EXHIBIT A
SCOPE OF WORK

1. Overview

The U.S. Geological Survey (USGS) agrees to provide the State Water Resources Control Board (referred to herein as the Water Board) research and technical assistance as described herein:

Senate Bill 4 of 2013 (hereinafter referred to as SB 4) mandated that the Water Board design and implement groundwater monitoring programs to assess and track the potential interactions between well stimulation methods used to increase oil/gas reservoir permeability and groundwater resources. These well stimulation methods include hydraulic fracturing and acid matrix dissolution. The groundwater monitoring described by SB4 consists of two groundwater activities: regional monitoring and well operator monitoring. The regional groundwater monitoring (Regional Oil and Gas Groundwater Monitoring) could assess and track the potential effects of well stimulation for oil and gas extraction on groundwater resources that currently or may in the future, have beneficial uses. The well operator monitoring (Operator Monitoring) would occur in the absence of state implementation of the Regional Oil and Gas Groundwater Monitoring, and involves oil/gas companies submitting a plan for monitoring groundwater quality. The Operator Monitoring can consist of either monitoring near individual wells undergoing well stimulation (well-by-well), or on an oil-field area basis (area-specific). The areas in which well stimulation methods are currently being used have long histories of oil and gas development, including current extraction by conventional means. In addition, oil and gas well construction standards, oil and gas extraction technologies, and oil and gas field waste management practices have changed over time. In order to distinguish the effects of well stimulation on groundwater resources from the effects of other past or present components of oil and gas development, the Regional Oil and Gas Groundwater Monitoring may include an overall assessment of the effects of oil and gas development on groundwater resources.

SB4 requires that the Water Board develop groundwater monitoring model criteria (model criteria) for the two programs by July 1, 2015, and that the development process include consultation with experts and input from stakeholders. This Agreement describes the technical assistance that the USGS shall provide to the Water Board during the development of the model criteria, and associated work. The USGS shall provide technical assistance in three areas of the process: (A) development of the model criteria; (B) preliminary assessment of the vulnerability of groundwater resources – which vary greatly across California – to oil and gas extraction activities; and (C) exploratory sampling to evaluate methods for detecting effects of oil and gas development on groundwater quality and to provide data needed by the Water Board for development of the model criteria for the programs.

EXHIBIT A
SCOPE OF WORK

2. Location

The work shall be performed as stipulated in Tasks 1 – 5.

3. Hours

The work shall be provided during normal USGS working hours.

4. Project Representatives

A. The project representatives during the term of this agreement will be:

State Water Resources Control Board	United States Geological Survey
Section/Unit: GAMA unit	Section/unit: California Water Science Center
Contract manager: John Borkovich	Project Director: Miranda Fram
Address: 1001 I Street, Sacramento, CA 95814	Address: 6000 J Street, Placer Hall, Sacramento, CA 95819-6129
Tel: (916) 341-5779	Tel: (916) 278-3088
Fax: (916) 341-5808	Fax: (916) 278-3071
E-mail: john.borkovich@waterboards.ca.gov	E-mail: mfram@usgs.gov

B. Either party may make changes to the information above by giving ten (10) days written notice to the other party. Said changes shall not require an amendment to this agreement.

5. Work to be Performed

A. Purpose and Objectives

California is in the process of developing model criteria to assess the potential effects of oil and gas development on groundwater resources. Currently, the Division of Oil, Gas, and Geothermal Resources (DOGGR), the Water Board, the Regional Water Quality Control Boards (RWQCBs), and the Department of Water Resources (DWR) all have roles in reviewing oil and gas development and waste disposal practices, managing activities which degrade water quality, and managing groundwater resources that currently, or can potentially in the future, support multiple beneficial uses, including sources of public and domestic drinking water, agricultural supply, and industrial supply.

