

The Cheyenne Basin: Geology and Well Construction



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DWR Hydrogeology Section
January 14, 2021



COLORADO
Division of Water Resources
Department of Natural Resources

Outline

- 1) Cheyenne Basin Memo
- 2) Geology of the Cheyenne Basin
- 3) Well Construction based on geology
- 4) Resources

Cheyenne Basin Memo

- April 2018

 **COLORADO**
Division of Water Resources
Department of Natural Resources
Board of Examiners of Water Well Construction
and Pump Installation Contractors

April 11, 2018

RE: Construction of Wells in the Laramie Fox Hills Aquifer (2 COR 402-2, Rule 10.4.8)

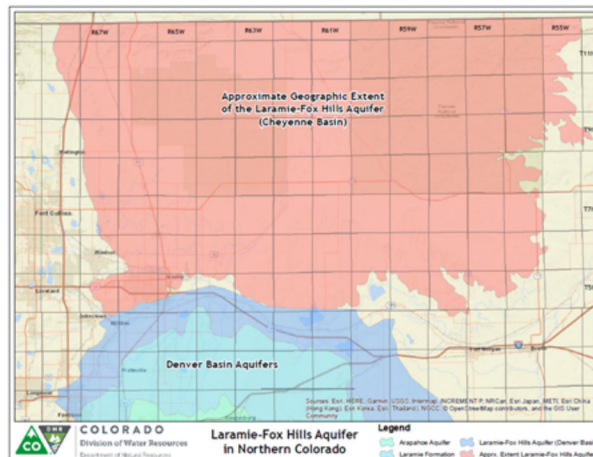
A permit application was received by our office that requested a depth of 800 ft for a well to be constructed east of Wellington. An aquifer determination was conducted by staff and it was determined that the well would be completed in the Laramie-Fox Hills aquifer (LFH). A note was added to the permit conditions indicating a well completed at this depth would likely be completed in the Laramie-Fox Hills aquifer and should be constructed pursuant to Rule 10.4.8. Permit staff have only recently started adding these permit notes even though the permit does not restrict the aquifer into which the well can be completed. We would like to bring this to the attention of the contractors to prevent any violations of the Construction Rules.

The Laramie-Fox Hills aquifer is present in locations outside of the Denver Basin, in particular to the north and east of Greeley in the Cheyenne Basin. Wells constructed into the LFH aquifer must comply with Rule 10.4.8, requiring steel casing and grout from the top of the production zone to the top of the well. If you are completing a bedrock well it is also the responsibility of the contractor (Rule 10.1.2) to familiarize themselves with all conditions that may exist at the well location. Regardless of whether the permit has been conditioned for construction into the LFH aquifer, if you are contracted to construct a well in a location that falls within the aquifer boundary (see attached map) you are required to comply with the applicable Construction Rules. Obviously, not all wells in this area will be completed in a Type 1 or LFH aquifer, but if you complete the well in bedrock you must know which aquifer type it is and construct appropriately.

Staff has also determined the potential for wells to be completed in multiple aquifers in the area of concern. Type 1 with multiple confining layers are a real possibility. Do your research before bidding any wells. The Construction Rules are in place to protect the consumer and contractors.

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O.G. Blain, Keith Branstetter Theresa John-Dickson, P.E. Robert Hiltges, CRMA Scott C. Callahan P.E.

