WELL STIMULATION TREATMENT ANNUAL REPORT

PROGRAM ASSESSMENT

Reporting Period: January 1, 2019 to December 31, 2019

Prepared Pursuant to Senate Bill 4 (Ch. 313, Stats. of 2013)

June 2021

Gavin Newsom, *Governor, State of California*
David Shabazian, *Director, Department of Conservation*
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MESSAGE FROM THE STATE OIL AND GAS SUPERVISOR

Dear California State Legislators,

It's my pleasure to present the California Geologic Energy Management (CalGEM) Division's 2019 annual well stimulation treatment (WST) legislative report. This report is submitted in response to the legislative report requirements of Senate Bill 4 (SB 4, Pavley, Ch. 313, Statutes of 2013) regarding all WSTs performed in California.

This is the fifth annual report issued since CalGEM's implementation of the WST program in 2015. As with the previous reports, it provides a summary of critical data regarding WST activities to the California Legislature and to the general public. Given increased interest in the use of WST in California, this report provides key information and data regarding the current utilization of WST.

During the current 2019 reporting period, 219 WSTs were performed with a total of 1,238 distinct stages stimulated. CalGEM reported 85 out of 219 well stimulations were witnessed by CalGEM field engineers, with 33 chemical spot checks performed. The reduced number of witnessed events was due to the reprioritization of district field staff to other ongoing major events. There were no casing integrity losses or emergency responses due to spills or releases associated with WSTs.

As in the previous year, 2019 WSTs were limited geographically to four mature oil fields in western Kern County. All WSTs were associated with oil production, not natural gas. The average fracture height, length, depth to top zones remained consistent with previous years reported.

Since the implementation of new permitting and disclosure requirements for well stimulation in 2015, the number of stimulations has been below 250 per year. Since the permitting program went into full effect, the number of permits issues has been

relatively steady, with 225 permits issued in 2017; 226 permits issued in 2018; and 213 permits issued in 2019. Since operators have 12 months from the permit issuance date to conduct the well stimulation, the number of stimulations performed during a calendar year do not align one-for-one with the number of permits issued. All the well stimulations conducted in 2019 were conducted by Aera Energy, Berry Petroleum, and California Resources Corporation, Elk Hills. These were the only oil and gas operators performing well stimulation during this reporting period.

I also want to highlight key recent efforts that commenced or predominantly took place after the reporting period for this report (calendar year 2019) – and I look forward to sharing more details about these efforts and their impact in future reports.

Beginning in late 2019, the California Geologic Energy Management (CalGEM) Division implemented major policy and programmatic changes, including a renewed mission that prioritizes protecting public health, safety, and the environment in its oversight of the oil, natural gas, and geothermal industries, while working to help California achieve its climate change and clean energy goals. To that end, CalGEM has put in place the strongest Well Stimulation (hydraulic fracturing) regulatory regime in the country; the state has completed a top to bottom audit of the Underground Injection Control and Well Stimulation programs and CalGEM has instituted major changes in response; and CalGEM has implemented a moratorium on high pressure cyclic steam injection until the researchers at Lawrence Livermore National Laboratory can determine whether the practice can be done safely. Significantly, CalGEM is also developing a major new health and safety rule to protect vulnerable communities from the impacts of oil and gas extraction.

As mentioned above, an independent audit of the permitting processes for WST and Underground Injection Control (UIC) was conducted by the California Department of Finance (DOF), Office of Audits and Evaluations and released in November 2020. The audit was focused on the permit process compliance with state regulations and policies and on strengthening operational processes and procedures. The audit's findings pertaining to well stimulation activities identified the need to improve program documentation. CalGEM issued a corrective action plan in response to the audit January 2021.

In parallel with the audit, CalGEM engaged experts from the Lawrence Livermore National Laboratory (LLNL) to conduct a third-party scientific review of pending WST permit and UIC project applications. This scientific review, which assesses the

methodology and completeness of each proposed permit application, informs the CalGEM's evaluation of the permit's compliance with the state's technical standards for public health, safety and environmental protection. To ensure the proposed permits comply with California law, the experts at the LLNL are tasked with assessing CalGEM's permit review process and evaluating the completeness of operators' application materials and CalGEM's engineering and geologic analyses. CalGEM will continue to engage LLNL on WST permitting, as appropriate.

The DOF audit can be found here:
https://esd.dof.ca.gov/reports/report.html
The findings to date from the technical review by the LLNL can be found at:
https://www.conservation.ca.gov/calgem/Pages/Well-Stim-National-Lab-Scientific-Review.aspx

Uduak-Joe Ntuk is the 17th California State Oil and Gas Supervisor responsible for managing the California Geologic Energy Management (CalGEM) Division. He was appointed by Governor Newsom in October 2019. Ntuk directs a statewide regulatory, technical, and field operations organization designed to emphasize the safe development of oil and natural gas conservation, which includes: protecting public health and safety, environmental quality, and the reduction and mitigation of greenhouse gas emissions associated with the development of hydrocarbon and geothermal resources in a manner that meets the energy needs of the state. He also serves as a Governor's representative to the Interstate Oil and Gas Compact Commission and as a governing board member of the Baldwin Hills Conservancy.

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ACRONYMS & ABBREVIATIONS

ADSA	Axial Dimensional Stimulation Area expressed as maximum length, width, height, and azimuth of the areas of well stimulation
BBLS	Barrels. This is the standard unit of measure for liquid volume in the oil and gas industry. For conversion to gallons or acre-feet: 1 barrel = 42 U.S. gallons 325,851 U.S. gallons = 1 acre-foot 7,758 barrels = 1 acre-foot
CalGEM	California Geologic Energy Management Division
CAS	Chemical Abstract Service
CCR	California Code of Regulations
District	An administrative regional CalGEM office
LLC	Limited Liability Corporation
mg/L	milligrams per liter
NOD	Notice of Deficiency
NOV	Notice of Violation
pCi/L	picocuries per liter
PRC	Public Resources Code
SB 4	California State Senate Bill 4 (Pavley, Ch. 313, Statutes of 2013)
TVD	True Vertical Depth
µg/L	micrograms per liter
UIC	Underground Injection Control
WST	Well Stimulation Treatment

ABOUT THE CALIFORNIA GEOLOGIC ENERGY MANAGEMENT DIVISION

The California Geologic Energy Management Division (CalGEM) prioritizes the protection of public health, safety, and the environment in its oversight of the oil, natural gas, and geothermal operations in California. To do that, CalGEM uses science and sound engineering practices to regulate the drilling, operation, and permanent closure of energy resource wells. CalGEM also regulates certain pipelines and facilities associated with production and injection. These regulatory duties include witnessing tests, inspections, and operations.

When CalGEM was established in 1915 (then known as the Division of Oil and Gas), the initial focus of regulation was the protection of oil and gas resources in the State from production practices that could harm the ultimate level of hydrocarbon recovery. Early CalGEM regulations included well spacing requirements and authority to limit production rates. However, those regulations and the focus of CalGEM have evolved and come to include the protection of public health, safety, and the environment.

CalGEM has grown significantly since it was established in 1915 and has taken major steps to ensure it will be able to handle challenges in a manner consistent with public expectations for a modern, efficient, collaborative, and science-driven regulatory agency.

In 2019, the mission of CalGEM changed to include protecting public health and safety, environmental quality, and the reduction and mitigation of greenhouse gas emissions associated with the development of hydrocarbon and geothermal resources in a manner that meets the energy needs of the state.

CalGEM Districts

CalGEM operates out of four districts to best serve the needs of the State: Northern, Coastal, Inland, and Southern. Each district has its own offices where staff are available to assist the public and stakeholders. For more information about CalGEM, visit our website at: https://www.conservation.ca.gov/CalGEM

EXECUTIVE SUMMARY

This annual report satisfies the legislative report requirements of Senate Bill 4 (SB 4, Pavley, Ch. 313, Statutes of 2013) regarding all well stimulation treatments (WSTs) performed in California. The reporting period spans from January 1, 2019, through December 31, 2019, per Public Resources Code (PRC) section 3215(c).