EXHIBIT A
SCOPE OF WORK

B. Project Tasks

The Scope of Work consist of five (5) tasks:

Task	Description
1	Project management and administration
2	Technical assistance during development of model criteria for the Regional Oil and Gas Groundwater Monitoring and Operator Monitoring
3	Preliminary assessment of vulnerability of California's groundwater resources to oil and gas extraction activities.
4	Exploratory groundwater sampling to identify potential effects of well stimulation
5	Publications and transfer information and skills to Water Board staff

The USGS shall carry out tasks that address the needs of the Water Board in designing groundwater monitoring programs as required by SB4. This work shall result in specified deliverables that include draft reports, groundwater-quality data, electronically complied information such as well completion information, and presentation materials. Technical assistance, monitoring, and assessment activities shall be conducted in accordance with the general requirements specified below:

1. All USGS reports shall contain the following title wording: SB 4 Oil and Gas Groundwater Monitoring
2. The USGS shall provide draft reports to appropriate personnel at the Water Board.
3. Prior to implementing sampling in any given geographic area, the USGS shall examine existing data, references, and ongoing studies relevant to the topic and area of interest. Reports and other documents prepared by USGSs shall appropriately acknowledge these data, references, and ongoing research.
4. Prior to implementing sampling in any given geographic area, the USGS shall contact appropriate local agencies or property owners to inform them of upcoming activities.

Task 1. Project Management and Administration

The USGS shall provide all staff tools, materials, and supplies and be responsible for the performance of the work as set forth herein below and for the preparation of the products and a final report as specified in this Exhibit. The USGS shall notify the Water Board Contract Manager of events, or proposed changes that could affect the scope, budget, or schedule of work performed under this agreement.

1.1 Provide all technical and administrative work as needed for agreement completion; monitor, supervise, and review all work performed; and coordinate budgeting and scheduling to assure that the agreement is completed within the budget, on schedule, and in accordance with approved procedures, applicable laws, and regulations.

1.2 The USGS shall coordinate with staff from the Water Board regarding sample collection, analysis, and data reporting. The USGS shall participate in SB4 meetings. The USGS shall notify the Water Board prior to any distribution or presentation of SB4 data. All presentation of SB4 data (e.g., meetings, reports, posters, press releases, interviews, and presentations)

EXHIBIT A
SCOPE OF WORK

shall credit and recognize the Water Board SB4 Oil and Gas Groundwater Monitoring and cooperative interagency efforts.

1.3 Ensure that Agreement requirements are met through completion of quarterly progress reports submitted to the Water Board Contract Manager by the 30th of the month following the end of the calendar quarter (January, April, July, and October) and through regular communication with the Water Board Contract Manager. The progress reports shall describe activities undertaken and accomplishments of each task during the quarter; milestones achieved; and any problems encountered in performance of work under this agreement. The description of activities and accomplishments of each task during the quarter shall be in sufficient detail to provide a basis for payment of invoices. The final quarterly report shall describe all work performed under this agreement.

Task 1 Deliverables:

1.1 Quarterly Progress Reports: The USGS shall submit quarterly progress reports and billings to the Water Board in a format agreed upon by both parties.
1.2 The USGS shall submit a final report and billing to the Water Board in a format agreed upon by both parties.

Task 2. Technical Assistance during development of model criteria for the Regional Oil and Gas Groundwater Monitoring and Operator Monitoring

The USGS shall provide technical assistance to the Water Board in development of the model criteria for the Regional Oil and Gas Groundwater Monitoring and the Operator Monitoring. This technical assistance shall consist of providing data, information, presentations, and documents needed by Water Board staff to meet the requirements listed in sub-sections (c) through (g) of Section 7 of SB4.

The USGS shall collaborate with the Water Board to evaluate how existing information can be used to achieve the objectives described above with the long-term objective of defining where new information and new wells may be needed.

2.1 Preparation of discussion document to be used as a resource by the experts charged with making recommendations to Water Board about the model criteria under SB4, section 7, subsection (d).

The USGS shall provide draft material presenting the concepts to Water Board staff during the initial design period, attend meetings with Water Board staff to collaboratively discuss, review, and revise the draft material. The USGS shall attend stakeholder meetings with the Water Board to hear concerns and work with Water Board staff to ensure these concerns are appropriately addressed in the draft material. The USGS shall assist Water Board staff to produce a discussion document appropriate for use by the group of experts. As part of this activity, the USGS shall assess the nature and extent of existing information, and develop a plan for extracting specific types of data needed to characterize the vulnerability of protected resources from sources including oil and gas field well logs, water well logs, and oil field descriptions managed by DOGGR and DWR. USGS staff shall present and explain the materials in the discussion document at public meetings as needed by Water Board staff.

