

MEMORANDUM

DATE: October 16, 2017

TO: John Laird, Secretary for Natural Resources
Matt Rodriguez, Secretary for Environmental Protection

FROM: Interagency Working Group on Well Stimulation

SUBJECT: State Agency Activities Associated with Recommendations from the California Council on Science and Technology on Well Stimulation in Oil Production

On September 20, 2013, Governor Brown signed into law Senate Bill 4 (Pavley, Chapter 313) to establish a comprehensive regulatory program for oil and gas well stimulation treatments, including hydraulic fracturing, commonly referred to as “fracking.” Senate Bill 4 also directed the Natural Resources Agency to conduct an independent scientific study of well stimulation techniques in California. This study was published in July 2015 by the California Council on Science and Technology (CCST), which assembled an interdisciplinary steering committee composed of scientists and technical experts to complete the study, and included various conclusions and recommendations. This memo serves to update you on the work informed by this study that various state agencies have since pursued.

The CCST conducted the study in collaboration with the Lawrence Berkeley National Laboratory (LBNL). The three-volume study identified a set of important data gaps and detailed research priorities to address unanswered questions about the impacts of well stimulation-enabled oil and gas production in California. Volume I describes how well stimulation technologies work, how and where operators deploy these technologies for oil and gas production in California, and where they might enable production in the future. Volume II discusses how hydraulic fracturing and acid stimulation could affect water, atmosphere, seismic activity, wildlife and vegetation, and human health in California. Volume III presents four case studies that assess environmental issues and qualitative risks for specific geographic regions: offshore, the Los Angeles Basin, the Monterey Formation, and the San Joaquin Basin. Major conclusions from the study include:

- The environmental impacts associated with hydraulic fracturing are found in almost all oil and gas development whether or not the oil is produced with well stimulation.

- Hydraulic fracturing operations in California are very different from those in other states. In California, it is conducted at shallower depths (< 2,000ft in CA; > 10,000ft in Pennsylvania) and utilizes significantly less water (e.g., 140,000 gallons in CA; 4.3 million gallons in Texas, Eagle Ford).
- The Monterey formation will not facilitate an oil development boom in the foreseeable future. Future use of hydraulic fracturing will most likely focus in and near existing oil fields in the San Joaquin Basin that currently require hydraulic fracturing.
- The environmental characteristics of many chemicals utilized in well stimulation remain unknown.
- More analysis should be done regarding surface discharges and regarding the treatment and reuse of produced water (water that is comingled in oil reserves). Some produced water is treated and reused for irrigation in the Central Valley.
- More studies are necessary to assess public health as a function of proximity to all oil and gas development, not just stimulated wells, to determine if policies such as how science-based surface setbacks could mitigate impacts.

An Interagency Working Group was assembled to review and assess the study's conclusions and recommendation. Participating agencies included the California Natural Resources Agency, the California Environmental Protection Agency, the Department of Fish and Wildlife, the Department of Public Health, the Office of Environmental Health Hazard Assessment, the Department of Toxic Substances Control, the California Air Resources Board, the State Water Resources Control Board, the Department of Conservation, and the California Department of Industrial Relations. The Interagency Working Group kicked-off in August 2015 by engaging in detailed briefings provided by members of the team of scientists and technical experts who conducted the study. Over the last two years, the agencies have convened in subsets based on policy issues and agency expertise. This study and ongoing science on well stimulation treatments have been valuable in establishing the facts necessary for state regulators to identify issues that need to be addressed.

Since the publication of this study, state agencies have demonstrated their responsiveness to recommendations from the scientific community through regulatory changes and by gathering data for future scientific assessments. The pages following this memo summarize how each recommendation from the study has informed actions by one or more of the members of the Interagency Working Group. Such studies and actions include:

- The State's 2017-18 budget includes funding for the Office of Environmental Health Hazard Assessment (OEHHA) to evaluate chemicals used in well stimulation treatments (WST). The information produced by OEHHA will serve to identify

chemicals that may pose significant health and environmental threats and, where feasible, encourage the use of less hazardous alternative chemicals.

- The Central Valley Regional Water Quality Control Board approved new rules to require oil and gas operators to disclose chemicals and conduct chemical analysis on produced water that is discharged to the surface. The regional board also formed a food safety expert panel to advise it on actions related to the use of produced water for irrigation.
- The California Air Resources Board (CARB) passed a methane regulation with a co-benefit of reduction in smog forming pollutant and toxic air contaminants. CARB is also in the process of implementing an enhanced air quality monitoring program in and around oil and gas facilities such as production fields and storage facilities, particularly in disadvantaged or highly impacted communities.
- On January 1, 2016, the State Water Board began implementation of an oil and gas Regional Monitoring Program, which seeks to protect all beneficial use water, but prioritizes the monitoring of groundwater that is or has the potential to be a source of drinking water. Factors considered for the Regional Monitoring Program include well stimulation treatments, and other events or activities that have the potential to contaminate groundwater, such as an oil well failure.
- The Division of Oil, Gas, and Geothermal Resources (DOGGR) now collects extensive data related to the location and depths of wells proposed to be stimulated in the DOGGR's SB 4 permitting forms. This data allows DOGGR to determine which new wells are being drilled into the Monterey Formation. Such data is being tracked and included in DOGGR's [annual report](#) on SB 4 activities submitted to the Legislature.
- DOGGR and the State Water Board have undertaken two significant efforts to protect groundwater. The aquifer exemption process, currently under way, ensures that underground injection (including disposal of fluids involved in well stimulation) is not permitted into underground sources of drinking water. DOGGR is also reviewing all previously permitted Underground Injection Control Projects to ensure protection of groundwater resources.

In addition to the aforementioned regulatory and research activities, California has implemented the most comprehensive regulatory program on well stimulation treatments in the nation. This regulatory program is responsive to public concerns and informed by science-based assessments. Emergency regulations for the well stimulation treatment program went in effect on January 1, 2014, and a more comprehensive permanent regulatory program went into effect on July 1, 2015. The regulatory program includes the following elements:

- Well stimulation treatments must be permitted by DOGGR and reviewed by the State Water Board to determine whether groundwater monitoring is required. Other agencies, such as CARB, also review and make recommendations.

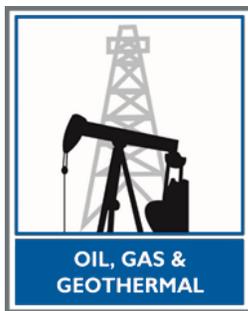
- Approval to conduct well stimulation treatment is contingent upon an extensive engineering review and well integrity evaluation in order to ensure that fractures are confined to the intended geologic zone.
- Neighboring parties (within 1,500 feet) must receive advance notification of projects and can request their water quality be tested to establish a baseline.
- The volumes and concentrations of chemicals used in the process must be disclosed.
- Comprehensive post-stimulation reports must be filed, including the amount of water used and the source of that water.
- Seismic monitoring must take place during well stimulation operations.
- DOGGR has developed a website to facilitate public disclosure of well stimulation projects and to allow the public to easily search and aggregate this information.

Since this regulatory program was begun more than two years ago, 187 permits have been issued. As of May 2017, 114 permits have been acted upon by the permittee. All have occurred in Kern County. In the years leading up to establishing the permanent program, the number of well stimulations per year ranged from 600 to 1,000.

This Interagency Working Group report provides updates on how several entities within the California Environmental Protection Agency, the California Natural Resources Agency, and the Department of Industrial Relations have responded to recommendations from the CCST study on well stimulation. This was a collaborative effort undertaken by a large cross section of state experts examining issues related to water quality, public health, worker safety, air emissions, and others. As new data and analyses become available, regulatory programs will be continually updated. Members of the working group will continue to meet in subgroups based on policy and technical expertise. If there are any follow-up questions on how CCST's recommendations are being implemented, we can connect you to the appropriate lead staff from the agency working on implementation of the specific recommendations.



