines § 15125).
3. Ensure compliance with CEQA by addressing direct, indirect, and cumulative impacts associated with the proposed amendments to the County Planning & Zoning Code, the Baldwin Hills Community Standards District, the County General Plan, and the County Environmental Protection Code (CEQA Guidelines §§ 15064, 15130).
4. Facilitate informed decision-making by County officials and provide opportunities for meaningful public and stakeholder participation (PRC § 21003, CEQA Guidelines § 15082).

While CEQA requires a Mitigation Monitoring and Reporting Program (MMRP) for projects with significant impacts that require mitigation (PRC § 21081.6, CEQA Guidelines § 15097), the Revised Oil Well Ordinance project has only two significant impacts, both related to the loss of mineral resources (CEQA Guidelines Appendix G, Section XIII [Mineral Resources]). These impacts are unavoidable and cannot be mitigated due to the nature of the project, which involves phasing out oil production activities. All other potential impacts have been determined to be less than significant and do not require mitigation measures. These impacts are effectively managed through compliance with existing federal, state, and local regulations. This Initial Study reflects the project's alignment with CEQA's goals of minimizing environmental harm and promoting sustainable land use practices (PRC § 21001).

ENVIRONMENTAL IMPACT ANALYSIS

I. Aesthetics

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Except as provided in Public Resources Code §21099, would the project:				
a. **Have a substantial adverse effect on a scenic vista?**	☐	☐	☒	☐
b. **Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?**	☐	☐	☒	☐
c. **In nonurbanized areas, substantially degrade the existing visual character or quality of public views of the site and its surroundings? (Public views are those that are experienced from publicly accessible vantage point). If the project is in an urbanized area, would the project conflict with applicable zoning and other regulations governing scenic quality?**	☐	☐	☒	☐
d. **Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?**	☐	☐	☒	☐

a. Have a substantial adverse effect on a scenic vista?

Less than Significant Impact. The project is expected to have a beneficial effect on scenic vistas within unincorporated Los Angeles County over the long term by phasing out oil production activities and removing associated industrial infrastructure. Scenic vistas are typically valued for their unobstructed views of natural or urban landscapes, including significant ridgelines, coastal areas, and other important visual resources identified in the County of Los Angeles General Plan.

Currently, existing oil wells, pump jacks, and related equipment can disrupt or diminish the quality of scenic vistas by introducing industrial elements into the landscape. By prohibiting new oil wells and phasing out existing operations, the project will lead to the eventual removal of these visible disruptions.

In the short term, temporary visual disturbances could occur during decommissioning activities. These may include the presence of heavy equipment, temporary fencing, or staging areas. However, such impacts would be localized, limited in duration, and would diminish once the dismantling and restoration processes are complete. By incorporating Site Maintenance standards in the proposed Title 22 (Planning & Zoning) Oil Well Ordinance and Baldwin Hills Community Standards District (CSD) Amendment, the project ensures orderly and aesthetically sensitive operations. These standards require keeping sites free from debris and obstructions, removing equipment within specified timeframes, and maintaining structures in good condition. As a result, any negative effects on scenic vistas would be limited and temporary.

Furthermore, the proposed Signage requirements would not substantially detract from scenic views. While operators must install or maintain visible identification and safety signs, the project limits their size, location, and design, thereby minimizing any visual intrusion.

The project does not introduce new structures that would adversely affect designated scenic highways, significant ridgelines, or other identified scenic resources as mapped by the County or adjacent jurisdictions. Instead, it supports existing County policies aimed at protecting and enhancing scenic character. Therefore, while minor temporary effects may occur, the overall long-term impact on scenic vistas is expected to be beneficial. Any short-term adverse visual effects associated with decommissioning would be less than significant.

b. Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?

Less than Significant Impact. The project would phase out existing oil production operations and remove associated infrastructure in unincorporated Los Angeles County. It does not involve constructing new buildings, major grading, or other activities that would substantially damage scenic resources such as trees, rock outcroppings, or historic buildings. Instead, it focuses on eliminating existing oil facilities and restoring or converting affected sites to land uses more compatible with surrounding communities and natural features. Decommissioning activities and interim operations are subject to the project's Well Plugging and Abandonment and Site Maintenance requirements that protect the surrounding environment by mandating the timely removal of equipment, debris, and any hazardous materials.

Sites affected by the project are not located adjacent to or within the viewshed of any state-designated scenic highways, as identified by the California Department of Transportation or the General Plan. Without proximity to a designated scenic highway or other identified scenic resources, the likelihood of adverse effects on views from or toward these landscapes is minimal. Any short-term visual changes during decommissioning, such as the presence of construction equipment, would be temporary and managed to reduce visual clutter. In the rare event that project activities occur near a scenic resource, compliance with the project's Site Maintenance and Bonds provisions would safeguard against impacts. The required Bonds ensure the County can address or correct any unremedied impacts if an operator fails to comply with restoration obligations. The project's Signage standards encourage neat, appropriately sized identification signs, which further reduces the potential for visual clutter.

Moreover, the removal of oil infrastructure may enhance the visual quality of previously industrialized landscapes over time, potentially improving the overall scenic character of the affected areas. Compliance with existing ordinances and best management practices ensures that the project avoids unnecessary damage to scenic elements.

In summary, the project's activities—limited to removing existing infrastructure, regulating interim operations, and restoring disturbed sites—would not substantially damage scenic resources within a state scenic highway corridor or similar protected area. Therefore, potential impacts to scenic resources are considered less than significant.

c. In nonurbanized areas, substantially degrade the existing visual character or quality of public views of the site and its surroundings? (Public views are those that are experienced from publicly accessible vantage point). If the project is in an urbanized area, would the project conflict with applicable zoning and other regulations governing scenic quality?

Less than Significant Impact. In nonurbanized areas of unincorporated Los Angeles County, existing oil infrastructure—such as pump jacks, tanks, and pipelines—introduces industrial elements that contrast with surrounding natural landscapes. Public views from trails, parks, scenic roads, or other publicly accessible vantage points can be adversely affected by these operations. Phasing out oil production and removing associated facilities—combined with the project's required Well Plugging and Abandonment provisions—would ultimately restore and improve the visual integrity of these areas. Over time, this would create a more harmonious visual environment, enhancing public views and scenic quality. During the amortization period, the project's Site Maintenance standards would limit any unsightly debris, graffiti, or abandoned equipment that could erode visual quality.

During the interim decommissioning and site restoration period, the use of heavy equipment, temporary fencing, and staging areas may result in short-term, localized visual changes. However, these effects are limited in duration and would not substantially degrade the overall visual character or quality of public views. The project's required Comment and Complaint Log mechanism also provides a pathway for addressing any aesthetic concerns raised by residents or visitors. Once decommissioning is complete and the sites are restored, the landscape would be returned to a more natural or compatible condition, resulting in a long-term improvement.

In urbanized areas, the project aligns with applicable zoning and existing regulations intended to protect and enhance visual quality. By designating existing oil wells as nonconforming uses and phasing them out, the project supports local and Countywide objectives for improved community aesthetics and land use compatibility. Existing standards—such as those within the County's Zoning Ordinance, Area Plans, or Community Standards Districts—already govern building form, signage, massing, and architectural style. Compliance with these regulations would further ensure that the project does not conflict with zoning or other requirements meant to preserve and enhance scenic quality in urbanized settings.

Overall, the project is expected to improve the visual environment in both nonurbanized and urbanized areas. Any temporary visual disturbances during the removal of oil infrastructure would be less than significant, and the long-term outcome would be a more visually cohesive, aesthetically pleasing landscape.

d. Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?

Less than Significant Impact. Existing oil production operations in unincorporated Los Angeles County often involve nighttime lighting for safety and operational purposes, as well as infrastructure (e.g., storage tanks, pipes) that can reflect sunlight and create glare during the day. By phasing out and removing oil wells and associated facilities, the project is anticipated to reduce these existing sources of artificial light and glare, thereby improving nighttime visibility and diminishing daytime glare conditions.

Temporary lighting may be required during the decommissioning process for worker safety and efficient site restoration. Such lighting would be limited to short-term periods, focused on the immediate work area, and shielded or directed downward to the extent feasible, thus minimizing potential off-site impacts. The project's Site Maintenance standards minimize potential nuisances by ensuring the timely removal of unnecessary equipment or visual disturbances. No new permanent facilities or features are proposed that would introduce substantial sources of light or glare.

Moreover, any new or existing lighting would be subject to County standards and regulations—such as the Rural Outdoor Lighting District Ordinance—to ensure appropriate shielding, directionality, and intensity control. Compliance with these standards helps prevent light trespass and reduces potential night sky illumination.

Overall, the project would not create a new source of substantial light or glare that would adversely affect day or nighttime views. Instead, it would likely result in a net reduction of glare and artificial light compared to existing conditions, rendering any impacts less than significant.

II. Agriculture and Forestry

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Department of Conservation as an optional model to use in assessing impacts on agriculture and farmland. In determining whether impacts to forest resources, including timberland, are significant environmental effects, lead agencies may refer to information compiled by the California Department of Forestry and Fire Protection regarding the state's inventory of forest land, including the Forest and Range Assessment Project and the Forest Legacy Assessment project; and forest carbon measurement methodology provided in Forest Protocols adopted by the California Air Resources Board.				
Would the project:				
a. **Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?**	☐	☐	☐	☒
b. **Conflict with existing zoning for agricultural use, with a designated Agricultural Resource Area, or with a Williamson Act contract?**	☐	☐	☐	☒
c. **Conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code § 12220 (g)), timberland (as defined in Public Resources Code § 4526), or timberland zoned Timberland Production (as defined in Government Code § 51104(g))?**	☐	☐	☐	☒
d. **Result in the loss of forest land or conversion of forest land to non-forest use?**	☐	☐	☐	☒
e. **Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use or conversion of forest land to non-forest use?**	☐	☐	☐	☒

a. Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?

No Impact. The project involves phasing out oil production activities and does not authorize any new development that would convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance to non-agricultural uses. Project activities are limited to previously developed, industrialized sites where oil wells and related infrastructure are currently or were historically located. Since the project does not propose extending into agricultural lands or altering existing farmland operations, no agricultural soils designated as Prime, Unique, or of Statewide Importance

would be converted to urban or non-farming uses. Therefore, there is no impact related to the conversion of important farmland.

b. Conflict with existing zoning for agricultural use, with a designated Agricultural Resource Area, or with a Williamson Act contract?

No Impact. The project would phase out oil production activities and remove associated infrastructure within unincorporated Los Angeles County. It does not involve new development that would convert or conflict with agricultural uses, nor does it introduce land uses incompatible with agricultural zoning, designated Agricultural Resource Areas (ARAs), or Williamson Act contracts.

The project does not propose converting farmland to non-agricultural uses or altering lands currently zoned for agriculture. Instead, it focuses on decommissioning oil wells and related equipment on sites already devoted to industrial energy production. As such, there is no encroachment into ARA lands or conversion of prime farmland, Farmland of Statewide Importance, Farmland of Local Importance, or Unique Farmland to other uses. The project's activities remain consistent with existing regulations and do not impede or interfere with agricultural operations.

The only remaining contracts under the Williamson Act in the County are located on Catalina Island and primarily serve as open space set-asides. Since the project does not affect these contract lands or other properties under the Williamson Act, there is no conflict with such agreements.

Given that the project neither alters agricultural zoning nor conflicts with ARAs or Williamson Act contracts, the impact related to agricultural land use designations and agreements is considered less than significant.

c. Conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code § 12220 (g)), timberland (as defined in Public Resources Code § 4526), or timberland zoned Timberland Production (as defined in Government Code § 51104(g))?

No Impact. The unincorporated areas of Los Angeles County do not include any zones designated solely for forest land, timberland, or timberland production as defined in Public Resources Code §§12220(g), 4526, and Government Code §51104(g). The project involves phasing out oil production activities and removing associated infrastructure from existing industrially used areas, without introducing new uses that would require rezoning to or from forest or timberland designations.

While the County does contain portions of National Forests, the project does not propose any activities within or adjacent to these federal forest lands that would necessitate rezoning or conflict with existing forest management objectives. Additionally, no timberland production zones (TPZ) exist in the unincorporated areas governed by the project's proposed regulations.

Since the project does not involve changes to forest- or timberland-related zoning, nor does it require the conversion, removal, or rezoning of such lands, there is no potential to conflict with existing zoning for forest or timberland uses. Therefore, the project has no impact regarding forest land and timberland zoning.

d. Result in the loss of forest land or conversion of forest land to non-forest use?

No Impact. The project involves decommissioning oil production infrastructure in unincorporated areas that are generally not characterized as forest land. The County does not have zoning designations strictly for forest land or timberland production in these project locations, and the sites in question are previously disturbed oil fields rather than forested tracts. Because no forested areas or timberland-zoned parcels would be affected by the project, there is no potential for converting forest land to non-forest use. As a result, no impact to forest resources would occur.

e. Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use or conversion of forest land to non-forest use?

No Impact. The project does not introduce new land uses, infrastructure, or policies that would indirectly pressure farmland or forest land to convert to another use. It does not entail expanding urban services, constructing roads into rural areas, or altering land use designations in ways that encourage development in areas currently used or zoned for farming or forestry. Instead, the project removes oil wells and industrial features from already disturbed sites, reducing rather than increasing the likelihood of encroaching into agricultural or forested regions. Therefore, there are no foreseeable indirect changes that would prompt farmland or forest land conversion, resulting in no impact.

III. Air Quality

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Where available, the significance criteria established by the applicable air quality management district or air pollution control district may be relied upon to make the following determinations. Would the project:				
a. **Conflict with or obstruct implementation of applicable air quality plans of either the South Coast AQMD (SCAQMD) or the Antelope Valley AQMD (AVAQMD)?**	☐	☐	☒	☐
b. **Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard?**	☐	☐	☒	☐
c. **Expose sensitive receptors to substantial pollutant concentrations?**	☐	☐	☒	☐
d. **Result in other emissions (such as those leading to odors) adversely affecting a substantial number of people?**	☐	☐	☒	☐

a. Conflict with or obstruct implementation of applicable air quality plans of either the South Coast AQMD (SCAQMD) or the Antelope Valley AQMD (AVAQMD)?

Less than Significant Impact. The project would eliminate oil production activities in unincorporated Los Angeles County, effectively reducing emissions associated with active wells and related infrastructure. Oil production operations typically release criteria pollutants (e.g., volatile organic compounds [VOCs], particulate matter [PM10 and PM2.5], and nitrogen oxides [NOx]) as well as methane, a potent greenhouse gas that also contributes to regional air quality concerns. The State of California, through agencies such as the California Air Resources Board (CARB) and the California Energy Commission, has identified methane leaks from active, idle, and abandoned oil wells as significant sources of emissions. By mandating that all California Geologic Energy M anagement Division (CalGEM) requirements be fulfilled related to the plugging and abandonment of a well, the project would help minimize or eliminate methane emissions from aging and improperly sealed wells. By phasing out and mitigating these sources of emissions, the project aligns with ongoing state research and mitigation priorities and directly supports the overall objectives of the South Coast Air Quality Management District (SCAQMD) and Antelope Valley Air Quality Management District (AVAQMD) to improve air quality and meet or maintain state and federal ambient air quality standards.

Both the SCAQMD and AVAQMD rely on Air Quality Management Plans (AQMPs) to guide strategies for reducing emissions and attaining clean air standards. By eliminating existing and future oil production activities, the project is expected to reduce pollutant loads and thus assist in achieving AQMP goals. In addition, the project is consistent with local and regional land use policies and does not introduce land uses that would increase vehicle miles traveled or population beyond what was envisioned in the General Plan. Therefore, it would not conflict with or obstruct the implementation

of the applicable AQMPs, which rely on consistency with adopted land use plans to project and manage emissions.

Temporary emissions may occur during well decommissioning, primarily from construction equipment. These short-term emissions would be subject to existing regulations and best management practices designed to minimize impacts and would be minimal relative to the long-term reduction in stationary source emissions achieved by the project. Consequently, the project would not conflict with or obstruct the implementation of the SCAQMD or AVAQMD air quality plans, and any temporary emissions during decommissioning would be less than significant.

b. Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard?

Less than Significant Impact. The project, which phases out oil production activities in unincorporated areas of Los Angeles County, would ultimately decrease stationary emissions of criteria pollutants. The region is currently non-attainment for several pollutants, including ozone (O3), particulate matter (PM10 and PM2.5), and nitrogen dioxide (NO2). Oil production operations typically emit volatile organic compounds (VOCs) and nitrogen oxides (NOx)—both ozone precursors—as well as particulate matter. By eliminating these sources, the project would support regional efforts to achieve and maintain compliance with federal and state air quality standards.

While short-term emissions may occur during the decommissioning and closure of wells, these activities would be temporary, localized, and comparatively minor in scale. Such emissions, including limited amounts of NOx and PM, would be subject to South Coast Air Quality Management District (SCAQMD) or Antelope Valley Air Quality Management District (AVAQMD) regulations, as well as best management practices designed to minimize construction-related air quality impacts. Compliance with these measures ensures that any temporary increases in pollutant emissions are effectively controlled and reduced.

Over the long term, the project removes a recognized source of ongoing emissions, thereby reducing the cumulative pollution burden in an area already designated as non-attainment. Because the project results in an overall net decrease in criteria pollutants over time, rather than a meaningful increase, it does not contribute to a cumulatively considerable net increase of non-attainment pollutants.

Therefore, considering both the temporary, controlled nature of decommissioning emissions and the permanent reduction in ongoing pollutant sources, the project's impact on cumulative non-attainment pollutants would be less than significant.

c. Expose sensitive receptors to substantial pollutant concentrations?

Less than Significant Impact. The project would phase out oil production activities in unincorporated Los Angeles County, reducing ongoing emissions of criteria pollutants and other contaminants associated with active wells. Sensitive receptors—such as schools, hospitals, residences, childcare facilities, and senior centers—are more vulnerable to adverse health effects from poor air quality. Currently, oil production operations can generate air pollutants, including volatile organic compounds (VOCs), nitrogen oxides (NOx), and particulate matter (PM10 and PM2.5), which may affect nearby sensitive receptors.

By permanently closing and removing oil production facilities, the project would diminish a source of localized emissions, thereby improving long-term air quality conditions for sensitive receptors in the area. Although short-term construction-related emissions may occur during the decommissioning phase, these temporary increases in pollutants would be limited in duration and spatial extent. Standard dust control measures, proper equipment maintenance, and compliance with South Coast Air Quality Management District (SCAQMD) or Antelope Valley Air Quality Management District (AVAQMD) regulations would minimize these effects. In addition, best management practices (BMPs) can be implemented to further reduce dust and diesel emissions during the removal of existing infrastructure.

No new long-term emission sources would be introduced, and the overall effect of the project would be to reduce, rather than increase, pollutant concentrations in areas where sensitive receptors may be present. Therefore, while there may be minimal, short-term construction-related impacts, they would not be substantial, and the project's long-term benefit of removing a stationary source of air pollution ensures that exposures to sensitive receptors would not be significantly affected. As a result, impacts related to exposing sensitive receptors to substantial pollutant concentrations would be less than significant.

d. Result in other emissions (such as those leading to odors) adversely affecting a substantial number of people?

