PROTECTING SOURCE WATER IN COLORADO

DURING OIL AND GAS DEVELOPMENT

August 2016

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ABOUT THIS GUIDE

This guide is intended for water providers and community members interested in learning more about water quality protection during oil and gas development. The information contained in this guide is provided for educational purposes only and does not constitute legal advice. It is intended to be up to date as of the time of publication, but likely will not remain current over the passage of time. This guide is not a substitute for a consultation with an attorney licensed in Colorado or your jurisdiction who can properly advise you regarding your specific situation.

ACKNOWLEDGMENTS

This report is a collaborative effort by the Intermountain Oil and Gas BMP Project, the Colorado Rural Water Association, AirWaterGas and Western Resource Advocates. The lead authors of the report are Matt Samelson and Matt Sura. Kathryn Mutz (Intermountain Oil and Gas BMP Project), Dylan Eiler, Paul Hempel, Tom Wall, and Colleen Williams (Colorado Rural Water Association), and Joan Clayburg and Laura Belanger (Western Resource Advocates) are the review editors. We would like to thank John Duggan and Dave Rogers from the Colorado Water Quality Control Division, Mike Paules, Regulatory Advisor at WPX Energy, and Mark O'Meara, Town of Carbondale Utilities Director for their assistance and review of this document. Their experience and thoughtful suggestions improved the quality of this report. We would also like to thank Matt Schechter of the University of Colorado Boulder Office for Outreach and Engagement for design of this guide. The authors take full responsibility for any mistake found in this report, and the review of this document by the above entities does not imply their agreement with or endorsement of the concepts, analysis, methodologies, or conclusions of this report. Funding for this report was provided in part by Western Resource Advocates and by a CU Outreach and Community Engagement grant to the University of Colorado's Getches-Wilkinson Center for Natural Resources, Energy and the Environment.

AirWaterGas

AirWaterGas is funded by the National Science Foundation as a Sustainability Research Network to address issues arising from rapid oil and gas development in the Rocky Mountain region. The network is comprised of scientists, engineers, public health experts, educators, policy analysts, economists, lawyers, and students working together to address a single driving question: "How can we better integrate information about the environmental, economic, and social trade-offs of oil and gas development into policies and regulations that guide and govern development?" The AirWaterGas water quality team is investigating groundwater and surface water quality in oil and gas basins in Colorado, identifying potential water contaminants of greatest concern, and improving knowledge of the fate and transport of these contaminants.

More information about AirWaterGas can be found at www.airwatergas.org

Colorado Rural Water Association

The Colorado Rural Water Association (CRWA) is a non-profit corporation that provides technical assistance and training to Colorado's public and private water and wastewater systems having populations less than 10,000. About 98% of Colorado's 2,095 public water systems serve communities that have populations less than 10,000. Colorado Rural Water Association receives funding from the U.S. Department of Agriculture (USDA) and the Colorado Department of Public Health and Environment (CDPHE) to help rural communities with source water protection. Our role is to provide technical assistance in order to coordinate and facilitate the process of developing a Source Water Protection Plan and to promote communication and collaboration between public water providers, communities, and government agencies.

More information about CRWA can be found at www.crwa.net.

Intermountain Oil and Gas BMP Project

The Intermountain Oil and Gas Best Management Practices (BMP) Project was developed by the Getches-Wilkinson Center for Natural Resources, Energy, and the Environment at the University of Colorado Law School. This project hosts a website addressing a wide range of resources that are affected by oil and gas development, specifically air and water quality, land surface disturbance, vegetation, wildlife, aquatic and riparian values, and community values. The project includes a searchable bibliography and background information on these issues, relevant laws, and a searchable database of both mandatory and voluntary BMPs currently in use and/or recommended for responsible resource development in the states of Colorado, Montana, New Mexico, Utah, and Wyoming. The Intermountain BMP Project also maintains a national comparative law database to compare state, federal, and local oil and gas laws and regulations. This LawAtlas database is hosted by Public Health Law Research at Temple University Law School.

More information about the BMP Project and LawAtlas can be found at www.oilangasbmps.org and http://lawatlas.org/oilandgas.

Western Resource Advocates

For over 25 years, Western Resource Advocates has been one of the West's leading conservation groups protecting the region's air, land, and water. Western Resource Advocates uses the law, science, and economics to craft innovative solutions to the most pressing conservation issues in the region. Western Resource Advocates works to transition electricity production away from conventional fossil fuel technologies toward clean, renewable energy and energy efficiency to end the electric industry's contribution to climate change. Western Resource Advocates protects the health of Western rivers and lakes so they remain vibrant parts of our communities, support robust economies, and provide a variety of recreational opportunities. Western Resource Advocates safeguards threatened landscapes and wildlife to leave a Western legacy for future generations.

More information about WRA can be found at http://westernresourceadvocates.org.

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EXECUTIVE SUMMARY

Throughout much of Colorado, oil and gas is being developed near our public drinking water supplies. This guide is intended for Colorado's public water providers and for residents who rely upon them for clean water. It outlines how oil and gas development could impact water quality — particularly the "source water" of our drinking water supplies. Source water includes both the surface water (streams, rivers, and lakes) and the groundwater (aquifers) that serve as sources of drinking water. This guide focuses on how local governments and water providers can work with the regulators and with the oil and gas industry to ensure that Colorado's water is not negatively impacted by oil and gas development activities.

Colorado's history of oil and gas development precedes statehood, with an oil well drilled near Florence, Colorado, in the 1860s. More recently, Colorado has experienced several bursts of oil and gas activity. In the 1990s and early 2000s, this included coalbed methane development, primarily in the San Juan Basin of southwest Colorado and the Raton Basin in southern Colorado. In the mid-2000s, major drilling activities shifted to Garfield County and natural gas development in the tight sands formation of the Piceance Basin. Since 2009, the bulk of oil and gas development moved to the Front Range, when the industry successfully utilized horizontal drilling and hydraulic fracturing to develop Colorado's Niobrara shale under Weld County. In 2014, Weld County produced 85% of the state's oil, 80.7 million barrels. The shifting landscape of oil and gas drilling activity in Colorado occurs because of the constant evolution and technological developments in the oil and gas industry, such as hydraulic fracturing and horizontal drilling.

Oil and gas development can impact water quality in many ways. Surface water can be contaminated by stormwater runoff and spills. Groundwater can be contaminated through surface spills, leaking waste pits, or poor disposal practices. In rare circumstances, a poorly constructed oil and gas well may allow gas and other pollutants to escape due to incomplete casing or cement failures.

Oil and gas development has four stages that could impact source water: 1) seismic exploration and discovery; 2) road and well pad construction; 3) drilling, completion, and production; and 4) interim and final reclamation.

Any potential threat posed by seismic testing can be greatly reduced or eliminated by simply requiring the seismic testing to be conducted a safe distance from any water wells. Appropriate placement of roads and well pads as well as utilization of simple stormwater management techniques can greatly reduce the impacts of erosion to surface waters. The drilling and production stages can impact water quality in the event of an accident or equipment failure, waste ponds or tanks, or poor borehole integrity. Accidental spills of produced water, condensate, and oil could affect water quality during both development and operations of a well field. Successful interim and final reclamation is important to prevent soil erosion, but it, too, can impact water quality. Earth-moving activities required for reclamation — both interim and final — can be a source of surface water contamination.

State, local, and federal government agencies have regulatory mechanisms for protecting source water from most of these impacts. Non-government water providers, conservation groups, and individuals — including both landowners and private citizens — can participate in these regulatory mechanisms and use other mechanisms, such as surface use agreements and leasing agreements, to protect source water.

Within the regulatory realm, the federal Safe Drinking Water Act (SDWA) broadly addresses source water protection, addressing potential impacts of all types of activities. The 1996 Amendments to the SDWA require states to develop and implement source water assessment programs to analyze existing and potential threats to the quality of the public drinking water throughout the state. The state, in turn, encourages water providers to take the information from the assessment to create and implement Source Water Protection Plans. Colorado Rural Water Association can help water providers and their communities develop and implement these plans.

Under the federal Clean Water Act, two major mechanisms for protecting source water include controlling point source discharges and controlling stormwater. In Colorado, these activities are regulated by two state agencies: the Colorado Water Quality Control Division (CWQCD) within the Colorado Department of Public Health and Environment and the Colorado Oil and Gas Conservation Commission (COGCC), in regards to oil and gas activities. COGCC regulations allow produced water from coalbed methane, as well as from other oil and gas wells, to be disposed of by discharging into the state's surface waters (Rule 907.c). But in order to do so, the operator must have a discharge permit from the CWQCD and must comply with other water quality regulations. The CWQCD's stormwater discharge regulation require a stormwater permit for construction activities on oil and gas sites that disturb or are part of a common plan of development that will disturb more than one acre. All other water quality standards and classifications established by the CWQCD that pertain to oil and gas development are enforced by the COGCC.

The public, including water providers, can influence both individual permits and the scope of state regulations through the public comment process. When new agency rules are proposed, the general public and water providers can provide public comments or engage more fully by requesting "party status" for the proceedings. When the COGCC is considering a permit, Local Governmental Designees (LGDs) are able to engage in that process

on behalf of the public and local governments. LGDs can help a water provider by asking for additional time for public comments or requesting additional mitigations or best management practices (BMPs) as conditions of approval for the permit.

Local governments also have an important role to play in protecting source water. State statute allows local governments to designate source water areas, to use zoning to protect source water areas, to enact watershed protection ordinances, and to limit oil and gas development within flood plains. Local governments can also protect source water areas through their own permitting processes, memorandums of understanding (MOUs), leases, and surface use agreement contracts, and by working within the COGCC decision-making process by commenting on oil and gas applications, challenging permits through COGCC hearings, and requesting the COGCC to issue orders regarding specific developments. Use of MOUs and other non-regulatory means are advantageous because they avoid the question of whether state interests preempt local jurisdictions regulating oil and gas production. However, these non-regulatory means can also be problematic because they require negotiating with individual companies, and they can be more difficult to enforce.

Protecting water quality is not limited to federal, state, and local regulatory or non-regulatory processes. A water provider may be able to negotiate with oil and gas operators to enter into various private-party contracts, such as leasing agreements and surface use agreements. If a water provider owns minerals, surface acreage, or water desired by the oil and gas operator, it can provide leverage to negotiate water quality protections beyond state or local government requirements. Water providers and individuals can also participate where federal lands and/or minerals are being developed. Two types of federal land use agency actions can impact water quality and require public input: land use planning and individual land use decisions.

No matter the type of land being developed, the best way to protect source water is to locate the oil and gas facilities away from source water areas. When facilities cannot be sited at a safe distance from source water areas, mitigation measures may prevent or reduce the likelihood of water contamination. Some of these BMPs receive widespread use and may eventually be adopted as regulations. However, many BMPs are applied on a case-by-case basis, depending on the characteristics of the oil and gas development. This guide describes both current regulations and BMPs used to prevent water contamination due to spills, waste disposal pits, stormwater discharge, hydraulic fracturing fluid, and wellbore integrity failures. Hydraulic fracturing ("fracking") has the potential to be a source water issue because millions of gallons of water, including tens of thousands of gallons of chemicals, are used to frack a single well. Spills and leaks of fracking fluid that can contain various chemicals that are dangerous to human health, even if present in minute quantities, can pose a risk to surface and ground water quality.

Best practices integrated into Colorado regulations to protect surface source waters include internal, intermediate, and external buffer areas. COGCC's Rule 317B protects surface public water sources by requiring some additional protections when a facility is proposed within a half-mile of a designated surface water source and by excluding oil and gas facilities within 350 feet from designated water sources. These water quality protections are significantly reduced when addressing expansion of an existing oil and gas well site, as the COGCC "grandfathers" existing well pads that were in place prior to 2008. Colorado regulations also provide specific protections within floodplains, and through requirements to report spills and releases.

The COGCC has general groundwater quality protection rules, such as requirements of baseline water testing and drilling requirements (e.g., well casing and cementing). But the basic standards for groundwater, as well as site-specific water quality classification and standards for groundwater, are adopted by the Colorado Water Quality Control Commission. The COGCC implements these rules for groundwater protection.

In 2012, the COGCC adopted a regulation (COGCC Rule 609) requiring baseline and post-completion groundwater monitoring. However, the baseline water sampling rule is not uniform across the state. The Greater Wattenberg Area, where most oil and gas production is currently occurring in Colorado, has a more limited groundwater monitoring regulation (COGCC Rule 318A.f). Nonetheless, landowners and water suppliers can request testing when development occurs near their water sources. Designing and constructing a well so hydrocarbons cannot migrate into fresh water formations is a fundamental way to protect drinking water aquifers during oil and gas operations. Assuring that the wellbore is properly cemented requires good drilling technique and proper testing. Cement bond logs, mechanical integrity tests, and bradenhead tests are important elements for assuring the integrity of every well. In addition, when a proposed well is in "close proximity" to the groundwater table or existing wells, a different level of water protection and regulation may be warranted for that well. Current COGCC policy requires that existing wells in the formation targeted by a proposed horizontal well must be identified and remediated in order to prevent the wells from serving as conduits for oil, gas, or drilling fluids to enter groundwater.

Surface pits are also a concern for groundwater contamination. All pits can eventually leak if used long enough. While COGCC regulations do not require installing leak detection and monitoring systems, many companies include them as a standard practice. Similarly, COGCC regulations do not require use of

closed-loop drilling systems that contain all fluids within a system of pipes and tanks. But use of a closed-loop system can be requested through surface use agreements or added as condition of approval for a COGCC permit. COGCC can also issue Special Orders in areas where water suppliers rely on shallow water wells.

Knowing the potential impacts of oil and gas development is only the first step. Taking an active role in ensuring that the appropriate regulations are applied and that additional mitigation measures are used, when necessary, will help ensure source water protection in Colorado.

Keys to source water protection are to:

Work with federal, state, and local governments and operators to site facilities — including wells, pits, and disposal activities — a safe distance from source waters.

Establish a relationship with federal agencies and advocate for best practices on federal lands during federal management planning and minerals leasing and permitting processes.

Use your leverage as a water provider, mineral owner, or surface owner to advocate for best practices if the wells are "too close for comfort." Best practices might include establishing a baseline water quality for source waters, reducing the area of disturbance, monitoring stormwater mitigations to ensure they are in place and functional, monitoring reclamation activities with "before and after" photographs, and requesting use of non-toxic fracking fluids.

I. INTRODUCTION

This Guide Focuses on How to Avoid Negative Impacts to Water from Oil and Gas Activities

This guide is intended to provide advice for public water providers throughout Colorado and for the residents of Colorado who rely upon them for a safe and reliable domestic water supply. The state has more than 2,000 public water systems, and oil and gas development occurs near many of them.

This guide focuses on how oil and gas development could impact water quality and quantity, and how local governments and other water providers can work with federal and state agencies and with the oil and gas industry to ensure that Colorado's water resources are not negatively impacted by oil and gas industrial activities.