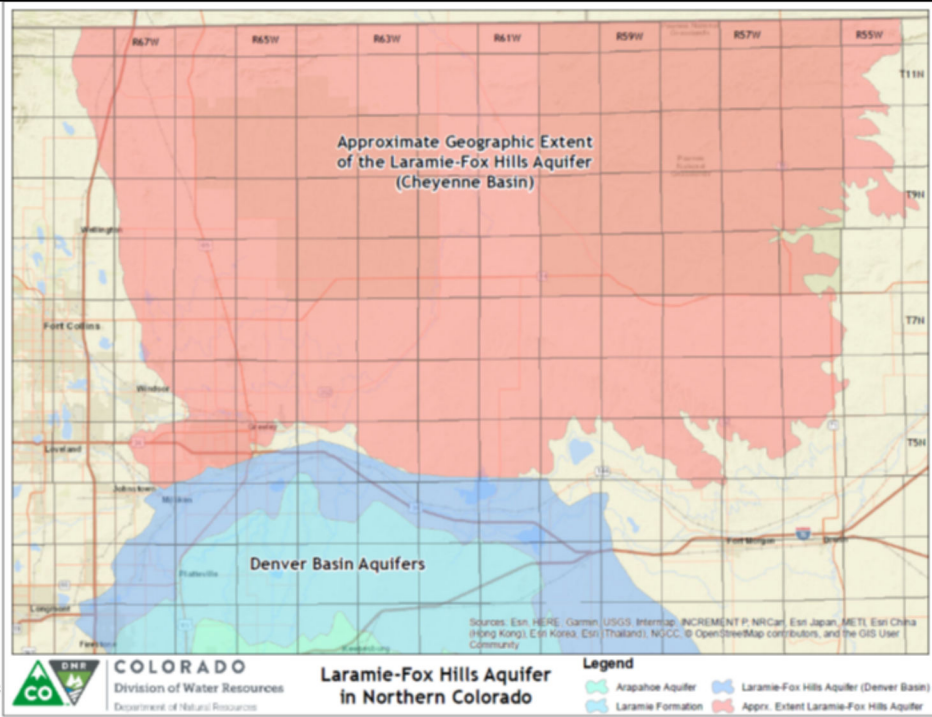


- April 2018 memo sent to all contractors – explaining that the LFH aquifer is present outside the Denver Basin to the North in the Cheyenne Basin
- Important because the LFH Rule 10.4.8 applies to the aquifer wherever it is present and used as an aquifer.
- You should know that all permit applications in the Cheyenne Basin are reviewed by the Hydrogeology Section
 - Each of the well permits will have a NOTE below the Well Conditions that gives depths for the top and base of the LFH or other potential target aquifers.
- It is imperative that a contractor be familiar with the potential aquifers and confining layers, and other conditions at their well site. (Rule 10.1.2)
- The rest of this talk is about helping you, the contractor, be familiar with geology and well construction in the Cheyenne Basin.

Where is the Cheyenne Basin?



Where is the Cheyenne Basin?



- No real break in LFH from Denver Basin up into Cheyenne Basin
- Dark blue is the LFG outcrop in the Denver Basin
- Pink is the extent of the LFH in the Cheyenne Basin

Geology of the Cheyenne Basin

Cheyenne Basin				
Geologic Period	Phase	Stratigraphic Unit		Hydrogeologic Unit
Quaternary	Modern-Glaciation	Alluvium associated with present rivers		Alluvial Aquifers
Neogene	Extension	Ogallala Fm. and Arikaree Fm.		High Plains Aquifer
Paleogene	Transition	White River Fm. – Brule Member – Chadron Member		
Cretaceous	Laramide	No strata		
		Laramie Formation		Upper Laramie Aquifer
		Fox Hills Sandstone		Laramie-Fox Hills Aquifer
	Interior Seaway	Pierre Shale	Upper member	Pierre confining unit
			Upper Pierre sand	Upper Pierre Aquifer
			Main body	Pierre confining unit
		Regional Cretaceous Seaway shale-dominated formations form multiple hydrogeologic units, most are confining units		

