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**MODEL CRITERIA FOR GROUNDWATER MONITORING
IN AREAS OF OIL AND GAS WELL STIMULATION**

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SCHEDULED FOR BOARD CONSIDERATION ON JULY 7, 2015

STATE WATER RESOURCES CONTROL BOARD

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Placeholder for Adopted Resolution

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1.0 Introduction

1.1 Background

California has been producing oil and natural gas (gas) for over 100 years and currently is the third largest producer in the United States. The majority of oil production in the state is concentrated in the southern San Joaquin Valley, but oil production also occurs in the Los Angeles and Central Coast areas.

The volume of oil and gas that is produced from an oil or gas well may be enhanced by using well stimulation treatment. Well stimulation treatments include processes such as hydraulic fracturing (also known as fracking), acid fracturing, and acid matrix stimulation. Hydraulic fracturing involves pumping a mixture of liquid, chemicals, and sand down an oil or gas well under high pressure to cause the geologic rock formation to part or fracture (crack). This process forms passages where oil and gas can more easily flow toward the well.

In response to concerns over potential impacts of well stimulation activities on water resources, Governor Brown signed Senate Bill 4 (SB 4) in 2013, which amended the Public Resources Code and Water Code as they relate to oil and gas well stimulation activities. This legislation created new requirements for oil and gas operators, the Division of Oil, Gas, and Geothermal Resources (DOGGR), the State Water Resources Control Board (State Water Board), regional water quality control boards (Regional Water Boards), and other agencies to implement when performing or permitting well stimulation treatments.

1.2 Purpose

Added to the Water Code by SB 4, section 10783 (**Appendix A**) requires the State Water Board to develop model criteria for groundwater monitoring in areas of oil and gas well stimulation. This document outlines groundwater monitoring methods to be used in assessing the potential effects of well stimulation treatments, as defined in Article 3 (commencing with Section 3150) of Chapter 1 of Division 3 of the Public Resources Code, on California's groundwater resources, and is effective upon adoption by the State Water Board. These methods are not intended for site investigation and cleanup.

Monitoring of groundwater that is or has the potential to be a source of drinking water is a priority, but the monitoring shall also consider the protection of water designated for any beneficial use (referred to herein as "beneficial use waters"). Both current and future beneficial uses will be considered in light of California's increasing reliance on groundwater resources due to climate change and drought.

Access to safe drinking water is a major issue for California, especially to its disadvantaged communities. The methods outlined in this document are critical to meet California's policy that every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes (Water Code section 106.3).

1.3 Scope

These Model Criteria for Groundwater Monitoring (Model Criteria) outline the methods to be used for assessment, sampling, analytical testing, and reporting of water quality associated with oil and gas well stimulation activities, including:

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- Area-specific oil and gas well operator required monitoring,
- Designated contractor sampling and testing requirements, and
- A regional groundwater monitoring program to be implemented by the State Water Board or the applicable Regional Water Board.

Unless expressly provided, the terms in this document have the same definitions provided in Article 3 of Chapter 1 of Division 3 of the Public Resources Code and California Code of Regulations, title 14, section 1761 and section 1781. As required in Water Code section 10783, these Model Criteria shall be reviewed and updated periodically, as needed.

Area-Specific Groundwater Monitoring

Water Code section 10783 refers to “well-by-well” and “area-specific” groundwater monitoring. Since groundwater monitoring wells may be used to monitor a group of stimulated oil and gas wells, the methods described apply to “area-specific” groundwater monitoring. The methods for area-specific groundwater monitoring shall also be used in “well-by-well” monitoring in cases where only a single well is to be stimulated.

The methods described herein shall be used to satisfy the groundwater monitoring requirements for permits for well stimulation treatments on oil and gas wells pursuant to Public Resources Code section 3160 upon adoption of these Model Criteria by the State Water Board. The methods do not apply to groundwater monitoring that was approved for any stimulated wells prior to the adoption of these Model Criteria, but groundwater monitoring for subsequent well stimulation permits for previously stimulated wells must follow the methods in these Model Criteria.

The area-specific requirements described in this document are not designed for early detection of impacts to groundwater from well stimulation, but rather are designed to characterize baseline¹ water quality conditions and detect potential impacts to beneficial use waters from well stimulation treatments. In cases of well failure or breach, operators are required to notify the State Water Board and comply with applicable DOGGR well stimulation regulations. In addition, the State Water Board and Regional Water Boards (collectively, Water Boards) may exercise their authority under the Porter-Cologne Water Quality Control Act to direct well operators to implement necessary actions to assess and remediate any impacts to groundwater.

Designated Contractor Sampling and Testing

Standards and protocols to perform property owner requested water sampling and testing as provided by Public Resources Code section 3160, subdivision (d)(7) are also included in the Model Criteria. These requirements include how to become a designated contractor for water sampling, and water quality testing standards, protocols, and data submittal.

¹ Most well stimulation is conducted where extensive oil and gas exploration has already been conducted. Depending on location and depth, the existing “baseline” will be a combination of natural constituents mixed with variable legacy impacts from a variety of oil and gas activities. Assessing geochemical and water quality trends at any one location will be a challenge. It is not expected that groundwater quality in these areas would reflect naturally occurring, or background conditions of the regional aquifers.

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Regional Groundwater Monitoring

Water Code section 10783, subdivision (h)(1), requires the State Water Board to begin implementing a Regional Monitoring Program by January 1, 2016 in order to protect all waters designated for any beneficial use, while prioritizing the monitoring of groundwater that is or has the potential to be a source of drinking water. Factors considered for the Regional Monitoring Program include well stimulation treatments, among other events or activities that have the potential to contaminate groundwater, such as an oil and gas well failure or breach.

Water Code section 10783, subdivision (f)(5), notes that the monitoring methods shall include a determination of threshold criteria on the transition from area-specific monitoring to the Regional Monitoring Program. It will take a considerable amount of time before an appropriate level of data is collected and the density of the groundwater monitoring well network is fully established. As a result, area-specific monitoring will be required until the Regional Monitoring Program has been fully implemented in the vicinity of wells to be stimulated.

Even though the volume of fluid used in well stimulation activities is a relatively small part of oil and gas activity-related fluids (e.g., water flood, wastewater disposal), well stimulation fluids become part of the overall fluid and waste stream. As a result, all fluids produced or introduced in the well stimulation process will be examined in the Regional Monitoring Program including, but not limited to, produced water ponds and Underground Injection Control (UIC) wells.

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2.0 Area-Specific Groundwater Monitoring

The purpose of this section is to outline methods for area-specific groundwater monitoring to satisfy well operator permitting requirements for well stimulation and to address the following:

1. Area-specific groundwater assessment, sampling, analytical testing, and reporting requirements; and
2. Requests for written concurrence for a monitoring exclusion.

2.1 Groundwater Monitoring Where Protected Water is Present

In order to assess the state's groundwater resources in a systematic way, the requirement for groundwater monitoring is currently limited to areas where "protected water" is present. (See Water Code section 10783, subdivisions (g)(2) and (j).) "Protected water" is used herein as:

- Water with less than 10,000 milligrams per liter (mg/L) of total dissolved solids (TDS), and
- Outside an exempt aquifer (meeting the criteria of Code of Federal Regulations, title 40, part 146.4).

