

Water Sources and Demand for the Hydraulic Fracturing of Oil and Gas Wells in Colorado from 2010 through 2015¹

Recently, questions have been raised about the quantity of water that will be needed for the hydraulic fracturing of oil and gas wells in Colorado. This report is intended to address these questions.

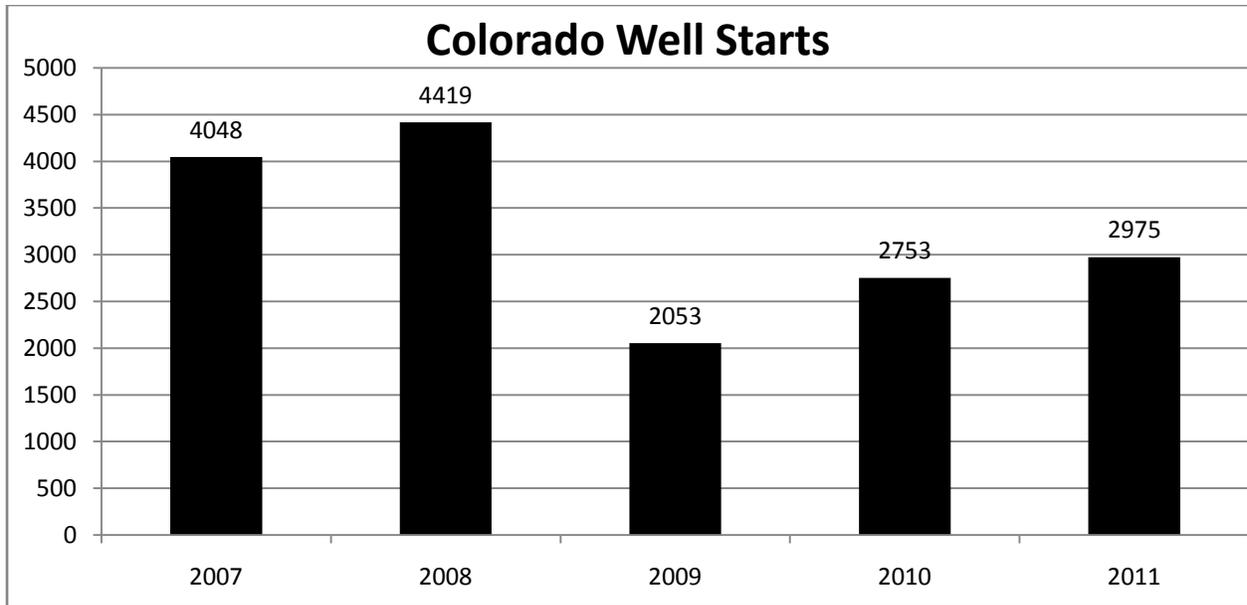
Hydraulic fracturing is the process of creating small cracks, or fractures, in underground geological formations to allow oil and natural gas to flow into the wellbore and thereby increase production. To fracture the formation, special fracturing fluids are injected down the well bore and into the formation under high pressure. These fluids typically consist of approximately 90% water, 9.5% sand, and 0.5% chemicals. The volume of fluids used for this purpose depends upon a variety of factors, including the well type and the formation depth and geologic composition. For example, horizontal wells require more water than vertical or directional wells (because of the length of the borehole that will be fracture stimulated), and deeper shale formations require more water than shallower coal bed methane formations. Hydraulic fracturing has been used in Colorado to increase the production of oil and gas wells since the 1970s, and in recent years most Colorado oil and gas wells have been hydraulically fractured.

The following pages will examine the current and projected water demands for hydraulic fracturing in Colorado, compare those demands to the amount of water that is used for other purposes in Colorado, identify potential sources of water for hydraulic fracturing, and summarize the legal and administrative requirements for using those sources.