Less than Significant Impact. Oil production activities commonly emit odorous compounds—such as volatile organic compounds (VOCs) and, in some cases, hydrogen sulfide (H_2S)—that can negatively affect nearby communities. By phasing out and removing oil wells and related infrastructure, the project would eliminate these long-term sources of nuisance odors. This reduction in odorous emissions would improve the quality of life in surrounding areas, particularly where sensitive receptors (e.g., residences, schools, or healthcare facilities) could be affected.

During the short-term decommissioning period, certain activities—such as operation of diesel-powered equipment or soil disturbance—could produce temporary odors. These odors, however, would be localized, transitory, and subject to existing regulations, including South Coast Air Quality Management District (SCAQMD) or Antelope Valley Air Quality Management District (AVAQMD) Rule 402, which prohibits emissions that cause nuisance odors affecting a substantial number of people. Compliance with applicable air quality regulations and best management practices would minimize and control any transient odor issues.

In the long run, the project would substantially reduce the presence of odorous emissions in areas currently affected by oil production activities. As a result, any short-term odors during decommissioning would be minimal, temporary, and managed through adherence to regulatory standards. Therefore, the project's impact related to other emissions, including odors, would be less than significant.

IV. Biological Resources

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Wildlife (CDFW) or U.S. Fish and Wildlife Service (USFWS)?	☐	☐	☒	☐
b. Have a substantial adverse effect on any sensitive natural communities (e.g., riparian habitat, coastal sage scrub, oak woodlands, non-jurisdictional wetlands) identified in local or regional plans, policies, regulations or by CDFW or USFWS?	☐	☐	☒	☐
c. Have a substantial adverse effect on state or federally protected wetlands (including, but not limited to, marshes, vernal pools, coastal wetlands, etc.) through direct removal, filling, hydrological interruption, or other means?	☐	☐	☒	☐
d. Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?	☐	☐	☒	☐
e. Convert oak woodlands (as defined by the state, oak woodlands are oak stands with greater than 10% canopy cover with oaks at least 5 inch in diameter measured at 4.5 feet above mean natural grade) or other unique native woodlands (juniper, Joshua, southern California black walnut, etc.)?	☐	☐	☒	☐
f. Conflict with any local policies or ordinances protecting biological resources, including Wildflower Reserve Areas (L.A. County Code, Title 12, Ch. 12.36), the Los Angeles County Oak Tree Ordinance (L.A. County Code, Title 22, Ch. 22.174), the Significant Ecological Areas (SEAs) (L.A. County Code, Title 22, Ch. 102), Specific Plans (L.A. County Code, Title 22, Ch. 22.46), Community Standards Districts (L.A. County Code, Title 22, Ch. 22.300 et seq.), and/or Coastal Resource Areas (L.A. County General Plan, Figure 9.3)?	☐	☐	☒	☐
g. Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved state, regional, or local habitat conservation plan?	☐	☐	☐	☒

a. Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Wildlife (CDFW) or U.S. Fish and Wildlife Service (USFWS)?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure in unincorporated areas of Los Angeles County. Many existing oil operations occur in areas already disturbed, where native habitats and the sensitive species that depend on them have been substantially altered or displaced. By eliminating a source of ongoing disturbance and pollution, the project is expected to improve ecological conditions over time.

As oil facilities are removed and sites are restored or converted to compatible uses, habitats can recover, allowing native vegetation and wildlife to return. Over the long term, this would create more favorable conditions for candidate, sensitive, or special status species recognized by the California Department of Fish and Wildlife (CDFW), U.S. Fish and Wildlife Service (USFWS), or other regulatory agencies. Restoration efforts and compliance with all applicable federal, state, and local environmental regulations—including the California Endangered Species Act (CESA), Federal Endangered Species Act (FESA), and any local Significant Ecological Area (SEA) protections—would ensure that sensitive species and their habitats are protected.

During short-term decommissioning and restoration activities, limited ground disturbance could occur. In instances where sensitive biological resources may be present, the project would implement standard measures such as pre-construction surveys, consultation with CDFW or USFWS, avoidance of active nests or burrows during critical breeding seasons, and adherence to best management practices. These steps would minimize potential impacts and help maintain compliance with protective regulations.

Overall, the project would not adversely affect sensitive species populations. Instead, it would likely result in long-term habitat quality improvements once oil operations cease and disturbed sites are restored. Consequently, potential impacts to candidate, sensitive, or special status species would be less than significant.

b. Have a substantial adverse effect on any sensitive natural communities (e.g., riparian habitat, coastal sage scrub, oak woodlands, non-jurisdictional wetlands) identified in local or regional plans, policies, regulations or by CDFW or USFWS?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure in unincorporated areas of Los Angeles County. Many existing oil production sites are in areas already disturbed by industrial activity, limiting the extent and quality of sensitive natural communities—such as riparian habitats, coastal sage scrub, oak woodlands, or non-jurisdictional wetlands—that may be present. By eliminating these industrial uses, the project can improve long-term ecological conditions and increase the potential for these sensitive communities to recover or reestablish.

While short-term decommissioning actions (e.g., equipment staging, limited grading) could temporarily affect adjacent habitat areas, these impacts would be localized and transitory. Prior to and during these activities, compliance with applicable regulations—including any requirements related to Significant Ecological Areas (SEAs) and other protected habitats—would minimize and avoid substantial effects on sensitive natural communities. Such regulations may include conducting

biological surveys, following best management practices to control erosion and dust, and scheduling work to avoid sensitive wildlife breeding periods.

Over time, as oil production infrastructure is removed and sites are restored or converted to more compatible uses, habitats can regenerate and potentially support a greater abundance and diversity of native species. By reducing barriers, contamination, and noise sources, the project is likely to benefit sensitive natural communities in the long run. Therefore, any short-term disturbance during decommissioning would be minimal and controlled, and the overall impact on sensitive natural communities would be less than significant.

c. Have a substantial adverse effect on state or federally protected wetlands (including, but not limited to, marshes, vernal pools, coastal wetlands, etc.) through direct removal, filling, hydrological interruption, or other means?

Less than Significant Impact. The project would phase out oil production activities in unincorporated areas of Los Angeles County, generally reducing disturbance in areas that may currently be occupied by oil production infrastructure. While these facilities are often located in already disturbed or developed areas, if any state or federally protected wetlands (such as marshes, vernal pools, or coastal wetlands) are present on or near affected sites, they would receive indirect benefits over the long term due to the cessation of industrial activities.

In the near term, decommissioning activities—such as equipment operation or limited grading—could potentially cause minor, localized effects on nearby wetland areas if not properly managed. However, these impacts would be temporary and subject to existing regulatory requirements and best management practices (BMPs) designed to protect wetland resources. Project activities would be required to comply with all applicable federal, state, and local regulations, including those administered by the U.S. Army Corps of Engineers (Clean Water Act Section 404), the California Department of Fish and Wildlife (California Fish and Game Code Sections 1600–1616), and the Regional Water Quality Control Board (Porter-Cologne Water Quality Control Act).

These regulations and permitting requirements ensure that any work occurring near wetlands would be carefully evaluated and, if necessary, mitigated to avoid or minimize adverse impacts. Moreover, without ongoing oil production, the likelihood of long-term hydrological disruptions or contaminant inputs to wetland areas would be reduced. Although the project does not directly mandate restoration of these areas, removing oil operations could facilitate the transition of sites toward more compatible land uses that are less harmful to nearby wetland habitats.

As a result, any short-term effects on wetlands would be adequately controlled, and no substantial adverse impacts are anticipated. Therefore, the project's impact on state or federally protected wetlands would be less than significant.

d. Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?

Less than Significant Impact. Phasing out oil production activities and removing associated infrastructure in unincorporated Los Angeles County would generally reduce barriers to wildlife movement and improve connectivity over time. Oil production operations can fragment habitats, introduce noise and light, and impede wildlife corridors, including the movement of resident and

migratory species, as well as the use of nursery sites. By eliminating these industrial impacts, the project is expected to support habitat conditions more conducive to wildlife movement and breeding.

In the short term, decommissioning activities—such as equipment use, grading, and staging—may temporarily disturb local wildlife movement. These effects would be limited in duration and scope, and would be managed in compliance with federal, state, and local regulations protecting native species. For example, the Migratory Bird Treaty Act and California Fish and Game Code protect active nests and breeding birds from harm or disturbance. Best management practices, including pre-construction surveys and seasonal avoidance measures, can be implemented to prevent impacts to active nests, nursery sites, or established wildlife corridors during decommissioning.

Over the long run, phasing out oil operations can facilitate land uses that are less disruptive to wildlife. While the project does not directly mandate habitat restoration, the cessation of ongoing industrial activities inherently reduces disturbance. This reduction in noise, lighting, and physical barriers would likely enhance habitat connectivity, supporting wildlife corridors and facilitating the safe and unobstructed movement of native and migratory species. As a result, any temporary impacts during the decommissioning phase would be minimal and less than significant.

e. Convert oak woodlands (as defined by the state, oak woodlands are oak stands with greater than 10% canopy cover with oaks at least 5 inch in diameter measured at 4.5 feet above mean natural grade) or other unique native woodlands (juniper, Joshua, southern California black walnut, etc.)?

Less than Significant Impact. The project would phase out oil production activities, reducing ongoing disturbances associated with these operations. Oil production sites are often established in previously disturbed areas where oak woodlands or other unique native woodlands have been largely cleared or degraded. As a result, the likelihood of the project directly removing or converting intact oak woodlands or other unique native woodlands (e.g., juniper, Joshua, southern California black walnut) is low.

While the project itself does not mandate restoration, eliminating oil operations may reduce barriers and pressures on nearby natural communities. Any future uses of these sites would still be subject to existing local and state regulations designed to protect native woodlands, including oak trees. Should oak trees or native woodlands be present, compliance with relevant ordinances (such as the Oak Tree Permit Ordinance) and consultation with County biologists would ensure that avoidance, minimization, or mitigation measures are employed as needed. This would prevent significant impacts to oak woodlands or other native woodlands.

Therefore, any potential impacts related to converting oak woodlands or other unique native woodlands would be less than significant.

f. Conflict with any local policies or ordinances protecting biological resources, including Wildflower Reserve Areas (L.A. County Code, Title 12, Ch. 12.36), the Los Angeles County Oak Tree Ordinance (L.A. County Code, Title 22, Ch. 22.174), the Significant Ecological Areas (SEAs) (L.A. County Code, Title 22, Ch. 102), Specific Plans (L.A. County Code, Title 22, Ch. 22.46), Community Standards Districts (L.A. County Code, Title 22, Ch. 22.300 et seq.), and/or Coastal Resource Areas (L.A. County General Plan, Figure 9.3)?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure in unincorporated Los Angeles County, thereby reducing industrial

disturbances that can affect local biological resources. While the project itself does not mandate restoration, the cessation of oil operations creates conditions more favorable to uses that are compatible with local policies and ordinances designed to protect biological resources.

- Wildflower Reserve Areas (Title 12, Ch. 12.36): The project is not expected to affect these designated areas, as oil facilities are generally not located within them. By removing oil operations, adjacent natural landscapes can be maintained or improved, supporting the integrity of wildflower areas.
- Oak Tree Permit Ordinance (Title 22, Ch. 22.174): Should any oak trees or oak woodlands be present on or adjacent to former oil production sites, future site activities would be subject to the Oak Tree Ordinance, including any required permits, mitigation, and best management practices. Compliance with these requirements ensures no substantial conflict with oak tree protections.
- Significant Ecological Areas (SEAs) (Title 22, Ch. 102): Eliminating oil production can reduce habitat fragmentation and improve ecological integrity within or near SEAs. Any future use of these sites would need to comply with SEA regulations, ensuring that sensitive habitats and species are protected.
- Specific plans and community standards districts (CSDs) (Title 22, Divisions 10 and 11): The project is consistent with relevant specific plans and CSD requirements, including those that regulate oil production. By ending such activities, the project aligns with long-term planning goals that often emphasize environmental protection.

Decommissioning activities may produce short-term, localized effects, but these would be managed under existing regulations and permit requirements to avoid conflicts with local environmental protections. Overall, the project supports rather than conflicts with local policies and ordinances aimed at conserving biological resources. Any temporary impacts would be less than significant, as ongoing compliance with existing regulations ensures effective protection of sensitive habitats and species.

g. Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved state, regional, or local habitat conservation plan?

No Impact. The project would phase out oil production activities in unincorporated Los Angeles County, potentially reducing disturbances that could conflict with habitat conservation efforts. Currently, there are several habitat conservation and natural community conservation plans at the state, regional, and local levels, as well as other conservation initiatives (such as the County's SEAs Program) that aim to maintain and restore ecological integrity within the County.

By discontinuing oil production, the project would lessen industrial impacts, such as noise, habitat fragmentation, and potential contamination, thereby aligning more closely with the goals and provisions of these conservation plans. Even though the project does not mandate restoration, transitioning away from oil production allows for future land uses that are more compatible with habitat conservation objectives. Any site-specific changes would continue to be subject to applicable laws, permits, and ordinances that protect biological resources. Should any Habitat Conservation Plan (HCP), Natural Community Conservation Plan (NCCP), or similar conservation framework apply, project-related activities would need to comply with all related requirements, including consultation with the appropriate regulatory agencies if necessary.

In the short term, limited construction-related activities associated with decommissioning may occur, but these would be regulated by existing environmental protections and best management

practices to minimize any potential adverse effects. In the long term, the reduction of industrial activities supports the conservation objectives of these plans rather than conflicts with them.

Therefore, the project would not conflict with adopted HCPs, NCCPs, or other approved habitat conservation strategies, and impacts would be less than significant.

V. Cultural Resources

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. **Cause a substantial adverse change in the significance of a historical resource pursuant to CEQA Guidelines § 15064.5?**	☐	☐	☒	☐
b. **Cause a substantial adverse change in the significance of an archaeological resource pursuant to CEQA Guidelines § 15064.5?**	☐	☐	☒	☐
c. **Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?**	☐	☐	☒	☐
d. **Disturb any human remains, including those interred outside of dedicated cemeteries?**	☐	☐	☒	☐

a. Cause a substantial adverse change in the significance of a historical resource pursuant to CEQA Guidelines § 15064.5?

Less than Significant Impact. The project would phase out oil production activities without proposing physical alterations or removal of historical resources in unincorporated Los Angeles County. Most affected areas are previously disturbed sites, limiting historical features. However, two notable exceptions require consideration.

Within the Baldwin Hills area, the Cone Trust House is recognized as a potentially significant historic architectural resource. The Baldwin Hills Community Standards District (CSD) includes measures to protect the structure's historic integrity from adjacent oil operations. These protections would remain under the project, ensuring no substantial adverse change to the Cone Trust House.

Another key site is Well No. 4 in the Pico Canyon Oil Field, located approximately seven miles west of Newhall, California, within the Santa Susana Mountains. Drilled in 1876, this well became California's first commercially successful oil well, spurring the growth of the state's petroleum industry. Well No. 4 is designated as a National Historic Landmark (NHL), listed on the National Register of Historic Places (NRHP), and designated as a California Historical Landmark (CHL), recognizing its cultural and industrial significance. The project prohibits new wells and phases out existing ones without requiring the demolition, relocation, or physical alteration of Well No. 4 or its contributing historical features.

Any future actions affecting Well No. 4, such as permanent modifications to structures contributing to its historical character, would be subject to review under federal and state preservation laws. Section 106 of the National Historic Preservation Act (NHPA) requires a review when a federal agency funds, permits, licenses, or approves an action that could affect historic properties. This review process involves identifying historic resources, assessing potential impacts, and consulting with stakeholders to resolve adverse effects, ensuring Well No. 4's historical integrity remains intact. At the state level, the California Environmental Quality Act (CEQA) requires agencies to evaluate and mitigate significant environmental impacts, including those affecting historical resources. Any action involving modifications to Well No. 4 would require separate environmental review under

CEQA to assess potential impacts on its historical significance. Since Well No. 4 was plugged and abandoned in September 1990 after 114 years of operation, this project itself would not require any further modifications to the site.

Outside of these two identified resources, the project affects highly disturbed oil-related sites that do not appear to host intact historic structures or features. If any such sites contain a previously unidentified historical resource, CEQA Guidelines Section 15064.5 requires evaluation and mitigation to prevent harm to the resource's integrity. Because the project aims to phase out oil extraction operations without authorizing new development or encouraging major construction, it would not result in physical alterations to potential historic buildings or districts.

The project does not facilitate direct changes to recognized historic resources, and any future actions requiring physical modifications at Well No. 4 or the Cone Trust House would be subject to separate evaluation and regulatory oversight. As a result, the project would not cause a substantial adverse change to a known historical resource, and any impact related to historical resources under CEQA is considered less than significant.

b. Cause a substantial adverse change in the significance of an archaeological resource pursuant to CEQA Guidelines § 15064.5?

Less than Significant Impact. The project would eliminate oil production activities in unincorporated Los Angeles County, focusing on areas already disturbed by industrial operations. Such sites are generally considered to have a lower likelihood of containing intact archaeological resources due to previous ground disturbance.

Where applicable, existing regulations and requirements—such as those established by the Baldwin Hills Community Standards District (CSD)—provide protection for archaeological resources. For example, within the Baldwin Hills Oil Field, construction personnel must receive archaeological training, ensuring that potential discoveries are handled appropriately. If previously unidentified archaeological materials are encountered during ground-disturbing activities, work would be halted in the immediate area until a qualified archaeologist, approved by the Department of Regional Planning, evaluates the find and recommends any necessary treatment or mitigation measures.

In addition, if any portion of the project site is located in an area with a known potential for archaeological resources, standard best management practices and compliance with General Plan mitigation measures (such as consulting the South Central Coastal Information Center and adhering to applicable CEQA guidelines) would be followed. These measures ensure that any significant archaeological materials are identified, evaluated, and protected as required by law.

Because the project does not involve new development in previously undisturbed areas, and due to the regulatory framework and requirements in place, the potential for a substantial adverse change in the significance of an archaeological resource is minimal. Therefore, impacts would be less than significant.

c. Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?

Less than Significant Impact. The project would phase out oil production activities in unincorporated areas of Los Angeles County, affecting sites that have largely been subject to past ground disturbance. Such disturbed industrial landscapes present a low likelihood of containing

intact paleontological resources or unique geologic features. Consequently, it is unlikely that discontinuing oil production and removing associated infrastructure would directly or indirectly destroy these types of resources.

If future site activities involve ground disturbance, standard procedures and best management practices would apply. For example, if a project component were to involve grading more than six feet in depth, compliance with General Plan Mitigation Monitoring and Reporting Program (MMRP) measures, such as CULT-5, may require a qualified paleontologist to monitor grading and excavation activities. Additionally, if there is any indication that paleontological resources could be present, the applicant would be advised to consult with the Natural History Museum of Los Angeles County (NHM) to determine the potential for such resources. If any fossils or unique geologic features are unexpectedly discovered during project activities, work would be halted until a qualified paleontologist has evaluated the find and implemented appropriate treatment or mitigation measures.