1) History of Oil and Gas Development in Colorado

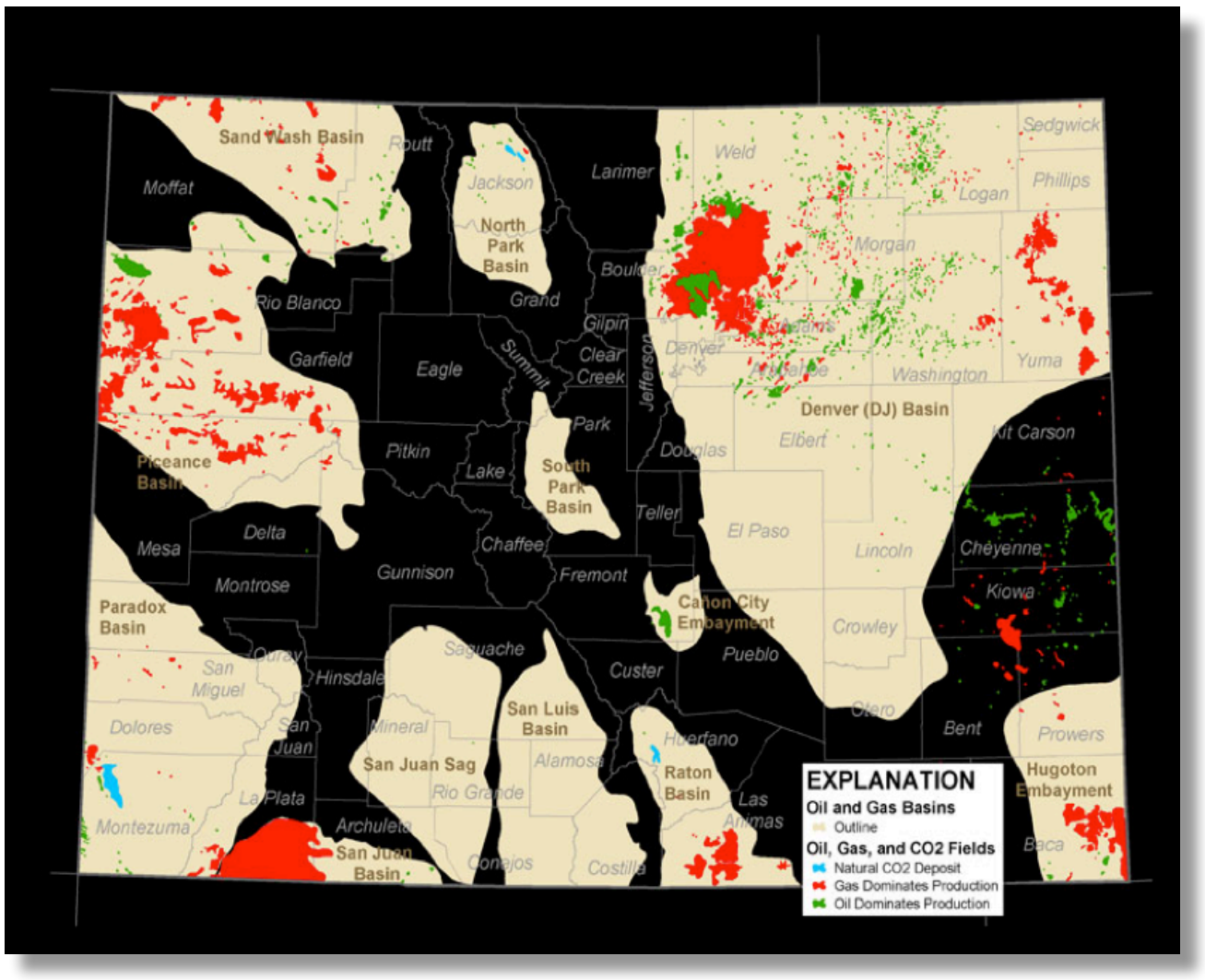


Figure 1. Map of Colorado's oil and gas basins showing primary type of production.[1]

Colorado's history of oil and gas development precedes statehood, with an oil well drilled near Florence, Colorado, in the 1860s. Multiple regions of the state experienced drilling activities over the next 150 years, and as of September 2015, 38 of 64 Colorado counties have at least one producing oil/gas well. However, most of the production occurs in five counties: Weld, Garfield, La Plata, Rio Blanco, and Las Animas.

Over the past two decades, Colorado has experienced several "booms" of increased oil and gas activity followed by "busts" or extended downturns in activity. In the 1990s and early 2000s, coalbed methane production grew from negligible to more than 500 billion cubic feet annually, primarily in the San Juan Basin of southwest Colorado and the Raton Basin in southern Colorado. Coalbed methane is generated and stored within coal seams. The methane is held in coal seams by water pressure, and the water must be removed in order to release the coalbed methane. These coalbed methane wells have typically been shallower than conventional wells.

In the mid-2000s, the majority of drilling activities in Colorado shifted to Garfield County and natural gas development in the tight sands formation of the Piceance Basin. Garfield County led the state in applications for permits to drill wells for four years (2005–2008) until natural gas commodity prices declined.
In 2009, horizontal drilling and hydraulic fracturing were successfully utilized to produce oil from Colorado's Niobrara shale under Weld County. The hydraulic fracturing process occurs after the well's borehole has been drilled horizontally through the targeted shale formation. Production in Colorado's Niobrara shale is primarily oil, and in 2014, Weld County produced 85% of the state's oil, 80.7 million barrels.

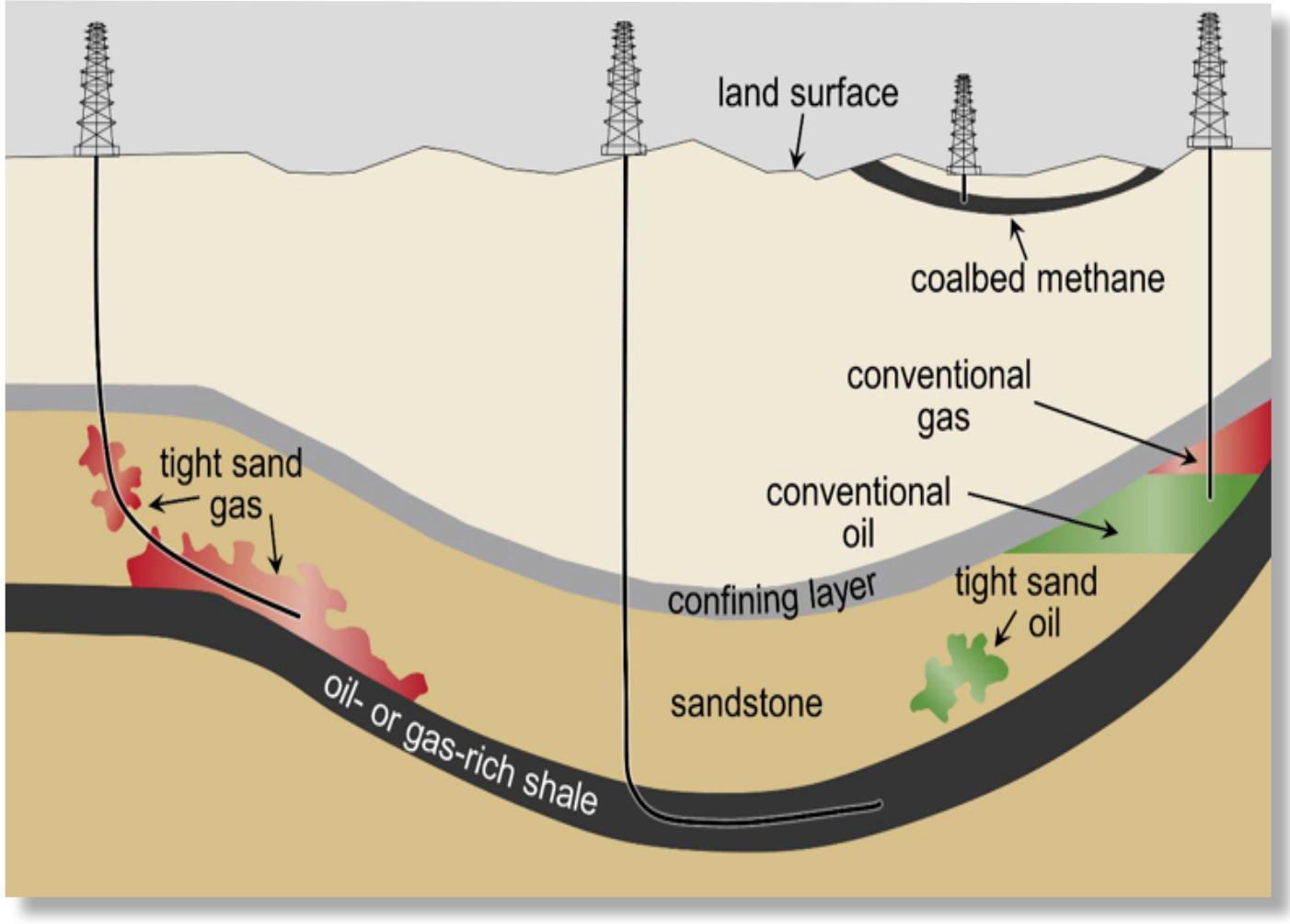


Figure 2. Shown are conceptual illustrations of types of oil and gas wells. A vertical well is producing from a conventional oil and gas deposit (right). In this case, a gray confining layer serves to "trap" oil (green) or gas (red). Also shown are wells producing from unconventional formations: a vertical coalbed methane well (second from right); a horizontal well producing from a shale formation (center); and a well producing from a tight sand formation (left). Note: Figure not to scale.[2]

2) Technological Advances Have Changed Oil and Gas Development in Colorado

The shifting landscape of oil and gas drilling activity in Colorado occurs in response to petroleum commodity prices and because of the constant evolution and technological developments in the oil and gas industry. Traditional oil and natural gas wells were drilled vertically into highly permeable formations where hydrocarbons were trapped, having one point of interface between the well and geological zone. However, newer horizontal wells start vertically and then turn horizontally to run within the geological zone, most typically a shale layer. A horizontal well has numerous points of interface with the shale, and water is forced down the well to fracture the shale in order for more hydrocarbons to be released. Several horizontal wells can be co-located on the same well pad, which increases the scale and surface impacts at those particular locations. However, having multiple wells from one pad also decreases the overall number of well pads on the landscape, which decreases the cumulative surface impacts.

The combination of horizontal drilling and hydraulic fracturing allowed the oil and gas industry to target hydrocarbon-bearing shales or other tight (low permeability) formations previously not economically viable. The successful application of combined horizontal drilling and hydraulic fracturing resulted in increased activity and production in both mature and immature oil and gas basins. Some of this new development is occurring in closer proximity to residences and in watersheds, where it had not existed previously. In other places, population growth has expanded urban development into mature oil and gas fields. State regulations and, to a much lesser extent, local regulations evolve to keep pace with how the industry operates. But an industrial activity with constantly evolving technologies results in tension between the industry, the regulators, and impacted communities. As the industry's technologies continue to change, concerns for air quality, water quality, and other community impacts will be raised.

II. OVERVIEW OF OIL AND GAS DEVELOPMENT AND POTENTIAL RISKS TO SOURCE WATER

"Source water" is a term referring to surface water (streams, rivers, and lakes) or groundwater (aquifers) that can serve as sources of public drinking water. Oil and gas development may impact water quality in many ways. Surface water may be contaminated by stormwater runoff and spills. Groundwater may be contaminated through infiltration by a surface spill, leaking waste pits, or poor disposal practices. In rare circumstances, a poorly constructed oil and gas well may allow gas and other pollutants to escape through loss of well integrity caused by inadequate casing or cement.

Oil and gas development has four stages that could impact source water: 1) seismic exploration and discovery; 2) road and well pad construction; 3) drilling, completion, and production; and 4) interim and final reclamation.

1) Seismic Exploration and Discovery

Exploration and discovery of oil and gas is often, but not necessarily, initiated through seismic testing. Seismic-imaging companies create a shock wave through the use of large machines such as vibrasizers ("thumper trucks") or underground ignition of explosives. The shock wave is sent down through the rock. Shock waves reflected off the geologic formations below are captured by monitoring equipment on the surface, indicating what types of formations are present and whether they may contain oil and gas.

Potential water quality impact: There is very little potential impact to water quality from seismic exploration. However, some academic literature suggests that seismic testing too close to water wells could pose a threat to the integrity of a water well and therefore water quality.[3] Any potential threat posed by seismic testing can be greatly reduced or eliminated by simply requiring the seismic testing to be conducted a safe distance from any water wells. The Bureau of Land Management (BLM) requires seismic testing to be at least 350 feet from water wells on lands they manage.[4]

2) Road and Well Pad Construction

Once the necessary permits are obtained, it may be necessary to construct a road to access the well pad. A well pad is typically three to ten acres in size and can vary depending on the operator's plans, the number of wells to be drilled, and the need to co-locate production equipment, including separators, treaters, tanks, and emission control equipment. Multi-well pads that contain production facilities can be as large as 15 acres.

Potential water quality impact: Proper stormwater protections need to be in place; otherwise, this ground disturbance can lead to increased soil erosion and additional sediment reaching surface waters, such as rivers, creeks, or lakes (see Section IV.3.g).

3) Drilling, Completion, and Production

As discussed in this guide, the drilling, completion, and production phase of oil and gas development may impact water quality. Local and state regulations can eliminate or mitigate some of these concerns. Other concerns may be addressed by adding conditions of approval to state drilling permits or local land use approvals.

The aspects of oil and gas drilling and production that may impact water quality include storage of fluids in pits or tanks and production equipment on the well pad, poor borehole integrity, ongoing production and drilling of additional wells, and trucking/transfer of drilling fluids and flowback water.

a. Waste Ponds, Tanks, and Production Equipment

The well site will contain at least one pond or tank to hold drilling fluids or produced water. Waste ponds ("pits") used to store drilling fluids or produced water are a significant source of potential groundwater contamination if not properly constructed. Equipment associated with production facilities where natural gas, condensate or crude oil, and produced water is transferred, separated, or stored will also be present. This equipment includes process piping, flowlines, and tanks (including partially buried and buried vaults and vessels). Tanks used during the production process may have spills that occur during transfer of liquids to trucks. Tanks can also deteriorate over time, causing slow leaks that may result in substantial soil and groundwater contamination over years.

Potential water quality impact: Pits can be a source of groundwater or surface water contamination if the liner is ruptured or a storm event causes the pit to breach. Tanks and their flowlines have been determined to be a major source of leaks and spills. An environmental consulting firm hired by the COGCC examined 1,638 spill reports between January 2010 and August 2013, and determined that the highest risk of a spill or release was associated with production facilities where natural gas, condensate or crude oil, and produced water is transferred, separated, or stored.[5] The equipment that failed most frequently was process piping, flowlines, tanks (including partially buried and buried vaults and vessels), and valves (see Section IV.4).

II. OVERVIEW OF OIL AND GAS DEVELOPMENT AND POTENTIAL HARM TO SOURCE WATER (cont.)

b. Poor Borehole Integrity

A well may have multiple layers of cement and casing — surface, intermediate, production. While the borehole is being drilled and drilling pipe (casing) placed, drilling mud is sent down the hole to prevent water, oil, and gas from escaping into the borehole until it is ready to be tested. Eventually, the casing is cemented to the borehole to ensure that water, oil, and gas do not migrate outside of the casing. Shot holes are then created in the pipe, at the depth of the geologic formation they want to produce.

At this point, the well may also be "stimulated" by pumping fluid at high pressures to fracture the targeted rock formation. This process is known as hydraulic fracturing or "fracking." Hydraulic fracturing can take more than four million gallons of water per well.

Potential water quality impact: Poor cementing of the borehole to the casing could allow oil and gas, or even hydraulic fracturing fluid, to escape outside of the casing and migrate up the borehole to contaminate groundwater. Recent revisions to COGCC rules and policies have made borehole integrity concerns far less likely.

c. Ongoing Production and Drilling of Additional Wells

If the well contains marketable quantities of oil or gas, more wells will be drilled in the area to determine the extent of the oil and gas development opportunity and the spacing of wells necessary to efficiently extract the oil or gas. This will vary, depending on the resource and the formation. One well per 160 acres may be enough in some cases; in other areas, the density needed to efficiently extract the resource is one well for every 10 acres. The COGCC typically requires the use of directional drilling and multi-well pads to develop a resource that requires a high density of wells.

Ultimately, the leased area will be "developed" through a series of wells and production facilities needed to extract, treat, store, and/or transport the resource. The type and number of facilities needed is entirely dependent on what is being produced, e.g., coalbed methane, oil and/or natural gas; the volumes recovered; the composition of the oil and/or gas; and the access to and use of pipelines.

Oil production may require a pump jack to pump the oil to the surface. After separation from gas and water, produced oil will typically be placed in tanks on site and hauled away by tanker trucks. However, some operators with contiguous acreage are utilizing pipelines to transport oil and gas and produced water to centralized separation and storage tank batteries. Coalbed methane is extracted by dewatering the coal layer, thereby releasing the methane from the coal seam. This requires a pump jack that pulls water out of the ground. Then, typically, the water is either evaporated in ponds or injected underground into a Class II injection (disposal) well. In some cases, when this water meets local water quality standards, it is discharged to area streams under a Colorado Discharge Permit System permit issued by CDPHE.

All oil and gas production requires an extensive system for separating and processing the oil and gas. Glycol dehydrators, separators, and other equipment are used to separate water from liquid hydrocarbons, such as oil, and natural gas. Gas must be transported through a network of pipelines. Increasingly, companies are also choosing to transport water and oil through pipelines as well.

Potential water quality impact: All of this equipment and processes may be a source of water contamination in the event of an accident or equipment failure. Accidental spills of produced water, condensate, and oil could affect water quality during this stage of development.

d. Trucking and Transfer of Liquids

A significant amount of flowback and produced water from Colorado oil and gas wells is disposed of by injecting it underground at Class II wells. The water most likely is transferred from tanks into a water truck and then transported from a producing well to the injection well.

Potential water quality impact: Spills during the transfer of liquids to and from water trucks have the potential to contaminate groundwater. However, the bigger concern is from accidents involving water trucks, which have resulted in major releases that reached both surface waters and groundwaters.

4) Interim and Final Reclamation

Once the well is completed and producing, the operator must perform interim reclamation to return most of the well pad and any pipeline corridors to their prior condition. The location of the wellheads, production equipment, and the road leading to the well will remain on site in order to support and service the well. A typical oil or gas well in Colorado can remain productive for a period of 20–30 years.