As defined in PRC section 3157(a), "Well stimulation treatment" means a treatment of a well designed to enhance oil and gas production or recovery by increasing the permeability of the formation. Well stimulation is a short term and non-continual process for the purposes of opening and stimulating channels for the flow of hydrocarbons. WSTs include, but are not limited to, hydraulic fracturing, acid fracturing, and acid matrix stimulation.

The following are key facts from this report:

- During the reporting period, 219 WSTs were performed with a total of 1,238 distinct stages stimulated.
- WSTs were limited geographically to four mature oil fields in western Kern County.
- All WSTs were associated with oil production, not natural gas.
- The average fracture height for all stimulated stages was 117 feet; the maximum fracture height was 376 feet.
- The average fracture length for all stimulated stages was 90 feet; the maximum fracture length was 408 feet.
- The average depth for the top of all WST zones was 1,779 feet; the average depth for the bottom of all WST zones was 2,553 feet.
- All recovered WST fluids, including produced water, were injected into Class II injection wells, which are regulated separately under CalGEM's UIC program.
- There were no requests for water sampling by surface owners or tenants.
- There were no acid matrix or acid fracture well stimulations conducted.
- 85 out of 219 well stimulations were witnessed by CalGEM field engineers; 33 chemical spot checks were performed.
- There were no casing integrity loss or emergency responses due to spills or releases associated to WSTs.
- There were no requests from the operators for confidential well status or trade secret protection of stimulation fluid additives.

INTRODUCTION

Objective & Scope of Report

The objective of this report is to provide aggregated information to the California Legislature and public regarding WSTs in California. Per PRC section 3215(c), the report covers well stimulation and related activities performed in California from January 1, 2019, through December 31, 2019.

PRC section 3215(c) requires that this report address:

1. Aggregated data detailing the disposition of any produced water from wells that have undergone WSTs.
2. Aggregated data describing the formations where wells have received WSTs, including the range of safety factors used and fracture zone lengths.
3. The number of emergency responses to a spill or release associated with a WST.
4. Aggregated data detailing the number of times trade secret information was not provided to the public, by county and company, in the preceding year.
5. Data detailing the loss of well and well casing integrity in the preceding year for wells that have undergone WST. For comparative purposes, data detailing the loss of well and well casing integrity in the preceding year for all wells shall also be provided. The cause of each well and well casing failure, if known, shall also be provided.
6. The number of spot check inspections conducted pursuant to PRC section 3160(l), including the number of inspections where the composition of well stimulation fluids were verified and the results of those inspections.
7. The number of WSTs witnessed by CalGEM.
8. The number of enforcement actions associated with WSTs, including, but not limited to, notices of deficiency, notices of violation, civil or criminal enforcement actions, and any penalties assessed.

PRC section 3215(c) also calls for inclusion of aggregated data of all the information required to be reported by the district, county, and operator pursuant to PRC section 3160.

WST data presented in this report are derived from operator disclosures (post-WST job reports) submitted to CalGEM per the requirements stated in PRC section 3160(b)(2). Operators have one year from the date of the WST permit to begin stimulation, and 60

days from the completion of the well stimulation to submit the WST disclosure form to CalGEM (PRC sections 3160(d)(4) and 3160(g)).

Contact Information

For more information about WST, visit:
https://www.conservation.ca.gov/calgem/Pages/WST.aspx

For questions regarding the content of this report, contact DOC's Public Affairs Office at pao@conservation.ca.gov.

WELL STIMULATION IN CALIFORNIA

1. Well Stimulation Base Fluids

PRC section 3160(b)(2)(D): The total volume of base fluid used during the well stimulation treatment, and the identification of whether the base fluid is water suitable for irrigation or domestic purposes, water not suitable for irrigation or domestic purposes, or a fluid other than water.

PRC section 3160(b)(2)(E): The source, volume, and specific composition and disposition of all water, including, but not limited to, all water used as base fluid during the well stimulation treatment and recovered from the well following the well stimulation treatment that is not otherwise reported as produced water pursuant to Section 3227. Any repeated reuse of treated or untreated water for well stimulation treatments and well stimulation treatment-related activities shall be identified.

1.1 Water Usage (Base Fluid)

This section discusses the sources, volumes, and suitability for domestic or irrigation purposes of water used to make up WST fluids. All WSTs permitted by CalGEM and performed by operators during this reporting period exclusively used water as a base fluid. Although nitrogen and hydrocarbons have been used as base fluids in the past, no stimulations performed during this reporting period used these compounds as base fluids.

1.1.1 Base Fluid Water Sources

The sources of water used to comprise WST base fluid were reported by the operators. Sometime operators may refer to the same source in a different terminology, therefore water sources have been categorized respectively under three categories to provide a clear breakdown of WST base fluid by the original source:

Domestic Water System:

- California Aqueduct

Produced Fluid:

- No produced fluid was used during this reporting period

Operator Water Production Well –operator owned water production wells:

- Tulare formation water

The following tables show total volumes by source aggregated, as required, by operator, county, and district. Units for volumes shown are rounded to the nearest barrel (BBLS).

Table 1: **WST BASE FLUID SOURCE BY OPERATOR (BBLS)**

Well Operator	Domestic Water System	Operator Water Production	Produced Fluid	Total Base Fluid
Aera Energy, LLC	356,396	34,141	0	390,537
Berry Petroleum Company, LLC	113,114	0	0	113,114
California Resources Elk Hills, LLC	139,394	0	0	139,394
Total	608,904	34,141	0	643,045

Table 2: WST BASE FLUID SOURCE BY COUNTY & DISTRICT (BBLS)

County & District	Domestic Water System	Operator Water Production	Produced Fluid	Total Base Fluid
Kern County – Inland District	608,904	34,141	0	643,045

1.1.2 Base Fluids Other Than Water

Operators did not report using any base fluids other than water during the reporting period.

1.1.3 Base Fluid Suitability for Irrigation or Domestic Purposes

This section provides information regarding the suitability or unsuitability of water used in base fluids for irrigation or domestic purposes as reported by operators during the reporting period.

Table 3: WST BASE FLUID SUITABILITY BY OPERATOR (BBLS)

Well Operator	Suitable for Irrigation/Domestic Use	Not Suitable for Irrigation/Domestic Use	Total by Operator
Aera Energy, LLC	356,396	34,141	390,537
Berry Petroleum Company, LLC	113,114	0	113,114
California Resources Elk Hills, LLC	139,394	0	139,394
Total	608,904	34,141	643,045

Table 4: WST BASE FLUID SUITABILITY BY COUNTY & DISTRICT (BBLS)

County & District	Suitable for Irrigation/Domestic Use	Not Suitable for Irrigation/Domestic Use	Total by County & District
Kern County – Inland District	608,904	34,141	643,045

1.1.4 Base Fluid Composition

The base fluid composition data presented in the following tables is a result of analyses of water sources used as a base fluid for well stimulation. For base fluid water sources used in multiple WSTs within a proximal time frame, CalGEM accepts a representative sample of the water source taken at least on a biannual basis.

Compounds detected in analyzed base fluid samples are divided into two broad categories:

- Inorganic compounds are shown in units of mg/L (milligrams per liter)
- Organic compounds are shown in units of µg/L (micrograms per liter)

The tables below present the average concentration by mass when detected in the base fluid. The tables also provide the percentage of when the constituent was detected relative to the total number of samples analyzed. The tables also provide a delineation of composition based upon whether the base fluid was identified as suitable or unsuitable for irrigation or domestic purposes.

