(5/19/15) Public Workshop- Item 6
Model Criteria for Groundwater Monitoring
Deadline: 5/29/15 by 12:00 noon

SUMMARY OF COMMENTS ON DRAFT REGIONAL MONITORING PROGRAM.

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Overview: The draft attempts to set out guidelines for groundwater monitoring in areas of oil and gas well stimulation, doing so on both an "area-specific" and "regional" scale. The draft proposes groundwater monitoring plan requirements, proposes an approach to define and establish baseline water quality within the monitoring zones, and proposes analytes to be assayed for in collected groundwater samples, sampling protocols, and testing and reporting requirements. Unfortunately, while the overall structure and approach of the draft is commendable, many key details are left unconsidered or poorly addressed. A summary of those concerns are listed below.

1. **Of critical concern is the fact that many important aspects of the "Regional" monitoring program are poorly defined, including the definition of "region" itself**. How small an area, for example, can constitute a "region"? How big an area can a single "region" embrace? Can a single region embrace more than 1 aquifer? More than 10? More than 100? Is there any limit on the total volume of potentially potable underground water present before the single "region" must be divided into multiple "regions"? Is there a minimum number or minimum density of oil and/or gas production wells that specifies a "region"? Is there a maximum density? How many working, idle and/or abandoned oil/gas production wells can be present within a single "region"? Is there a maximum density beyond which the "region" must be divided into two or more "regions"? Is there any limit to how many Underground Injection Control (UIC) wells can be present within a single region (or limit on the density of such wells)? Is there any limit to how much produced water and/or waste stream fluids can be injected into a single "region**"? None of these questions are "academic" or trivial, since they directly relate to the number of potential groundwater contamination sources in an "region" and thus the degree of threat to the aquifer(s) within that "region"**.

2. Answers to all the questions above will help in formulating a response to yet another unanswered question posed by the vague definition of "region". **Nowhere in the draft is there any formula or calculation or even rationale that would specify the minimum number of groundwater monitoring wells required for a "region**". Since "region" size, total well number, injection waste volumes, geology, aquifer characteristics etc will vary from region to region, there should be some rationale presented to determine the minimum number of groundwater monitoring wells needed. Will that number be determined relative to the number or density of oil/gas wells in the "region"? Relative to the number or density oil or gas wells to undergo stimulation? Relative to the number or density of UIC wells?

Relative to the volume of liquid waste injected underground through those UIC wells? Relative to the volume of groundwater that must be monitored within that "region"? **The rationale should be presented and thoroughly explained**.

3. Little information was given regarding the placement of UIC wells relative to groundwater monitoring wells. **Placement of all future UIC wells should be considered in this draft proposa**l. **Ideally, all UIC wells would be required to be placed somewhere between the "stimulated" oil/gas well and the "downgradient" monitoring well(s)**. If an UIC well is placed "downgradient" of a monitoring well, contamination associated with waste liquids injected though the UIC well would most likely go undetected. Proper placement of the UIC well is critical to effective groundwater monitoring efforts, and thus should be considered in this draft proposal.

4. Section 2.1.2 of the draft proposal states, "*an area-specific groundwater monitoring plan applies only to the stimulation well(s)*". Limiting groundwater monitoring only to "stimulated" wells would severely limit the value of the groundwater monitoring effort. Nearby working, idle and/or abandoned oil/gas wells… as well as UIC wells in the "area"… could also negatively impact the groundwater quality in the aquifer and should be monitored. In light of this reality, **all oil and gas wells and all associated UIC wells in the "monitoring area" should be monitored, even if it requires placement of additional monitoring wells**.

5. Section 2.1.3 of the draft proposal states, "*Following well stimulation, area-specific groundwater monitoring well shall be placed on a semi-annual monitoring schedule"*. **No scientific rationale for monitoring groundwater only twice per year is presented. In fact, however, a logical, data-based rationale for defining the time interval between monitoring events can be developed**. Using groundwater flow measurements, the minimum "transit time" for a pollutant to travel from a" source point" (a stimulated oil or gas well or stimulation zone, for example) to monitoring point (a monitoring well) can be estimated. That "transit time" (duration) can then be set as the **maximum** time interval between monitoring events. Additionally, while Section 2.1.3 of the draft requires that groundwater samples must be collected *before* and *following* well stimulation, it is curiously silent about monitoring *during* well stimulation. **Since well stimulation can occur multiple times over the course of many weeks, it seems reasonable to require that groundwater sampling also be undertaken *during* the well stimulation when multiple stimulation events over many weeks occur**. One might require, for example, that groundwater monitoring be undertaken every 2 weeks during a prolonged well stimulation protocol spanning more than a total of 4 weeks.