While some wells may be recompleted (i.e., targeting another formation) or restimulated (i.e., re-hydraulically fractured or injected with water or carbon dioxide), at some point the well no longer produces economic quantities of oil and/or gas. When this occurs, the operator may decide to shut in or plug, and abandon the well. Proper plugging of a well requires setting plugs and removing surface equipment and plugging the wellbore with cement to isolate the completed and surface intervals of the well. Equipment is next removed from the site. The access road and well pad is then subject to final reclamation, which requires re-contouring and reseeding to restore the disturbed area back to its pre-drilling condition.

Potential water quality impact: Earth moving required for reclamation can be a source of surface water contamination, but successful interim and final reclamation is important to prevent soil erosion from harming water quality. The COGCC has regulations covering reclamation[6], and individual companies are developing their own best practices for successful reclamation[7]. However, recent studies have indicated that reclamation is often unsuccessful in unirrigated lands or in poor soils.[8]

III. REGULATORY AND NON-REGULATORY APPROACHES TO PROTECTING SOURCE WATER

The following section provides an overview of the regulatory mechanisms state, local, and federal government agencies use in protecting source water while regulating the oil and gas industry. The section also describes how non-government water providers, conservation groups, and individuals — including both landowners and private citizens — can participate in these regulatory mechanisms and use other means, such as surface use agreements and leasing agreements, to protect source water.

1) Colorado Oil and Gas Conservation Commission

The COGCC has a legislative mandate to "foster the responsible, balanced development, production, and utilization of the natural resources of oil and gas in the state of Colorado in a manner consistent with protection of public health, safety, and welfare, including protection of the environment and willife resources."[9] Practically speaking, the COGCC has a dual mandate to (1) foster or promote oil and gas development and (2) protect public health and welfare. This dual mandate requires the COGCC to balance the needs of the industry with the protection of the environment, including water quality. The COGCC mandate is in statute, but most of the regulatory requirements for the oil and gas industry are found in the COGCC rules.[10]

Point source discharges and stormwater permits are issued and enforced by the Water Quality Control Division within the Colorado Department of Public Health and Environment. All other water quality standards and classifications established by the Water Quality Control Commission that pertain to oil and gas development are enforced by the COGCC via Senate Bill 89-181 authority.[11] The CDPHE recognizes the COGCC authority to regulate "drilling, casing, operation and plugging of seismic holes or exploratory wells, the shooting and chemical treatment of wells, the disposal of salt waters and oil field wastes, the protection of underground sources of drinking water affected by the construction and/or operation of Class II injection wells, the protection of the health, safety and welfare of persons at oil or gas wells, and protection of the health, safety and welfare of the general public."[12]

a. Public Comments on Proposed Oil and Gas Locations

The COGCC allows public comment on oil and gas permit applications and has been especially responsive to the comments of local governments and water providers. It is critical that water providers send comments to the COGCC on any application that has the potential to harm water quality. Because COGCC relies on third-party data about water well locations, the COGCC may not always know the exact location of water wells in the vicinity of a proposed oil and gas facility. However, operators are required to identify any man-made features within 500 feet of their oil and gas location in their permit documents.

i. Notification of Permits

Notice of a proposed oil and gas well or production facility is a function of property ownership and proximity. Only the affected local government and landowners within 1,000 feet of a proposed facility receive personal notification. The rest of the community has to monitor the COGCC website or have frequent contact with their Local Governmental Designee (LGD) to learn about proposed oil and gas facilities in the area. Any local government can designate an office and/or person as the LGD. Local governments voluntarily join the LGD program, which provides access to the COGCC well and location permitting process and participation in other COGCC matters. The COGCC conducts LGD training and provides materials for the position. The LGD has to provide the COGCC written notice, including the name, postal address, telephone number, fax number, email address, local emergency dispatch, and other emergency numbers of the Local Governmental Designee. A listing of participating LGDs is available on the COGCC website.[13]

If an operator proposes an oil and gas facility within 1,000 feet of a home or a commercial space or anywhere within an "urban mitigation area," then it must send a pre-application notice to both the LGD and all landowners within 1,000 feet of the proposed facility (per COGCC Rule 305). The pre-application notification must be sent at least 30 days prior to filing for an oil and gas location and must include some general information about the comment period as well as the proposed date when operations will begin.

An oil and gas operator applies for a new location (well or production facility) by filing a Form 2A application — Oil and Gas Location Assessment — with the COGCC. Once a Form 2A is sent to the COGCC, the agency has 30 days to determine its completeness. Upon determination of completeness, the operator must promptly notify the surface owner of the application, as well as landowners within 500 feet of the location, as well as owners of homes or commercial space proposed well or facility location, and the LGD (Rule 305(c)).

For landowners within 500 feet of the proposed oil and gas location the notice must include the submitted Form 2A, a list of major equipment proposed for the location, a map of the area, and information on how to comment and to request a meeting with the operator. Owners of homes or businesses located between 500–1,000 feet from the facility will receive a postcard stating where the facilities will be located, how to comment, and the operator's contact information. The oil and gas operator of the proposal is required to meet with anybody who owns a home or commercial space within 1,000 feet of the proposed facility (Rule 306(e)). Notification may be increased to 90 days for home and business owners if a large oil and gas facility is proposed within an urban mitigation area.[14] Operators are not required to give notice to landowners beyond 1,000 feet of a proposed oil and gas location. Instead, it falls on the landowner either to check the COGCC website frequently or form a good relationship with the LGD who would be willing to pass along notices.

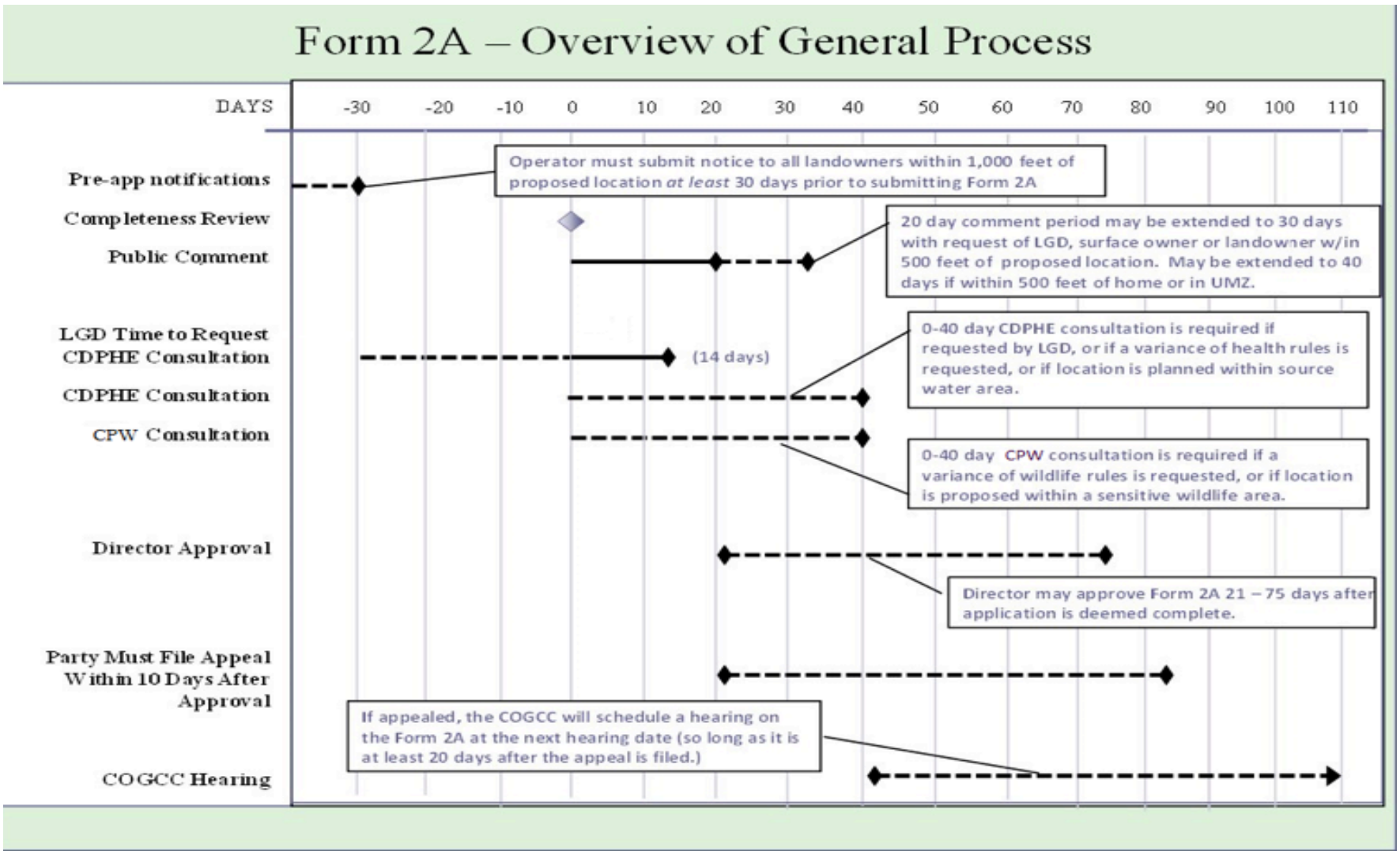


Figure 3. Time line and overview of process of completing a Form 2A (LGD: Local Governmental Designee; CDPHE: Colorado Department of Public Health and Environment; CPW: Colorado Parks and Wildlife; COGCC: Colorado Oil and Gas Conservation Commission; Director: Director of COGCC).

ii. Public Comment Period

After an application is deemed complete, the COGCC posts the Form 2A on its website and allows 20 days for public comment (Rule 305(d)). This comment period can be extended to 30 days, if requested by the surface owner, a landowner within 500 feet of the proposed location, the LGD, or either the CDPHE or Colorado Parks and Wildlife. If there is a facility proposed within 500 feet of a home or if the facility is proposed within an urban mitigation area, the LGD can have the comment period extended to 40 days. All comments on pending Applications for Permit to Drill (Form 2) and pending Applications for Location Assessment Permit (Form 2A) will be posted on the COGCC website.[15] Operators are required to consider all legitimate concerns raised in written comments, but they are not required to respond to those concerns in writing.

iii.Instructions for Viewing Permits and Commenting on the Web

Step-by step instructions are available online describing how to view and comment on pending permits on the COGCC website.[16] In some cases, comments by a local government have been accepted by the COGCC after the comment period.

b. Local Governmental Designees (LGD)

The LGD in the jurisdiction where the proposed facility will be located is given some additional authority that can be very helpful in protecting water supplies. As stated earlier, the LGD can assist a water provider by asking for additional time for public comments. The LGD can also request additional mitigations or best management practices as conditions of approval for the permit. These requests are often honored by the operator and/or COGCC. The LGD may also require consultation with the CDPHE to determine if the public health or welfare may be threatened by the proposed oil and gas development. Ultimately, the relevant local government may apply for a hearing under COGCC Rule 503.b.(7).C before the COGCC to challenge the permit if it believes that the COGCC rules or permit conditions are not sufficient to protect public health, safety, or welfare.

III. REGULATORY AND NON-REGULATORY APPROACHES TO PROTECTING SOURCE WATER (cont.)

c. COGCC Rulemakings

When a state agency such as the COGCC or the Colorado Water Quality Control Commission plans to promulgate a new rule, the agency files a notice with the Secretary of State. The public can make comments on the proposed rulemaking, and the agency must accept and consider the comments. However, a person or organization may participate in the rulemaking with requesting "party" status as well. Party status provides a more structured opportunity to engage in the entire rulemaking process. The agency will provide directions on how to obtain party status. The process is typically straightforward, asking for the applicant's name and contact information as well as a stated reason — policy, factual, and/or legal issues — for requesting status.

2) Colorado Department of Public Health and Environment

The federal Safe Drinking Water Act Amendments of 1996 required states to develop and implement source water assessment programs to analyze existing and potential threats to the quality of the public drinking water throughout the state.[17] The CDPHE completed its first round of source water assessments for every public water system in 2004.[18] The state also encourages water providers to take the information from the assessment to create and implement Source Water Protection Plans. The plans should be written through an open public process and take into account all water supplies and water demand, delineate the source water protection area, and include an in-depth contamination source inventory, a contingency plan in the event of an emergency, and a plan to protect both water quality and quantity through increased capacity and/or best management practices.

Source Water Protection Plans

Through funding from the CDPHE and the U.S. Department of Agriculture, the Colorado Rural Water Association can assist water providers that supply water to populations of less than 10,000 in developing a Source Water Protection Plan. At no expense to the water provider, the Colorado Rural Water Association will supply a team of specialists to start the collaborative planning process with local governments and other stakeholders. CRWA will also provide the technical assistance necessary to research and write the Source Water Protection Plan.

3) Local Governments — Municipalities and Counties

Local governments have an important role to play in protecting source water. State statute allows local governments to designate source water areas, to use zoning to protect source water areas, to enact watershed protection ordinances, and to limit oil and gas development within flood plains. However, due to some recent court decisions, the extent to which local governments can regulate oil and gas development without risking litigation with the state and/or industry is uncertain. To address the legal uncertainly and still ensure source water areas are protected, local governments have also protected source water areas through memorandums of understanding, leases, and surface use agreement contracts, and by working within COGCC processes such as commenting on oil and gas applications and requesting the COGCC to issue an order.

a. State Preemption of Local Government Regulation of Oil and Gas

In recent years, numerous discussions as well as several lawsuits have examined local governments' right to regulate oil and gas development in the manner they regulate other land uses and whether state oil and gas regulations preempt local governments from regulating the industry. Since the 1990s, the extent to which local governments may regulate oil and gas activities has been limited by several court decisions. The Colorado Supreme Court has recently found in City of Longmont v. Colorado Oil & Gas Ass'n, that local governments may only regulate oil and gas so long as the regulations do not "operationally conflict" with the state interest of permitting "each oil and gas pool in Colorado to produce up to its maximum efficient rate of production, subject to the prevention of waste, consistent with the protection of public health, safety, and welfare, including protection of the environment and wildlife resources.[19] The courts will only find a local regulation in operational conflict with the state's interest if the adverse party is able to show that the local regulation "authorizes what state law forbids or that forbids what state law authorizes" or "materially impairs or destroys" the state interest. The Court has done little to elucidate what actions would "materially impair or destroy" the state interest.

b. Interaction of Local Zoning Ordinances with State Regulations

In 2012, the COGCC decided to sue the City of Longmont because it enacted zoning regulations to limit where oil and gas operations may occur. Separating land uses through local zoning has occurred in the United States since 1916.[20] But since 1990, the state of Colorado has taken the position that local governments are preempted from applying local zoning restrictions on oil and gas development. This position causes conflict with many local governments because no other industries in Colorado, including hard rock mining, receive such an exemption.

Several local governments have devised creative approaches to regulate the industry while not coming into "operational conflict" with COGCC regulations. Gunnison County, for example, has adopted "performance-based regulations" in order to avoid operational conflicts with COGCC rules. The county lists the problems that can be caused by oil and gas operations, (such as water quality concerns) and then requires the operator to offer proposed solutions to those problems as part of its conditional-use permit application. Applications are evaluated based on how well the operator will avoid or mitigate impacts.[21] If the proposed plan or mitigations are deemed insufficient, the county retains the ability to deny the permit. By using performance-based regulations, Gunnison County avoids having specific regulations

conflict with COGCC rules, uses industry expertise in arriving at solutions, and retains the leverage to obtain protections that go beyond COGCC regulation requirements.

Boulder County has opted to use a two-track approach to regulating the industry. The first, called the "expedited development plan review process," promises a relatively quick review and approval by the staff — so long as Boulder County's "objective criteria" are met. "Objective criteria" are best management practices proven effective in reducing impacts and typically go beyond COGCC requirements. On the other hand, a company choosing to do only the minimum required by the COGCC will be sent through the "standard development plan review process."

The standard review process is a much more thorough vetting of the application that requires a public hearing and a vote by the planning commission, followed by another public hearing and a vote by the board of county commissioners. If the project is controversial, the standard review process may take months.

c. Right of Municipalities to Designate Watersheds and Create Watershed Protection Ordinances

Colorado municipalities can enact watershed protection ordinances. A Colorado statute gives municipalities the power to "acquire waterworks" in order to:

> Construct or authorize the construction of such water works without their limits and, for the purpose of main taining and protecting the same from injury and the water from pollution, their jurisdiction shall extend over the territory occupied by such works and all reser voirs, streams, trenches, pipes, and drains used in and necessary for the construction, maintenance, and oper ation of the same and over the stream or source from which the water is taken for five miles above the point from which it is taken and to enact all ordinances and regulations necessary to carry the power conferred in this paragraph (b) into effect.[22]

In Town of Carbondale v. GSS Properties, the town argued and the court agreed that C.R.S. § 31-15-707 gives municipalities the right to enact watershed protection ordinances.[23] The court stated that the statute "gives municipalities jurisdiction over 'the stream or source' from which the water in their waterworks is taken 'for five miles above the point from which it is taken.' This jurisdiction necessarily extends to groundwater underneath properties within the five-mile area that finds its way into streams in the watershed." This includes protecting source water outside of the jurisdiction of the municipality.