1.1.4.1 Composition of Base Fluids Suitable for Irrigation or Domestic Purposes

The following tables provide the average detected concentrations of inorganic compounds (in mg/L) and organic compounds (in µg/L) found in base fluids from sources reported as suitable for irrigation and suitable domestic purposes.

Table 5: INORGANIC COMPOUNDS IN "SUITABLE" WST BASE FLUID

Required Analytes	Average Concentration Detected (mg/L)	Percent Detected
Alkalinity, Total	62	100%
Antimony	0.011	14%
Arsenic	Not Detected	--
Barium	0.011	100%
Beryllium	Not Detected	--
Boron	0.14	100%
Bromide	0.30	29%
Calcium	18	100%
Cadmium	0.0012	14%
Chloride	46	100%
Cobalt	Not Detected	--
Chromium	0.0019	14%
Copper	0.0026	86%
Lead	Not Detected	--
Lithium	0.0067	14%
Magnesium	7.8	100%
Mercury	0.000045	14%
Molybdenum	0.0015	14%
Nickel	Not Detected	--
Nitrate	0.35	86%
Potassium	2.3	100%
Selenium	Not Detected	--
Silver	Not Detected	--
Sodium	42	100%
Strontium	0.25	100%
Sulfate	32	100%
Thallium	Not Detected	--
Total Dissolved Solids	220	100%
Vanadium	0.0030	86%
Zinc	0.004	57%

Table 6: ORGANIC COMPOUNDS IN "SUITABLE" WST BASE FLUID

Required Analytes	Average Concentration Detected (µg/L)	Percent Detected
Benzene	Not Detected	--
Ethyl Benzene	Not Detected	--
Toluene	Not Detected	--
Xylenes	Not Detected	--

1.1.4.2 Composition of Base Fluids Not Suitable for Irrigation or Domestic Purposes

The following tables provide the average detected concentrations of inorganic compounds (in mg/L) and organic compounds (in µg/L) found in base fluids from sources reported as not suitable for irrigation or domestic purposes.

Table 7: INORGANIC COMPOUNDS IN "NOT SUITABLE" WST BASE FLUID

Required Analytes	Average Concentration Detected (mg/L)	Percent Detected
Alkalinity, Total	15	100%
Antimony	0.023	100%
Arsenic	0.011	100%
Barium	0.093	100%
Beryllium	Not Detected	--
Boron	0.59	100%
Bromide	2.6	100%
Calcium	150	100%
Cadmium	Not Detected	--
Chloride	560	100%
Cobalt	Not Detected	--
Chromium	Not Detected	--
Copper	0.0048	100%
Lead	Not Detected	--
Lithium	Not Detected	--
Magnesium	0.26	100%
Mercury	Not Detected	--
Molybdenum	0.02	100%
Nickel	0.0025	100%
Nitrate	Not Detected	--

Required Analytes	Average Concentration Detected (mg/L)	Percent Detected
Potassium	0.84	100%
Selenium	Not Detected	--
Silver	Not Detected	--
Sodium	320	100%
Strontium	0.74	100%
Sulfate	230	100%
Thallium	Not Detected	--
Total Dissolved Solids	1,500	100%
Vanadium	0.0092	100%
Zinc	0.0091	100%

Table 8: ORGANIC COMPOUNDS IN "NOT SUITABLE" WST BASE FLUID

Required Analytes	Average Concentration Detected (µg/L)	Percent Detected
Benzene	Not Detected	--
Ethyl Benzene	Not Detected	--
Toluene	Not Detected	--
Xylenes	Not Detected	--

1.2 Recovered Fluids

PRC section 3160(b)(2)(E): The source, volume, and specific composition and disposition of all water, including, but not limited to, all water used as base fluid during the well stimulation treatment and recovered from the well following the well stimulation treatment that is not otherwise reported as produced water pursuant to section 3227. Any repeated reuse of treated or untreated water for well stimulation treatments and well stimulation treatment-related activities shall be identified.

PRC section 3160(b)(2)(F): The specific composition and disposition of all well stimulation treatment fluids, including waste fluids, other than water.

PRC section 3160(b)(2)(H): The radioactivity of the recovered well stimulation fluids.

PRC section 3215(c)(1): Aggregated data detailing the disposition of any produced water from wells that have undergone well stimulation treatments.

All WSTs performed during the reporting period used water as the base fluid. Fluids produced from wells that undergo WST include petroleum, formation water, base fluid, and remaining chemical additives. Produced fluids are predominately composed of hydrocarbons and formation water, occurring in greater quantity than fluids associated with WST, such as base fluid and chemical additives. The data described here relates to recovered fluids and their disposition.

One caveat to consider when reviewing this data is the fact that some wells may not have sufficient pressure to generate flow back of WST fluids. Such situations frequently require clean out operations prior to putting the well on production. There are also instances where some of the base fluid from the stimulation may have leaked off to the formation. As such, the information below cannot be compared on a one-to-one basis against reported base fluid volume to establish an accurate ratio.

1.2.1 Disposition of Recovered Fluid

All fluids recovered from WSTs during the reporting period were disposed of by injection into Class II injection wells, which are regulated separately under CalGEM's UIC program. Recovered WST fluids were not reused for subsequent treatments.

1.2.2 Composition & Radioactivity of Recovered Fluids

The recovered fluid composition is tested for specific compounds. These can be divided into three broad categories, which are measured in different units:

- Inorganic compounds are shown in units of mg/L (milligrams per liter)
- Organic compounds are shown in units of µg/L (micrograms per liter)
- Radiochemical compounds are shown as pCi/L (picocuries per liter)

The tables below present the average concentration by mass when detected in the recovered fluid. The table also provides the percentage of when the constituent was detected relative to the total number of samples analyzed.

Table 9: AVERAGE CONCENTRATION OF INORGANIC COMPOUNDS DETECTED IN WST RECOVERED FLUID BY OPERATOR (mg/L)

Required Analytes	Aera Energy, LLC	Berry Petroleum Company, LLC	California Resources Elk Hills, LLC
Alkalinity, Total	2,811	3,146	1,357
Antimony	4.65	0.132	Not Detected
Arsenic	0.26	0.32	Not Detected
Barium	61.24	6.80	7.12
Beryllium	0.033	0.011	Not Detected
Boron	92.22	99	76.9
Bromide	91.4	97.8	66.9
Calcium	187	147	135
Cadmium	0.036	0.010	Not Detected
Chloride	17,402	15,478	12,957
Cobalt	0.043	0.063	0.021
Chromium	0.048	0.254	0.056
Chromium, Hexavalent	0.0060	0.0048	Not Detected
Copper	0.628	0.040	0.171
Fluoride	9.8	Not Detected	8.1
Iron	43.9	37.9	46.3
Hydrogen sulfide (H_2S)	0.13	0.086	Not Detected
Lead	0.109	0.112	0.026
Lithium	6.5	4.3	2.7
Magnesium	127	105	22
Manganese	0.83	0.86	0.74
Mercury	0.00016	0.00797	0.00015
Molybdenum	0.066	0.029	0.018
Nickel	0.08	0.054	0.234
Nitrate	Not Detected	Not Detected	Not Detected
Nitrite	0.30	0.22	Not Detected
Potassium	254	150	3524
Selenium	0.29	0.14	0.18
Silver	Not Detected	0.0095	Not Detected
Sodium	11,463	10,192	6,978
Strontium	11.1	12.9	18.6
Sulfate	124	46	57
Thallium	Not Detected	0.48	Not Detected
Total Dissolved Solids	31,212	28,667	30,087
Vanadium	0.058	0.040	Not Detected
Zinc	7.2	0.102	1.32

Table 10: AVERAGE CONCENTRATION OF INORGANIC COMPOUNDS DETECTED IN WST RECOVERED FLUID BY COUNTY & DISTRICT (mg/L)

