Overview of Groundwater Protection Regulations in Oil and Gas States

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Executive Summary

This report is part of an update to the Ground Water Protection Council's 2009 Report, *State Oil and Gas Regulations Designed to Protect Water Resources*.[1] The purpose is to document and outline the range of definitions and requirements for protecting groundwater, based on the regulations of oil and gas agencies and water quality protection agencies in 27 oil and gas producing states. The report is divided into two parts, the first documents the groundwater protection standards for oil and gas agencies and the second part addresses the standards for the water quality protection agencies within the same states. The scope is limited to an overview of regulations that address groundwater quality protection standards through policy statements, definitions, technical requirements such as well casing and cementing depths, groundwater classification and groundwater protection standards.

Oil and gas agencies have comprehensive rules and regulatory programs that include groundwater quality protection. This review focused on two elements of their protection regulations, protection standards and well casing and cementing depth requirements. Variations are evident in regard to the specificity of water quality standards and surface casing and cementing depth requirements. Definitions used for water quality standards were often not linked to a specific numerical standard and the rationale for standards was often not clearly stated.

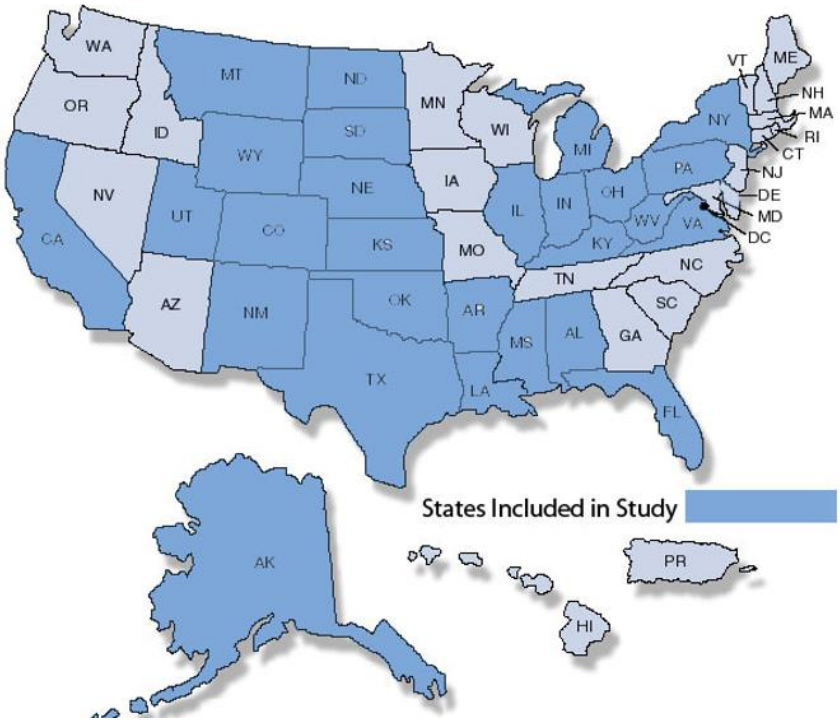
State water quality agencies utilize a variety of regulatory approaches to protect groundwater quality. The review focused on the following types of regulations: Groundwater Protection Policy, Groundwater Classification, and Groundwater Standards. While several states have sophisticated and detailed groundwater quality protection programs and regulations, less than half the states agencies in the study employ formal water quality classification and standards for groundwater protection.

Potential next steps are identified including expanding this research to the agencies within the states not included in this report and agencies that focus on state water resource planning. Further efforts could be directed to evaluating both state and national brackish water assessments and conducting a more detailed review of state water quality classification and standards.

Purpose and Scope

The purpose of the overall EDF project is to update the 2009 Report, *State Oil and Gas Regulations Designed to Protect Water Resources*[1]. As a part of the overall project, this report summarizes the results of a review of groundwater protection regulations of state water quality agencies as well as an update of the rules for state oil and gas agencies. The scope of this report is focused on groundwater protection regulations in 27 oil and gas producing states (Figure 1[1]) which regulate over 98 percent of the oil and gas production[1] in the United States. The scope is limited to an overview of regulations that address water quality protection standards through policy statements, definitions, technical requirements such as well casing and cementing depths, groundwater classification and groundwater standards. The purpose is to document and outline the range of definitions and requirements for protecting groundwater based on state regulations.