6. As presented in Section 2.1.1 for "area-specific" monitoring, "*At a minimum, one upgradient and two downgradient monitoring wells will be required for each protected aquifer that is penetrated by the stimulated well"*. It may be that 3 wells per aquifer is sufficient, but no scientific basis for that conclusion is presented. Neither does there appear to be any consideration given to the size of the aquifer or the volume of water it contains. As was pointed out for the "regional" monitoring scheme, **without presenting some kind of rationale for determining how many monitoring wells are needed the decision to use "one upgradient and two downgradient" monitoring wells appears arbitrary**, if not logically groundless. Three monitoring wells may in fact be the perfect number, but some logical rationale for that needs to be presented.

7. In Section 2.1.3 (Sampling and Testing Requirements) for "area-specific" groundwater monitoring, the draft states (in 2.1.3 Part 5) that "*groundwater samples shall be analyzed using current applicable U.S. EPA-approved analytical methods*", and then proceeds to cite a number of minerals, salts, metals, radionuclotides, hydrogen sulfide, and a list of various organics that might be present in hydraulic fracturing fluids, produced water, UIC well fluids etc. **Nowhere in Part 5, however, does the draft address at what concentration levels the assays will be undertaken. Will all analytes, for example, be assayed for at the parts per million level?** The parts per trillion level? This should either be specified here or in an addendum attached to the draft.

   Furthermore, while the list of analytes presented in Part 5 admirable, there are some omissions that stand out. What of **halogenated hydrocarbons** and solvents used in drilling, stimulation and/or well production? Other common chemicals (such as **alcohols, glycols, and biocides**) are (as stated in Section 2.1.3 Part 6) only to be included for assay "*if concentrations of the analytes listed in part 5 change between sampling events… then additional laboratory analysis shall be conducted*", but that hardly seems reasonable. Since those chemicals are routinely used in well stimulation and production (and thus can also appear in the UIC well injection fluids), they **should be include in the analyte assay list in Part 5**.

   Finally, the idea of "change" between sampling events (as stated in Section 2.1.3 Part 6) as a trigger for broadening the analyte analysis seems needlessly arbitrary. Change to what degree? **It is far better to specify the minimum level of "change" that will trigger "additional laboratory analysis"**. Any change beyond 10% of the **initial** sampling value, for example, could be used to automatically trigger additional testing.

8. Also conspicuously absent from the draft document is an answer to the following question. **What happens if contamination of groundwater is found? Is the State Water Board legally bound to immediately contact**

the State and Federal EPA so that any applicable action can be undertaken as quickly as possible? There should be no "grace period" for reporting groundwater contamination.

9. Unfortunately, it is unclear that "regional" groundwater monitoring will assay for exactly the same set of analytes as is specified for "area-specific" monitoring. If indeed the "regional" groundwater monitoring plan will assay for exactly the set of analytes, that should simply be stated in the draft to clarify the ambiguity. If, however, the "regional' groundwater monitoring plan will assay for a different set of analytes (or assay at a different concentration range), that too should be clearly stated and all analytes to be tested for listed as they are in Section 2.1.3 Part 5.

10. The responsibility for groundwater monitoring under the program laid out by this draft vs monitoring which might be carried out by the GAMA (Groundwater Ambient Monioring and Assessment) program, as suggested in Section 4.2 "Surface Activity Effects" of the draft, seems ambiguous. According to Sec. 1.0 (page 3) of the draft, oil and gas well operators will conduct, and thus be directly responsible for, groundwater monitoring. Logically that would include monitoring groundwater present under produced water ponds (which generally also contain chemicals far more toxic than water) and groundwater near UIC wells associated with the oil or gas production wells. If there is a logical reason for excluding oil and gas well operators from monitoring produced water ponds or UIC wells in an "area-specific" monitoring plan, the draft should present that argument.

11. As stated in Section 1.0, regional groundwater monitoring programs will be implemented by the State Water Resources Control Board (State Water Board). Does that mean that the oil and gas well operators are absolved of legal and financial responsibility for carrying out groundwater monitoring on a "regional" scale? If so, this is unacceptable, and for a number of reasons. First, the activities of the oil and gas companies are the major reason this gigantic groundwater monitoring program is necessary in the first place. They reap the profit, so they must bear the cost of monitoring. Second, it seems as though a "long term" plan in the draft is to shift from "area-specific" to "regional" groundwater monitoring. If that is the case, then the cost of groundwater monitoring shifts from oil/gas operator-financed "area-specific" monitoring to taxpayer-financed monitoring via the State Water Resources Control Board. The oil and gas well operators should either pay: (i) the full cost of "regional" groundwater monitoring, or (ii) some clearly defined and publically/legislatively debated per cent of the total cost.

12. Other, less pressing concerns are provided in comments to the draft, which I have sent along with this document. Thank you for reviewing my comments. Sincerely and respectfully, Dr. Steven White

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

STATE WATER RESOURCES CONTROL BOARD

April 29, 2015

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1.0 INTRODUCTION

Pursuant to Water Code section 10783, this document outlines model criteria for groundwater monitoring (Model Criteria) in areas of oil and gas well stimulation. These Model Criteria will be used 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 California's groundwater resources. Factors considered in these Model Criteria include well stimulation treatments, among other events or activities that have the potential to contaminate groundwater. These Model Criteria are intended to evaluate whether groundwater contamination can be attributable to a particular event, and if any changes to the monitoring plan are necessary if groundwater contamination is observed. 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. Current and future beneficial uses will also be considered relative to our 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 Model Criteria outlined in this document are critical to meet the policy of the state that every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes (Chapter 524, Statutes of 2012 (Assembly Bill 685, Eng)).