Projected Water Demands for Hydraulic Fracturing in Colorado During the Period from 2010 Through 2015

The pace and type of oil and gas well construction in Colorado and other states depend upon a variety of factors that are difficult to predict or control. These factors include national and regional economic conditions, oil and gas prices, capital availability, corporate strategies, and technological innovations. The variability in these factors is reflected in recent well starts in Colorado, which increased from 2007 to 2008, decreased from 2008 to 2009, and then increased again from 2009 to 2010 and from 2010 to 2011:

¹ Jointly prepared by the Colorado Division of Water Resources, the Colorado Water Conservation Board, and the Colorado Oil and Gas Conservation Commission



The various factors that influence oil and gas development, and the resulting variations in development activity, make it extremely difficult to predict future development levels. Nevertheless, the Colorado Oil and Gas Conservation Commission has attempted to predict such development during the period of 2010 through 2015 for the purpose of quantifying the amount of water that could be used for hydraulic fracturing during these years. These predictions are tentative, general, and should be used with caution. They are based upon the following assumptions, which may or may not prove accurate:

- The demand for new gas wells will remain relatively flat.
- The number of drilling rigs in the state will remain relatively flat.
- The number of wells drilled will remain relatively flat because of rig count.
- The number of horizontal oil wells drilled will increase approximately 20% each year.
- The number of vertical wells drilled will decrease proportionally with the increase in horizontal wells drilled.

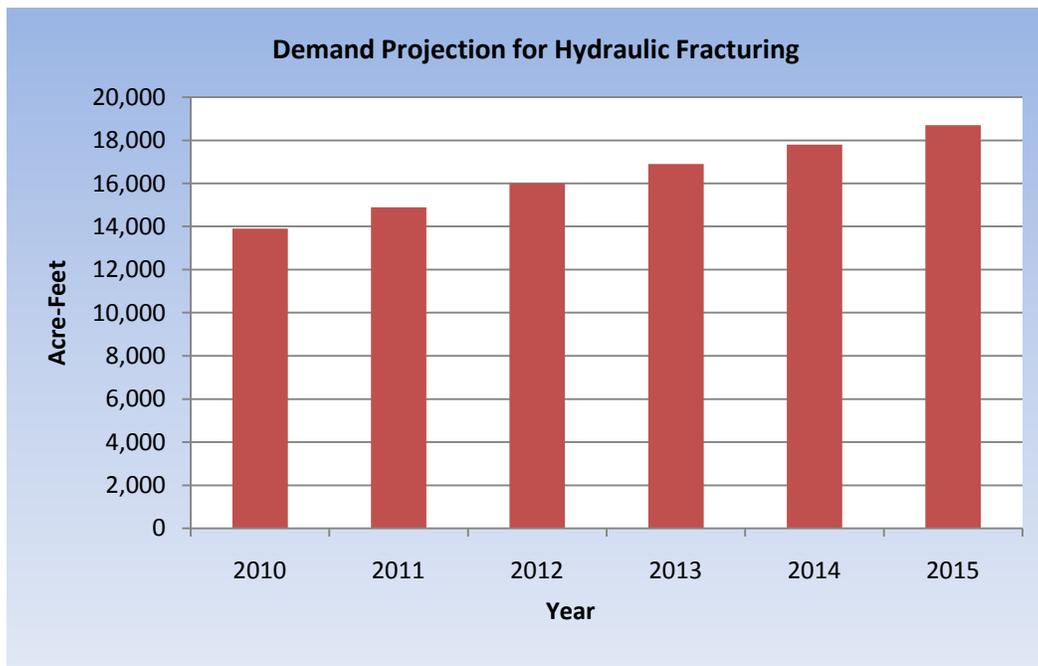
Based upon these assumptions, the Colorado Oil and Gas Conservation Commission estimates that during the period from 2010 through 2015 hydraulic fracturing will require the following volumes of water:

Projection of Annual Demand for Hydraulic Fracturing (Acre-Feet ²) ³					
2010	2011	2012	2013	2014	2015
13,900	14,900	16,100	16,900	17,800	18,700

² One acre-foot is approximately equal to 326,000 gallons.

³ The demands for hydraulic fracturing are based on actual numbers of wells constructed for the years 2010 and 2011 and estimated numbers of wells to be constructed for the following years based on a county-specific projection. The amount of water demand was determined using the number of wells, using vertical or horizontal construction practices, multiplied by an amount of water required for hydraulic fracturing per well. The amount of water required per well is based on reported data.

