

Economic Impacts of Oil Production Tied to Well Stimulation Treatments in California

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Executive Summary

Oil and gas exploration and production (E&P) is a major economic force in California, particularly in the San Joaquin Valley. In contrast to public statements that have been made, our analysis concludes that approximately one-sixth of current statewide oil and gas production is attributable to wells that have received well stimulation treatments (WSTs), primarily hydraulic fracturing. Oil producers in this state have utilized these treatments for over one-half century, predominantly in Kern County, to access oil and natural gas resources by improving the permeability of certain geologic formations. Comparatively, most of these WSTs conducted in Kern County can be characterized as “conventional hydraulic fracturing” and use only a small fraction of the water and additives used in other states like Colorado, New Mexico, North Dakota, Oklahoma, and Texas. Under SB 4, passed in 2013, WSTs in California are subject to transparency, reporting, and monitoring requirements that are the most stringent in the nation. Since November 2019, all well stimulation permit applications are also subject to review by experts at the Lawrence Livermore National Laboratory (LLNL) to ensure that permits issued meet all state standards for public health, safety, and environmental protection.

Despite these factors, activist groups have sought a statewide ban on WSTs, and have sought to equate these operations with WST activity conducted in other states. Governor Newsom announced on September that he was seeking legislation in 2021 that would ban WST treatments effective no later than 2024. In view of these developments, Californians for Energy Independence commissioned Capitol Matrix Consulting to estimate the economic and revenue-related contributions of oil production tied to WST in California. The estimates in this summary are based on sources and methods discussed in the body of the report and in Appendix 1. Estimates of the economic impacts of the full California E&P industry are shown in Appendix 2.

WSTs Account for 17 Percent of the California Oil and Gas E&P Industry

Based on feedback from oil producers and our review of public data on oil and gas wells, we estimate that about 17 percent of all oil produced in 2019 was from wells that have been subject to WSTs at some point in the life of the well. (See box on page 13 for a comparison of our 17 percent estimate to the Governor’s 2 percent estimate.) This translates into about 26.5 million barrels of oil during the year. Over 90 percent of the treated wells are in the San Joaquin Valley and are mostly wells in relatively low-permeability reservoirs within large oil fields in western Kern County.

As indicated in Figure Exec-1 (next page) we estimate that employment related to drilling and production linked to treated wells was 7,520 jobs in 2019 (about 15 percent of the E&P industry-wide total), consisting of 3,000 industry jobs and 4,520 jobs from multiplier effects. State and local taxes and other revenues related to these wells totaled \$260 million. This total includes \$160 million levied directly on oil producers as well as \$100 million related to multiplier effects.

Figure Exec-1
Economic and Revenue Activity Related to WST in California

Measure	Amount in 2019
Annual production	26.5 million barrels
Employment	7,520 jobs, including 3,000 industry jobs (direct effect), and 4,520 in other sectors (multiplier effect).
State and local taxes and other revenues	\$260 million, including \$160 million paid by companies and royalty owners (direct effect), and \$100 million paid by employees and supplying industries (multiplier effect).

Most production and jobs related to WSTs in Kern County

Well over 90 percent of statewide oil production tied to treated wells occurs in Kern County (“County”). The WST-related operations support 6,900 jobs, \$595 million in labor income, and \$230 million in revenues to state and local governments in the county. The average wage paid by the oil and gas production and support industries in the County is \$105,000 per year, well over twice the average wage for the remaining private sector industries (\$45,000 per year).

WSTs in California

WSTs are used only in certain oil and natural gas reservoirs depending on the geology of the formations. Because of the state’s geological characteristics, well stimulation is not used as frequently in California as it is in most other oil and gas-producing states, like Colorado, New Mexico, North Dakota, Oklahoma, and Texas. Specifically, of the 240 active oil and gas fields in California only 5 have a significant amount of WST activity – all of them located in Kern County. WSTs usually occur once in the 40-plus-year life of a well at the time it is being completed.¹ The purpose of these treatments is to access oil and gas resources by increasing the permeability of certain formations surrounding the well bore, thereby improving the flow of oil and natural gas into the well.

There are three primary types of WSTs used in the worldwide E&P industry. These are defined in Senate Bill 4 (SB 4), and their use is dictated by the geologic properties of the oil and gas formation. The first is *hydraulic fracturing (HF)*, which involves pumping a mixture of water and small amounts of chemical additives and proppants (usually sand) out through perforations in the well casing under pressure to create small fractures in the surrounding rock formation. The second is *acid matrix stimulation*, which involves the low-pressure injection of a low volume of an acid solution to dissolve minerals in natural fractures in the surrounding rock and make the oil and gas reservoir more permeable. The third is *acid fracturing*, which involves the higher-pressure injection of an acid solution to fracture the rock and etch the walls of the fractures.

¹ WSTs also occasionally take place in an existing well when it is recompleted to restore its productivity or to access and produce from a different oil and gas formation from the same well.

Hydraulic fracturing accounts for over 95 percent of WSTs in California. Very little acid matrix stimulation and almost no acid fracturing takes place in this state.

WSTs taking place in California are significantly smaller in scale and involve less intensive use of resources than other states such as Colorado, New Mexico, North Dakota, Oklahoma, and Texas. The treatments in California generally require fewer stages, use much less water and energy, and involve wells of less depth than in other states. Further, the area subject to stimulation is much smaller than the high-volume horizontal operations found in other states.

Recent contributions depressed by permitting delays and moratoriums

Our estimates are based on oil production, jobs, and income totals for 2019, the most recent year for which we have annual data. These estimates understate the true long-term average contribution of WSTs to California oil production. This is because drilling and completion of wells requiring WSTs have been depressed during the past 5 years due to a lengthening of the review process for HF permits, a 9-month moratorium on new WST permits that commenced in July 2019, and other regulatory delays from the multiple state agencies that are involved in WST permitting and oversight. These and related regulatory practices have added significant costs to both drilling and hydraulic fracturing relative to other states, further depressing investment in California.