Figure 1. Study Area



Study Assumptions

Each state has specific regulatory language designed to address its geographic, geologic, hydrologic, and climatic and public policy issues. Regulations do not comprise the full scope of regulatory programs. States' legislation provides laws and policies which guide the implementation of regulatory programs. States adopt rules and regulations to implement these laws and policies. Research and discussion of states' legislation and policies were beyond the scope of the project.

Groundwater Regulatory Provisions of State Oil and Gas Agencies

The following oil and gas regulatory provisions are common to all the states in the study: pollution prevention, permitting, and underground injection control.

Pollution Prevention:

States have adopted specific rule language to implement pollution prevention. In general, rules require operators to conduct all oil and gas operations in a manner that would prevent the pollution of usable and freshwater resources and any groundwater meeting specified water quality or use standards. These provisions include both surface and groundwater. These regulations provide a basis for agencies to mandate and enforce more specific protection requirements.

Permitting:

All of the states in the study have permitting authority and regulatory requirements for oil and gas drilling, well completion, well plugging and abandonment, and re-entry of wells. Permits provide specific requirements for well construction and testing.

Underground Injection Control Program (UIC):

The federal UIC program under the Safe Drinking Water Act (SDWA) regulates the subsurface disposal of produced fluids from oil and gas activities, termed Class II underground injection in all states in the study. This program addresses disposal of drilling fluids, hydraulic fracturing flowback fluids, and water produced in the recovery of oil and gas. Twenty-one states in the study administer delegated EPA-approved UIC primacy programs and EPA implements the federal program in 6 states. Two of the 6 nonprimacy states have state rules coexisting with EPA's Direct Implementation program for UIC permitting. The nationwide groundwater protection standard in the UIC Program is applied to an "Underground Source of Drinking Water" (USDW) that is defined as an aquifer or portion of an aquifer that supplies any public water system or that contains a sufficient quantity of groundwater to supply a public water system, and currently supplies drinking water for human consumption, or that contains fewer

than ten thousand milligrams per liter total dissolved solids and is not an exempted aquifer. Exempted aquifers must meet a certain set of criteria under the SDWA which allow certain permitted injection activities into aquifers that would otherwise be designated an USDW.

Groundwater Protection Requirements and Standards:

Groundwater protection standards, while common to all the state programs in the study, vary significantly in their specific requirements. These groundwater protections programs are and have traditionally been state, rather than federal, programs and have been developed to address each state's unique geologic and hydrologic conditions. The study focused on two elements of states' groundwater protection regulations referred to here as groundwater protection standards and casing and cementing depth requirements.

Figure 2. Simplified geologic cross-section.[2]