Regional geology dictates how wells will be drilled, either vertical or horizontal, and the volume of water that will be necessary to provide the most effective fracture stimulation treatment (frac). Frac water volumes have been calculated by predicting the number of new vertical and horizontal wells to be drilled in each county. Completion records were then evaluated to determine a typical water volume used in 2011 completions for each type of well construction in the county. The number of vertical and horizontal wells was multiplied by the typical water volume used in order to predict a total county water use. All of the county volumes were summed to determine the statewide use.



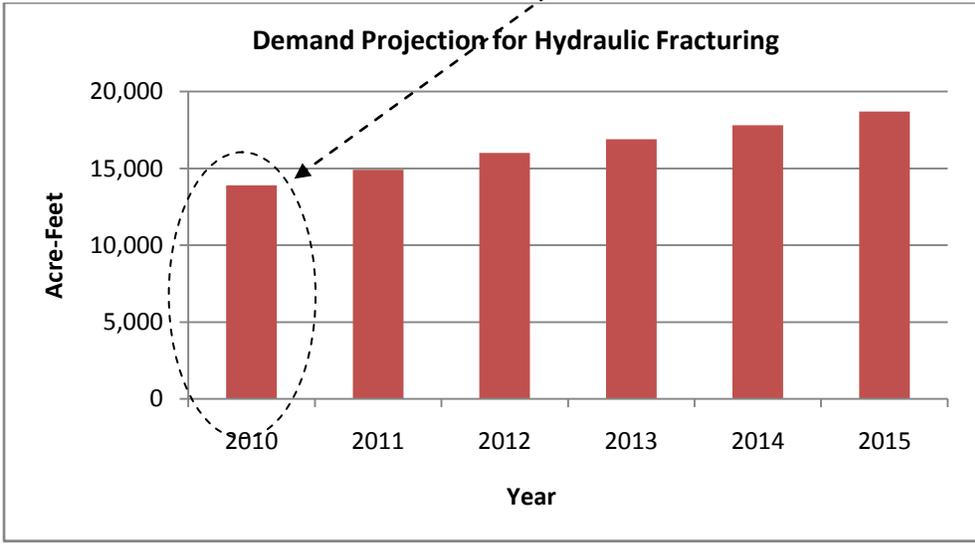
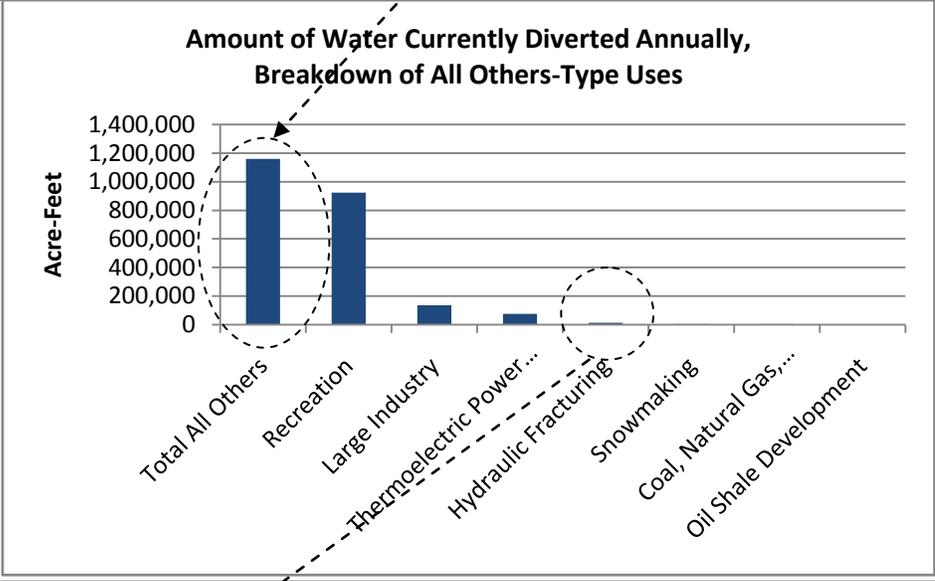
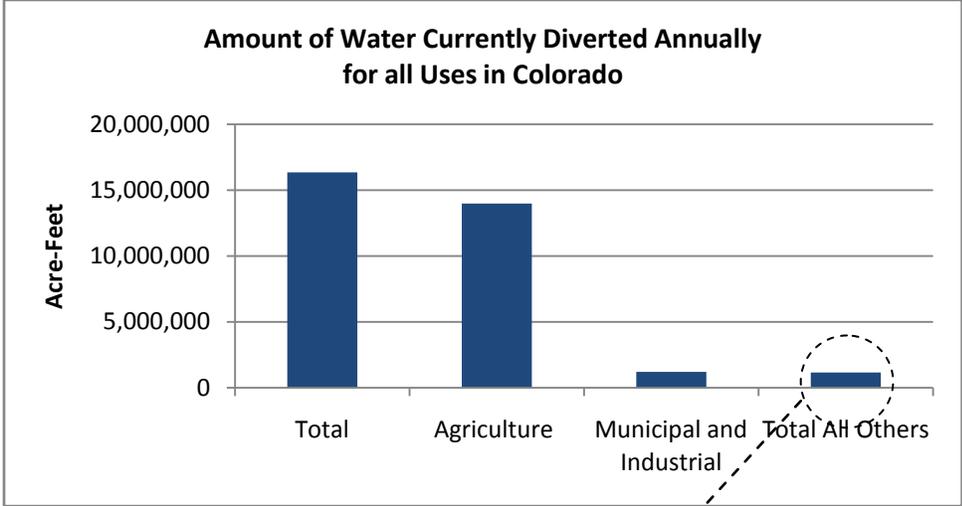
Water Demands in Colorado