Covid-19 impacts have also been severe but global industry expected to recover in 2022 or 2023

The Covid-19 pandemic has had multiple negative effects on the global oil and gas E&P industry. These effects have clearly been felt in California, where partial-year data for 2020 indicates that the industry is experiencing major losses in production and jobs. Industry experts anticipate that global and U.S. markets will continue to struggle in 2021 and possibly into 2022, but then embark on a recovery as global economies open up, demand for petroleum products improves, and inventories fall.

However, California's participation in global recovery will be affected by state regulatory policies

The important question for California is whether investment in renewed oil and gas production will return to California once global market conditions improve. The question applies to the overall industry in California, and especially to the portion related to WSTs.

Given the ample amount of oil and gas reserves remaining in California, the potential certainly exists for renewed oil and gas investment, production and jobs in California. However, this potential will not be realized if recent permitting delays and moratoriums are extended, and certainly will not be realized if a ban on WSTs is enacted. Our simulations (described in the body of the report) indicate that, relative to a baseline that assumes a moderate number of WST permits are issued each year, a WST ban starting in 2024 would result in **a loss of over 8,000 jobs within**

the next decade. Many of the jobs lost would be high-paying and with benefits, and most of them would be in Kern County.

E&P production and job losses would have effects on downstream industries and consumers

Beyond the direct losses in the E&P industry, production losses resulting from a hydraulic fracturing ban would put at risk several thousands of workers in Kern County that are involved in the transportation of crude oil from the oilfields to California's refineries in Los Angeles County and the Bay Area.

The loss of production would also reduce a stable source of crude oil inputs that California refiners use to optimize refined petroleum production. The loss in California-sourced crude oil would need to be replaced by additional waterborne imports of oil from the Middle East and South America – countries that do not apply California's stringent safety, labor, and environmental standards. The increased dependence on foreign oil would raise costs to refiners, expose the state to supply disruptions, and ultimately lead to higher retail fuel prices at the pump. These increases would act like a regressive tax, disproportionately affecting low- and moderate-income households in the state.

Introduction

After more than 100 years of production, the oil and gas E&P industry remains an important part of California's economy. It is an important source of high-paying middle-class jobs that otherwise have been disappearing from California as manufacturing jobs migrate to lower-cost regions in the U.S. or are shipped offshore. Furthermore, oil producers make large purchases from other industries, creating strong multiplier effects on the California economy.

The E&P industry also provides an extremely important measure of energy security and reliability to the state, supplying nearly 30 percent of the crude oil consumed in California.² A significant share of current oil production is from wells that have received well stimulation treatments (WSTs), mostly hydraulic fracturing, at some point during the life of the well.

Oil and gas drilling activity is highly regulated in California. Over two-dozen federal and state agencies regulate production in California, and WSTs are specifically regulated by the California Geologic Energy Management Division (CalGEM), the State Water Resources Control Board, Regional Water Quality Control Boards, the California Air Resources Board, Regional Air Quality Management, the Air Pollution Control Districts, and the California Department of Toxic Substances Control. In addition, SB-4 required two comprehensive studies of WSTs in California, including the California Council on Science and Technology's report titled "An Independent Scientific Assessment of Well Stimulation in California," (issued in 2015 and updated in part in 2016) and CalGEM's Environmental Impact Report (EIR) titled "Analysis of Oil and Gas Well Stimulation Treatments in California" prepared in 2015 under the California Environmental Quality Act (CEQA).

Despite the fact that California oil production and WSTs are subject to the most intense environmental reviews in the world, environmental activists have been pushing state and local bans on oil and gas production and WSTs.³ In September of 2020, Governor Newsom called for legislation banning new WSTs effective no later than 2024. Although a statewide ban on all production would have devastating effects, even a focused ban on WSTs (the focus of this report) would have substantial adverse economic impacts on the state. Given these concerns, Californians for Energy Independence commissioned Capitol Matrix Consulting to estimate the economic and revenue-related contributions of oil production tied to WSTs in California.

² Source of consumption estimates: U.S. Energy Information Agency, State Profile and Energy Estimates, California, 2018.
https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_fuel/html/fuel_use_pa.html&sid=US&sid=CA

³ In 2014, voters in Santa Barbara rejected a measure prohibiting "high intensity" oil and gas operations such as WSTs and cyclic steam injection. In 2016, voters in Monterey County approved an initiative that was promoted as a ban on fracturing, but in fact went much further, essentially banning all oil production in the County. Key provisions of the initiative were overturned by a court ruling in the following year. Voters in San Luis Obispo County rejected a similar measure in November 2018.

Background

California is the seventh largest oil producer in the nation. As indicated in Figure 1, statewide production during 2019 totaled 156 million barrels, placing it between Colorado and Wyoming.⁴

Figure 1
Top Oil Producing States
Annual Production, 2019

State	Annual Barrels (Millions)
Texas	1,851
North Dakota	518
New Mexico	329
Oklahoma	212
Alaska	170
Colorado	190
California	156
Wyoming	102

We estimate that California’s full E&P industry was responsible for \$19 billion in annual economic output, 50,100 jobs and \$1.5 billion in state and local revenues in 2019 when direct and multiplier effects are taken into account. The data sources, assumptions and methods underlying our estimates for the full E&P industry, as well as for the segment related to WSTs are outlined in Appendix 1. Our estimates for the full E&P industry are shown in Appendix 2.