EXHIBIT A
SCOPE OF WORK

2.2 Preparation of program design documents for Water Board adoption. USGS staff shall collaboratively work with Water Board staff to appropriately address expert review and stakeholder comments and recommendations, and provide technical assistance to Water Board staff as they prepare the Regional Oil and Gas Groundwater Monitoring and Operator Monitoring design documents for Water Board approval.

2.3 Preparation of SB4 Oil and Gas Groundwater Monitoring communication materials. The USGS shall collaborate with Water Board staff to prepare communication materials required for Water Board hearings and workshops.

Task 2 Deliverables:

2.1 Draft materials and concept papers appropriate for consideration by experts and use in public / stakeholder meetings.

Task 3. Preliminary assessment of vulnerability of California's groundwater resources to oil and gas operations.

The USGS shall provide all staff, tools, materials, and supplies and be responsible for the design and implementation of a preliminary assessment of the vulnerability of California's groundwater resources to oil and gas operations. The vulnerability assessment shall include: (3.1) preliminary statewide evaluation needed for the designing the Regional Oil and Gas Groundwater Monitoring; (3.2) pilot demonstration of detailed processes for doing comprehensive evaluations; (3.3) mapping of groundwater salinity; and (3.4) modification to numerical codes to assess the effects of oil and gas development on the groundwater resources.

3.1 Preliminary categorization of oil and gas fields according to vulnerability of groundwater resources.

Description: The USGS shall complete a preliminary vulnerability categorization of oil and gas fields statewide. This preliminary categorization shall be based on the proximity measure of vulnerability. For each field, the three-dimensional volume associated with oil and gas operations (including waste disposal) shall be defined from publically available data from DOGGR for depths and uses of wells associated with oil and gas operations, and stratigraphic data provided to DOGGR or present in published USGS reports. The three-dimensional volume of the currently used groundwater resource shall be defined from DWR well completion reports (WCRs). For this preliminary categorization, the currently used groundwater resource shall be defined in the 2,500 one-square mile sections statewide that contain active oil and gas extraction or injection wells.

Task 3.1 Deliverables:

3.1a The USGS shall provide the Water Board with a presentation showing the preliminary vulnerability categorization of oil and gas fields or groups of fields statewide and the data collected to develop that categorization. The presentation shall be delivered to the Water Board by March 2015, and shall include maps and brief description of the methods used to develop the categorization.

3.1b The data compiled for defining the volume used by oil and gas operations and the data compiled from the DWR WCRs shall be delivered to the Water Board in a format suitable for incorporation into the Water Boards GeoTracker GAMA database.

EXHIBIT A
SCOPE OF WORK

3.2 Identification of methods for compiling and assessing existing data, sampling design, and sampling density to best identify pathways for groundwater contamination.

Description: The USGS shall begin a detailed characterization of the vulnerability of groundwater in and around two oil fields to refine methods for compiling and assessing existing data, and developing groundwater sampling study designs to best identify pathways for groundwater contamination from oil and gas operations. The two fields shall include one field with relatively close proximity between the oil/gas field operation areas and protected groundwater, and one field with relatively large spatial separation between groundwater resources and oil field operation areas. The characterization shall include multiple components of vulnerability (proximity, number and age of boreholes, geologic structures, well stimulation techniques used, historic waste injection and disposal). The two fields shall be located in the Los Angeles basin because of the large number of oil fields, significant groundwater pumping for municipal and industrial supply, and the existing relationships the USGS has established with water agencies in the basin that have significant amounts of data and are interested in participation.

Task 3.2 Deliverables:
The USGS shall provide the Water Board with a presentation that explains selection of methods for compiling and assessing existing data, and developing groundwater sampling study designs to best identify pathways for contamination, and shows how these methods have been applied to the pilot areas in the Los Angeles Basin. The presentation shall be delivered to the Water Board by March 2015.