Municipalities have frequently placed greater protections on watersheds than does the COGCC.

> More than 40 local municipalities have municipal watershed protection ordinances.[24]

While the courts have not addressed this issue directly, a municipality could make a strong case that since state law explicitly gives municipalities the right to protect municipal water quality, the local government's regulations to protect water quality would be upheld so long as the restrictions did not prohibit oil and gas development altogether.

In 2006, the Bureau of Land Management leased federal minerals (under private land) in the watersheds of the City of Grand Junction and the Town of Palisade. As a home rule city, the citizens of Grand Junction had the ability to pass municipal ordinances through a citizen initiative. In one month, the community organization Western Colorado Congress gathered enough signatures to put a watershed ordinance on the ballot. The publicity and public awareness that came from the effort spurred the City Council to unanimously adopt the ordinance — stopping the need for the issue to go to the ballot. The Grand Junction and Palisade watershed ordinances now require the use of pitless drilling systems, and the use of "green" (non-toxic) fracking fluids throughout the watersheds that provide drinking water to those municipalities.[25] The BLM later convened a stakeholder process, which included the oil and gas industry, and adopted additional protections for the watershed.

d. Memorandums of Understanding Between Local Governments and Operators

The state of Colorado and the oil and gas industry have been very favorable to the option of local governments entering into memorandums of understanding (MOUs) with operators to gain protections that go beyond the COGCC rules. The MOU is a private contract signed by the local government and each operator, which can contain any protections agreed upon by the parties.

> The protections in the agreement can be stipulated conditions within applications for permit to drill to the COGCC and therefore could be enforced by the COGCC.

However, if agreed-upon stipulations from the MOU are not within the COGCC permit, the local government would have to enforce the protections through a breach of contract lawsuit- unless the local government incorporates the MOU requirements as part of its land use permitting process.

As of this writing, the City of Broomfield has, by far, the most comprehensive MOU in Colorado.[26] Similar to Boulder County's process, Broomfield offers two paths for oil and gas operations to occur within the city limits. The "use by special review" allows

the industry to follow less stringent protections and regulations but requires a more thorough review and typically multiple public hearings. If an operator opts for an MOU, it will commit to "enhanced standards" and will be able to obtain a permit through administrative review — typically without any formal public hearings.

Broomfield purchases treated water from Denver Water and receives raw water from the Colorado-Big Thompson Project and Windy Gap system via the Northern Colorado Water Conservancy District. Since both of these water supplies are piped to Broomfield, the MOU is not protecting the source of its drinking water supply. However, the Broomfield MOU does require several water quality protections that go beyond COGCC rules. The Broomfield municipal code requires any MOU to contain the following protections:

- No storage of hydraulic fracturing chemicals, flowback from hydraulic fracturing, or produced water in the city limits for longer than 30 days.

- In addition to complying with COGCC Rule 609 water quality monitoring regulations, the operator must also conduct additional testing for dissolved metals, including arsenic, mercury, uranium, radium, and other dissolved metals as determined by the city.

- To the maximum extent feasible, all flowlines, gathering lines, and transmission lines shall be sited a minimum of 50 feet away from the high-water mark of any surface water body.

- Pipelines and gathering lines that pass within 150 feet of the high-water mark of any surface water body shall incorporate leak detection, secondary containment, or other mitigation, as appropriate.

- The operator shall report to the city the amount and source for water used in both the drilling and production phases of operations.

- The disposal of water used on site shall also be documented in detail by the operator, including anticipated haul routes, approximate number of vehicles needed to supply and dispose of water, and the final destination for water used in its operations.

MOUs are advantageous because they avoid the question of state interests preempting local jurisdictions regulating oil and gas production. Other advantages include the municipality's ability to negotiate greater protections than required by state law and starting a cooperative relationship with the oil and gas industry. Industry prefers a MOU as well because it avoids lawsuits and gives the industry the certainty of knowing the requirements it will have to follow in order to operate within that jurisdiction.

WHAT YOU CAN DO

Engage/partner with local government to protect source water.

Local governments have the ability to protect water supplies through zoning, designating a watershed, or establishing greater water quality protections by entering into an MOU with oil and gas operators. These actions should happen well before any oil and gas development is proposed within or near a source water area. As stated above, the LGD and local government also have a unique ability to impact the COGCC processes and decisions if an oil and gas location is proposed near source water areas. It is best to engage the relevant local government and the LGD early in the process.

The MOU approach can be disadvantageous because the local government would potentially have to negotiate a different MOU with each oil and gas company operating within that jurisdiction. MOUs are also private agreements and are therefore more difficult to enforce than local or state laws. Protections for public health and safety are typically not subject to negotiation with the regulated industry. The police powers given to local governments by state constitution and state statute allow them to protect public welfare by adopting ordinances (laws) rather than through negotiated contracts.

4) Watershed Protection Using Private-Party Contracts

Protecting water quality is not limited to state and local regulatory processes. A water provider may be able to negotiate with oil and gas operators to enter into various private-party contracts, such as leasing agreements and surface use agreements. Leases and surface use agreements are contracts that grant a legal right to access minerals. In the event that a local government or other water provider is a party to these negotiations, it may be able to prevent surface impacts in source water areas or gain other water quality protections as part of those contractual agreements.

The leasing and lease consolidation phase of oil and gas development is often the first time people with mineral rights know that any development has or will occur in their area. An oil and gas employee called a "landman" will contact mineral owners in an effort to negotiate leasing their mineral rights. The landman will also negotiate "surface use agreements" with landowners who own the surface where the oil and gas operators would like to locate wells, pipelines, or other production equipment. A surface use agreement is a binding agreement between an operator and the owner of surface property that governs the operator's activities when locating a well, well pad, production facility, or other activities on the surface owner's property. A discussion about what to request in a lease or surface use agreement are discussed further in Section III.4.

III. REGULATORY AND NON-REGULATORY APPROACHES TO PROTECTING SOURCE WATER (cont.)

In some cases, a water provider may be able to negotiate water quality protections with oil and gas operators through a mineral lease agreement, a surface use agreement, or as conditions for selling water to an operator. Negotiations may occur when a water provider has something that the oil and gas operator wants, such as ownership of mineral rights, land, and/or water.

When the oil and gas industry believes oil and gas is under a property, the owner of the mineral rights for that property may be approached by oil and gas operators to sell or lease those mineral rights. Like any financial transaction, the leasing of mineral rights to an oil and gas operator may benefit both parties.

The oil and gas landman will offer a standard industry lease (often referred to as a "standard 88 lease"), which is typically written to protect the industry, not the landowner. Depending on how much mineral acreage is being negotiated, the water provider may be able to negotiate a lease that not only provides better financial terms, but can also contain additional protections such as a "no surface occupancy" stipulation that allows extraction of the minerals but does not allow any disturbance of the surface. Oil and gas under an area with a "no surface occupancy" stipulation must be accessed from other lands through directional or horizontal drilling.

Before the industry locates any oil and gas facilities on private property, COGCC rules require the company to make a "good faith effort" to negotiate a surface use agreement with the landowner (Rule 306(a)). Landowners who also own mineral rights will want to negotiate the surface use agreement as part of their mineral lease. Mineral ownership provides significant leverage to the landowner to gain needed protections for the surface property. Landowners without mineral rights also have leverage in these negotiations as well as through statutes that require the industry to "reasonably accommodate" the current surface uses of the landowner and to disturb only the amount of land that is "reasonable and necessary" to produce the minerals.[27]

If a water provider does not own its mineral rights, and those rights have been leased or sold to an oil and gas company, it is possible that the oil and gas company may decide to drill on the land without the water provider's permission. Ultimately, the oil and gas company has the legal right to access its minerals from the surface — so long as it reasonably accommodates the current surface uses of the landowner and disturbs only the amount of land reasonable and necessary for the well.

Finally, a water provider may be approached because the oil and gas operator would like to purchase water for drilling and hydraulic fracturing. As described earlier, hydraulic fracturing can require more than four million gallons per well. Some water providers may sell water to oil and gas operators at a higher rate than residential customers. Water providers asked to provide water to oil and gas companies could also ask the oil and gas companies to avoid sensitive areas or to utilize best management practices to protect water quality in the area.

Owning minerals, surface acreage, or water desired by the oil and gas operator can provide leverage to a water provider to negotiate additional protections for water quality that go beyond what is required by the state or local governments. It makes sense to negotiate these agreements with the help of an experienced oil and gas attorney to ensure that the agreement is protective of water quality and as well as financially beneficial to the water provider.

WHAT YOU CAN DO

Utilize minerals, land, or water to negotiate greater protections.

The ownership of mineral rights can give a domestic water supplier great leverage in determining where and how the oil and gas development will occur. It is important that a water provider use this leverage to its best advantage by:

1) Finding out who the oil and gas operator will be;
2) Influencing where the oil and gas facilities are located; and
3) Requiring water quality protection BMPs as a condition of the lease.

If the oil and gas operator is looking to locate a well on the property of a water supplier or to purchase water for the oil and gas development, the water supplier may have even more leverage in the negotiations. It is advisable to hire an experienced oil and gas attorney to negotiate protection of water resources or for negotiating fair market value for a lease or surface use agreement.

III. REGULATORY AND NON-REGULATORY APPROACHES TO PROTECTING SOURCE WATER (cont.)

5) Leasing of Federal Minerals

In Colorado, federal lands comprise more than 24 million acres, or more than 36% of the state.[28] Not surprisingly, a fair number of source water areas are on federal land, and this is especially true for communities on the Western Slope. These communities have long understood they need to build relationships with the federal land agencies and engage in their decision-making processes. A full description of federal land use decision-making is beyond the scope of this guide.[29] The following discussion is meant to give a public water provider only a general overview of the federal land decision-making processes.

The Bureau of Land Management (BLM) and United States Forest Service (USFS) are the primary federal land management agencies in Colorado that manage lands with oil and gas development. Both agencies make planning decisions about what lands are open to oil and gas development and the conditions imposed on this development.

Generally, there are two types of federal land use agency actions that can impact water quality: land use planning and individual land use decisions.

a. Federal Land and Resource Management Planning

Land use planning at the federal level is accomplished through planning processes that result in large documents often referred to as "Resource Management Plans" (RMPs) for the BLM and "Land Management Plans" or "Forest Plans" for the USFS. These plans are blueprints of how the agencies plan to manage an area for a period of 10–20 years.[30] Federal law prohibits a federal agency from making decisions that are contrary to its plan. If necessary, federal agencies may issue amendments rather than issuing a new plan.

The planning process is typically a multi-year public process that must comply with the National Environmental Policy Act (NEPA). NEPA requires public notice and then a public process to develop the scope of the issues to be considered in the Environmental Analysis or through the more comprehensive Environmental Impact Statement, which evaluates the potential environmental impacts of the proposed plan as well as reasonable alternatives. Once the draft RMP or Forest Plan is released, the public land agency allows public comment on the plan. Those public comments are considered, the issues they raised are addressed, and a final RMP or Forest Plan is released, followed by a Record of Decision. If a party believes that an issue was not adequately analyzed in the plan, the decision can be appealed to the Department of the Interior for RMPs or the Department of Agriculture for Forest Plans.

The RMP will state what lands are "available" for leasing for oil and gas development and if any additional land use protections will be applied to certain lands to protect other resources, such as clean drinking water. Source water areas may be placed off limits to oil and gas leasing or can have a high standard of protection, such as a "no surface occupancy" stipulation placed on those areas.

b. Individual Land Use Decisions for Mineral Development on Federal Lands

Any oil and gas development on public or private land with federally owned minerals starts with leasing the property from the BLM, which is the leasing agency for all mineral development on federally owned land. The land is typically nominated by an operator and then is subject to an open bidding process. The leasing process is usually not subject to any NEPA review, but there are opportunities for public comment on the proposed leases.

Once leased, the land can be accessed by the operator submitting an application for permit to drill (APD) to the BLM. The APD must contain a "drilling plan" and a "surface use plan of operations." At a minimum, the APD will have a 30-day public comment period.

Before any surface activities can begin, the BLM must approve the APD. Depending on the proposal, the drilling allowed by the APD may be considered an action "significantly affecting the quality of the human environment" and therefore requiring a separate NEPA analysis.

WHAT YOU CAN DO

Establish relationships with local offices of the federal agencies.
Communities that could be impacted by oil and gas development on federal land need to engage the federal land agencies to ensure their interests are being protected. For public water providers, this means meeting with federal agencies well before any project is proposed or a NEPA decision-making process is underway with the potential to impact water quality. It is important that federal agencies receive frequent reminders that, in the arid West, clean water is our most precious natural resource.

Engage in the NEPA review of Resource Management Plans with the BLM and Land Management Plans with the USFS.

Participate in COGCC's public comment process for proposed permits on federal public lands in Colorado.
In Colorado, an operator proposing activities on federal public lands must also submit an oil and gas location assessment (Form 2A) to the COGCC. Public water providers should also engage in the Form 2A process by commenting to the COGCC, as discussed above in Section III.1.a.

IV. ADDRESSING POTENTIAL RISKS TO SOURCE WATER FROM OIL AND GAS DEVELOPMENT

1) Location: The Most Important Protection of Source Water

A fundamental goal of land use planning is to prevent conflicts between incompatible land uses. This is typically accomplished first by separating uses and then through implementing mitigations, such as best management practices, to minimize and address unavoidable impacts. Historically, the location of oil and gas resources drove the location of wells, and industry would locate its wells vertically above the resource. But the advent of technology allowing wells to be drilled horizontally up to two miles away from the well pad has created more flexibility about the location of the well pad for industry, state regulators, and local communities.

> The best way to protect source water is to locate the oil and gas facilities away from source water areas.

If the oil and gas facilities cannot be sited to avoid source water areas, the public water suppliers will want to use private negotiations and local government regulations, or work through the COGCC permitting process to minimize the impact to water quality and require mitigation measures that will help protect source water.

Here are some well site location issues a water provider might want to negotiate in any agreement with an oil and gas operator or as conditions of approval for oil and gas facilities proposed near source water areas:

Location of the well(s) — Does the proposed well location have to be in close proximity to source water? Many wells in Colorado are now directionally or horizontally drilled. These technologies allow the operator to drill underground at a slant or horizontally, thereby enabling the drilling rig and well pad to be placed several thousand feet away from the underground target the operator wants to produce. Negotiate a location that will be protective of water quality.

Multi-well pads — Does the operator intend to place multiple wells in close proximity to each other? If there will be multiple wells in the area, operators have the ability to co-locate wells on a single well pad, thereby minimizing the impacts to the surface. However, these multi-well pads are larger, concentrate air emissions and nuisance (noise, traffic, light), and have longer drilling times. If allowed, multi-well pads should be located far away from source water areas, such as surface waters and domestic water wells.

Location of roads — Roads are potential sources of stormwater runoff and sedimentation to streams. Here are questions a water provider might consider: Can the well be drilled near an existing road? If a new road is necessary to access the well site, could it be built in a location where it would serve multiple purposes? Should the road be built to county standards or should it be built to provide only temporary access?

WHAT YOU CAN DO

Locate wells and other oil and gas facilities away from source water areas.

Water providers should work with local governments, the COGCC, and the oil and gas operators to find alternative locations that are away from source water areas.

Additional equipment and facilities — If the water provider owns the property, it should consider whether to allow additional production facilities, such as pipelines, oil and gas processing, compressor engines, or temporary worker housing, on its property. Keep in mind that production and transportation facilities that serve adjacent properties are not necessary to the development of the resources under that land and therefore should be negotiated separately and require additional compensation to the landowner.

2) Mitigation: Reducing the Potential Impacts to Source Water

Mitigation measures to prevent or reduce the likelihood of water contamination should be utilized if the location cannot be moved a safe distance away from source water areas. The industry has a large suite of mitigation measures available to protect water quality at its development sites.[31] The mitigation measures described below are often described as best management practices. Some BMPs receive widespread use and may eventually be adopted as regulations. However, many BMPs are applied on a case-by-case basis, depending on the characteristics of the oil and gas development, such as topography, soil type, proximity to residences and communities, number of wells, and type of equipment. BMPs cover a variety of topics, such as air quality and emissions, aquatic and riparian values, grazing and agriculture, surface disturbances, noise, soil conservation and reclamation, visual aesthetics, water quality and pollution, and water quantity issues.

The following discussion describes some of the current regulations and BMPs used to prevent water contamination due to spills, waste disposal pits, stormwater discharge, hydraulic fracturing fluid, and wellbore integrity concerns. BMPs for the oil and gas industry change and improve every year, so this list cannot be considered exhaustive.