Types of WSTs

Well stimulation treatments are used to access oil and natural gas resources by increasing the permeability of certain tight, low-permeability formations to improve the flow of oil and gas into the well. These treatments normally take place just after a well has been drilled and the casing (along with surrounding cement) and liner have

⁴ Source: U.S. Energy Information Agency, Petroleum and other Liquids, Crude Oil Production. https://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbbl_a.htm. California also produces about 181 billion cubic feet (Bcf) of natural gas, which is about 30 million barrels of oil equivalent (BOE). (Source: 2018 Annual Report of California Oil and Gas Production Statistics. Department of Conservation, Division of Oil, Gas, and Geothermal Resources. October 2019.) Nearly 90 percent of the total is “associated gas” that is extracted as a byproduct of oil production, and a significant portion of it is used to meet producers’ energy needs. The non-associated gas produced in California does not come from wells that are hydraulically fractured, and hence would not be impacted by a ban on fracturing. For this reason, our subsequent discussion focuses on oil production in the State. It should be noted, however, that non-associated gas production in the Rocky Mountains states like Colorado and Wyoming, which supplies over one-third of California’s natural gas imports, depends on hydraulic fracturing.

been placed in the wellbore.⁵ There are three primary types of WSTs typically used worldwide by oil producers:

- **Hydraulic fracturing.** This treatment involves pumping a mixture of primarily water, a small amount of chemical additives and proppants (usually sand) under high pressure out through perforations in the well casing to create small fractures in the surrounding rock formation. After the fracturing is completed, the water and additives are recovered from the well, while the proppants remain in the reservoir to prevent the fractures from closing.
- **Acid matrix stimulation.** This treatment involves a lower volume of an acid solution in water being pumped into the well at relatively low pressure for the purpose of dissolving minerals in natural fractures in the surrounding rock and making the oil and gas reservoir more permeable.
- **Acid fracturing.** This treatment involves the high-pressure injection of an acidic solution into a well to fracture the rock and etch the walls of the fractures.

Most WSTs in California involve hydraulic fracturing – in fact, all but one well completed using WSTs since the enhanced SB 4 reporting period began in July 2015 have been hydraulically fractured. One was acid matrix stimulation, and no wells received acid fracturing during the period.⁶

Geographic Distribution of WSTs

The great majority of wells receiving WSTs are located in the San Joaquin Valley, and specifically in Kern County. As indicated in Figure 2, a total of 1,193 wells have been completed with WSTs since mid-2015. All of them are in Kern County, and 85 percent were in the Belridge South or Belridge North fields.⁷ Other fields with smaller, though significant amounts of hydraulic fracturing during this period were Lost Hills, Elk Hills, and McKittrick.

⁵ WSTs also occasionally take place in an existing well when it is recompleted to restore its productivity or to access and produce a different oil and gas formation from the same well.

⁶ Wellstar Database, California Department of Conservation, Geologic Energy Management Division, Wellstar database. <https://wellstar-public.conservaion.ca.gov/>.

⁷ Ibid.

Figure 2
Wells Completed Using Well Stimulation Treatments:
July 1, 2015 through December 31, 2019

Oilfield	Permits Issued
Belridge South	984
Belridge North	39
Lost Hills	118
Elk Hills	13
McKittrick	4
Other/Not Identified	35
Total	1,193

WSTs in California Versus Other States

The majority of WST activity currently taking place in California, mostly comprising conventional hydraulic fracturing, are significantly smaller in scale and involve less intensive use of resources as compared to well stimulation occurring in other states including Colorado, New Mexico, North Dakota, Oklahoma, and Texas. The hydraulic fracturing in these mid-continent regions is associated with deep shale wells that access oil and natural gas at or near *source rock* where it was originally formed. In contrast, hydraulic fracturing in California today is primarily associated with reservoirs located in tight, low-permeability sand or shale formations supplied by oil that has migrated from its source rock.

Typical wells completed with WSTs in Kern County are less than 4,000 feet deep and are drilled vertically. This is in sharp contrast to horizontal wells in North Dakota, New Mexico and Texas, which sometimes have total lengths exceeding 20,000 feet (including horizontal components that are 5,000 to 10,000 feet long). Hydraulic fracturing and other WST jobs in California generally require fewer stages, use much less water and energy, and involve wells of less depth than in other states.⁸ Further, the area subject to stimulation is much smaller than the high-volume horizontal operations found in other states.

California Regulation of WSTs

In 2013, Governor Brown signed SB 4 (Chapter 313, 2014), which included stringent transparency, reporting and monitoring requirements for WSTs. According to the California Department of Conservation, these provisions provided important safeguards for public health and safety and the environment related to WSTs, and

⁸ In its 2015 report on well stimulation treatments in California, the California Council on Science and Technology reported that a hydraulic fracturing operation in California consumes on average 530 cubic meters, which is about 3 percent of the 16,000 cubic meters per well used in horizontal wells in the Eagle Ford Formation in Texas. Based on this and related findings, CCST concluded that “the practices and impacts of hydraulic fracturing in other states do not directly apply to current hydraulic fracturing in California, (see Chapter 3, “An Independent Scientific Assessment of Well Stimulation in California, Volume 2,” CCST, July 2015).

complemented California’s comprehensive oil & gas regulatory system in place before the enactment of SB 4 that already included among the “strongest well construction and operations standards in the nation.”⁹ Key provisions of SB 4 are shown in Figure 3. The regulations associated with SB 4 were finalized on July 1, 2015.