These Model Criteria outline the methods to be used for sampling, analytical testing, and reporting of water quality associated with oil and gas well stimulation activities and address:

- Groundwater monitoring to be conducted by oil and gas well operators;
- Requirements for designated contractor sampling and testing; and
- Methods for conducting a regional groundwater monitoring program to be implemented by the State Water Resources Control Board (State Water Board).

The State Water Board developed these Model Criteria in consultation with the Department of Conservation Division of Oil, Gas, and Geothermal Resources (DOGGR), Regional Water Quality Control Boards (Regional Water Boards), and with the advice and input of technical experts. In addition State Water Board staff received input from members of the public, and stakeholders representing diverse interests of the oil-and gas-producing areas of the state including the oil and gas industry, agriculture, environmental justice, and local government.

The State Water Board staff sought expert technical advice from Lawrence Livermore National Laboratory (LLNL). LLNL, along with other experts, developed specific recommendations to be outlined in an upcoming final report to be delivered to the State Water Board on June 2015. The State Water Board relied on the LLNL expert input as a foundation for the Model Criteria and obtained significant input from stakeholders.

Since there is limited available information about groundwater conditions near oil and gas well stimulation areas, the State Water Board staff sought the support and expertise of the U.S. Geological Survey (USGS) to collect preliminary data and information that was used to assist in the development of the Model Criteria.

Water Code section 10783 refers to "well-by-well" and "area-specific" groundwater monitoring. Since groundwater monitoring wells may be used to monitor more than one stimulated oil and gas well, these Model Criteria apply to "area-specific" groundwater monitoring. If there is only one oil and gas stimulated well, area-specific groundwater monitoring shall also serve as well-by-well groundwater monitoring. Does that imply that these criteria do NOT apply to "regional" groundwater monitoring?

These Model Criteria shall be used to satisfy the permitting requirements for well stimulation treatments on oil and gas wells pursuant to Public Resources Code section 3160 for all wells that have not received a permit from DOGGR prior to the adoption of the Model Criteria by the State 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 section 1761. As required in Water Code section 10783, these Model Criteria shall be reviewed and updated periodically, as needed.

Does this mean that all existing wells are "grandfathered", whether or not they could pass current permitting standards?

2.0 AREA-SPECIFIC GROUNDWATER MONITORING

Public health implications?

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

1. Area-specific groundwater sampling, analytical testing, and reporting where protected water is present.
2. Requests for written concurrence for a monitoring exclusion.
3. Property owner requested water sampling requirements.

Protected water for current and future beneficial use is defined as:

- Water with less than 10,000 milligrams per liter (mg/L) of total dissolved solids (TDS);
- Within an aquifer of sufficient volume (yields more than 200 gallons per day); and
- Outside an exempt aquifer (pursuant to the Code of Federal Regulations, title 40, part 146.4).

2.1 Groundwater Monitoring Where Protected Water is Present

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.

It appears as though volume (rather than simply area) are being considered here. Is that the case?

Many parameters of the Model Criteria (outlined below) refer to the Axial Dimensional Stimulation Area (ADSA) of the oil and gas well to undergo well stimulation treatment. The ADSA is the estimated dimensions (maximum length, width, height, and azimuth) of the subsurface area(s) targeted by a well stimulation treatment.

It is not just the area but the VOLUME of the aquifer that is of critical concern.

Groundwater monitoring plans processed as complete by DOGGR staff prior to the adoption of these Model Criteria are effective only for stimulated well permits issued by DOGGR prior to the adoption of these Model Criteria. For additional stimulated well permits to be issued in these areas, previous groundwater monitoring plans must be resubmitted consistent with these Model Criteria.

If "volume" is actually what is being considered, substitute "volume" for "area" in Sec. 2.1.

2.1.1 Groundwater Monitoring Design

Area-specific groundwater monitoring shall be designed for early detection of 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 aquifers.

Groundwater could be initially sampled from a nearby water well or from one drilled specifically for groundwater sampling (as opposed to using the oil/gas borehole as the initial sampling well).

The very act of drilling the well uses toxic drilling mud that could potentially contaminate the aquifer. Groundwater should be sampled PRIOR TO DRILLING the oil/gas well borehole, as well as after creating the well, then prior to and after well stimulation.

Establishing Baseline Water Quality Conditions

Groundwater monitoring data will be used to initially establish baseline conditions of monitored chemical constituents in protected water. Baseline data collection shall start 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. Data from wells upgradient of the stimulation may be used to help establish a baseline of water quality impacts.

What if the operator proposes inadequate methods? Where is the oversight?

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.

