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**Sent:** Tuesday, March 21, 2023 3:29 PM  
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**Subject:** CBD Sources Part 1.7

**-EXTERNAL-**

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October 1, 2021

**RE: Response to CalGEM Questions for the California Oil and Gas Public Health Rulemaking Scientific Advisory Panel**

Director Shabazian and Supervisor Ntuk,

Please find attached the responses from the California Oil and Gas Public Health Rulemaking Scientific Advisory Panel to the written questions sent by the California Geologic Energy Management Division (CalGEM) on August 31, 2021.

We would be glad to answer any further questions that may arise.

Best Regards,

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# CalGEM Questions for the California Oil and Gas Public Health Rulemaking Scientific Advisory Panel

CalGEM requests the California Oil and Gas Public Health Rulemaking Scientific Advisory Panel assistance with the following questions:

- 1. How would the panel characterize the level of certainty that proximity to oil and gas extraction wells and associated facilities in California causes negative health outcomes? Is there a demonstrated causal link between living near oil and gas wells and associated facilities and health outcomes?***

We have focused our review on epidemiological studies carried out in multiple oil and gas regions, including Colorado, which has a similar regulatory context as California. Given that similar environmental health hazards and risks are intrinsic to both conventional and unconventional oil and gas development (OGD), including exposure pathways, chemicals associated with hydrocarbon reservoirs, use of ancillary equipment, and non-chemical stressors (See section on “Similarities and Differences Between Unconventional and Conventional OGD”), the California Oil and Gas Public Health Rulemaking Scientific Advisory Panel (Panel) concludes that the full body of epidemiologic literature is relevant to assess the human health hazards, risks and impacts of upstream OGD in California.

Our Panel concludes with a high level of certainty<sup>1</sup> that the epidemiologic evidence indicates that close residential proximity to OGD is associated with adverse perinatal and respiratory outcomes, for which the body of human health studies is most extensive in California and other locations.

## Studies on Oil and Gas Development and Perinatal Outcomes

Perinatal outcome studies provide the largest [19 studies]<sup>2</sup> and strongest body of evidence linking OGD exposure during the sensitive prenatal period with adverse health effects. The majority of studies that examine perinatal effects found increased risk of adverse birth outcomes in those most exposed to OGD (measured using metrics including, but not limited to proximity, well density, and production volume). It should also be noted that adverse perinatal outcomes, including preterm births, low birth weight, and small-for-gestational age births

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<sup>1</sup> In this document, the statement, “a high-level of certainty” is based on the professional judgement of all California Oil and Gas Public Health Rulemaking Scientific Advisory Panel (Panel) members in their assessment of the scientific evidence. In terms of panel process, all Panel members agree with the responses to the questions in this document. Any Panel member could have written a dissenting opinion, but no one requested to do so. This document reflects the perspective of the Panel members and not necessarily the opinions of their employers or institutions.

<sup>2</sup> Apergis et al., 2019; Busby & Mangano, 2017; Caron-Beaudoin et al., 2020; Casey et al., 2016; Currie et al., 2017; Cushing et al., 2020; Gonzalez et al., 2020; 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, *Forthcoming*; Walker Whitworth et al., 2018; Whitworth et al., 2017; Willis et al., 2021.

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).

### ***Perinatal Outcomes Associated with Conventional and Unconventional Oil and Gas Development***

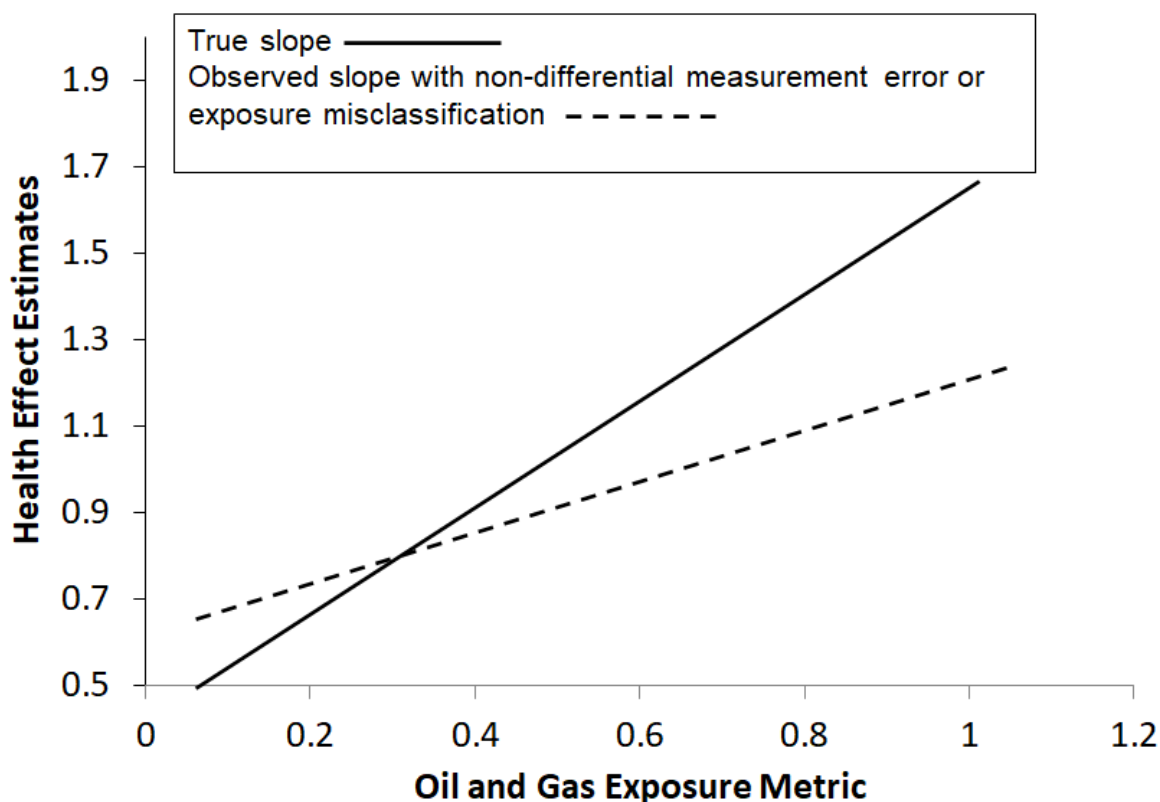
While many perinatal outcome studies outside of California focus on unconventional OGD (e.g., high-volume hydraulic fracturing), a recent review of the literature (Deziel et al., 2020), highlighted the need for an updated assessment of the health effects associated with OGD more generally, as both conventional and unconventional OGD operations present health risks, especially to those living in close proximity. This bolsters conclusions reached by the authors of the 2015 independent scientific study of hydraulic fracturing and well stimulation in California led by the California Council on Science and Technology (CCST) (Long et al., 2015) pursuant to Senate Bill 4 (2013, Pavley). Recent studies in California have reported associations between exposure to OGD and adverse birth outcomes, considering wells under production using 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, *Forthcoming*). Similar findings regarding adverse birth outcomes have been reported while examining unconventional OGD in Colorado, Oklahoma, Pennsylvania and Texas (Apergis et al., 2019; Casey et al., 2016; Cushing et al., 2020; Gonzalez et al., 2020; Hill, 2018; McKenzie et al., 2019; Stacy et al., 2015; Walker Whitworth et al., 2018; Whitworth et al., 2017). In the California independent scientific study on well stimulation pursuant to Senate Bill 4 (2013, Pavley), the authors concluded that while hydraulic fracturing introduces some specific human health risks, the majority of environmental risks and stressors are similar across conventional and unconventional oil and gas operations (Long et al., 2015; Shonkoff et al., 2015). Further, a handful of epidemiological studies explicitly examine potential differences in associations between conventional or unconventional oil or natural gas development and adverse outcomes. For example, Apergis et al. (2019) reported statistically significant reductions in infant health index within 1 km of both conventional and unconventional drilling sites in Oklahoma. In summary, the Panel concludes with a high level of certainty that human health studies focused on unconventional and conventional OGD are relevant to consider in the California context where conventional development is most prevalent.