3.3 Mapping of groundwater salinity

Description: The USGS shall begin a survey of existing data to define the extent of groundwater that may be suitable for beneficial uses in and near oil and gas fields, and identify data gaps. Salinity criteria commonly are used to categorize the suitability of groundwater for beneficial uses., USGS shall compile existing data on groundwater salinity (as measured by total dissolved solids and/or specific conductance) and produce three-dimensional maps of salinity distributions. It is expected that there will be significant data gaps. Once data gaps are identified, the USGS shall develop proposal for how these data gaps can be filled, such as collection of new data from existing wells, application of geophysical tools, or installation of new monitoring wells. The potential application of geophysical tools for mapping groundwater salinity shall be investigated in selected oil field areas of the Los Angeles Basin because of extensive available high quality geophysical log and water chemistry data from samples in fresh and brackish aquifers overlying oil and gas areas, well characterized geology and three-dimensional geologic framework models, and the abundance of oil and gas wells and borehole electric logs.

Task 3.3 Deliverables:
3.3a The USGS shall produce maps and/or three-dimensional visualizations showing the salinity distributions in groundwater in and around oil and gas fields in California using existing readily available data. The USGS shall provide the Water Board with a presentation by March 2015 showing these results.

EXHIBIT A
SCOPE OF WORK

3.3b The data compiled shall be delivered to the Water Board in a format suitable for incorporation into the Water Board's GeoTracker GAMA database.

3.3c The USGS shall submit a proposal to the Water Board for addressing the gaps in the data, particularly through use of geophysical tools.

3.4 Evaluating the potential role of numerical modeling of groundwater flow

Description: Numerical models of groundwater flow in areas with oil and gas development may be useful for simulating how oil and gas operations can affect groundwater flow in nearby groundwater resources. The USGS has already developed groundwater flow simulation models for most of the basins containing oil and gas fields (Central Valley, Los Angeles, etc.). Other researchers and oil companies have developed simulation models for oil and gas fields at scales ranging from entire basins to individual oil and gas fields. Injection and extraction of fluids as part of oil and gas operations, pressure fields and deformation associated with geologic processes in oil and gas generating basins, and other factors related to oil and gas operations could have a substantial effect on groundwater flow. Groundwater flow modeling is a significant effort and should only be used in select situations. The USGS shall evaluate when such modeling would be most beneficial for evaluating effects of oil and gas operations on the quality of usable groundwater resources, how linkages between existing groundwater flow models and models oil and gas systems and of deeper parts of groundwater basins would be made, and what modifications would be required to the USGS's existing numerical groundwater modeling code (MODFLOW) to simulate groundwater flow and/contamination issues in oil and gas fields.

Task 3.4 Deliverables:
The USGS shall provide the Water Board with suggestions describing how groundwater modeling could be applied to the Regional Oil and Gas Groundwater Monitoring as part of the discussion document deliverable in Task 2.

Task 4. Exploratory groundwater sampling to identify potential effects of well stimulation

The USGS shall provide all staff, tools, materials, and supplies and be responsible for the design and implementation of an exploratory groundwater sampling program to identify potential effects of well stimulation on groundwater resources. The objectives of sampling program shall be: (a) to provide new groundwater quality data that may be relevant to developing the model criteria for the Regional Oil and Gas Groundwater Monitoring and Operator Monitoring; and (b) to explore potential methods for detecting effects of oil and gas development on groundwater quality.

Under the SB4 interim regulations, oil and gas companies must receive from DOGGR either approval for a groundwater monitoring plan, or written concurrence from the Water Board that no groundwater monitoring is required. It was hoped that groundwater quality data collected during the period of interim regulations would be useful to the Water Board in developing model criteria for the Regional Oil and Gas Groundwater Monitoring and Operator Monitoring. However, few data have been collected. The USGS shall provide technical assistance to the Water Board in this process by providing new groundwater quality data that may be relevant to developing the criteria.

The USGS shall conduct exploratory sampling in two regions to explore methods for detecting effects of oil and gas development on groundwater quality, with emphasis on areas where well

EXHIBIT A
SCOPE OF WORK

stimulation technologies are currently used or have been used in the past. One of the areas shall be in the Los Angeles basin (***task 4.1***) and one shall be in Kern County (***task 4.2***). In addition to water-quality sampling, the sampling shall include evaluation of methods of detecting potential leakage from well casings using hydrocarbon gas (methane) emissions at the land surface (***task 4.3***).