A description of how area-specific groundwater monitoring shall be conducted is provided in the following section. Details on what shall be included in an area-specific groundwater monitoring plan are outlined in Section 2.1.2. Details regarding area-specific groundwater sampling and reporting are included in Sections 2.1.3 and 2.1.4, respectively.

2.1.1 Groundwater Monitoring Design

Area-specific groundwater monitoring shall be designed to characterize baseline water quality conditions and detect potential impacts to protected water from well stimulation treatments. A groundwater monitoring plan may be developed for multiple oil and gas wells to undergo stimulation if it is designed to sufficiently monitor protected water. The development of a groundwater monitoring plan may require preliminary data collection by the operator in order to identify the location(s) and depth(s) of protected water to be monitored.

Establishing Baseline Water Quality Conditions

Groundwater monitoring data will be used to establish baseline or reference point conditions of monitored chemical constituents. Baseline data collection shall commence prior to well stimulation. Water quality information from existing wells may be used to assist in establishing a baseline only if the information meets the requirements for area-specific groundwater monitoring.

As part of the groundwater monitoring plan, the operator shall submit proposed methods to be used to identify evidence of changes in chemical constituent concentrations in groundwater. A recommended method is the prediction limit in United States Environmental Protection Agency (U.S. EPA) (2009) Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance., U.S. EPA 530/R-09-007.

<http://www.epa.gov/solidwaste/hazard/correctiveaction/resources/guidance/sitechar/gwstats/index.htm> .

Water Boards staff will evaluate data and statistical test results to determine changes in water quality and whether additional monitoring requirements or corrective actions are necessary.

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Number and Locations of Monitoring Wells

Groundwater monitoring wells to be used for area-specific monitoring shall adequately characterize water quality in the vicinity of the stimulated well(s). Water supply wells and Regional Monitoring Program wells may be used as monitoring wells if approved by Water Boards staff. The number and locations of proposed monitoring wells in the monitoring plan shall address the following:

1. At a minimum, one upgradient and two downgradient monitoring wells will be required for each aquifer containing protected water that is penetrated by the stimulated well, or group of stimulated wells. Monitoring wells completed in each aquifer shall be constructed in similar zones of the aquifer, with similar construction details. Groundwater monitoring wells shall be located within 0.5 mile of the surface projection of the zone(s) of stimulation.
2. When multiple aquifers containing protected water are present, each aquifer shall be monitored separately. For each aquifer containing protected water located within 0.5 mile of the surface projection of the zone(s) of stimulation that is not penetrated by the well to undergo well stimulation, at least one monitoring well is required.
3. All groundwater monitoring wells shall be completed with limited screen lengths, preferably less than 50 feet. Approved screen lengths will be based on site geology and hydrostratigraphic conditions.
4. Monitoring wells shall be completed so the screened interval is located in a portion of the aquifer(s) that will best detect any impacts from well stimulation.
5. For any drinking water supply well located within one mile and downgradient of the surface projection of the zone(s) of stimulation, a sentry monitoring well shall be located between the stimulated well(s) and the drinking water supply well. The sentry monitoring well shall be located within 0.5 mile of the surface projection of the zone(s) of stimulation. If the drinking water supply well is screened across multiple protected water aquifers, then each protected water aquifer shall have a sentry monitoring well. In some cases, one sentry monitoring well may be used to monitor multiple drinking water supply wells. Monitoring wells, as described above, may act as the sentry well.
6. Any new water wells that are used for area-specific groundwater monitoring shall be constructed and properly developed and permitted in accordance with any applicable local well ordinances. If there are no applicable local well ordinances, they shall be constructed in accordance with Department of Water Resources Bulletin 74-81 as supplemented by Department of Water Resources Bulletin 74-90 (California Well Standards). Repurposed wells will be considered as alternative groundwater monitoring wells on a case-by-case basis. Under these specific circumstances, California Well Standards may not be applicable.

Water Boards staff may consider proposed alternatives and modifications to the methods described above, based on factors such as site-specific conditions (e.g. terrain, geology, access), number and depth of aquifers containing protected water, and potential risk to receptors (e.g., groundwater resources). A modification must not impair the Water Board's ability to assess the potential effects of well stimulation treatments as required by Water Code section 10783. Modifications to the methods described above must be proposed by an operator to the Water Boards prior to submitting a final monitoring plan.

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2.1.2 Groundwater Monitoring Plan Requirements

In order to develop a science-based groundwater monitoring plan, operators shall submit site-specific information including geology, geophysics, hydrogeology, geochemistry, and current and past field operations. Site-specific information will be used to evaluate potential mechanisms and pathways that may lead to groundwater impacts, and will be used to help in the design and review of a groundwater monitoring plan.

Area-specific groundwater monitoring plans shall include all of the items listed below.

1. A map of the oil field with a 0.5 mile buffer surrounding the oil field and any oil and gas wells located outside of the oil field boundary, that shows, at a minimum, the following:
 - a) Administrative boundary of the oil field
 - b) DOGGR-approved oil and gas production limits
 - c) Proposed area-specific groundwater monitoring boundary
 - d) Any other Water Boards approved area-specific groundwater monitoring boundaries
 - e) Active or inactive produced water ponds
 - f) Water supply wells (public, private domestic, irrigation, and industrial)
 - g) Surface features displayed on a topographic map
 - h) Legend, north arrow, and bar scale

2. A map of the area proposed for area-specific groundwater monitoring and a one mile buffer surrounding the area, that shows, at a minimum, the following:
 - a) Administrative boundary of the oil field
 - b) DOGGR-approved oil and gas production limits
 - c) Active or inactive produced water ponds
 - d) Active, inactive, idle, or abandoned water supply wells (public, private domestic, irrigation, and industrial)
 - e) Active, inactive, idle, or abandoned oil and gas wells, indicating which wells have previously undergone well stimulation
 - f) Oil and gas well(s) proposed to be stimulated
 - g) Active, inactive, idle, or abandoned UIC wells
 - h) Proposed groundwater monitoring wells
 - i) Line(s) of cross section

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- j) Surface features displayed on a topographic map
 - k) Legend, north arrow and bar scale
3. A map of the proposed groundwater monitoring network including a one mile buffer surrounding the area that shows, at a minimum, the following:
- a) Administrative boundary of the oil field
 - b) DOGGR defined oil and gas production limits
 - c) Active or inactive produced water ponds
 - d) Water supply wells (public, private domestic, irrigation, and industrial)
 - e) Oil and gas well(s) proposed to be stimulated
 - f) Estimated extent and orientation of the planned stimulation
 - g) Active, inactive, idle, or abandoned UIC wells
 - h) Proposed groundwater monitoring wells
 - i) Where available, contours showing the potentiometric surface for each protected water aquifer, showing arrows indicating groundwater flow direction. The operator shall document whether the water levels were measured during pumping or non-pumping conditions
 - j) Surface features displayed on a topographic map
 - k) Legend, north arrow, and bar scale
4. At a minimum, two scale cross-section(s) approximately perpendicular to one another that extend the length and width of the proposed monitoring area, and are representative of the area geology and hydrogeology, that show, at a minimum, the following:
- a) Depths and/or extent of current oil and gas production limits as defined by DOGGR and zone to be stimulated
 - b) Location of active or inactive produced water ponds
 - c) Depths of the vadose zone and water table
 - d) All geologic units, formations, and structures clearly labeled
 - e) The distribution of TDS in groundwater along the stratigraphic section between the water table and zone of stimulation
 - f) The distribution of gas presence and composition in groundwater, where available, along the stratigraphic section between the water table and zone of stimulation
 - g) Depths and extent of any aquifers classified as exempt by the U.S. EPA (pursuant to Code of Federal Regulations, title 40, part 146.4)