The table below shows the amount of water currently diverted for beneficial use for all uses in Colorado on an average annual basis. It is important to note that water use in Colorado varies significantly on a year to year basis, and the projected increase in demand for hydraulic fracturing is well within Colorado's current year to year variation. This table is broken down into three categories. The third category, "Total All Others", is then further broken down into seven categories, including hydraulic fracturing.

Sector	2010 Use (Acre-Feet/Yr)⁴	Percent of State Total
Total	16,359,700	
Agriculture	13,981,100	85.5%
Municipal and Industrial	1,218,600	7.4%
Total All Others	1,160,000	7.1%
Breakdown of "All Others"		
Total All Others	1,160,000	
Recreation	923,100	5.64%
Large Industry	136,000	0.83%
Thermoelectric Power Generation	76,600	0.47%
Hydraulic Fracturing	13,900	0.08%
Snowmaking	5,300	0.03%
Coal, Natural Gas, Uranium, and Solar Development	5,100	0.03%
Oil Shale Development	0	0.00%

The graphs on the following pages indicate that the amount of water currently used for hydraulic fracturing in Colorado is a small portion of the total amount of water used. In 2010, it reflected slightly less than one-tenth of one percent of the total water used. In 2015, it is projected to increase by 4,800 acre-feet to slightly more than one-tenth of one percent of the total water used.

⁴ The estimated values for Current Annual Use are based on diversion records from the Colorado Division of Water Resources. For some categories, those amounts are further apportioned consistent with 2010 Statewide Water Supply Initiative data from the Colorado Water Conservation Board.



Potential Sources of Water for Hydraulic Fracturing

Several sources of water are available for hydraulic fracturing in Colorado. Because Colorado's water rights system is based in the prior appropriation doctrine, water cannot be simply diverted from a stream/reservoir or pumped out of the ground for hydraulic fracturing without reconciling that diversion with the prior appropriation system. Like any other water user, companies that hydraulically fracture oil and gas wells must adhere to Colorado water laws when obtaining and using specific sources of water for this purpose.

Below is a discussion of the sources of water that could potentially be used for hydraulic fracturing. The decision to use any one source is dependent on the ability to satisfy the water rights obligations and will also be driven by the economics associated with that source.