This list is divided into threats to surface water and those to groundwater, although these distinctions are somewhat arbitrary. Some threats, such as spills, can affect both surface water and groundwater. Surface waters and groundwaters are often interconnected as well. Water providers should consider threats to both surface water and groundwater when oil and gas development is proposed near source water.

IV. ADDRESSING POTENTIAL RISKS TO SOURCE WATER FROM OIL AND GAS DEVELOPMENT (cont.)

3) Mitigating Risks to Surface Water Quality

a.General COGCC Protections for Surface Source Water

The COGCC's Rule 317B protects public surface water sources by requiring some modest additional protections when a facility is proposed within a half-mile of a designated surface water source and by excluding oil and gas facilities within 350 feet from designated water sources. Within the state's 257 designated surface water supply areas for a public water system, a suite of water quality protection regulations apply to drilling an oil and gas well, completing a well (typically via hydraulic fracturing), and producing and storing oil and natural gas. A map and list of all the public water systems that this rule applies to can be found in Appendix VI of the COGCC rules.[32]

Table 2. Buffer zones associated with oil and gas development.

Zone	Classified water supply segments in feet	Requirements
Internal buffer	0–300	No new drilling, completion of a well, production from a well, storage of chemicals or production fluids
Intermediate buffer	301–500	Pitless drilling systems, berms to contain spills around storage tanks, collection of baseline water quality data, emergency spill response program
External buffer	501–2,640	Collection of baseline water quality data, emergency spill response program

Internal buffer regulations: No new drilling, completion, production, or storage may occur within 0–300 feet of source water for a public water system. However, exceptions to this rule may be granted by the COGCC (after consultation with CDPHE) if the industry can show that its procedures will substantially protect the water and that it would be a greater risk to public health, safety, and welfare if drilled further away. If a variance is granted, then requirements for operations 301–500 feet from surface water must be followed.

Intermediate buffer regulations: These regulations require pitless drilling systems (in which drilling fluids — water, mud, and additives — are deposited in storage tanks instead of open pits after they circulate through the wellbore and return to the surface), the containment of fracking fluids and flowback fluids in tanks, berms around all tanks, and baseline testing of water before drilling to take place immediately downslope of the oil and gas location. Follow-up water quality sampling is required within three months after drilling, completion, and operation activities. Also, all public water systems within 15 miles downstream of a proposed oil and gas activity must be notified prior to work on the site.

External buffer regulations: Baseline water quality sampling and notification are the only requirements for wells within 501–2,640 feet of source water for a public water system.

These water quality protections outlined in COGCC Rule 317B are significantly reduced when expansion of an existing oil and gas well site occurs. The COGCC "grandfathers" existing well pads that were in place prior to May 1, 2009 for federal land or prior to April 1, 2009 for all other land. New surface disturbance at an existing disturbed area can be doubled up to a maximum of three acres. Water quality sampling is required, but it can be delayed up to six months after oil and gas activity has begun. Unlike regulation required at a new well site, if new oil and gas activities occur at an existing well site 301–500 feet from a public water system source, the site is permitted to have open pits, berms are not required, and neither fracking fluids nor flowback water must be contained in tanks. The COGCC could require that the operator implement these protections as a condition of approval of a permit, but it is not mandated.

A similar exception occurs for existing oil and gas sites 0–300 feet from a public water system source. New oil and gas sites are not permitted within 300 feet of a public water system source. However, existing sites within 300 feet of a public water system may be expanded by up to three acres. The COGCC does require pitless drilling systems, containment of fracking fluids and flowback fluids in tanks, as well as berms around tanks for oil and gas development within 300 feet of a public water supply system.

b. COGCC Water Quality Protections Within Floodplains

Oil and gas development within a designated 100-year floodplain must also provide additional protections. After the 2013 floods in several Front Range counties, the COGCC implemented new requirements for tanks. COGCC Rule 603.h requires that new and existing tanks constructed within a floodplain must be within a lined and steel-reinforced bermed containment area (or the equivalent). Waste pits are prohibited within the floodplain without a variance from the COGCC Director.

c. COGCC Water Quality Protections Near Homes

"Spills" and "releases" occur with oil and gas development. The COGCC differentiates between the two, with a release meaning an unauthorized discharge of exploration and production waste over time, and a spill meaning a sudden unauthorized discharge of exploration and production waste. But in the COGCC rule book, spills and releases are almost referred to in tandem. COGCC Rule 604.c(2).G requires that berms or other secondary containment devices be constructed around crude oil, condensate, and produced water storage tanks within 500–1,000 feet of homes and other occupied buildings. The area within the berm must be sufficient to contain and provide secondary containment for 150% of the largest single tank. The berms have to be sufficiently impervious to contain any spilled or released material and must be inspected at regular intervals and maintained in good condition. Similar berm construction is required for flowback and fracking fluid tanks in close proximity to source waters (Rule 317B (d) & (f)).

d. Required Reporting of Spills and Releases

Of all the potential issues with oil and gas development, spills are one of the most likely to cause water contamination. Legislation in

IV. ADDRESSING POTENTIAL RISKS TO SOURCE WATER FROM OIL AND GAS DEVELOPMENT (cont.)

2013 changed reporting requirements for spills; and in 2014 alone, there were 840 spills reported to the COGCC. Eight of those spills were reported to have contaminated surface water and 97 spills contaminated groundwater.

- Spills of exploration and production wastes of more than 42 gallons outside of containment areas must be reported to the COGCC within 24 hours of detection (Rule 906.b.1).

- A spill of more than 210 gallons must also be reported to the COGCC, even if within a containment area (Rule 906.b.1).

- If a spill threatens a surface water supply area, a residence, livestock, or a public byway, it must be immediately reported to the COGCC and to the emergency contact for the water provider (Rule 906.b.1).

- The operator also has to notify the surface owner and the local government's emergency response unit of any spill as soon as practicable, but no later than 24 hours after discovery (Rule 906.b.2 and 3).

e. Spill and Release Prevention of Fluids

Collecting, storing, and transporting fluids are the major long-term activities at an oil and gas production facility. As a result, there are significant regulations around pits, tanks, and flowlines. For example, COGCC Rules 902, 903, 904, and 905 set standards for permitting, pit lining requirements, reporting, and closure of pits. COGCC Rule 605.a lays out tank standards, locations on well pads, and setbacks for oil and condensate tanks.

Produced water and other liquids collected at an oil and gas production facility frequently have high salinity content. Because of concerns of spills or releases of produced water, all tanks that contain oil, condensate, or produced water with greater than 3,500 milligrams per liter of total dissolved solids must have secondary containment berms around the tank (Rule 906.d). Operators are also required to determine and document the cause of a spill or release and to implement measures to prevent similar spills or releases in the future.

A study of the 1,638 spill reports between January 2010 and August 2013 determined that 78% of reported spills occurred during the production phase of oil and gas development. However, no matter what the phase, equipment failure was the culprit for 67% of the reported spills. "The four major pieces of equipment that most frequently fail are process piping, flowlines, tanks (including partially buried and buried vaults and vessels), and valves. Process piping and vaults are often underground, making identification of non-catastrophic releases or spills difficult to detect."[33]

The study recommended that action was needed to reduce the risk of spills and releases from flowline failures through appropriate construction standards, periodic testing and maintenance, and COGCC audits of required pressure testing. "Flowlines" is a generic term that refers to pipe segments for gas lines, oil lines, and water lines from the wellhead downstream through the production facilities. For water lines, the endpoint is the water loading point, the point of discharge to a pit, the injection wellhead, or the permitted surface water discharge point. In response to the study, the COGCC released an Operator Guidance document in February 2016 that recommended eight best practices for installation of new flowlines.[34]

f. Permit Conditions to Discharge Waste Water into Streams

Oil and gas wells produce large amounts of water. Depending on the type of hydrocarbon resource and the region where the drilling occurs, a well may produce more water than anything else. For example, in order to collect coalbed methane, the water holding the methane in place has to be removed. Collecting and disposing of this produced water properly is required to maintain source water quality in the area.

Produced water from coalbed methane, as well as other oil and gas wells, may be disposed of by discharging into the state's surface waters (Rule 907.c.(2).E). But in order to do so, the operator must have a Colorado discharge permit from the Colorado Water Quality Control Division and must comply with state water quality regulations. Once a month, the Water Quality Control Commission gives public notice of draft permit actions on its website.[35] The commission allows the public 30 days to comment on the proposed permit.[36] If a water provider is concerned about a specific stretch of surface water, it can be helpful to notify your area of concern to the Water Quality Control Commission, even prior to a permit request.

The COGCC requires that the operator provide the discharge permit number, latitude and longitude coordinates, and a U.S. Geological Survey topographic map of the discharge outfall, as well as the sources of produced water on a Source of Produced Water for Disposal form (COGCC Form 26). The COGCC may issue an operator a General Permit for Discharges Associated with Produced-Water Treatment Facilities, which covers produced water[37] from Centralized Exploration and Production Waste Management Facilities[38] (Rule 908). This general permit authorizes facilities engaged in the treatment and/or disposal of produced water generated from oil and gas producing formations to discharge from authorized locations throughout the state to surface waters of the state.[39]

Under a general permit, the effluent limitations and monitoring requirements are determined on the basis of state water quality standards that apply to all waters, state water quality standards that apply to specific stream segments, state effluent limitations, state watershed limitations, state policies guiding how specific standards are implemented in permits, interstate watershed limitations, and federal effluent limitation guidelines. An operator may apply for an individual discharge permit for produced water through the Colorado Water Quality Control Division. An individual permit is more finely tailored to the site, but can take several months longer to receive.

g. Stormwater Discharge Permits Mitigate Impacts from Runoff

Both the COGCC and CDPHE regulate stormwater management to control erosion. The State of Colorado's stormwater discharge regulations require a stormwater permit for construction activities on oil and gas sites that disturb more than one acre or are part of a com-

IV. ADDRESSING POTENTIAL RISKS TO SOURCE WATER FROM OIL AND GAS DEVELOPMENT (cont.)

mon plan of development that will disturb more than one acre. For oil and gas development, a "common plan of development" includes infrastructure, such as well pads, roads, pipelines, and pumping stations, located within one-fourth mile of each other and used during the same time frame or that is part of a long-term development plan. The Colorado Water Quality Control Division issues these stormwater permits, which are in addition to requirements of the COGCC.[40] The permit requires operators to control and eliminate the sources of pollutants in stormwater. A stormwater management plan is required that identifies best management practices, such as silt fences, sediment ponds, vehicle tracking controls, inspection and maintenance schedules, and personnel training.

Sites actively under construction require an inspection at least once every two weeks to ensure BMPs are in place and in good condition. Furthermore, if a storm causes surface erosion, the site must be inspected within 24 hours.[41] Permit coverage must be maintained until the site is finally stabilized. A stormwater permit is required on federal lands within Colorado, even though oil and gas operations were exempted from federal Clean Water Act permits in 2005.[42]

The COGCC requires that operators maintain BMPs on site in order to minimize erosion and impede the movement of sediment off the site (Rule 1002.f). Specific BMPs are not mandated, but the rule suggests measures for spill prevention, erosion controls, covering material, and vehicle tracking control practices. After termination of the stormwater permit, the COGCC still requires a post-construction stormwater plan.

h. Hydraulic Fracturing

Hydraulic fracturing ("fracking") has the potential to be a source water issue because millions of gallons of water and tens of thousands of gallons of chemicals are used to frack a single well. The major concern of source water impacts on a short time horizon comes from spills and leaks of fracking fluid.

Hydraulic fracturing is the process whereby a geologic formation containing oil or gas is fractured multiple times to access more of the resource and make a well more productive. The widespread use of hydraulic fracturing for nearly all new wells has allowed the industry to tap many "non-conventional" (previously considered to be uneconomical) hydrocarbon sources in Colorado, such as tight sand formations (in the Piceance Basin on the Western Slope of Colorado), shale formations (in the Niobrara Formation on the Front Range Denver-Julesberg Basin), and coalbed methane (in the San Juan Basin in southwest Colorado).

The hydraulic fracturing process varies by formation and by company. Often the formation is first subjected to a strong acid that helps open pores in the rock. Then the company pumps down large volumes of fluid at a pressure great enough to cause the rock formation to fracture. The fluid also contains proppants (sand or ceramic beads) that are pushed into the cracks in the formation. Once the hydraulic fracturing is completed, the proppants hold the cracks open, allowing the well to access more of the oil and/or gas formation.[43]

WHAT YOU CAN DO

Stormwater

Monitor stormwater mitigations to ensure they are still in place and functional. If the well pad is on your property, after a rain storm or when snow is melting, examine the perimeter of the well pad to make sure that all the mitigation measures are in place and working. The goal of the mitigations is to ensure that sediment is not being transported off the pad.

Request operators to limit surface disturbance. How much surface will be disturbed? How much acreage will you lose access to? Requesting the operator to use an existing surface well site location or access road can avoid the impacts of new construction. Operators may be able to reduce the size of the well pad or to limit the width of the access road. Using a closed-loop drilling fluid system (with holding tanks) instead of reserve pits can reduce surface impacts.

Reclamation

Request detailed interim and final reclamation plans. What will the land look like when work is done? Operators may be asked to prepare a plan to control noxious weeds and undesirable species in disturbed areas. When the drilling is complete, the well site should be reduced to the minimum size needed to maintain the well. All other areas should be reclaimed with native species or a seed mix recommended by the landowner. It is a good idea to take pictures of the land before the industry clears the land and moves in equipment.

Hydraulic Fracturing Chemicals

Ask for company to use non-toxic chemicals in drilling and hydraulic fracturing fluids. Encana's Responsible Products Program should be seen as a national model. Water providers, landowners, and municipalities should request that any wells being drilled or hydraulically fractured near source water areas comply with Encana's policy that prohibits the use of dangerous and unnecessary chemicals.

Although groundwater contamination from hydraulic fracturing is highly unlikely, hydraulic fracturing fluid does contain chemicals hazardous to human health, which can be spilled or leaked. The specific ingredients of hydraulic fracturing fluid have been the subject of great debate. In 2005, the industry secured an exemption from the Safe Drinking Water Act that requires the disclosure of any fluids placed underground.[44] Companies also resisted any disclosure of fracking fluids at the state level. Not surprisingly, these actions raised public suspicions about hydraulic fracturing. In 2011, the COGCC required disclosure of most of the chemicals in hydraulic fracturing fluid through a website called FracFocus.[45] However, if the industry claims a chemical is a "trade secret," then that chemical is exempt from full disclosure. One of five chemicals is classified as a "trade secret" on FracFocus.[46]

IV. ADDRESSING POTENTIAL RISKS TO SOURCE WATER FROM OIL AND GAS DEVELOPMENT (cont.)

Through industry disclosure, we know that hydraulic fracturing fluid typically contains a wide range of chemicals, as it is highly engineered to perform several jobs at once. The fluid needs to withstand incredible pressures to open up fractures in the rock and deposit proppants to keep those cracks open. The fluid must be viscous and heavy enough to carry the proppants. To accomplish these tasks, the industry adds numerous chemicals to fracking fluid, such as gelling agents, surfactants, biocides, corrosion inhibiters, clay stabilizers, acids, and friction reducers, to name a few.[47]

The industry states that hydraulic fracturing fluids generally consist of 90% water, 9.5% sand, and only 0.5% chemicals.[48] But because an average hydraulic fracturing job uses 3–7 million gallons of water, 0.5% equates to 15,000–35,000 gallons of chemicals per well. Some of the common chemicals used in hydraulic fracturing, such as biocides and corrosion inhibitors, can be dangerous, even if present in minute quantities.

Using the data from FracFocus, researchers have identified 15 fracking chemicals of greatest concern based on their mobility, persistence, and toxicity.[49] According to FracFocus data, two of the most dangerous compounds (napthalene and 2-butoxyethanol) were used in more than 20% of hydraulically fractured wells in Colorado, North Dakota, Pennsylvania, and Texas.