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- h) Depth and location of oil and gas well(s) proposed to be stimulated, showing the DOGGR-approved Axial Dimensional Stimulation Area (ADSA)². If multiple zones are proposed to be stimulated, include at least one proposed well to be stimulated for each zone
 - i) The estimated extent and orientation of the planned stimulation
 - j) Any wellbore within two times the DOGGR-approved ADSA of individual stimulation stages (this excludes wells located within the plan area of the DOGGR-approved ADSA, but that do not extend into this area)
 - k) Any known geologic features within or intersecting five times ADSA of any stage that have the potential to constitute a leakage pathway, including faults, fractures, or changes in stratigraphy
 - l) Depths and locations of any active and inactive UIC wells showing their zones of injection
 - m) Depths and locations of all active, inactive, idle, or abandoned oil wells that have previously undergone well stimulation
 - n) Any available geophysical logs (e.g., spontaneous potential, resistivity, and any porosity logs)
 - o) Depths of low-permeability zones and the strata (lithologic layers) that contain them that will or might function to hydraulically isolate the protected waters or the surface from any fluids injected or produced during or following the well stimulation
 - p) All wells shall be clearly marked and include well name(s) or identification numbers
 - q) Legend
 - r) Elevation reference, preferably normalized to mean sea level elevation, with scale clearly shown
5. At a minimum, two scale cross-section(s) approximately perpendicular to one another that extend from the surface to a depth of at least 500 feet below the stratigraphically lowest protected water aquifer, that show, at a minimum, the following (if vertical scale allows, the list of elements below can be included in the cross-section as outlined in 4, above):
- a) Depths of all protected water aquifers and the strata that contain them
 - b) Depths of the vadose zone and water table
 - c) All geologic units, formations, and structures clearly labeled
 - d) The distribution of TDS in groundwater along the stratigraphic section between the water table and zone of stimulation

² As defined in DOGGR's Well Stimulation Treatment Regulations, the ADSA is the estimated axial dimensions, expressed as maximum length, width, height, and azimuth of the area(s) stimulated by a well stimulation treatment.

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- e) The distribution of gas presence and composition in groundwater, where available, along the stratigraphic section between the water table and zone of stimulation
 - f) Depths and extent of any aquifers classified as exempt by the U.S. EPA (pursuant to Code of Federal Regulations, title 40, part 146.4)
 - g) Location of active or inactive produced water ponds
 - h) All wells should be clearly marked and include well name(s) or identification numbers
 - i) Groundwater elevation information
 - j) Depths and locations of any active and inactive UIC wells showing their zones of injection
 - k) At least one cross-section shall include an upgradient groundwater monitoring well, and one or more downgradient monitoring wells
 - l) For each protected water aquifer, indicate any available hydraulic conductivity data (in meters per second) and the source of the data (e.g., hydraulic test)
 - m) Any available geophysical logs (e.g., spontaneous potential, resistivity, and any porosity logs)
 - n) Depths of low-permeability zones and the strata that contain them that will function to hydraulically isolate the protected waters or the surface from any fluids injected or produced during or following the well stimulation
 - o) All wells shall be clearly marked and include well name(s) or identification numbers
 - p) Map Legend
 - q) Elevation reference, preferably normalized to mean sea level elevation, with scale clearly shown
6. Information, including methods and supporting data, used for the determination of TDS in groundwater along the stratigraphic section between the water table and zone of stimulation.
7. The locations, depths, screened intervals, and justification for each existing and new groundwater monitoring well(s) shall be included in the groundwater monitoring plan, including well completion reports for existing wells.
8. If any water wells identified within 0.5 mile of individual stimulation stages are not to be used for groundwater monitoring, a technical justification for their exclusion shall be included.
9. A detailed description of the well(s) to be stimulated, and any wells within two times the DOGGR-approved ADSA for any stage, including all of the following:
- a) American Petroleum Institute (API) identification numbers
 - b) Any available geophysical logs (e.g., including Spontaneous Potential, Resistivity, and any porosity logs), and any other logs or tests that can provide information about the integrity of annular seals, including past mechanical integrity tests.

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- c) Casing diagrams, including the following:
- Depths of perforation intervals
 - Diameter and depth of borehole
 - Cement plugs inside casings, including top and bottom of cement plug, with indication of method of determination
 - Cement fill behind casings, including top and bottom of cement fill, with indication of method of determination
 - Depths and names of the formations, zones, and markers penetrated by the well, including the top and bottom of the zone where well stimulation treatment will occur
 - Wellbore path giving both inclination and azimuth for directionally drilled wells
10. For any geologic features within or intersecting five times the DOGGR-approved ADSA of any stage that have the potential to constitute a leakage pathway (including faults, fractures, and changes in stratigraphy), the operator shall identify the potential risk where the geologic feature may act as a conduit and impact protected water.
11. For all existing wells to be used for monitoring, the operator shall submit well construction details and any lithologic information collected during well installation.
12. For all proposed water wells that will be used for monitoring, the operator shall submit well construction details.
13. A list of chemical additives and tracers anticipated to be used in the well stimulation, including:
- a) A complete list of the names, Chemical Abstract Service (CAS) numbers, and estimated concentrations, in percent by mass, of each chemical constituent of the well stimulation fluids anticipated to be used in the treatment (if a CAS number does not exist for a chemical constituent, another unique identifier may be used, if available), and
 - b) Radiological components or tracers to be used during the well stimulation treatment.
14. Details regarding sampling and testing procedures to be used that are consistent with the methods outlined in Section 2.1.3.
15. Details regarding reporting procedures to be used that are consistent with the methods outlined in Section 2.1.4.
16. The proposed plan is to be signed and sealed by a California registered professional geologist or engineer.