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 State Water Board staff. The number and locations of proposed monitoring wells in the monitoring plan shall consider the following:

A minimum of 3 wells/aquifer is proposed here. How is the OPTIMUM number of monitoring wells to be defined (as opposed to the mere minimum)?

Note that there is no consideration given to the VOLUME of the aquifer here.

1. At a minimum, one upgradient and two downgradient monitoring wells will be required for each protected aquifer that is penetrated by the stimulated well, or group of stimulated wells. Upgradient and downgradient groundwater monitoring wells shall be located within 0.5 mile of the surface projection of the zone(s) of stimulation.
2. When multiple protected aquifers are present, each protected aquifer shall be monitored separately. At a minimum, one monitoring well is required for each protected aquifer within 0.5 mile of the surface projection of the zone(s) of stimulation. Wells are to be screened at discrete depths in separate aquifers. Various well construction options may be proposed for State Water Board staff approval.

When is this minimum of 1 well/aquifer justified? When is it inadequate? How is the OPTIMUM number of monitoring wells to be defined?

3. All groundwater monitoring wells shall be completed with limited screen lengths; preferably less than 50 feet.

What is the justification for this 50 foot limit? Advantages and disadvantages?

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 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 water supply well. The monitoring well shall be located within 0.5 mile of the surface projection of the zone(s) of stimulation. If the water-supply well is screened across multiple protected aquifers, then each protected aquifer shall be monitored separately. Monitoring shall include, to the extent possible, changes in water level and electrical conductivity (e.g., specific conductance) using real-time monitoring technologies (e.g., transducers). In some cases, one sentry monitoring well may be used to monitor multiple water supply wells. Downgradient and upgradient monitoring wells, as described above, may act as the sentry well.

In addition to testing water in the "sentry" well, water from the nearby water supply well should also be monitored (this could detect a toxin plume that somehow missed 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).

2.1.2 Groundwater Monitoring Plan Requirements

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

1. A map of the oil field and a 0.5 mile buffer surrounding the oil field, that shows the following:

   Why require a 1 mile buffer for Map 2 and only a 0.5 mile buffer for Map 1?

   a) Administrative boundary of the oil field

   b) DOGGR-approved oil and gas production limits

   Shouldn't all active, inactive and abandoned oil and gas wells also be indicated on this map?

   How is this "monitoring boundary" defined?

   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

   Doesn't the "boundary" above define the "area proposed for area-specific groundwater monitoring"?

2. A map of the area proposed for area-specific groundwater monitoring and a one mile buffer surrounding the area, that shows the following:

   Map 1 and Map 2 seem largely redundant. Why not incorporate all required elements of both maps 1 and 2 into one map?

   a) Administrative boundary of the oil field

   b) DOGGR-approved oil and gas production limits

   c) Active or inactive produced water ponds

   d) Water supply wells (public, private domestic, irrigation, and industrial)

   e) Active, inactive, or abandoned oil and gas wells

   f) Oil and gas well(s) proposed to be stimulated

   g) Active, inactive, or abandoned Underground Injection Control (UIC) wells

   h) Proposed groundwater monitoring wells

   i) Line(s) of cross section

   j) Surface features displayed on a topographic map

   l) 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 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, or abandoned UIC wells

h) Proposed groundwater monitoring wells

i) Contours showing the potentiometric surface for each protected 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

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 the following:

a) Depths and/or extent of current oil and gas production limits as defined by DOGGR

b) Location of active or inactive produced water ponds

c) Depths of the vadose zone and water table

d) Depths of all protected water aquifers and the strata that contain them

e) The distribution of groundwater salinity, and gas presence and composition, in aquifers along the stratigraphic section between the water table and target formations

f) Depths and extent of any aquifers classified as exempt by the U.S. EPA (pursuant to the Code of Federal Regulations, title 40, part 146.4)

g) Depth and location of oil and gas well(s) proposed to be stimulated, showing the ADSA. If multiple zones are proposed to be stimulated, include at least one proposed well to be stimulated for each zone

h) The estimated extent and orientation of the planned stimulation

i) Any wellbore within two times the ADSA of individual stimulation stages (this excludes wells located within the plan area of the ADSA, but that do not extend into this area)

How will these geologic features be identified? What is the degree of uncertainty in their identification?

j) 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

k) Depths and locations of any active and inactive UIC wells showing their zones of injection

How precisely and accurately are these UIC zones of injection mapped? What is the spatial resolution and degree of uncertainty?

l) Any available geophysical logs (e.g., spontaneous potential, resistivity, and any porosity logs

m) 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

n) All wells shall be clearly marked and include well name(s) or identification numbers

o) Legend

p) 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 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) The distribution of groundwater salinity, and gas presence and composition, in aquifers along the stratigraphic section between the water table and target formations

d) Depths and extent of any aquifers classified as exempt by the U.S. EPA (pursuant to the Code of Federal Regulations, title 40, part 146.4)

e) Location of active or inactive produced water ponds

f) All wells should be clearly marked and include well name(s) or identification numbers

g) Groundwater elevation information

h) Depths and locations of any active and inactive UIC wells showing their zones of injection

i) At least one cross-section shall include an upgradient groundwater monitoring well, and one or more downgradient monitoring wells

j) For each protected aquifer, indicate any available hydraulic conductivity data (in meters per second) and the source of the data (e.g., hydraulic test)

k) Any available geophysical logs (e.g., spontaneous potential, resistivity, and any porosity logs