California Interagency Working Group on Well Stimulation Treatment



Introduction

California oil production ranks third in the nation, and for more than 50 years, various techniques have been used to enhance oil and gas production. One of these techniques, known as well stimulation, encompasses hydraulic fracturing, acid fracturing, and acid matrix stimulation. Well stimulation treatments (WST) enhance oil and gas production by making the reservoir rocks more permeable, thus allowing more oil or gas to flow to the well.

In 2013, the California Legislature passed Senate Bill 4 (Pavley, Chapter 313 statutes of 2013), which established regulatory requirements for WST technologies in California. SB 4 also directed the Natural Resources Agency to conduct an independent scientific study of such oil and gas production techniques in California. This [study](#) was published in July 2015 by the California Council on Science and Technology (CCST), a non-partisan, not-for-profit corporation established to provide objective scientific advice to California policymakers. CCST assembled an interdisciplinary steering committee composed of scientists and technical experts to complete the study. Among other things, the study was required to do the following:

- Evaluate hazards and risks WST may pose to natural resources and public, occupational, and environmental health and safety.
- Identify areas with existing and potential conventional and unconventional oil and gas reserves where WST could spur or enable oil and gas exploration and production.
- Examine the use and potential for use of non-toxic additives and the use or reuse of treated or “produced” water in WST fluids and evaluate the potential for the use of recycled water in WST, including appropriate water quality requirements and available treatment technologies.
- Identify additional information necessary to inform and improve the analyses.

The following document describes efforts planned or currently under way by State agencies based on the each of the recommendations in the [study](#).

RECOMMENDATION 1.1

Now that SB 1281 has produced roughly a year of water data, the State should begin assessing this data to evaluate water use, production, reuse, and disposal for the entire oil and gas industry. Early assessment will shed light on the adequacy of the data reporting requirements, or if these need adjustment, such as adding information about the quality of the water used and produced. When several years of data become available, a full assessment should identify opportunities to reduce freshwater consumption or increase the beneficial use of produced water, and regularly update opportunities for water efficiency and conservation.

**Lead agencies: Division of Oil, Gas, and Geothermal Resources
 State Water Resources Control Board**

The Division of Oil, Gas, and Geothermal Resources (Division), in consultation with the State Water Resources Control Board (State Water Board), is currently working with the CCST to assess the data that has been collected to date under the requirements of SB 1281. The intent of this initial study is to assess whether the data being collected under SB 1281 is adequate to inform future policy decisions with respect to water use in oil and gas production operations. CCST will assemble an expert panel to guide this study.

Senate Bill 1281 became effective on January 1, 2015, and expanded the requirements for oil and gas operators to file, on a quarterly basis, detailed water reports for all water produced and used in oil field operations. Previous reporting requirements had two to four water data elements provided on a monthly basis. SB 1281 requires 121 data elements per quarter, in addition to 144 new possible data elements for previously unreported stored and non-injection water uses. Prior to these new reporting requirements, operators only filed monthly production and injection reports, in which the water reporting requirements were minimal. The new quarterly water report provides six additional disposal methods and four additional water sources. Operators must submit their data in a uniform software application, allowing Division staff to quickly and precisely load the information into a comprehensive database. Overall, the new reporting options and requirements provide more detail to enhance data accuracy.

In the first phase of the study, CCST will identify important questions on the water life cycle in California's oil and gas production and a description of the data required to answer these questions. The CCST steering committee will consult with relevant state agencies and stakeholders to define these questions.

The second phase will include a preliminary assessment of the SB 1281 data, as well as other available water data, to determine whether the type of information reported is necessary and sufficient to answer the questions identified in the first phase. The steering committee will make recommendations on how the data collected can be improved and streamlined, and identify new questions that may arise through the preliminary data assessment.

RECOMMENDATION 1.2

The State should request the federal government improve data collection and record keeping concerning well stimulation conducted in federal waters to at least match the requirements of SB 4. When representative data becomes available, the US EPA should conduct an assessment of ocean discharge and, based on these results, consider if alternatives to ocean disposal for well stimulation fluids returns are necessary.

Lead agency: Division of Oil, Gas, and Geothermal Resources

Since the passage of SB 4, the Division has engaged with various federal agencies on issues related to WSTs, including the United States Environmental Protection Agency (US EPA), Bureau of Land Management (BLM), and Bureau of Ocean Energy Management (BOEM). The Division has consistently advocated for greater data transparency of well stimulation activities approved by federal agencies on federal lands and waters.

For instance, in its submitted comments on BOEM's Programmatic Environmental Assessment (PEA) for the use of WSTs on the Southern California Outer Continental Shelf, the Division recommended the PEA be revised to consider additional mitigation measures that would achieve a level of transparency similar to what is required under SB 4. The measures recommended included the following:

- Requirement to disclose WST fluid constituents and additives on a publicly available website such as the Division's WST Disclosure Search or FracFocus.
- Requirement to notify stakeholders within the region of influence prior to WST and/or discharge of waste WST fluids into open waters. Applicable State agencies may include the California Coastal Commission, State Lands Commission, and Department of Fish and Wildlife/Office of Oil Spill Prevention and Response.
- Requirement of operators to specifically include information on the handling of WST fluids and additives in their Oil Spill Response Plans to demonstrate that systems and resources are in place to act quickly and effectively in the event of a spill.
- Requirement of testing permitted discharge waters following each WST to address data gaps regarding WST fluid toxicity.

In addition, in March 2015, the BLM released its final rule on WST activities on federal lands. The rule consists of data and transparency requirements similar to those required under SB 4, including submittal of detailed information about the proposed operation such as wellbore geology, the location of faults and fractures, the depths of all usable water, estimated volume of fluid to be used, and estimated direction and length of fractures, as well as public disclosure of the chemicals to be used in the operation.

This rule has not gone into effect due to a legal challenge filed by the States of Wyoming, Colorado, North Dakota, and Utah. On June 21, 2016, the United States District Court for the

District of Wyoming struck down the rule, concluding the BLM does not have authority to regulate WST activities. This ruling was appealed to the 10th U.S. Circuit Court of Appeals, which heard oral arguments in July 2017. In the meantime, under direction from the Trump Administration, the Department of Interior has announced plans to rescind this regulation.

RECOMMENDATION 2.1

The State should request a comprehensive, science-based and peer-reviewed assessment of source-rock (“shale”) oil resources in California and the technologies that might be used to produce them. The State could request such an assessment from the USGS, for example.

Lead agency: Division of Oil, Gas, and Geothermal Resources

In October 2015, the United States Geological Survey (USGS) released a geology-based assessment of continuous unconventional oil and gas resources in the Miocene-Monterey Formation in the southern San Joaquin Basin. The assessment estimates there are 21 million barrels of oil, 27 billion cubic feet of gas, and 1 million barrels of natural gas liquids in this area of the formation.

These estimates differ greatly from those previously published by the United States Energy Information Administration (EIA). In May 2015, EIA estimated there were 600 million barrels of technically recoverable oil in the Monterey Formation. This estimate was a 96 percent reduction of an estimate published by EIA in 2011, which estimated 13.7 billion barrels of technically recoverable oil from the Monterey Formation.

The USGS assessment concluded that most of the petroleum that has originated from shale of the portion of the Monterey Formation studied has migrated from the source rock to more shallow conventional reservoirs due to natural fracturing, faulting, and folding. Studies in 2003 and 2012 suggest that a mean of about 3 billion barrels of oil might eventually be added to conventional reservoirs in the San Joaquin Basin from the Monterey Formation.

The USGS study provided valuable information given it is focused on the largest basin for shale oil development in California. Primarily, it served as an additional indicator of the unlikelihood of an unconventional oil boom in California for the foreseeable future.

RECOMMENDATION 2.2

DOGGR should track well permits for future drilling in Monterey source rocks (and other extensive source rocks, such as the Kreyenhagen) and be able to report increased activity.