Addendum to an Approved Groundwater Monitoring Plan

An area-specific groundwater monitoring plan applies only to the stimulation well(s) identified by the operator in its proposal and approved by Water Boards staff. Where an operator proposes to stimulate additional wells in an area that has been approved by Water Boards staff for area-specific groundwater monitoring based on these Model Criteria, the

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operator is required to submit an addendum to the approved area-specific groundwater monitoring plan that includes, at a minimum, the following:

1. A map of the area-specific groundwater monitoring network, including a one mile buffer zone, that shows the following:
 - a) Administrative boundary of the oil field
 - b) DOGGR defined oil and gas production limits
 - c) Active or inactive produced water ponds
 - d) Water supply wells (public, private domestic, irrigation, and industrial)
 - e) All oil and gas well(s) proposed to be stimulated
 - f) Estimated extent and orientation of the planned stimulation
 - g) Active, inactive, or abandoned UIC wells
 - h) Proposed groundwater monitoring wells
 - i) Where available, contours showing the potentiometric surface for each protected water aquifer, showing arrows indicating groundwater flow direction. The operator shall document whether the water levels were measured during pumping or non-pumping conditions
 - j) Line(s) of cross section
 - k) Surface features displayed on a topographic map
 - l) Legend, north arrow, and bar scale
2. A detailed description of the well(s) to be stimulated, and any wells within two times the DOGGR-approved ADSA for any stage, including all of the following:
 - a) API numbers
 - b) Any available geophysical logs (e.g., including Spontaneous Potential, Resistivity, and any porosity logs) and any other logs or tests that can provide information about the integrity of annular seals, including past mechanical integrity tests.
 - c) Casing diagrams, including the following:
 - Depths of perforation intervals
 - Diameter and depth of borehole
 - Cement plugs inside casings, including top and bottom of cement plug, with indication of method of determination
 - Cement fill behind casings, including top and bottom of cement fill, with indication of method of determination
 - Depths and names of the formations, zones, and markers penetrated by the well, including the top and bottom of the zone where well stimulation treatment will occur
 - Wellbore path giving both inclination and azimuth for directionally drilled wells

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2.1.3 Sampling and Testing Requirements

For area-specific groundwater monitoring, the operator shall sample the groundwater monitoring wells as follows:

- Collect samples before well stimulation. Following well stimulation, area-specific groundwater monitoring wells shall be placed on a semi-annual monitoring schedule.
- The quarter selected for semi-annual sampling shall alternate each year. For example, the first year, the operator will collect samples during the first and third quarter; the following year, samples will be collected during the second and fourth quarters.
- All sampling work shall be collected under the oversight of a California Registered Professional Engineer or Professional Geologist.

All groundwater sampling, analytical testing, and monitoring conducted pursuant to these monitoring methods shall be done in accordance with all of the following:

1. All groundwater sampling is to be performed by a qualified person.
 - a) A qualified person is any person with the knowledge and training in proper sampling methods, chain of custody, and quality assurance/quality control protocols.
 - b) Any person conducting groundwater sampling, other than personnel from an approved laboratory, shall consult with the laboratory to ensure that the sampler understands and follows the proper sample collection procedures and protocols.
2. All procedures to sample groundwater monitoring wells shall be consistent with [US EPA Groundwater Sampling Guidelines for Superfund and RCRA Project Managers \(May 2002\)](#). All procedures to sample water supply wells shall be consistent with [US EPA Science and Ecosystem Support Division Operating Procedure for Groundwater Sampling](#) (March 2013). Alternative sampling methods may be used if approved by Water Boards staff.
3. Groundwater level and field parameters including pH, temperature, electrical conductivity, hydrogen sulfide, dissolved oxygen, and oxidation-reduction potential shall be measured and recorded before sample collection.
4. All analytical testing shall be performed by a laboratory that is certified by the State Water Board environmental laboratory accreditation program (ELAP).
5. Groundwater samples shall be analyzed for the analytes listed in **Table B1** of **Appendix B** using current applicable U.S. EPA-approved analytical methods. Based on analytical results, the State Water Board may modify the list of required analytes.
6. If information suggests potential impact(s) from a stimulation treatment (based on interpretation of baseline water quality conditions) Water Boards staff shall require testing of the analytes listed in **Table B2** of **Appendix B**.
7. Water Boards staff may request aquifer testing at monitoring wells if data are needed to evaluate aquifer conditions in the area of stimulated well(s).

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8. All purge water, soil cuttings, debris and other investigation derived materials are to be sealed and secured in clearly and properly labeled containers and shall be properly managed (removed, and/or disposed of) in accordance with all pertinent regulatory agency requirements, including permitting.

2.1.4 Reporting Requirements

All groundwater monitoring data collected in accordance with an area-specific groundwater monitoring plan shall be compiled in a groundwater monitoring report. The groundwater monitoring report and associated water quality data shall be submitted to the State Water Board in an electronic format and uploaded to the online GeoTracker groundwater information system following the guidelines detailed in California Code of Regulations, title 23, division 3, chapter 30 (commencing with section 3890).

Data collected prior to commencement of the well stimulation treatment and public disclosures required under California Code of Regulations, title 14, section 1788, shall be submitted in the first semi-annual groundwater monitoring report.

Data collected prior to commencement of the well stimulation request for water testing required under California Code of Regulations, title 14, section 1783.3, shall be submitted in the first semi-annual groundwater monitoring report.

Semi-annual groundwater monitoring reports shall include, at a minimum:

- 1) Site map clearly labeling and showing the location of all oil and gas wells that have or will undergo stimulation, all groundwater monitoring and water supply wells (public, private domestic, irrigation, and industrial), sample location(s) requested for water testing required under California Code of Regulations, title 14, section 1783.3, active or inactive UIC wells, active or inactive oil and gas wells, any oil and gas wells that have been previously stimulated, and active or inactive produced water ponds:
 - a) Within one mile of any vertical well(s) that underwent stimulation, or
 - b) Within one mile of the surface projection of the portion of the well that underwent stimulation in directionally drilled horizontal wells.
- 2) Table(s) of analytical results, with both recent and historical data in chronological order and tabulated by monitoring well number or other identification.
- 3) Potentiometric map(s) for each protected water aquifer and at least one cross-section displaying groundwater analytical results for TDS by depth.
- 4) Description of field activities, including well installation, groundwater sampling, and decontamination procedures.
- 5) Copies of analytical laboratory reports, including quality assurance/quality control procedures and analytical test methods.
- 6) Well completion reports for all new water wells that will be used for monitoring.
- 7) A detailed description of any additional wells installed within two times the DOGGR-approved ADSA for any stage, including all of the following:
 - a) American Petroleum Institute (API) identification numbers

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- b) Any available geophysical logs (e.g., including Spontaneous Potential, Resistivity, and any porosity logs), and any other logs or tests that can provide information about the integrity of annular seals, including past mechanical integrity tests
- c) Casing diagrams, including the following:
 - Depths of perforation intervals
 - Diameter and depth of borehole
 - Cement plugs inside casings, including top and bottom of cement plug, with indication of method of determination
 - Cement fill behind casings, including top and bottom of cement fill, with indication of method of determination
 - Depths and names of the formations, zones, and markers penetrated by the well, including the top and bottom of the zone where well stimulation treatment will occur
 - Wellbore path giving both inclination and azimuth for directionally drilled wells
- 8) Changes, if any, to the scope of work, and rationale for the changes.
- 9) Waste management and disposal procedures, including associated documentation, permits, manifests, and bills of lading.
- 10) The report is to include a detailed description, which should include at a minimum a summary of groundwater flow patterns, gradients, known velocities, and analysis and interpretation of data collected to date and any potential impacts from well stimulation activities for each monitored aquifer zone.
- 11) The report is to be signed and sealed by a California registered professional geologist or engineer.

Water Boards staff will evaluate data and statistical test results to determine changes in water quality and whether additional monitoring requirements or corrective actions are necessary.

2.2 Requests for Exclusion from Area-specific Groundwater Monitoring Requirement Based on Absence of Protected Water

Area-specific groundwater monitoring related to well stimulation treatment on oil or gas wells is required, unless an operator has received written concurrence from Water Boards staff for an exclusion from the monitoring requirement (written concurrence).