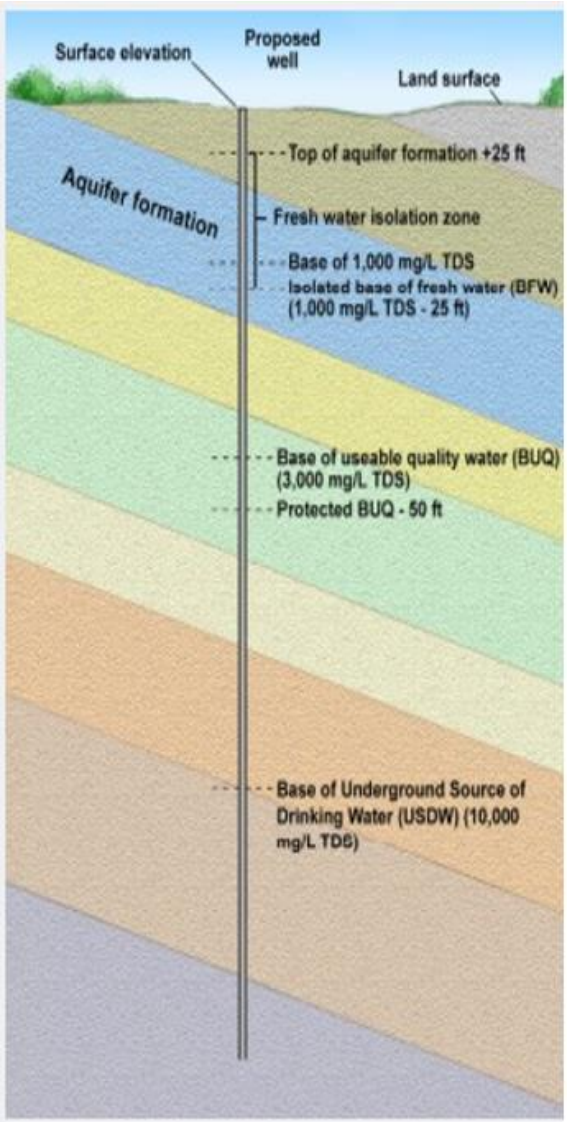


Figure 2 illustrates a simplified picture of a geologic cross-section with a deep well penetrating a number of geologic units including several aquifers with differing salinities and separated by confining units. The picture illustrates depths at which higher levels of groundwater protection (for example- 1,000, 3,000, and 10, 000 mg/L Total Dissolved Solids, TDS) are applied. These protection depths would be translated to casing and cementing requirements through a drilling permit. While this is a simplified example, many years of drilling and regulatory experience are reflected in the agencies' geologic review and permitting of oil and gas wells.

Groundwater Protection Standards:

For the purposes of this report, the term "Groundwater Protection Standard" describes a state's water quality or water use definition that identifies the type of groundwater for which the state requires protective measures. Examples of a water quality definition might be "freshwater" or "water containing less than 1,000 milligrams per liter (mg/L) total dissolved solids (TDS)." Examples of a water use definition include "usable quality water" or "water suitable for agricultural uses."

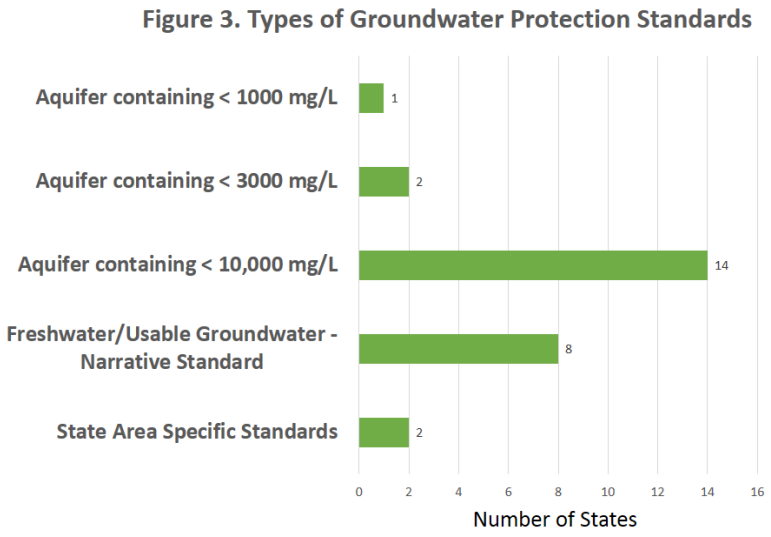


Figure 3 lists the various groundwater protection standards found in the study and the number of states using a particular standard. The two most commonly used standards are "aquifer containing less than 10,000 mg/l TDS" for 14 states and "freshwater/usable groundwater" for eight states.

The first three listed standards are numerical standards with a specific water quality-based measure. One state has numerical standards for protecting aquifers that contain less than 1,000 mg/L TDS , two states have a numerical standard for protecting aquifers that contain less than 3,000 mg/L TDS, and 14 states have a numerical standard for protecting aquifers that contain less than 10,000 mg/L TDS. The second type of standard, found in eight states, is a narrative standard describing groundwater to be protected. The standard is not specifically defined by numerical water quality in the rule. The last type of standard in Figure 3 is "State Area Specific Standards," described here as a formal set of numerical standards linked to an established groundwater classification system. This standard is used by two states for their oil and gas program. This type of standard is discussed more fully in the section on water quality protection agencies. In general, the 10,000 mg/l TDS standard is the more protective and conservative standard when compared to the narrative and lower TDS standards.