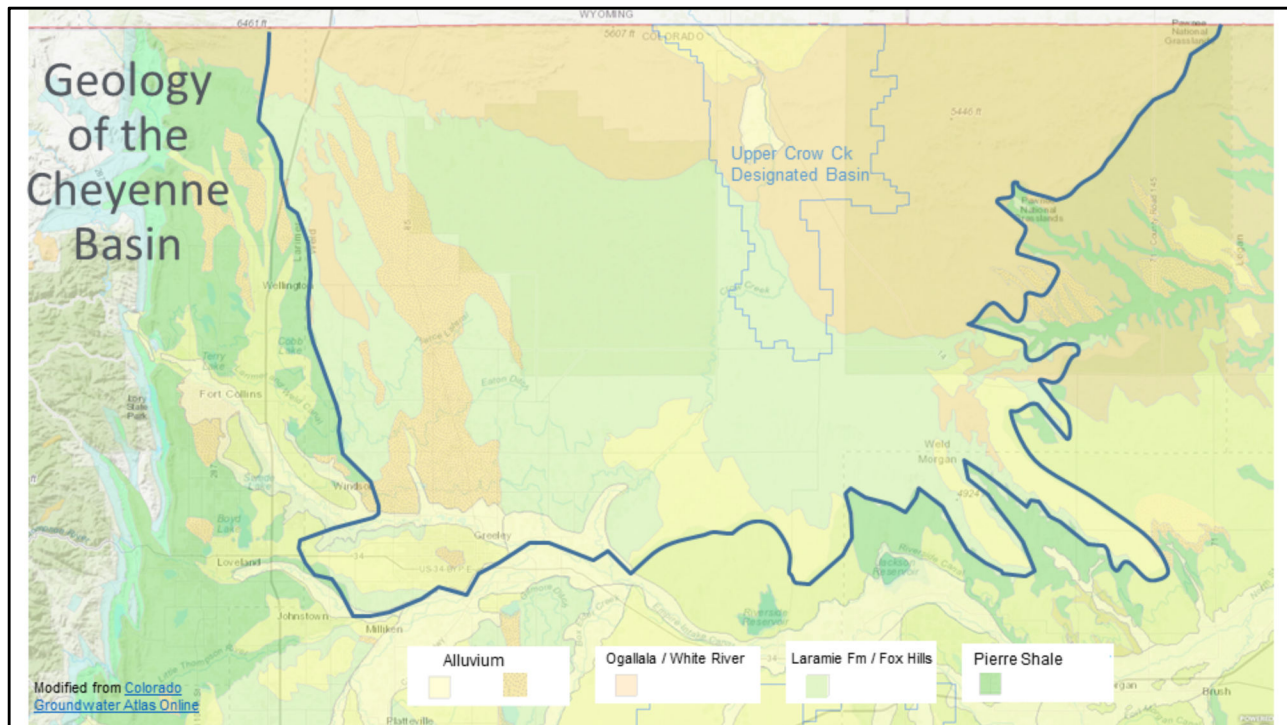
Modified from Colorado Groundwater Atlas Online
<https://coloradogeologicalsurvey.org/water/colorado-groundwater-atlas/#qwa11b-02-02>



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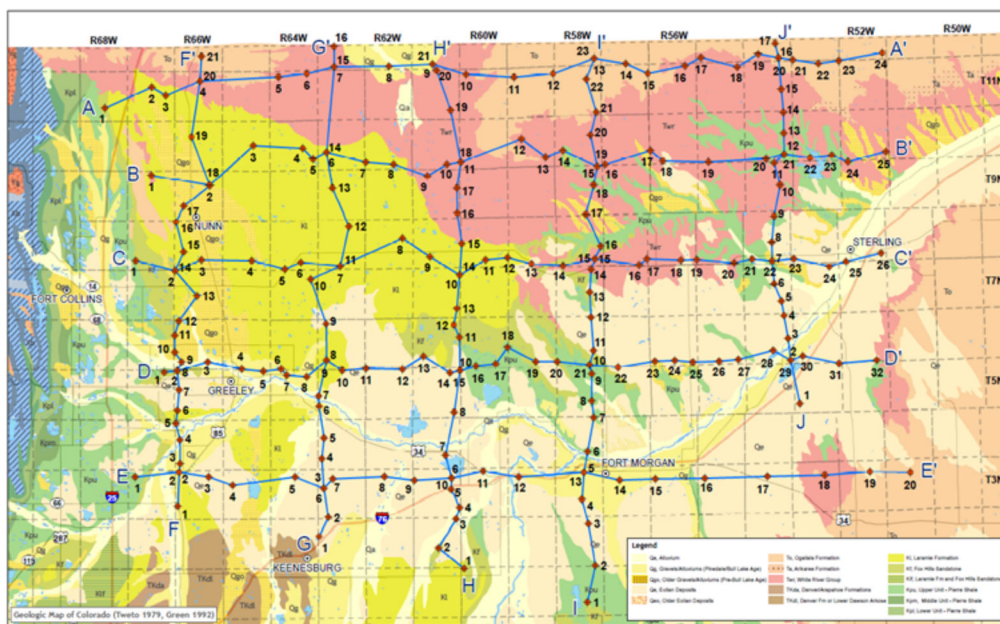
A look at Hydrogeologic Units:

- Alluvium
- High Plains aquifer is divided by formation here: Ogallala and White River are considered different aquifers
- Laramie Formation – shale with sandstone. An upper Laramie aquifer is broken out in certain parcels where it's defined as a separate nontributary aquifer. There is a confining layer between Upper Laramie and LFH
- LFH aquifer
- Upper Pierre aquifer



- Basin boundary is drawn along the extent of the Laramie-Fox Hills aquifer – outside the line the LFH is not present – it’s been eroded away.
- Modern Alluvium along the South Platte River and tributaries – light yellow
- Older alluvium on western side of the basin – along SH-85 in the Greeley–Nunn–Carr corridor -stippled orange and light green
- Northern tier with Ogallala Fm and White River Fm at the surface – light orange
- Medium green color in middle and south is Laramie Fm and LFH at the surface
- Pierre Shale is the dark green color outside the perimeter of the basin boundary
- Note the Upper Crow Creek Designated Basin - specific DesBas rules apply here (read your permit!)

Cheyenne Basin Cross-Section Grid



THE UPPER PIERRE AQUIFER OF THE CHEYENNE BASIN, NORTHEASTERN COLORADO, GEOLOGIC CROSS SECTIONS

Ralf Topper, Clinton D. Meyer, Marshall Havorth, Kevin C. Donegan, Hillary Banks, Aaron Bandler, Andrew Flor, and Matthew A. Sares
WRI 2017-1a