Trade secrets and full-disclosure exemptions for the chemicals used in hydraulic fracturing fluid have caused skepticism from many, but there has been a bit of a shift within the industry on hydraulic fracturing fluids. Encana Corporation, the largest natural gas producer in North America, recently developed and implemented a company-wide "Responsible Products Program" to manage the fluid products used in its hydraulic fracturing operations. Encana announced the program in a recent memorandum of understanding with Erie, Colorado.[50] Encana uses a risk-based product assessment tool to evaluate the potential risk to public health or the environment of the chemical constituents used in drilling products. As a result of the Responsible Products Program, Encana prohibits the use of diesel fuels (as defined by EPA 816-R-12-004), 2-butoxyethanol (2-BE), benzene, or heavy metals (e.g., lead, mercury, arsenic, cadmium, and chromium).[51]

4. Mitigating Risks to Groundwater Quality

The COGCC promulgated protections for source water specifically for public surface water sources. The COGCC has general groundwater quality protection rules, such as casing and cementing requirements, but not specific rules to protect groundwater that serves as public source water supplies. Instead, the COGCC is an implementing agency for groundwater quality standards and classifications adopted by the Colorado Water Quality Control Commission (WQCC) for groundwater protection.[52]

The WQCC sets the basic standards for groundwater (Regulation 41) and site-specific water quality classification and standards for groundwater (Regulation 42).[53] Regulation 41 establishes statewide standards and a system for classifying groundwater and adopting water quality standards for such classifications to protect existing and potential beneficial uses of groundwaters. Regulation 42 applies the framework for groundwater classifications and water quality standards to specific groundwaters in the state; it also adopts interim narrative standards to protect these groundwaters prior to the adoption of use classifications and numerical standards for specific areas. For example, the WQCC has assigned use classification and water quality standards to specified areas in the oil and gas fields of Adams, Arapahoe, Baca, Cheyenne, Jackson, Kit Carson, Logan, Moffat, Morgan, Rio Blanco, Washington, and Weld counties.

There are approximately 1,990 public water systems in the state of Colorado.[54] More than 80% of those systems are groundwater-sourced systems,[55] but they are generally smaller systems. Only 16% of Colorado's population is served by public water systems that use groundwater. The vast majority of Colorado residents are served by larger water systems that use surface water.

As these figures show, the smaller public water systems located in rural areas often depend on groundwater. Many of these water systems, as well as individual water wells, are located near existing and future oil and gas facilities. The following guidance is meant to help those water providers better understand and mitigate the threats oil and gas development poses to groundwater.

a. Requiring Proper Casing and Well Construction Are the Most Important Measures to Protect Groundwater

As was stated by the COGCC during the Oil and Gas Task Force meetings, "Designing and constructing a well so that hydrocarbons cannot migrate through or along the wellbore into fresh water formations is one of the most fundamental ways of protecting the environment, especially drinking water aquifers, during oil and gas operations."[56]

A peer-reviewed study published in the Proceedings of the National Academy of Sciences on July 11, 2016 supports this assertion by finding that faulty well integrity was the primary cause of drinking water contamination from oil and gas development in Colorado. [57] The study reported that thermogenic stray gas sourced from deep oil and gas reservoirs impacted 42 water wells in 32 separate cases, a rate of about two cases per year from 2001 to 2014. Of the 924 water wells tested in the Denver-Julesburg Basin of Colorado, 4.5% were contaminated with thermogenic methane.

The U.S. Environmental Protection Agency has identified five potential pathways for fluid movement in a cemented wellbore: "These pathways include: (1) casing/tubing leak into a permeable formation, (2) migration along an uncemented annulus (the empty space between the borehole and the casing), (3) migration along microannuli (tiny cracks) between the casing and cement, (4) migration through poor cement, or (5) migration along microannuli between the cement and formation."[58] Surface casing and other casing lines (intermediate, production, etc.) must be properly cemented in order to maintain wellbore integrity to prevent migrating gas and other leaks that may impact groundwater.

IV. ADDRESSING POTENTIAL RISKS TO SOURCE WATER FROM OIL AND GAS DEVELOPMENT (cont.)

Colorado requires oil and gas wells to be constructed with steel pipe well casing that is cemented inside the drilled wellbore in order to protect fresh water zones and groundwater. The intention is to use steel casing and cement to isolate oil and gas production zones to ensure they cannot contaminate potable groundwater. Depending on the depth and location, different names are given to the casing: conductor, surface, intermediate, and production. In Colorado, the surface casing is required to reach a depth below all known or reasonably estimated usable domestic fresh water levels (COGCC Rule 317.f). Cement is then pumped down the casing until it fills space (the annulus) between the wellbore and the casing. The cement is intended to prevent fluids and gases from migrating into groundwater zones.

In Colorado, groundwater contamination from the act of hydraulic fracturing is highly unlikely. Most groundwater supplies in Colorado are adequately protected by the COGCC regulations, stated above, and also because of the state's geologic formations. On the Front Range, for example, the Niobrara Formation is more than one mile (5,280 feet) beneath the surface. Even the deepest fresh water aquifers will not be much lower than 1,000 feet below the surface. In this case, nearly a mile of rock, consisting of different geologic formations, separates the hydraulic fracturing activity and fresh water. The hairline cracks created by hydraulic fracturing are believed to extend a maximum of 500 feet.

b. Testing the Casing and Well Integrity

Assuring that the wellbore is properly cemented requires good drilling technique and also proper testing. The state requires several tests for well casing integrity. One such test is the requirement for a cement bond log soon after the well has been completed (COGCC Rule 317.p). A cement bond log is an ultrasonic measurement that records how well the cement has filled up the annulus to prevent the leaking of fluids or gases outside of the casing.

The state also requires a mechanical integrity test for wells that are not producing oil and gas (injection, shut-in, or temporarily abandoned wells) "to determine if there is a significant leak in the well's casing, tubing, or mechanical isolation device, or if there is significant fluid movement into an underground source of drinking water through vertical channels adjacent to the wellbore" (COGCC Rule 326). A mechanical integrity test typically must occur after 30 days for a temporarily abandoned well; after two years for a shut-in well, a waiting-on-completion well, or suspended operations well; and thereafter every five years.

The mechanical integrity test is a particularly important test. In its 2014 publication "State Oil and Natural Gas Regulations Designed to Protect Water Resources," the Ground Water Protection Council stated that the risk of contaminating groundwater comes from the potential for well treatment fluids to migrate upward through the annulus during the treatment process. The most effective means of protecting groundwater from upward migration outside of the casing is proper cementation of well casing across vertically impermeable zones and groundwater zones.[59] In Colorado, the production casing and, if installed, the intermediate casing must be adequately pressure-tested for conditions anticipated during the completion and production phases (COGCC Rule 317.k).

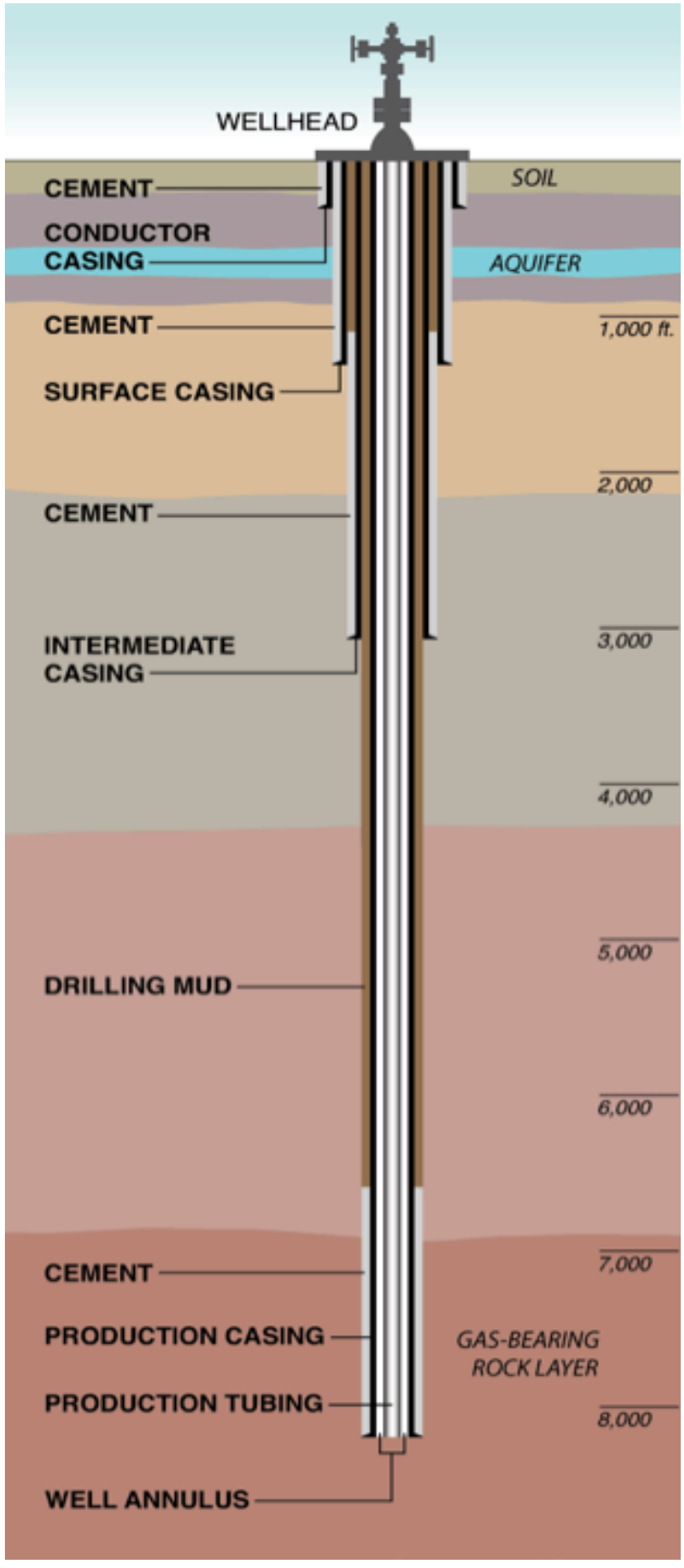


Figure 4. Several layers of steel casing typically enclose a well bore through ground water aquifers. The empty spaces between can be sealed with cement. Note: Figure not to scale. Graphic by Al Granberg, ProPublica.

IV. ADDRESSING POTENTIAL RISKS TO SOURCE WATER FROM OIL AND GAS DEVELOPMENT (cont.)

Another important wellbore test is the bradenhead test. Bradenhead is the space between the surface casing and the next smaller diameter casing in the wellhead. The test records the pressure inside the casing and monitors fluids in that space as well. High bradenhead pressures would indicate that the cement is not adequately blocking the migration of fluids or gases outside of the casing. The bradenhead test is required only for wells within regions designated by the COGCC Director. However, during hydraulic fracturing operations, the bradenhead annulus pressure must be continuously monitored and recorded on all wells being stimulated (COGCC Rule 341).

c. Close-Proximity Wells Should Have Additional Protections

Colorado has established setbacks for surface water, but very little statewide protections of groundwater. Protection of quality groundwater, like surface water, requires knowing where the water exists. Every COGCC application for a permit to drill should reference databases, such as the Aquifer Determination Tools database developed by the Colorado Division of Water Resources and enhanced by Colorado's Decision Support Systems, and note whether the production zone will be in "close proximity" to an aquifer containing potable water.[66] A "close-proximity well" should trigger additional protections as it could pose a threat to water quality because either the production zone is close to the source water or there is an inadequate "confining layer" making it incapable of safely containing the hydraulic fracturing fluid. As defined by the Environmental Defense Fund, a close-proximity well is a well that:

1) has less than 1,000 vertical feet of rock between the targeted shale and quality water source without a known confining layer, or

2) has more than 1,000 vertical feet of intervening zone, but which the regulatory agency determines should nevertheless be classified as a close-proximity well because the intervening zone does not contain an adequate confining layer.[67]

If a well is defined as a close-proximity well, then regulations should provide a different level of water protection and regulation may be warranted for that well. Cement should be circulated all the way to the surface on close-proximity wells. Ongoing bradenhead testing, mechanical integrity testing, and groundwater monitoring should also be required for close-proximity wells to ensure oil and gas is not migrating to groundwater.

CASE EXAMPLE: RATON BASIN COALBED METHANE CONTAMINATES DRINKING WATER

Petroglyph Energy, Inc. developed the Coalbed Methane Little Creek Field near the River Ridge Ranch subdivision in Huerfano County between Walsenburg and La Veta, Colorado, eventually completing more than 50 wells ranging in depth from 1,300 to 3,900 feet deep. [60]

Over the course of a decade, multiple problems emerged, including the contamination of dozens of drinking wells, water well explosions, impacts to farm and dairy operations, and depletion of the regional watershed.[61]

The COGCC found thermogenic natural gas in a number of drinking water wells. Thermogenic gas is typically produced several thousand feet below the surface and occurs from chemical reactions triggered by heat and pressure. Thermogenic gas, unlike biogenic gas typically found near the surface, is the gas targeted by industry. In its investigations, the COGCC found that:

• Underlying aquifers feeding more than a dozen domestic water wells were contaminated with dangerous levels of methane. Two cases resulted in explosions.

• Petroglyph produced huge amounts of water but very little gas, drawing local water tables down more than 2,000 acre feet per year.[62]

On October 16, 2007, the COGCC issued a rare Cease and Desist Order to Petroglyph Energy, ordering it to shut down 52 wells until it could operate "in a manner that protects [the] public health and safety."[63] Included in the order is this important finding:

Based on Questa's and Petroglyph's extensive investigations to date, the COGCC staff believes that the conduits for methane migration are most likely the naturally occurring igneous dikes and, perhaps, fractures associated with the dikes and that the potential for plugging these naturally occurring conduits is very low. As a result, returning the wells to production would continue to result in migration of methane into the Poison Canyon Formation and the water wells completed in it.[64]

Subsequently, the Environmental Protection Agency chose Huerfano County as one of two Colorado counties in the Raton Basin to conduct a case study analyzing the effects of hydraulic fracturing from coalbed methane.[65]

In June 2015, the EPA released a draft study of the potential effects of hydraulic fracturing on drinking water. The study found instances of contamination from oil and gas development, even though the report declared it did not find evidence of widespread, systemic impacts on drinking water from hydraulic fracturing.

In this case, Petroglyph was developing "close-proximity wells" because it was drilling shallow wells, and there was not an adequate confining layer. Ongoing pressure testing and groundwater monitoring may have identified methane leaks earlier, caught the problems in this field, and prevented contamination of local source water.

IV. ADDRESSING POTENTIAL RISKS TO SOURCE WATER FROM OIL AND GAS DEVELOPMENT (cont.)

d. COGCC Offset Well Plugging Policy Addresses Nearby Abandoned Wells that Could Lead to Groundwater Contamination

Another potential pathway for oil and gas and other contaminates to reach groundwater is through nearby wells that were improperly plugged and abandoned. In 2014, the COGCC implemented a statewide "offset well policy" requiring operators that are developing new horizontal wells to conduct an "offset well evaluation" as part of their drilling permit applications.[68] The offset well evaluation will determine if any producing, shut-in, temporarily abandoned, plugged and abandoned, or dry and abandoned wells exist within 1,500 feet of the projected horizontal wellbore. If there are existing wells within 1,500 feet of the projected borehole drilled into the formation targeted by the proposed horizontal well, then the existing wells must be remediated in order to prevent the well from serving as a conduit for oil and gas or drilling fluids to enter groundwater.

For existing wells subject to the offset well policy, the operator will have to undertake one of the following actions:

1. If the Well of Concern is to remain, provide remedial cement needed to adequately isolate all hydrocarbon and fresh water formations.

2. If the Well of Concern is to be plugged, plug the Well of Concern to adequately isolate all hydrocarbon and fresh water formations.

3. If the Well of Concern is PA (plugged and abandoned) or DA (dry and abandoned), re-enter and re-plug the Well of Concern to adequately isolate all hydrocarbon and fresh water formations.

4. Secure COGCC approval for alternative measures or COG CC agreement that additional mitigation is unnecessary under the circumstances.[69]

The policy is implemented by the COGCC. Even so, if a water provider knows of a historic well in the area, it should follow up with the COGCC to inquire if the well has been property plugged and abandoned before new horizontal wells are permitted in the area.

e. Use of Pits to Store Water and Other Fluids

In Colorado, the oil and gas industry uses pits for temporary storage of water and other fluids. All pits used at Centralized Exploration and Production Waste Management Facilities and underground injection wells, as well as most drilling pits, production pits, and multi-well pits, require liners. The COGCC has specific pit construction and liner characteristics rules (Rule 904). For example, all liners require a minimum thickness of liner and minimum thickness of compacted soil where the pit will be located. A double liner may be substituted for compacted soil.

All pits can eventually leak if used long enough. Chemicals and the sun's rays will eventually break down even the thickest liners ––— creating a potential pathway for the fluids to seep into groundwater. Installing leak detection and monitoring systems is not required by Colorado law, but many companies include them as a standard practice. The purpose of liners is to block a potential pathway for fluids contained in pits to mix with groundwater or surface water, and a leak detection system provides warning that a leak has occurred.