Lead agency: Division of Oil, Gas, and Geothermal Resources

Data related to the location and depths of wells proposed to be stimulated are captured in the Division’s SB 4 permitting forms. This data allows the Division to determine which new wells are being drilled into the Monterey Formation. Such data is being tracked and included in the Division’s [annual report](#) on SB 4 activities submitted to the Legislature.

RECOMMENDATION 3.1

Over the next several years, relevant agencies should assess the adequacy and effectiveness of existing and pending regulations to mitigate direct impacts of hydraulic fracturing and acid stimulations.

**Lead agency: Division of Oil, Gas, and Geothermal Resources
California Air Resources Board
State Water Resources Control Board**

As described under Recommendation 3.3 (below) a number of regulatory efforts are underway at each of the identified lead agencies. According to CCST's SB 4 study, all activities associated with oil and gas production enabled by WST can bring about indirect impacts from oil and gas development, which usually occur whether or not the wells are stimulated.

The Division is in the process of developing regulations covering [underground injection control \(UIC\)](#), [oil and gas facility pipelines](#), [idle well testing](#), and [underground gas and storage facilities](#). The permanent WST regulations went into effect in July 2015. Based on experience implementing the program, the Division is in the early stages of developing revisions. Also, as described later, the California Air Resources Board (CARB) is in the process of developing comprehensive [oil and gas field regulations](#) to reduce methane and other emissions.

The Division also is conducting ongoing work under a contract with Lawrence Berkeley National Laboratory (LBNL) to gain scientific support in the area of SB 4 data reporting requirements, structure, quality control, management, interpretation, and user interface design. LBNL is working with Division staff to examine information collected under new disclosure requirements to determine how the new requirements address recommendations made as part of the SB 4 Report. LBNL scientists have provided recommendations concerning the new data structure, improved data reporting requirements and methods, and data access interfaces. They are analyzing the meaning, significance or importance of specific types of information and evaluating specific and general problems identified with data collection in the SB 4 Report.

All of the lead agencies identified in this recommendation intend to revisit regulations that are pertinent to WST to assess adequacy. For example, CARB has recently adopted methane regulations on oil and gas facilities that will achieve co-benefits in reductions emissions of smog forming compounds as well as toxic air contaminants. CARB will evaluate the effectiveness of this regulation over time. Results from air sampling during well stimulation will also provide information.

RECOMMENDATION 3.2

Operators should apply Green Chemistry principles to the formation of hydraulic fracturing fluids, particularly for biocides, surfactants, and quaternary ammonium compounds, which have widely differing potential for environmental harm. The overall number of different chemicals used in hydraulic fracturing could be limited to those on an approved list that would consist only of those chemicals with known and acceptable environmental hazard profiles. Operators should report the unique Chemical Abstract Service Registry Number (CASRN) identification for all chemicals used in hydraulic fracturing and acid stimulation. Relevant state agencies, including DOGGR, 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.

**Lead agencies: Office of Environmental Health Hazard Assessment
 Division of Oil, Gas, and Geothermal Resources**

The Legislature has enacted the Governor's 2017-18 budget [proposal](#) providing the [Office of Environmental Health Hazard Assessment](#) (OEHHA) with funding from the Division's Oil and Gas Administrative Fund for three years to evaluate chemicals used in WST. The Division would use the information produced by OEHHA to potentially restrict the use of WST chemicals that may pose significant health and environmental threats and encourage the use of less hazardous alternative chemicals. Information on chemical usage, function (including necessity), toxicity, environmental fate and transport, and impacts on wildlife are all needed to determine which WST chemicals are safer to use. There are extensive data gaps on the toxicity of WST chemicals, potential for exposure, and environmental transformation products. The absence of data on a chemical is not evidence that there is no potential harm.

OEHHA's evaluation will include:

- Development of an inventory of chemicals used in WSTs.
- Gathering and synthesizing health and environmental hazard information on WST chemicals and their potential for human exposure.
- Closing data gaps involving the health and environmental impacts of these chemicals.
- Identifying chemicals likely to pose the greatest risks, and identifying potentially less hazardous alternatives.
- Characterizing the hazards or risks to human health and the environment from current WSTs and potentially preferable alternatives.
- Recommending preferred WST chemicals to the extent feasible.

OEHHA will conduct its evaluation in consultation with the Division and with an Interagency Working Group of scientists from relevant state agencies. In addition, OEHHA, the Division, and the working group would seek input from external stakeholders. These would include academics specializing in a number of areas (including toxicology, public health, environmental fate, green chemistry, alternatives assessment, and engineering), scientists and engineers from the petroleum industry, representatives of nongovernmental organizations with environmental

and public health expertise, and members of the public. Input from these external parties and discussion of specific issues would take place at public meetings or workshops.

Beginning in fiscal year 2017-18, OEHHA will work in consultation with the Division and the Interagency Working Group to develop a work plan and initiate the longer-term evaluation of chemicals used in WST using green chemistry principles. A full analysis will take a number of years, so recommendations will be provided in an iterative manner, with a preliminary near-term categorization of chemicals proposed for use in permit applications, followed by sequential refinement of the categorization over time as more data become available.

RECOMMENDATION 3.3

Concern about hydraulic fracturing might cause focus on indirect impacts associated with fractured wells, but concern about the impacts themselves should lead to study of wells in all types of oil and gas production, not just those that are enabled by hydraulic fracturing. Agencies with jurisdiction should evaluate impacts of concern for all oil and gas development, rather than just the portion of development enabled by well stimulation. As appropriate, many of the rules and regulations aimed at mitigating indirect impacts of hydraulic fracturing and acid stimulation should also be applied to all oil and gas wells.

**Lead agencies: Division of Oil, Gas, and Geothermal Resources
 California Air Resources Board
 State Water Resources Control Board**

This recommendation is being applied.

The Division has several [rulemakings](#) under way. These include underground gas storage regulations, underground injection control (UIC) regulations, idle well testing regulations, and oil and gas facility pipeline testing. To reduce the likelihood of gas leaks, the underground gas storage regulations set well performance standards, require detailed risk mitigation plans, and establish rigorous, prospective well testing requirements. The UIC regulations require additional project data, enhanced well mechanical integrity testing requirements, injection fluid testing and chemical analysis, seismic monitoring, and other requirements to protect groundwater from potential contamination. Idle well testing regulations provide for additional mechanical integrity testing, fluid level surveys, and ensure that wells that are no longer economically viable are properly plugged and abandoned. The pipeline testing regulations will reduce the risk of potentially dangerous and toxic gas exposures by expanding the number and type of pipelines at oil and gas production facilities that are required to undergo regular leak testing. The UIC and idle well testing regulations are being developed concurrently. Workshops on discussion drafts were held in July 2017, and the Division plans on having the regulations in place by September 2018.

CARB has approved a regulation that will reduce methane emissions from oil and gas production, processing, and storage. The regulation will require oil and gas operators to limit intentional (vented) and unintentional (leaked or fugitive) emissions from active and idle equipment and operations. The goal of the regulation is to obtain the maximum greenhouse

gas emission reductions from the sector in a technically feasible and cost-effective manner. The oil and gas operations covered under the regulation currently emit approximately two and a half million metric tons (MMT) of carbon dioxide equivalent emissions. CARB's regulation is projected to reduce those emissions by over 50 percent. The regulation is also expected to reduce both volatile organic compound (VOC) and toxic air contaminant (TAC) emissions. The regulation was approved by the Office of Administrative Law in July of 2017 and took effect October 1, 2017.

The State Water Board began implementation of an oil and gas Regional Monitoring Program on January 1, 2016, as required by Water Code section 10783, subdivision (h)(1). The monitoring is designed to protect all waters designated for any beneficial use, while prioritizing the monitoring of groundwater that is or has the potential to be a source of drinking water. Factors considered for the Regional Monitoring Program include well stimulation treatments, among other events or activities that have the potential to contaminate groundwater, such as an oil well failure. Fluids produced or introduced in the well stimulation process, including produced water ponds and UIC wells, are examined in the Regional Monitoring Program. The USGS is currently under contract with the State Water Board to implement the Regional Monitoring Program.