Overall, because the project affects previously disturbed sites and includes provisions for compliance with relevant regulations and procedures, it would not result in a substantial adverse effect on paleontological resources or unique geologic features. Therefore, the impact would be less than significant.

d. Disturb any human remains, including those interred outside of dedicated cemeteries?

Less than Significant Impact. The project would phase out oil production activities in areas that have largely been disturbed by previous industrial use, making the discovery of human remains on-site unlikely. If any ground-disturbing activities occur during decommissioning, standard procedures are in place should human remains be unexpectedly encountered. In accordance with California Health and Safety Code § 7050.5, work in the vicinity of the find would stop immediately, and the County Coroner would be notified. If the Coroner determines the remains are Native American, the Native American Heritage Commission would be contacted, and consultation with the most likely descendant would guide the appropriate treatment of the remains, as required by Public Resources Code § 5097.98.

Because the project area consists of previously disturbed industrial sites and due to the regulatory protocols that must be followed if human remains are encountered, the potential for significant impacts is very low. Any impact related to disturbing human remains would be less than significant.

VI. Energy

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. **Result in potentially significant environmental impact due to wasteful, inefficient, or unnecessary consumption of energy resources, during project construction or operation?**	☐	☐	☒	☐
b. **Conflict with or obstruct a state or local plan for renewable energy or energy efficiency?**	☐	☐	☒	☐

a. Result in potentially significant environmental impact due to wasteful, inefficient, or unnecessary consumption of energy resources, during project construction or operation?

Less than Significant Impact. The project would phase out oil production activities in unincorporated Los Angeles County, thereby reducing long-term energy demands associated with drilling, pumping, and processing. While short-term construction-related energy use would occur during the decommissioning of oil wells and associated infrastructure, these activities would be limited in duration and scope. The temporary use of fuel and electricity during this phase would be typical of standard construction practices and not considered wasteful or inefficient.

Moreover, no new energy-intensive operations are proposed as part of the project. Once oil production ceases, the eliminated industrial activities would substantially decrease on-site energy consumption, aligning with local and state objectives to reduce reliance on nonrenewable energy sources. Any subsequent land uses would remain subject to applicable energy efficiency requirements, such as those in the California Green Building Standards Code (CALGreen) and Los Angeles County's Green Building Standards (Title 31), further ensuring energy conservation in future development scenarios.

Given that decommissioning activities represent a temporary and necessary energy use and considering the long-term reduction in energy demand resulting from the cessation of oil production, the project would not lead to wasteful, inefficient, or unnecessary consumption of energy resources. Therefore, impacts would be less than significant.

b. Conflict with or obstruct a state or local plan for renewable energy or energy efficiency?

Less than Significant Impact. The project would phase out oil production activities in unincorporated Los Angeles County, thereby reducing energy consumption tied to fossil fuel production and supporting the state's and County's overarching goals for energy efficiency and renewable energy development. By eliminating oil pumping and processing operations, the project inherently aligns with California's Renewable Portfolio Standard (RPS) and Senate Bill 100, which seek to transition the state's electricity supply to 100% renewable energy by 2045. The project supports the Los Angeles County Climate Action Plan objectives to reduce greenhouse gas emissions and transition to sustainable land uses. By phasing out oil operations, the project helps achieve the County's energy and sustainability targets.

In addition, any subsequent activities on the project sites would be subject to existing energy efficiency standards set forth by Title 24 of the California Code of Regulations and Los Angeles County Green Building Standards Code. These requirements ensure that future developments or uses of the property maintain high standards of energy efficiency, further advancing state and local energy conservation objectives.

Because the project would not introduce any new energy-intensive operations and would remove existing fossil fuel extraction activities, it would not conflict with or obstruct state or local renewable energy or energy efficiency plans. Instead, it supports the broader transition toward sustainable energy use, resulting in a less than significant impact.

VII. Geology and Soils

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. Directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving:				
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.	☐	☐	☒	☐
ii) Strong seismic ground shaking?	☐	☐	☒	☐
iii) Seismic-related ground failure, including liquefaction?	☐	☐	☒	☐
iv) Landslides?	☐	☐	☒	☐
b. Result in substantial soil erosion or the loss of topsoil?	☐	☐	☒	☐
c. Be located on a geologic unit that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse?	☐	☐	☒	☐
d. Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial direct or indirect risks to life or property?	☐	☐	☒	☐
e. Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater?	☐	☐	☐	☒
f. Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	☐	☐	☒	☐
g. Conflict with the Hillside Management Area Ordinance (L.A. County Code, Title 22, Ch.22.104)?	☐	☐	☐	☒

a. (i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map or known fault?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure in unincorporated areas of Los Angeles County. While the region is seismically active and includes numerous known faults (such as the Newport-Inglewood Fault Zone, among others), the project does not involve the construction of new habitable structures that could be subject to fault rupture hazards. Instead, it reduces the number of operational oil facilities that might otherwise be at risk.

In areas subject to the Alquist-Priolo Earthquake Fault Zoning Act, new structures for human occupancy are prohibited from being placed directly on active fault traces. Because the project does not authorize new construction for human occupancy, it avoids increasing exposure to fault rupture hazards. Any decommissioning activities (e.g., plugging wells, removing equipment) would be temporary, localized, and would comply with all applicable safety regulations and standard engineering practices. If any future site redevelopment occurs after oil operations cease, it would be subject to existing seismic safety regulations—including fault rupture avoidance measures—as required by the California Building Code and County ordinances.

By removing industrial infrastructure rather than adding new structures, the project effectively reduces the overall level of seismic risk on affected sites. Adherence to existing regulatory frameworks and best management practices ensures that the project does not expose people or new structures to significant fault rupture hazards. Therefore, impacts related to the rupture of a known earthquake fault would be less than significant.

(ii) Strong seismic ground shaking?

Less than Significant Impact. The project would phase out oil production activities and remove related infrastructure in unincorporated Los Angeles County. While the region is seismically active and could experience strong ground shaking during an earthquake, the project does not involve constructing new habitable buildings or increasing the number of people exposed to seismic hazards. Instead, it focuses on plugging and abandoning oil wells and removing industrial equipment associated with oil production.

Any decommissioning activities would be short-term, localized, and conducted under standard safety protocols. Because no new permanent structures for human occupancy would be added, the project does not increase exposure to strong seismic ground shaking. If future redevelopment occurs on these sites, such projects would be subject to the latest California Building Code and County regulations governing seismic design, ensuring that any new development is adequately designed to resist ground shaking.

By reducing industrial infrastructure rather than adding new sensitive uses, the project does not introduce new risks associated with strong seismic ground shaking. Therefore, impacts related to this hazard would be less than significant.

(iii) Seismic-related ground failure, including liquefaction?

Less than Significant Impact. Some areas in unincorporated Los Angeles County are identified as liquefaction zones, where water-saturated, loose soils could lose strength during intense seismic activity. While portions of the project area may be prone to liquefaction, the project does not involve constructing new buildings or otherwise placing additional people or sensitive structures at risk. Instead, it would phase out and remove existing oil production infrastructure, activities which are limited in duration, occur primarily on already-disturbed sites, and do not substantially alter subsurface conditions.

Temporary ground-disturbing activities associated with decommissioning (e.g., removal of wells and equipment per all California Geologic Energy Management Division (CalGEM) requirements for plugging and abandonment) would be conducted in compliance with applicable seismic safety regulations and standard engineering practices. If site-specific conditions warrant, all project

activities would follow existing state and local requirements for addressing liquefaction risks, such as conducting geotechnical investigations prior to any substantial ground disturbance and implementing recommended stabilization or compaction measures.

Because the project does not introduce new habitable structures or long-term uses that could be adversely affected by liquefaction, and since any temporary work would comply with established safety protocols, the potential impact related to seismic-induced ground failure, including liquefaction, would be less than significant.

(iv) Landslides?

Less than Significant Impact. Some areas of unincorporated Los Angeles County, including portions of the Baldwin Hills, contain steep slopes or unstable terrain that may be subject to landslides, particularly during significant seismic events or heavy rainfall. However, the project does not involve constructing new buildings or conducting extensive grading that could destabilize slopes or increase landslide risk.

Instead, the project focuses on phasing out and removing existing oil production infrastructure. Ground-disturbing activities associated with well plugging, equipment removal, or minor grading for site restoration would be limited in scope and duration and would occur on sites previously disturbed by industrial operations. Compliance with standard construction practices, erosion control measures, and applicable California Building Code requirements would ensure that any temporary soil disturbance does not exacerbate landslide conditions. If necessary, site-specific evaluations and recommended stabilization measures would be implemented before and during decommissioning.

In the long term, removing oil production facilities may reduce the number of structures potentially affected by landslides and allow for restoration activities that improve slope stability (e.g., proper grading, revegetation). Because the project does not introduce new habitable structures or uses that would increase exposure to landslide hazards, and because all activities would adhere to existing regulations and best management practices, impacts related to landslides would be less than significant.

b. Result in substantial soil erosion or the loss of topsoil?

Less than Significant Impact. The project would phase out oil production activities and remove existing industrial infrastructure in unincorporated Los Angeles County. While limited ground-disturbing activities—such as grading, excavation, and equipment removal—may temporarily increase the potential for soil erosion, these activities would be short-term, localized, and occur primarily within previously disturbed, compacted industrial sites. Consequently, the likelihood of substantial topsoil loss is reduced.

To ensure protection against erosion, decommissioning activities must comply with applicable regulations and standard industry practices. For instance, if ground-disturbing activities exceed one acre, the project would need a Stormwater Pollution Prevention Plan (SWPPP) as part of the National Pollutant Discharge Elimination System (NPDES) General Construction Permit. Such a plan typically includes best management practices (BMPs) like silt fencing, fiber rolls, or stabilized construction entrances to minimize sediment runoff. Additionally, the Los Angeles County Grading Code and the County's Low Impact Development (LID) Ordinance provide guidelines and requirements that limit soil erosion and manage stormwater runoff effectively.

Following decommissioning, any subsequent site restoration or conversion—such as regrading, revegetation, or properly engineered construction—would help stabilize soils, reduce erosion potential, and prevent long-term topsoil loss. Because the project involves only temporary ground disturbance and must adhere to existing regulatory requirements designed to prevent erosion, impacts related to soil erosion or loss of topsoil would be less than significant.

c. Be located on a geologic unit that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure in areas already characterized by industrial disturbances. These sites have typically undergone previous grading, compaction, and other alterations to the natural soil profile. Since the project does not involve the construction of new, habitable structures or major grading that could create large new slopes or significantly alter the subsurface conditions, it is not expected to induce instability in underlying geologic units.

Some portions of unincorporated Los Angeles County may contain soils prone to subsidence, liquefaction, or lateral spreading, particularly those in proximity to historic oil extraction sites. However, by ending extraction activities, the project would help reduce future risks of subsidence associated with ongoing resource removal. Any temporary ground disturbance related to the plugging of wells or removal of infrastructure would be limited in scope and duration, and would comply with relevant building codes, seismic safety requirements, and grading regulations. Where necessary, site-specific investigations and engineering measures would be implemented to ensure that no significant instability is introduced. Over time, as oil operations cease, regrading and potential revegetation would help stabilize soils and slopes, improving long-term geotechnical conditions.

Because the project does not create new instability risks and instead reduces activities that can contribute to subsidence or soil weakening, the potential for on- or off-site landslides, lateral spreading, subsidence, liquefaction, or collapse would be less than significant.

d. Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial direct or indirect risks to life or property?

Less than Significant Impact. Some areas within unincorporated Los Angeles County may contain expansive soils, which swell or shrink with changes in moisture content. Such soils can pose a risk to structures if not properly managed. However, the project involves the phased cessation of oil production activities and the removal of existing industrial infrastructure—actions that generally reduce long-term structural risks rather than increase them. The project does not propose new habitable structures that would be susceptible to damage from expansive soils.

Any ground-disturbing activities associated with well plugging, equipment removal, or minor grading would be short-term and localized. Standard industry practices and compliance with the California Building Code and County grading ordinances would address potential soil stability issues, including those posed by expansive soils. If future uses are proposed on these sites, they would be subject to site-specific geotechnical evaluations and compliance with applicable engineering standards to ensure that soil conditions, including expansion potential, do not create substantial risks to life or property.

As a result, the project's activities would not lead to significant hazards associated with expansive soils. Any impact would be less than significant.

e. Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater?

No Impact. The project would phase out oil production activities in unincorporated Los Angeles County and does not involve new development or operations requiring on-site wastewater treatment systems such as septic tanks or alternative disposal methods. Therefore, the suitability of soils for supporting such systems is not a concern under this project.

If any limited, temporary wastewater needs arise during decommissioning (e.g., portable restrooms for workers), these would be managed through permitted and regulated services that do not rely on permanent on-site disposal systems. No new septic systems or alternative wastewater disposal facilities are proposed.

Since the project does not depend on soils for wastewater disposal, no impacts related to soils incapable of supporting septic tanks or similar systems would occur.

f. Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure at previously disturbed, industrialized sites in unincorporated Los Angeles County. Due to the long history of ground disturbance in these areas, the likelihood of encountering previously undisturbed paleontological resources or unique geologic features is low.

If any ground-disturbing activities occur, such as limited grading or excavation, they would be short-term and confined to already modified soils. Should previously unknown fossils or unique geological formations be encountered during decommissioning, standard procedures would be followed, including temporarily halting work in the immediate vicinity and consulting with a qualified paleontologist or geologist to evaluate the find and recommend appropriate treatment. Compliance with applicable local and state regulations ensures that such discoveries would be handled with care and properly documented, reducing any potential impact to a less than significant level.

Because the project would not introduce new large-scale development or require extensive grading in undisturbed areas, and due to compliance with established regulations and protocols, the potential for directly or indirectly destroying unique paleontological resources or unique geologic features is less than significant.

g. Conflict with the Hillside Management Area Ordinance (L.A. County Code, Title 22, Ch.22.104)?

No Impact. The project, which phases out oil production activities in unincorporated Los Angeles County, aligns with the objectives of the Hillside Management Area (HMA) Ordinance and is not expected to conflict with its provisions. The HMA Ordinance is designed to preserve the physical integrity, scenic value, and open space of hillside areas while ensuring development is compatible with community character.

Phasing out oil production activities supports the goals of the HMA Ordinance by reducing industrial impacts on hillside areas and improving scenic and environmental values. Restoration or conversion activities, such as regrading and revegetation, may help stabilize soils, reduce erosion, and enhance the natural landscape, further aligning with the ordinance's open space preservation goals.

The project does not propose new construction, grading-intensive activities, or development that would trigger the Conditional Use Permit (CUP) requirements under the HMA Ordinance. This avoids conflicts related to building placement, hillside grading, or scenic view disruption. Grading activities required for the removal of oil wells and associated facilities will adhere to all local regulations to minimize impacts. These activities are temporary and aim to restore, rather than alter, natural landforms. The project does not propose large-scale grading or landform changes that would affect the scenic or physical integrity of HMAs. The removal of oil wells and production facilities aligns with the HMA Ordinance's requirement to enhance the aesthetic value of hillside areas.

Per Section 22.104.030(H), development related to oil and gas production in the Baldwin Hills Community Standards District (CSD) is exempt from the HMA Ordinance CUP requirement, provided compliance with the provisions of the CSD.

The project supports the objectives of the Hillside Management Area Ordinance by phasing out industrial activities, restoring natural landscapes, and preserving scenic and physical hillside integrity. Temporary impacts during decommissioning are limited and managed in compliance with applicable regulations. Therefore, the project does not conflict with the provisions of the ordinance, and impacts are less than significant.

VIII. Greenhouse Gas Emissions

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. **Generate greenhouse gas (GHGs) emissions, either directly or indirectly, that may have a significant impact on the environment?**	☐	☐	☒	☐
b. **Conflict with any applicable plan, policy, or regulation adopted for the purpose of reducing the emissions of greenhouse gases?**	☐	☐	☒	☐

a. Generate greenhouse gas (GHGs) emissions, either directly or indirectly, that may have a significant impact on the environment?

Less than Significant Impact. The project, which phases out oil production activities in unincorporated Los Angeles County, is not expected to result in significant greenhouse gas (GHG) emissions. While temporary GHG emissions will be generated during decommissioning activities, the project's long-term benefits include the elimination of operational GHG emissions from oil production, aligning with state and local GHG reduction goals.

While the phase-out of local oil production could result in increased reliance on imported oil in the short term, potentially increasing GHG emissions from transport and production, the project supports long-term climate goals by reducing regional emissions and fostering a transition away from fossil fuels. The extent to which reliance on imported oil might increase, and the duration of any resulting GHG increase, is uncertain and dependent on factors like market dynamics, energy policies, and shifts in demand for oil. The project itself does not directly cause an increase in oil imports—it contributes to transitioning away from fossil fuel dependence.

Decommissioning activities will involve the use of heavy machinery, equipment, and vehicles, which emit GHGs such as carbon dioxide (CO_2) and nitrous oxide (N_2O) through fuel combustion. Transportation of materials, equipment, and waste to and from project sites will also contribute to temporary emissions. These emissions are limited to the duration of decommissioning activities, which are temporary and localized.

Oil production activities produce significant GHG emissions from processes such as pumping, refining, and transporting oil. Methane, a potent greenhouse gas, is also released during extraction. By phasing out oil production, the project eliminates these operational sources of emissions, providing a substantial and lasting reduction in the region's GHG footprint. Proper decommissioning of oil wells will seal and close wells, reducing the risk of methane leaks from abandoned or improperly managed wells, which are a significant source of GHG emissions.

The project supports California's GHG reduction targets outlined in Assembly Bill (AB) 32, Senate Bill (SB) 32, and Executive Order B-55-18, which aim to reduce emissions and achieve carbon neutrality by 2045. The project aligns with the County's Climate Action Plan (CAP) by contributing to reduced fossil fuel use, lowering emissions, and supporting transitions to more sustainable land uses. Given the temporary nature of decommissioning activities and the long-term cessation of oil

operations, GHG emissions generated by the project are expected to remain below the relevant thresholds (South Coast and Antelope Valley Air Quality Monitoring Districts).

While the project will generate temporary GHG emissions during decommissioning, these emissions are not significant when compared to the long-term reductions achieved by eliminating oil production operations. The project aligns with state and local climate action goals and does not generate GHG emissions at a level that would significantly impact the environment. Therefore, impacts are less than significant.

b. Conflict with any applicable plan, policy, or regulation adopted for the purpose of reducing the emissions of greenhouse gases?

Less than Significant Impact. The project would phase out oil production activities in unincorporated Los Angeles County. Although decommissioning efforts will temporarily generate greenhouse gas (GHG) emissions from construction equipment, trucks, and associated activities, these emissions would be short-term and limited in scope. No new operational sources of GHGs would be introduced once oil production ceases.