Water Code section 10783 provides that groundwater monitoring is not required if the wells to be stimulated do not penetrate groundwater of beneficial use, or solely penetrate aquifers exempted under section 146.4 of title 40 of the Code of Federal Regulations.

An operator may seek written concurrence from Water Boards staff where the operator can demonstrate the absence of protected water. Written concurrence may relate to a single proposed well to be stimulated, a group of proposed wells to be stimulated, or a geographic area.

As previously stated, protected water for current and future beneficial use is defined as:

- Water with less than 10,000 mg/L TDS, and

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- Outside an exempt aquifer (meeting the criteria of Code of Federal Regulations, title 40, part 146.4).

To seek written concurrence that groundwater monitoring is not required, an operator shall submit information to Water Boards staff that clearly indicates the absence of protected water in the vicinity of the well to undergo stimulation. If the technical submittal provided by the operator clearly indicates the absence of protected water, Water Boards staff will issue written concurrence. However, if future information indicates the well will penetrate protected water, the State Water Board may reevaluate its determination.

Written concurrence issued prior to the date of adoption of the Model Criteria for Groundwater Monitoring by the State Water Board are effective only for well stimulation permits issued by DOGGR prior to that date.

Operator requests for written concurrence shall be in a defined geographic area that is generally no larger than a map section (one-square mile). To demonstrate the absence of protected water, an operator shall provide the information as outlined below (Water Boards staff may also request additional information as warranted):

1. Oil field site map clearly labeled to show the location of all oil and gas wells (with legend, north arrow, and bar scale) that have or will undergo stimulation, active or inactive UIC, oil and gas wells, active or inactive produced water ponds, all water wells (public, private domestic, irrigation, industrial, and monitoring), and all abandoned wells of any type.
2. A map of the subject area where the operator is proposing absence of protected water displaying the location (with legend, north arrow and bar scale) of the following:
 - a) All oil and gas wells that have or will undergo stimulation, all UIC wells, and all active, abandoned, or inactive oil and gas wells within the subject area where the operator is proposing absence of protected water,
 - b) All existing water supply wells (public, private domestic, irrigation, and industrial) and any groundwater monitoring wells within one mile of the subject area where the operator is proposing absence of protected water, and
 - c) Any additional applicable information.
3. Geologic cross-sections through each well to undergo stimulation, showing the well construction details from the surface (outcrop) to total depth, depicting all geologic units, geologic structure, fluid-bearing formations, extent of oil and gas production zones, and depth to first encountered fluid for each well (oil and water). At a minimum, two cross-sections: one across the strike, one across the dip (where available, at least 5 wells per cross-section).
4. Applicable geophysical well log information, including digital copies of well logs.
5. Proposed stimulation depth(s) for each well.
6. Laboratory analysis for any water samples that demonstrate the proposed well to be stimulated does not penetrate protected waters.
7. Detailed analysis and methods used to estimate TDS concentrations using geophysical log data.
8. Any available detailed borehole logs.
9. Distance to the nearest water supply well(s).

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10. Aquifer exemption documentation per Code of Federal Regulations, title 40, part 146.4, as applicable.
11. Any additional documentation and evidence that supports the operator's assertion that there are no protected waters in the area.
12. Submittal signed and sealed by California registered professional geologist or engineer.

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3.0 Requirements for Designated Contractor Sampling and Testing

This section describes standards and protocols to perform property owner requested water sampling and testing as described in Public Resources Code section 3160, subdivision (d)(7). These requirements include:

- How to become a designated contractor for water sampling, and
- Water quality testing standards, protocols, and data submittal.

3.1 How to Become a Designated Contractor for Water Sampling

The State Water Board is required to designate one or more qualified independent third-party contractors to perform property owner requested water quality sampling and testing. All water sampling and analytical testing conducted pursuant to this section, shall be performed by an independent third-party contractor that meets the following requirements:

- 1) A person representing a corporation, sole proprietorship, partnership, or any other business entity, not owned in whole or part, by the oil or gas well owner or operator, or any of their parent companies, subsidiaries or contractors, for the well stimulation project for which water sampling and analytical testing is to be performed.
- 2) Not an employee or contractor of the oil or gas well owner or operator, or any of their parent companies, subsidiaries or contractors, for the well stimulation project for which water sampling and analytical testing is to be performed.
- 3) A person with the knowledge and training in proper sampling methods, chain of custody, and quality assurance/quality control protocols.
- 4) Any person conducting water sampling, other than personnel from an approved laboratory, shall consult with the laboratory to ensure that the sampler understands and follows the proper sample collection procedures and protocols.
- 5) A qualified person shall notify the State Water Board at least two working days prior to water sampling.
- 6) A qualified person shall retain all records associated with designated contractor property owner requested water sampling for three calendar years following sampling and analytical testing, and to promptly submit copies of these records to the State Water Board upon request.
- 7) All parties interested in becoming a designated sampler shall complete and submit the "Application to be a Designated Third-Party Contractor for Property Owner Requested Water Sampling and Testing" found at the State Water Board's website.

3.2 Water Quality Testing Standards, Protocols, and Data Submittal

- 1) All procedures to sample water supply wells shall be consistent with US EPA Science and Ecosystem Support Division Operating Procedure for Groundwater Sampling U.S. EPA (March 2013), including pre-sampling purge methods and purge volumes consistent with Detection Monitoring protocol.
- 2) All procedures to sample surface water shall be in accordance with the State Water Board's Surface Water Ambient Monitoring Program Quality Assurance Project Plan.

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- 3) All analytical testing shall be performed by a laboratory that is ELAP certified.
- 4) All water quality data and water monitoring reports shall be submitted to the State Water Board in an electronic format that follows the guidelines detailed in California Code of Regulations, title 23, division 3, chapter 30 (commencing with section 3890).
- 5) Groundwater level and field parameters including pH, temperature, electrical conductivity, dissolved oxygen, and oxidation-reduction potential shall be measured and recorded before sample collection.
- 6) For all water sampling and analytical testing conducted pursuant to this section, water samples shall be analyzed using the analytes listed in **Table B1** of **Appendix B** using current applicable U.S. EPA-approved analytical methods.

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4.0 Regional Groundwater Monitoring Program

The State Water Board is required to begin implementing a Regional Monitoring Program by January 1, 2016. Factors considered for the Regional Monitoring Program design include well stimulation treatments, among other events or activities that have the potential to contaminate groundwater, such as an oil and gas well failure or breach. The volume of fluid used in well stimulation activities while small compared to other oil and gas production generated fluids (e.g. water flood, wastewater disposal), still becomes part of the overall waste stream in oil production. As a result, all fluids produced or introduced in the well stimulation process will be examined in the Regional Monitoring Program including, but not limited to, produced water ponds and UIC wells.

Due to the large scale associated with a regional groundwater monitoring program, it will take a considerable amount of time before an appropriate level of data is collected and the density of the groundwater monitoring well network is fully established. The program will be conducted in a phased approach, with the first phase anticipated to take approximately five years to accomplish. Details on the approach are discussed in the following sections.