Figure 3
California Well Stimulation Treatment Requirements Under SB 4¹⁰

• Operators to obtain a permit from CalGEM for each WST. Application to include information on well location, type, depth; anticipated water source, volume and disposal method; a spill contingency; chemicals used; and the fracture design.
• Extensive engineering and geologic review and well integrity evaluations to ensure that WSTs are confined to the intended geologic zone.
• Neighbors to receive advance notification of projects and can request that their water quality be tested to establish a baseline.
• Comprehensive post-stimulation reports that include the amount of water used and the source of that water.
• Seismic monitoring to take place during well stimulation operations. If a magnitude 2.7 or larger earthquake occurs nearby, the project must halt while an evaluation is conducted by CalGEM and the California Geological Survey.
• California Air Resources Board to develop air monitoring criteria. State Water Board or appropriate regional board to develop and implement ground water monitoring. California Department of Toxic Substances Control to review the storage and management of WST fluids.
• California Air Resources Board to develop air monitoring criteria. State Water Board or appropriate regional board to develop and implement ground water monitoring. California Department of Toxic Substances Control to review the storage and management of WST fluids.
• An independent scientific study on well stimulation treatments (completed by the California Council on Science and Technology in 2015) and California Environmental Quality Act review (for which the California Department of Conservation completed an Environmental Impact Report in 2015).

In November 2019, CalGEM requested the Lawrence Livermore National Laboratory (LLNL) to conduct a scientific review of all pending well stimulation permit applications to ensure that permits issued meet all state standards for public health, safety, and environmental protection. Experts at the LLNL were also asked to review

⁹ “SB 4 Well Stimulation Treatment Regulations, Final Statement of Reasons.” California Department of Conservation, <https://www.conservation.ca.gov/index/Documents/12-30-14%20Final%20Statement%20of%20Reasons%20for%20SB%204%20WST%20Regulations.pdf>

¹⁰ Source: California Senate Rules Committee, Office of Senate Floor Analysis. SB 4 (Pavley, et al), amended 9/6/2013.

http://leginfo.legislature.ca.gov/faces/billAnalysisClient.xhtml?bill_id=201320140SB4

Economic Impacts of Oil Production Tied to WSTs

CalGEM's permit review process, along with operators' application materials and CalGEM's engineering and geologic analyses processes for consistency with regulatory requirements. The LLNL review found that the permitting process met statutory and regulatory requirements, but it did note areas in which CalGEMs review process could be improved. In response to the LLNL findings, CalGEM now requires all operators to provide an Axial Dimensional Stimulation Area Narrative Report for each oilfield and fracture interval which must be validated by LLNL and conform to the new CalGEM process. These additional steps ensure even greater production of public health.

Economic and Revenue Contributions of WSTs

In this section we estimate the present and potential future economic and revenue contributions of the portion of the E&P industry that is related to wells that have received WSTs. The estimates include (1) the *direct* effects on employment and income within the E&P industry, and (2) the *multiplier* effects on businesses in other industry sectors of the economy. More specifically, the multiplier effects include impacts on businesses that provide goods and services to oil producers and their field contractors (indirect effects), as well as impacts on businesses that provide goods and services to the households of employees the oil producers and field contractors (induced effects). The multiplier effects are based on the IMPLAN input-output model of the California economy (see Appendix 2 for a description of the model).

2019 Impacts

Production. We estimate that about 26.5 million barrels of oil produced in 2019 were attributable to wells that were completed with WSTs (mostly hydraulic fracturing) – either in 2019 or any time in the past over the life of the well. This represents 17 percent of the 156 million barrels of total production from all wells (including both those that have been treated and those that have not) during the year. Our estimate is based on feedback from producers as well as a review of public well data. Our estimate is less than the estimate contained in the 2015 study prepared in response to SB 4 by the California Council on Science and Technology (CCST). In that report, the authors indicated that, based on a detailed review of well records from 2003 through 2013, WSTs account for approximately 20 percent of oil and gas production.¹¹ While some of the discrepancy may be because the CCST estimate was based on a sample of wells, we believe the larger reason is the major decline in WSTs that has occurred over the past 5 years, due to regulatory delays and moratoriums (discussed in more detail below).

Economic and tax impacts. As indicated in Figure 4, operations involving WSTs supported an estimated 7,520 jobs in 2019. This includes 3,000 industry jobs plus 4,520 jobs in other industries that supply goods and services to the oil the producers and the households of their employees (multiplier effects). State and local revenues related to hydraulically fractured wells are estimated to be \$260 million in 2019-20.

¹¹ “Well Stimulation in California, Chapter 3, Historical and Current Application of Well Stimulation Technology in California.” California Council on Science and Technology, https://ccst.us/projects/hydraulic_fracturing_public/SB4.php.) The estimates were based CCST’s review of records from a sample of wells drilled between 2002 and 2013.

Figure 4
Economic Impact of Oil Production from Wells that Received WSTs

Output (Billions of Dollars)	Contributions in 2019
Direct	\$2.0
Multiplier	1.0
Total	\$3.0
Gross State Product (Billions of Dollars)	
Direct	\$1.2
Multiplier	0.6
Total	\$1.8
Employment	
Direct	3,000
Multiplier	4,520
Total	7,520
Labor Income (Millions of Dollars)	
Direct	\$360
Multiplier	330
Total	\$690
State & Local Taxes and Other Revenues (Millions of Dollars)	
Direct	\$160
Multiplier	100
Total	\$260

Impacts on Kern County. Over 90 percent of statewide production tied to hydraulically fractured wells occurs in Kern County. As shown in Figure 5, we estimate that operations tied to these wells directly and indirectly supported \$1.7 billion in gross regional product during 2019 – about 4 percent of the Kern County private sector total.¹² The operations support 6,900 jobs, \$595 million in labor income, and \$230 million in revenues to state and local governments. The latter includes \$100 million in property taxes, sales taxes and fees paid to local entities within the county. The average wage paid by the oil and gas production and support industries in the County is \$105,000 per year, well over twice the average wage for the remaining private sector industries (\$45,000 per year).¹³

¹² Source of Kern County Gross Regional Product is “Current Dollar Gross Domestic Product by County: California.” Federal Reserve Bank of St. Louis, Economic Research. <https://fred.stlouisfed.org/release/tables?rid=397&eid=1055532#snid=>.