In the long term, ending oil production reduces a significant source of regional GHG emissions. Oil production processes release substantial amounts of carbon dioxide (CO_2) and methane (CH_4), both potent greenhouse gases. By decommissioning wells, sealing them properly, and removing facilities that support fossil fuel production, the project directly contributes to reducing these emissions. Over time, this aligns with California's overarching GHG reduction goals as set forth in Assembly Bill 32, Senate Bill 32, and Executive Orders aimed at carbon neutrality. It also supports the transition away from fossil fuels, consistent with the General Plan and 2045 Climate Action Plan (2045 CAP).

The 2045 CAP guides the County's approach to decreasing GHG emissions through various strategies and is part of the Air Quality Element of the General Plan. The project's elimination of a GHG-intensive industrial activity (oil production) is consistent with the County's climate policies, which encourage reducing reliance on fossil fuels and lowering overall GHG emissions. Additionally, because the project does not involve adding new GHG-generating uses and is consistent with the General Plan's designated land use and density, it may rely on the existing framework and analysis provided in the 2045 CAP. Thus, a separate, project-level GHG emissions analysis is not required under CEQA Guidelines Section 15183.5.

In summary, while minor, temporary GHG emissions would occur during decommissioning, the project facilitates long-term GHG reductions by permanently removing oil production operations. Therefore, any GHG emissions impact would be less than significant.

IX. Hazards and Hazardous Materials

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. Create a significant hazard to the public or the environment through the routine transport, storage, production, use, or disposal of hazardous materials?	☐	☐	☒	☐
b. Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials or waste into the environment?	☐	☐	☒	☐
c. Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of sensitive land uses?	☐	☐	☒	☐
d. Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code § 65962.5 and, as a result, would it create a significant hazard to the public or the environment?	☐	☐	☒	☐
e. For a project located within an airport land use plan, or where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard or excessive noise for people residing or working in the project area?	☐	☐	☒	☐
f. Impair implementation of, or physically interfere with, an adopted emergency response plan or emergency evacuation plan?	☐	☐	☒	☐
g. Expose people or structures, either directly or indirectly, to a significant risk of loss, injury or death involving fires, because the project is located:				
i) within a high fire hazard area with inadequate access?	☐	☐	☒	☐
ii) within an area with inadequate water and pressure to meet fire flow standards?	☐	☐	☒	☐
iii) within proximity to land uses that have the potential for dangerous fire hazard?	☐	☐	☒	☐
h. Does the proposed use constitute a potentially dangerous fire hazard?	☐	☐	☒	☐

a. Create a significant hazard to the public or the environment through the routine transport, storage, production, use, or disposal of hazardous materials?

Less than Significant Impact. The project would phase out oil production activities at previously industrialized sites in unincorporated Los Angeles County. Decommissioning oil wells and related

facilities may involve handling hazardous substances commonly associated with oil production, including residual hydrocarbons, drilling fluids, and possibly Naturally Occurring Radioactive Materials (NORM) on equipment. However, these activities would be temporary and subject to stringent regulatory controls.

All hazardous materials handling, storage, and transport would be conducted in accordance with state and federal regulations administered by agencies such as the Department of Toxic Substances Control (DTSC) and the Los Angeles County Fire Department's Health Hazardous Materials Division. Compliance with the Resource Conservation and Recovery Act (RCRA), the California Hazardous Waste Control Law, and other applicable regulations ensure that hazardous materials are properly identified, packaged, documented, and transported to permitted disposal or treatment facilities by licensed hazardous waste haulers. The project's integrated Site Maintenance requirements and Well Plugging and Abandonment standards ensure that any stored or transported hazardous materials are promptly cleaned up or removed, eliminating their long-term presence on-site. These regulations, combined with the project's new Bonds requirement, provide an additional layer of assurance that site remediation and proper waste disposal will be funded if an operator fails to act.

If any contaminated soil or materials are encountered, they would be handled following established protocols, including proper containment and disposal at approved facilities, to prevent releases that could harm the public or the environment. Given the oversight, best management practices, and emergency response plans in place, routine transport, use, and disposal of hazardous materials during decommissioning would not create a significant hazard.

No new long-term operations involving hazardous materials are proposed. Eliminating oil production activities would ultimately reduce the quantity of hazardous materials managed on-site over the long run. Therefore, any impacts related to hazardous materials handling and disposal during the project's limited decommissioning phase would be less than significant.

b. Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials or waste into the environment?

Less than Significant Impact. Decommissioning oil production facilities in unincorporated Los Angeles may involve handling potentially hazardous substances such as residual hydrocarbons, drilling fluids, and contaminated soil. While the presence of these materials carries some risk, the potential for accidents or unplanned releases is minimized through stringent regulatory oversight, established safety protocols, and best management practices.

Before and during decommissioning, operators must comply with applicable federal, state, and local regulations designed to prevent the release of hazardous materials. These regulations include requirements set forth by the California Geologic Energy Management Division (CalGEM) for proper well abandonment, and by the Department of Toxic Substances Control (DTSC) and the Los Angeles County Fire Department's Health Hazardous Materials Division for managing hazardous waste. Activities are conducted in accordance with approved hazardous materials handling plans, spill prevention and response measures, and ongoing inspections to ensure compliance.

The project's safety measures—particularly those required by Site Maintenance and Well Plugging and Abandonment provisions—mitigate the potential for releases. These standards require site operators to keep the vicinity free of oil pools or debris, promptly address spills, and remove

unneeded pipelines and equipment once wells are no longer in use. The project's Complaint and Comment Log requirement also provides an avenue for reporting any release or accidental spill, ensuring rapid response and corrective action.

If unknown contaminants are discovered, work would cease in the affected area until the material is characterized and removed in accordance with regulatory standards. Licensed hazardous waste haulers and permitted disposal facilities would be used for transporting and disposing of hazardous materials, reducing the likelihood of accidental releases during transport.

In the long run, by permanently phasing out oil operations, the project would eliminate ongoing risks associated with active extraction, storage, and processing of oil and related hazardous substances. Consequently, the potential for future accidents involving hazardous materials would be substantially reduced.

Given the robust regulatory framework, required safety measures, and careful handling procedures, the risk of creating a significant hazard to the public or the environment through accidental release of hazardous materials is minimized. Therefore, impacts would be less than significant.

c. Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of sensitive land uses?

Less than Significant Impact. Decommissioning oil production facilities in unincorporated Los Angeles County may require the handling of hazardous materials associated with well abandonment and infrastructure removal. These could include residual hydrocarbons, drilling fluids, contaminated soil, and other materials typical of oil production sites. Although such materials are hazardous, their handling is strictly regulated by federal, state, and local agencies, ensuring proper containment, transport, and disposal. Compliance with regulations under the California Hazardous Waste Control Law and oversight by the Los Angeles County Fire Department's Health Hazardous Materials Division would minimize any potential exposure risk. Compliance with the project's Site Maintenance provisions helps ensure proper containment, rapid spill response, and removal of materials that could pose risks to nearby sensitive receptors. Further, the project's Complaint and Comment Log requirement facilitates quick reporting and resolution of any issue related to emissions or potential exposures.

If sensitive land uses (e.g., residences, schools, healthcare facilities, daycare centers, or parks) exist within one-quarter mile of a project site, project activities would still be subject to stringent safety protocols designed to prevent hazardous emissions or releases. Standard best management practices—such as covering haul trucks, using spill containment measures, and implementing proper storage and disposal methods—would be employed to ensure that hazardous materials are handled safely and do not pose a risk to nearby sensitive populations.

Because the project does not introduce new long-term operations involving hazardous materials and is focused on removing existing petroleum-related infrastructure, any potential hazardous material handling would be temporary, controlled, and closely monitored. Given the robust regulatory framework and implementation of best management practices, the likelihood of hazardous emissions or materials affecting sensitive land uses within a quarter mile is very low. Therefore, impacts would be less than significant.

d. Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code § 65962.5 and, as a result, would it create a significant hazard to the public or the environment?

Less than Significant Impact. Some oil production sites within unincorporated Los Angeles County may be listed under Government Code § 65962.5 (often referred to as the Cortese List) due to past operations that potentially contaminated soil or groundwater with hazardous substances. However, the project would not introduce new contaminating activities; rather, it would phase out oil production and result in the removal of appurtenant infrastructure from affected sites.

If an oil production site is listed on the Cortese List, it would already be subject to investigation and cleanup requirements overseen by agencies such as the Department of Toxic Substances Control (DTSC) and the Regional Water Quality Control Board (RWQCB). Decommissioning and closure of oil wells, along with any required remediation, would follow applicable environmental regulations and established protocols to ensure that contaminated soils or other hazardous materials are handled and disposed of properly. The California Geologic Energy Management Division (CalGEM) standards for well abandonment, in conjunction with the DTSC oversight and compliance with the Resource Conservation and Recovery Act (RCRA), ensure that these operations mitigate existing hazards. The project further regulates these activities via its integrated Well Plugging and Abandonment and Bonds provisions, ensuring that operators or the County have sufficient resources to carry out remediation if contamination is discovered or if the operator fails to remediate a site. These measures bolster existing investigative and cleanup requirements under DTSC and RWQCB oversight.

By safely removing or remediating contaminated infrastructure and materials, the project would ultimately reduce long-term risks to the public and the environment. As a result, even if the site is listed on the Cortese List, the project's activities are anticipated to improve, rather than worsen, existing conditions. Therefore, any impacts related to site listings under Government Code § 65962.5 would be less than significant.

e. For a project located within an airport land use plan, or where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard or excessive noise for people residing or working in the project area?

Less than Significant Impact. The project would phase out oil production activities, resulting in the removal of associated infrastructure on sites that may or may not be located within an airport land use plan area or within two miles of a public airport. If a site does fall within an airport's area of influence, the activities resulting from the project involve dismantling existing facilities rather than introducing new development or uses that would increase safety hazards or expose people to excessive noise related to airport operations.

Any decommissioning work that may occur near an airport would be temporary and closely regulated. Tall equipment or cranes used during well plugging or facility removal would comply with Federal Aviation Administration (FAA) regulations and any applicable requirements of the local airport land use plan to ensure they do not create airspace obstructions or safety hazards. The project does not propose structures that would conflict with flight paths or increase the density of people living or working near runways or approach/departure zones. Additionally, the project's performance standards—such as the Site Maintenance rules—would keep sites free of debris or tall, unwieldy structures that might pose hazards to aircraft operations.

The cessation of oil production activities would ultimately reduce industrial noise and activity in the area, potentially improving the local noise environment over the long term. Existing regulations and review processes—such as consultation with the Los Angeles County Airport Land Use Commission, if applicable—ensure that any project activities within an airport land use plan or near an airport are consistent with safety guidelines and compatibility criteria.

Therefore, the project would not result in a significant safety hazard or create excessive noise for people residing or working in the project area, and impacts would be less than significant.

f. Impair implementation of, or physically interfere with, an adopted emergency response plan or emergency evacuation plan?

Less than Significant Impact. The project would phase out oil production activities, resulting in the removal of associated infrastructure in unincorporated Los Angeles County. While decommissioning activities may involve construction equipment and temporary work areas, these are not anticipated to interfere with established emergency response or evacuation routes.

Los Angeles County's Operational Area Emergency Response Plan (OAERP) and the Local All-Hazards Mitigation Plan guide the County's emergency response and recovery efforts. These plans designate specific disaster routes—shown in the County's General Plan Safety Element—to ensure that emergency vehicles can access affected areas and that evacuations can be carried out efficiently. Any temporary lane closures or traffic control measures required during well abandonment or equipment removal would be coordinated with local agencies and conducted in compliance with County regulations, ensuring that critical routes remain passable for emergency services.

Moreover, by eliminating oil production activities, the project would reduce the potential for hazards such as spills, fires, or explosions that could complicate emergency responses. Removing these sources of risk and potentially restoring sites to safer uses aligns with the County's hazard mitigation goals and supports long-term community resilience. The project's Site Maintenance provisions require clearing flammable materials and debris, and the Bonds required guarantee resources for safe site closure.

Because the project's short-term activities can be managed to avoid disrupting emergency routes, and the long-term effect of discontinuing oil production reduces hazard potential, the project would not impair or interfere with adopted emergency response or evacuation plans. Therefore, the impact is less than significant.

g. (i) Located within a high fire hazard area with inadequate access?

Less than Significant Impact. Some oil production sites in unincorporated Los Angeles County are located within Very High Fire Hazard Severity Zones (VHFHSZs), where the risk of wildfire is elevated. These areas often have steep slopes, dense vegetation, and other conditions that can contribute to intense fires. However, the project, which involves phasing out oil production and decommissioning associated infrastructure, does not introduce new development or permanent uses that would increase fire risk or strain emergency access. Instead, it phases out oil production activities and ensures proper site maintenance under the project's integrated Site Maintenance standards, which mandate the removal of combustible materials within 25 feet of wells and the clearance of debris. These standards, paired with existing Los Angeles County Fire Department regulations, help minimize the likelihood of wildfires.

Decommissioning activities would be temporary and conducted in compliance with all applicable fire safety regulations. The Los Angeles County Fire Department enforces stringent requirements for developments and projects within VHFHSZs, including maintaining adequate emergency access, ensuring sufficient fire flow, and removing flammable materials that could contribute to fire spread. The project's removal of oil-related infrastructure and hazardous materials would likely reduce the overall fire risk at the site over the long term.

While decommissioning work may involve construction equipment and temporary on-site personnel, these activities are short-term, localized, and subject to oversight by the County Fire Department. Compliance with fire codes, defensible space regulations, and any necessary vegetation management practices ensure that emergency access routes remain unobstructed and first responders can reach the site if needed. Moreover, eliminating ongoing oil production removes a source of potential fire hazard, thereby diminishing long-term fire risks.

In summary, although some project areas are located within high fire hazard zones, the project would not worsen fire risk or limit emergency access. Instead, by ceasing oil production and restoring the site, the project may improve conditions for fire safety. Therefore, impacts related to fire hazards and emergency access in high fire hazard areas would be less than significant.

(ii) Located within an area with inadequate water and pressure to meet fire flow standards?

Less than Significant Impact. The project would phase out oil production activities, resulting in the removal of associated infrastructure, rather than introducing new development that demands long-term water service or enhanced fire flow capacity. While some existing oil production sites may be in areas with limited water infrastructure and reduced water pressure, the project's activities are temporary, limited to decommissioning and restoration tasks.

Fire flow standards and requirements, established by the Los Angeles County Fire Department (LACoFD), are typically determined based on the nature of ongoing land uses and the types of structures present. Active oil production operations may have previously addressed fire safety needs through on-site measures—such as storage tanks or portable water supplies—to compensate for limited municipal water systems. As the project focuses on removing wells, equipment, and associated infrastructure, the need for substantial, long-term fire flows diminishes.

During decommissioning, water use would be minimal and largely confined to activities like dust suppression and equipment cleaning. These do not strain existing water supplies or pressure. In areas lacking robust municipal infrastructure, any required fire safety measures (e.g., on-site water storage or alternative fire suppression systems) can be implemented on a temporary basis.

The project's Site Maintenance and Well Plugging and Abandonment requirements reduce the presence of flammable materials, thus diminishing potential fire-fighting needs over the long term. Additionally, by eliminating a source of flammable materials and industrial hazards in the form of oil wells and production facilities, the project reduces fire risks over the long term, thereby lessening the reliance on high fire flow capacities in the future.

In all cases, compliance with local fire codes and LACoFD guidelines ensures that any short-term needs for fire suppression resources are adequately addressed. Consequently, even in areas with limited water availability and pressure, the project would not result in significant impacts related to inadequate fire flow.

(iii) Located within proximity to land uses that have the potential for dangerous fire hazard?

Less than Significant Impact. The project would phase out oil production activities, resulting in the removal of associated infrastructure and thereby reducing long-term fire risks at affected sites. While some oil operations may currently be located near land uses with potential fire hazards—such as wildlands, industrial facilities, or other areas storing flammable materials—the project's decommissioning process is designed to minimize immediate fire risks and align with all applicable safety regulations.

During decommissioning, any flammable substances or equipment will be handled and removed according to fire safety standards set by the Los Angeles County Fire Department, the California Fire Code, and the project's integrated the Site Maintenance standards that ensure prompt cleanup of any flammable fluids and mandatory vegetation clearance. Temporary increases in fire risk from construction equipment or handling of materials would be short-lived and mitigated through best management practices, emergency preparedness plans, and adherence to all relevant codes and regulations.

Over the long term, the cessation of oil production eliminates sources of potentially combustible materials and infrastructure that could have contributed to fire hazards. The resulting site conditions would be more compatible with surrounding land uses and less prone to fire incidents. As a result, impacts related to proximity to dangerous fire hazards would be less than significant.

h. Does the proposed use constitute a potentially dangerous fire hazard?

Less than Significant Impact. While the decommissioning of oil production activities may involve the use of machinery, handling of residual flammable substances, and activities that could generate heat or sparks, these operations are temporary, strictly regulated, and employ robust fire safety measures. All decommissioning activities must adhere to the applicable fire codes and standards enforced by the Los Angeles County Fire Department, including proper storage, handling, and disposal of flammable materials, the use of fire suppression equipment and emergency response protocols, and the project's integrated Site Maintenance rules for keeping oil and debris off-site.

By phasing out oil production activities, the project eliminates a long-term source of potential fire hazards—namely, the ongoing presence of combustible materials and equipment characteristic of active oil production. Once decommissioned, the absence of active oil operations significantly reduces the likelihood of dangerous fire hazards associated with industrial operations. Any temporary risks present during the removal of infrastructure are managed and mitigated through regulatory compliance and best management practices.

As a result, while the project's short-term activities are subject to fire safety precautions, the project does not constitute a potentially dangerous fire hazard. The long-term effect is a net reduction in fire risk compared to continued oil production operations. Thus, impacts would be less than significant.

X. Hydrology and Water Quality

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. Violate any water quality standards or waste discharge requirements or otherwise substantially degrade surface or groundwater quality?	☐	☐	☒	☐
b. Substantially decrease groundwater supplies or interfere substantially with groundwater recharge such that the project may impede sustainable groundwater management of the basin?	☐	☐	☒	☐
c. Substantially alter the existing drainage pattern of the site or area, including through the alteration of a Federal 100-year flood hazard area or County Capital Flood floodplain; the alteration of the course of a stream or river; or through the addition of impervious surfaces, in a manner which would:				
i) Result in substantial erosion or siltation on- or off-site?	☐	☐	☒	☐
ii) Substantially increase the rate, amount, or depth of surface runoff in a manner which would result in flooding on- or offsite?	☐	☐	☒	☐
iii) Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?	☐	☐	☒	☐
iv) Impede or redirect flood flows which would expose existing housing or other insurable structures in a Federal 100-year flood hazard area or County Capital Flood floodplain to a significant risk of loss or damage involving flooding?	☐	☐	☒	☐
d. Otherwise place structures in Federal 100-year flood hazard or County Capital Flood floodplain areas which would require additional flood proofing and flood insurance requirements?	☐	☐	☒	☐
e. Conflict with the Los Angeles County Low Impact Development Ordinance (L.A. County Code, Title 12, Ch. 12.84)?	☐	☐	☒	☐
f. Use onsite wastewater treatment systems in areas with known geological limitations (e.g. high groundwater) or in close proximity to surface water (including, but not limited to, streams, lakes, and drainage course)?	☐	☐	☐	☒
g. In flood hazard, tsunami, or seiche zones, risk release of pollutants due to project inundation?	☐	☐	☒	☐

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
h. **Conflict with or obstruct implementation of a water quality control plan or sustainable groundwater management plan?**	☐	☐	☒	☐

a. Violate any water quality standards or waste discharge requirements or otherwise substantially degrade surface or groundwater quality?