Additionally, the State Water Board is in the process of collaborating with the Division to ensure that aquifers are protected in accordance with the Federal Safe Drinking Water Act. This process, described in more detail below, involves the review of oil and gas enhanced oil recovery wells and waste disposal wells. Additionally, the State Water Board is in the process of updating their memorandum of agreement with the Division related to the permitting of oil and gas UIC projects. The new agreement will clarify roles and ensure that both the Division and the Board concur that underground sources of drinking water are not at risk from these projects.

RECOMMENDATION 3.4

Enact regional plans to conserve essential habitat and dispersal corridors for native species in Kern and Ventura counties. The plans should identify top-priority habitat and require restrictions on development in these regions. The plan should also define and require those practices, such as clustering multiple wells on a pad and using centralized networks of roads and pipes, which will minimize future surface disturbances. A program to set aside compensatory habitat in reserve areas when oil and gas development causes habitat loss and fragmentation should be developed and implemented.

**Lead agencies: Division of Oil, Gas, and Geothermal Resources
 Department of Fish and Wildlife**

The Division and the Department of Fish and Wildlife (CDFW) are coordinating with both Kern and Ventura counties regarding local planning that would include assessing the potential impacts of oil and gas activities on local habitat.

As Lead Agencies under the California Environmental Quality Act (CEQA), and having land use authorities, both Kern County and Ventura County review and approve permits for oil and gas activities that potentially impact biological resources in and around designated oil fields. As a Responsible Agency, the Division works to address environmental impacts to those parts of a project that it approves. These include permit approvals for oil and gas activities “down-hole,” which typically do not result in direct impacts to biological resources. As a result, there is little to no potential for significant adverse impacts to wildlife directly resulting from the Division’s down-hole well permitting activities. Additionally, the counties, along with CDFW, would have the primary responsibility to oversee compliance of the project’s mitigation measures to avoid or minimize adverse impacts to biological resources.

When the Division is the Lead Agency for oil and gas activities, the environmental analysis considers the “whole of the action.” However, there are not many of these types of projects, since the Division primarily conducts its CEQA reviews as a Responsible Agency and relies on a county’s environmental review.

The Kern Valley Floor Habitat Conservation Plan (HCP), a coordinated, multi-agency effort that includes the Division and CDFW, began in 1989 for the purpose of conserving habitat for multiple special status species and streamlining the Incidental Take Permit process for covered oil and gas activities within Kern County from the valley floor up to 2,000 feet in elevation. The HCP planning process was intermittent and paused in 2013. Two years later, Kern County amended its zoning ordinance to include oil and gas activities and prepared an Environmental Impact Report (EIR) for their Amended Zoning Ordinance for Oil and Gas Activities. Both the zoning ordinance and EIR were approved by the Board of Supervisors on November 9, 2015, and implemented on December 10, 2015.

As a result of the Amended Zoning Ordinance, Kern County has taken on new permitting requirements for oil and gas activities within the unincorporated county, which makes the county the Lead Agency under CEQA to issue permits and conduct environmental reviews for these projects. As part of Kern County’s environmental analysis, impacts from oil and gas activities on biological resources were determined, specifically identifying impacts to Special Status Species (as defined by the Endangered Species Act) on a county-wide basis.

The Division contacted Kern County in September 2016 to convey its interest in seeing the HCP process resume and participate in a support role by attending meetings, reviewing documents, and providing technical assistance. Kern County indicated its intent to resume the HCP process in the near future. Those efforts have been further stalled due to the decrease in oil prices and the associated impacts to Kern County’s budget.

In June 2017, Division staff met with Kern County to discuss the status of the HCP process. Kern County anticipates beginning work on the Natural Communities Conservation Plan/ Habitat Conservation Plan (NCCP/HCP) for the Kern County Valley Floor in late 2017/early 2018. The Division will participate when meetings are scheduled. Once the NCCP/HCP is completed, Kern County plans to develop an interactive online tool, connected to their online permitting database. A substantial portion of the initial work on the NCCP/HCP was completed when this process initially began in 2006, so Kern County believes the process can be completed in 2019.

Ventura County issues Conditional Use Permits for new projects that undergo environmental review, and oil and gas activities are covered in the county General Plan. The county does not have a Programmatic EIR that covers all oil and gas activities. According to Ventura County, biological resources and wildlife corridors are addressed in the current General Plan, therefore, an HCP is not likely in the near future. The County is in the process of updating its General Plan, and the Division will participate.

RECOMMENDATION 4.1

Agencies with jurisdiction should promptly ensure through appropriate testing that the water discharged into percolation pits does not contain hazardous amounts of chemicals related to hydraulic fracturing as well as other phases of oil and gas development. If the presence of hazardous concentrations of chemicals cannot be ruled out, they should phase out the practice of discharging produced water into percolation pits. Agencies should investigate any legacy effects of discharging produced waters into percolation pits including the potential effects of stimulation fluids.

**Lead agencies: State Water Resources Control Board
Regional Water Quality Control Boards**

The State's Regional Water Quality Control Boards (Regional Water Boards) have jurisdiction over discharges into ponds (percolation pits). In order to discharge produced water into a pond, waste discharge requirements (WDRs) issued by a Regional Water Board are required. These ponds are predominantly located in the Central Valley. Produced water ponds have also been used in other areas of the state including the Central Coast, Ventura, and greater Los Angeles.

Senate Bill 83 Section 45 (Chapter 24 of Statutes of 2015) requires that the State Water Board post on its website a status report on the regulation of oil field produced water ponds within each region by January 30, 2016, and every six months thereafter. Produced water ponds are permitted only when the local Regional Water Board determines that the discharge will not adversely impact water of current or potential future beneficial use. The report includes the total number of ponds in each region, the number of permitted and unpermitted ponds, enforcement actions, and the status of permitting the unpermitted ponds. Details on Produced Water Ponds for the Produced Water Pond Inventory Status Report are available here: http://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/announcements.shtml

The Regional Water Boards are in various phases of produced water pond inventory, review, and enforcement. For example, over the last two years, the Central Valley Regional Water Board has identified permitted and unpermitted facilities throughout its jurisdiction and performed field inspections to verify the status of ponds with WDRs and initiate inspections of ponds without WDRs.

The Central Valley Regional Water Board has adopted three general orders for WDRs for discharges related to historical and current ponds. The WDRs need to meet the water quality

objectives set by the Regional Boards. If the water is to be reused for beneficial uses, then treatment may be required to meet water quality objectives. Each WDR requires routine monitoring to ensure that the discharges are in compliance with the WDR.

For unpermitted ponds, the Regional Water Boards have issued cleanup and abatement orders (CAOs) or other enforcement orders, which lay out a time schedule for the completion of tasks including:

- Collection of information regarding the ponds, site conditions and characteristics, depth to groundwater, and quality of groundwater (using an analyte list consistent with the State Water Board's Model Criteria for Groundwater Monitoring in Areas of Well Stimulation).
- Assessment of potential or actual impacts to groundwater.
- Submittal of a Report of Waste Discharge (ROWD) or Notice of Intent.
- If necessary, submittal of an estimate of when termination of discharge will occur.

Each CAO will be in effect until the facility is issued a WDR or until the discharge ceases and any required remedial activity is completed.

To inform potential actions regarding ponds, and as part of the State Water Board's implementation of the Regional Monitoring Program required under SB 4, the State Water Board has contracted with the USGS to implement the Regional Monitoring Program to conduct scientific investigations that will serve to identify potential groundwater risk zones and will include characterizing the risk of any fluid related to oil and gas development that may migrate into waters of beneficial use, while prioritizing the monitoring of water that is (or has the potential to be) a source of drinking water, and establishing monitoring networks, to provide early warning in high risk zones.