Water transported from outside the state

An Operator may transport water from outside of the state. As long as the transport and the use of the water carries no legal obligation to Colorado, this is an allowable source of water from a water rights perspective.

Irrigation water leased or purchased from a landowner

A landowner may have rights to surface water, delivered by a ditch or canal, that is used to irrigate land. An Operator may choose to enter into an agreement with the owner of the water rights to purchase or lease a portion of that water. This is allowable, however, in nearly every case, the use of an irrigation water right is likely limited to irrigation uses and cannot be used for Well Construction. To allow its use for Well Construction, the owner of the water right and the Operator may apply to change the water right through a formal process. (See "Change of Water Right" below.)

Treated water or raw water leased or purchased from a water provider

An Operator may choose to enter into an agreement with a water provider to purchase or lease water from the water provider's system. Municipalities and other water providers may have a surplus of water in their system before it is treated (raw water) or after treatment that can be used for Well Construction. Such an arrangement would be allowed only if the Operator's use is compliant with the water provider's water rights.

Water treated at a waste water treatment plant leased or purchased from a water provider

An Operator may choose to enter into an agreement with a water provider to purchase or lease water that has been used by the public, and then treated as waste water. Municipalities and other water providers discharge their treated waste water into the streams where it becomes part of the public resource, ready to be appropriated once again in the priority system. But for many municipalities a portion of the water that is discharged has the character of being "reusable." As a result, it is possible that after having been discharged to the stream, it could be diverted by the Operator to be used for Well Construction. Such an arrangement could only be exercised with the approval of the Division of Water Resources' Division Engineer and would be allowed only if the water provider's water rights include uses for Well Construction.

New diversion of surface water flowing in streams and rivers

In most parts of the state, the surface streams are "over appropriated," that is, the flows do not reliably occur in such a magnitude that all of the vested water rights on those streams can be satisfied. Therefore, the only time that an Operator will be able to divert water directly from the

river is during periods of higher flow and lesser demand. Those periods do occur but not necessarily reliably or predictably.

Ground water diverted from wells completed in tributary formations **outside** [Designated Ground Water Basins](#) (“Designated Basins”)

An Operator may choose to enter into an agreement with the owner of a well outside of the Designated Basins to divert the well’s water for Well Construction, or to divert additional water for Well Construction. However, most existing wells will be located in parts of the state where the surface streams are over appropriated. In those locations, because of the wells’ relatively junior water rights, the well is actually a diversion structure only and not a source of appropriated water. Instead, all water withdrawn by the well must be withdrawn according to a plan that acknowledges the impact of the well’s pumping on the over-appropriated stream and an accompanying plan for replacing that water to the stream to correct for the depletive impact. Therefore, the complexity of using the well to divert ground water for Well Construction will be primarily a result of the need to develop a plan for replacing depletions to the stream system. (See “Augmentation Plans” below.)

Ground water diverted from wells **inside** Designated Basins

An Operator may choose to enter into an agreement with the owner of a well inside the Designated Basins to divert the well’s water for Well Construction. If the well’s water right allows Well Construction as a use and there are no other restrictions on its use, this is a viable source of water. However, the water right for most wells in the Designated Basins generally does not include an allowance for oil and gas well construction purposes. If there is a question as to whether some other term in the well’s water right can be construed as an allowance for Well Construction, since these terms are usually ambiguous, the Division of Water Resources will evaluate them on a case-by-case basis to determine whether the intent of that term could have been for Well Construction purposes. If the well’s water right does not allow for Well Construction, the owner of the well and the Operator may apply to change the water right through a formal process. (See “Change of Water Right” below.)