Less than Significant Impact. The project would phase out oil production activities, resulting in the removal of associated infrastructure in unincorporated Los Angeles County. Although decommissioning work involves ground disturbance and the handling of potentially hazardous materials, compliance with existing regulatory frameworks ensures that water quality standards and waste discharge requirements are not violated, and that surface and groundwater resources are protected.

During decommissioning, residual contaminants such as hydrocarbons or drilling fluids may be encountered. However, the California Geologic Energy Management Division (CalGEM) regulates well abandonment and requires wells to be properly sealed and secured to prevent fluid migration into groundwater. Any contaminated soil or materials discovered must be treated or disposed of in accordance with state and federal laws, including the Resource Conservation and Recovery Act (RCRA) and the California Hazardous Waste Control Law, ensuring that pollutants do not migrate to water resources. In addition, the project's Site Maintenance provisions require operators to promptly clean up and remove pools of oil or other fluids, and the Well Plugging and Abandonment standards impose a regulated closure process that further minimizes any potential for groundwater contamination.

If the project disturbs one acre or more of soil, it would be subject to the National Pollutant Discharge Elimination System (NPDES) Construction General Permit. Under this permit, a Storm Water Pollution Prevention Plan (SWPPP) would be prepared and implemented, incorporating best management practices (BMPs) such as silt fencing, wattles, or sediment basins to minimize erosion, sedimentation, and pollutant discharge into local waterways. These measures reduce the likelihood of contaminants leaving the project site and entering surface waters.

In addition, compliance with the Los Angeles County Low Impact Development Ordinance and any applicable requirements from the Regional Water Quality Control Board ensures that project activities do not degrade water quality. As the project phases out oil production, long-term risks of leaks, spills, or other contamination are reduced, ultimately benefiting regional water quality. The project's required Bonds also guarantee that financial resources are available for site remediation should an operator fail to perform adequate cleanup.

Given these regulatory controls, mandatory compliance measures, and the new performance standards for well abandonment, the project would not violate water quality standards or waste discharge requirements, nor would it substantially degrade surface or groundwater quality. Impacts would therefore be less than significant.

b. Substantially decrease groundwater supplies or interfere substantially with groundwater recharge such that the project may impede sustainable groundwater management of the basin?

Less than Significant Impact. The project would phase out oil production activities and remove related infrastructure, rather than introduce new long-term uses that significantly depend on or alter groundwater supplies. Any temporary water uses during the decommissioning phase (e.g., for dust suppression or soil remediation) would be minimal and not require the development of new groundwater wells. Water, if needed, would be sourced from existing municipal or permitted supplies, thus avoiding direct withdrawals from local aquifers.

By eliminating active oil operations, the project also removes infrastructure that can impede natural infiltration, such as paved well pads and compacted access roads. Subsequent site restoration efforts—such as regrading and revegetating formerly developed areas—may enhance natural percolation of rainwater into the soil, thereby promoting groundwater recharge. This restoration can offset any minor, short-term disturbance from decommissioning and may even improve long-term groundwater conditions compared to the status quo.

Furthermore, properly plugging and abandoning oil wells, as required by the California Geologic Energy Management Division (CalGEM) standards, prevents potential vertical pathways that could contaminate or affect groundwater flows. The project's performance standards—particularly the Well Plugging and Abandonment provisions—reinforce these requirements, reducing the risk that abandoned wells could allow pollutants to enter aquifers. Removing or remediating any site contamination supports sustainable groundwater management practices.

In summary, the project does not create substantial new demands on groundwater supplies, nor does it significantly interfere with groundwater recharge. Instead, it may lead to improved infiltration and reduced contamination risks over time. Therefore, impacts related to groundwater supplies and recharge would be less than significant.

c. (i) Result in substantial erosion or siltation on- or off-site?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure, potentially involving ground-disturbing activities like grading and soil excavation during the decommissioning phase. These short-term construction activities could temporarily increase the risk of erosion or siltation, particularly if rain events occur while soils are exposed. However, such risks would be effectively managed through compliance with existing regulatory requirements and the project's integrated performance standards.

For any soil disturbance of one acre or more, the project would be subject to the National Pollutant Discharge Elimination System (NPDES) Construction General Permit, which requires the preparation and implementation of a Stormwater Pollution Prevention Plan (SWPPP). The SWPPP outlines best management practices (BMPs) such as silt fencing, sediment basins, stabilized construction entrances, and other erosion-control measures to minimize soil loss and prevent sediments from entering waterways. Additionally, adherence to the Los Angeles County Low Impact Development Ordinance and grading regulations would further limit erosion and siltation both during and after construction.

In the long term, removing oil-related infrastructure and restoring the site can improve soil stability and reduce impervious surfaces, potentially enhancing natural infiltration and reducing runoff velocities. As a result, once decommissioning is complete, the site may experience reduced erosion compared to conditions present under active operations. Moreover, the project's Site Maintenance requirements ensure that operators remove debris and any potential sources of sediment promptly, decreasing the risk of erosion issues.

Given the project's compliance with existing regulatory frameworks and the implementation of BMPs, any potential erosion or siltation impacts would be short-term, controlled, and minimized. Therefore, the impact on erosion and siltation would be less than significant.

(ii) Substantially increase the rate, amount, or depth of surface runoff in a manner which would result in flooding on- or offsite?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure, potentially involving ground-disturbing actions like grading or soil excavation during the decommissioning phase. Such activities may slightly alter on-site drainage patterns and temporarily increase surface runoff. However, these changes would be localized and short-term.

Because project activities are subject to the National Pollutant Discharge Elimination System (NPDES) Construction General Permit requirements, Stormwater Pollution Prevention Plans (SWPPPs) would be prepared and implemented as required. These plans outline best management practices (BMPs) designed to control runoff, including measures to prevent water from accumulating on-site or overwhelming downstream drainage systems. Additionally, compliance with the Los Angeles County Low Impact Development Ordinance ensures that post-decommissioning conditions do not substantially increase runoff volumes or velocities.

Over the long term, the cessation of oil production and removal of impervious surfaces associated with industrial operations may improve infiltration and reduce runoff. Restoring or regrading the site and planting vegetation can enhance infiltration capacity and decrease the likelihood of on- or off-site flooding. The project's performance standards such as Site Maintenance provisions also require operators to keep areas free of debris and ensure adequate drainage, further reducing flood risks. Therefore, any short-term increase in surface runoff would be effectively managed, and the project would not cause substantial flooding. Thus, impacts related to surface runoff and flooding would be less than significant.

(iii) Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure, which may involve some short-term ground disturbance (e.g., grading, excavation) during decommissioning. While these activities could temporarily alter the site's runoff characteristics, compliance with applicable regulations and implementation of best management practices (BMPs) would ensure that any changes in runoff volume or quality do not exceed the capacity of existing or planned stormwater drainage systems, nor result in substantial additional sources of polluted runoff.

During decommissioning, construction-related pollutants such as sediment or hydrocarbons could potentially be carried off-site by stormwater runoff. However, if one acre or more of ground is disturbed, the project would be subject to the National Pollutant Discharge Elimination System (NPDES) Construction General Permit, requiring preparation and implementation of a site-specific Stormwater Pollution Prevention Plan (SWPPP). The SWPPP would include erosion and sediment controls, spill prevention measures, and other BMPs designed to minimize runoff impacts and prevent pollutants from entering the storm drain system. Additionally, compliance with the County's Low Impact Development Ordinance and stormwater regulations would further reduce runoff

volumes and improve runoff quality through on-site infiltration, retention, or treatment measures as appropriate.

Over the long term, removing oil wells and associated hardscape—such as pads, roads, and equipment areas—may decrease impervious surfaces and restore more natural infiltration conditions. This shift can improve on-site permeability, reduce peak runoff flows, and lower the potential pollutant load compared to ongoing oil production operations. Properly abandoning and sealing wells will eliminate potential contamination pathways, further reducing the risk of polluted runoff reaching stormwater systems. By also adhering to the project's Site Maintenance standards, operators must keep surfaces free of pooled liquids or debris that could contribute pollutants to the runoff.

Consultation with the County Public Works would ensure that any incremental runoff changes remain within the capacity of the local stormwater infrastructure. Given that the project's activities are designed to comply with regulatory standards and improve site conditions relative to existing industrial operations, the potential impacts associated with exceeding stormwater system capacity or adding significant sources of polluted runoff would be less than significant.

(iv) Impede or redirect flood flows which would expose existing housing or other insurable structures in a Federal 100-year flood hazard area or County Capital Flood floodplain to a significant risk of loss or damage involving flooding?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure, none of which are intended to result in new structures that could impede or redirect flood flows. While some existing oil production sites may be located within or near Federal Emergency Management Agency (FEMA)-designated 100-year flood hazard areas or County Capital Flood floodplains, the proposed decommissioning and restoration activities are not expected to significantly alter regional flooding patterns or increase flood risk to existing housing or insurable structures.

During decommissioning, activities such as grading, soil removal, and well plugging could temporarily modify on-site drainage patterns. However, these changes would be limited in extent and duration. Any work conducted within flood-prone areas would be subject to federal, state, and local floodplain management requirements, ensuring that surface contours are not altered in a way that would substantially impede or redirect flood flows. County Public Works would review proposed activities near flood hazard areas to verify compliance with all applicable regulations, including FEMA guidelines and County floodplain ordinances. If necessary, project activities would incorporate appropriate design measures or obtain required approvals (e.g., Conditional Letter of Map Revision) to ensure flood hazards are not exacerbated.

Furthermore, removing oil production infrastructure—such as well pads, tanks, and pipelines—can restore more natural floodplain function. Eliminating these potential obstructions may improve the flow and storage capacity of floodwaters, reducing the risk that floodwaters would be redirected toward existing developments. Site restoration efforts, including regrading and revegetation, would also promote infiltration and stabilize soils, potentially enhancing natural flood management functions over the long term.

By complying with all relevant floodplain management regulations, coordinating with responsible agencies, and removing industrial infrastructure that could impede floodwaters, the project would not expose existing housing or other insurable structures to increased flood risks. Therefore, impacts

related to impeding or redirecting flood flows within a 100-year flood hazard area or County Capital Flood floodplain would be less than significant.

d. Otherwise place structures in Federal 100-year flood hazard or County Capital Flood floodplain areas which would require additional flood proofing and flood insurance requirements?

Less than Significant Impact. The project would phase out and decommission existing oil production infrastructure rather than construct new permanent structures. Consequently, it would not introduce new buildings or facilities into Federal Emergency Management Agency (FEMA) 100-year flood hazard areas or County Capital Flood floodplains that would necessitate additional floodproofing measures or the purchase of flood insurance.

During the decommissioning phase, temporary equipment and staging areas may be used, but such activities are short-term and do not involve constructing permanent structures. Any work that occurs within or near flood hazard areas would comply with federal, state, and local floodplain management regulations. County Public Works and FEMA guidelines ensure that activities in these zones do not increase flood risk or require floodproofing measures beyond those already in place.

In addition, the removal of existing oil well pads, pipelines, and associated equipment from flood-prone areas can ultimately reduce flood-related risks by eliminating infrastructure that could otherwise impede flood flows or be damaged during flood events. Restoring or converting the site following decommissioning (e.g., regrading and revegetating surfaces) may enhance natural infiltration and stabilize soils, further reducing the likelihood that new flood protection measures or flood insurance requirements would arise.

Since the project does not involve placing permanent structures in flood hazard areas, no additional floodproofing or insurance mandates would be triggered. Therefore, the impact associated with placing structures in a FEMA 100-year flood hazard area or County Capital Flood floodplain is considered less than significant.

e. Conflict with the Los Angeles County Low Impact Development Ordinance (L.A. County Code, Title 12, Ch. 12.84)?

Less than Significant Impact. The project would phase out oil production activities and decommission existing infrastructure within unincorporated Los Angeles County, ultimately reducing impervious surfaces and improving on-site hydrologic conditions. Rather than introducing new impervious areas, the project involves the removal of oil well pads, paved access roads, and other industrial installations. These actions facilitate increased infiltration, reduce runoff volumes and velocities, and help restore more natural drainage patterns—measures that align with the goals of the Los Angeles County Low Impact Development (LID) Ordinance.

The LID Ordinance (Los Angeles County Code, Title 12, Chapter 12.84) aims to protect water quality, preserve natural hydrology, and minimize the impacts of stormwater runoff through strategies that retain, detain, or filter stormwater on-site. Although the ordinance typically applies to new or redevelopment projects that create additional impervious surfaces, the project does the opposite by removing industrial infrastructure and reducing impervious coverage. This results in fewer pollutant sources, improved infiltration, and reduced stormwater runoff, all of which support LID principles.

During the decommissioning phase, any temporary construction activities must comply with applicable local and state stormwater management regulations, including NPDES permits and

standard erosion and sediment control measures. Because the project's long-term effects promote, rather than hinder, natural hydrology and infiltration, it does not conflict with the LID Ordinance's requirements. Additionally, the project's integrated Site Maintenance requirements aid in keeping sites free from debris and contamination, further supporting LID objectives.

In summary, by eliminating oil production facilities and allowing sites to revert to conditions more supportive of infiltration and natural drainage, the project supports the LID Ordinance's core objectives. Consequently, the project would not conflict with, but instead complement, the LID Ordinance, resulting in a less than significant impact.

f. Use onsite wastewater treatment systems in areas with known geological limitations (e.g. high groundwater) or in close proximity to surface water (including, but not limited to, streams, lakes, and drainage course)?

No Impact. The project would phase out oil production operations and decommission associated infrastructure but does not include the installation or use of any onsite wastewater treatment systems such as septic tanks. Since no new development or land uses requiring wastewater disposal are introduced, there is no need for a septic system or other private sewage disposal method.

Onsite wastewater treatment systems can pose risks when sited in areas with high groundwater tables, unstable geologic conditions, or near surface waters like streams, lakes, or drainage courses, as they may contaminate groundwater or surface water. However, the project does not involve any activities that would generate or manage wastewater onsite. Decommissioning efforts and site restoration work are temporary and focus on removing oil-related equipment and restoring the site to conditions more supportive of natural infiltration and reduced pollution sources. No components of the project would result in increased wastewater flows, nor require the placement of wastewater systems close to sensitive water bodies.

Because the project does not propose septic tanks or other private sewage disposal systems, it avoids the potential pitfalls associated with onsite wastewater management in geologically constrained areas or near surface water features. Consequently, no impact would occur in this regard.

g. In flood hazard, tsunami, or seiche zones, risk release of pollutants due to project inundation?

Less than Significant Impact. The project would phase out existing oil production operations, removing infrastructure that could otherwise release pollutants if inundated by floodwaters, a tsunami, or a seiche event. By eliminating the industrial equipment and storage facilities associated with oil production, the project effectively reduces the potential for pollutant release during any future inundation scenario.

Portions of the project area may lie within flood hazard zones designated by the Federal Emergency Management Agency (FEMA), or within areas identified as susceptible to tsunamis or seiches. However, the project does not introduce new structures or operations that would store hazardous materials or otherwise increase the risk of pollutant release during an inundation event. Instead, decommissioning activities remove existing sources of potential contamination—such as pipelines, well pads, and processing equipment—and ensure that any residual hazardous materials are properly disposed of in accordance with applicable regulations. The project's included performance standards, including Site Maintenance and Well Plugging and Abandonment, further decrease the potential for pollutants to remain on-site in the long term.

All activities conducted within or near flood hazard, tsunami, or seiche zones must comply with federal, state, and local standards, including Los Angeles County floodplain ordinances and applicable emergency management and hazard mitigation plans. Compliance with these requirements ensures that the project's decommissioning activities do not exacerbate existing flood risks or introduce new pollutant sources vulnerable to inundation.

In the long term, removing industrial infrastructure from these hazard zones may improve environmental conditions by reducing the presence of potential contaminants. Thus, the project would not significantly increase the risk of pollutant release due to inundation in flood hazard, tsunami, or seiche zones. Impacts would be less than significant.

h. Conflict with or obstruct implementation of a water quality control plan or sustainable groundwater management plan?

Less than Significant Impact. The project would phase out oil production activities and remove related infrastructure, ultimately reducing potential pollutant sources and improving conditions for both surface and groundwater resources over time. Rather than introducing new contamination risks, the project focuses on eliminating existing industrial operations that could degrade water quality.

The project area spans the unincorporated area of Los Angeles County, which falls under the jurisdiction of the Los Angeles Regional Water Quality Control Board (RWQCB) and, in certain areas, the Lahontan RWQCB. Each RWQCB administers a Basin Plan with water quality objectives designed to protect beneficial uses of surface and groundwater. By removing oil wells, pipelines, and associated facilities, the project diminishes the likelihood of hydrocarbons, heavy metals, or other pollutants entering local waterways. Compliance with relevant NPDES permits, adherence to the Porter-Cologne Water Quality Control Act, and ongoing coordination with RWQCBs ensure that all decommissioning and restoration activities uphold the Basin Plan's standards for maintaining and enhancing water quality.

Los Angeles County includes several groundwater basins managed under the Sustainable Groundwater Management Act (SGMA). Sustainable groundwater management plans aim to maintain long-term groundwater quality, availability, and reliability. The project does not involve new groundwater extraction or substantial changes to groundwater recharge processes. Instead, decommissioning reduces the risk of groundwater contamination by properly plugging and abandoning oil wells in accordance with California Geologic Energy Management Division (CalGEM) regulations. This preventative measure is further supported by the project's Well Plugging and Abandonment standards, which ensure that wells are sealed and remediated, thereby aligning with SGMA goals to prevent aquifer pollution.

With the removal of industrial infrastructure, impervious surfaces may be reduced, potentially improving natural infiltration and supporting sustainable groundwater recharge over time. This shift aligns with both water quality control and groundwater management objectives, as it lessens the long-term pollution load and fosters more resilient water resources management.

In summary, by eliminating a source of industrial pollutants, adhering to all applicable regulatory requirements, and restoring sites to more natural conditions, the project neither conflicts with nor obstructs the implementation of applicable water quality control plans or sustainable groundwater

management plans. The overall effect is consistent with improving and maintaining water quality and groundwater sustainability, resulting in a less than significant impact.