Wouldn't a 3-D representation of the confining "low-permeability zones" be far more useful, as it would provide much more confidence that the aquifer was completely isolated.

l) 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

Methods used to map the low permeability zones? Methods used to map aquifer dimensions? Spatial resolution and degree of uncertainty of these methods?

m) All wells shall be clearly marked and include well name(s) or identification numbers

n) Map Legend

o) 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 salinity distribution in aquifers along the stratigraphic section between the water table and target formations.

Accuracy and degree of uncertainty of these methods?

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 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 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)
    c) Casing diagrams, including the following:

Are such casing diagrams required to adhere to any specific industry or regulatory standard format? If so, it may be useful to cite that here.

        - 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 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.

Operator should also supply any lithologic information collected during subsequent well construction.

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 Model Criteria outlined in Section 2.1.3.
15. Details regarding reporting procedures to be used that are consistent with the Model Criteria outlined in Section 2.1.4.
16. The proposed plan is to be signed and sealed by a California registered professional geologist or engineer.

Monitoring should apply to ALL oil and gas wells, whether "stimulated" or not, since all have at least some potential to contaminate aquifers.

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 State Water Board staff. Where an operator proposes to stimulate additional wells in an area that has been approved by State Water Board staff for area-specific groundwater monitoring based on these model criteria, the operator is required to submit an addendum to the approved area-specific groundwater monitoring plan that includes, at a minimum, the following:

Equally important is the idea that all UIC wells should be monitored as well, since they too can contaminate aquifers.

1. A map of the area-specific groundwater monitoring network, including a one mile buffer zone, that shows the following:

Placement of future UIC wells should also be considered. Ideally, all UIC wells would be placed between the "stimulated" well and the "downgradient" monitoring well(s). If the UIC well is "downgradient" of the monitoring well, contamination associated with the UIC well will probably never be detected! Correct placement of the UIC well is critical to effective groundwater monitoring efforts.

   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) Contours showing the potentiometric surface for each protected 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 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)
   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

What will be the frequency of sampling prior to and DURING well stimulation? What is the scientific rationale for that frequency? Will all water samples be assayed as described in Sec. 2.1.3.5-6 below?

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.

What is the scientific rationale for monitoring groundwater only twice per year? What is the minimum "transit time" for various pollutants to move from a well, fracture zone or UIC well to a monitoring well? That transit time (duration) should be set as the MAXIMUM time interval between monitoring events.

All groundwater sampling, analytical testing, and monitoring conducted pursuant to these Model Criteria 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 State Water Board staff.
3. Groundwater level and field parameters including pH, temperature, electrical conductivity, 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 using current applicable U.S. EPA-approved analytical methods, if available, as described below. Please note that State Water Board staff may require additional sampling and testing, if warranted.

a) Total dissolved solids;

b) Major and minor cations, including sodium, potassium, magnesium, calcium, and ammonium;

c) Major and minor anions, including nitrate, nitrite, chloride, fluoride, sulfate, bromide, iodide, and total inorganic carbonate (bicarbonate + carbonate);

d) Trace elements, including iron, manganese, lithium, strontium, boron and uranium;

e) All metals listed in California Code of Regulations, title 22, section 66261.24, subdivision (a)(2)(A), including arsenic, barium, cadmium, chromium, lead mercury, and selenium;

f) Radionuclides listed under California Code of Regulations, title 22, Table 64442;

g) Radon;

h) Hydrogen sulfide;

What of aliphatic hydrocarbons longer than hexane?

What of halogenated hydrocarbons, solvents etc used in well drilling, stimulation and/or production? Alcohols and glycols? Biocides?

What are the limits of sensitivity required here in testing? Will all analytes be tested at the part per million (ppm) sensitivity level? Part per billion (ppb) level? Alternatively, will the testing sensitivity levels be determined by the "good will" of the well operator?

i) Methane, ethane, propane, butane, pentane, hexane;

j) Dissolved organic carbon (DOC);

k) Benzene, toluene, ethylbenzene, and xylenes;

Limiting testing to "crude oil and gasoline ranges" can ONLY be justified if ALL hydrocarbons used in well drilling, stimulation and/or production also fall totally within this range.

l) Total petroleum hydrocarbons for crude oil and gasoline ranges; polynuclear aromatic hydrocarbons (including acenaphthene, acenaphthylene, anthracene, benz[*a*]anthracene, benzo[*b*]fluoranthene, benzo[*k*]fluoranthene, benzo[*a*]pyrene, benzo[*ghi*]perylene, chrysene, dibenzo[*a,h*]anthracene, fluoranthene, fluorene, indeno[1,2,3-*cd*]pyrene, naphthalene, phenanthrene, and pyrene);

m) Stable carbon isotopes in dissolved methane (if present);

n) Stable isotopes of oxygen and hydrogen in water;

o) Guar gum sugars (if guar is used in the well stimulation);and

p) At least two additional analytes selected by the operator, to be reviewed by State Water Board 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.