### ***Consistency Across Perinatal Epidemiology Studies***

We have a high level of certainty in the findings in the body of epidemiological studies for perinatal health outcomes 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 (see **Table 1** below). Most of these studies entail rigorous, high quality analyses (i.e., study designs that establish temporality based on large sample sizes, 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., PM<sub>2.5</sub> and air toxics) and other OGD stressors are associated with these same adverse birth outcomes (Dzhambov & Lercher, 2019; Nieuwenhuijsen et al., 2017; Shapiro et al., 2013), which further strengthens the evidence of the link between OGD and adverse perinatal outcomes. Therefore, the totality of the epidemiological evidence provides a high level of certainty that exposure to OGD (and associated exposures) cause a significant increased risk of poor birth outcomes.

Further, imprecision in exposure assessment or non-differential exposure misclassification in some of the epidemiological studies is more likely to attenuate observed relationships, thus leading to an underestimate of the true adverse impacts of OGD on birth outcomes (Figure 1). 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 1**, which has a shallower slope compared to the hypothetical “true” solid line.



**Figure 1. Effect of imprecise exposure estimates on a hypothetical exposure-response relationship (Source: Adapted from Seixas & Checkoway, 1995).**

## **Respiratory Risks and Impacts from Oil and Gas Development**

Respiratory health outcomes are the second most studied health outcomes in the epidemiological literature examining OGD, with eight peer-reviewed studies published to date. Two peer-reviewed studies in California found an association between 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). Six studies in other oil and gas regions (Pennsylvania and Texas) reported an association between OGD and asthma exacerbations, asthma hospitalizations, and respiratory symptoms (Koehler et al., 2018; Peng et al., 2018; Rabinowitz et al., 2015; Rasmussen et al., 2016; Willis et al., 2018, 2020).

Epidemiological studies, by design, often use aggregate measures of exposure to account for multiple potential stressors and pathways associated with OGD (e.g., air pollution, noise pollution, groundwater and/or drinking water contamination). Many criteria air pollutants (e.g., particulate matter, ozone, nitrogen oxides) and hazardous air pollutants emitted from OGD have a well-established body of scientific literature 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). We reiterate the relevance of studies on both conventional and unconventional OGD for respiratory health outcomes. For example, (Willis et al., 2020) found that both conventional and unconventional natural gas development at the ZIP code level was associated with pediatric asthma hospitalizations in Texas.

## **Comparing The Body of Perinatal and Respiratory Outcome Studies Against The Bradford Hill Criteria for Causation**

Below, we demonstrate how the body of epidemiological studies on the relationship between 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. These criteria are widely used in the field of epidemiology and public health practice to guide decision-making. After considering 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 1).

**Table 1. Application of the Bradford Hill Criteria for Causation to the peer-reviewed epidemiological literature on oil and gas development and perinatal and respiratory health outcomes.**

Criteria for Causation (Bradford-Hill)	Description of Criteria	Perinatal Health Studies	Respiratory Health Studies
<b>Strength of Association</b>	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 <sub>2.5</sub> (Dadvand et al., 2013; C. Li et al., 2020). Some studies, particularly those in California, have found stronger effect estimates for OGD exposures among socially marginalized groups (Cushing et al., 2020; Gonzalez et al., 2020; Tran et al., 2020, <i>Forthcoming</i> ).	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).
<b>Consistency</b>	Consistent findings observed by different persons 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, 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 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 OGD and asthma-related metrics (asthma prevalence, exacerbations, pediatric hospitalizations) (Koehler et al., 2018; 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
<b>Specificity</b>	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 (i) accounting or adjusting for other individual-level or area-level factors (e.g., other air pollution sources, neighborhood socioeconomic status) in the analysis (Casey et al., 2016; McKenzie et al., 2014; Tran et al., 2020, <i>Forthcoming</i> ). Other studies applied statistical modeling approaches such as difference-in-difference that accounts for temporal and spatial trends that may confound observed effects (Willis et al., 2021).	Most respiratory health studies have controlled for other potential explanatory or confounding factors by (i) 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., 2018, 2020), or in the study design, such as utilizing a difference-in-difference methodology (Peng et al., 2018; Willis et al., 2018).
<b>Temporality</b>	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 (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.

Criteria for Causation (Bradford-Hill)	Description of Criteria	Perinatal Health Studies	Respiratory Health Studies
<b>Biological Gradient (Dose-Response)</b>	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).	Larger reductions in lung function observed with decreased distance from active oil development sites (Johnston et al., 2021).
<b>Plausibility</b>	The exposure pathway and biological mechanism is plausible based on other knowledge.	Individual health-damaging chemical pollutants are well-understood to be emitted from OGD (e.g., PM <sub>2.5</sub> , benzene) and established as contributing to increased risk for the same adverse perinatal outcomes observed in the epidemiology studies. Stressors associated with OGD (e.g., psychosocial stress; (Casey et al., 2019) can also contribute to increased adverse perinatal outcomes.	Many air pollutants associated with OGD are well-known to contribute to respiratory morbidity and mortality, including exacerbations of existing respiratory conditions (Guarnieri & Balmes, 2014).
<b>Coherence</b>	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.

Criteria for Causation (Bradford-Hill)	Description of Criteria	Perinatal Health Studies	Respiratory Health Studies
<b>Experiment</b>	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.
<b>Analogy</b>	For similar programs operating, similar results can be expected to bolster the causal inference concluded.	Pollutants well known to be emitted during OGD including benzene, toluene and 1,3 butadiene are listed as reproductive or developmental toxicants under Prop 65 and thus are recognized as such by the State of California (CalEPA OEHHA, 2021). EPA's current Integrated Science Assessments of particulate matter and tropospheric ozone 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 <sub>2.5</sub> 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).	EPA's current Integrated Science Assessments of particulate matter and tropospheric ozone conclude that there is: a casual relationship between respiratory outcomes, including asthma and short term ozone exposure; and likely a causal relationship between respiratory outcomes, including asthma and: short and long term PM <sub>2.5</sub> exposure; and long term ozone exposure (US EPA, 2019, 2020).