Ground water diverted from wells completed or to be completed in nontributary aquifers

An Operator may choose to enter into an agreement with a landowner to divert nontributary ground water from the aquifer underlying the landowner’s land. The most recognizable occurrence of nontributary ground water is the water in the **Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers** of the [Denver Basin](#) situated along the Front Range of Colorado. This is permissible and can be done through the issuance of a well permit. In most cases there are no restrictions on the types of use allowed for nontributary ground water if it is not already subject of a decree or a well permit. There are, however, limits to the amount of water that may be withdrawn in a given period of time. Specifically, the amount of water that may be withdrawn from a piece of land under consideration is the amount of ground water calculated to be contained in the aquifer underlying that land; and no more than one percent of the amount calculated may be withdrawn annually (many will recognize this limitation as the basis for the term: “100-year aquifer life”). This withdrawal limitation would be applied to any well permit that allows the use of Well Construction and it is the exact same limitation that would be applied to wells that would withdraw the water for domestic, commercial, agricultural, or other uses. The amount of water currently being withdrawn for all uses from the bedrock aquifers of the Denver Basin is estimated to be 350,000 acre-feet annually.⁵

⁵ According to the *Citizens Guide to Denver Basin Groundwater*, 2007, produced and distributed by the Colorado Foundation for Water Education.

Produced Water

An Operator may choose to use water produced in conjunction with oil or gas production at an existing oil or gas well. The water that is produced from an oil or gas well falls under the administrative purview of the State Engineer's Office and as a result is either nontributary, in which case, it is administered independent of the prior appropriation system; or is tributary, in which case, the depletions from its withdrawal must be fully augmented if the depletions occur in an over-appropriated basin. The result in either case is that the produced water is available for consumption for other purposes, including Well Construction. The water must not be encumbered by other needs and a proper well permit must be obtained by the Operator before the water can be used for Well Construction. The exception to this permitting requirement is the allowance in [Section 37-90-137\(7\), C.R.S.](#), whereby produced water from a nontributary formation using a non-coal-bed methane operation may be applied to uses associated with Well Construction without a well permit.

Reused or Recycled Well Construction Water

For all of the different sources listed above that are used for Well Construction, the water right in question must contain provisions that allow the water to be fully consumed. Under that scenario, water that is used for well construction of one well may be recovered and reused in the construction of subsequent wells.

The COGCC encourages reuse and recycling of both the water used in Well Construction and the water produced in conjunction with oil or gas production. Reuse and recycling of water is covered in COGCC Rule 907 MANAGEMENT OF E&P WASTE, which describes the process for submitting a plan to the COGCC for review and approval. In the Piceance Basin several of the larger operators have constructed pipelines and use trucks to convey produced and already used water and other fluids to their centrally located water management facilities. At these facilities the water is treated so that it can be reused for drilling and completing new wells.

Explanation of Terms

Change of water right

In Colorado, a water right may be changed to allow for uses other than those originally granted to the water right and the water right can keep its original priority date. However, whether it is a water right inside or outside of the Designated Basins, such a change of use must be done through a formal process with notice to other water users. While the standards vary for each individual situation, in each case the change process is meant to ensure there will be no increase in use of the water right over what the water right allows or what has historically been done. Further, the change must include provisions to ensure that other owners of vested water rights are not impacted by a change to the system as a result of the change of water right. For designated ground water in the Designated Basins, the change of water right will be accomplished through an application to the Colorado Ground Water Commission according to the [Designated Basin Rules \[2-CCR-410-1\]](#). Outside the Designated Ground Water Basins, the change of water right may be accomplished through an application to the [water court](#) or an application to the State Engineer for temporary approval of a substitute water supply plan pursuant to [37-92-308](#) and the State Engineer's [Policy No. 2003-2](#), or an Interruptible Water Supply Agreement pursuant to [37-92-309](#).

Augmentation plans

In Colorado, water may be diverted when the result is a depletive effect on the stream system even though the diverter does not have a water right with the priority to do so, as long as the

diverter obtains formal approval of a plan to offset the depletive effect on the stream with a source of replacement water. Such a plan is called an augmentation plan. The plan must acknowledge the depletive effect of the diversion on the stream, including consideration of the amount of the depletion as well as the time and location of the depletion. Then the plan must identify a source of water that has been obtained to replace those depletions to ensure that no party with a senior vested water right will be injured. Approval to operate the augmentation plan may be accomplished through an application to the [water court](#) or an application to the State Engineer for temporary approval of a substitute water supply plan pursuant to [37-92-308](#).