Required Analytes	Kern County – Inland District	Percent Detected
Alkalinity, Total	2,788	100%
Antimony	1.89	26%
Arsenic	0.28	5%
Barium	37.23	100%
Beryllium	8.5	5%
Boron	93.95	100%
Bromide	184.3	99%
Calcium	169	100%
Cadmium	0.030	6%
Chloride	16,624	100%
Cobalt	0.038	5%
Chromium	0.119	29%
Chromium, Hexavalent	0.0057	3%
Copper	0.425	33%
Fluoride	9.1	2%
Iron	41.9	89%
Hydrogen sulfide (H_2S)	0.12	4%
Lead	0.085	10%
Lithium	5.5	100%
Magnesium	112	100%
Manganese	0.83	100%
Mercury	0.00013	50%
Molybdenum	0.044	15%
Nickel	0.11	20%
Nitrate	Not Detected	--
Nitrite	0.27	17%
Potassium	403	100%
Selenium	0.183	8%
Silver	0.0095	0.25%
Sodium	10,714	100%
Strontium	12.2	100%
Sulfate	101.4	57%
Thallium	0.48	0.25%
Total Dissolved Solids	30,517	100%
Vanadium	0.049	1%
Zinc	3.5	28%

Table 11: AVERAGE CONCENTRATION OF ORGANIC COMPOUNDS DETECTED IN WST RECOVERED FLUID BY OPERATOR (µg/L)

Required Analytes	Aera Energy, LLC	Berry Petroleum Company, LLC	California Resources Elk Hills, LLC
Benzene	923	347	3,174
Ethylbenzene	266	304	236
Methane	0.0016	0.0022	0.0010
Toluene	1,973	2,706	2,567
Total Carbohydrates	66,977	71,062	432,727
Xylenes	1,441	1,932	1,138

Table 12: AVERAGE CONCENTRATION OF ORGANIC COMPOUNDS DETECTED IN WST RECOVERED FLUID BY COUNTY & DISTRICT (µg/L)

Required Analytes	Kern County – Inland District Average Concentration	Percent Detected
Benzene	944	100%
Ethylbenzene	273	99%
Methane	0.0017	100%
Toluene	2,193	100%
Total Carbohydrates	94,793	93%
Xylenes	1,538	100%

Table 13: AVERAGE CONCENTRATION OF RADIOCHEMISTRY DETECTED IN WST RECOVERED FLUID BY OPERATOR (pCi/L)

Required Analytes	Aera Energy, LLC	Berry Petroleum Company, LLC	California Resources Elk Hills, LLC
Alpha, Gross	79	61	185
Beta, Gross	177	123	2,211
Radium-226	28	28	33
Radon	169	135	79

Table 14: AVERAGE CONCENTRATION OF RADIOCHEMISTRY DETECTED IN WST RECOVERED FLUID BY COUNTY & DISTRICT (pCi/L)

Required Analytes	Kern County – Inland District Average Concentration
Alpha, Gross	82
Beta, Gross	309
Radium-226	28
Radon	154

1.2.3 Waste Fluids Other Than Water

Fluids associated with well stimulation include flowback fluids and produced fluids that are primarily composed of water. Waste fluids other than water are not generally associated with well stimulation treatments.

There were no waste fluids other than water recovered during the reporting period.

1.3 Well Stimulation Chemicals & Additives

PRC section 3150 defines additive as a substance or combination of substances added to a base fluid for purposes of preparing WST fluid. An additive may, but is not required to, serve additional purposes beyond the transmission of hydraulic pressure to the geologic formation. An additive may be of any phase and includes proppants. Each additive may be made up of different combination of chemicals and therefore a full disclosure of the chemical constituents is required for each WST fluid.

1.3.1 Chemical Constituents Used in WST

PRC section 3160(b)(2)(B): A complete list of the names, Chemical Abstract Service (CAS) numbers, and maximum concentration, in percent by mass, of each and every chemical constituent of the well stimulation treatment fluids used. If a CAS number does not exist for a chemical constituent, the well owner or operator may provide another unique identifier, if available.

Not counting water, a total of 52 chemical constituents were reported used in WST fluids during the reporting period. A complete list of disclosed chemicals, sorted by chemical constituent, is provided below with the number of times each constituent

was used. Note that some of the chemical constituents were used as a component in various combinations for more than one purpose and therefore may be reported as being used more than once per stimulation. Water (CAS number 7732-18-5) was used in every WST.

Additional information concerning chemical constituents can be accessed online through the CalGEM disclosure website: https://wellstar-public.conservation.ca.gov/

Table 15: CHEMICAL CONSTITUENTS USED IN WST BY CONSTITUTENT NAME

Constituent Name	CAS Numbers	Number of Times Used in WST Fluid
1,2-Benzisothiazolin-3-one	2634-33-5	2
2,2 Dibromo-3-nitrilopropionamide	10222-01-2	217
2-Hydroxy-n,n,n-trimethylethanaminium chloride	67-48-1	2
2-Monobromo-3-nitrilopropionamide	1113-55-9	216
4-Methyl-1,3-dioxolan-2-one	108-32-7	13
Acetic acid	64-19-7	144
Ammonium acetate	631-61-8	8
Ammonium chloride	12125-02-9	206
Ammonium persulfate	7727-54-0	2
Ammonium; diallyldimethyl-; chloride; polymers	26062-79-3	206
Amorphous silica	7631-86-9	2
Arsenic	7440-38-2	13
Calcium magnesium sodium phosphate frit	65997-18-4	2
Castor oil, ethoxylated	61791-12-6	20
Chlorous acid, sodium salt	7758-19-2	13
Citric acid	77-92-9	5
Cobalt acetate	71-48-7	8
Crystalline silica (Quartz),	14808-60-7	219
Ethanol	64-17-5	53
Ethylene glycol	107-21-1	2
Formaldehyde-hexamethylenetetramine-phenol copolymer	37337-65-8	4
Glutaraldehyde	111-30-8	55
Glycerol	56-81-5	2
Guar gum	9000-30-0	219
Hemicellulase enzyme	9012-54-8	206

Constituent Name	CAS Numbers	Number of Times Used in WST Fluid
Hexamethylenetetramine	100-97-0	16
Hydrotreated light petroleum distillate	64742-47-8	13
Isopropanol	67-63-0	20
Isotridecanol, ethoxylated	9043-30-5	13
Lactose	63-42-3	206
Lauryl dimethyl hydroxysulfobetaine	13197-76-7	40
Magnesium silicate hydrate (talc),	14807-96-6	1
Methanol	67-56-1	53
Monoethanolamine borate	26038-87-9	206
Orange terpenes	68647-72-3	20
Phenol-formaldehyde resin (Novolak)	9003-35-4	16
Phosphoric Acid	7664-38-2	53
Pigment Red #2	7023-61-2	15
Polyoxyethylene (12) polyoxypropylene (66) glyceryl ether	9082-00-2	15
Polyurethane resin	57029-46-6	15
Potassium carbonate	584-08-7	9
Potassium chloride	7447-40-7	13
Potassium hydroxide	1310-58-3	7
Potassium metaborate	13709-94-9	7
Quaternary ammonium compounds, benzyl-C12-16-alkyldimethyl, chlorides	68424-85-1	53
Quaternary ammonium compounds, bis(hydrogenated tallow alkyl) dimethyl, salts with bentonite	68953-58-2	13
Sodium bisulfite	7631-90-5	40
Sodium chloride	7647-14-5	219
Sodium citrate	68-04-2	2
Sodium hydroxide	1310-73-2	211
Sodium persulfate	7775-27-1	206
Sodium polyacrylate	9003-04-7	40
Sodium sulfate	7757-82-6	206
Sodium tetraborate decahydrate	1303-96-4	2
Sorbitan, monododecanoate, poly (oxy-1,2-ethanediyl) dervis.	26266-58-0	13

Constituent Name	CAS Numbers	Number of Times Used in WST Fluid
Sorbitan, monohexadecanoate,poly(oxy-1,2-ethanediyl) derivs.	9005-66-7	20
Ulexite	1319-33-1	13
Water	7732-18-5	219

1.3.2 Additives Used in WST

PRC section 3160(b)(2)(C): The trade name, the supplier, concentration, and a brief description of the intended purpose of each additive contained in the well stimulation treatment fluid.