## Similarities and Differences Between Unconventional and Conventional Oil and Gas Development

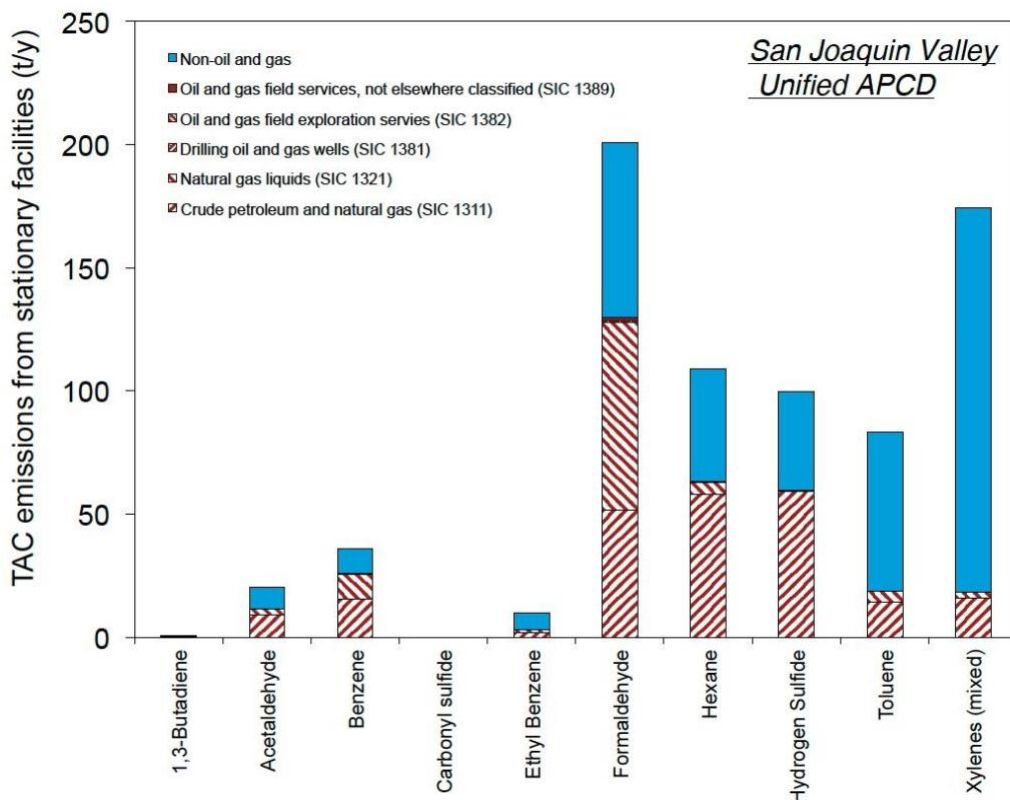
Though definitions of conventional and unconventional OGD may differ across different regulatory and policy landscapes, the majority of OGD in California is often considered conventional, involving vertical drilling at shallower depths into target geologies that hold migrated hydrocarbons. These attributes of development are often considered in contrast to unconventional OGD, which can involve horizontal directional drilling in deeper wells to access source rock formations by increasing the permeability of these tight formations using mostly hydraulic fracturing. In addition, these 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 environmental and health hazards and risks 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<sub>2.5</sub> and nitrogen oxides emissions result from the use of diesel-powered equipment and trucks and hazardous air pollutants such as benzene, toluene, ethylbenzene and xylene (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., 2020b) 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).

In California, policy, regulatory and scientific emphasis has been placed 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, Pavley), reported 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). 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).

**2. What are the air pollutants released from these activities that cause negative health outcomes? How do we know exposure to these is likely from oil and gas extraction wells and associated facilities, as opposed to other sources?**

The wells, valves, tanks and other equipment used to produce, store, process and transport petroleum products at both unconventional and conventional OGD sites are associated with emissions of toxic air contaminants, hazardous air pollutants and other health-damaging non-methane VOCs (Helmig, 2020; Moore et al., 2014). Diesel engines used to power on-site equipment and trucks at unconventional and conventional OGD sites directly emit health-damaging hazardous air pollutants, fine particulate matter (PM<sub>2.5</sub>), nitrogen oxides and volatile organic compounds (VOCs) (CalEPA OEHHA, 2001). Many VOCs and nitrogen oxides are precursors to ground level ozone (O<sub>3</sub>) formation, another known health harming pollutant. Hazardous air pollutants that are known to be emitted from OGD sites include benzene, toluene, ethylbenzene, xylenes, hexane and formaldehyde--many of which are known, probable or possible carcinogens and/or teratogens and which have other adverse effects for non-cancer health outcomes (CalEPA OEHHA, 2008, 2009; Moore et al., 2014). In the San Joaquin Valley Air Pollution Control District, OGD activities are responsible for the majority of emissions of multiple toxic air contaminants including acetaldehyde, benzene, formaldehyde, hexane and hydrogen sulfide (**Figure 2**) (Brandt et al., 2015; Long et al., 2015).



**Figure 2. Toxic Air Contaminant emissions from stationary facilities in the San Joaquin Valley Air Pollution Control District (Source: (Brandt et al., 2015).**

A recently published study using statewide air quality monitoring data from California investigated whether drilling new wells or increasing production volume at active wells resulted in emissions of PM<sub>2.5</sub>, nitrogen dioxide (NO<sub>2</sub>), VOCs, or O<sub>3</sub> (Gonzalez et al., 2021). To assess the effect of oil and gas activities on concentrations of air pollutants, the authors used daily variation in wind direction as an instrumental variable and used fixed effects regression to control temporal factors and time-invariant geographic factors. The authors documented higher concentrations of PM<sub>2.5</sub>, NO<sub>2</sub>, VOCs, and O<sub>3</sub> at air quality monitoring sites within 4 km of pre-production OGD well sites (i.e., wells that were between spudding and completion) and 2 km of production OGD well sites, after adjusting for geographic, meteorological, seasonal, and time trending factors. In placebo tests, the authors assessed exposure to well sites downwind of the air monitors and observed no effect on air pollutant concentrations. **Table 2** summarizes the increases in each pollutant for each additional upwind well site by distance.

**Table 2. Summary of air pollutant concentrations measured between 2006-2019 at 314 air quality monitoring sites in the EPA Air Quality System for California (Gonzalez et al., 2021).**

Distance	PM <sub>2.5</sub> µg/m <sup>3</sup> *	NO <sub>2</sub> ppb	VOCs (ppb C)*	O <sub>3</sub> (ppb)
Estimated increase for each additional upwind pre-production well site				
Within 2 km	2.35 (0.81, 3.89)	2.91 (0.99, 4.84)	No increase	no increase
2-3 km	0.97 (0.52, 1.41)	0.65 (0.31, 0.99)	No increase	0.31 (0.2, 42)
3-4 km	no increase	no increase	no increase	0.14 (0.05, 0.23)
Estimated Increase for each 100 BOE of total oil and gas upwind production volume				
1 km	1.93 (1.08, 2.78)	0.62 (0.37, 0.86)	0.04 (0.01, 07)	no increase
1-2 km	no increase	no increase	no increase	0.11 (0.08, 0.14)

\*No PM<sub>2.5</sub> or VOC monitoring sites with 1 km of pre-production well sites; BOE, barrels of oil equivalents.

These multiple stressors, along with other physical factors such as noise and vibration, are consistently found in exposure studies to be measurably higher near oil and gas extraction wells and other ancillary infrastructure in California. As such, the Panel concludes with a high level of certainty that concentrations of health-damaging air pollutants, including criteria air pollutants and toxic air contaminants, are more concentrated near OGD activities compared to further away.