4.1 Los Angeles Basin exploratory sampling

Description: The Los Angeles basin has been an area of active oil and gas development for about 150 years, and also is an area with intensive use of groundwater for drinking water and irrigation supplies. In order to assess the impact of well stimulation and other oil and gas extraction activities on groundwater, the distribution of constituents potentially derived from these activities in deep groundwater near oil and gas fields must be identified. This will aid in identifying the pathways for the movement of hydrocarbons from oil and gas resources into groundwater.

The Water Replenishment District of Southern California (WRD) has a network of 55 monitoring well clusters, and collects water samples from these sites annually to monitor changes in groundwater quality in the basin. These clusters include monitoring wells over 2,000 ft deep. This well network was installed by USGS over the last 15 years and includes extensive lithologic, borehole geophysical, and aquifer properties data that support analysis of the effects The USGS shall collaborate with the WRD to identify an appropriate subset of these monitoring wells that includes wells that are in or near oil and gas fields. USGS staff will accompany WRD staff during sampling of the selected wells in August-October 2014 when the WRD collects samples for analysis of general minerals, metals, and a limited suite of VOCs using standard methods. At this time, the USGS plans to collect samples for analysis of:

(a) a more complete suite of dissolved hydrocarbons and other volatile organic compounds (VOCs) using the low-level detection methods available through USGS laboratories; the VOCs include constituents that could be associated with well stimulation or waste injection activities;
(b) Dissolved combustible gases – short-chain hydrocarbons (C1-C6) and their isotopic ratios, which can serve as early warning indicators for impacts of oil and gas operations on groundwater resources because the gases can move faster through aquifer systems than dissolved constituents;
(c) Dissolved gases that may be used as tracers – noble gases, atmospheric gases;
(d) Isotopic tracers, such as stable isotopes of water, carbon isotopes, strontium and boron isotopes – for determining sources of water and salts and groundwater ages,
(e) Additional dissolved halogens (iodide and bromide) and trace elements not currently sampled for determining sources of salinity, and
(f) Naturally occurring radioactive materials – which can be effective tracers of fluids from oil and gas zones compared with other sources.

At least 30 wells shall be sampled. This set of analytes, selected based on literature from other oil and gas studies, would provide an ensemble of groundwater-quality data about the extent and distribution of constituents potentially derived from oil and gas activities in groundwater in selected oil field areas of the Los Angeles Basin. This data will potentially

EXHIBIT A
SCOPE OF WORK

contribute to better understanding of pathways for contaminant movement and will inform the design of Regional Oil and Gas Groundwater Monitoring sampling in the future, as well as provide information about what analytes may be most useful for the well-by-well program.

Task 4.1 Deliverables:

4.1a The USGS shall provide the Water Board with a presentation by March 2015 showing the extent and distribution of constituents potentially related to oil and gas activities in groundwater in selected oil field areas of the Los Angeles Basin.

4.1b The USGS shall deliver water-quality data to the Water Board in a format suitable for incorporation into the Water Board's GeoTracker GAMA database.

4.2 Kern County exploratory sampling

Description: Kern County, particularly western Kern County, currently has the greatest concentration of wells undergoing well stimulation in California. In response to the mandates of SB4, the USGS shall conduct exploratory sampling in a selected oil field or fields in Kern County with the goal to assess the extent and distribution of constituents potentially related to oil and gas activities in groundwater. Very little data about groundwater quality in western Kern County are available, due to the paucity of water-supply wells. Characterizing groundwater in this area will require significant effort to identify and sample wells. The lack of wells available to sample representing different depths in the groundwater system may require use of techniques to collect vertical profiles of wellbore flow and water quality in available long-screened supply wells under pumping conditions. These techniques allow existing wells to be used to collect water-quality data from different depths in the aquifer and assess the depths at which contaminants enter the well.

Approximately 20 to 30 samples shall be collected along a gradient away from an area of interest, such as oil field with wells undergoing well stimulation. Analytes would be those listed in task 4.1, plus the general minerals and metals. The project shall include an assessment of where and how the installation of new MWs could be used to augment groundwater data from existing wells.