¹³ Source: Quarterly Census of Employment and Wages, California Employment Development Department (EDD). <https://www.labormarketinfo.edd.ca.gov/qcew/qcew-select.asp>.

Figure 5
Contribution of Oil Production Tied to Wells that Received WSTs
Kern County (2019)

Measure	Amount in 2019 (Direct & Multiplier Effects)
Jobs	6,900
Labor income	\$595 million
Gross regional product	\$1.7 billion
State and local taxes and fees	\$230 million (\$100 million paid to local governments)

A continued slowdown or ban on WSTs would have an extremely harsh impacts on Kern County. These include thousands of lost jobs and hundreds of millions in lost wages, as well as reductions in tens of millions in revenues to local governments. which already faces major budget challenges due to the economic fallout of the Covid-19 pandemic. A substantial portion of the local revenues put at risk by a WST ban are property and sales taxes, which are general-purpose revenues used to support high-priority programs such as public safety, parks, and social services.

The Governor's 2 Percent Estimate of Production from Hydraulically Fractured Wells Vastly Understates the True Impact of a Hydraulic Fracturing Ban

On September 23, 2020, Governor Newsom announced that he was seeking legislation in 2021 that ends new hydraulic fracturing (HF) permits by 2024. As part of his announcement, the Governor stated that, while the legislation is important symbolically, it will have only a limited impact on California oil production, since hydraulically fractured wells account for only 2 percent of total oil output in the state. This estimate, which is based on calculations by California Geologic Energy Management Division (CalGEM) within the California Department of Conservation, is well below both our estimate of 17 percent and the 20 percent estimate included in the CCST study commissioned by the California Natural Resources Agency in 2015.

Why the Governor's Estimate is So Low

The low estimate cited by the Governor is due to the inconsistent way in which the administration compares production from HF wells to total production from all wells. For the former, it strictly included only production from wells drilled and completed during the past five years (subsequent to July 1, 2015, the beginning of the SB 4 enhanced reporting period). For the latter, the administration includes production from all wells, regardless of when they were completed. The exclusion of production of older wells from the HF totals (but not the overall totals) is an important omission, since the great majority of current production is from wells completed prior to mid-2015. In fact, we estimate that current production from WST wells completed since mid-2015 accounts for just 14 percent of the total production from all wells that have received treatments at some point in the past.

More specifically, as the accompanying table shows, the Governor’s estimate includes the 3.7 million barrels of oil from HF wells completed since July 1, 2015 (the beginning of the SB 4 enhanced reporting period) but excludes the 22.8 million barrels of oil produced by HF wells completed prior to that date. Its estimate of total production, however, includes both the 25.3 million barrels from wells completed since July 1, 2015 and the 130.8 million barrels from wells completed prior to that date – for a total production from all wells of 156.1 million barrels. When the production from older HF wells is included, total HF related production is 26.5 million barrels, which is 17 percent of the 156.1 million barrels in total production.

The Administration’s Skewed Estimate of the Contribution of WSTs (Millions of Barrels Produced in 2019)

When Wells Were Drilled/Completed	Production of HF Wells		Production of All Wells (CalGEM Data)	% of Total Production Attributable to HF	
	Actual/Est.*	Governor		Actual	Governor
Prior to July 1, 2015	22.8	0	130.8	17.4%	0
July 1, 2015 or Later	3.7	3.7	25.3	14.6%	N/A
Total	26.5	3.7	156.1	17.0%	2.4%

*Post July 1, 2015 based on estimates prepared by Catalyst Environmental Solutions (a diversified environmental consulting firm), using public data from CalGEM. Pre July 1, 2015 total is based on the difference between total production (from our survey of producers) and the post July 1, 2015 totals estimated by Catalyst.

If the intention of the administration is to just look at the contribution of treated wells completed since July 1, 2015, then the appropriate comparison should be total production from all wells completed since the same date. Using this narrower time frame for both WST-related production and total production, the share of production attributable to WSTs is 14.6 percent.¹⁴

Why the Governor’s Understatement Matters

The Governor’s understatement of the contribution of hydraulic fracturing has major implications for the economic impacts of a ban on WSTs. While a 2 percent production loss would imply relatively modest impacts, a loss of 17 percent of statewide production would clearly have substantial economic effects, in terms of additional reliance on imported oil and the eventual loss of thousands of California jobs, the great majority of which would occur in Kern County where over 90 percent of WSTs occur. Any state analysis that relies on the inconsistent methodology used by CalGEM would be similarly flawed.

¹⁴ It is not surprising that the share of hydraulically fractured-related production is lower for wells completed since mid-2015 (14.6%) as compared to all wells (17.0%). This reflects the slowdown in new fracking permits that have been issued subsequent to passage of SB 4.

Impact of Recent State Policies on WST Contributions

Our estimates are based on oil production, jobs, and income totals for 2019, the most recent year for which we have annual data. These estimates understate the true long-term average contribution of HF to California oil production for two principal reasons: First, drilling and completion of wells requiring hydraulic fracturing have been depressed during the past 5 years due to several factors. Following enactment of SB 4, there was a nearly 2-year delay in WST authorizations as new permitting and monitoring processes were being developed through regulations. Once the regulations were in place, the pace of review and approval remained depressed due to lengthy reviews by multiple agencies, a 9-month moratorium starting July 2019, and a requirement that all WST permit applications submitted beginning in November 2019 be reviewed by independent experts from the Lawrence Livermore National Laboratory.