6. If concentrations of the analytes listed above in part 5 change between sampling events suggesting potential impact from a stimulation treatment (based on interpretation of baseline water quality conditions), then additional laboratory analysis shall be conducted for the following compounds if applicable:

The term "change" here seems needlessly arbitrary.

It is far better to specify a minimum level of change that will trigger "additional analysis". Any change beyond 10% of the initial sampling value, for example, could automatically trigger additional testing.

a) Cationic, anionic, and nonionic surfactants used during well stimulation;

b) Alcohols and glycols used during well stimulation;

c) Biocides used during well stimulation, including any of the following compounds and their known harmful or persistent degradation products:

- Glutaraldehyde;
- DBNPA (2,2-dibromo-3-nitrilopropionamide) and its degradation products dibromoacetonitrile, dibromoacetic acid, and dibromoacetamide;
- Isothiazolinones (e.g., 2-methyl-3-isothiazolinone, 5-chloro-2-methyl-3-isothiazolinone); and

d) Tracers used during well stimulation

7. 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 GeoTracker online 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.

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), 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) Changes, if any, to the scope of work, and rationale for the changes.
8) Waste management and disposal procedures, including associated documentation, permits, manifests, and bills of lading.

Will this include all chemical assay results required in Sec. 2.1.3.5 and 6?

What happens if one or more toxic chemical assayed for are in fact detected in any of the groundwater samples? Is the State Water Board required to notify the EPA? If not, why not?

9) The report is to be signed and sealed by a California registered professional geologist or engineer.

2.2 Requests for Exclusion from Area-specific Groundwater Monitoring Requirement

Area-specific groundwater monitoring related to well stimulation treatment on oil or gas wells is required unless:

1. An operator has received written concurrence from State Water Board staff for an exclusion from the monitoring requirement (written concurrence); or
2. The stimulated well is located within the boundary of a regional groundwater monitoring program that has been approved by Water Boards staff and is being fully implemented in the vicinity of the well(s) to be stimulated.

2.2.1 Exclusion Based on Absence of Protected Water

Pursuant to Water Code section 10783, monitoring is not required for oil and gas well stimulation where the wells do not penetrate groundwater of beneficial use, or solely penetrate exempt aquifers pursuant to section 146.4 of title 40 of the Code of Federal Regulations.

An operator may seek written concurrence from State Water Board 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
- Within an aquifer of sufficient volume (yields more than 200 gallons per day); and
- Outside an exempt aquifer (pursuant to the 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 State Water Board 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, State Water Board 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 concurrences issued by State Water Board staff prior to the adoption of these Model Criteria are effective only for stimulated well permits issued by DOGGR prior to the adoption of these Model Criteria. These areas must be reassessed for written concurrence consistent with these Model Criteria.

Operator requests for written concurrence shall be in a defined geographic area that is typically 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 (State Water Board 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; and
    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.
    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 (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).
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.

2.2.2 Exclusion Based on Regional Monitoring Program

If the well to be stimulated is located within the area covered by a Regional Monitoring Program that has been approved by Water Boards staff and is being fully implemented in the vicinity of the well(s) to be stimulated, then the State Water Board staff may approve the use of the Regional Monitoring Program in lieu of area-specific groundwater monitoring. In order to use the Regional Monitoring Program, the well to be stimulated must be located no less than 0.5 mile from the boundaries of a portion of a Regional Monitoring Program that is fully implemented.

Note that there is no specification of the number of monitoring wells required per square mile or relative to the number of oil/gas wells for a "region", nor is there any definition of how big a "region" might be or how many oil/gas wells it can contain. Neither is there any stated relationship between region size (area) and the number of aquifers or volume of potentially useful water that may be contained within the "region". The functional definition of "region" here… as in Sec. 4.0… is uselessly vague.

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 defined in the California Code of Regulations, title 14, section 1783.3. These requirements include:

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

Will criteria used to approve a lab for "property owner requested" water sampling and testing differ from that used for labs employed by oil/gas operators? If so, how?

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 a 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. The SWB should ALWAYS promptly request the test data, without exception.
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

Pre-purge samples should also be taken and analyzed, since they provide an indication of well (as opossed to aquifer) contamination.