XI. Land Use/Planning

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. **Physically divide an established community?**	☐	☐	☐	☒
b. **Cause a significant environmental impact due to a conflict with any County land use plan, policy, or regulation adopted for the purpose of avoiding or mitigating an environmental effect?**	☐	☐	☒	☐
c. **Conflict with the goals and policies of the General Plan related to Hillside Management Areas or Significant Ecological Areas?**	☐	☐	☒	☐

a. Physically divide an established community?

No Impact. The project involves phasing out oil production activities, resulting in the decommissioning of existing wells and related infrastructure, rather than introducing new development features that could disrupt existing neighborhoods or separate communities. The project does not include building new roads, walls, freeways, or other substantial barriers that would impede access or circulation within established communities. Instead, it focuses on restoring or converting affected sites to conditions more consistent with surrounding land uses.

By eliminating oil production operations and associated equipment, the project may improve the visual and functional integration of these areas with their surroundings. This reduction in industrial infrastructure could enhance community cohesiveness rather than diminish it. Furthermore, the project aligns with the County's long-term land use goals, which favor compatible and community-serving uses over industrial ones, thereby supporting local neighborhood character and connectivity.

Moreover, the project's performance standards—including Site Maintenance and Well Plugging and Abandonment—ensure that oil-related facilities are dismantled in a manner that removes residual industrial elements and prevents lingering hazards. These requirements help blend formerly industrial sites back into the surrounding environment without creating physical obstructions. Because the project neither introduces physical barriers nor alters the existing street grid or access routes, it would not create divisions within neighborhoods or disrupt existing community patterns. As a result, no impact related to the physical division of an established community would occur.

b. Cause a significant environmental impact due to a conflict with any County land use plan, policy, or regulation adopted for the purpose of avoiding or mitigating an environmental effect?

Less than Significant Impact. The project, which phases out oil production activities and removes associated industrial infrastructure, is designed to align with the County's land use plans, policies, and regulations adopted to avoid or mitigate environmental impacts. Rather than introducing potentially conflicting land uses, the project reduces the intensity of industrial operations and enhances compatibility with surrounding areas.

The General Plan emphasizes sustainable development, protection of environmental resources, public health, and compatibility between land uses. By decommissioning oil wells and appurtenant facilities, the project reduces potential sources of air, noise, and water pollution. This transition supports General Plan policies aimed at improving environmental quality, remediating incompatible uses, and promoting ecological restoration.

The project adheres to the County Zoning Code, including those pertaining to nonconforming uses. By designating existing oil wells as nonconforming and establishing a defined amortization period, the project facilitates phase-out of industrial operations. The project's integrated Site Maintenance standards and required Bonds further ensure that any interim operations are kept in compliance with regulations until final decommissioning, reducing potential land use conflicts. In areas with Community Standards Districts (CSDs) or other overlays—such as the Baldwin Hills CSD—the project's oil well prohibition and performance standards integrate with local requirements, safeguarding community character and mitigating environmental effects.

The project also complies with state and regional requirements enforced by entities such as the California Geologic Energy Management Division (CalGEM) and the Regional Water Quality Control Boards (RWQCBs). By removing potential pollutant sources, ensuring proper well abandonment, and preventing contamination risks, the project supports the goals of water quality control plans, air quality management strategies, and sustainable groundwater management efforts.

Because the project does not propose new development or uses that would create inconsistencies with established land use plans or environmental protection policies, it presents no conflicts. Instead, it lowers historical environmental risks and advances the County's objective of transitioning to more compatible land uses. Therefore, any potential impacts due to conflicts with County land use plans or policies are considered less than significant.

c. Conflict with the goals and policies of the General Plan related to Hillside Management Areas or Significant Ecological Areas?

Less than Significant Impact. The project, which phases out oil production activities and decommissions associated infrastructure, does not conflict with General Plan policies related to Hillside Management Areas (HMAs) or Significant Ecological Areas (SEAs). Instead, it supports the General Plan's environmental conservation objectives by removing industrial operations and restoring affected sites, thereby reducing impacts on sensitive hillside and ecological resources.

HMAs are designated to preserve natural landforms, minimize grading, protect scenic resources, and ensure environmentally sensitive hillside development. The project does not introduce new structures or extensive earthwork in hillside areas. Rather, it involves dismantling and removing oil production facilities that may currently disrupt natural slopes or views. Compliance with the County's HMA Ordinance and relevant design guidelines ensures that any temporary ground-disturbing activities during decommissioning are carefully managed. Additionally, the project's Site Maintenance provisions require operators to keep sites free of debris and combustible materials, aligning with policies that protect hillside integrity and scenic values.

SEAs are established to conserve habitat integrity, biodiversity, and ecological functions. Oil production can fragment habitats, introduce pollutants, and generate disturbances that negatively affect SEAs. By eliminating these industrial activities, the project removes pollution sources, reduces habitat disturbances, and allows for natural vegetation reestablishment. These actions directly support General Plan goals and SEA-related policies aimed at preserving sensitive habitats and

promoting ecological connectivity. The project's Well Plugging and Abandonment standards and required Bonds further ensure that decommissioning activities do not leave hazardous or obstructive remnants that could harm ecological resources.

Any short-term effects associated with dismantling equipment—such as localized soil disturbance or temporary noise—are minor, regulated, and take place within a framework of compliance with County ordinances and guidelines. Over the long term, removing oil infrastructure and restoring sites to more compatible uses fosters improved environmental conditions that are consistent with the General Plan's policies for HMAs and SEAs. Accordingly, the project does not conflict with the General Plan's goals and policies for hillside and ecological areas, and impacts are less than significant.

XII. Mineral Resources

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. **Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?**	☒	☐	☐	☐
b. **Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?**	☒	☐	☐	☐

a. Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?

Potentially Significant Impact. The project would prohibit new oil wells and phase out existing oil production operations, effectively curtailing the availability of locally-produced oil and gas—recognized mineral resources of regional and state importance. By permanently ending extraction at these sites, the project would foreclose future access to these known mineral resources, thereby resulting in their loss to the region and state.

Oil and gas have historically contributed to the local and regional economy, energy supply, and industrial base. While the project aligns with the State of California's and the County's policy goals to transition from fossil fuels to renewable energy sources, from a mineral resources perspective, discontinuing oil production operations represents a long-term loss of a valuable nonrenewable resource. Once these wells are plugged and abandoned, the potential to recover these materials in the future would be foregone.

Under CEQA, the permanent loss of availability of a known mineral resource is considered a significant impact. Although the project may have social, economic, and environmental benefits—such as improving public health, mitigating environmental justice concerns, and supporting climate policy objectives—this does not negate the fact that the mineral resource itself would no longer be accessible. Therefore, this aspect of the project results in a potentially significant impact related to the loss of a known mineral resource.

b. Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?

Potentially Significant Impact. The project would phase out oil production activities and prohibit new oil wells in unincorporated Los Angeles County. Many of the affected oil fields are identified in local land use documents—including the General Plan and the Baldwin Hills Community Standards District—as locally important mineral resource recovery sites. By eliminating oil production operations at these locations, the project would permanently remove the opportunity to recover these locally important mineral resources.

This loss of locally significant oil resources could have notable economic repercussions. Reduced extraction activities may diminish regional energy independence, decrease local tax revenues and

royalties, and lead to fewer employment opportunities in communities historically reliant on oil production.

The project's planned amendments to the General Plan would remove the existing designation of some oil fields as resource recovery sites, thereby solidifying the irreversible loss of locally available mineral resources. Once extraction ceases, these finite resources cannot be restored or utilized for future benefit. Although the project advances important goals such as environmental protection and land-use compatibility, the trade-off includes a permanent reduction in mineral resource availability.

Given that these sites are delineated as mineral resource recovery locations in local planning documents, and the project would effectively foreclose future resource extraction, the impact is considered potentially significant under CEQA.

XIII. Noise

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. Generation of a substantial temporary or permanent increase in ambient noise levels in the vicinity of the project in excess of standards established in the County General Plan or noise ordinance (Los Angeles County Code, Title 12, Chapter 12.08), or applicable standards of other agencies?	☐	☐	☒	☐
b. Generation of excessive groundborne vibration or groundborne noise levels?	☐	☐	☒	☐
c. For a project located within the vicinity of a private airstrip or an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☒	☐

a. Generation of a substantial temporary or permanent increase in ambient noise levels in the vicinity of the project in excess of standards established in the County General Plan or noise ordinance (Los Angeles County Code, Title 12, Chapter 12.08), or applicable standards of other agencies?

Less than Significant Impact. The project would phase out oil production operations, resulting in the removal of existing industrial infrastructure, which may generate temporary construction-related noise during the decommissioning process. While these activities could increase ambient noise levels, they would be short-term, localized, and subject to strict controls. By removing the existing exemption for oil wells from the County's noise ordinance (Title 12, Chapter 12.08), all construction and decommissioning activities must comply with allowable noise levels and time-of-day restrictions, as well as the General Plan policies aimed at minimizing noise impacts on sensitive receptors.

The provisions of Los Angeles County Code, Title 12, Chapter 12.08—such as maintaining equipment in good working order, using mufflers, and limiting construction hours—ensure that any temporary increase in noise remains below regulatory thresholds and does not constitute a substantial permanent increase in ambient noise levels. Additionally, the project's Comment and Complaint Log requirement provides a mechanism for community members to report noise issues, prompting swift responses from operators to address potential nuisances. Once decommissioning is complete, oil production-related noise sources would be removed, likely resulting in a net reduction of long-term ambient noise in the vicinity. As a result, the project would not exceed established noise standards or create a lasting noise impact, and any temporary noise increases would be less than significant.

b. Generation of excessive groundborne vibration or groundborne noise levels?

Less than Significant Impact. The project involves the decommissioning and removal of oil wells and associated industrial infrastructure. Decommissioning activities—such as well plugging, equipment removal, and on-site restoration—may temporarily generate groundborne vibration and noise from heavy machinery or occasional vibratory equipment. These operations would be short-term, localized, and subject to best management practices that limit vibration levels.

The Los Angeles County Code and General Plan policies establish requirements to prevent or minimize excessive groundborne vibration, protecting both structures and sensitive receptors. By adhering to these regulations, the project ensures that any vibration from decommissioning remains below thresholds associated with building damage or undue annoyance. Moreover, the project's Site Maintenance provisions dictate the timely removal of heavy equipment once well work is finished, further reducing the duration of vibration impacts.

Once decommissioning is complete, no long-term vibration sources would remain, and the removal of oil production infrastructure would likely reduce ongoing operational noise and vibration relative to existing conditions. Consequently, the potential for the project to cause excessive groundborne vibration or noise is minimized, and impacts would be less than significant.

c. For a project located within the vicinity of a private airstrip or an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?

Less than Significant Impact. The project would phase out oil production activities, resulting in the removal of appurtenant infrastructure in unincorporated Los Angeles County. This action does not involve adding residential units or other uses that would bring new long-term occupants into areas exposed to aircraft noise. Instead, it removes industrial operations that may currently exist in or near such areas.

If any oil production sites are located within an airport land use plan area, near a private airstrip, or within two miles of a public airport, these conditions are already established by existing land use patterns and regulations. Noise from airport operations—such as takeoffs, landings, and overflights—is regulated at the federal and state level, and the Airport Land Use Commission (ALUC) establishes compatibility guidelines to protect communities from excessive aircraft-related noise.

The project's decommissioning and restoration activities are short-term and temporary. While there may be intermittent periods of on-site work during well plugging, equipment removal, or remediation, these do not constitute permanent noise-sensitive uses (such as residential developments, schools, or hospitals) that would be adversely affected by airport-related noise. Temporary workers are not considered sensitive receptors in the same way long-term residents or employees would be, since they are present only for limited periods and are protected by occupational safety and health standards.

Furthermore, once decommissioning is complete, no new structures or uses that increase occupancy or sensitivity to noise would be introduced near airports or private airstrips. In fact, by removing industrial machinery and equipment, the project could slightly reduce the overall noise profile of the area. The project does not alter existing flight paths, airport operations, or any established noise mitigation measures in effect under airport land use plans.

In summary, the project neither introduces new permanent noise-sensitive uses into areas affected by airport-related noise nor alters conditions in a manner that would expose people to excessive

airport noise. Therefore, the potential impact related to noise exposure from airports or private airstrips remains less than significant.

XIV. Population/Housing

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. **Induce substantial unplanned population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?**	☐	☐	☒	☐
b. **Displace substantial numbers of existing people or housing, especially affordable housing, necessitating the construction of replacement housing elsewhere?**	☐	☐	☐	☒

a. Induce substantial unplanned population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?

Less than Significant Impact. The project would phase out existing oil production operations, resulting in the removal of associated infrastructure, without introducing new housing, businesses, or infrastructure that could directly or indirectly induce population growth. Unlike projects that increase development capacity—such as building new residential units or extending utilities to previously undeveloped areas—this project focuses on eliminating industrial uses, rather than creating conditions conducive to unplanned growth.

The project does not expand services like water, sewer, or roads that could open new areas to development. The County's growth forecasts and housing needs, as reflected in the General Plan and Housing Element, are met by existing designated areas and do not rely on continued oil production. In fact, by removing oil infrastructure, the project helps free land for more compatible uses identified in the General Plan's long-term vision without encouraging unplanned or accelerated population growth.

Any workforce associated with the decommissioning activities would be temporary and sourced from existing labor pools, not resulting in a permanent increase in population or housing demand. Consequently, the project would not alter population distribution, density, or growth rates beyond what the County's plans and projections anticipate. Thus, the project would not induce substantial unplanned population growth, and impacts would be less than significant.

b. Displace substantial numbers of existing people or housing, especially affordable housing, necessitating the construction of replacement housing elsewhere?

No Impact. The project would phase out oil production operations and decommission existing wells on sites historically dedicated to industrial activities, not residential use. Because these sites do not contain housing units—affordable or otherwise—no one would be displaced because of the project's implementation. The project does not involve the demolition or alteration of existing housing, nor does it require relocation of any residents.

Following decommissioning, the affected sites could be restored or converted to uses more compatible with surrounding communities, consistent with County land use policies and housing preservation goals. This transition supports broader community and environmental objectives without displacing existing residential areas.

Since the project does not remove or reduce available housing stock, including affordable housing, it does not create a need for replacement housing elsewhere. As a result, no impact would occur in relation to the displacement of existing people or housing.

XV. Public Services

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project create capacity or service level problems, or result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services:				
a. Fire protection?	☐	☐	☒	☐
b. Sheriff protection?	☐	☐	☒	☐
c. Schools?	☐	☐	☒	☐
d. Parks?	☐	☐	☒	☐
e. Libraries?	☐	☐	☒	☐
f. Other public facilities?	☐	☐	☒	☐

a. Fire protection?

Less than Significant Impact. The project involves phasing out existing oil production activities and removing associated infrastructure rather than introducing new development that would increase population or fire service demand. Because the project does not create new residential, commercial, or industrial uses, it does not generate a substantial additional need for fire protection services beyond what is already provided by the Los Angeles County Fire Department (LACoFD).

In the short term, decommissioning activities require compliance with all applicable fire safety regulations, including the California Fire Code and the project's integrated Site Maintenance provisions, which mandate clearing flammable materials and cleaning up potential ignition sources (e.g., oil spills, dry brush). By removing oil-related infrastructure, the project ultimately reduces long-term fire hazards often associated with active wells, such as the presence of combustible materials or fuel storage. The Bonds required by the project further ensure that funds are available for proper site remediation, preventing scenarios where abandoned equipment or poorly sealed wells might contribute to fire risk.

Because no new population centers or structures are introduced, and because the dismantling of hazardous facilities may reduce fire risks, there is no adverse impact on local fire service capacity or response times. Consequently, the project's effect on fire protection remains less than significant.

b. Sheriff protection?

Less than Significant Impact. The project does not involve creating new residential or commercial uses that would substantially increase population or generate additional law enforcement demands. Instead, it phases out oil production and removes associated equipment, thereby eliminating industrial operations that may occasionally require sheriff intervention for trespassing, theft, or accidental spills.

During the temporary decommissioning phase, there may be a brief increase in on-site workers, but this workforce is finite and focused on specialized tasks such as well plugging and equipment

removal. This short-term presence does not lead to a permanent change in local population or ongoing calls for service. Moreover, the project's Site Maintenance provisions require operators to keep areas secure and free of hazards, thereby minimizing circumstances that could require law enforcement response.

Because it does not necessitate new or expanded sheriff facilities, any impacts on sheriff protection are less than significant.

c. Schools?

Less than Significant Impact. The project would phase out existing oil production activities and remove associated infrastructure and does not include any new residential development or land uses that would increase the local population. Without introducing additional households or creating conditions that attract new families to settle in the area, the project does not generate demand for new or expanded school facilities.

Decommissioning and restoration activities are temporary, involving specialized workers who typically commute from established residences rather than relocating with their families. As such, no measurable increase in student enrollment at local schools would occur. The project area would not experience any long-term population growth that could strain existing school capacity or require construction of new school facilities because of project activities.

Because the project does not contribute to population growth or generate new students, it poses no risk of exceeding current school capacities or necessitating additional educational services. Therefore, any impacts related to schools are considered less than significant.

d. Parks?

Less than Significant Impact. The project would phase out existing oil production activities and remove associated infrastructure, without introducing new residential or commercial development that could increase the local population. As a result, it does not generate additional demand for parkland or recreational facilities.

Unlike projects that add housing units or attract new workers and patrons, this project primarily involves decommissioning wells and restoring or converting sites to uses more compatible with surrounding communities. Because it neither contributes to population growth nor encourages new economic activity that would bring more people to the area, it does not place added pressure on local or regional park resources. The temporary workforce involved in decommissioning activities will not significantly use nearby parks, as their presence on-site is short-term and focused on the task at hand.

Once decommissioning is complete, affected sites could potentially be restored or transformed in ways that benefit surrounding communities via uses that align with the County's General Plan goals for sustainable and balanced land use. In doing so, the project may indirectly enhance community livability over time. However, the project does not require new or expanded park facilities to maintain existing service levels, nor does it diminish current recreational resources, as it does not authorize any new development.

In summary, because the project does not increase population or long-term park use, no substantial changes to park facility demands occur. Therefore, the impact on parks would be less than significant.

e. Libraries?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure and does not introduce new residential or commercial uses that would increase local population or user demand for library services. Without a corresponding rise in the number of residents, employees, or patrons, there would be no need to expand library facilities or services.

Any temporary workforce involved in the decommissioning process would be on-site for a limited duration and focused on industrial tasks, making it unlikely that they would significantly utilize nearby library resources. After the project's completion, the restored or converted sites will not create conditions that generate sustained library use. This outcome is fully consistent with County of Los Angeles Public Library planning guidelines and does not reduce existing library service ratios.