4.1 Interim Period – Preliminary Surveys and Pilot Studies

Since there is a lack of sufficient groundwater data and information related to oil and gas fields, State Water Board staff worked with the United States Geological Survey (USGS) to develop a conceptual model for a Regional Monitoring Program starting in 2014. Assessment of existing information, as well as collection of new information, was conducted through reconnaissance-level vulnerability assessments, and detailed characterization of two oil fields.

Reconnaissance-level vulnerability assessments were conducted at two oil fields in Kern County. The proximity of oil and gas production zones to groundwater resources in these areas was assessed. The preliminary results indicated one field had a higher number of oil and gas wells screened at similar depths, or were in close proximity to screened intervals of nearby water supply wells. In contrast, the other field indicated a higher degree of separation between oil and gas wells and screened intervals of nearby water supply wells. The results from this assessment were used to inform the development of characterizing groundwater risk zones.

The USGS also evaluated TDS concentrations in three dimensions by analyzing water quality information in the Wilmington and Santa Maria Field areas. Preliminary results indicate that high TDS waters within oil and gas production zones have greater vertical separation from lower TDS groundwater in the Santa Maria Field than in the Wilmington Field. This assessment suggests oil fields that show a smaller separation between oil and gas production zones and higher quality, lower TDS groundwater, may be a higher priority for groundwater monitoring.

Accurately identifying the location of protected waters relative to current and past well stimulation, among other activities that have the potential to impact groundwater, is critical. A preliminary review identified the location of domestic water supply wells in relation to oil and gas wells, including UIC wells. This well survey identified several areas that have significant horizontal and vertical well overlap that indicates groundwater resources may be at risk (**Figure 1**).

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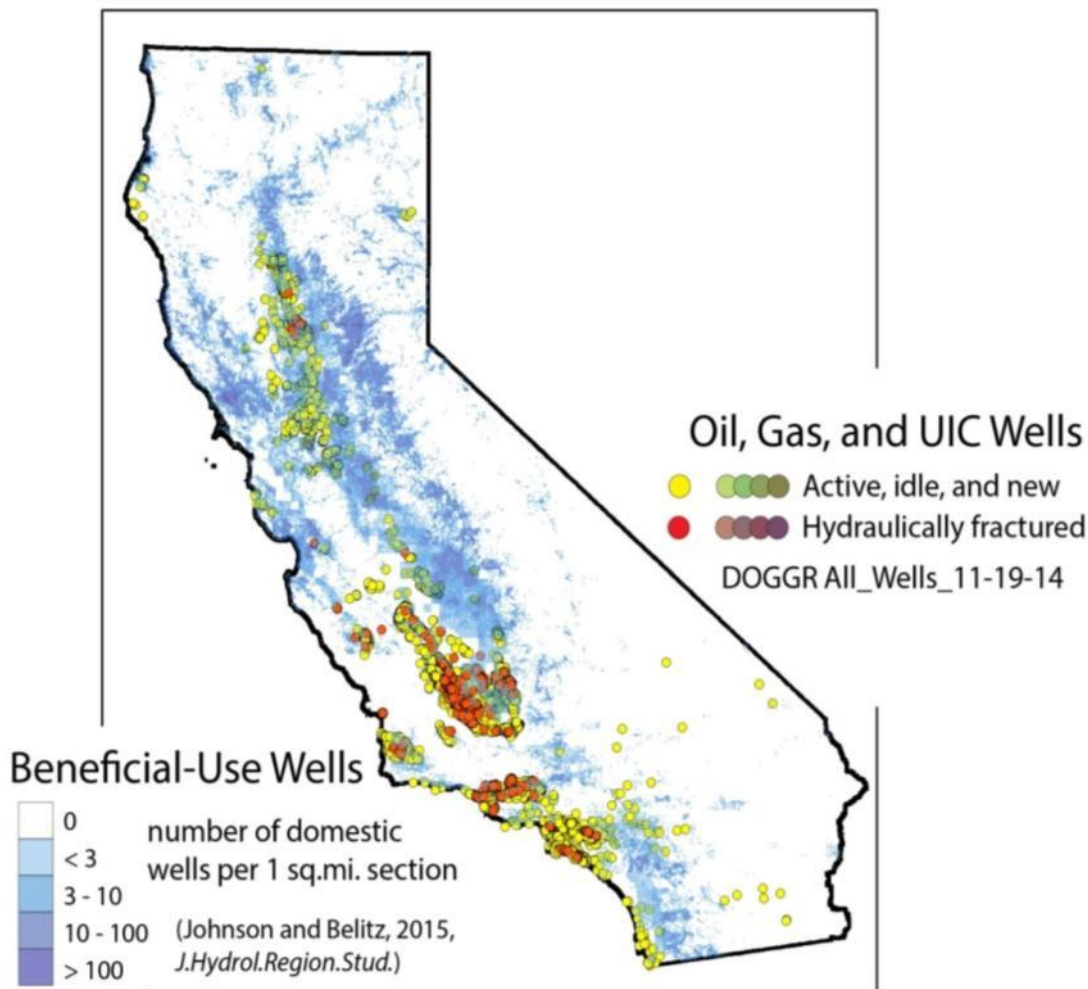


Figure 1. Comparison of Locations of Water Supply Wells (Beneficial Use Wells) and Oil, Gas, and Underground Injection Control Wells.

4.2 Components of the Regional Monitoring Program

Information collected during the exploratory background surveys have been used to develop an initial approach for the Regional Monitoring Program. Three main components of the Regional Monitoring program have been established and include:

- Characterizing and Monitoring Groundwater Risk Zone,
- Surface activity effects, and
- Well integrity.

Assessing potential water quality impacts related to these three components will help to systematically and comprehensively collect and interpret information that will support management and protection of waters designated for any beneficial use, while prioritizing the monitoring of groundwater that is or has the potential to be a source of drinking water.

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Characterizing and Monitoring Groundwater Risk Zones

The goals of characterizing and monitoring related to groundwater risk are to:

- Characterize the risk of any fluid related to well stimulation migrating into waters of beneficial use, while prioritizing monitoring of water that is or has the potential to be a source of drinking water, and
- Establish monitoring networks to provide early warning in higher risk zones.

This will be achieved by mapping the extent, in three dimensions, of beneficial use water resources near oil and gas fields, and performing assessments to determine if fluids related to well stimulation, or other events or activities that have the potential to contaminate groundwater (e.g. well failure or breach), have migrated into these groundwater resources. These assessments require geochemical, hydrogeological, geological, and geophysical tools and the development of integrated conceptual models of transport potential for each oil field under investigation. Other events or activities associated with well stimulation that have the potential to contaminate groundwater may include underground injection and surface releases.

Surface Activity Effects

The goals of groundwater monitoring related to surface activity effects are to:

- Characterize the effect of legacy and currently regulated surface activities, including sumps and spills, and
- Characterize risks to shallow water users from chemical constituents associated with well stimulation.

Near-surface contamination associated with well stimulation activities may pose a risk to groundwater resources, specifically shallower groundwater resources that are typically used for beneficial use such as drinking water. Surface spills and produced water ponds are currently regulated by Regional Water Boards, which commonly require site-specific investigations and corrective actions. The State Water Board Groundwater Ambient Monitoring and Assessment (GAMA) Program design applied to an area with a history of surface activities would be an appropriate approach. This component would require sampling and analyses of produced water ponds, oil and gas formation water, and groundwater under produced water ponds.

