

EXHIBIT A SCOPE OF WORK

1. SERVICES OVERVIEW:

A. The United States Geological Survey (USGS) agrees to provide the State Water Resources Control Board (State Water Board) with all labor, materials, and supplies needed to conduct research as described herein:

The USGS shall collaborate with the State Water Board to characterize and monitor groundwater risk zones, in support of the implementation of the Regional Monitoring Program.

The USGS shall conduct scientific investigations to identify potential groundwater risk zones; which shall include the following activities:

- i. Characterizing the risk of any fluid related to oil and gas development that migrates into waters of beneficial use, while prioritizing the monitoring of water that is (or has the potential to be) a source of drinking water, and
- ii. Establishing monitoring networks, to provide early warning in high risk zones.

2. LOCATION OF SERVICES:

A. The work shall be performed at various locations. Sample and data analyses shall be performed at USGS offices and contract laboratories in California and other states, which may include Colorado, Virginia, Connecticut, and North Carolina. Field work to collect new data shall be conducted in and near selected oil fields in California, which may include the Fruitvale, Lost Hills, South Belridge, North Belridge, and Poso Creek oil fields.

B. The work shall be provided during normal USGS working hours, including the core hours of 9 AM to 3 PM. The USGS shall allow remaining hours to be worked before or after the core period.

3. PROJECT REPRESENTATIVES:

A. The Project Representatives during the term of this Agreement shall be:

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| State Water Resources Control Board | United States Geological Survey |
| Section/Unit: Oil and Gas Monitoring Unit I | Section/unit: California Water Science Center |
| Contract Manager: Janice Zinky | Project Director: Matthew Landon |
| Address: 1001 I Street, Sacramento, CA 95814 | Address: 4165 Spruance Road, Suite 200, San Diego, CA 92101 |
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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.

4. BACKGROUND AND GOALS:

A. Senate Bill 4 of 2013 (SB4) mandated that the State Water Board design and implement groundwater monitoring programs to assess potential effects of well stimulation treatments used to increase oil/gas reservoir permeability on California's groundwater resources. These well stimulation treatments include hydraulic fracturing, acid matrix stimulation, and acid fracturing. On July 7, 2015, the State Water Board adopted model criteria for groundwater monitoring in areas of oil and gas well stimulation (Model Criteria). The Model Criteria outlined a program for regional groundwater monitoring to be implemented by the State Water Board (Regional Monitoring Program) and the methods to be used for assessment, sampling, and analytical testing for area-specific monitoring by oil and gas well operators.

5. WORK TO BE PERFORMED:

- A. The USGS shall prepare reports containing groundwater-quality data, and other electronically complied information, such as well completion information, and presentation materials. In addition, the USGS shall provide draft reports to the State Water Board Contract Manager for review. The USGS shall provide technical assistance, and conduct monitoring, and assessment activities in accordance with the requirements specified below:
- i. The USGS shall ensure that reports contain the following title: "Oil and Gas Regional Groundwater Monitoring Program."
 - ii. The USGS shall examine existing water sampling data, published manuscripts, and any ongoing studies relevant to regional groundwater quality and monitoring in the selected study areas prior to implementing water sampling. The USGS shall ensure that reports and other documents prepared acknowledge this data, references, and ongoing research.
 - iii. Prior to implementing sampling in any given geographic area, the USGS shall contact the State Water Board, local agencies, and property owners to inform them of water sampling or geophysical data collection activities and, if required, obtain their permission to begin work. In addition, the USGS shall work with State Water Board staff to identify where there is overlap between the sampling required for this project, and monitoring required under other regulatory programs, in order to most cost-effectively conduct monitoring and leverage existing information to focus new data collection in areas where it is most needed.
 - iv. The USGS shall work collaboratively with the State Water Board to ensure that all peer-reviewed data is publicly available (including online data releases, maps, presentations, abstracts, and graphs.)