A closed-loop drilling system that avoids using pits by containing all fluids within a system of pipes and tanks greatly minimizes the potential for groundwater contamination. Colorado requires closed-loop drilling systems within the Buffer Zone Setback, which is 1,000 feet of residences and some commercial properties (COGCC Rule 604c.2.B). However, the COGCC rules do not require closed-loop drilling systems specifically to protect groundwater sources. But the requirement for closed-loop systems can be requested through surface use agreements or added as a condition of approval for a COGCC permit.

f. Groundwater Protections Through Orders

An Order is essentially a COGCC Rule that has limited applicability to specific locations. In 2014, the COGCC issued an Order that protected groundwater sources for several wells that provide a majority of the drinking water for the City of Brighton. The COGCC Order, which was supported by the City of Brighton as well as local operators, excludes oil and gas facilities from within 500 feet of Brighton's shallow groundwater wells. The Order also established a "BMP Buffer Zone" within one-half mile of the water wells. Any oil and gas locations within one-half mile of a water well that serves Brighton may not use waste pits. Any tanks within the BMP Buffer Zone must be within a steel-bermed secondary containment system that utilizes synthetic liners. Earth berms are also required on the downslope side of the production facilities. Any operations within one-half mile of the city's water supply infrastructure must also comply with the COGCC's Rule 609 groundwater baseline sampling and monitoring requirements (described below), despite the fact that Brighton is within the sampling exception zone. The Brighton Source Water Protection Order does set a precedent, and similar Orders could be issued for other water suppliers that rely on shallow water wells.

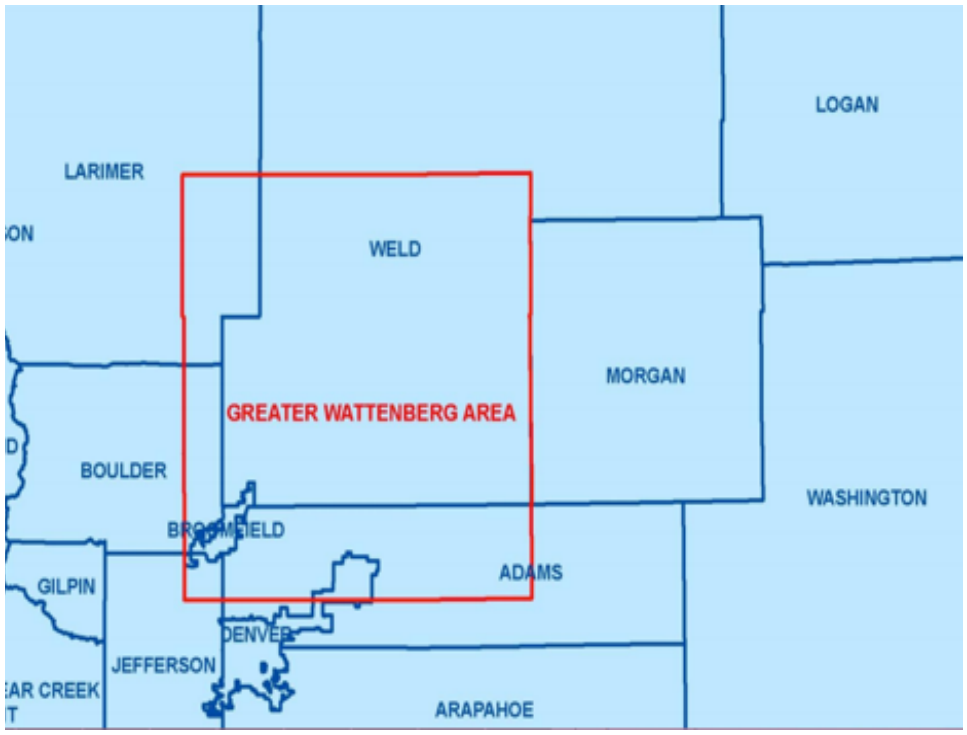
IV. ADDRESSING POTENTIAL RISKS TO SOURCE WATER FROM OIL AND GAS DEVELOPMENT (cont.)

g. Baseline Monitoring of Groundwater Quality

In 2012, the COGCC passed a regulation (COGCC Rule 609) requiring baseline and post-completion groundwater monitoring for Colorado oil and gas operators. The rule requires the industry to pay for up to four water well samples within one-half mile of the proposed well. If a well cannot be located, then samples from springs may be substituted. The same areas must be sampled 6–12 months after completion of the oil and gas well, and then a final sample is taken five to six years after completion of the well. The sampling results are shared with the water well owner and the COGCC.

However, the baseline water sampling rule does not apply to the Greater Wattenberg Area (Rule 318A.f), which underlies portions of Adams, Boulder, Larimer, and Weld counties currently experiencing the highest level of development activity. Under Rule 318A, the industry in the Greater Wattenberg Area can rely on data collected up to five years prior within the same quarter section to set the initial baseline water quality. Operators are only required to sample one available water source within the quarter section (160 acres) where they are drilling. If there are no water sources available within the quarter section, the industry must look for a previously unsampled water source within one-half mile of the well site. After completion of the well, the operator must sample that well once within 6–12 months.

Roughly 72% of all new wells in Colorado from January 1, 2014 to April 1, 2015 were drilled in the Greater Wattenberg Area, which also accounted for 59% of all the new drilling application permits in Colorado during that same time period. The area has a long history of oil and gas development and is home to 45% of all of the wells in Colorado. In 2013, a bill that would have made baseline water sampling requirements uniform across the state passed the House of Representatives, but died in the Senate.[70] The Colorado Oil and Gas Association claims that the exception for the Greater Wattenberg Area was needed "due to the combination of energy development, agriculture, and other industrial and residential use unique to this area." However, the bill sponsors argued that because there is a greater number of wells, there is a greater likelihood of groundwater contamination. More oil and gas activity occurring in an area with agriculture, residential, and other industrial uses should require more water sampling, not less.



Statewide Rule (609)	GWA Rule (318A.e(4))
Baseline sample must be collected within six to 12 months prior to setting conductor pipe for a new well.	For a baseline sample, operators can rely on data collected up to five years prior to completion by any operator in the same quarter-section.
Operators are required to sample up to four water sources within a ½ mile radius of the well.	Operators are required to sample one water source within each quarter section.
Post completion, operators must sample all four water sources two times (between six and 12 months post-completion and between 60 and 72 months post completion.)	Post completion, operators are required to sample the one water source one time (between six and 12 months post completion.)

IV. ADDRESSING POTENTIAL RISKS TO SOURCE WATER FROM OIL AND GAS DEVELOPMENT (cont.)

WHAT YOU CAN DO

While the COGCC rules do not require as comprehensive of a baseline water sampling regimen, water providers in the Greater Wattenberg Area should request that operators follow Rule 609 if their wells or facilities will be close to source water areas.
Surface owners can request so during surface use agreement negotiations, and mineral owners during lease negotiations.

Ensure that water wells are tested prior to and after oil and gas development, and expand statewide requirements into the Greater Wattenberg Area. If you have a well, establish a baseline for the quality of the water from your well.
This is especially pertinent if you live in the Greater Wattenberg Area because the state's baseline monitoring rule is more lax in that region. The Colorado Water and Energy Research Center published a guide in August 2014 outlining how to do this, entitled Monitoring Water Quality in Areas of Oil and Natural Gas Development: A Guide for Water Well Users and is available at http://cwerc.colorado.edu. Establishing a baseline for water quality before oil and gas development occurs is crucial in order for a landowner to determine if a water well was affected by nearby drilling. It may be possible to have the operator for a proposed oil or gas well pay for the testing under Colorado's Baseline Groundwater Monitoring Rule 609.

Use additional BMPs for close-proximity wells.
Close-proximity wells (like some coalbed methane wells in Colorado) should either be located a safe distance away from source water areas or, at the very least, cement should be circulated all the way to the surface. Ongoing bradenhead pressure testing, mechanical integrity tests, and groundwater monitoring should be required for close-proximity wells to ensure oil and gas is not migrating to groundwater.

Use additional BMPs to prevent leaks from contaminating groundwater and surface water.
Locating oil and gas facilities away from water sources needs to be the first priority. Beyond that, BMPs worth considering include: 1) use of pads designed to prevent any spills from contaminating groundwater, 2) use of secondary containment around facilities that include steel-rimmed berms and liners under equipment, 3) frequent inspections and pressure-testing of pipelines, and 4) use of tanks instead of pits.

Make a conscious choice for pit type.
Several different types of pits can be part of the oil and gas drilling and production process, including drilling pits, production pits, storage pits, and evaporation pits. Many of these pits eventually leak into and should be avoided if at all possible. The best operators have gone to "pitless drilling" systems (also called closed-loop drilling systems) that use holding tanks rather than pits to hold drilling fluids and flowback from fracking or produced water.

Make a conscious choice for waste disposal. How will liquid and solid waste be disposed of? Is the operator proposing to use waste pits or closed-loop systems? Some operators try to convince landowners to allow them to "land farm" their drilling muds. This is generally a bad idea because even drilling muds approved for such use exit the hole with naturally occurring petroleum and other contaminants that are toxic to soil and could pose a risk to drinking water.

GLOSSARY

APD: Application for permit to drill- called a "Form 2" by the COGCC.

BEST MANAGEMENT PRACTICES (BMPS): Practices that are designed to prevent or reduce impacts caused by oil and gas operations to air, water, soil, or biological resources, and to minimize adverse impacts to public health, safety and welfare, including the environment and wildlife resources (COGCC 100 Series rule). According to the Bureau of Land Management, a BMP is "a state-of-the-art mitigation measure applied to oil and natural gas drilling and production to help ensure that energy development is conducted in an environmentally responsible manner."[71]

BLM: U.S. Bureau of Land Management

CDPHE: Colorado Department of Public Health and Environment

CDPS: Colorado Discharge Permit System

COGCC: Colorado Oil and Gas Conservation Commission
completion: An oil well shall be considered completed when the first new oil is produced through wellhead equipment into lease tanks from the ultimate producing interval after the production string has been run. A gas well shall be considered completed when the well is capable of producing gas through wellhead equipment from the ultimate producing zone after the production string has been run. A dry hole shall be considered completed when all provisions of plugging are complied with as set out in these rules. Any well not previously defined as an oil or gas well shall be considered completed ninety (90) days after reaching total depth. If approved by the Director, a well that requires extensive testing shall be considered completed when the drilling rig is released or six months after reaching total depth, whichever is later (COGCC 100 Series rule). Use of the term "completion" as synonym for "hydraulic fracturing" is frequently used, but is simplistic and misleading.

CWQCD: Colorado Water Quality Control Division

DERRICK: A machine for lifting and moving heavy objects with a boom equipped with cables and pulleys connected to a stationary beam. At an oil or gas well, it is used to support boring equipment to hoist and lower lengths of pipe.

DESIGNATED SETBACK LOCATION: Any Oil and Gas Location upon which any Well or Production Facility is or will be situated within, a Buffer Zone Setback (1,000 feet), or an Exception Zone Setback (500 feet), or within one thousand (1,000) feet of a High Occupancy Building Unit or a Designated Outside Activity Area, as referenced in Rule 604. The measurement for determining any Designated Setback Location shall be the shortest distance between any existing or proposed Well or Production Facility on the Oil and Gas Location and the nearest edge or corner of any Building Unit, nearest edge or corner of any High Occupancy Building Unit, or nearest boundary of any Designated Outside Activity Area (COGCC 100 Series rule).

EPA: U.S. Environmental Protection Agency

FLOWBACK: The fluids and solids that flow back to the surface during well drilling and completion, including hydraulic fracturing operations. The period of time for flowback to occur is relatively short. See also "produced water."

FLOWLINES: Those segments of pipe from the wellhead downstream through the production facilities ending at, in the case of gas lines, the gas metering equipment; or in the case of oil lines, the oil loading point; or in the case of water lines, the water loading point, the point of discharge to a pit, the injection wellhead, or the permitted surface water discharge point (COGCC 100 Series rule).

FORM 2A/LOCATION ASSESSMENT APPLICATION: The application that must be submitted and approved by the COGCC for any new oil and gas well, surface disturbance to modify or expand an existing oil and gas site, or the addition of a pit. The application requires such things as a drawing of the site, pictures of the site, an access road map, and a hydrology map.

HORIZONTAL WELL: A well which is drilled in such a way that the wellbore deviates laterally to an approximate horizontal orientation within the target formation with the length of the horizontal component of the wellbore extending at least one hundred feet (100') in the target formation, measured from the initial point of penetration into the target formation through the terminus of the horizontal component of the wellbore in the same common source of hydrocarbon supply (COGCC 100 Series rule).

HYDRAULIC FRACTURING: The process of injecting hydraulic fracturing fluid under pressure down an oil and/or gas well under pressure with the objective of initiating or propagating fractures in a geologic formation in order to facilitate the production of oil and natural gas. Low-volume hydraulic fracturing has been used for decades to enhance production from conventional oil and gas reservoirs; high-volume, multi-stage hydraulic fracturing is used for unconventional reservoirs, e.g., tight sands and shales.

LANDMAN: The person who researches mineral ownership and contacts mineral owners in an effort to negotiate leasing of mineral rights. Landmen will also negotiate "surface use agreements" with landowners who own the surface where the oil and gas operators would like to locate wells, pipelines, or other production equipment.

GLOSSARY

LOCAL GOVERNMENTAL DESIGNEE (LGD): The office (or person) designated to receive, on behalf of the local government, copies of all documents required to be filed with the local governmental designee pursuant to these rules (COGCC 100 Series rule).

MINIMIZING EROSION: Implementing best management practices that are selected based on site-specific conditions and maintained to reduce erosion. Representative erosion control practices include, but are not limited to, revegetation of disturbed areas, mulching, berms, diversion dikes, surface roughening, slope drains, check dams, and other comparable measures (COGCC 100 Series rule).

OPERATOR: Any person who exercises the right to control the conduct of oil and gas operations (COGCC 100 Series rule).

ORDERS: Official modifications of COGCC rules by the Commission. An Order is essentially a COGCC Rule that has limited applicability to specific locations.

PITLESS DRILLING SYSTEM: A system that deposits drilling fluids — water, mud, and additives — in storage tanks instead of open pits after they circulate through the wellbore and return to the surface. These systems are undefined in the COGCC rules, but referred to frequently in Rule 317B (Public Water System Protection).

POINT SOURCE DISCHARGE: A stationary location or fixed facility from which pollutants are discharged or emitted or any single, identifiable discharge point of pollution, such as a pipe, ditch, or smokestack.[72]

PRODUCED WATER: The water that exists in subsurface formations and is brought to the surface during oil and gas production. Water is generated from conventional oil and gas production, as well as the production of unconventional sources, such as coalbed methane, tight sands, and oil and gas shale. The concentration of constituents and the volume of produced water differ dramatically depending on the type and location of the petroleum product. In general, the total dissolved solids concentration can range from 100 milligrams per liter (mg/L) to over 400,000 mg/L. Silt and particulates, sodium, bicarbonate, and chloride are the most commonly occurring inorganic constituents in produced water. Benzene, toluene, ethylbenzene, and xylene (BTEX) compounds are the most commonly occurring organic contaminants in produced water. Produced water accounts for the largest waste stream volume associated with oil and gas production. [73] While the volume of production varies, this water may be produced for the life of the well.

PUBLIC WATER SYSTEMS: Systems listed in Appendix VI to COGCC Rules. These systems provide water for human consumption through pipes or other constructed conveyances, if such systems have at least fifteen (15) service connections or regularly serve an average of at least twenty-five (25) individuals daily at least sixty (60) days out of the year. Such definition includes:

(i) Any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system.

(ii) Any collection or pretreatment storage facilities not under such control, which are used primarily in connection with such system.

The definition of "Public Water System" for purposes of Rule 317B [Public Water System Protection] does not include any "special irrigation district," as defined in Colorado Primary Drinking Water Regulations, 5 C.C.R. 1003.1 (COGCC 100 Series rule).

Public Water Systems include community and non-community as well as transient and non-transient systems serving the requisite persons/days.

PUMP JACK: The aboveground drive for a reciprocating pump in an oil well. It provides artificial lift that moves oil to the surface if there is not enough bottom hole pressure for the liquid to flow all the way to the surface. The bobbing head of the pump jack is a common sight in oil-producing regions.

RELEASE: Any unauthorized discharge of exploration and production waste to the environment that occurs over time (COGCC 100 Series rule).

RESERVE PITS: Pits used to store drilling fluids for use in drilling operations or to contain oil and gas exploration and production waste generated during drilling operations and initial completion procedures (COGCC 100 Series rule).

RESIDENTIAL BUILDING UNIT means a building or structure designed for use as a place of residency by a person, a family, or families. The term includes manufactured, mobile, and modular homes, except to the extent that any such manufactured, mobile, or modular home is intended for temporary occupancy or for business purposes (COGCC 100 Series rule).

GLOSSARY

SENSITIVE AREA: An area vulnerable to potential significant adverse groundwater impacts due to factors such as the presence of shallow groundwater or pathways for mixing with deeper groundwater or proximity to surface water, including lakes, rivers, and perennial or intermittent streams, creeks, irrigation canals, and wetlands. Additionally, sensitive areas are those classified for domestic use by the Colorado Water Quality Control Commission, local (water supply) wellhead protection areas, areas within one-eighth of a mile of a domestic water well, areas within one-fourth of a mile of a public water supply well, groundwater basins designated by the Colorado Ground Water Commission, and surface water supply areas (COGCC 100 Series rule).