Because the project neither induces population growth nor increases long-term demands on library infrastructure, it would not require new or expanded library facilities to maintain acceptable service levels. Therefore, the impact related to libraries would be less than significant.

f. Other public facilities?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure without introducing new development that could increase demands on public facilities other than those already considered (e.g., fire, law enforcement, schools, parks, libraries). It does not add residential, commercial, or industrial uses that would generate additional users of government offices, community centers, or other local services.

During decommissioning, a temporary workforce may be present, but their needs would be minimal, short-lived, and easily accommodated by existing public facilities. Once oil operations cease and affected sites are restored or converted to uses more compatible with surrounding communities, there would be no ongoing population increase or long-term need for expanded public services or infrastructure as the project does not authorize future development of affected project sites.

Given that the project neither induces new population growth nor significantly alters existing land use intensities, it does not require the construction or expansion of other public facilities to maintain acceptable levels of service. Therefore, impacts related to other public facilities would be less than significant.

XVI. Recreation

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. **Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?**	☐	☐	☒	☐
b. **Does the project include neighborhood and regional parks or other recreational facilities or require the construction or expansion of such facilities which might have an adverse physical effect on the environment?**	☐	☐	☒	☐
c. **Would the project interfere with regional trail connectivity?**	☐	☐	☒	☐

a. Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure and does not introduce new housing, commercial development, or other uses that would substantially increase the local population. Without added residents or a significant number of new workers or visitors, the project would not create additional demand for neighborhood or regional parks and other recreational facilities in the area.

While decommissioning activities may involve a temporary workforce on-site, these workers are focused on specialized industrial tasks and are unlikely to significantly use nearby parks. Any on-site presence is short-term and would not result in a noticeable increase in recreational facility usage. Once operations cease and affected sites are restored or converted to more community-compatible uses, the project may even contribute to improved environmental quality and potentially enhance local open space. However, this positive outcome would not place additional strain on existing parks.

Since the project neither draws new residents nor expands the local workforce in a way that would increase park visitation, it does not cause or accelerate physical deterioration of recreational facilities. As a result, impacts related to increased use of neighborhood or regional parks, or other recreational facilities, are considered less than significant.

b. Does the project include neighborhood and regional parks or other recreational facilities or require the construction or expansion of such facilities which might have an adverse physical effect on the environment?

Less than Significant Impact. The project would phase out existing oil operations and restore or convert affected sites, but it does not include constructing new neighborhood or regional parks or expanding existing recreational facilities. Nor does the project create conditions that would increase

population or demand for recreational services, as it does not involve residential development or attract new, long-term users to the area.

While restoration efforts may enhance open space and potentially support future compatible land uses, this outcome does not necessitate new or expanded park facilities to serve a larger population. Since the project does not generate substantial demand for recreation services, there is no need to construct additional recreational amenities that could result in adverse environmental effects.

In summary, the project does not include or require the development or enlargement of parks or recreational facilities that could negatively impact the environment. Therefore, any impacts related to recreation facilities construction or expansion would be less than significant.

c. Would the project interfere with regional trail connectivity?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure without introducing new development that would block, reroute, or permanently alter regional trails. Oil well sites are restricted areas, not within established trail corridors, and the project does not include facilities or operations that would disrupt existing regional trail networks.

While short-term decommissioning activities may temporarily require limited access restrictions or safety measures near active work areas, any such disruptions to trail connectivity would be localized and brief. Compliance with County guidelines, including coordination with appropriate agencies if trails exist near project sites, would ensure that any temporary effects on trail access or continuity are minimized.

Following decommissioning, restored or converted sites could potentially enhance open space quality and availability. In some cases, this might indirectly benefit nearby regional trails by improving scenic values or future open space planning. Because the project does not create permanent barriers or significantly change the landscape in a way that would impede trail connectivity, any impacts related to regional trails would be less than significant.

XVII. Transportation

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. **Conflict with an applicable program, plan, ordinance, or policy addressing the circulation system, including transit, roadway, bicycle, and pedestrian facilities?**	☐	☐	☒	☐
b. **Conflict or be inconsistent with CEQA Guidelines section 15064.3, subdivision (b)?**	☐	☐	☒	☐
c. **Substantially increase hazards due to a geometric design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?**	☐	☐	☒	☐
d. **Result in inadequate emergency access?**	☐	☐	☒	☐

a. Conflict with an applicable program, plan, ordinance, or policy addressing the circulation system, including transit, roadway, bicycle, and pedestrian facilities?

Less than Significant Impact. The project would phase out oil production activities and remove related infrastructure and does not introduce new development or land uses that would alter the region's circulation system or conflict with applicable transportation policies. Unlike projects that add homes, businesses, or large-scale facilities, this project does not generate significant new vehicle trips or demand for transit, bicycle, or pedestrian improvements.

Any transportation effects are tied to the short-term decommissioning phase, during which specialized equipment and materials would be delivered to and removed from the project sites. Although this may result in temporary increases in truck traffic, these trips would be limited in number and duration. The project's contractors would coordinate with local agencies to ensure compliance with existing roadway standards and traffic management regulations, minimizing disruptions. Measures such as scheduling deliveries during off-peak hours and following established haul routes can further reduce any temporary impact to vehicle, transit, bicycle, or pedestrian circulation.

The project does not involve permanent infrastructure changes or long-term activities that would necessitate modifications to transit routes, bicycle facilities, or sidewalks. Once decommissioning is complete, the affected sites could be restored or converted to uses more compatible with the surrounding communities without introducing circulation conflicts. Thus, the project remains consistent with local and regional transportation plans, ordinances, and policies, including those encouraging multimodal travel.

In summary, any short-term transportation effects would be managed and minor, and the project does not create conditions that would permanently conflict with or hinder established transportation policies or programs. As a result, impacts related to the circulation system are considered less than significant.

b. Conflict or be inconsistent with CEQA Guidelines section 15064.3, subdivision (b)?

Less than Significant Impact. CEQA Guidelines Section 15064.3(b) requires evaluating transportation impacts based on vehicle miles traveled (VMT) rather than traditional measures like congestion. The project, which entails decommissioning and removing oil production infrastructure, does not propose new developments that would generate long-term vehicle trips or substantially alter regional travel patterns.

Any transportation-related activities would be short-term and limited to the decommissioning phase, involving a temporary increase in trips associated with equipment and material delivery. These activities are short-lived, localized, and would not result in a permanent increase in VMT. Once the decommissioning work is complete, no ongoing VMT-generating operations remain.

By phasing out fossil fuel extraction, the project may indirectly reduce future transportation-related energy use and associated emissions over the long term. It does not create conditions that conflict with efforts to reduce VMT or hinder broader goals of State and Local CEQA Guidelines to minimize transportation-related environmental impacts.

In sum, the project neither introduces new long-term VMT sources nor conflicts with the objectives of CEQA Guidelines Section 15064.3(b). Therefore, impacts related to VMT are considered less than significant.

c. Substantially increase hazards due to a road design feature (e.g., sharp curves) or incompatible uses (e.g., farm equipment)?

Less than Significant Impact. The project does not involve constructing new roadways or altering existing ones in a manner that would introduce hazardous design features. It decommissions oil production operations and removes associated infrastructure, activities that occur within or adjacent to existing industrial sites already accessed by established roads designed to accommodate similar equipment and traffic.

During the temporary decommissioning period, the project may generate a limited number of trips by heavy trucks and specialized machinery. However, these vehicles would use existing roadways that currently serve industrial or similarly intensive uses. Compliance with local safety standards, permitting requirements, and traffic control measures will ensure that any short-term changes in traffic patterns are managed responsibly. This may include scheduling vehicle movements during off-peak hours and using proper signage or flaggers if necessary.

No modifications to road layouts, such as adding sharp curves or narrowing lanes, are proposed. The project also does not introduce long-term incompatible uses that would pose ongoing traffic safety concerns. Once decommissioning is complete, traffic will return to baseline levels, and no new hazards will be introduced.

As a result, the project does not substantially increase roadway hazards due to design features or incompatible uses, and any minor, short-term impacts on road use are effectively mitigated by adherence to existing traffic and safety regulations. The impact is therefore considered less than significant.

d. Result in inadequate emergency access?

Less than Significant Impact. The project would not introduce new structures, permanent changes to roadways, or ongoing activities that would impede emergency response routes. While

temporary decommissioning activities may generate short-term increases in truck traffic and occasional equipment movement, these effects would be carefully managed. Standard traffic control measures, coordinated with local authorities, would ensure that emergency vehicles maintain unobstructed access to and through the project area.

The project will comply with all applicable Los Angeles County fire and safety regulations, including those regarding emergency access in areas such as Very High Fire Hazard Severity Zones. Any temporary restrictions during decommissioning would be minimal, localized, and short-lived, with existing measures in place—such as scheduling deliveries during off-peak hours, using flaggers or temporary signage—to maintain emergency vehicle flow.

Once oil production activities cease and the sites are restored or converted to more compatible uses, there would be no long-term changes that compromise emergency access. In fact, removing industrial facilities may reduce certain risks associated with operational hazards. Therefore, the project would not result in inadequate emergency access, and impacts would be less than significant.

XVIII. Tribal Cultural Resources

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
a. Would the project cause a substantial adverse change in the significance of a tribal cultural resource, defined in Public Resources Code §21074 as either a site, feature, place, cultural landscape that is geographically defined in terms of the size and scope of the landscape, sacred place, or object with cultural value to a California Native American tribe, and that is:				
i) **Listed or eligible for listing in the California Register of Historical Resources, or in a local register of historical resources as defined in Public Resources Code § 5020.1(k)?**	☐	☐	☒	☐
ii) **A resource determined by the lead agency, in its discretion and supported by substantial evidence, to be significant pursuant to criteria set forth in subdivision (c) of Public Resources Code § 5024.1. In applying the criteria set forth in subdivision (c) of Public Resources Code § 5024.1, the lead agency shall consider the significance of the resource to a California Native American tribe?**	☐	☐	☒	☐

a. Listed or eligible for listing in the California Register of Historical Resources, or in a local register of historical resources as defined in Public Resources Code § 5020.1(k)?

Less than Significant Impact. The project would phase out oil production operations and remove associated infrastructure primarily located in previously disturbed industrial areas, where the likelihood of encountering intact tribal cultural resources is low. Under Public Resources Code §21074, tribal cultural resources include sites, features, places, cultural landscapes, sacred places, and objects with cultural value to a California Native American tribe that may be listed, or eligible for listing, in the California Register of Historical Resources or a local register of historical resources. Because the project does not introduce new ground-disturbing activities in previously undisturbed areas, the potential to affect such resources is minimal.

In accordance with Assembly Bill (AB) 52, the County initiated consultation with California Native American tribes that have requested notification of proposed projects in the area. This consultation process provides tribes with the opportunity to identify any known or suspected tribal cultural resources within or near the project sites. If any such resources are identified as listed or eligible for listing in the California Register or a local register, the County will work collaboratively with the tribe(s) and, if needed, a qualified archaeologist, to avoid or mitigate potential impacts. Standard treatment protocols would be implemented if tribal cultural resources are inadvertently discovered during decommissioning activities, including halting work in the immediate vicinity and consulting with tribal representatives and cultural resource professionals to determine appropriate next steps.

Given that the project sites are industrial in nature and previously disturbed, and that the County will comply with all applicable consultation and resource protection requirements, it is unlikely that tribal cultural resources would be adversely affected. Therefore, any impact to tribal cultural resources

listed or eligible for listing in the California Register of Historical Resources or a local register would be less than significant.

b. A resource determined by the lead agency, in its discretion and supported by substantial evidence, to be significant pursuant to criteria set forth in subdivision (c) of Public Resources Code § 5024.1. In applying the criteria set forth in subdivision (c) of Public Resources Code § 5024.1, the lead agency shall consider the significance of the resource to a California Native American tribe?

Less than Significant Impact. The project would phase out oil production activities and remove associated infrastructure from previously disturbed industrial sites. These areas are generally unlikely to contain intact tribal cultural resources that hold significance to California Native American tribes. Nonetheless, the County, as the lead agency, has complied with AB 52 requirements by notifying tribes traditionally and culturally affiliated with the project area early in the CEQA process, providing them with the opportunity to identify any tribal cultural resources of concern.

If any resource is brought to the County's attention during consultation, the County will evaluate its significance under the criteria in Public Resources Code §5024.1(c). This assessment would be informed by tribal input, cultural record searches, and professional archaeological expertise. Should a resource meeting the criteria be identified, the project would incorporate measures to avoid, preserve, or mitigate impacts to that resource, in cooperation with the tribes and consistent with state and local regulatory frameworks.

Given that the project area is already disturbed and no tribal cultural resources meeting the criteria set forth in Public Resources Code §5024.1(c) have been identified thus far, the likelihood of encountering a significant tribal cultural resource is low. In the unlikely event that previously unknown resources are discovered during decommissioning, work in the vicinity would cease until appropriate evaluation and treatment measures are implemented. As a result, potential impacts to tribal cultural resources under this category are anticipated to be less than significant.

XIX. Utilities/Service Systems

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. Require or result in the relocation or construction of new or expanded water, wastewater treatment, storm water drainage, electric power, natural gas, or telecommunication facilities, the construction or relocation of which could cause significant environmental effects?	☐	☐	☒	☐
b. Have sufficient water supplies available to serve the project and reasonably foreseeable future development during normal, dry and multiple dry years?	☐	☐	☒	☐
c. Result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?	☐	☐	☒	☐
d. Generate solid waste in excess of State or local standards, or in excess of the capacity of local infrastructure, or otherwise impair the attainment of solid waste reduction goals?	☐	☐	☒	☐
e. Comply with federal, state, and local management and reduction statutes and regulations related to solid waste?	☐	☐	☒	☐

a. Require or result in the relocation or construction of new or expanded water, wastewater treatment, storm water drainage, electric power, natural gas, or telecommunication facilities, the construction or relocation of which could cause significant environmental effects?

Less than Significant Impact. The project would phase out oil production operations and remove associated infrastructure on previously disturbed industrial sites. It would not introduce new development, housing, businesses, or other uses that increase long-term demands on public utilities and service systems. As a result, it is not expected to require or result in the relocation or construction of new or expanded water, wastewater treatment, stormwater drainage, electric power, natural gas, or telecommunication facilities that could lead to significant environmental impacts.

The project involves temporary decommissioning activities and does not introduce a new water demand or substantial wastewater generation. Any minimal water use during decommissioning would be short-term and easily accommodated by existing supplies and facilities. Compliance with the project's Site Maintenance requirements and Well Plugging and Abandonment standards ensures that vacated facilities do not become sources of ongoing utility burdens. No new sewer connections or expansions are needed because the project does not generate long-term wastewater discharges that would exceed current system capacities.

The project sites are already developed with industrial infrastructure. Decommissioning and restoration activities may improve natural infiltration or encourage more compatible future land uses that reduce reliance on engineered drainage systems. The project does not involve adding large areas of impervious surfaces or altering stormwater flow to such an extent that it would necessitate new or expanded stormwater drainage facilities. Compliance with the County's Low Impact Development (LID) standards ensures that potential changes in runoff are managed sustainably and within existing system capabilities.

Temporary electrical and other utility demands during decommissioning are minimal and can be met by existing infrastructure. No long-term operational changes would occur that increase demand for energy or communication services. Consequently, no new or upgraded utility infrastructure is needed beyond what is already in place.

Considering that the project does not increase permanent population, alter land uses to more intensive activities, or require substantial new infrastructure, impacts related to utilities and service systems are less than significant.

b. Have sufficient water supplies available to serve the project and reasonably foreseeable future development during normal, dry and multiple dry years?

Less than Significant Impact. The project would not introduce new residents, businesses, or long-term operations that significantly increase water demand. Instead, it involves the temporary use of minimal water supplies to support decommissioning activities, such as dust control and equipment cleaning, followed by site restoration or conversion to more compatible uses. Once oil production ceases, there is no ongoing need for substantial water consumption.

Any short-term water needs can be met by existing water sources and infrastructure, as these demands are neither continuous nor large enough to strain local supplies. The project does not meet thresholds that would trigger the preparation of a water supply assessment under Senate Bill (SB) 610 or SB 221, nor does it require new entitlements. It also does not alter regional water supply plans or compromise water availability during normal, dry, or multiple dry years.

Compliance with County and state water conservation measures and water quality standards ensures that any temporary water use will be managed responsibly. By requiring operators to meet Bonds obligations and fulfilling Well Plugging and Abandonment standards, the project ensures that old infrastructure is removed and sites do not demand future water resources. Because the project does not significantly increase water demand, impacts related to having sufficient water supplies for the project and reasonably foreseeable future development are less than significant.

c. Result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?

Less than Significant Impact. The project requires the decommissioning and removal of oil wells and associated infrastructure, which are not activities that would generate a substantial volume of wastewater. Any wastewater produced during decommissioning—such as from equipment cleaning or temporary sanitation facilities for workers—would be minimal, short-term, and easily accommodated by existing wastewater treatment infrastructure.

Once decommissioning is complete, the project does not introduce new land uses or operations that would produce ongoing wastewater flows. In fact, the cessation of oil production may reduce any previous wastewater loads associated with those activities, freeing up capacity in the long term. Because the project's limited and temporary wastewater demands do not approach the capacity limits of the existing service providers, no expansions or new wastewater treatment facilities would be required. The project's Site Maintenance and Well Plugging and Abandonment provisions help ensure that contaminants are properly contained, preventing any unexpected load on wastewater systems.

As a result, the project would not hinder a wastewater treatment provider's ability to serve its existing commitments or require adjustments to their operational capacity. Thus, the impact on wastewater treatment capacity would be less than significant.

d. Generate solid waste in excess of State or local standards, or in excess of the capacity of local infrastructure, or otherwise impair the attainment of solid waste reduction goals?

Less than Significant Impact. The project would decommission and remove oil wells and associated infrastructure, generating a temporary increase in construction and demolition debris rather than ongoing solid waste. Any waste produced during these decommissioning activities—such as piping, equipment, and concrete—would be managed in accordance with applicable State and local regulations, including those focused on waste diversion, recycling, and proper disposal.

California's solid waste regulations (e.g., AB 939) and the County's Integrated Waste Management Plan guide the proper handling and reduction of solid waste. A substantial portion of construction and demolition debris can often be recycled or reused, minimizing the amount sent to landfills. Existing regional landfill facilities have sufficient remaining capacity, as confirmed by regular assessments in the Integrated Waste Management Plan, to accommodate the temporary volume of materials generated by the project. Moreover, no new long-term waste streams would be created, and once decommissioning is complete, the project would not generate operational waste.

Compliance with established waste management standards ensures that the project's short-term increase in solid waste would not exceed State or local thresholds or hinder solid waste reduction goals. Adhering to the project's Site Maintenance provisions also ensures prompt removal of debris to avoid any accumulation or environmental hazards. As a result, impacts related to solid waste capacity and standards would be less than significant.

e. Comply with federal, state, and local management and reduction statutes and regulations related to solid waste?

Less than Significant Impact. The project would generate a limited amount of solid waste as part of the temporary oil well decommissioning process, including dismantled infrastructure and construction and demolition debris. All handling, storage, transportation, and disposal of this waste would occur in accordance with federal, state, and local statutes and regulations related to solid waste management and reduction.