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B. Task 1: Project Management and Administration

- i. The USGS shall enter into Cooperative Agreements with California State University Sacramento (CSUS) and other universities on an as-needed basis, and work collaboratively with these entities to carry out (1) construction of databases and scientific analysis of existing information from oil and gas well records (CSUS) for use in groundwater salinity and aquifer characteristics mapping and planning of new data collection to fill gaps in information, and (2) sample analysis (other universities). The USGS shall notify the State Water Board Contract Manager of events or proposed changes that could affect the scope, or schedule of work performed under this Agreement.
- ii. The USGS shall provide all technical and administrative work needed for Agreement completion. Additionally, the USGS shall monitor, supervise, and review all work performed, and coordinate budgeting and scheduling to ensure that the Agreement is completed within the budget, on schedule, and in accordance with approved procedures, applicable laws, and regulations.
- iii. The USGS shall coordinate with State Water Board staff to determine which oilfields and regions to address regarding sample collection, analysis, and data reporting. The USGS shall participate in Oil and Gas Program monthly, briefings, and provide State Water Board staff review opportunities prior to distribution of groundwater monitoring data to the public. At times monthly briefings may not be needed because other information meetings or presentations are occurring; the timing of the briefings will be closely coordinated with State Water Board staff. The USGS shall ensure that work includes coordination with other agencies, including the Division of Oil, Gas and Geothermal Resources (DOGGR), the Department of Toxic Substances Control (DTSC) and other California Environmental Protection Agency (CalEPA) agencies, local water management agencies, and stakeholders. The USGS shall ensure that presentations of data (e.g., meetings, reports, posters, media releases and interviews, and public presentations) credits and recognizes the State Water Board's Oil and Gas Monitoring Program and cooperative interagency efforts.
- iv. Task 1 Deliverables:
 - Quarterly progress reports (in a format agreed upon by both parties.)
 - A final report (in a format agreed upon by both parties.)

C. Task 2: Subsurface Salinity Mapping, Including Analysis of Existing Water Sample Data, Estimating Salinity from Existing Borehole Geophysical Logs, and Analysis of Newly Collected Surface/Airborne Electromagnetic Geophysical Data:

The USGS shall, in collaboration with the State Water Board, map the distribution of salinity in groundwater. The USGS shall use three approaches to map salinity:

- Analysis of existing water sample data;
- Analysis of existing borehole geophysical logs to estimate salinity; and

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- Analysis of newly collected airborne and ground-based electromagnetic (EM) geophysical data in selected areas as a pilot study.
- i. In proximity to the selected oilfields, the USGS shall prepare a delineation of water resources with less than 3,000 milligrams per liter (mg/L) total dissolved solids (TDS), between 3,000 and 10,000 mg/L TDS, greater than 10,000 mg/l TDS, and the location of approximate boundaries between these zones.
 - ii. The USGS shall use existing water sample data to provide a foundation for the detailed mapping of salinity distributions for approximately ten (10) oil fields in Kern County. The USGS shall supplement the analysis of existing data with a collection of new water sample data gathered as part of Task 4.
 - iii. The USGS shall map salinity distributions using borehole geophysical log data for approximately five or more oil fields in Kern County, including fields on the west side and the east side of the San Joaquin Valley. This analysis is planned for the Fruitvale, Lost Hills, South Belridge, North Belridge, and Poso Creek oil fields. A student research team at CSUS by Dr. David Shimabukuro, Scientist GS13, is playing a vital role in data acquisition and management by cataloging data from scanned DOGGR well and geophysical log files. The resulting well construction and geophysical data will be combined with other sources of salinity data in visualizations of three-dimensional (3D) salinity distributions overlying and surrounding selected oil fields. Additionally, the USGS shall work with the State Water Board to ensure peer reviewed data is available to the public.
 - iv. The USGS shall employ surface and airborne electromagnetic (EM) methods to map salinity distributions in groundwater in selected rural areas without a high density of buried pipes or wires or power lines; these approaches will be applied in agricultural areas adjacent to three or four oil fields (these methods cannot be used in oil fields or urban areas.) After analyzing the pilot data, the USGS shall inform the State Water Board of where these approaches provide more cost-effective methods for future salinity mapping (regional scales vs. traditional methods.) The areas for deployment of surface and airborne EM methods, and the timing of the deployments, are subject to change if permission from land owners and cooperation from well owners in the selected areas cannot be obtained.
 - v. Task 2 Deliverables:
 - Maps, graphs, cross-sections and/or 3D visualizations showing the salinity distributions in groundwater (using estimates from surface and airborne geophysical data], borehole geophysical logs, and water sample data) and presentations of these results to the State Water Board.
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- Borehole geophysical log data, delivered to the State Water Board in a GeoTracker compatible format.
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- Draft copies of manuscripts, submitted to the State Water Board for review during the scientific review process and prior to publication.
- Surface and airborne geophysical data, archived in a digital format according to the USGS policy and available for download following publication of results.
- A link to the website where surface and airborne geophysical data will be archived.