Task 4.2 Deliverables:

4.2a The USGS shall provide the Water Board with a presentation by March 2015 showing the groundwater chemistry data of the western Kern County, specifically the extent and distribution of constituents potentially derived from oil and gas activities in groundwater in areas of active well stimulation.

4.2b The water-quality data shall be delivered to the Water Board in a format suitable for incorporation into the Water Board's GeoTracker GAMA database.

4.3 Detection of leaky well casings.

Description: In addition to water-quality sampling, the sampling in exploratory areas shall include evaluation of methods of detecting potential leakage from oil and gas wells. Identifying the locations and numbers of leaking oil and gas wells is essential for prioritizing fields that may be leaking due to natural seismic shearing of well casings, failed well-casings, and leaking annulus. Leaking wells will be identified by the detection of combustible gases (short chain hydrocarbons C1-C6) at the land surface using field portable detectors. Statistical sampling will be conducted to measure emission of methane and other light hydrocarbons

EXHIBIT A
SCOPE OF WORK

around abandoned oil and gas wells. USGS teams will use hand-held methane/hydrocarbon detectors to sample a statistically representative number of abandoned (and possibly active) oil and gas wells to assess the fraction of wells that are leaking. Concentrations of short-chain hydrocarbons measured at the land surface according to a measurement design based upon oil and gas well proximity and density has been used as a reconnaissance method for identifying potentially leaky well casings contributing to contamination of groundwater. This reconnaissance analysis would help evaluate a cost-effective method for potentially assessing the locations of what may be one of the primary pathways for contamination of protected resources from oil and gas activities, leaky well casings.

Task 4.3 Deliverables:
The USGS shall provide the Water Board with a presentation summarizing the results of the assessment of the utility and cost-effectiveness of monitoring combustible gas concentrations at the land surface as a tool to indicate leaky well casings that may serve as pathways for contaminants from oil and gas development activities to reach protected resources. The presentation shall be delivered to the Water Board by March 2015.

Task 5. Publications

Description: USGS shall prepare reports for publication on aspects of the work conducted under Tasks 3 and 4. This component includes transferring the information and skills gained from the work to Water Board staff because it is required for beginning program implementation adopted by the Water Board on July 1, 2015. The number of reports and the format of the publications (USGS series report, factsheet, journal article) will be determined in consultation with the Water Board.

Task 5 Deliverables:
5.1 Draft publications for Water Board review.
5.2 Final publications.

6. Schedule of Completion Dates

Task No.	Task Description	Completion Date
1	*Project Management and Administration*	
1.1	Quarterly progress reports	January, April, July, and October 15, 2015; January 15 2016
1.2	Final progress report	April 15, 2016
2	*Technical Assistance during development of model criteria for the Regional Oil and Gas Groundwater Monitoring and Operator Monitoring*	
2.1a	Presentations at meetings	As needed
2.1b	Preparation of discussion document	October 2014
2.2	Preparation of final documents	March 2015
2.3	Preparation of communication materials	As needed
3	*Preliminary Vulnerability Assessment*	

EXHIBIT A
SCOPE OF WORK

3.1a	Presentation showing preliminary categorization of oil and gas fields according to vulnerability of groundwater resources, and draft of data compiled	March 2015
3.1b	Final data compilation in format for GeoTracker GAMA	March 2016
3.2	Presentation explaining methods for compiling and assessing existing data and showing results for two Los Angeles Basin oil fields	March 2015
3.3a	Presentation showing preliminary mapping of protected groundwater (groundwater with no more than 10,000 mg/L TDS) in oil and gas fields, and draft of data compiled	March 2015
3.3b	Proposal for addressing data gaps, with emphasis on geophysical tools	March 2016
3.3c	Final data compilation in format for GeoTracker GAMA	May 2015
3.4	Presentation on groundwater modeling	March 2015
4	*Exploratory Sampling*	
4.1a	Presentation on Los Angeles Basin sampling	March 2016
4.1b	Final data compilation in format for GeoTracker GAMA	March 2016
4.2a	Presentation on Kern County sampling	March 2015
4.2b	Final data compilation in format for GeoTracker GAMA	March 2016
4.3	Presentation about use of hydrocarbon emissions to detect leaky well bores	March 2015
5	*Publications*	
5.1	Draft reports for publication	December 2015
5.2	Final reports for publication	March 2016