3. **Does the evidence evaluated clearly support a specific setback? If so, what is this setback distance and what oil and gas extraction activities would it specifically apply to? What is the supporting evidence?**
- a. **How does this evidence justify the recommended setback distance, as opposed to another distance?**

Existing epidemiologic studies were not designed to test and establish a specific “safe” buffer distance between OGD sites and sensitive receptors, such as homes and schools. Nevertheless, studies consistently demonstrate evidence of harm at distances less than 1 km, and some studies also show evidence of harm linked to OGD activity at distances greater than 1 km. In addition, exposure pathway studies have demonstrated through measurements and modelling techniques, the potential for human exposure to numerous environmental stressors (e.g., air pollutants, water contaminants, noise) at distances less than 1 km (e.g., Allshouse et al., 2019; Holder et al., 2019; McKenzie et al., 2018; DiGiulio et al., 2021; Soriano et al., 2020), and that the likelihood and magnitude of exposure decreases with increasing distance.

- b. **What are the health benefits from this setback? Can the panel quantify them or recommend a methodology CalGEM can use to quantify them? Can the panel establish that these health benefits can only be achieved with the setback? Or can they also be achieved with mitigation controls?**

Figure 3 presents a hierarchy of strategies to reduce human health hazards, risks and impacts from OGD activities. Table 3 presents the advantages and disadvantages of each strategy from an environmental public health perspective.

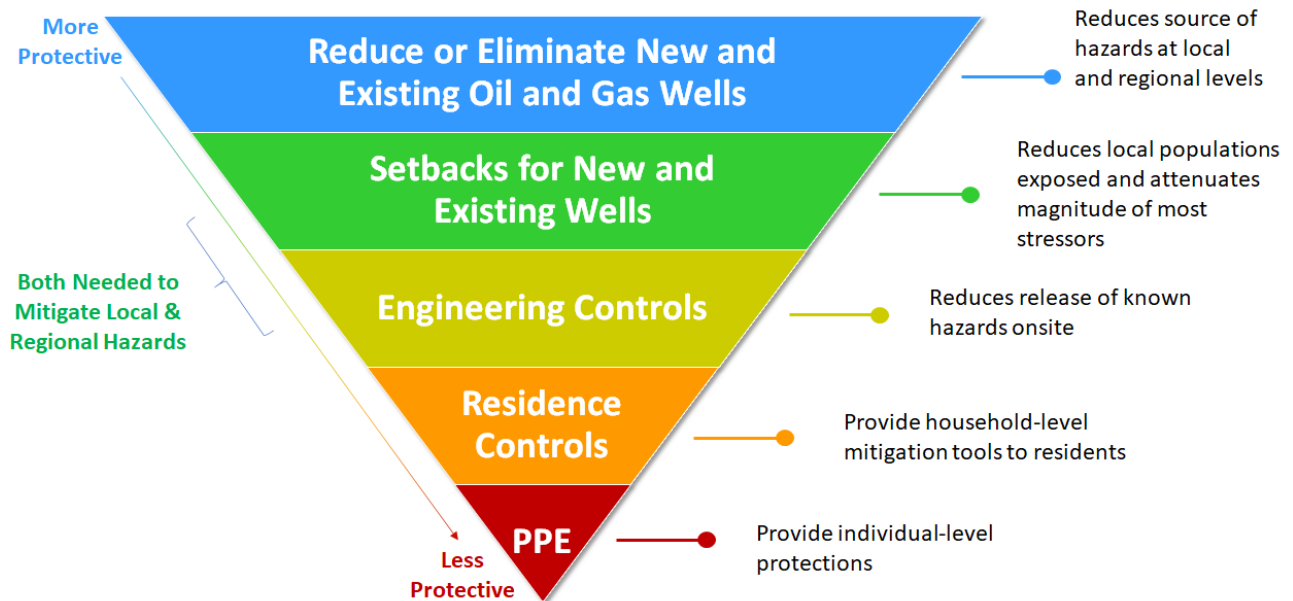


Figure 3. Hierarchy of strategies to reduce or eliminate public health harms for OGD activities. Note: the use of the term “wells” includes the ancillary infrastructure used to develop, gather and process oil and gas in the upstream oil and gas sector.

At the top of Figure 3 is the most health protective strategy: to stop drilling and developing new wells, phase out existing OGD activities and associated infrastructure, and properly plug remediate legacy wells and ancillary infrastructure.

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: 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 OGD contributions to regional air pollutant levels, such as secondary particulate matter and ozone, or greenhouse gases, such as methane, which are nearly always co-mingled with health-damaging air pollutants (Michanowicz et al., *Forthcoming*). 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 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. Advantages and Disadvantages of Oil and Gas Development Control Strategies from an Environmental Public Health Perspective.**

<b>Control Strategy</b>	<b>Description</b>	<b>Advantage</b>	<b>Disadvantage</b>
<b>Elimination</b>	Eliminate or reduce new and existing wells and ancillary infrastructure in combination with proper plugging and abandonment of wells and other legacy infrastructure.	Eliminates the source of nearly all environmental stressors (e.g., air and water pollutants, noise); protects local and regional populations	None.
<b>Setbacks</b>	Increase the distance 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 and therefore does not adequately address air pollutant and greenhouse gas emissions from OGD and their impacts on regional air quality and the climate.
<b>Engineering Controls</b>	Reduces or eliminates release of specific 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. Often not feasible to apply engineering solutions to multiple, complex stressors each requiring different control technologies (e.g. noise, air and water impacts, social stressors) and lacks the important factor of safety provided by a setback when engineering controls fail.
<b>Residence Controls</b>	Provides households with devices to reduce hazard at the home (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 devices properly and to maintain and regularly replace controls to maximize effectiveness. Not feasible to apply devices to address numerous, complex stressors.
<b>Personal Protective Equipment</b>	Provide individuals with devices to reduce exposure (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 and is not feasible for the complex stressors.

## **Attributable Risk Calculations**

One method to estimate health harms from OGD is to use the measures of association from the epidemiologic literature and population counts to calculate the excess number of specific health outcomes. This is what is known as an attributable risk method. We may be able to derive these estimates in the final report for birth outcomes using estimates of population counts for women of reproductive age in California living near OGD sites. We will also attempt to derive similar estimates for respiratory outcomes by using age appropriate population counts near OGD sites. This attributable risk method can allow us to estimate the number of adverse perinatal or respiratory cases that are attributable to OGD exposures and could be attenuated through the implementation of elimination or setback strategies.

### ***c. Can the panel quantify or recommend a methodology CalGEM can use to quantify the health benefits associated with mitigation controls?***

The Panel was not tasked to estimate health benefits of various setbacks and mitigation strategies, which pose significant methodological challenges and would require considerable time and effort. Among the challenges is the need to consider the benefits of reducing multiple stressors -- multiple air pollutants and other chemicals, noise, vibration, light, subsurface contamination, etc.