D. Task 3. Produced water characterization.

Implementation of the produced water sampling program requires cooperation from oil and gas operators. If the USGS and the State Water Board cannot obtain the necessary cooperation from the oil and gas operators, then Task 3 Produced Water Characterization will be impossible to complete as described in this section. In that case, USGS shall work collaboratively with the State Water Board to revise the Scope of Work and Deliverables for Task 3 and reallocate funding from Task 3 to other tasks as appropriate.

- i. The USGS shall design and implement a produced water, pond, and injectate sampling (mixtures of produced waters and other waters injected into oil fields for enhanced oil recovery or waste disposal purposes) to characterize their geochemical signatures for a diverse set of chemical constituents (see analyte list). This effort shall be coordinated with produced water and pond sampling efforts of the Regional and State Water Boards, DOGGR, other CalEPA agencies, and oil and gas companies and their consultants operating oil field infrastructure (hereinafter defined as operators). The intent of the produced water sampling is to augment existing efforts by putting the data in a 3D context and to provide additional gas, isotopic, and groundwater age data.
- ii. The USGS shall assist the State Water Board with analysis and interpretation of the data collected by the Regional and State Water Board, DOGGR, and oil and gas operators, and shall collect samples from selected sites to augment these data. The USGS shall collect and analyze approximately sixty-five (65) produced water, pond, or injectate samples per year, in addition to coordination with sampling conducted for other regulatory and monitoring programs. Coordination with produced water sampling activities of other organizations/efforts will enable the new produced water data collection for the regional monitoring program to be optimized to fill gaps and understanding in existing information. The USGS shall work collaboratively with the State Water Board to select sample sites which will provide a 3D understanding of produced water, pond, and injectate sample chemistry, and span a range of oil field operational conditions. The oilfield sampling sites will not necessarily be limited to those fields concurrently being evaluated for groundwater zone risk (Task 4), but will be distributed according to a regional characterization strategy. Additional analytes (see Task 4) include: noble and atmospheric gases, hydrocarbon gas

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isotopes, solute isotopes (strontium, boron, lithium) and groundwater age tracers (carbon-14, tritium, helium isotopes).

iii. Task 3 Deliverables:

- Maps, graphs, cross-sections and/or visualizations showing the 3D distribution of geochemical conditions of produced water, sump, and injectate samples at a regional scale
- The USGS shall provide the State Water Board with periodic presentations showing these results.
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- Water-quality data shall be delivered to the State Water Board in a GeoTracker compatible format.

E. Task 4. Groundwater risk zone analysis

The USGS shall collaborate with the State Water Board to conduct Regional monitoring and assessment of groundwater zones overlying and adjacent to oilfields that may be impacted by the movement of oil and gas production related fluids (groundwater risk zone). This analysis includes the following subtasks:

- Collection, management, and analysis of existing data;
 - Groundwater sampling and analysis;
 - Hydrogeologic framework analysis;
 - Drilling and installation of new monitoring wells.
- i. The USGS shall compile existing data to analyze the groundwater risk zone including oil well construction data, lithologic descriptions, data on injection volumes/pressures, and altitudes of oilfield pools from DOGGR records, and groundwater level data, and the location/depth of water wells from Department of Water Resources (DWR) records or other sources. The student research team at CSUS is populating databases with oil well construction data and ancillary data related to well operations and integrity, providing inventories of borehole geophysical logs (see Task 2), and coding drillers' lithologic descriptions and data on injection volumes and pressures. The CSUS team has developed and tested a cloud-based online data management system that facilitates sharing and quality-assurance of the data. The outcome is a searchable database of DOGGR well records vital for Task 4 (visualization and hydrogeologic framework subtasks). The effort may include students from other CSU campuses. These CSU specific efforts are funded through a cooperative agreement between USGS and CSUS. In addition, CSU students and USGS project team employees are digitizing borehole geophysical logs that provide data for salinity mapping (Task 2) and hydrogeologic framework modeling (Task 4). Members of the USGS team are compiling ancillary data including groundwater level data, digitized altitudes of oilfield pools from DOGGR records, analysis of data from injection