Well Integrity

The goal of groundwater monitoring related to well integrity is to assess potential risks to water quality from well bore integrity and inadequate seals. There is a limited amount of information regarding the age of an oil well, standards of well construction, well material degradation, improper well abandonment, and whether external forces (e.g., subsidence) correspond to well failure or breach, and groundwater degradation. Evaluation methods are best carried out after the fluid transport component is determined in an oil field. This sequence will ensure that enough detailed information is available to differentiate between well integrity and other pathways for groundwater contamination.

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4.3 Regional Monitoring Program Approach

The first phase of the Regional Monitoring Program will focus on identifying where vulnerable beneficial use water resources are located. Part of that effort will systematically delineate aquifer zones containing less than 3,000 mg/L TDS and between 3,000 and 10,000 mg/L TDS to help create a tiered approach for the regional monitoring.

Establishing a baseline of water quality is a critical step of the Regional Monitoring Program and likely will require years of data gathering and analysis. The next step will consist of establishing a vulnerability model to consider ranking levels of relative risk to groundwater resources. Risk parameters may include, but are not limited to, oil and gas field proximity (vertically and horizontally) to beneficial use water with an emphasis on those areas used for drinking water purposes. Over the course of time, these approaches may be modified as necessary to best make use of time and resources.

The Regional Monitoring Program well network will be designed using shallow, mid-depth, and deep monitoring wells along multiple flow paths in and adjacent to a given oil field. Initially, well types to be used will rely on existing wells using depth dependent sampling techniques. New monitoring wells will be installed in areas as necessary. Options include a cluster of single wells, each screened at discrete depths in separate aquifers, nested wells where several wells are placed in a single borehole, or a depth-discrete multilevel monitoring system in a multiple screened well casing. For deeper zones, converting idle oil and gas production-related wells into monitoring wells will also be investigated as an alternative to installing new monitoring wells.

Due to the number and density of monitoring wells necessary to properly assess the potential effects of well stimulation treatments, it is expected that the Regional Monitoring Program well network will need to be supplemented with additional monitoring wells installed as part of an area specific groundwater monitoring plan.

Monitoring wells must be constructed properly, developed, and permitted in accordance with applicable local well ordinances. If there are no applicable local well ordinances, they will be constructed in accordance with the California Well Standards. Waste management and disposal procedures, including associated documentation, permits, manifests, and bills of lading will also be documented.

Sampling and Testing Parameters

Regional Monitoring Program groundwater monitoring wells will be sampled frequently enough to detect changes in water quality. Water quality monitoring will also be coordinated with other related water quality monitoring efforts, such as the area-specific groundwater monitoring conducted by well operators, any environmental monitoring associated with other oil and gas activities, and any other groundwater monitoring efforts such as the GAMA Program. Water quality data associated with the Regional Monitoring Program will be uploaded to the online GeoTracker groundwater information system.

Groundwater sampling and analytical testing conducted pursuant to the Regional Monitoring Program will consist of the chemical constituents analyzed in samples collected for the operator area-specific monitoring and additional constituents that may be useful for identifying and understanding constituent sources and transport processes. These additional chemical constituents may include, but may not be limited to:

- Hydrocarbon gas concentrations and isotopic compositions,

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- Noble gas concentrations and isotopic compositions,
- A broader suite of volatile and semi-volatile organic compounds,
- Groundwater age dating tracers,
- Isotopic compositions of water and dissolved inorganic constituents (e.g. Lithium, Boron, Sulfur, and Strontium), and
- Concentrations of additional inorganic constituents.

Pilot and Special Studies

Understanding of the impact of oil and gas development on groundwater resources in California and how to best monitor for potential impacts is limited. To help address these and other data gaps, focused field or pilot studies will be conducted in parallel with other activities. These focused studies could include investigations of:

- The use of inactive oil and gas production or injection wells as monitoring wells,
- Tracking the movement (fate and transport) of chemicals associated with oil and gas production in groundwater,
- Various monitoring methods,
- Ways to define potential contamination pathways, and
- Potential risks associated with well failure or breach.

4.4 Regional Monitoring Program Review

The implementation of the Regional Groundwater Monitoring Program is the first of its type in the United States. The State Water Board will periodically review data associated with well stimulation and groundwater monitoring to assure quality results and assessments.

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APPENDIX A

Text of Water Code Section 10783

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Water Code Section 10783

- (a) The Legislature finds and declares that protecting the state's groundwater for beneficial use, particularly sources and potential sources of drinking water, is of paramount concern.
- (b) The Legislature further finds and declares that strategic, scientifically based groundwater monitoring of the state's oil and gas fields is critical to allaying the public's concerns regarding well stimulation treatments of oil and gas wells.
- (c) On or before July 1, 2015, in order to assess the potential effects of well stimulation treatments, as defined in Article 3 (commencing with Section 3150) of Chapter 1 of Division 3 of the Public Resources Code, on the state's groundwater resources in a systematic way, the state board shall develop model groundwater monitoring criteria, to be implemented either on a well-by-well basis for a well subject to well stimulation treatment or on a regional scale. The model criteria shall address a range of spatial sampling scales from methods for conducting appropriate monitoring on individual oil and gas wells subject to a well stimulation treatment, to methods for conducting a regional groundwater monitoring program. The state board shall take into consideration the recommendations received pursuant to subdivision (d) and shall include in the model criteria, at a minimum, the components identified in subdivision (f). The state board shall prioritize monitoring of groundwater that is or has the potential to be a source of drinking water, but shall protect all waters designated for any beneficial use.
- (d) The state board, in consultation with the Department of Conservation, Division of Oil, Gas, and Geothermal Resources, shall seek the advice of experts on the design of the model groundwater monitoring criteria. The experts shall assess and make recommendations to the state board on the model criteria. These recommendations shall prioritize implementation of regional groundwater monitoring programs statewide, as warranted, based upon the prevalence of well stimulation treatments of oil and gas wells and groundwater suitable as a source of drinking water.
- (e) The state board shall also seek the advice of stakeholders representing the diverse interests of the oil- and gas-producing areas of the state. The stakeholders shall include the oil and gas industry, agriculture, environmental justice, and local government, among others, with regional representation commensurate with the intensity of oil and gas development in that area. The stakeholders shall also make recommendations to the state board regarding the development and implementation of groundwater monitoring criteria, including priority locations for implementation.
- (f) The scope and nature of the model groundwater monitoring criteria shall include the determination of all of the following:
- (1) An assessment of the areas to conduct groundwater quality monitoring and their appropriate boundaries.
 - (2) A list of the constituents to measure and assess water quality.
 - (3) The location, depth, and number of monitoring wells necessary to detect groundwater contamination at spatial scales ranging from an individual oil and gas well to a regional groundwater basin including one or more oil and gas fields.
 - (4) The frequency and duration of the monitoring.
 - (5) A threshold criteria indicating a transition from well-by-well monitoring to a regional monitoring program.