In some states, such as Wyoming, the oil and gas agency program rules rely on the groundwater classification program and standards of the state's water quality agency. In states where one agency manages both oil and gas and water quality protection as separate programs, there may be a similar reliance on the water quality program for groundwater standards.

Often, the variations in definitions can be traced to the time period in which they were originally promulgated and to the availability of information about groundwater resources at that time. Regulations enacted prior to the 1972 SDWA will not typically refer to underground sources of drinking water, a TDS limit of 10,000 mg/L, or exempted aquifers, because these terms and the standard were developed in the SDWA. Furthermore, when some groundwater protection definitions were developed, information about the depth, quality, and quantity of groundwater was likely limited to data gathered from existing fresh water wells that were drilled and in use[3].

Protection Depth and Casing and Cementing Standards:

Two other factors, protection depth and well construction, combine with the groundwater protection standard to provide confinement of groundwater zones and prevent contamination from drilling and production activities. A determination of the location of the aquifer to be protected, both on the ground and importantly at depth, is needed. Depths to subsurface formations can change significantly over a few miles. For layered sedimentary rock, a gentle dip of the formations can result in a change in depth of tens of feet per mile. Faults affecting geologic units can result in much greater changes in depth over shorter distances. The well or drilling permit requires a determination of the depth, provides a depth, or references already known information on the depth of lowest occurring zone of groundwater requiring protection, often termed "base of usable quality or fresh groundwater" as near to the drilling site as possible. The permit and rules further provide requirements for setting and cementing surface casing to protect the water quality in identified zone(s).

Figure 4. Casing/Cementing Depth

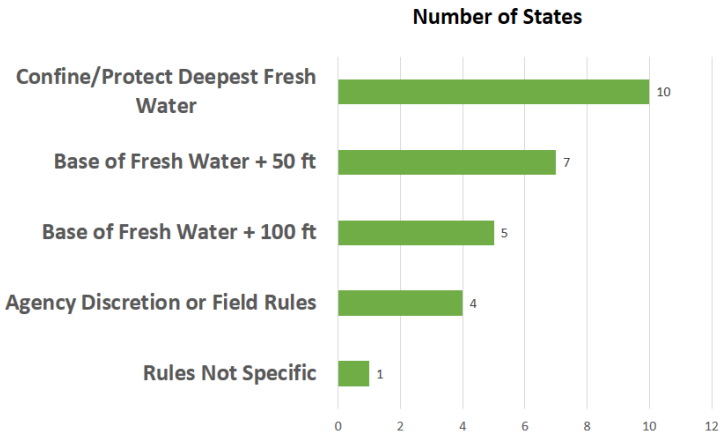


Figure 4 shows the variation in the language of states' rules for well surface casing and cementing depth requirements. The rules in all of the states require and specify protection of the deepest occurrence of groundwater meeting the state-specified standard. Rules in 10 states simply required the confinement and protection of the deepest freshwater zone. Rules in 12 states required surface casing and cementing to depths of either 50 feet or 100 feet below the base of the deepest protected zone. Rules in another four states referenced agency discretion or field rules for the depth determination. State Oil and Gas agencies often have field rules, which govern specific geographic areas or fields of oil and gas development. An agency or its regional offices will have developed area-specific information on subsurface groundwater hydrology and petroleum occurrence that are applied in the evaluation of drilling permit requests. Rules in one state were not specific regarding the protection depth. These rules did specify the setting and cementing of surface casing to protect freshwater, but make reference to other provisions with only general application for depth determinations.

For states in the basin and range physiographic province in the western U.S., groundwater zones in some deep, fault-block basins are capable of providing water of a quality that is suitable for public drinking water supply from depths as great as 8,000 feet.[3] Given the

availability of much shallower groundwater and the costs of developing the deeper zones for use, these aquifers are more likely to be sources of water for future use. Drilling rules in one state provide alternate aquifer protection by stage cementing. In the areas where the depth of the aquifers make it impractical or uneconomical to set the full amount of surface casing, the owner may comply with this requirement by stage cementing the intermediate and/or production casing to provide the required protection.