All project activities must comply with the California Integrated Waste Management Act (AB 939), which mandates recycling and waste diversion, as well as local ordinances requiring construction and demolition waste diversion. This includes adherence to the County's Source Reduction and Recycling Element and compliance with regional and state-mandated diversion targets. Additionally, the project must follow the County's Construction and Demolition Debris Recycling Ordinance,

ensuring that a significant portion of generated debris is recycled or reused rather than disposed of in landfills.

Facilities receiving solid waste from the project would be properly permitted and operated in accordance with the Integrated Waste Management Plan and other relevant guidelines, ensuring adequate disposal capacity. Since the project does not create new sources of ongoing waste but merely addresses temporary demolition waste, it will not impair the County's ability to meet solid waste reduction goals. Under the project's Site Maintenance requirements, operators are responsible for removing demolition debris and potential contaminants in a timely, regulated manner. Licensed waste haulers and permitted disposal facilities ensure compliance with relevant codes, while performance standards in Bonds guarantee financial resources for any necessary remediation or proper waste handling. Furthermore, no permanent increase in solid waste generation will occur once the decommissioning is complete.

By adhering to all applicable solid waste regulations and policies, the project will ensure that any waste generated is managed responsibly and sustainably. As a result, the project's impact related to compliance with solid waste management and reduction statutes is considered less than significant.

XX. Wildfire

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
If located in or near state responsibility areas or lands classified as very high fire hazard severity zones, would the project:				
a. **Substantially impair an adopted emergency response plan or emergency evacuation plan?**	☐	☐	☒	☐
b. **Due to slope, prevailing winds, and other factors, exacerbate wildfire risks, and thereby expose project occupants to pollutant concentrations from a wildfire or the uncontrolled spread of a wildfire?**	☐	☐	☒	☐
c. **Require the installation or maintenance of associated infrastructure (such as roads, fuel breaks, emergency water sources, power lines or other utilities) that may exacerbate fire risk or that may result in temporary or ongoing impacts to the environment?**	☐	☐	☒	☐
d. **Expose people or structures to significant risks, including downslope or downstream flooding or landslides, as a result of runoff, post-fire slope instability, or drainage changes?**	☐	☐	☒	☐

a. Substantially impair an adopted emergency response plan or emergency evacuation plan?

Less than Significant Impact. The project requires the phasing out of oil production activities, resulting in the removal of existing appurtenant infrastructure. Project activities are expected to occur within existing industrial sites and rights-of-way, without introducing new permanent land uses or significant physical changes that could obstruct or interfere with emergency response routes or evacuation procedures.

Los Angeles County maintains emergency response and evacuation plans, such as the Operational Area Emergency Response Plan and the All-Hazards Mitigation Plan, which designate emergency routes and procedures. These plans are designed to ensure adequate public safety and effective disaster response across the County, including areas where oil wells are located.

During decommissioning activities, temporary increases in vehicle traffic and equipment staging may occur near project sites. However, these effects will be localized and short-term, and project activities will be required to coordinate with local agencies, such as the County Department of Public Works and Office of Emergency Management, to ensure compliance with emergency access requirements. Such coordination includes maintaining clear access to designated emergency routes and complying with traffic control measures to minimize disruptions.

Additionally, the project does not propose any alterations to critical infrastructure or public rights-of-way that would permanently impair emergency response capabilities. Compliance with existing regulatory frameworks, including building and safety codes, further reduces the potential for significant impacts. By removing industrial hazards and following the project's Site Maintenance

standards—such as clearing debris and combustible materials—the project may actually enhance overall safety.

Given the temporary and manageable nature of potential disruptions and the regulatory oversight in place, the project is not expected to substantially impair any adopted emergency response or evacuation plan. Therefore, the impact is considered less than significant.

b. Due to slope, prevailing winds, and other factors, exacerbate wildfire risks, and thereby expose project occupants to pollutant concentrations from a wildfire or the uncontrolled spread of a wildfire?

Less than Significant Impact. The project would phase out oil operations and remove associated infrastructure within areas already designated and managed for industrial use. Some project sites lie within or near Very High Fire Hazard Severity Zones (VHFHSZs), where factors such as slope and prevailing winds can contribute to wildfire risks. However, the project would not introduce new permanent development or occupants who could be exposed to wildfire-related hazards. Instead, it focuses on removing oil production infrastructure and restoring or converting disturbed areas to uses more compatible with surrounding communities.

Temporary decommissioning activities might involve equipment that could ignite sparks or generate heat. Compliance with applicable fire prevention and safety requirements—including coordination with the Los Angeles County Fire Department, adherence to the California Fire Code, and implementing best management practices such as spark prevention, regular equipment maintenance, and on-site fire suppression—will minimize fire risks during this short-term phase.

Once oil production equipment is removed, potential ignition sources decrease, potentially reducing long-term fire risks. Without the introduction of residents or employees to areas of elevated wildfire risk, there is no added population at risk of exposure to wildfire smoke or pollutant concentrations. While the site's natural conditions and climate factors remain unchanged, the project neither increases vulnerability to wildfires nor places people in harm's way.

In summary, due to strict compliance with fire safety measures, no permanent occupancy, and the elimination of industrial hazards, the project would not exacerbate wildfire risks or expose occupants to significant pollutant concentrations from a wildfire. Therefore, the impact is considered less than significant.

c. Require the installation or maintenance of associated infrastructure (such as roads, fuel breaks, emergency water sources, power lines or other utilities) that may exacerbate fire risk or that may result in temporary or ongoing impacts to the environment?

Less than Significant Impact. The project requires phasing out of oil production activities, which results in the removal of industrial infrastructure. The project would not create new infrastructure or facilities that could elevate fire risk or cause ongoing environmental impacts. Instead, it focuses on decommissioning and removing existing oil production equipment, with all work occurring within or adjacent to areas already served by established roads, utilities, and industrial access points.

No new roads, fuel breaks, emergency water sources, or additional power lines are needed to implement the project. Temporary modifications may occur during the decommissioning phase, such as using existing roads for equipment transport or making minor adjustments to existing utilities. However, these activities will be short-term and conducted in compliance with applicable fire

safety regulations (e.g., California Fire Code requirements) and environmental standards. All project activities must follow best management practices—such as controlling spark sources, maintaining defensible space, and ensuring the availability of fire suppression tools—to prevent increasing wildfire risk.

By eliminating oil production infrastructure, the project may reduce long-term fire hazards by removing potential ignition sources. No ongoing maintenance of new infrastructure is required, minimizing the potential for habitat disturbance or other environmental impacts.

The project does not involve the installation or maintenance of additional infrastructure that could exacerbate wildfire risk. Any temporary impacts during decommissioning are managed through adherence to existing safety and environmental protocols, ensuring that the overall impact remains less than significant.

d. Expose people or structures to significant risks, including downslope or downstream flooding or landslides, as a result of runoff, post-fire slope instability, or drainage changes?

Less than Significant Impact. The project would phase out oil production operations and remove associated industrial infrastructure on previously disturbed sites, rather than introducing new development or major land alterations. Consequently, it does not create conditions that would increase the likelihood of downslope or downstream hazards, including flooding or landslides, resulting from altered drainage or post-fire slope instability.

While decommissioning activities involve some ground disturbance, these are short-term and localized. Compliance with County grading and erosion control regulations, as well as adherence to stormwater management requirements, ensures that any disturbed areas are stabilized promptly. Restoration or conversion of the sites to more compatible land uses will improve soil stability and infiltration capacity, thereby reducing the potential for post-project runoff or slope destabilization.

Because the project does not create large expanses of impervious surfaces or modify slopes in ways that could exacerbate post-fire instability or alter natural drainage patterns, the risk of inducing new flood or landslide hazards is minimal. If any site work occurs near potentially sensitive slopes, geotechnical evaluations and corresponding mitigation measures would be applied, further reducing the risk of adverse effects.

In summary, by following existing regulatory standards and best management practices, the project will not expose people or structures to significant risks from runoff, post-fire slope instability, or drainage changes. Therefore, impacts are considered less than significant.

XXI. Mandatory Findings of Significance

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less than Significant Impact	No Impact
Would the project:				
a. **Does the project have the potential to substantially degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, substantially reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?**	☐	☐	☒	☐
b. **Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)?**	☐	☐	☒	☐
c. **Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?**	☐	☐	☒	☐

a. Does the project have the potential to substantially degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, substantially reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?

Less than Significant Impact. The project phases out oil production activities and removes associated industrial infrastructure from sites that are largely previously disturbed. Although decommissioning may involve short-term ground-disturbing activities, these occur under stringent regulatory frameworks and established best management practices (BMPs) that safeguard sensitive biological and cultural resources. Compliance with laws and regulations, such as the California Endangered Species Act, the Migratory Bird Treaty Act, and the County's Significant Ecological Area (SEA) protections, ensures that fish, wildlife, and plant communities are not substantially harmed. If any tribal cultural or archaeological materials are encountered, work would cease, and appropriate consultation and treatment measures would be implemented to prevent significant impacts to cultural resources.

Over the long term, ceasing oil production and removing infrastructure would likely improve local environmental conditions, reduce pollution sources, and allow for habitat recovery or more compatible land uses. Therefore, the project does not substantially degrade environmental quality or threaten ecological or cultural integrity. Any potential impacts are considered less than significant.

b. Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)?

Less than Significant Impact. The project does not introduce new development or activities that would notably increase population, traffic, or pollution. Instead, it phases out an existing source of environmental impacts—oil production—resulting in the removal of industrial infrastructure and associated emissions, hazards, and disturbance. This action aligns with broader regional and state goals to reduce fossil fuel reliance, improve air quality, and protect habitats, thus making an incremental positive contribution to cumulative environmental conditions.

While short-term decommissioning activities may generate minor increases in noise, dust, and localized emissions, these are temporary, controlled by BMPs and regulations, and do not significantly contribute to cumulative adverse conditions. Viewed alongside other past, current, and future projects aimed at environmental improvement and sustainable resource use, the project's incremental effects are beneficial rather than cumulatively considerable. Thus, the project's contribution to cumulative impacts is less than significant.

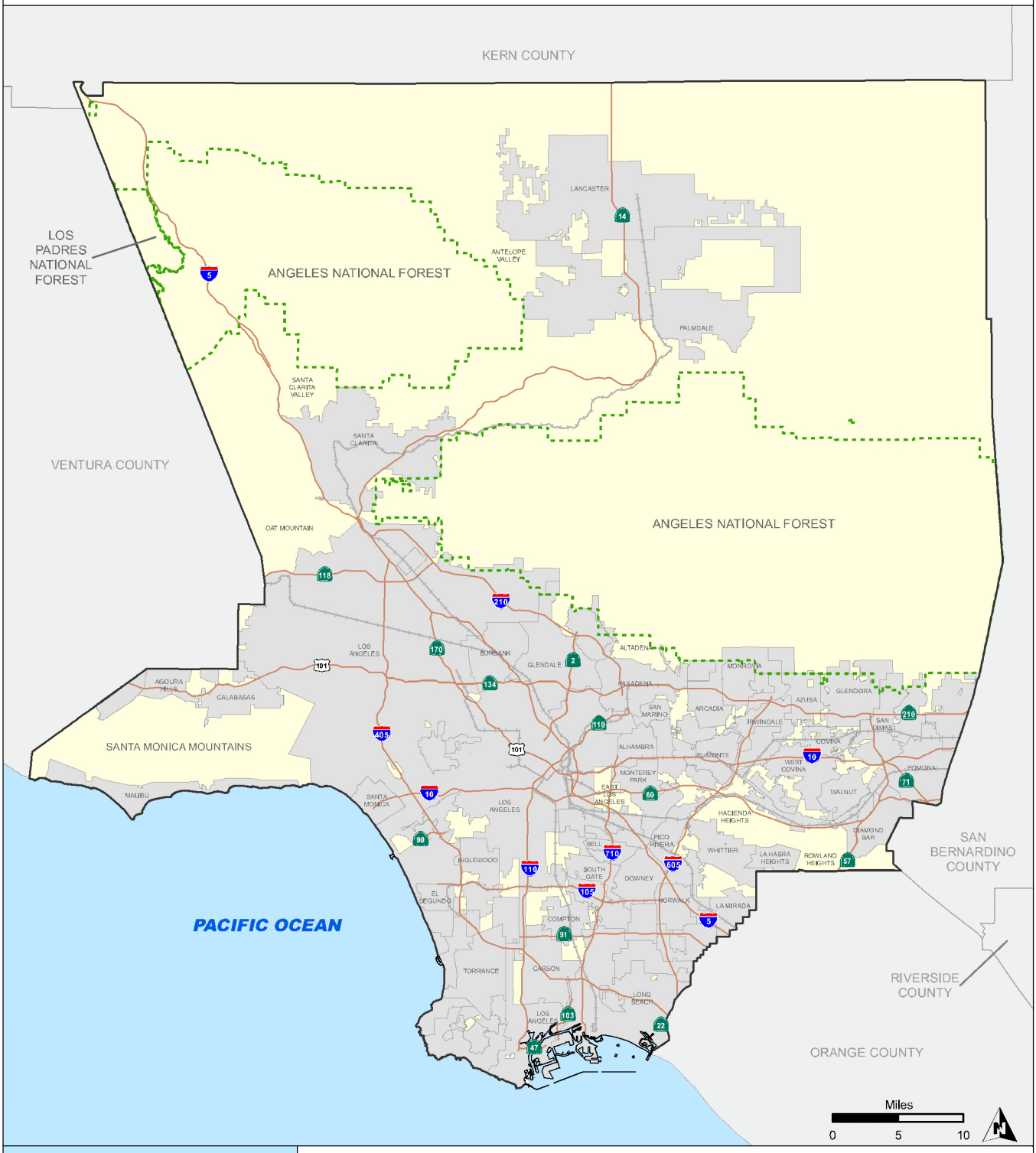
c. Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?

Less than Significant Impact. By eliminating oil production operations and associated hazards, the project is expected to improve local environmental quality over time, thereby reducing potential health risks to surrounding communities. Short-term construction-related effects—such as noise, dust, and limited equipment traffic—are temporary, subject to compliance with local ordinances, and minimized through standard control measures. There are no permanent increases in activities that would adversely affect public health, such as introducing new sources of pollution or hazards.

In the long term, the absence of operational oil wells and infrastructure reduces exposure to industrial contaminants, vibrations, and noise. This outcome supports better public health outcomes and environmental justice goals. Consequently, any direct or indirect effects on human beings are short-lived, well-managed, and less than significant.

Los Angeles County Unincorporated Areas

Figure 1





Unincorporated Areas

Cities

Source: Department of Regional Planning, May 2014

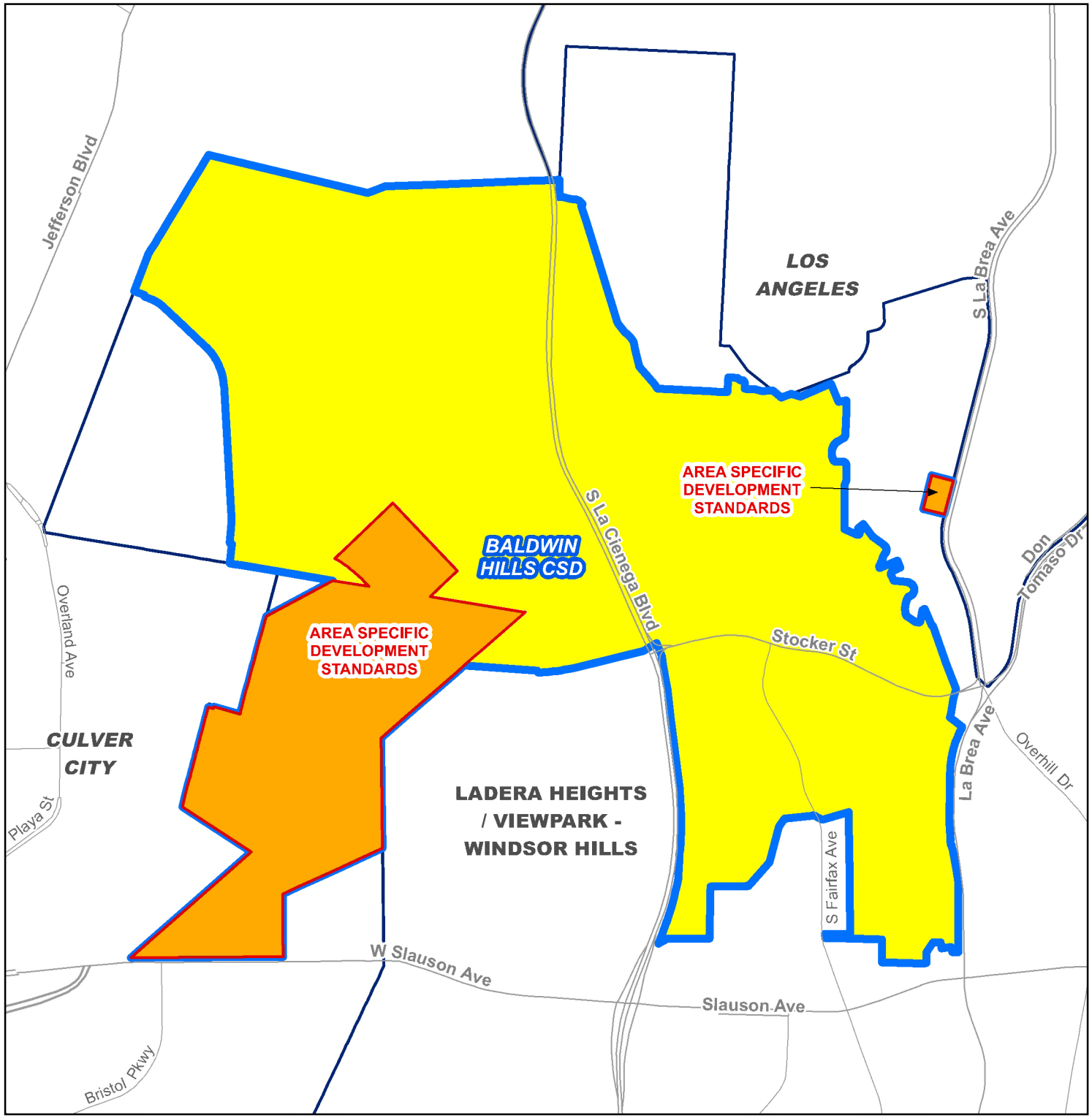


Figure 2

COUNTY OF LOS ANGELES

Baldwin Hills Community Standards District

LEGEND:

- Community Standards District
- Area Specific Standards
- City / Unincorporated

Key Map:



N

0 375 750 1,500 Feet

Los Angeles County
Dept. of Regional Planning
320 W. Temple St.
Los Angeles, CA 90012

..\OTHER\MAP_SERIES\supp_dist\map_documents\Supp_Dist_CSD_Baldwin_Hills