The USGS will analyze produced water, pond, and injectate sampling (mixtures of produced waters and other waters injected into oil fields for enhanced oil recovery or waste disposal purposes) to characterize their geochemical signatures for a diverse set of chemical constituents. This effort shall be coordinated with produced water and pond sampling efforts of the Regional and State Water Boards, and other entities within the California Environmental Protection Agency (CalEPA). The intent of the produced water sampling is to augment existing efforts by putting the data in a 3D context and to provide additional gas, isotopic, and groundwater age data that can inform policy and permitting decisions.

In addition, the Department of Toxic Substances Control, in coordination with the Division, is conducting a hazardous waste characterization study on produced water and other wastes that are generated during well stimulation to determine whether any of the wastes exhibit characteristics of hazardous waste and be subject to regulation under the Hazardous Waste Control Law.

RECOMMENDATION 4.2

Evaluate the chemistry of produced water from hydraulically fractured and acid stimulated wells, and the potential consequences of that chemistry for the environment. Determine how this chemistry changes over time. Require reporting of all significant chemical use, including acids, for oil and gas development.

**Lead agencies: State Water Resources Control Board
Regional Water Quality Control Boards**

As required by California Water Code section 10783, as amended by SB 4, and detailed in the Model Criteria for Groundwater Monitoring in areas of Oil and Gas Well Stimulation (Model Criteria), the State Water Board is to implement a Regional Monitoring Program in order to protect all waters designated for any beneficial use, while prioritizing the monitoring of groundwater that is or has the potential to be a source of drinking water. Factors considered for the Regional Monitoring Program include WST, among other events or activities that have the potential to contaminate groundwater, such as an oil and gas well failure or breach. Fluids produced or introduced in the well stimulation process including, but not limited to, produced water ponds and UIC wells will be examined in the Regional Monitoring Program. The USGS is currently under contract with the State Water Board to implement the Regional Monitoring Program.

As part of the Regional Monitoring Program, the USGS will conduct studies on produced water, including produced water from wells that have undergone hydraulic fracturing and acid well stimulation. Initially, a two-pronged study of the persistence of hydraulic fracturing fluids in produced water will be conducted that will include: (1) identifying any differences in produced water chemistry in wells where hydraulic fracturing/acid well stimulation occurred in the last year, between one to five years, and over five years prior to sampling, and (2) conducting a time series sampling protocol at a limited set of production wells following hydraulic fracturing and acid well stimulation. These studies are estimated to have results reported in 2017, and 2018, respectively.

The hazardous waste characterization study being conducted by the Department of Toxic Substances Control, in addition to evaluating produced water and other well stimulation wastes for hazardous waste characteristics, will also be gathering data on radionuclides on behalf of the Department of Public Health to determine potential impacts from naturally occurring radioactive elements that may be present in produced waters.

RECOMMENDATION 4.3

Agencies of jurisdiction should clarify that produced water from hydraulically fractured wells cannot be reused for purpose such as irrigation that could negatively impact the environment, human health, wildlife or vegetation. This ban should continue until or unless testing the produced water specifically for hydraulic fracturing chemicals and breakdown products shows non-hazardous concentrations or required water treatment reduces concentrations to non-hazardous levels.

**Lead agencies: State Water Resources Control Board
 Regional Water Quality Control Boards**

The Regional Water Boards require WDRs for produced water reclamation (reuse) projects for the purpose of irrigation. These projects are predominantly located in the Central Valley. These projects do not receive produced water from wells that have been hydraulically fractured.

In January 2016, the Central Valley Regional Water Board convened a [food safety expert panel](#) to address the issues raised in Recommendation 4.3. The Central Valley Water Board encourages the reuse of produced water for irrigation, if it is deemed suitable for reuse through the WDR permitting process. In an effort to ensure that food safety is adequately considered, the Central Valley Water Board staff has convened experts in food safety to ascertain if there are any unknown risks associated with using produced water on crops, since no data is available to indicate that there is an issue with reusing produced water for irrigation.

The objective of the panel is to seek input from experts in the area of human health and safety of crops irrigated with oil field produced water. The panel's recommendations will be in the form of guidance and opinions provided in written documents that the Board will consider when developing and implementing its oil field regulatory program and orders that address the use and application of treated produced oil wastewater to irrigate crops for human consumption. The project will also identify data gaps so that future research can focus on achieving specific goals, and procuring practical outcomes.

California's San Joaquin Valley is a major oil producing area. In 2013, approximately 150 million barrels of oil (42 gallons/barrel) were produced along with nearly 2 billion barrels of water (about 250,000 acre feet). Much of this produced water is recycled for use in the oil fields during enhanced recovery efforts (steam injection and water flood). The remaining produced water is typically disposed in permitted UIC wells or surface disposal (ponds). A portion of the produced water is recycled for irrigation of crops for human consumption; as mentioned this produced water does not come from wells that have been hydraulically fractured.

Produced water is often saline because the oil-producing rocks are of marine origin. Occasionally, such as along the east side of the southern San Joaquin Valley, oil has migrated from its native marine formation to non-marine formations. In these circumstances, the produced water is relatively low in salinity and can be recycled for irrigation without significant treatment to remove salts and boron.

Produced water from the areas east and north of Bakersfield has been recycled for irrigation for about 30 years with no known impacts. There is significant interest in expanding this water

reuse practice due in part to recurring droughts and new requirements to manage groundwater sustainably. Produced water is treated to remove oil. The Regional Board is reviewing the chemical characteristics of this water and any additional chemicals used by oilfield operators that could be in the water and has assembled the food safety panel to confirm if there are unacceptable risks associated with using this water.

Cawelo Water District, North Kern Water District, Jasmin Mutual Water District, and Kern-Tulare Water District are located within the Tulare Lake Basin and receive oil field produced water. These districts use produced water to supplement imported surface water and pumped groundwater to meet irrigation needs. The districts combined can receive up to 75,000 acre feet per year of produced water. The historical average of produced water received is approximately 38,000 acre feet per year. This water is one of the significant water sources to 105,000 acres of cropland. These discharges of produced water to the districts are regulated by WDRs that conditionally allow the water to be used for irrigation and require monitoring.

The State Water Board-initiated studies outlined in the implementation of Recommendations 4.1 and 4.3 will also inform when produced water used for beneficial purposes should be treated to meet waste discharge requirements, basin plan objectives and other relevant standards, as well as inform whether future treatment of produced water may require the development of alternative treatment methods. An assessment of the availability of current treatment options and potential challenges associated with developing new types of treatment will be pursued by the State Water Board.

The hazardous waste characterization study being conducted by the Department of Toxic Substances Control, in evaluating produced water for hazardous waste characteristics, will provide additional information that can inform if or when produced water is hazardous waste, and the applicability of the Hazardous Waste Control Law.

RECOMMENDATION 4.4

In the ongoing process of reviewing, analyzing, and remediating the potential impacts of wastewater injection into protected groundwater, agencies of jurisdiction should include the possibility that stimulation chemicals may have been present in these wastewaters.

**Lead agency: Division of Oil, Gas, and Geothermal Resources
 State Water Resources Control Board**

The Division and the State Water Board have undertaken two significant efforts to protect groundwater. They are currently in the process of reviewing previously approved aquifer exemptions and all projects permitted under the UIC program.

In 1982, the US EPA delegated to the Division primary authority to enforce the federal Safe Drinking Water Act's protections for certain aquifers that meet a regulatory definition of underground sources of drinking water (USDW) with respect to the underground injection of fluids associated with oil and gas production. The Division implements these protections through its UIC program. Wells covered by the UIC program include those that inject water or steam for the purposes of enhancing oil recovery at nearby production wells, while others are

used to dispose of briny fluid known as produced water that is drawn up from the hydrocarbon reservoir by production wells and reinjected into an underground formation or zone after the hydrocarbons have been removed.

Many of the underground formations receiving fluid injection associated with oil and gas production do not meet the federal regulatory definition of a USDW and are therefore not protected under the Safe Drinking Water Act. An aquifer that would otherwise qualify as a USDW may nevertheless be exempted from protection if it is found to meet specific federal regulatory criteria. When the US EPA delegated primacy to the Division in 1982, US EPA approved aquifer exemptions for various USDWs that were then being used for oil and gas related injection.