While not reviewed in detail for this study, states' rules have specific provisions with design criteria and specifications for well casing and cementing programs which include testing and logging for verification of cementing. This information can be found in the 2009 Report, *State Oil and Gas Regulations Designed to Protect Water Resources*[1] and the 2013 update of the Report[3].

Groundwater Protection Provisions of Water Quality Protection Agencies

Most of the states in the study have separate agencies that manage and regulate water quality protection activities that are not associated with oil and gas activities. In eight of the states, one agency regulates both oil and gas activities and water quality programs for the state. The scope of the study did not include water resources programs, such as water rights administration or water planning; and does not include state water resource agencies if separate from state water quality agencies. Figure 5 identifies five types of groundwater regulatory provisions or programs used by state water quality protection agencies and lists the number of states in the study which have adopted these provisions.

Figure 5. Groundwater Protection Regulatory Provisions

Groundwater Protection Policy:

Regulations in nine states provide a policy statement identifying the use and value of groundwater and the need and requirement to protect the resource. The policy is often linked to the establishment of a classification and/or standards for the purpose of protecting existing

and potential beneficial uses of groundwater. Standards and use classifications serve as fundamental support for other ground water regulatory programs in the states. While the emphasis of these programs is on prevention of impacts to groundwater, most policies recognize some limited discharges and existing impairments to groundwater.

Groundwater Classification:

Regulations in 10 states formally identify specific categories of groundwater based on quality, use, or both. Examples would be drinking water at less than 1,000 mg/l TDS, groundwater with quality suitable for agriculture, industry, mining or other uses with dissolved solids concentrations of 1,000 mg/L to 3,000 mg/L TDS; moderately saline groundwater that may be brackish but can be treated and used for a beneficial purpose; and very saline and brine groundwater that is usable for waste disposal generally via underground injection (see Table 1). Some states have a classification for pristine or special high quality groundwater that supports recreational waters or valued ecosystems. These classifications are linked to permitting activities that limit discharge of wastewaters to usable groundwaters and may prohibit discharges to the higher quality groundwaters.

Water Quality Standards:

Twelve states have requirements listing specific contaminants and their maximum allowable concentrations in water, including groundwater. Examples include listings of metals, inorganic chemicals, pesticides and other organic compounds, microorganisms, and radiological constituents. These standards can be described as a formal set of numerical standards established for specific geographic areas and/or hydrologic units for groundwater. The application of the standards is based on an inventory of state groundwaters and assignment of a specific classification for each aquifer unit or group of aquifers based on characteristics including type of use, quality, degree of vulnerability, and degree of connection to other groundwater units or surface water. The standards are used in permitting to limit or prohibit discharge of the listed contaminants to groundwater.

Groundwater Discharge Permitting:

Regulations in 8 states provide specific permits for some types of waste to be discharged to the ground, to the vadose zone or unsaturated zone of an aquifer, or into groundwater. Examples would include: septic system effluent, stormwater runoff, cooling water, and nonhazardous wastewater. Groundwater discharge permitting in some states is linked to their classification system, where groundwater discharges are only allowed in certain classifications of lower quality groundwater.

Corrective Action Standards:

Seven of the states also use their water quality protection standards for remediation standards, a use of groundwater quality standards to guide clean up of contamination that has already

occurred. Other states also use corrective action standards but these are found in their waste management program.

Underground Injection Control Program:

As noted in the earlier discussion of Groundwater Regulatory Provisions of State Oil and Gas Agencies, the federal UIC program regulates the injection of fluids underground to protect groundwater. Generally the water quality agencies administer the UIC program in the states for Classes I, III, IV, V and VI injection. Class I includes the injection of industrial, municipal, and hazardous waste for disposal below the base of protected groundwater. Class III includes injection wells used for the solution mining of minerals. Class IV are hazardous waste wells generally prohibited from injection or discharge to a USDW, except in cases where specific waste cleanup activities are required. Class V includes miscellaneous types of wells that inject nonhazardous fluids often at shallow depths. Class VI wells inject carbon dioxide for purposes of carbon sequestration. If the state has not received delegation of the Federal UIC program from EPA, then the EPA Region Office implements the program. The UIC program requires a groundwater protection standard of less than 10,000 mg/l TDS for an underground source of drinking water. The full definition is given above in the section on Oil and Gas agencies.