The combined effect of these policies is that permits that take days to obtain from a single agency in most other oil and gas producing states have taken months or even years in California to process through multiple agencies and levels of review under SB 4.

In addition to the direct impact of permitting delays, California regulations, including SB 4, have added significant costs to both drilling and hydraulic fracturing relative to other states. This has further depressed drilling activity in California, as investments have flowed to other regions. Some companies that perform hydraulic fracturing have relocated their equipment and crews out of California or even stopped doing business here.

The impact of these regulatory delays can be seen when current WST-related production is compared to the 2015 CCST estimate of 20 percent cited above, which was based on well records through 2013 – prior to the implementation of the state’s comprehensive SB 4 regulatory and permitting program and its repeated slowdowns and delays in issuing WST permits.

Another indication is found by comparing recent activity to actual and projected levels of WSTs included in the Kern County 2015 Draft Environmental Impact Report (EIR) on proposed revisions to its zoning ordinance related to oil and gas permitting. The report indicated that 936 wells in Kern County were subjected to well stimulation treatments in 2012, the year preceding the passage of SB 4. (Because Kern County accounts for between 90 and 95 percent of statewide WST, we estimate the statewide total in that year was approximately 1,000 treatments.) The EIR also indicated that the levels and distribution of SB 4 regulated activity in the County would likely be similar in future years – and in fact it increased the totals to 1,200 per year for purposes of its future emissions projections. In reality, however, WST treatments statewide averaged just 237 wells per year between July 2015 and December 2019 – one quarter the rate projected for Kern County in its 2015 EIR.

To be sure, oil prices and market conditions during the post-SB4 reporting period were less favorable than anticipated by the 2015 Kern County EIR. However, the decline in California is still in stark contrast to the increases in WSTs that took place in other oil-producing states between 2015 and 2019.

Covid-19 Impacts on the California E&P Industry

As noted above, our estimates are based on oil production, jobs, and income totals for 2019, the most recent year for which we have annual data. Partial year data for 2020 indicates that the Covid-19 pandemic has had a serious impact on the California oil and gas industry, including the segment related to WSTs. Total production from all wells declined 10 percent during the first 10 months of 2020 relative to the same period of 2019, and employment in the overall California E&P industry was down 17 percent in the first half of 2020 relative to the first half of 2019.

The declines were consistent with a major reduction in the global E&P industry, which faced a plunge in demand for transportation fuels following the Covid-19 outbreak in early 2020. A production and price war between Saudi Arabia and Russia added to the supply glut and temporarily drove benchmark prices into negative territory. Prices partially rebounded in the second half of the year as production fell, economies partially opened up, and inventories declined. However, producers remain under intense pressure as of early 2021 due to ongoing weakness in global demand for transportation fuels.

Global E&P Industry will Recover but Outlook for California is Uncertain

Industry experts anticipate that global and U.S. markets will continue to struggle in 2021 and possibly into 2022, but then embark on a recovery as vaccinations are distributed, the pandemic fades, global economies open up, travel increases, and the demand for petroleum products improves.

A key question, however, is whether the California oil and gas industry will share in this rebound. That is, will investment return to California once global market conditions improve, or will it flow to other U.S. and global regions.

California continues to have a vast amount of recoverable oil and gas reserves, a significant amount of which is associated with the limited number of fields where hydraulic fracturing is required. Thus, the potential certainly exists for a meaningful rebound in investment, production and jobs once market conditions improve. However, California is in competition for investment capital with other regions in the U.S. and around the world. With respect to WSTs, the high costs and uncertainty created by the state's unending rounds of permitting reviews and delays, if continued, will place California at a decided disadvantage in this competition, thereby causing investment capital to flow elsewhere, and investment, production, and jobs in this state to languish. A ban on WSTs in 2024 would, of course, accelerate these reductions.

Estimated impact of California regulatory policies. To provide an indication of what is at stake in terms of jobs and projection, we developed three alternative scenarios involving different rates of permitting approvals over the next decade. All three scenarios are based on improving global market conditions starting in 2022, and assume that, under these more favorable market conditions, producers seek permits for 500 WSTs per year. This amount is about double the recent rate of WST

Economic Impacts of Oil Production Tied to WSTs

permit approvals, but it is only one-half the rate of approvals that occurred immediately before SB 4 was enacted. For purposes of these comparisons, we use the same assumptions about new well production rates and other technical and financial factors in all three scenarios. The only difference between the alternatives is the number of WST permits that approved each year. Specifically:

- The first alternative assumes that producers are able to obtain authorizations for all of the 500 WSTs they are seeking each year.
- The second alternative assumes that producers continue to receive authorizations at a pace of 250 wells per year – near the depressed rate that occurred between July 1, 2015 and December 31, 2019.
- The third alternative assumes that the number of WST permits authorized average 250 wells per year through 2023, then decline to zero in 2024 and beyond as the Governor’s proposed WST ban is approved by the Legislature.

Figure 6 shows production and jobs in 2019, 2025 and 2031 under the three alternatives. It shows that if 500 WSTs are approved annually, production would rise modestly 26.8 million barrels by 2025, and further to 28.6 million barrels by 2031. Jobs associated with drilling and operations of wells receiving WSTs would likewise increase from 7,520 in 2019 to 9,900 by 2025, and 10,200 by 2030.