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.
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 current applicable U.S. EPA-approved analytical methods for water, if available, for all of the following:

Why is this list of analytes less complete than that given in Sec. 2.1.3 Part 5?

a) Total dissolved solids;

b) Major and minor cations, including sodium, potassium, magnesium, calcium, and ammonium;

c) Major and minor anions, including nitrate, nitrite, chloride, fluoride, sulfate, bromide, iodide, and total inorganic carbonate (bicarbonate + carbonate);

d) Trace elements, including iron, manganese, lithium, strontium, boron and uranium;

e) All metals listed in California Code of Regulations, title 22, section 66261.24, subdivision (a)(2)(A), including arsenic, barium, cadmium, chromium, lead mercury, and selenium;

f) radionuclides listed under California Code of Regulations, title 22, Table 64442;

See also comments provided in Sec. 2.1.3 Part 5.

g) Radon;

h) Hydrogen sulfide;

i) Methane, ethane, propane, butane, pentane, hexane;

j) Dissolved organic carbon (DOC);

k) Benzene, toluene, ethylbenzene, and xylenes;

l) Total petroleum hydrocarbons for crude oil and gasoline ranges; polynuclear aromatic hydrocarbons (including acenaphthene, acenaphthylene, anthracene, benz[*a*]anthracene, benzo[*b*]fluoranthene, benzo[*k*]fluoranthene, benzo[*a*]pyrene, benzo[*ghi*]perylene, chrysene, dibenzo[*a,h*]anthracene, fluoranthene, fluorene, indeno[1,2,3-*cd*]pyrene, naphthalene, phenanthrene, and pyrene);

4.0 REGIONAL GROUNDWATER MONITORING PROGRAM

Water Code section 10783(h)(1) required 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 in Model Criteria for the Regional Monitoring Program include well stimulation treatments, among other events or activities that have the potential to contaminate groundwater, such as oil and gas well failures.

Water Code section 10783(f) (5) notes that the Model Criteria must include a determination of threshold criteria on the transition from area-specific monitoring to the Regional Monitoring Program. Several circumstances need to be in place before that transition can be achieved. One aspect is that it will take a considerable amount of time before the appropriate level of data are collected and the density of the monitoring well network at oil fields with well stimulation is established. For at least the near future, area-specific monitoring will be required until the Regional Monitoring Program is fully implemented.

The volume of fluid used in well stimulation activities is a very small fraction of fluid used relative to other oil and gas production activities such as steam-injection, water flood, and wastewater

disposal. However, fluids used in well stimulation become part of the overall waste stream in the oil production process and are most likely to be indistinguishable from other fluids. 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.

Examined how? As specified in Sec. 2.1.3.5 and 6?

How will a "regional" ground water sample differ from an "area specific one?

4.1 Exploratory Background Surveys

State Water Board staff worked with the USGS to develop a conceptual model for the Regional Monitoring Program. 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 Rose Field and Kern River Field. The proximity of oil and gas production zones to groundwater resources in these areas was assessed. The results indicate that the Kern River Field has a higher number of oil and gas wells screened at similar depths, or in close proximity to screened intervals of nearby water supply wells. In contrast, information for the Rose Field indicates a much higher degree of separation between oil and gas wells and screened intervals of nearby water supply wells. This assessment supported the development of characterizing groundwater risk zones discussed in the Regional Monitoring Program (Section 4.2).

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

4.2 Components of the Regional Monitoring Program

Information collected during the exploratory background surveys has been used to develop the 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
- 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.