1.3.2.1 Additive Suppliers

The following companies supplied additives for WSTs in California during the reporting period:

- California Drilling Fluids
- Halliburton
- Operators: Aera Energy, LLC; Berry Petroleum Company, LLC; and California Resources Elk Hills, LLC.

1.3.2.2 Additive Usage & Purpose

There are 36 different additives identified for use in WST fluids. The following tables provide a listing of all additives used during the reporting period, including the number of times each was used in WST base fluid, as well as the supplier for the additive and the purpose for which the additive was used.

Additional information concerning additives can be accessed through the CalGEM disclosure website: https://wellstar-public.conservation.ca.gov/

Table 16: ADDITIVES USED IN WST BY SUPPLIER & PURPOSE

Supplier Name	Additive Trade Name	Purpose	Number of Times Used in WST Fluid
California Drilling Fluids	DCA-32011	Surfactant	1
California Drilling Fluids	KCL Potassium Chloride	Clay Control	11
California Drilling Fluids	MC B-8614	Biocide	1
Halliburton	Acetic Acid	pH Control	128
Halliburton	Acetic Acid (60%)	pH Control	2
Halliburton	Acetic Acid (80%)	pH Control	14
Halliburton	BC-140C	Crosslinker	206
Halliburton	BE-3S Bactericide	Biocide	215
Halliburton	Citric Acid, Liquid	pH Control	3
Halliburton	DCA-11004	Activator	7
Halliburton	DCA-13002	Breaker	206
Halliburton	DCA-13003	Breaker	13
Halliburton	DCA-14002	pH Control	9
Halliburton	DCA-14005	pH Control	211
Halliburton	DCA-16002	Clay Control	206
Halliburton	DCA-19010	Crosslinker	13
Halliburton	DCA-19011	Crosslinker	7
Halliburton	DCA-25005	Gelling Agent	219
Halliburton	DCA-30001	Scale Inhibitor	40
Halliburton	DCA-32005	Surfactant	40
Halliburton	DCA-32011	Surfactant	19
Halliburton	DSC-01, 16/30	Proppant	2
Halliburton	DSC-01, 20/40	Proppant	10
Halliburton	DSC-02, 16/30	Proppant	4
Halliburton	DSC-03	Proppant	3
Halliburton	DSC-04, 16/30	Proppant	15
Halliburton	GBW-30 Breaker	Breaker	205
Halliburton	KCL Potassium Chloride	Clay Control	2
Halliburton	MC B-8614	Biocide	52
Halliburton	Sand-Arizona-16/30	Proppant	1
Halliburton	Sand-Common White-100 Mesh, SSA-2	Proppant	7
Halliburton	Sand-Premium White-12/20	Proppant	11

Supplier Name	Additive Trade Name	Purpose	Number of Times Used in WST Fluid
Halliburton	Sand-Premium White-16/30	Proppant	179
Halliburton	Sand-Premium White-20/40	Proppant	77
Halliburton	Water	Base Fluid	141
Operator	Water	Base Fluid	78

1.3.3 Radiological Components & Tracers

PRC section 3260(b)(2)(G): Any radiological components or tracers injected into the well as part of, or in order to evaluate, the well stimulation treatment, a description of the recovery method, if any, for those components or tracers, the recovery rate, and specific disposal information for recovered components or tracers.

There were no radiological components or tracers used in WST during the reporting period.

1.3.4 Trade Secret Information

PRC section 3215(c)(4): Aggregated data detailing the number of times trade secret information was not provided to the public, by county and by each company, in the preceding year.

Operators are required to report information regarding all additives and chemical constituents of fluids used for well stimulation. The law imposes substantial limitations on the ability of operators to avoid public disclosure of treatment fluid constituents on the basis of trade secret protection.

There were no trade secret claims made by any operator for wells stimulated during this reporting period, therefore, the withholding of public disclosure based on a trade secret did not occur.

2. Surface Owner/Tenant Water Sampling Requests

Operators are required to hire an independent third-party contractor to provide neighbor notification to surface owners and tenants of properties that are either located within a 1,500-foot radius of the wellhead receiving WST, or within 500 feet of the surface representation of the horizontal path of the subsurface parts of the well. Notified neighbors with an existing water well or surface water on the parcel that is suitable for drinking or irrigation purposes may request water quality testing. Operators are required to send a copy of the water quality testing results to CalGEM.

The third-party notice provider also sends information to CalGEM detailing the surface owners and tenants notified, the date of notification, and the method of delivery. Operators may not perform stimulation on a well prior to 30 calendar days from the date the surface owners and tenants were notified. CalGEM retains the neighbor notification data and checks for reporting compliance prior to well stimulation. Performance of the independent entities is reviewed and subject to random audits conducted by CalGEM. The last audit conducted showed full compliance with neighbor notification requirements.

There have been no neighbor notifications sent since August 9, 2019. There were no requests for water sampling by surface owners or tenants during the reporting period.

3. Stimulated Zones & Formations

PRC section 3215(c)(2): Aggregated data describing the formations where wells have received well stimulation treatments including the range of safety factors used and fracture zone lengths.

PRC section 3160(b)(2)(I): The location of the portion of the well subject to the well stimulation treatment and the extent of the fracturing or other modification, if any, surrounding the well induced by the treatment.

3.1 Stimulated Formations

The names of stimulated zones were reported by operators. Oil and gas "zones" refer to the areas within a geologic formation where oil, gas, and water are trapped due to a geologic structure such as a fault, variable stratigraphy, or other feature that traps a resource in a particular area. For the purposes of this report, the formation and zone names reported by operator are grouped respectively as:

- Reef Ridge Formation – Reported zones:
  Reef Ridge-Diatomite
- Etchegoin Formation – Reported zones:
  Etchegoin-Diatomite
- Monterey Formation – Reported zones:
  Monterey-Antelope
  Monterey-McDonald

The following table provides the number of times each formation was stimulated during the reporting period.

Table 17: NUMBER OF STIMULATIONS IN EACH FORMATION BY COUNTY & DISTRICT

County & District	Formations Name	Number of Stimulations
Kern County - Inland District	Reef Ridge	184
	Etchegoin-Reef Ridge	20
	Monterey-Antelope	13
	Monterey-McDonald	2
TOTAL		**219**

3.2 Safety Factors & Fracture Zone Dimensions

Safety factors are established by creating a protective area around the proposed fracture zone that is used to make risk management and mitigation determinations. Fracture zone dimensions are also referred to in regulation [CCR, title 14, section 1781(f)] as the axial dimensional stimulation area (ADSA). The safety factors in regulation consist of evaluating wellbores or other possible migration pathways within two times the ADSA and geological features within five times the ADSA.

Fracture zone lengths and heights may be estimated by well operators according to sophisticated hydraulic fracturing models or previous field measured data. These estimations provide the basis for the minimum safety factor calculations to determine risk factors for well stimulation. One of the key factors in estimating the fracture zone is the type of formation involved at the point of stimulation.

The figure below is a visual representation of the fracture length and height generated by a WST into the formation. These are key data points to determine safety factors. In this report and in California's WST statutes and regulations, the terms "length" and "height" of stimulation mean the following:

Length: Generally, a hydraulic fracture is propagated in two sides of a wellbore. The horizontal length of a fracture in each side is called the fracture half-length. However, in this report a fracture length is equal to a fracture half-length (Figure 1).