Figure 6
Future California Production and Jobs Under
Alternative WST Permitting Assumptions

	<u>2019</u>	<u>2025</u>	<u>2031</u>
500 WSTs Approved Per Year			
Oil Production (Million Barrels)	26.5	26.8	28.6
Jobs	7,520	9,900	10,200
250 WST's Approved Per Year			
Production (Barrels of Oil)	26.5	22.0	19.8
Jobs	7,520	6,800	6,450
250 WSTs Approved Per Year; Ban in 2024			
Production (Barrels of Oil)	26.5	19.6	10.4
Jobs	7,520	3,100	1,700

Figure 6 also shows, however, that a continuation of the recent sluggish pace of WST approvals would result in a continued decline in production attributable to treated wells. Specifically, if WST permit approvals average 250 per year, production would fall from 26.5 million barrels in 2019 to 22 million barrels in 2025 and 19.8 million in 2031. The associated number of jobs would fall from 7,520 in 2019 to 6,800 and 6,450 by 2031.

Economic Impacts of Oil Production Tied to WSTs

Finally, if WST permits are issued at the recent rate of 250 wells per year through 2023, then are banned altogether in 2024, production attributable to WSTs would fall sharply – from 26.5 million barrels in 2019 to 19.6 million barrels in 2025, and to just 10.4 million in 2031 – as declining production from wells completed prior to 2024 is no longer replaced. Jobs tied to WSTs would fall sharply as new drilling ceases – from 7,520 in 2020 to 3,100 in 2025, and to 1,700 by 2031.

In short, a ban on WSTs would put over 17 million barrels of crude oil production and 8,500 in potential jobs at risk within a decade. Most of the industry related jobs lost because of a ban would be high paying, and most would be located in Kern County. Even the continuation of current burdensome regulatory policies will have serious negative effects on California, resulting in a loss of 3,750 potential jobs within a decade.

Other Effects of a WST Ban

The above estimates focus on the impacts of WST related production on the E&P industry and its suppliers. However, a ban on WSTs would also have notable effects in other areas of the economy. For example:

- **Mid-stream and downstream industries.** In California, there are over 30,000 employees in mid-stream and downstream industries related to the distribution and refining of crude oil.¹⁵ These industries include crude oil pipeline construction and transportation, petroleum bulk stations and terminals, petroleum merchant wholesalers and refineries. Many employees in these industries would face job disruptions if WSTs were banned and California subsequently lost 17 percent of its domestic oil production. The impact would be felt most acutely by the several thousand workers involved in the shipment of crude oil from Kern County (where most WST-related production occurs) to refineries in Northern and Southern California.¹⁶
- **Energy security and oil prices.** California currently supplies about 30 percent of the crude oil needed to meet California's demand for petroleum products. The loss of some or all of the 26.5 million barrels currently attributable to WSTs will make the state substantially more dependent on imported oil. Because California's petroleum market is disconnected from the other lower-48 states¹⁷ and production in Alaska has been declining, the increased imports will need to come from sources in the Middle East and South America that do not apply California's stringent safety, labor, and environmental standards. (Replacement of the associated natural gas that results from restrictions on WSTs would need to be replaced through increased imports from mid-continent sources that use hydraulic fracturing.) Additional reliance on remote foreign sources would result in higher costs to refiners, greater risk of supply, increased international competition, and increased congestion through California ports, and increased international competition. These factors will ultimately lead to higher retail prices at the pump and negative impacts on California's consumers and businesses.

¹⁵ Mid-stream and downstream job estimates based on EDD's Quarterly Census of Employment and Wages (QCEW). <https://www.labormarketinfo.edd.ca.gov/qcew/qcew-select.asp>.

¹⁶ This includes about 3,800 jobs located in Kern County related to oil and gas pipeline construction, crude oil transportation, and refining. In addition, a significant portion of the approximately 3,000 jobs in oil and gas pipeline construction and transportation industries in Los Angeles County are related to transportation of crude oil from Kern County to the Southern California refineries and thus would also be affected. (Source: EDD, Quarterly Census of Employment and Wages.)

¹⁷ There are no crude oil pipelines between the mid-continent and California, and high costs, as well as safety and environmental concerns, are barriers to significant increases in rail shipments of crude oil into the state.

- **Value of oil fields.** We estimate the total economic value of producing oil and reserves related to treated wells is about \$4 billion.¹⁸ This does not include the well-over one million in currently undeveloped mineral acres held by individuals and businesses in areas likely requiring WSTs to develop. Any loss in value of these resources due to a ban on WSTs could represent a major liability to the state if mineral rights owners and producers were to prevail in “takings” lawsuits.¹⁹ At a minimum, the state would incur substantial legal expenses in defending against such lawsuits,²⁰ and if the plaintiffs were to prevail, the state’s exposure could be dramatically larger.

¹⁸ The value of these reserves is based on the present discounted value of after-tax cash flows (i.e. annual revenues minus operational and investment costs) generated from all future extraction of oil from reserves accessed by wells that have been subjected to WSTs. For purposes of this estimate, we used an inflation adjusted discount rate of 10 percent, and assumed that per-barrel cash flows (in constant dollars) will average \$10 per barrel in 2021, rising to \$25 per barrel in 2025 and subsequent years.

¹⁹ Under the “takings” theory, a state ban on access to mineral rights or production of minerals could result in the government “taking” a valuable asset owned by producers and other mineral rights owners. As compensation, the State would be required to pay the affected individuals and entities an amount equal to the present value of the lost profits from the oil and gas that would no longer be recovered from oil and gas fields in the State. In December 2017, the Monterey County Superior Court ruled that the 2016 Monterey County Measure Z was substantially preempted by State law, and, if applied, would constitute an unlawful taking of the property of numerous mineral rights owners. The Court did not rule on a provision of the measure restricting WSTs, finding the issue was not ripe for decision because WSTs were not being used or proposed for use in Monterey County.