During the 30-year history of the UIC Program, however, the Division permitted injection into some formations that were never exempted (or into areas outside the lateral boundaries of exempt aquifers). The Division identified this problem and alerted the US EPA in mid- 2014. Since then, the Division, USEPA and the State Water Board have developed a plan to address wells injecting into non-exempt aquifers, including efforts to obtain aquifer exemptions for certain qualifying formations that are not expected to serve as sources of drinking water. The wells injecting into non-exempt aquifers have been identified, categorized by type (water disposal or enhanced oil recovery), and prioritized by the relative risk the wells pose to existing water supply wells. Some wells were found to pose an immediate threat and, as a result, the Division either ordered them shut or obtained permit relinquishment. Others were shut down as of December 31, 2016. In collaboration with US EPA and the State Water Board, the Division is currently working to ensure a timely cessation of injection at a final remaining subset of wells potentially given prior approvals to inject into USDWs that are not likely to be exempted by the US EPA.

It is important to note that most of the remaining wells are injecting into known oil-bearing formations. In order for a formation to be proposed for exemption, the Division and the State Water Board must concur that the injection will not impact waters of beneficial use or waters that may potentially serve beneficial use. Once the two state agencies agree, a public hearing is held on each proposed exemption prior to sending the proposal to US EPA.

In addition to the aquifer exemption process, the Division is also conducting a statewide review of all UIC projects. UIC projects consist of one or more injection wells drilled as a part of an overall system to support oil and gas production activities. The Division has approved thousands of projects since the inception of the Division's UIC program. The Division is currently engaged in an effort to review every existing injection project in the state. This review involves examining all active injection projects to determine whether they are supported by all required documentation, and whether the project reflects appropriate protection of groundwater sources. Mechanical integrity testing of wells will also be confirmed as part of the project review.

If additional conditions or reporting requirements are identified as necessary during the review, new Project Approval Letters—which describe project-specific requirements—will be required. Under a memorandum of agreement with the Division, the Regional Water Boards have an opportunity to review all pending UIC projects in their jurisdiction before they are given final approval. In the review process, the appropriate Regional Water Board may request additional information and impose new requirements on the project. The Division cannot approve new UIC

projects or amendments to existing UIC projects until any concerns raised by the Regional Water Boards are addressed.

RECOMMENDATION 4.5

Conduct a comprehensive multi-year study to determine if there is a relationship between oil and gas-related fluid injection and any of California’s numerous earthquakes. In parallel, develop and apply protocols for monitoring, analyzing, and managing produced water injection operations to mitigate the risk of induced seismicity. Investigate whether future changes in disposal volumes or injection depth could affect potential for induced seismicity.

Lead agency: Division of Oil, Gas, and Geothermal Resources

The Department of Conservation is working with the Lawrence Berkeley National Laboratory (LBNL) to develop a comprehensive, statewide investigation of the potential for induced seismicity related to California oilfield operations. The investigation comprises the three phases of work summarized below.

Phase One is being conducted in conjunction with UC Santa Cruz and is focused on developing a methodology and appropriate databases to detect and characterize induced seismicity. The study is designed to identify correlations between wastewater injection and seismicity on a pool-by-pool basis, and to characterize the relationships of the locations, frequencies of occurrence and magnitudes of induced seismicity to net injected volume, reservoir pressure and injection depth. LBNL will further develop recommended specifications for future data reporting by operators, which can be used to conduct risk assessments and assist with permitting of new projects.

At the culmination of Phase One, a report will be produced that includes the following components:

- A review and evaluation of the injection and production data available from the Division and also injection data for UIC Class 1 wells from the USEPA. The review will include specifications for augmented databases, and for future reporting requirements for Division operators.
- A map of the minimum magnitude of complete earthquake detection and discussion of the impact of minimum magnitude on correlation analyses.
- A description of existing fault, stratigraphic and in situ stress data, and an assessment of how this data can be augmented by additional site-specific information.
- Description of the pool-scale correlation analysis methodology and results of demonstration analyses in selected oil-producing basins.

Phase Two will carry out systematic correlation analyses statewide at a set of oil pools prioritized according to criteria that include past seismicity, net injected volumes, injection pressures and depths, and proximity to faults. Modeling of selected induced seismicity

sequences identified by the correlation analyses will be carried out in an initial investigation of the mechanics of induced seismicity in specific geological settings in California.

Phase Three will consist of a comprehensive field experiment that includes monitoring of induced seismicity at a wastewater injection site selected at the end of Phase Two, and data analysis and modeling. It will characterize in detail the mechanics of induced seismicity. The results will be used to further develop and demonstrate methods of assessing site-specific seismic hazards and to develop a protocol to manage risk.

Unlike regions in the central U.S., where the natural rate of earthquake occurrence is low, distinguishing between induced and naturally occurring earthquakes in regions of high seismicity like California is particularly challenging. Investigations into the relationship of seismicity to wastewater disposal in California began only during the last two years. An initial study by Hauksson and others in 2015 found no evidence for induced earthquakes due to wastewater injection in the Los Angeles Basin. A 2015 study by Goebel and others identified four seismicity sequences possibly associated with wastewater injection in Kern County oilfields, one of which (near the Tejon oilfield in the southern San Joaquin Valley) Goebel and others investigated in more detail in a 2016 publication. While these studies are an important beginning, they are not conclusive.

Additional studies specifically examining net volume change of injected fluid, using better data that incorporates shorter-term variations in injection parameters, looking at a broader range of seismic events, and including areas near active faults are necessary to better understand induced seismicity. The LBNL study commissioned by the Department will provide a more complete and in-depth analysis of potential injection-induced seismicity using augmented databases and by applying statewide a comprehensive suite of detection and characterization techniques developed based on the latest research. The study will also investigate the mechanics of induced seismicity in California as a basis to tailor methods to assess site-specific induced seismicity hazard in the state and design a risk mitigation protocol.

RECOMMENDATION 4.6
As California moves to change disposal practices, for example, by phasing out percolation sumps or stopping injection into protected aquifers, agencies with jurisdiction should assess the consequences of modifying or increasing disposal via other methods.

**Lead agency: Division of Oil, Gas, and Geothermal Resources
 State Water Resources Control Board**

This assessment will be included in the study described in the response to Recommendation 1.1 as well as the work under way by the Central Valley Regional Water Quality Control Board described in the response to Recommendation 4.3.

RECOMMENDATION 5.1

Agencies with jurisdiction should act promptly to locate and catalog the quality of groundwater throughout the oil producing regions. Operators proposing to use hydraulic fracturing operation near protected groundwater resources should be required to provide adequate assurance that the expected fractures will not extend into these aquifers and cause contamination. If the operator cannot demonstrate the safety of the operation with reasonable assurance, agencies with jurisdiction should either deny the permit, or develop protocols for increased monitoring, operational control, reporting and preparedness.

**Lead agency: State Water Resources Control Board
Division of Oil, Gas, and Geothermal Resources**

SB 4 requires the State Water Board to establish and implement a comprehensive regulatory groundwater monitoring and oversight program for WST activities in areas of oil and gas operations.

Water Code section 10783 requires the State Water Board, on or before January 1, 2016, to implement regional groundwater monitoring based on the Model Criteria, to prioritize monitoring of groundwater that is or has the potential to be a source of drinking water, and to protect all waters designated for any beneficial use.

Water Code section 10783, subdivision (h)(2), provides for well owners and operators to develop and implement area-specific groundwater monitoring programs based upon the State Water Board's Model Criteria in the absence of the implementation of a regional groundwater monitoring program.