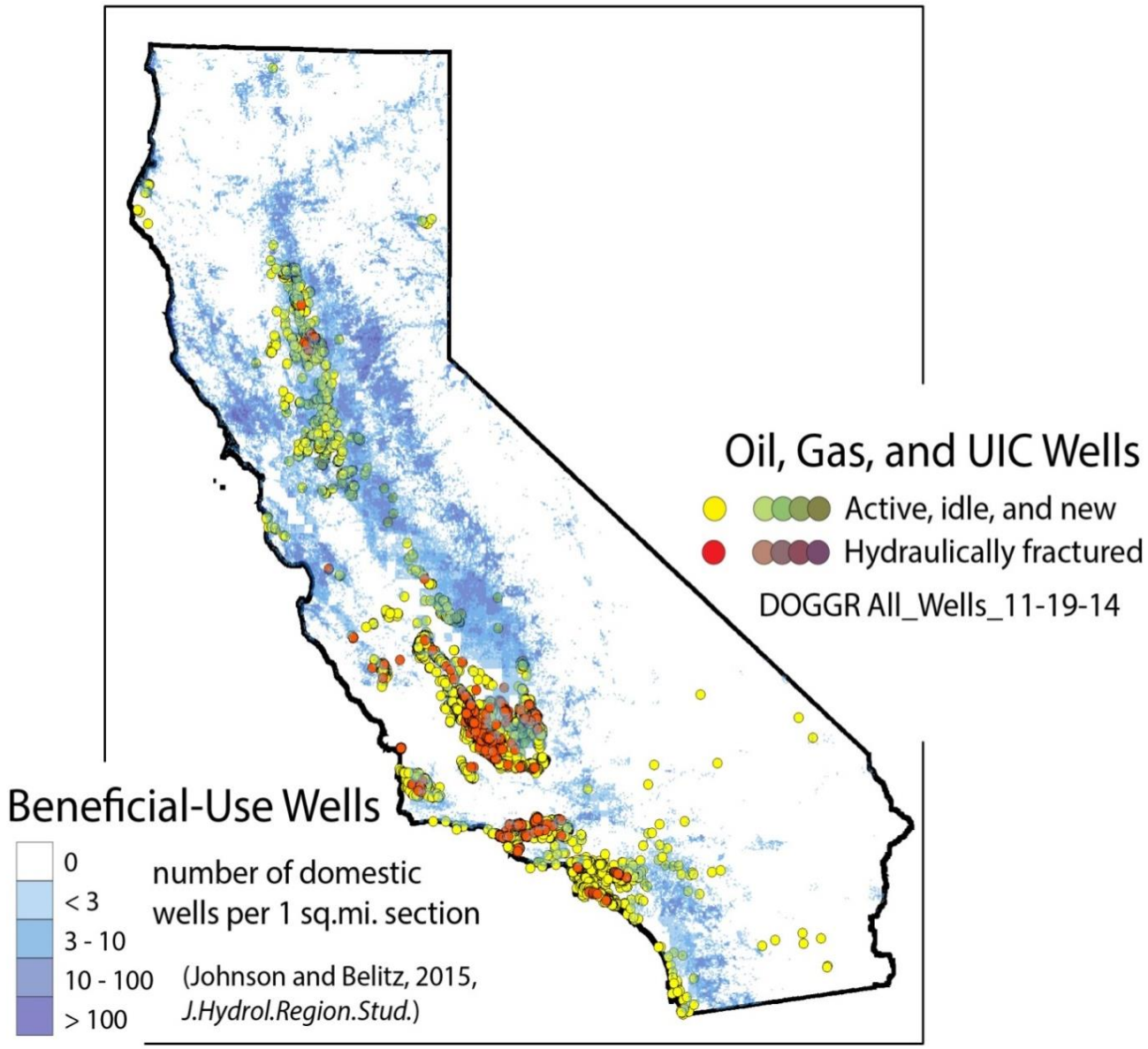

Figure 1. Comparison of Locations of Water Supply Wells (Beneficial Use Wells) and Oil, Gas, and Underground Injection Control Wells.

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.
- 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), 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 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.

The monitoring should be done as part of this Ground-water Monitoring Program.

Is this comment meant to imply that testing of produced water ponds, oil/gas formation water etc is not still the responsibility of the operator?

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(s), 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.

The whole idea of a "Regional monitoring" program is vague. Groundwater baselines will be established by sampling from individual monitoring wells, but you will not logically be able to "average" the data. You will instead be able to create a map of discrete well baseline values distributed across a "region".

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.

Other "risk parameters": formation permeability; # of aquifers present &/or penetrated; # UIC wells used, fluid composition and volumes injected; # wells stimulated and extent of stimulation zones; inadequate # of monitoring wells etc.

Why will it take longer (multiple years) to obtain baseline values from individual wells in a region than from individual "area-specific" wells?

Establishing a baseline of water quality is a critical step of the Regional Monitoring Program, and may require multiple 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 make best use of time and resources.

Using the parameters described above, 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. Previous oil/gas activities make it likely that such wells are already contaminated.

Monitoring wells shall be constructed properly, developed, and permitted in accordance with applicable local well ordinances. If there are no applicable local well ordinances, they shall be constructed in accordance with the California Well Standards.

Once again no explanation is offered for defining how many monitoring wells will be needed per unit area (or volume) of "region" to be monitored. Will this be determined in some scientifically based RATIONAL fashion? If so, state that rationale. Conversely, will the decision of monitoring well number and placement be left to the operators and their "unbiased" judgement?

Waste management and disposal procedures, including associated documentation, permits, manifests, and bills of lading shall also be documented.

Sampling and Testing Parameters

"Frequently enough" is unacceptably vague.

Once a week? Every 2 weeks? Every month?

Regional Monitoring Program groundwater monitoring wells shall be sampled frequently enough to detect changes in water quality. Water quality monitoring shall 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 State Water Board's GAMA Program.

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
- 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)
- Concentrations of additional inorganic constituents

Delete the qualifier "to the extent possible". All such samples MUST be provided to the Monitoring Program.

In some instances these chemical constituents may require laboratory analytical methods that are not commercially available. To the extent possible, the Regional Monitoring Program staff shall have access to monitoring sites, injected fluid samples, produced water samples, and groundwater samples collected by the operator or their consultants in related monitoring programs or actions.

Data and information collected as part of the Regional Monitoring Program will be made publicly available to the extent allowed by laws, policies, or procedures.

4.4 Regional Monitoring Program Review

"Periodic" review is simply too vague and arbitrary. Regular review should be mandated and the review interval specified.

The implementation of the Regional Groundwater Monitoring Program is the first of its type in the United States. Currently, there is not a similar program that has universal agreement on an approach. The State Water Board will periodically review data associated with well stimulation and groundwater monitoring to assure quality results and assessments. The Regional Monitoring Program design will be re-evaluated based upon the review, utilizing the current state of knowledge from related studies. The State Water Board may seek the advice of experts and other stakeholders to assist in this review.