Height: For both vertical and horizontal wells, fracture height is the maximum vertical extent of fracture growth. In other words, fracture height is the distance between the top and bottom of the fracture (Figure 1).

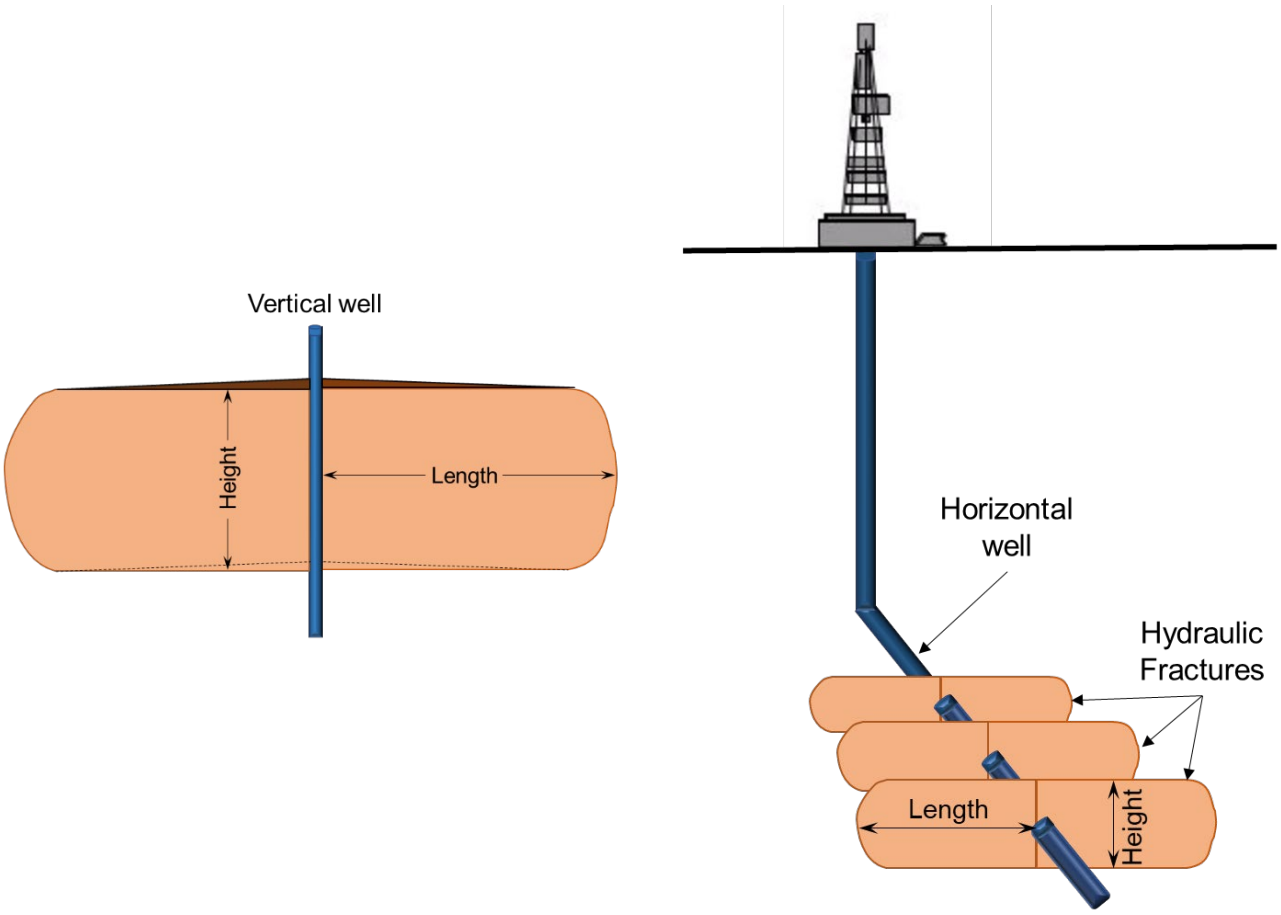

Figure 1: Use of "Height" & "Length" in describing WST Fractures in California

The tables below show average fracture length and height (length of stimulation and height of stimulation) for all stimulated stages. The number of stages per WST varied; of 219 WSTs completed during the reporting period, a total of 1,238 distinct stages were stimulated. The numbers are rounded to the nearest foot. As required, they show the information by district, county, and operator.

Table 18: AVERAGE LENGTH OF STIMULATION BY OPERATOR (Feet)

Well Operator	Average Fracture Length
Aera Energy, LLC	64
Berry Petroleum Company, LLC	95
California Resources Elk Hills, LLC	330

Table 19: AVERAGE LENGTH OF STIMULATION BY COUNTY & DISTRICT (Feet)

County & District	Average Fracture Length
Kern County – Inland District	90

Table 20: AVERAGE HEIGHT OF STIMULATION BY OPERATOR (Feet)

Well Operator	Average Fracture Height
Aera Energy, LLC	135
Berry Petroleum Company, LLC	58
California Resources Elk Hills, LLC	308

Table 21: AVERAGE HEIGHT OF STIMULATION BY COUNTY & DISTRICT (Feet)

County & District	Average Fracture Height
Kern County – Inland District	117

3.3 Acid Matrix Stimulation – Depth of Acid Penetration

Acid matrix stimulation does not fracture the target formation. It utilizes lower pressures than hydraulic fracturing and the distance of stimulation into the formation is less than that of hydraulic fracturing. Because acid matrix stimulation does not fracture the formation, this section will focus on depth of acid penetration rather than fracture zone length.

For a vertical well, the depth of penetration is a horizontal distance extending from the vertical wellbore. For a horizontal well, the depth of penetration is a vertical distance extending from the horizontal wellbore. Measurements are rounded to the nearest foot.

There were no acid matrix well stimulations conducted during the reporting period.

3.4 Depth of Stimulation

This section presents aggregated information regarding the depths at which WSTs were performed during the reporting period. The minimum depth provided is the true vertical depth (TVD) from ground surface to the top of the uppermost stage. The maximum depth provided is the true vertical depth from ground surface to the bottom of the deepest stage. Depth measurements are presented in the following tables by

operator and by county and district. All measurements are rounded to the nearest foot.

Table 22: TOP OF STIMULATION (TVD) BY OPERATOR (Feet)

Well Operator	Minimum	Maximum	Average
Aera Energy, LLC	630	4,263	1,298
Berry Petroleum Company, LLC	1,087	1,267	1,142
California Resources Elk Hills, LLC	9,366	10,246	9,879

Table 23: TOP OF STIMULATION (TVD) BY COUNTY AND DISTRICT (Feet)

County & District	Minimum	Maximum	Average
Kern County – Inland District	630	10,246	1,779

Table 24: BOTTOM OF STIMULATION (TVD) BY OPERATOR (Feet)

Well Operator	Minimum	Maximum	Average
Aera Energy, LLC	1,344	4,894	2,102
Berry Petroleum Company, LLC	1,845	2,251	1,986
California Resources Elk Hills, LLC	9,621	10,727	10,050

Table 25: BOTTOM OF STIMULATION (TVD) BY COUNTY & DISTRICT (Feet)

County & District	Minimum	Maximum	Average
Kern County – Inland District	1,344	10,727	2,553

4. Well Stimulation Witnessing & Spot Checking

Witnessing and spot checking involve different levels of oversight by CalGEM district field staff. The numbers reported in the tables below are from the WST Tracker excel file.