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- (6) Data collection and reporting protocols.
- (7) Public access to the collected data under paragraph (6).
- (g) Factors to consider in addressing subdivision (f) shall include, but are not limited to, all of the following:
 - (1) The existing quality and existing and potential use of the groundwater.
 - (2) Groundwater that is not a source of drinking water consistent with the United States Environmental Protection Agency's definition of an Underground Source of Drinking Water as containing less than 10,000 milligrams per liter total dissolved solids in groundwater (40 C.F.R. 144.3), including exempt aquifers pursuant to Section 146.4 of Title 40 of the Code of Federal Regulations.
 - (3) Proximity to human population, public water service wells, and private groundwater use, if known.
 - (4) The presence of existing oil and gas production fields, including the distribution, physical attributes, and operational status of oil and gas wells therein.
 - (5) Events, including well stimulation treatments and oil and gas well failures, among others, that have the potential to contaminate groundwater, appropriate monitoring to evaluate whether groundwater contamination can be attributable to a particular event, and any monitoring changes necessary if groundwater contamination is observed.
- (h)
 - (1) On or before January 1, 2016, the state board or appropriate regional board shall begin implementation of the regional groundwater monitoring programs based upon the model criteria developed under subdivision (c).
 - (2) In the absence of state implementation of a regional groundwater monitoring program, a well owner or operator may develop and implement an area-specific groundwater monitoring program, for the purpose of subparagraph (D) of paragraph (3) of subdivision (d) of Section 3160 of the Public Resources Code, based upon the model criteria developed under subdivision (c), subject to approval by the state or regional board, and that meets the requirements of this section.
- (i) The model criteria for either a well-by-well basis for a well subject to well stimulation treatment, or for a regional groundwater monitoring program, shall be used to satisfy the permitting requirements for well stimulation treatments on oil and gas wells pursuant to Section 3160 of the Public Resources Code. The model criteria used on a well-by-well basis for a well subject to a well stimulation treatment shall be used where no regional groundwater monitoring plan approved by the state or regional board, if applicable, exists and has been implemented by either the state or regional board or the well owner or operator.
- (j) The model criteria shall accommodate monitoring where surface access is limited. Monitoring is not required for oil and gas wells where the wells do not penetrate groundwater of beneficial use, as determined by a regional water quality control board, or solely penetrate exempt aquifers pursuant to Section 146.4 of Title 40 of the Code of Federal Regulations.
- (k)
 - (1) The model criteria and groundwater monitoring programs shall be reviewed and updated periodically, as needed.
 - (2) The use of the United States Environmental Protection Agency's definition of an Underground Source of Drinking Water as containing less than 10,000 milligrams per liter total dissolved solids in groundwater (40 C.F.R. 144.3) and whether exempt aquifers pursuant to Section 146.4 of Title 40 of the Code of Federal Regulations shall

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be subject to groundwater monitoring shall be reviewed by the state board through a public process on or before January 1, 2020.

- (l) (1) All groundwater quality data collected pursuant to subparagraph (F) of paragraph (1) of subdivision (d) of Section 3160 of the Public Resources Code shall be submitted to the state board in an electronic format that is compatible with the state board's GeoTracker database, following the guidelines detailed in Chapter 30 (commencing with Section 3890) of Division 3 of Title 23 of the California Code of Regulations.

(2) A copy of the reported data under paragraph (1) shall be transferred by the state board to a public, nonprofit doctoral-degree-granting educational institution located in the San Joaquin Valley, administered pursuant to Section 9 of Article IX of the California Constitution, in order to form the basis of a comprehensive groundwater quality data repository to promote research, foster interinstitutional collaboration, and seek understanding of the numerous factors influencing the state's groundwater.
- (m) The adoption of criteria required pursuant to this section is exempt from the rulemaking provisions of the Administrative Procedure Act (Chapter 3.5 (commencing with Section 11340) of Part 1 of Division 3 of Title 2 of the Government Code). The adoption of criteria pursuant to this section shall instead be accomplished by means of a public process reasonably calculated to give those persons interested in their adoption an opportunity to be heard.

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APPENDIX B

List of Required Analytes

Tables B1 and B2

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Table B1 – List of Required Analytes for Area-specific and Designated Contractor Water Sampling

Analyte	Area-Specific	Designated Contractor
Total dissolved solids (TDS)	x	x
Major and minor cations, including sodium, potassium, magnesium, calcium, and ammonium	x	x
Major and minor anions, including nitrate, chloride, fluoride, sulfate, bromide, iodide, and total inorganic carbonate (bicarbonate + carbonate)	x	x
Trace elements, including iron, manganese, lithium, strontium, barium, and boron	x	x
All metals and metalloids listed in California Code of Regulations, title 22, section 66261.24, subdivision (a)(2)(A), including arsenic, barium, cadmium, chromium, lead mercury, and selenium (excluded from the Title 22 list are asbestos and fluoride salts)	x	x
Radionuclides listed under California Code of Regulations, title 22, Table 64442 (includes Ra-226, Ra-228, and uranium)	x	x
Methane, ethane, propane	x	x
Dissolved organic carbon (DOC)	x	x
BTEX (benzene, toluene, ethylbenzene, and xylenes) and tentatively identified compounds (TICs)	x	x
Trimethylbenzenes, trimethylbenzene, acetone, methylene chloride	x	x
Total petroleum hydrocarbons for crude oil, gasoline, and diesel ranges	x	x
PAH (polynuclear aromatic hydrocarbons) including the 16 priority pollutant PAHs (acenaphthene, acenaphthylene, anthracene, benz[<i>a</i>]anthracene, benzo[<i>b</i>]fluoranthene, benzo[<i>k</i>]fluoranthene, benzo[<i>a</i>]pyrene, benzo[<i>ghi</i>]perylene, chrysene, dibenzo[<i>a,h</i>]anthracene, fluoranthene, fluorene, indeno[1,2,3- <i>cd</i>]pyrene, naphthalene, phenanthrene, and pyrene) and (TICs)	x	x
Stable carbon isotopes in dissolved methane (if present)	x	
Stable isotopes of oxygen and hydrogen in water	x	
Guar gum sugars (if guar gum is used in the well stimulation)	x	
At least two additional analytes selected by the operator, to be reviewed by Water Boards staff. The analytes chosen shall be well stimulation chemical additives or their degradation products. One chemical constituent shall be chosen based on large soluble mass used during well stimulation; the other chemical constituent will be chosen based on high persistence in the subsurface. Availability of a laboratory analytical method shall also be considered. For instance, if there are several chemical constituents of high persistence, then the constituent with a combination of greatest injected mass and persistence shall be monitored, if there is an accepted laboratory analytical method available.	x	

Note: Analytes are to be tested using available EPA-approved analytical methods, using drinking water detection limits.

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Table B2 - Additional Analytes for Area-specific Sampling That May Be Required

Cationic, anionic, and nonionic surfactants used during well stimulation
Alcohols and glycols used during well stimulation
<p>Biocides used during well stimulation, including any of the following compounds and their known harmful or persistent degradation products:</p> <ul style="list-style-type: none"> - Glutaraldehyde, - DBNPA (2,2-dibromo-3-nitrilopropionamide) and its degradation products dibromoacetonitrile, dibromoacetic acid, and dibromoacetamide, and - Isothiazolinones (e.g., 2-methyl-3-isothiazolinone, 5-chloro-2-methyl-3-isothiazolinone).
Tracers used during well stimulation

Note: Analytes are to be tested using available EPA-approved analytical methods, using drinking water detection limits.