## **Known Health Benefits of Reducing Air and Noise Pollution**

There is a significant body of literature and available tools that address the potential health benefits that can be achieved by reducing air and noise pollution exposures. The National Institute of Environmental Health Sciences has linked air pollution and specifically PM<sub>2.5</sub> to respiratory disease, cardiovascular disease, cancer, and reproduction harm and provides references supporting these links (NIEHS (National Institute of Environmental Health Sciences), 2021). Schraufnagel et al. (2019) examined in detail the health benefits of air pollution reductions in different geographic regions. Friedman et al. (2001) showed that improvements in air quality in preparation for the 1996 Atlanta Olympics resulted in significantly lower rates of childhood asthma events, including reduced emergency department visits and hospitalizations. Avol et al. (2001) demonstrated that children in southern California who moved to communities with higher air pollution levels had lower lung function growth rates than children who moved to areas with lower air pollution levels. Gauderman et al. (2015), examining the impact of reductions in PM<sub>2.5</sub> and nitrogen dioxide in the Los Angeles air basin, found that children who grew up after air quality improvements had less than ½ the chance of having clinically low lung function results. Ha et al. (2014) found PM<sub>2.5</sub> exposures in all trimesters to be significantly and positively associated with the risk of all adverse birth outcomes.

In an analysis of noise exposure reductions. Based on sound levels measured and/or modeled across the US together with an EPA exposure- response model for levels exceeding EPA standards, Swinburn et al. (2015) found that a 5-dB noise reduction scenario in communities with noise exceeding EPA standards would reduce the prevalence of hypertension by 1.4% and coronary heart disease by 1.8%. The types of health-benefit studies noted here provide a basis for conducting a health-benefits analysis using a tool such as US EPA's Environmental Benefits Mapping and Analysis Program—Community Edition (BenMAP-CE) (US EPA, 2021).

### **Possible Approaches to Quantify Health Benefits**

CalGEM could obtain estimates of the health benefits achieved from different mitigation strategies individually or in combination with tools such as the Community Multiscale Air Quality Model (CMAQ) (Binkowski & Roselle, 2003) and/or other exposure assessment tools and link model output to EPA's BenMAP-CE (US EPA, 2021). However, these models and approaches are only focused on air quality and noise. It should also be noted that a significant drawback of using BenMAP-CE for this application is that it only considers impacts from criteria air pollutants and not from toxic air contaminants or other emerging air pollutants.

BenMAP-CE estimates the number and economic value of health impacts resulting from changes in air pollution concentrations. BenMAP-CE estimates benefits in terms of the reductions in the risk of premature death, heart attacks, and other adverse health effects. BenMAP-CE requires as input, pollutant concentrations at a scale that matches with population data. These concentrations can be obtained from a model such as CMAQ (Binkowski & Roselle, 2003) or from a monitoring network. BenMAP-CE takes the concentration fields for a base case and then for a pollution reduction (or increase) to assess health benefits (or detriments). BenMAP-CE then estimates changes in health endpoints, allowing the user to specify the concentration–response function and either use built-in population and baseline mortality rates or specify them as inputs.

It should be noted that in order to use a model such as BenMAP-CE to assess health benefits of setbacks and mitigation controls at well sites across California would involve a significant level of time and effort in data collection and model executions. In addition, these models are limited to characterizing the health benefits of criteria air pollutant reductions, but do not account for other OGD related exposures such as toxic air contaminants, other chemical exposures and exposures to other stressors through other environmental pathways (e.g., water and noise). Additionally, and importantly, the lack of spatially resolved emissions data from upstream OGD introduces challenges when assessing local- and sub-regional scaled health impacts that would be required for calculating benefits of specific policies such as setbacks and emission control. As such, attempts to quantify benefits using BenMAP-CE are likely to underestimate them.

**4. CalGEM is aware of health risk assessments, health impact assessments, air exposure studies, and workforce safety studies that have been conducted but were not evaluated as part of your preliminary advice. How do these studies align with your causation determination, any recommended setback distance, and recommendations on health benefits quantification?**

The Panel determined early in its deliberations that it would limit the studies assessed in its report to those in the peer-reviewed scientific literature. This criterion ensures that studies have been evaluated by scientists who have not been involved with the study but have expertise in the relevant topic area and/or the methods used to carry out analyses, prior to publication. The peer-review process helps to ensure that high quality data and scientific interpretations are at the core of the science-policy decision-making process. Authors of peer reviewed studies are more likely to have been questioned about their methods, data interpretations, and conclusions, leading to greater confidence in the results.

In addition, the Panel was not tasked with assessing occupational studies. If CalGEM staff are aware of any peer-reviewed studies that were not included in our preliminary advice, we encourage them to send the Panel references so that we can evaluate them for inclusion in the final report. We intend to scan the literature again to assess whether relevant studies have been published since we completed the draft report. Should additional peer-reviewed studies be identified, the Panel will evaluate them to determine if they align with the scope of the report and should be added.

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For Immediate Release, April 11, 2018

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## **Records: Nearly 400 Violations at California Offshore Drilling Operations**

### ***State Records Reveal Corroded Wellheads, Neglected Platforms, Failed Well Integrity Tests***

LOS ANGELES— Companies drilling for oil and gas off the southern coast of California have violated state regulations at least 381 times since 2015, according to [state records](#) obtained by the Center for Biological Diversity.

The violations range from major corrosion and other serious safety threats on offshore drilling platforms to a pattern of missing and failed well-integrity tests on four offshore drilling islands owned by the city of Long Beach.

“These violations show a disturbing pattern of neglect at offshore oil platforms near Southern California’s biggest cities and most famous beaches,” said Kristen Monsell, a Center attorney. “If this disrepair causes a well failure or an oil spill, marine life and coastal communities will pay a terrible price. It’s time to get this decaying infrastructure and the oil drilling that comes with it out of our ocean for good.”

The state’s biggest oil and gas producer, California Resources Corporation, operates Long Beach’s coastal drilling operations through its subsidiaries Tidelands and THUMS Long Beach Company. The three related entities have been hit with 293 notices of violation since February 2015, both in Long Beach and the nearby Huntington Beach Oil Field.

Two offshore drilling platforms operated by DCOR, LLC were found to be poorly maintained during state inspections in March 2015. Regulators found that all 42 wellheads on Platform Eva off Huntington Beach “have moderate to significant corrosion,” in violation of state law. On Platform Esther off Seal Beach, most of the 30 wellheads were found corroded, as were the valves and flanges, to the point where it could impair operation of the equipment, the report said.

The records, obtained by the Center through a public records request, also detail public safety threats from offshore platforms that were neglected by two companies as they filed for bankruptcy protection.

Rincon Island’s platform off Ventura County was found to be in a “severe state of disrepair” in April 2016 as the state ordered corrective actions “to prevent damage to life, health, property, natural resources.”

Regulators inspecting Platform Holly near Santa Barbara last year found evidence that Venoco had abandoned wells that needed to be plugged and remediated. The California Legislature is considering [allocating more than \\$100 million](#) in state funds this year to secure the Venoco and Rincon Island wells.

Most of California's offshore drilling infrastructure was built in the 1960s and has already passed its originally intended life span. Much of it is failing.

Venoco filed for bankruptcy in 2016 following the 2015 Refugio oil spill that blackened Santa Barbara area beaches and killed hundreds of seabirds and marine mammals. That spill was caused by the rupture of a severely corroded onshore pipeline carrying oil from offshore platforms.

The city of Long Beach owns the THUMS offshore platforms and shares revenues from oil sales with the state, which also regulates the operation through California's Division of Oil, Gas and Geothermal Resources. Its records often show long lapses with missing well integrity tests that are required by state law at least every five years.