Issues Identified

State oil and gas rules can be confusing with regard to groundwater protection standards. Definitions, such as “usable groundwater” are often not linked to a specific water quality standard(s). Additionally, the rationale supporting a protection standard may not be in the rule or not clearly stated. While a rationale may be provided in other state law or guidance, it can be challenging to make the link from the regulations back to laws or policies set out in state legislation.

While the rules in all of the states in the study require and specify protection of the deepest occurrence of groundwater meeting the state-specified standard, the rule language was varied and in a few cases confusing. In some states the protection depth required was found in a separate rule or reference for a range of activities such as injection wells or well plugging.

The increasing use of unconventional oil and gas drilling technology employing hydraulic fracturing has led to a growing public interest in water quality protection related to oil and gas activities. With the advent of the new technology, many states are reviewing their current rules and adopting new or revised rules. Results of this study suggest that states could benefit from a review of their groundwater protection regulations for clarity of intent and supporting policy statements.

Since the scope of this project was limited to 27 states with Oil and Gas agencies. The study did not review regulations addressing groundwater protection policies, classifications, or standards for water quality protection programs of the 23 remaining states. Also, as noted previously, the study did not review the protection programs of water resource or water planning agencies.

In order to further understand groundwater quality protection issues, sources of future water supplies should also be considered. These sources of groundwater may occur at greater depths or contain water with increased salinity or both. Generally among states, a water resource planning or development function has been authorized, and is conducted by a water quality agency or a separate planning agency with a specific mandate to consider, assess or develop sources of water for future use.

A general groundwater quality classification which may be useful in this discussion has been published by the U.S. Geological Survey in a report reviewing data from across the United States[4]. The classification in Table 1 identifies Fresh water as less than 1,000 mg/L, Slightly Saline as 1,000 – 3,000 mg/L, Moderately saline as 3,000 – 10,000 mg/L, Very saline as 10,000 – 35,000 mg/L, and Brine as greater than 35,000 mg/L.

The U.S. Geological Survey, as well as some states, have conducted data reviews of the occurrence and quality of saline groundwaters. The U. S. Geological Survey has a number of publications and ongoing studies on the subject that are discussed on their saline water and brackish groundwater websites[6].

Table 1. General Groundwater Quality Classification U.S. Geological Survey[4, 5, 6]

Based on Total Dissolved Solids Content

Fresh Water	less than 1,000 mg/L
Slightly Saline	1,000 to 3,000 mg/L
Moderately Saline	3,000 to 10,000 mg/L
Very Saline	10,000 to 35,000 mg/L
Brine	greater than 35,000 mg/L

Milligrams per liter (mg/L) is generally equivalent to parts per million (ppm) when dissolved-solids concentrations are less than about 7,000 mg/L. For larger concentrations, a density correction should be used when converting from mg/L to ppm.

Potential Next Steps

- Expand the review to remaining states.
- Review quality concerns of state water resource and planning agencies.
- Review state and federal brackish water resource assessments and mapping programs.
- Develop a more detailed review of states' water quality classifications and standards.
- Conduct additional review of corrective action standards in state waste management programs for comparison.

References

[1] Ground Water Protection Council, "State Oil and Gas Regulations Designed to Protect Water Resources". Prepared for the U.S. Department of Energy – National Energy Technology Laboratory, May 2009, 63 pp.

[2] Figure courtesy of the Groundwater Advisory Unit, Oil and Gas Division, Railroad Commission of Texas.

[3] Ground Water Protection Council, "State Oil and Natural Gas Regulations Designed to Protect Water Resources: 2013 Edition", In Progress, March 2014.

[4] R. A. Krieger, J. L. Hatchet, and J. L. Poole, "Preliminary Survey of Saline-Water Resources of the United States," U.S. Geological Survey Water Supply Paper 1374, 1957, 171 pp.

[5] U.S. Geological Survey, **"**National Brackish Groundwater Assessment," Info Sheet, 2013

[6] U.S. Geological Survey websites on saline waters and brackish groundwater, **http://ga.water.usgs.gov/edu/saline.html** and **http://ne.water.usgs.gov/ogw/brackishgw**