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- wells received from DOGGR, and locations and depths of water wells from DWR well completion reports (drillers' logs). Water well depths and ancillary data from DWR drillers' logs have been compiled into a database that includes approximately 60,000 wells located in proximity to oil and gas fields. Overall, the quality-assured data sets built and organized through the CSUS & USGS collaborative efforts shall support ongoing monitoring and assessment efforts by the State Water Board and other agencies. During 2015-17, the data compilation shall occur for a list of priority oilfields located on the western and eastern sides of the Southern San Joaquin Valley.
- ii. The USGS shall compile numerical data on well construction and lithology into databases from existing scanned images of well records as part of Task 4. The USGS shall ensure that this data is analyzed, quality-assured, and cross-compared in graphs, maps, and other data visualizations. The USGS shall input preliminary salinity distribution data from Task 2 and from Task 4 into 3D visualization software such as Earth Vision, which may include primary chronostratigraphic units in the subsurface developed by the USGS in the Southern San Joaquin Valley, and Los Angeles Basins. These visualizations and analysis of all available data will be used to select locations and zones to include in regional groundwater monitoring. The well selection will occur according to a scientific plan designed to understand how groundwater quality changes along regional groundwater flow paths overlying or adjacent to oil fields.
 - iii. The USGS shall prepare the design for the spatial distribution of monitoring within the groundwater risk zone in a manner which allows for the monitoring of groundwater at shallow, intermediate, and deep depths, along multiple flowpaths extending from groundwater overlying oil and gas deposits in an oilfield, to the mapped boundary of the oilfield, and to down-gradient.
 - iv. During the monitoring network design process for each studied oilfield or sub-regional group of oilfields, the USGS shall consult with the State Water Board and stakeholder groups identified by the State Water Board to coordinate monitoring with other state and local programs such as the Irrigated Lands Regulatory Program and Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS). It is anticipated that wells used in other monitoring programs may not be deep enough to provide complete coverage for the Regional Monitoring Program and some existing deep wells or newly drilled wells will need to be added to existing well networks to provide complete 3D coverage.
 - v. The USGS shall collect approximately sixty (60) groundwater samples from existing water supply or monitoring wells, divided between an eastern San Joaquin Valley oilfield (Fruitvale) and a sub-regional group of oilfields (Lost Hills, South and North Belridge) along the western San Joaquin Valley. The USGS shall collect depth-dependent flow, and water chemistry profiles from long-screened production wells if available wells are insufficient for

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evaluating vertical profiles of water chemistry in the aquifer. Collection of groundwater samples from existing wells requires cooperation from well owners. If the USGS and the State Water Board cannot obtain the necessary cooperation from well owners, the number and locations of wells samples will need to be altered. Inability to obtain permission to sample wells in critical locations may significantly affect the results of the project. If sufficient well owner cooperation cannot be obtained, the USGS shall work collaboratively with the State Water Board to revise the Scope of Work and Deliverables for Task 4vi and reallocate funding among tasks as appropriate.

vi. The USGS shall collect the following samples for analysis, to provide an ensemble of groundwater-quality data about the regional extent and distribution of constituents potentially derived from oil and gas activities. Analysis shall be done by USGS laboratories with two exceptions. USGS shall establish a Cooperative Agreement with a university laboratory for analysis of helium (total, ^3He , ^4He), neon (total, ^{20}Ne , ^{21}Ne , ^{22}Ne), argon (total, ^{36}Ar , ^{38}Ar , ^{40}Ar), krypton (total, ^{82}Kr , ^{83}Kr , ^{84}Kr , ^{86}Kr), and xenon (total, ^{129}Xe , ^{130}Xe , ^{131}Xe , ^{132}Xe , ^{134}Xe , ^{136}Xe) in produced-water and groundwater samples, and in natural gas samples, and quality control samples. The laboratory shall assist in modeling and interpretation of the data produced. USGS shall establish a Cooperative Agreement with a university laboratory for analysis of $^{87}/^{86}\text{Sr}$, $^{228}/^{226}\text{Ra}$, $^{11}/^{10}\text{B}$, and $^7/^6\text{Li}$ isotopes and other naturally occurring inorganic constituents in produced-water and groundwater samples and quality control samples. The reason for these two Cooperative Agreements with university laboratories is that neither USGS nor commercial laboratories are equipped to analyze these constituents in produced water samples which may contain up to ~15% oil and TDS up to 50,000 mg/L,