Most of the missing and failed well tests in the THUMS notices of violation were for underground injection wells, which are used to stimulate oil and gas production and help prevent the land subsidence that has caused billions of dollars in damage to Long Beach. Drilling wastes contaminated with toxic chemicals and heavy metals can be injected into these wells, which state law requires to be enclosed and able to withstand pressure so that the ocean and freshwater aquifers don't get contaminated.

"Mechanical integrity tests" are required before any underground injections take place. THUMS had 103 violations for missing tests and 47 failed tests and Tidelands had 68 missing tests and 10 wells that failed the tests over the past three years. CRC had 40 violations for failing to perform required well integrity tests in the Huntington Beach Oil Field in 2017 alone.

"Offshore drilling is dirty and dangerous work," Monsell said. "It's even more dangerous when toxic chemicals are being injected into wells that fail or lack safety tests and could contaminate our marine environment."

*The Center for Biological Diversity is a national, nonprofit conservation organization with more than 1.6 million members and online activists dedicated to the protection of endangered species and wild places.*

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For Immediate Release, October 7, 2021

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**Analysis: Even Before Orange County Leak, California Pipeline Incidents Caused \$1.2 Billion In Damages**

***Video Maps Nearly 1,400 Pipeline Leaks, Spills, Other Problems Since 1986***

HUNTINGTON BEACH, *Calif.*— As Orange County beaches suffer a massive oil spill reportedly caused by an undersea pipeline linked to offshore drilling rigs, a new analysis reveals a troubling history of pipeline accidents in California.

Released today by the Center for Biological Diversity, the analysis found that since 1986, nearly 1,400 oil and gas pipeline leaks, spills and other incidents in the Golden State have caused at least \$1.2 billion in damages, as well as 230 injuries and 53 deaths.

A new [time-lapse video](#) informed by the analysis maps every significant pipeline incident in California — along with their financial costs and toll in injuries and deaths — from 1986 to July of 2021. On average California has suffered 40 significant pipeline incidents a year, according to the federal data.

“The Orange County spill is a wake-up call on the risks of oil and gas pipelines, but these things have been wreaking havoc in California for decades,” said Kristen Monsell, oceans legal director for the Center. “The leaks and spills and pollution go on year after year. These deadly and costly incidents will continue until we put an end to this dirty extraction business.”

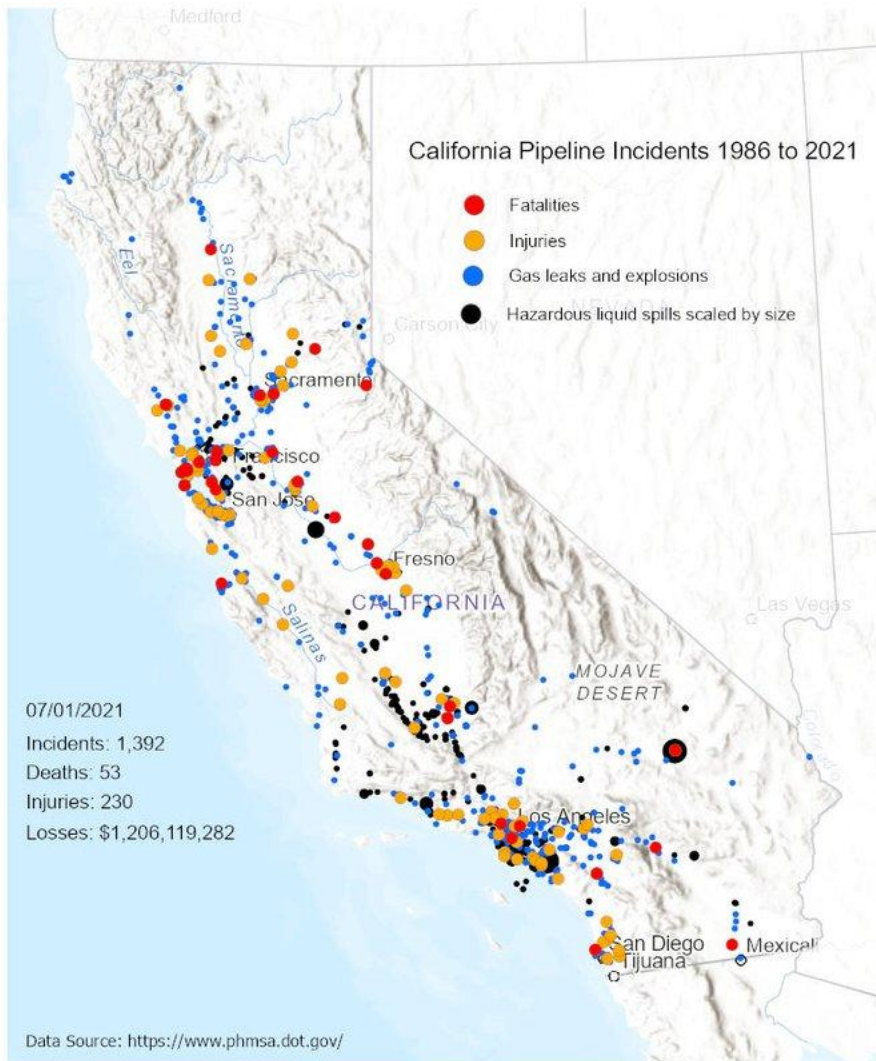
Today’s analysis focuses on pipeline incidents since 1986, including spills, leaks, ruptures and explosions. It’s based on records from the federal [Pipeline and Hazardous Materials Safety Administration](#), which maintains a database of all U.S. pipeline incidents classified as “significant” — those resulting in death or injury, damages more than \$50,000, more than five barrels of highly volatile substances or 50 barrels of other liquid released, or where the liquid exploded or burned.

Hundreds of miles of pipelines run through California’s coastal areas. They transport oil and gas from drilling and fracking.

Today’s analysis does not include the damage caused by the Orange County leak, which investigators believe came from a breach in an undersea pipeline linked to the Elly platform, an offshore rig built in 1980. The leak released an estimated 144,000 gallons of oil into the ocean, killing birds, fouling beaches and saturating the Talbert Marsh ecological reserve.

“Whether oil and gas pipelines are in the ocean or on land, they’re basically time bombs,” said Monsell. “This video shows how much damage they do to our coastlines and in our communities. That’s one more reason why President Biden and Gov. Newsom must stop approving new fossil fuel projects and wind down existing drilling.”





Video of California pipeline incidents from 1986 to 2021 by Curt Bradley/Center for Biological Diversity [Image](#) and video available for media use.

The Center for Biological Diversity is a national, nonprofit conservation organization with more than 1.7 million members and online activists dedicated to the protection of endangered species and wild places.