Witnessing is a visit made to evaluate many aspects of an operation including, but not limited to:

- Casing and tubing pressure testing to ensure well integrity prior to WST
- WST surface equipment pressure testing prior to WST
- Observation of WST stages

Spot checking is an onsite assessment made specifically to verify the WST fluid compositions conforms to the composition that was approved by CalGEM during the application review.

The percentage of witnessing and spot checking for WSTs in 2019 were low compared to the previous years. This was due to the Cymric surface expression event that occurred in the Inland district. A majority of the district's field staff were continually delegated to the surface expression event and were infrequently available to witness other operations like WSTs.

4.1 Field Tests/Witnessing Performed

PRC section 3215(c)(7): The number of well stimulation treatments witnessed by CalGEM field staff.

Table 26: NUMBER OF WSTs WITNESSED BY CalGEM

County & District	Numbers of WST Witnessed
Kern County – Inland District	85

4.2 Spot Checks Conducted

PRC section 3215(c)(6): The number of spot check inspections conducted pursuant to subdivision (l) of Section 3160, including the number of inspections where the composition of well stimulation fluids were verified and the results of those inspections.

All spot checks performed found that the composition of fluids used in WSTs was substantially consistent with the composition proposed in the WST Notice or application.

Table 27: NUMBER OF CHEMICAL SPOT CHECKS PERFORMED BY CalGEM

County & District	Numbers of Chemical Spot Checks Performed
Kern County – Inland District	33

5. CalGEM Enforcement

PRC section 3215(c)(8): The number of enforcement actions associated with well stimulation treatments, including, but not limited to, notices of deficiency, notices of violation, civil or criminal enforcement actions, and any penalties assessed.

Enforcement actions may include:

- Notices of Deficiency (NOD)/Notices of Violation (NOV): During the reporting period, CalGEM did not issue any NODs or NOVs to operators for violations relating to WST.
- Civil or Criminal Enforcement Actions**:** CalGEM may issue civil enforcement orders to operators who violate legal requirements, or for the purposes of ordering necessary tests or remedial work. (*See, e.g.,* PRC sections 3106, 3224, 3225, 3226, and 3236.5.) CalGEM did not issue any civil enforcement orders relating to WSTs during the reporting period. CalGEM did not initiate any criminal enforcement actions during the reporting period.
- Penalties Assessed: During the reporting period, CalGEM did not assess any monetary penalties relating to WSTs.

6. Reports of Incidents/Events

For public safety and health, any loss of well and casing integrity issues for wells that have undergone WST is reviewed and reported along with other loss of well and casing integrity issues of all wells in California. Spills and release associated with WSTs are also reported. Per the requirements stated in PRC section 3215(c), the following sections present the reports of incidents during the reporting period.

6.1 Loss of Well & Well Casing Integrity

PRC section 3215(c)(5): Data detailing the loss of well and well casing integrity in the preceding year for wells that have undergone well stimulation treatment. For comparative purposes, data detailing the loss of well and well casing integrity in the preceding year for all wells shall also be provided. The cause of each well and well casing failure, if known, shall also be provided.

For the purpose of this report, loss of well and well casing integrity in wells that have undergone WST is defined as a breach in casing strings utilized in WST operations, or breach of the geologic or hydrologic isolation of the formation. Loss of well and well casing integrity for all other wells is identified by any incidence involving a well's permanent construction indicated by inspection and/or mechanical integrity testing (MIT). Integrity losses typically develop over time, and it can be difficult to identify a precise point at which a loss first occurs. A failure of the integrity test is not always conclusive evidence of casing integrity loss. It may require additional tests and review to verify the actual cause of failure.

Currently, CalGEM does not have a standardize method to capture the actual well or casing integrity loss data. With the new Incident Report form available in WellSTAR, the Division is working toward a uniform and more transparent way of reporting well integrity loss.

A query of CalGEM records yielded 422 instances that could potentially indicate loss of well or well casing integrity during the reporting period, including failed mechanical integrity tests, pressure tests and reported anomalies. Records were segregated by the oil field where WST had occurred and cross-referenced with wells that had undergone well stimulation. Using this analysis, CalGEM determined that there was no well or casing integrity loss associated with WSTs during the reporting period.

The number of incidences of potential casing integrity loss in 2019 for wells not receiving WST has increased compared to the number of incidences reported for those wells in the 2018 report. This was due to the following factors:

- The new centralized database system, WellSTAR, which captures all the data within the Division, resulted in a more complete data set.
- New regulations coming into effect for programs such as UIC, Idle Well and Underground Gas Storage in 2019 that require an increased number of tests.
- The newly adopted regulations also impose more stringent testing requirements to better demonstrate the mechanical integrity of the wells, which may have led to more test failures. A detailed review of the well files and data is needed to determine the actual causes of the failures.

6.2 Spills & Emergency Responses

PRC section 3215(c)(3): The number of emergency responses to a spill or release associated with a well stimulation treatment.

There were no emergency responses to spills or releases of any liquids or regulated substances associated with WSTs performed during the reporting period.

Appendix A – References & Data Sources

The following were used as data sources for this report:

CalGEM Statutes and Regulations (January 2020):
https://www.conservation.ca.gov/index/Documents/CALGEM-SR-1%20Web%20Copy.pdf

Well Statewide Tracking and Reporting System (WellSTAR):
https://wellstar-public.conservation.ca.gov/

CalGEM WST Unit's *WST Tracker.xlsx*. This is an internal Excel workbook developed by WST unit staff specifically to track the progress of requests to perform WSTs, through notices/applications, actual stimulations, and disclosing of stimulations.

Operator WST disclosures submission data located in WellSTAR database.

Appendix B – Statutory Requirement for Annual Report

§ 3215. (c) Notwithstanding Section 10231.5 of the Government Code, on or before July 30 of each year, the supervisor shall, in compliance with Section 9795 of the Government Code, prepare and transmit to the Legislature a comprehensive report on well stimulation treatments in the exploration and production of oil and gas resources in California. The report shall include aggregated data of all of the information required to be reported pursuant to Section 3160 reported by the district, county, and operator. The report also shall include relevant additional information, as necessary, including, but not limited to, all of the following:

(1) Aggregated data detailing the disposition of any produced water from wells that have undergone well stimulation treatments.

(2) Aggregated data describing the formations where wells have received well stimulation treatments including the range of safety factors used and fracture zone lengths.

(3) The number of emergency responses to a spill or release associated with a well stimulation treatment.

(4) Aggregated data detailing the number of times trade secret information was not provided to the public, by county and by each company, in the preceding year.

(5) Data detailing the loss of well and well casing integrity in the preceding year for wells that have undergone well stimulation treatment. For comparative purposes, data detailing the loss of well and well casing integrity in the preceding year for all wells shall also be provided. The cause of each well and well casing failure, if known, shall also be provided.

(6) The number of spot check inspections conducted pursuant to subdivision (l) of Section 3160, including the number of inspections where the composition of well stimulation fluids were verified and the results of those inspections.

(7) The number of well stimulation treatments witnessed by the division.

(8) The number of enforcement actions associated with well stimulation treatments, including, but not limited to, notices of deficiency, notices of violation, civil or criminal enforcement actions, and any penalties assessed.

(d) The report shall be made publicly available and an electronic version shall be available on the division's Internet Web site.