²⁰ As an indication of potential litigation costs, in May 2018 Monterey County dropped its appeal of the December 2017 Superior Court ruling overturning a substantial portion of Measure Z, citing the potential for “millions of dollars in attorney fees and costs, potentially tens of millions of dollars.” <http://www.co.monterey.ca.us/Home/Components/News/News/1421/1336>

Conclusion

WSTs are responsible for approximately 17 percent of the oil production, jobs, income, and state and local revenues in California. The great majority of these contributions is in Kern County, an area that is otherwise experiencing high unemployment, below-average household incomes, and significant fiscal challenges relating to shortfalls in its County budget. WSTs also boost employment in mid-stream and downstream industries – such as pipeline construction and transportation, and refining – that are involved in moving crude oil from Kern County to refiners in Los Angeles County and the San Francisco Bay Area. These contributions are threatened by a continuation of state regulatory policies that have depressed WSTs and contributed to declines in oil production in this state over the past five years. A continuation of recent policies, or an outright ban on WSTs will significantly diminish production and jobs contributions from the E&P industry, with 90 percent of the impact occurring in Kern County. A ban would also make California more dependent on foreign sources of crude oil – much of it produced in regions with less strict safety, labor and environmental standards. The heightened dependence on remote foreign oil sources would raise imports and make California more susceptible to supply disruptions and higher petroleum prices in the future.

Appendix 1 – Methodology and Assumptions Behind Our Forecasts

In this appendix we discuss the data sources, methods, and assumptions behind the estimates shown in this report.

Data Sources. Our estimates are based on information available as of early 2021 regarding crude oil production, the percentage of production that is attributable to wells that have received WSTs, employment, wage payments, annual costs of production, taxes, fees, royalty payments, and other cost and revenue measures related to the E&P industry.

We developed this information from a combination of data from public sources and feedback from oil producers. Examples of public data include:

- Company expenditure data from SEC 10(k) annual filings, which we used to develop estimates of production costs and capital expenditures.
- Well production and well stimulation treatments data from CalGEM, which we used as a basis for our estimates of production decline curves for individual wells (used in our outyear projections under different alternatives).
- Crude oil price data – both history and projections - from the EIA.
- Industry specific employment and wage data from the California Employment Development Department’s Quarterly Census of Employment and Wages.

We also reviewed County data on property tax payments, well drilling fees, and other local revenue sources related to the E&P industry.

Methodology. Based on these data sources, we estimated output, employment, wages and taxes directly attributable to the full E&P industry. We then estimated multiplier impacts on supplying industries using the IMPLAN input-output model of the California economy (described in box below).

A key input to our estimate of multiplier effects is the magnitude of expenditures for operations and investment. We assume average expenditures of \$22 per barrel (including administrative overhead) for well operations and \$17 per barrel for capital expenditures in 2019. We allocate those expenditures to spending on labor, raw materials, energy, and equipment. We also assume that 80 percent of overall expenditures go to employees and business contractors located within California (and thus have impacts on California sales, employment, and wage total), and the remaining 20 percent will go to businesses located outside the state. Most of the 20 percent going outside the state is related to capital expenditures for equipment, which is primarily manufactured in other states. We then estimated indirect and induced effects of these expenditures based on the IMPLAN input-output model.

After developing estimates for the full E&P industry, we then apportioned production, expenditures, employment, and wages to the WST segment of the E&P industry primarily based on its share of total production. As indicated in the body of the report, we estimate that about 17 percent of total production is attributable to the WST segment, but that a slightly lower 15 percent of jobs and income are related to the WST segment. The lower share of jobs and income relative to production mainly reflects the non-apportionment of certain producer overhead operations and the lower cost-per-barrel of production in the San Joaquin Valley relative to coastal regions (as evidenced by data in public 10(k) financial reports for companies with operations in this state).

To estimate future production under varying levels of WSTs per year, we developed a spreadsheet model that translates assumptions about annual drilling and completions into annual production based on production decline rates for newly completed wells, which we derived from a review of existing well records. We developed employment estimates associated with new production by first translating new production into new annual costs (based on per-barrel expenditure assumptions discussed above) and translating additional expenditures into employment based on the IMPLAN input output model.

IMPLAN Input-Output Model

IMPLAN is an input-output modeling system that enables users to calculate the direct, indirect, and induced effects of output and/or spending in one industry on other industries located within a geographical region (national, state, county, metropolitan statistical area, or zip code). IMPLAN is widely used by academic institutions, federal, state, and local government agencies, and private companies for economic impact analyses. The model is based on benchmark U.S. input-output accounts produced by the U.S. Bureau of Economic Analysis (BEA). These accounts describe commodity inputs that are used by each industry to produce its output, the commodities produced by each industry, and the use of commodities by final consumers. When combined with other industry tables describing employment per unit of output, the system can be used to measure the impacts of changing outputs in one industry on employment requirements in that industry as well as other supplying industries.

The relationships in the national accounts are then modified by IMPLAN for each local region to take into account such factors as the relative size of the region's various industrial sectors. Based on these inter-industry tables, IMPLAN calculates a total requirements table, which estimates the full impacts (including multiplier effects) of a given change in output in one industry on all other industries in the economy.

Appendix 2 – Full Industry Impacts

The following table shows our estimates of the full oil and gas E&P industry's economic and fiscal impacts in California.

Economic Impact of the Full Oil and Gas Exploration and Production Industry on the California Economy

Output (\$ Billions)	Contribution in 2019
Direct	\$11.8
Multiplier	7.3
Total	\$19.1
Gross State Product (\$ Billions)	
Direct	\$7.3
Multiplier	4.3
Total	\$11.6
Employment	
Direct	17,830
Multiplier	32,270
Total	50,100
Labor Income (\$ Billions)	
Direct	\$2.1
Multiplier	2.3
Total	\$4.4
State & Local Taxes and Other Revenues (\$ Millions)	
Direct	\$880
Multiplier	570
Total	\$1,450
Production agreements and royalties to state & local governments	\$100
Grand Total	\$1,550