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**CalEPA**  
California Environmental  
Protection Agency

Edmund G. Brown Jr.  
Governor

Matthew Rodriguez  
Secretary for Environmental Protection

**MEMO: CalEPA Review of UIC Program**

**TO:** Cliff Rechtschaffen, Senior Advisor  
Office of the Governor  
  
John Laird, Secretary  
California Natural Resources Agency

**FROM:** Matthew Rodriguez, Secretary  
California Environmental Protection Agency

**DATE:** March 2, 2015

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For the last eight months, the State of California, through the Division of Oil, Gas & Geothermal Resources (DOGGR) and the State Water Resources Control Board (State Water Board), and in coordination with the United States Environmental Protection Agency (U.S. EPA), has been systematically reviewing thousands of wastewater disposal and enhanced oil recovery wells to determine their proximity to water supply wells and the potential for contamination of any drinking water. Where the risk of contamination is unacceptable, the State has ordered and will continue to order those wells be shut in. As of early February 2015 the State has identified approximately 2,500 wastewater disposal and enhanced oil recovery wells injecting into potentially non-exempt zones, 2,100 of which are still active. Of these, there are approximately 140 active wastewater disposal wells injecting into aquifers with Total Dissolved Solids (TDS) less than 3,000 mg/l, a key indicator under the federal Safe Drinking Water Act (SDWA) of higher quality water. (DOGGR regulates over 50,000 oilfield injection wells in California.) To date, preliminary water sampling of select, high-risk groundwater supply wells has not detected any contamination from oil production wastewater.

Three years ago, DOGGR notified U.S. EPA that discrepancies and confusion concerning 30-year-old agreements by which the federal government granted the State regulatory authority over wastewater disposal wells likely led to the permitted injection of oil production wastewater into aquifers that are or could become sources of drinking water. In some cases, this occurred due to conflicting documentation, both in California and with the federal government, as to whether 11 aquifers were exempted from regulation when the State received authority from U.S. EPA to implement the Underground Injection Control (UIC) program of the Safe Drinking Water Act. In other cases, this permitting and injection occurred due to confusion over the precise borders of aquifers that had been authorized for injection.

In June 2014 the Governor's Office requested that the California Environmental Protection Agency (CalEPA) perform an independent review of the state's Underground Injection Control Program, as administered by DOGGR over the decades, to better understand how this occurred. This memo presents CalEPA's findings.

**Background**

The federal Safe Drinking Water Act was enacted in 1974 to protect public health by regulating the nation's public drinking water and its sources. Pursuant to the SDWA, U.S. EPA

promulgated regulations creating an Underground Injection Control Program to protect from contamination aquifers that are, or could become, potential sources of drinking water.

In 1981, California's Division of Oil and Gas (DOG<sup>1</sup>) applied to U.S. EPA to become the primary enforcing agency of the UIC portion of the SDWA in California; DOG was granted primacy over the program in 1983. As part of the application process, DOG proposed to exempt certain aquifers from regulation under the UIC Program (so-called "exempt aquifers") because they were not, and would not become, sources of drinking water. Most but not all of these proposed aquifers -- which were either hydrocarbon-producing (i.e. a source of oil or gas) or already being injected with oil production wastewater -- were exempted under a Memorandum of Agreement between DOG and U.S. EPA signed on September 28 and 29, 1982.

This first version of the Memorandum of Agreement (MOA1) expressly designated as non-exempt 11 aquifers that DOG had sought to exempt and required all existing injection wells into those aquifers to be phased out over 18 months. These non-hydrocarbon-producing aquifers all had a TDS concentration below 3,000 mg/l. However, all 11 were being used at the time of the Primacy Application for wastewater disposal and, even at that point, some had been injected into for decades.

As will be discussed below, at least by December 3, 1982, a second version of that Memorandum (MOA2) was being circulated between DOG and U.S. EPA *exempting* the 11 aquifers that had been *rejected* for exemption in the prior version. MOA1 and MOA2 were virtually identical, differing only in their treatment of the 11 aquifers and in the omission of one sentence from MOA2 requiring that injection in non-exempt aquifers be phased out within 18 months. Adding to the confusion, MOA2's signature page was photocopied from MOA1, so both documents share the same date and signatures. From the early 1980s on, DOG (then DOGGR) staff and U.S. EPA staff treated the list of exempt aquifers in MOA2 as correct; after a number of years, staff was no longer even aware of the fact that MOA1 had existed.

Further, under the terms of a 1983 interagency agreement (renewed in 1988) between the Department of Conservation (which oversaw DOG) and the State Water Board, the Regional Water Quality Control Boards were to review all well permit applications approved by DOG to ensure wastewater disposal would not degrade state waters. However, having other priorities and no dedicated staff or resources for an independent review, the Regional Boards generally deferred to DOGGR's determination of whether or not an aquifer was exempt without scrutinizing the applications.

### **DOGGR and U.S. EPA Agreed to Exempt the 11 Aquifers, But May Not Have Followed Regulatory Procedures**

As discussed below, U.S. EPA and DOG agreed in the early 1980s to exempt the 11 aquifers and seemingly adopted MOA2 as the basis for permitting of wastewater disposal wells. Nevertheless, there are questions about whether this was done in accordance with federal UIC regulations. Procedurally, there is conflicting evidence as to whether MOA2 was approved as part of the state's initial Primacy Application in February 1983 or after an aquifer exemption appeals process in June 1983. There is also little evidence in the files of state and federal agencies justifying the decision to exempt the 11 aquifers in MOA2.

After representatives of DOG and U.S. EPA Region 9 signed MOA1 on September 28 and 29 (respectively), 1982, the agreement was forwarded to U.S. EPA's national office for review. The

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<sup>1</sup> DOG was the precursor entity to DOGGR. The name change occurred in 1992.

national office returned the agreement, asking for changes. Notes from an internal U.S. EPA phone conversation indicate that the national office specifically requested that the 18-month phase-out of the injection wells in the 11 non-exempt aquifers be removed. The next version of the Memorandum sent by Region 9 to the national office for review, on December 13, was MOA2: the 18-month phase-out had been removed *and* the 11 non-exempt aquifers had been transposed into the list of exempt aquifers. In transmitting MOA2, Region 9 noted that "with the addition of these attachments, all known issues regarding the Primacy Application have been resolved." The national office submitted California's Primacy Application, including a version of the Memorandum, to the U.S. EPA Administrator for review, which was approved on February 4, 1983 (effective March 14, 1983). However, which version was transmitted to the Administrator, MOA1 or MOA2, is unknown.

The federal regulations<sup>2</sup> memorializing the delegation of UIC Primacy to DOG incorporate by reference the Memorandum signed on September 29, 1982; however, because MOA1 and MOA2 have identical signature pages it is unclear which version is being referred to. MOA2 is the last version of the Memorandum that DOG and Region 9 agreed to and presumably would have been the version transmitted to the Administrator. DOG files include a version of MOA1 with "VOID" handwritten across the top and strikethroughs of the 11 non-exempt aquifers that were ultimately exempted under MOA2. Similarly, U.S. EPA files include a version of MOA2 with asterisks indicating the 11 aquifers that had been newly exempted. This suggests MOA2 was adopted along with the transfer of UIC Program primacy.

In February and April 1983, however, DOG wrote oil operators injecting into the 11 aquifers to notify them the aquifers were not exempt and that they had 18 months to cease injecting. This would only be the case if MOA1 were correct (as MOA2 had exempted those aquifers). In June 1983 DOG wrote a second set of letters saying DOG's appeal of these aquifers' status to U.S. EPA had been successful, and they were now exempt. Aside from these representations, there is no evidence DOG put together an appeals packet with information justifying an exemption and transmitted it to U.S. EPA. Nor is there evidence that the procedures required to approve a post-primacy aquifer exemption were followed, which at minimum required the written approval of the Administrator and may have required a new public process and publication in the *Federal Register*.