Appendix C – Glossary

TERM	DESCRIPTION
Acid Fracture Stimulation	The combined use of acid and fracturing to increase the permeability of (stimulate) a portion of rock or sediment formation intercepted by a well.
Acid Matrix Stimulation	The use of acid to dissolve mineral material to increase the permeability of (stimulate) a portion of rock or sediment formation intercepted by a well.
Additive	One or more substances added to a base fluid to make up a WST fluid.
Base Fluid	A liquid (or potentially a gas) into which additives are mixed, to make up a WST fluid.
Base Fluid Source	The source or origin of a base fluid.
Base Fluid Suitability	The suitability of water base fluid for domestic use (e.g., human or livestock consumption) or irrigation (e.g., agricultural use).
California Code of Regulations (CCR)	The official compilation and publication of the regulations adopted, amended or repealed by state agencies pursuant to the Administrative Procedure Act. WST is regulated within title 14, sections 1751 through 1789 of the California Code of Regulations.
Chemical Abstract Service Registry Number	A unique identification number assigned by the Chemical Abstract Service (CAS) for every chemical compound or mixture of chemical compounds described in scientific literature.
Class II (Injection) Well	Class II wells in California are approved and regulated by CalGEM for the injection of fluids produced as byproducts of the recovery or production of oil or gas, or for storage of hydrocarbons pursuant to CalGEM's UIC program. See *Underground Injection Control (UIC)*.
Confidential Well	A temporary well status approved by CalGEM to protect certain information about a well from disclosure to public and presumably competing operators.
Constituent	A chemical used in a WST additive or base fluid; a chemical component of a WST fluid.

TERM	DESCRIPTION
Diatomite	A rock of very high porosity and usually low permeability that may contain oil or gas. Diatomite is found within the Monterey Formation and other petroleum-bearing rock formations in California and elsewhere.
Directionally Drilled Well	A well that has been intentionally constructed away from vertical, on or close to a pre-planned pathway. Some directionally-drilled wells are curved upward during drilling to be finished as horizontal wells.
Disclosure	The electronic report of a WST submitted to CalGEM under WST regulations.
Disposition	Term used in WST statutes for the management or disposal of water or other wastes from WST operations.
District	An administrative regional CalGEM office.
Gas	Natural gas. Natural gas consists of methane and other simple hydrocarbon molecules that are gasses rather than liquids at room temperature and pressure. Natural gas is present both dissolved in oil and in pore space above oil, within the Earth.
Hydraulically Fracture Stimulation	Refers to the intentional, short-term injection of fluid at sufficient pressure to break apart rock to enhance the permeability of (stimulate) a portion of rock or sediment formation intercepted by a well.
Measured Depth	The distance along the actual path of wellbore, from the ground surface, drilling mat, kelly bushing, drill floor, or other aboveground reference point used during drilling. Measured depth can be thought of as the total length of drill pipe in the ground to reach the end of a wellbore, no matter how curved and twisted the well bore path may be from the reference point.
Monterey Formation	The name used in much of California for a portion of the Miocene-aged, fine-grained sedimentary rock (i.e., commonly shale) deposited and still present along the margin of the Pacific Ocean.

TERM	DESCRIPTION
Neighbor Notification	The requirement and process to notify landowners and occupants of parcels of property located within specified distances of a well where a WST is to be performed. The notification allows landowners or occupants to request that ground or surface waters that are suitable for drinking or irrigation be sampled and tested to assess possible impact from WST.
Notice of Violation	Written notification made to an oil or gas well operator from the State Oil and Gas Supervisor of violation of a regulation or statute. A Notice of Violation is commonly the first formal correspondence to an operator preceding an Order or other potential enforcement action.
Notice to Operators	A written clarification, transmission of, or request for information made by CalGEM to oil and gas well operators about a specific topic.
Notification	The process of providing information about an upcoming action, an opportunity, or an action taken, made in writing, to a party. See *Neighbor Notification* for one example of a notification required by SB 4.
Operator	A party that owns or has legal responsibility for the maintenance and operation of an oil or gas well or other well that falls within the jurisdiction of CalGEM.
Permeability	The property of or rate at which a solid can or does transmit oil, water, air, or other fluids. See *Porosity*.
Porosity (Pore Space)	The presence within and amount of a solid that is void (potentially empty) space. Pore space within rocks and soil is filled with oil, water, air or other gasses or fluids. See *Permeability*.
Pressure Testing	The requirement implemented July 1, 2015, that an operator notify CalGEM of and record pressure tests of all well casings and tubings to be used in a WST operation. See *Zonal Isolation* and *Well Integrity*.

TERM	DESCRIPTION
Produced Water	Water that is extracted from beneath the ground surface as a byproduct of oil or gas production. In mature oil fields such as those common in California, most of the fluid that is pumped from the ground is produced water. In California, most produced water is naturally salty.
Public Resources Code (PRC)	One of 29 groupings of California statutes (laws). The Public Resources Code contains key statutes affecting oil and gas resources, wells, and operations. SB 4 added language primarily to the PRC to give CalGEM greater authority and responsibility to regulate WST.
Recovered Water or Fluid	Fluids (e.g., water, oil, and gas) that come out (either naturally or by pumping or other assistance) of an oil or gas well after WST and prior to the routine production or other stabilized use and flow of fluids from a well. SB 4 requires operators to chemically test and provide information to CalGEM about recovered fluids.
Rulemaking Process	The procedure used by any component of the Executive Branch (of the State of California government) in adopting regulations and rules that will have the force of law. CalGEM followed both the emergency rulemaking process and regular rulemaking process in implementing SB 4.
Senate Bill 4 (SB 4)	California State Senate Bill 4 (Pavley, Chapter 313, Statutes of 2013) was passed by the Legislature and signed by Governor Jerry Brown in September 2013 to better regulate WST.
Spot Check (Inspection)	The term used in SB 4 to describe a visit by CalGEM staff to a WST operation for the specific purpose of comparing the additives, chemicals, and base fluid at the WST location with the information about the additives, chemicals, and base fluid that was supplied in the Notice.
Stage	A subset or smaller portion of the total interval or portion of a well that is stimulated. A typical WST has several to more than ten stages that are performed in rapid succession in a single effort.

TERM	DESCRIPTION
Trade Secret	The withholding of certain information about one or more WST additives from the public and presumably competitors. SB 4 allows an operator to request trade secrecy from CalGEM through a rigorous and formal process.
True Vertical Depth	The straight-line extent of a well vertically down into the Earth, calculated without regard to actual twists, curves or intentional deviations of the well bore. It is measured from the ground surface, drilling mat, kelly bushing, drill floor, or other aboveground reference point used during drilling.
Underground Injection Control (UIC)	CalGEM has responsibility and authority to regulate the injection of any fluid into the ground via any oil or gas or other well under its jurisdiction. CalGEM's UIC regulations and authority conform to and were granted by federal authority in compliance with the federal Safe Drinking Water Act of 1974. See "Class II well."
Wellbore	A hole that is drilled to aid in the exploration and recovery of natural resources including oil, gas, or water.
Well (Casing) Integrity	The reliability of a well to perform its functions. This includes intact and functioning casing and cement that can durably resist all foreseeable changes (such as pressures, corrosive fluids or earth settlement or lateral shift) in conditions within and outside the well and ensure zonal isolation. See *Zonal Isolation*.
Well Stimulation	The brief and intentional application of pressure, chemicals, or other method to rock or sediment intercepted by a well, to increase the rock or sediment permeability to enhance oil or gas production, or potentially to increase water production or the ability of rock or sediment to accept injection water or other fluid.
Well Stimulation Treatment (WST)	Any treatment of a well designed to enhance oil and gas production or recovery by increasing the permeability of the formation. WSTs include, but are not limited to, hydraulic fracturing treatments and acid well stimulation treatments.

TERM	DESCRIPTION
Witnessing (Inspection)	The term used in SB 4 to describe a general or all-purpose visit by CalGEM staff to a WST operation to observe, monitor, or verify any regulated or required aspect of the WST.
Zonal Isolation	The principal of constructing, verification-testing, and maintenance of a well to ensure that fluids are not migrating along or inside a well from one zone to another. Zones of concern that are protected from contamination of one another include oil or gas-bearing zones, zones of abnormally high pore pressures, zones of fresh water, zones of water of actual or potential beneficial use, zones of saline water, and zones of water contaminated by human activity.

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California
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