- A complete suite of dissolved hydrocarbons and other volatile organic compounds (VOCs) using the low-level detection methods available through the USGS's laboratories; the VOCs include constituents that could be associated with well stimulation or waste injection activities;
- 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;
- Semi-volatile organic constituents and polycyclic aromatic hydrocarbons that may be derived from oilfield waters;
- Dissolved organic carbon, fractions of different kinds of organic matter, and optical properties of organic matter that may be used to identify different sources of organic carbon;
- Low molecular weight organic acids, which can be used as natural tracers of produced waters in some areas;
- Dissolved gases that may be used as tracers – noble gases, atmospheric gases;

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- Isotopic tracers, such as stable isotopes of water, carbon isotopes of dissolved inorganic carbon, strontium, boron, and lithium isotopes, for determining sources of water and salts;
 - Major ions, trace elements, nutrients, and additional dissolved halogens (iodide and bromide) for determining sources of salinity;
 - Naturally occurring radioactive materials which can be used as effective tracers of fluids from oil and gas zones compared with other sources; and
 - Groundwater age tracers, including tritium, helium-3, carbon-14, and sulfur hexafluoride, which can be used to help to understand rates of water movement and groundwater sources and vulnerability.
- vii. The USGS shall add lithology data from drillers' logs, interpreted borehole geophysical logs, and new surface and airborne geophysical data to 3D visualizations developed in Task 4.
- viii. The USGS shall use lithologic data from drillers' logs and or geophysical log interpretations will be coded into a database for a subset of wells as part of Task 4 Modern frameworks use geostatistical tools to interpolate lithologic data between boreholes. The framework models then provide the foundation for numerical modeling of fluid flow to better understand fluid movement between oil and gas resource and groundwater resource zones.
- ix. The USGS shall conduct hydrogeologic framework modeling collaboratively, in multiple science centers and California State University Sacramento (CSUS). The USGS shall construct these framework models from an existing regional 3D model of the San Joaquin Valley, developed by the USGS's petroleum resource assessment team in Denver, CO and includes the distribution of major chronostratigraphic formations (but does not include lithology.)
- x. As part of groundwater risk assessment under this Agreement, Dr. David Shimabukuro's CSUS team will be conducting pilot studies of cases where data indicate risks associated with injection well practices. These data may include seismicity data and evidence of transport of fluids along preferential pathways. These pilot studies shall contribute to the long-term goal of understanding risks to groundwater from injections and designing monitoring of these risks.
- xi. The USGS shall identify gaps in monitoring data using existing wells. It is anticipated that there will be a limited number of wells available for monitoring between groundwater zones in the upper few hundred feet below ground surface (bgs) and oil wells perforated thousands of feet bgs.
- xii. The USGS shall analyze existing data and collect new water sample data from existing wells to determine the requirements for installing new monitoring wells. The objective is to plan for

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new monitoring well installation where regional flow systems cannot be sampled by existing wells. New wells will likely require construction enabling sampling at multiple depths. The USGS shall plan, select sites, permit, and make supply purchases.