Even more confusingly, during the two-month period when the "appeal" was apparently being considered, the Department of Conservation and the State Water Board signed their interagency agreement to review well permit applications, attaching for reference MOA2 as the valid agreement between DOG and U.S. EPA. Other documents similarly suggest that, despite the shut-down notice letters, the 11 aquifers had already been exempted per MOA2. Two February and March 1983 letters from oil producers expressed concern about one of the 11 aquifers being non-exempt; DOG district staff wrote across the top of both letters that "[t]his zone is exempted." A February 1983 summary of the responses to public comment regarding DOG's 1983 Primacy Application, found in U.S. EPA files, states that U.S. EPA approved "all but two" of the aquifers DOG had requested for exemption, short of the 11 listed in MOA1.<sup>3</sup>

Regardless of timing, by early or mid-1983 U.S. EPA and DOG appear to have agreed that MOA2 governed and the 11 aquifers were exempt. Both agencies treated the aquifers as exempt from that point through 2012, when DOGGR staff re-discovered MOA1 and notified U.S. EPA. For example:

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<sup>2</sup> 40 CFR §147.250 (1984).

<sup>3</sup> MOA2 listed no non-exempt aquifers, but DOG and U.S. EPA would discuss exempting two new aquifers in late 1983, which may have been the two referred to.

- An undated DOGGR letter, likely from 1983, includes a list of exempt aquifers and “recently” exempted aquifers that includes the 11 aquifers. This list would be periodically reissued by DOGGR management to district office staff into the 1990s.
- In 1984, U.S. EPA noted in the *Federal Register* that some parties were confused over which aquifers had been exempted in California and pledged that U.S. EPA Region 9 would maintain a public list of all exempt aquifers. The next year, in 1985, U.S. EPA wrote an oil producers association clarifying which aquifers had been exempted in California, attaching the list of exempt aquifers from MOA2, which included the 11 formerly non-exempt aquifers from MOA1.
- From at least the late 1980s through the 2010s, DOGGR’s UIC Manual of Instruction, an injection well permitting manual issued to all the districts, also included a copy of MOA2.
- In 2011, an independent audit of DOGGR’s UIC permitting program prepared at the request of U.S. EPA Region 9 included an attachment of MOA2 as the relevant agreement.

### **DOGGR Also Permitted Injection in Non-Exempt Zones**

About half of the active wastewater disposal wells injecting into sub-3,000 mg/l TDS aquifers are injecting into the 11 aquifers that were listed as *non-exempt* in MOA1, but *exempt* in MOA2. The remaining half are the result of different types of permitting errors. Until the 2010s, project and well permitting decisions were mostly delegated to DOGGR’s six district offices. DOGGR headquarters in Sacramento generally did not review district permitting decisions; nor did it provide standardized guidance on identifying the injectable zone for exempt aquifers. Limited oversight from DOGGR headquarters may have contributed to several types of permitting errors, including:

- Border Confusion: Permits were granted for injection wells that fell just *outside* the productive limits of a hydrocarbon-producing field but *inside* the slightly larger administrative boundaries for that field.<sup>4</sup> Many DOGGR staff believed the administrative limits to define an exempt aquifer. However, the state’s UIC Primacy Application to U.S. EPA had proposed to exempt certain hydrocarbon-producing aquifers based on their 1973 and 1974 productive limits, and not their administrative limits.
- Expanding Productive Limits: With advances in oil extraction technology, the effective productive limits for many fields have expanded since they were drawn in the 1970s. Staff may have believed that injection was permitted in the actual, present productive limits of a field, rather than looking to the boundaries established in the Primacy Application.
- Depth Confusion: Some injection wells were within the areal boundaries of an exempt aquifer, but were nonetheless injecting above or below the exempt aquifer, into a non-exempt zone. It appears, in certain cases, staff based their permitting decisions only on the contour maps included in the Primacy Application without also looking to the depth

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<sup>4</sup> “Productive limits” means the outermost areas of a field where hydrocarbons could be extracted. They differ from administrative field limits, which are the administrative boundaries created using the Public Land Survey System. In practice, productive limits have expanded over time with improvements in oil production technology.

interval for the exempted aquifer, which was produced in a table elsewhere in the Primacy Application.

- Partial Exemption: In certain cases, only portions of an aquifer were exempted and not the whole aquifer. Staff granting permits based solely off of a list of which field and zone had been exempted, without referring back to the Primacy Application, may have mistakenly believed the whole aquifer was exempt.

## **Recent Discovery and Actions**

DOGGR staff first became aware of a potential systemic problem with the aquifer exemption process in 2011, when a headquarters staffer temporarily working in a district office noticed a discrepancy between lists of exempted aquifers. In late 2011, DOGGR staff further discovered that there were two different versions of the Memorandum in DOGGR files: MOA1 classifying the 11 aquifers as not exempt and MOA2 classifying them as exempt. DOGGR notified U.S. EPA in early 2012. DOGGR and U.S. EPA agreed that DOGGR would identify all the wells injecting into non-exempt zones and ask oil operators in those zones to start the process of applying for an aquifer exemption.

In 2014 the Central Valley Regional Water Board independently discovered that injection had been permitted in sub-3,000 mg/l TDS aquifers. It notified DOGGR that there may be groundwater supply wells at risk. Until that time, DOGGR had not treated the injection wells, which are located in oil fields, as a significant public health risk, although questions about this had been raised within DOGGR. The Governor's office assembled an inter-agency team to assess and address any public health risk.

The State, in coordination with U.S. EPA, responded by initiating a process to review most of the state's injection wells, prioritizing wells that were injecting into non-exempt, non-hydrocarbon-bearing aquifers, as well as the 11 aquifers which had historically been treated as exempt. Thus far, the State Water Board has evaluated just over 200 injection wells of highest concern for potential risk to water supplies. In 2014, 11 injection wells were ordered shut-in, along with orders requiring oil producers to provide testing of injection well injectate and nearby groundwater supply wells. In March, 2015, DOGGR confirmed or requested the closure of 12 additional wells. Injection permits for 11 wells were voluntarily relinquished at DOGGR's request. A 12th well was ordered shut in by DOGGR.

Additionally, DOGGR headquarters is now doing a second review of all new or expanded project permit applications prior to approval by the districts. This will provide another opportunity to correct any permitting errors and will promote greater permitting consistency across the six DOGGR districts.

Going forward, in conjunction with U.S. EPA, DOGGR and the State Water Board have proposed an enforceable compliance schedule to eliminate injection into non-exempt aquifers, as outlined in a February 6, 2015 letter to U.S. EPA. Specifically, for non-exempt aquifers between 3,000 to 10,000 mg/l TDS, all injections must cease by February 15, 2017, unless an aquifer exemption is applied for by the state and approved by U.S. EPA. For non-exempt aquifers with less than 3,000 mg/l TDS, the deadline to stop injecting is October 15, or immediately where the injection is potentially impacting water supplies. For the 11 aquifers historically treated as exempt, DOGGR and the State Water Board will work with U.S. EPA on a case-by-case basis to determine by February 15, 2017, whether these aquifers qualify for exemption. During the review process, DOGGR will continue to issue emergency orders to stop any injection that potentially impacts water supply wells.