SOURCE WATER: Surface water (streams, rivers, and lakes) or groundwater (aquifers) that can serve as sources of drinking water. Source water provides water for public drinking water supplies and private water wells.[74]

SPILL: Any unauthorized sudden discharge of exploration and production waste to the environment (COGCC 100 Series rule).

STORMWATER PERMITS: Permits required for construction activities that will disturb more than one acre, including at oil and gas operations, in Colorado. The Colorado Water Quality Control Division within the Colorado Department of Public Health and Environment issues these permits.

SURFACE USE AGREEMENT: Any agreement in the nature of a contract or other form of document binding on the operator, including any lease, damage agreement, waiver, local government approval or permit, or other form of agreement, which governs the operator's activities on the surface in relation to locating a well, multi-well site, production facility, pipeline, or any other oil and gas facility that supports oil and gas development located on the surface owner's property (COGCC 100 Series rule).

SURFACE WATER INTAKE: The works or structures at the head of a conduit through which water is diverted from a classified water supply segment and/or source (e.g., river or lake) into the treatment plant (COGCC 100 Series rule).

SURFACE WATER SUPPLY AREA: The classified water supply segments within five (5) stream miles upstream of a surface water intake on a classified water supply segment. Surface water supply areas shall be identified on the Public Water System Surface Water Supply Area Map or through use of the Public Water System Surface Water Supply Area Applicability Determination Tool described in Rule 317B.b (COGCC 100 Series rule).

UNDERGROUND INJECTION WELL: A well dedicated to the disposal of exploration and production waste, which are wastes such as produced water, chemicals, and solids associated with operations to locate and remove oil and natural gas from the ground. These wells are also known as Class II injection wells. Injection wells are regulated by the U.S. Environmental Protection Agency.

URBAN MITIGATION AREA shall mean an area where: (A) At least twenty-two (22) Building Units or one (1) High Occupancy Building Unit (existing or under construction) are located within a 1,000' radius of the proposed Oil and Gas Location; or (B) At least eleven (11) Building Units or one (1) High Occupancy Building Unit (existing or under construction) are located within any semi-circle of the 1,000' radius mentioned in section (A) above (COGCC 100 Series rule).

> BUILDING UNIT shall mean a Residential Building Unit; and every five thousand (5,000) square feet of building floor area in commercial facilities or every fifteen thousand (15,000) square feet of building floor area in warehouses that are operating and normally occupied during working hours (COGCC 100 Series rule).
>
> HIGH OCCUPANCY BUILDING UNIT shall mean: any operating Public School as defined in § 22-7-703(4), C.R.S., Nonpublic School as defined in § 22-30.5-103.6(6.5), C.R.S., Nursing Facility as defined in § 25.5-4-103(14), C.R.S., Hospital, Life Care Institutions as defined in § 12-13-101, C.R.S., or Correctional Facility as defined in § 17-1-102(1.7), C.R.S., provided the facility or institution regularly serves 50 or more persons; or an operating Child Care Center as defined in § 26-6-102(1.5), C.R.S. (COGCC 100 Series rule).

APPENDIX: ADDITIONAL RESOURCES

Governmental Agencies

Colorado Oil and Gas Conservation Commission: http://cogcc.state.co.us/

The COGCC maintains a database of water well sampling data at: http://cogcc.state.co.us/documents/data/downloads/environmental/WaterWellDownload.html

Colorado Water Quality Control Commission: https://www.colorado.gov/pacific/cdphe/wqcc

Colorado Water Quality Control Commission, Commission Policy #98-2, A Guide to Colorado Programs for Water Quality Management and Safe Drinking Water: https://www.colorado.gov/pacific/sites/default/files/T1_WQCC_Policy98-2.pdf

United States Environmental Protection Agency, EPA's Study of Hydraulic Fracturing for Oil and Gas and Its Potential Impact on Drinking Water Resources: https://www.epa.gov/hfstudy

United States Environmental Protection Agency. "Drinking Water Mapping Application to Protect Source Waters (DWMAPS)." Last updated March 8, 2016. https://www.epa.gov/sourcewaterprotection/dwmaps.

Non-Profit Organizations

Air Water Gas Sustainability Resource Network: AirWaterGas is funded by the National Science Foundation as a Sustainability Research Network to address issues arising from rapid oil and gas development in the Rocky Mountain region. The AirWaterGas water quality team is investigating groundwater and surface water quality in oil and gas basins in Colorado, identifying potential water contaminants of greatest concern, and improving knowledge of the fate and transport of these contaminants. https://www.airwatergas.org/

American Petroleum Institute: API's mission is to influence public policy in support of a strong, viable U.S. oil and natural gas industry. API also conducts research and maintains a website that lists best management practices to protect water quality. http://www.api.org/oil-and-natural-gas/environment/clean-water

American National Standards Institute and American Petroleum Institute. 2015. Managing Environmental Aspects Associated with Exploration and Production Operations Including Hydraulic Fracturing, ANSI/API Recommended Practice 100-2. August. http://www.api.org/~/media/Files/Policy/Exploration/100-2_e1.pdf

American Petroleum Institute. 2015. API Recommended Practice 100-1, Hydraulic Fracturing—Well Integrity and Fracture Containment. October. http://www.api.org/Publications-Standards-and-Statistics/Standards/WhatsNew/Publication-Updates/New-Exploration-And-Production-Publications/API_RP_100-1

Colorado Water Watch, Colorado State University: The Colorado Water Watch (CWW) is a real-time groundwater monitoring pilot program developed by the Center for Energy Water Sustainability at Colorado State University. The monitoring system is comprised of a network of water quality sensors capable of detecting changes in groundwater quality due to natural or operational impacts. The data is monitored, gathered, analyzed and reported by CWW and posted on this website to provide information to communities in the DJ Basin. http://waterwatch.colostate.edu/

Earthworks' Oil & Gas Accountability Project (OGAP): OGAP serves drilling impacted communities around the country. OGAP works on government reform and its website contains information about preventing water pollution during oil and gas development. https://www.earthworksaction.org/protect_environment/water

Environmental Defense Fund: EDF's Model Regulatory Framework for Hydraulic Fracturing is based on "best-in-class" state rules and regulations, and incorporates industry best practices with regard to safety, efficiency and environmental protection. The MRF is meant to give state governments a road-map which can be used to implement hydraulic fracturing regulation that: (i) utilizes the structure of currently-effective state laws and regulations; (ii) mandates the use of effective operational industry practices; (iii) encourages technological advances and innovation in order to continually improve industry practices; and (iv) ensures the protection of human health and safety and the environment. https://www.edf.org/sites/default/files/content/Model_Regulatory_Framework_For_Hydraulically_Fractured_Hydrocarbon_Production_Wells_2014.pdf

Environmentally Friendly Drilling Systems: EFD is a program managed by HARC - a research hub providing independent analysis on energy, air, and water issues to people seeking scientific answers. We are focused on building a sustainable future that helps people thrive and nature flourish. EFD is performing tests on frac water flow back and produced brine to identify the required level of treatment that is best for re-use in subsequent fracturing operations. http://efdsystems.org/index.php/produced-water-treatments/

APPENDIX: ADDITIONAL RESOURCES (cont.)

FracFocus Chemical Disclosure Registry: The site was created to provide the public access to reported chemicals used for hydraulic fracturing within their area. To help users put this information into perspective, the site also provides objective information on hydraulic fracturing, the chemicals used, the purposes they serve and the means by which groundwater is protected. The primary purpose of this site is to provide factual information concerning hydraulic fracturing and groundwater protection. https://fracfocus.org/

Groundwater Protection Council (GWPC): GWPC members consist of state ground water regulatory agencies which come together within the GWPC organization to mutually work toward the protection of the nation's ground water supplies. The purpose of the GWPC is to promote and ensure the use of best management practices and fair but effective laws regarding comprehensive ground water protection http://www.gwpc.org/

State Review of Oil and Natural Gas Environmental Regulations (STRONGER): STRONGER is a 501(c)3 non-profit, multi-stakeholder educational organization whose purpose is to assist states in documenting the environmental regulations associated with the exploration, development and production of crude oil and natural gas. http://www.strongerinc.org/

ENDNOTES

1. Colorado Geologic Survey. n.d. "Natural Gas Map." Accessed December 30, 2015. http://coloradogeologicalsurvey.org/energy-resources/natural-gas-2/map.

2. U.S. Environmental Protection Agency. 2015. Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources (External Review Draft). Washington, DC. EPA/600/R-15/047. http://yosemite.epa.gov/sab/sabproduct.nsf/fedrgstr_activites/F7A9DB9ABBAC015785257E540052DD54/$File/HF_Main.pdf.

3. Kalinski, M. E. 2007. "Effect of Vibroseis Arrays on Ground Vibrations: a Numerical Study." Journal of Environmental and Engineering Geophysics, Environmental and Engineering Geophysical Society 12 (3): 281–287.

4. U.S. Bureau of Land Management. 2007. "Onshore Oil and Gas Geophysical Exploration Surface Management Requirements (Public)," Illustration 16, page 3. In BLM Geophysical Manual H-3150, Rel 3-330. http://www.blm.gov/pgdata/etc/medialib/blm/mt/blm_programs/energy/oil_and_gas/geophysical.Par.6164.File.dat/safeoperatingdistance.pdf. Note that Canada requires seismic testing to be at least 100 meters (328 feet) from a water well; see "Canada Oil and Gas Geophysical Operations Regulations (SOR/96-117) 17.(1)(d)(iv)." Government of Canada Justice Laws website. http://laws-lois.justice.gc.ca/eng/regulations/sor-96-117/page-4.html.

5. Colorado Oil and Gas Conservation Commission. 2014. Risk-Based Inspections: Strategies to Address Environmental Risk Associated with Oil and Gas Operations. February. http://cogcc.state.co.us/documents/library/Technical/Risk_Based_Inspections/DNR%20-%20OGCC%20Risk%20Based%20Inspection%20Strategy%20FINAL.pdf.

6. Colorado Oil and Gas Conservation Commission 1000 Series Reclamation Regulations, http://cogcc.state.co.us/documents/reg/Rules/LATEST/1000Series.pdf.

7. For example, see "Encana and the Lifespan Learning Approach" and "Spotlight: QEP Reclamation" on the Intermountain Oil and Gas BMP Project website, http://www.oilandgasbmps.org/resources/casestudies/index.php.

8. Minnick, Tamera J., and Richard D. Alward. 2015. "Plant–Soil Feedbacks and the Partial Recovery of Soil Spatial Patterns on Abandoned Well Pads in a Sagebrush Shrubland." Ecological Applications. 25 (1): 3–10.

9. § 34-60-102, C.R.S.

10. Colorado Oil and Gas Conservation Commission Rules can be found at http://cogcc.state.co.us/reg.html#/rules.

11. In 1989, the Colorado General Assembly passed SB89-181 making the COGCC the implementing agency for water quality standards and classifications for groundwater protection as adopted by the Colorado Water Quality Control Commission.

12 Memorandum of Agreement for the Implementation of SB 181 Amendments to the Water Quality Control Act (25-8-101, et seq) Section 5.1.c., August 28, 1990.

13. Colorado Oil and Gas Conservation Commission. n.d. "List of Participating Local Governmental Designees." http://cogcc.state.co.us/Infosys/lgd/list.cfm.

14. COGCC Rule 305A requires 90-day notice if a proposal of eight or more wells (or over 4,000 barrels of hydrocarbon storage capacity) is placed within a neighborhood of 11 Building Units within a semi-circle 1,000 feet of an oil and gas location.

15. Colorado Oil and Gas Conservation Commission website, http://cogcc.state.co.us/permits.html#/permits.

16. Colorado Oil and Gas Conservation Commission website, http://cogcc.state.co.us/permits2.html#/permitshelp.

17. U.S. Environmental Protection Agency. n.d. "Protect Sources of Drinking Water." Accessed September 25, 2015. http://water.epa.gov/infrastructure/drinkingwater/sourcewater/protection/epastateandtribalprograms.cfm.

18. Colorado source water assessment programs (by county) are on the state website, https://www.colorado.gov/pacific/cdphe/swap-assessment-phase.

19. City of Longmont v. Colorado Oil & Gas Ass'n, 369 P.3d 573, 584 (Colo. 2016). (Citing C.R.S. § 34-60-102.)

20. Mandelker, Daniel R. Land Use Law § 5.02 (5th ed. 2003).

ENDNOTES

21. Gunnison County website, http://www.gunnisoncounty.org/DocumentCenter/View/108. See also Baumgartner, David. 2007. "Keeping Public Drinking Water Supplies Clean: Opportunities and Challenges for Protecting Water Supply Watersheds."

22. C.R.S. § 31-15-707(b)

23. Town of Carbondale v. GSS Properties, LLC, 140 P.3d 53 (Colo. Ct. App. 2005), overruled on other grounds. Town of Carbondale v. GSS Properties, LLC, 169 P.3d 675 (Colo. 2007).

24. Lummis, Kristen. 2002. "Colorado Municipal Watershed Ordinances."

25. The Grand Junction Watershed Protection Ordinance and Regulations, http://www.gjcity.org/Watershed_Protection.aspx.

26 "Ordinance No. 1986, An Ordinance Amending Chapter 17-54, Oil And Gas Land Use Regulations, Of The Broomfield Municipal Code," As Amended September 24, 2013. http://www.broomfield.org/DocumentCenter/View/5772

27. H.B. 1252 located at C.R.S. § 34-60-127.

28 Congressional Research Service. 2014. "Federal Land Ownership: Overview and Data," page 4. December 29. https://fas.org/sgp/crs/misc/R42346.pdf.

29. For a useful guide, see Zimmerman, Kathleen. 2008. Fuel for Thought: A Citizen's Guide to Participating in Oil and Gas Decisions on Your Public Lands. Boulder, Colo.: National Wildlife Federation. http://www.ourpubliclands.org/files/upload/OilandGasGuide.pdf.

30. The BLM provides a frequently asked questions about RMPs on its website; see U.S. Bureau of Land Management. 2014. "Land Use Planning: Frequently Asked Questions." Last updated May 7.

31. Search the Intermountain Oil and Gas BMP Project BMP database at http://www.oilandgasbmps.org/bmpadvsearch.php.

32. Colorado Oil and Gas Conservation Commission website, http://cogcc.state.co.us/documents/reg/Rules/LATEST/AppendixVI.pdf.

33. Colorado Oil and Gas Conservation Commission. 2014. Risk-Based Inspections: Strategies to Address Environmental Risk Associated with Oil and Gas Operations, page 26. February. http://cogcc.state.co.us/documents/library/Technical/Risk_Based_Inspections/DNR%20-%20OGCC%20Risk%20Based%20Inspection%20Strategy%20FINAL.pdf

34. Colorado Oil and Gas Conservation Commission. 2016. "COGCC Operator Guidance, Rules 1101 and 1102: Flowline Guidance." February 25. http://cogcc.state.co.us/documents/reg/OpGuidance/Rule%201101%20and%201102%20Flowline%20Guidance%20-%202-25-16.pdf.

35. Colorado Department of Public Health and Environment website, https://www.colorado.gov/pacific/cdphe/cdphe/wq-public-notice-actions.

36. Comment via mail: CDPHE WQCD Permits, 4300 Cherry Creek Dr. South B2, Denver, CO 80246 or by phone at 303-692-3517.

37. "Produced water includes all waters and particulate matter associated with formations that produce oil and gas. Consistent with the scope of the oil and gas extraction point source category established by the EPA in the development of Federal Effluent Limitation Guidelines, produced water discharges associated with production of crude petroleum and natural gas, drilling oil and gas wells, and oil and gas field exploration services are included within the scope of the permit. In addition to formation water, produced water may be commingled with injection water, any chemicals added downhole, chemicals added during the oil/water separation processes, or chemicals added during the treatment process." See Colorado Department of Public Health and Environment, Water Quality Control Division. n.d. "Discharges Associated with Produced-Water Treatment Facilities Fact Sheet." https://www.colorado.gov/pacific/sites/default/files/WQ%20COG840000%20FS_0.pdf.

38. Centralized Exploration and Production Waste Management Facilities are defined by the COGCC and in this document: Colorado Department of Public Health and Environment, Water Quality Control Division. n.d. "Discharges Associated with Produced-Water Treatment Facilities Fact Sheet." https://www.colorado.gov/pacific/sites/default/files/WQ%20COG840000%20FS_0.pdf. The types of facilities that fall into this category include land farm facilities, evaporation facilities, water treatment, and central water storage facilities.

ENDNOTES

39. COGCC Rule 908.b.(9) and (10) outline groundwater and surface water monitoring requirements for these facilities.

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