- xiii. The USGS shall select monitor well sites, obtain permits, identify targeted monitoring zones, and complete logistical and supply arrangements in preparation for drilling and well construction to begin. The USGS shall coordinate with the State Water Board throughout the planning, design, permitting, and preparation process.
- xiv. The USGS shall provide a PowerPoint presentation describing drilling/well installation plans within the scope of the regional monitoring design to the State Water Board and interagency/stakeholder committees coordinating groundwater monitoring programs in advance.
- xv. Task 4 Deliverables:
 - Data, delivered to the Water Board in a GeoTracker compatible format.
 - Maps, graphs, and/or 3D visualization, showing the distribution of groundwater chemistry, and of water, oil/gas, and injection wells.
 - At least one (1) Synthesis Manuscript
 - Draft Copies of Synthesis Manuscript
 - Presentation Materials
 - Framework model data, archived in digital format, in accordance with the USGS's policy.
 - A link to the archival website.

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6. TASKS AND DELIVERABLES:

| Task Number: | Deliverables: | Deliverable Due Date: ¹ |
|--------------|--|---|
| Task 1: | Quarterly Progress Reports | The 15 th of the month (following the first full quarter of work), and quarterly thereafter. |
| | Final Progress Report | March 31, 2018 |
| Task 2: | Presentations on salinity mapping & peer reviewed, publicly available information (subtasks 2a, 2b) | As-needed |
| | Final data, in a Geotracker compatible format. (subtasks 2a, 2b) | March 2017 and March 2018 |
| | Presentations on salinity mapping (using airborne and surface geophysics) and peer reviewed publicly available information. (subtask 2c) | As-needed |
| | Final archival of geophysical data, publicly available. (subtask 2c) | March 2018 |
| | Draft Manuscript (subtask 2d) | September 2017 |
| | Final Manuscript (subtask 2d) | March 2018 |
| Task 3: | Presentations on produced water sampling (and analysis), and peer reviewed, publicly available information. (subtask 3a) | As-needed |
| | Draft Manuscript (subtask 3b) | September 2017 |
| | Final Manuscript (subtask 3b) | March 2018 |
| | Final data, in a Geotracker compatible format (subtask 3a) | March 2017, and March 2018 |
| | | |
| Task 4: | Final Data in a Geotracker compatible format. (subtasks 4a, 4c) | March 2017 and March 2018 |
| | Presentation on existing data visualization (subtask 4a) | September 2016 |
| | Data Collection Design (subtask 4b) | As-needed |
| | Presentations on groundwater sampling and analysis, and peer reviewed publicly available information. (subtask 4c) | As-needed |
| | Draft Manuscript (subtask 4f) | September 2017 |
| | Final Manuscript (subtask 4f) | March 2018 |
| | Presentations on hydrogeologic framework (subtask 4d) | As-needed |
| | Final archival of geophysical data, publicly available. (subtask 4a) | March 2018 |
| | Design Plans for drilling and installation of new monitoring wells (subtask 4e) | March 2017 |

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1 Deliverable due dates may be changed upon notice and approval of the State Water Board Contract Project Manager. Said changes shall not require an Amendment to this Agreement. If due date falls on a Saturday, Sunday or State holiday, deliverables shall be due the following business day.

7. REPORTS:

- A. The USGS shall complete quarterly progress reports, and submit them to the Water Board Contract Manager by the 30th of the month following the end of the calendar quarter (April, July, October, and January). The USGS shall maintain regular communication with the Water Board Contract Manager. The USGS shall ensure that progress reports describe activities undertaken and accomplishments of each task during the quarter, milestones achieved, and any problems encountered. Additionally, the USGS shall ensure the description of activities and accomplishments for each task during the quarter contains sufficient detail. The USGS shall ensure that the final quarterly report describes all work performed under this Agreement.
- B. The USGS shall provide three (3) extended abstracts and presentations per-year, to summarize findings and study progress. The USGS shall schedule these presentations upon approval of the State Water Board Contract Manager.
- C. The USGS shall prepare manuscripts summarizing and integrating results of Tasks 2, 3, and 4. The number of manuscripts and the format of the publications (series report, factsheet, journal article) will be determined by the State Water Board. At least one (1) synthesis manuscript shall be produced. Draft copies of manuscripts shall be submitted to the State Water Board for review during the scientific review process, and prior to publication.
- D. The USGS and shall coordinate with the State Water Board to review monitoring results and assessments. Formal reports on the status and findings of the Regional Monitoring Program are anticipated to be prepared on at least a biennial (every other year) basis. Adjustments to the Regional Monitoring Program elements may be necessary periodically as data and information are evaluated.