The State Water Board developed and adopted Model Criteria as part of the added requirements by SB 4 to the Water Code, section 10783. The Model Criteria sets the standards for groundwater monitoring in areas of oil and gas well stimulation to assess potential impacts from well stimulations on groundwater resources. The Model Criteria consists of two groundwater monitoring activities: area-specific monitoring conducted by operators and the Regional Groundwater Monitoring Program conducted by the State Water Board.

Area-specific monitoring requires operators to obtain either a State Water Board approved groundwater monitoring plan or an exclusion from groundwater monitoring before a WST can be conducted. As part of a groundwater monitoring plan, operators are required to submit depth and location of oil and gas wells proposed to be stimulated, including the Axial Dimensional Stimulation Area (ADSA). The ADSA is the estimated maximum length, width, height, and azimuth of the area(s) affected by a WST. Division regulations require operators to analyze and review all geologic features, including known faults (active or inactive), within five times the ADSA to ensure the geologic and hydrologic isolation of the oil and gas formation during and following well stimulation. The operator is required to provide an evaluation of whether any geologic features or other wells may act as a migration pathway for injected fluids or displaced formation fluids and assess the risk that the well stimulation treatment will communicate with the geologic feature. This information is used by the State Water Boards to help design the groundwater monitoring network.

In cases of well failure or breach, operators are required to notify the State Water Board and comply with applicable Division well stimulation regulations and any orders issued by the Regional Water Boards directing them to assess and remediate any impacts to groundwater.

The Regional Monitoring Program examines where and to what degree groundwater quality may be at potential risk from past or future oil and gas well stimulation and associated production activities. These activities include discharge to produced-water ponds and underground injection for production and disposal purposes, with related well integrity issues. The Regional Monitoring Program also is to establish baseline water quality information for all fields and prioritize sampling in areas where groundwater is or may be an underground source of drinking water. The USGS is currently under contract with the State Water Board to implement the Regional Monitoring Program

RECOMMENDATION 5.2

Within a few years of the new regulations going into effect, DOGGR should conduct or commission an assessment of the regulatory requirements for existing wells near stimulation operations and their effectiveness in protecting groundwater with less than 10,000 TDS from well leakage. This assessment should include comparison of field observations from hydraulic fracturing sites with theoretical calculations for stimulation area or well pressure that are required in the regulations.

Lead agency: Division of Oil, Gas, and Geothermal Resources

As indicated in the response to Recommendation 3.3, the Division is committed to implementing this recommendation. The WST permitting program under the permanent regulations went in effect on July 1, 2015. The first permits were issued in September 2016, and the Division is now in the initial stages of reevaluating the regulations based on experience implementing the program and new information as it becomes available.

RECOMMENDATION 6.1

Conduct rigorous market-informed life-cycle analyses of emissions impacts of different types of oil and gas production to better understand GHG impacts of well stimulation.

Lead agency: California Air Resources Board

Current research suggests that greenhouse gas (GHG) emissions from petroleum production vary depending on several factors. Facilities may have low GHG emissions per unit of energy produced if they do not rely on energy intensive production methods (e.g. steam injection) and apply effective controls on emissions sources. In contrast, some crude oil sources may have higher GHG emissions if they rely on energy-intensive production methods. The variability in crude oil production emissions is partly due to the use of energy-intensive secondary and tertiary recovery technologies. Another major factor is variation in the

control of venting, flaring, and fugitive emissions. Other emissions arise from increased pumping and separation work associated with increased fluid handling in depleted oil fields (i.e., fields with a high water-oil ratio) and transport emissions.

The Oil Production Greenhouse Gas Emissions Estimator (OPGEE) is an engineering-based life cycle assessment (LCA) tool that estimates GHG emissions from the production, processing, and transport of crude petroleum. The system boundary of OPGEE extends from initial exploration to the refinery gate. CARB has used OPGEE since 2012 as a rigorous tool to assess the differences between crude oil sources. The model uses detailed data, where available, to provide maximum accuracy and flexibility, and was designed to be readily extended to include additional functionality.

Under a recently completed contract with Stanford University, OPGEE was updated to include a module that can be used to estimate GHG emissions associated with hydraulic fracturing. The revised model was released publicly for stakeholder feedback. Consistent with the recommendation, CARB will conduct analyses to assess and compare the GHG signatures of different types of oil production in California. This comparison will include assessing GHG emissions for the following types of production:

- Light crude production from hydraulically fractured reservoirs
- Light crude production from conventionally produced reservoirs
- Heavy crude from thermally enhanced reservoirs.

Emissions estimates derived using OPGEEv2.0 will be used to inform future CARB programs and regulations such as the Low Carbon Fuel Standard.

RECOMMENDATION 6.2

Apply reduced-air-emission completion technologies to production wells, including stimulated wells, to limit direct emissions of air pollutants, as planned. Reassess opportunities for emission controls in general oil and gas operations to limit emissions. Improve specificity of inventories to allow better understanding of oil and gas emissions sources. Conduct studies to improve our understanding of toxics concentrations near stimulated and un-stimulated wells.

Lead agency: California Air Resources Board

As mentioned above, the Air Resources Board has developed an oil and gas methane mitigation regulation titled, Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities. The regulation, which took effect October 1, 2017 is designed to apply methane standards and require control measures to be implemented for onshore and offshore crude oil or natural gas production, processing, and storage; natural gas underground storage; natural gas gathering and boosting stations; and natural gas transmission compressor stations. Reductions

in methane emissions, as well as co-benefits of reductions in associated toxic air contaminants

(TAC), are expected as a result of the regulation. Although the regulation does not technically require reduced-air-emissions completion technologies as specified in the federal EPA New Source Performance Standards, local air district regulations that have been in place for decades to reduce VOC emissions have resulted in most oil fields in California already being well controlled. Produced fluids, including well stimulation fluids, are typically routed to separators and tanks that have vapor control already on them. Accordingly, the CARB's regulation will apply control requirements to the remaining uncontrolled operations and will result in comparable benefits.

The CARB also plans to collect data from oil and gas operations through air sampling associated with the SB 4 well stimulation permit process and through a research contract currently being prepared.

To develop a more complete understanding of the air emissions present in the vicinity of wells undergoing well stimulation, CARB staff has developed, in cooperation with the Division, an Air Sampling and Analysis Plan (Plan) to include as guidance for an air monitoring permit requirement for selected operations. Operators will implement the Plan and provide data to CARB staff. This permit requirement is intended to result in data representative of a variety of operations, geographic areas, meteorological conditions, and well stimulation chemical additive formulations. Operations will be selected based on these, and other, parameters. The Plan will require operators to obtain air samples before and during a well stimulation operation and analyze the samples for GHG, volatile organic carbon (VOC) and toxic air contaminant (TAC) emissions. The Plan will serve as a screening analysis to inform CARB and local air district future efforts and to provide data to inform future permit review.

Finally, CARB has entered into a research contract related to air emissions associated with oil and gas operations. The contract to perform percolation pond testing to determine the presence and quantity of well stimulation chemicals is titled, Measurement of Wastewater Emissions from Crude Oil and Natural Gas Operations (Pond study). The Pond study will consider well stimulation but will be broader in scope and measure GHG, VOC, and TAC emissions from wastewater used in California's crude oil and natural gas operations. Wastewater, also known as produced water, is generated as a result of crude oil and natural gas production, and may be disposed of in open-air ponds that allow the water to evaporate and percolate, or may be discharged for agriculture use or other purposes. Several of California's air districts currently regulate wastewater for VOCs. This information will be used to develop emissions estimates and provide information that may be used to develop informed policy decisions. Under this contract, the study of percolation pond emissions testing is expected to be completed by June 2019.

RECOMMENDATION 6.3

Conduct studies in California to assess public health as a function of proximity to all oil and gas development, not just stimulated wells, and develop policies such as science-based surface setbacks, to limit exposures.

**Lead agency: California Air Resources Board
Office of Environmental Health Hazard Assessment**

To develop a more complete understanding of the air emissions present in the vicinity of wells undergoing well stimulation, CARB staff has developed, in cooperation with the Division, an Air Sampling and Analysis Plan (Plan) to include as guidance for an air monitoring permit requirement for selected operations. Operators will implement the Plan and provide data to CARB. This permit requirement is intended to result in data representative of a variety of operations, geographic areas, meteorological conditions, and well stimulation chemical additive formulations. Operations will be selected based on these, and other, parameters. The Plan will require operators to obtain air samples before and during a well stimulation operation and analyze the samples for GHG, VOC, and TAC emissions. The Plan will provide data to inform future permit review and will serve as a screening analysis to inform the future efforts of CARB and local air agencies to determine air concentrations in the vicinity of oil and gas operations and potential health impacts to nearby populations.

The CARB is also initiating an air monitoring study in neighborhoods around oil and gas facilities such as production fields and storage facilities, particularly in disadvantaged or highly impacted communities. The study will include short-term (three to four months per site) community monitoring near oil and gas activities, source testing as indicated to identify potential areas of elevated risk, and health risk assessment as indicated. Air monitoring conducted in specific communities of concern and the data generated from the effort will help CARB and others assess potential community exposure to pollutants of concern, provide the public with information they need to make informed decisions, and assess the effectiveness of onsite mitigation activities at reducing levels of pollution in the community. The study is expected to begin by mid-2018.

The Office of Environmental Health Hazard Assessment (OEHHA) will assist CARB staff in site selection. To inform the selection, in addition to other considerations, OEHHA will use its CalEnviroScreen screening tool, which characterizes pollution burdens in communities across the state as well as socioeconomic and public health conditions that can increase a population's vulnerability to the adverse health effects of pollution.

OEHHA will assist CARB staff in choosing chemicals to be monitored, and will use the monitoring results to assess health risks in communities near oil and gas facilities and other industrial sources.

RECOMMENDATION 6.4

Conduct California-based studies focused on silica and volatile organic compounds exposures to workers engaged in hydraulic fracturing-enabled oil and gas development based on National Institute for Occupational Safety and Health occupational health findings and protocols.

Lead Agency: Division of Occupational Safety and Health (Cal/OSHA)

On September 16, 2016, the Occupational Safety and Health Standards Board adopted regulations addressing respirable crystalline silica similar to those promulgated by the U.S. Department of Labor, Occupational Safety and Health Administration on March 25, 2016. The regulation lowers the permissible exposure limit (PEL) for crystalline silica to 50 micrograms per cubic meter of air, averaged over an eight-hour shift. It also requires employers to use engineering controls and work practices to limit worker exposure, provide respiratory protection when controls do not limit exposures to the PEL, limit access to high exposure areas, train workers, and provide medical exams to workers exposed to silica more than 30 days per year.

The new PEL for silica became effective October 17, 2016, for all employers. The remaining requirements of the silica regulation became effective on June 23, 2017, for construction operations and will become effective June 23, 2018, for general industry (all non-construction operations).

For hydraulic fracturing operations in the oil and gas industry, the effective dates of the silica regulation are as follows:

1. PEL – October 17, 2016.
2. The requirement to use engineering controls to reduce silica exposures commences on June 23, 2021.
3. The requirements to provide medical surveillance to employees commences on June 23, 2018 for employees exposed above the PEL for more than 30 days per year. For employees exposed to less than the PEL, but greater than the action level of 25 micrograms per cubic meter of air for more than 30 days per year, the requirements to provide medical surveillance commences on June 23, 2020.
4. All other provisions of the silica regulation commence on June 23, 2018. The Standards Board has committed their staff to begin advisory committee meetings for a second round of silica rulemaking, which will be specific to construction operations and will not affect petroleum drilling and production.

Cal/OSHA convenes advisory committee meetings on a regular basis to consider updates to PELs for airborne contaminants through a review of the scientific and medical literature and feasibility data. Volatile organic compounds are among the airborne contaminants that are being reviewed by the advisory committee for possible rulemaking to reduce exposure limits. Please see the Cal/OSHA Health Effects Advisory Committee website for information on the

specific chemicals under review or being considered for review:
<http://www.dir.ca.gov/dosh/doshreg/5155Meetings.html>.

RECOMMENDATION 7.1

DOGGR should digitize paper records and organize all datasets in databases that facilitate searches and quantitative analysis. DOGGR should also institute and publish data quality assurance practices, and institute enforcement measures to ensure accuracy of reporting. When a few years reporting data are available, a study should assess the value, completeness and consistency of reporting requirements for hydraulic fracturing and acid treatments operations and as necessary, revise or expand reporting requirements. The quality and completeness of the data collected by SCAQMD provides a good example of the completeness and availability the state should seek to emulate. The Department of Conservation should reevaluate well stimulation data trends after 3 to 5 years of reporting.

Lead agency: Division of Oil, Gas, and Geothermal Resources

The Division has historically collected data from operators and managed well records using an essentially paper-based system. Regulations did not require operators to submit data in any uniform format, and the records that are submitted are frequently hand written, missing data, or sent staggered in multiple mailings. The Division further lacked a uniform business process to manage and store data and documents, leading each District to develop its own system independently. Overall, this has made it difficult for precise records to be located when needed, and led to major gaps in existing records.

In order to improve data management practices, the Division is in the process of implementing a new well management system. This system, from the Ground Water Protection Council (GWPC), is named WellSTAR (Well Statewide Tracking And Reporting) and is powered by the Risk Based Data Management System from GWPC. This system is currently being utilized by 23 other states. This project is being split up into four separate releases with the first release in August 2017. Subsequent releases will follow with a project end date of the fall of 2019. The three major goals of this project are to improve the accuracy and ease of data management; increase transparency of Division data by allowing efficient, searchable access for the public; and develop an e-permitting functionality for operators to submit required documents.

The Division is currently working with contractors and the California Department of Technology to develop the system and coordinating all district staff to create a uniform business practice. In addition to developing the system to intake new data from permits and drilling activities, the Division will need to migrate legacy data comprised of more than 100 years of records.

While the Division has made data and records available to the public in several formats, none of these methods were very useful or efficient. The Annual Report of the State Oil and Gas Supervisor provides annual data about the oil and gas industry, but there is no formal procedure to answer inquiries. Well records have been available online since 2004, yet these

records, often consisting of hundreds pages of data, were in PDF format and not able to be searched. WellSTAR will address these issues by creating a comprehensive, efficient, online source that is easy to access and available to the public. In addition to WellSTAR, the enactment of SB 4 required the Division to provide more information to the public regarding chemicals used during well stimulation. The Division met this requirement with the creation of an interim public database, which works in conjunction with the existing Well Finder application to provide web-based GIS search capability for the public. SB 1281 requires regular water data reporting from the Division and, though statute does not require it, that data has also been made available online.

Finally, the Division is working to incorporate an e-permitting function with WellSTAR. Though many operators do submit permits and other documents digitally, there is no uniform file format and paper applications are still received. By developing an e-permitting function, documents will automatically be in a file format that the database can process. Files will be reviewed and available to the public online more quickly, and staff will have more time to perform other regulatory duties. This feature is anticipated to be complete by late 2018.

RECOMMENDATION 7.2

Conduct integrated research in California to answer key questions about the environmental, health, and seismic impacts of oil and gas production enabled by well stimulation. Integrated research studies should include regional hydrologic characterization and field studies related to surface and groundwater protection, induced seismicity, ecological conditions, as well as air and health effects.

The agencies of the working group have consulted and are collaborating (where their expertise is pertinent) in the development and execution of the various studies described above.

In addition, many of the studies contracted for with third-party institutions (e.g., CCST, the National Labs, and USGS) include authors of the CCST study as part of the research/assessment teams.

RECOMMENDATION 7.3

The State should establish a standing scientific advisory committee to support decisions on the regulations of oil and gas development.

At this point, the agencies are not pursuing a standing advisory committee. However, the agencies regularly consult with the leading scientific experts at the USGS, Lawrence Berkeley, Lawrence Livermore, and Sandia National Labs, and other leading research organizations.