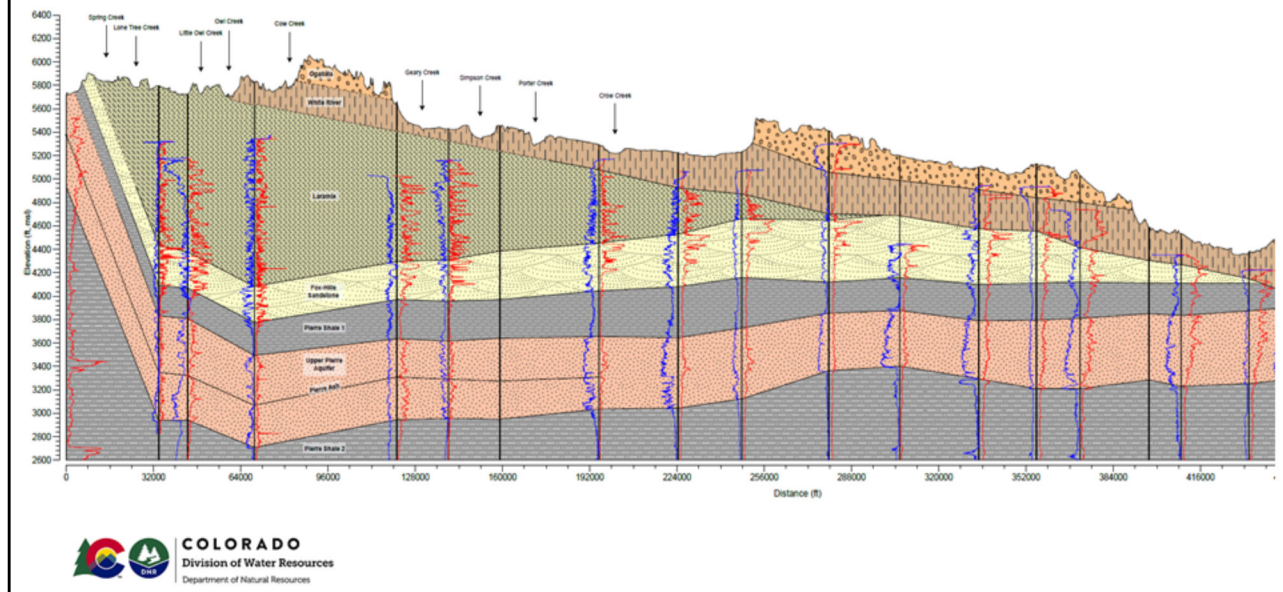


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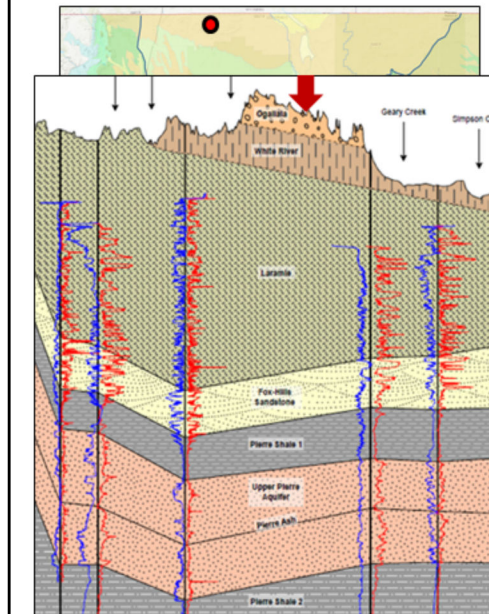
- Cross-sections from DWR's report on the Upper Pierre aquifer in the Cheyenne Basin –
- The cross-sections can be very helpful to understand the geology near your drilling site — from the surface down to the Pierre Shale.
- We'll be using the west to east A-A' cross-section for illustration purposes in following slides.

Cheyenne Basin Geologic Cross-Section



- Note the structure of the basin
- Laramie and older sediments have been folded into bowl-like structure that tilts to the east
- Time of erosion after the Laramie was deposited
- The younger White River and Ogallala are deposited on the old eroded landscape

Well Construction in the Cheyenne Basin

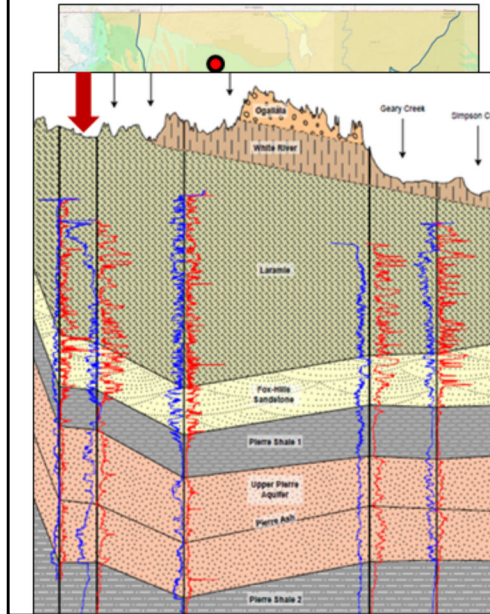


Well on Ogallala in northern part of basin:

- Target = Ogallala aquifer
 - ✓ Type II well (Rule 10.4.6.2)
- Target = White River Fm
 - ✓ Type I - single confining layer (Rule 10.4.5.1)
- Target = Laramie Fm (shale with some sandstone)
 - ✓ Type I – multiple confining layers (Rule 10.4.5.2)
- Target = Laramie-Fox Hills aquifer
 - ✓ Laramie-Fox Hills (Rule 10.4.8)

- Now let's look at some well construction scenarios...

Well Construction in the Cheyenne Basin

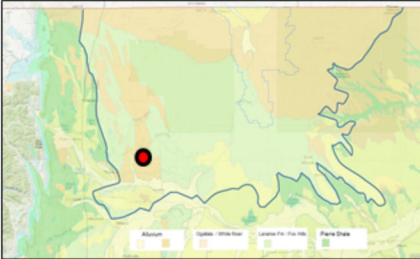


Well on Laramie Fm in northern part of basin:

- Target = Laramie Fm (shale with some sandstone)
 - ✓ Type II well (Rule 10.4.6.2)
- Target = Laramie-Fox Hills aquifer
 - ✓ Laramie-Fox Hills (Rule 10.4.8)
- Target = Upper Pierre Aquifer
 - ✓ Type I – multiple confining layers (Rule 10.4.5.2)

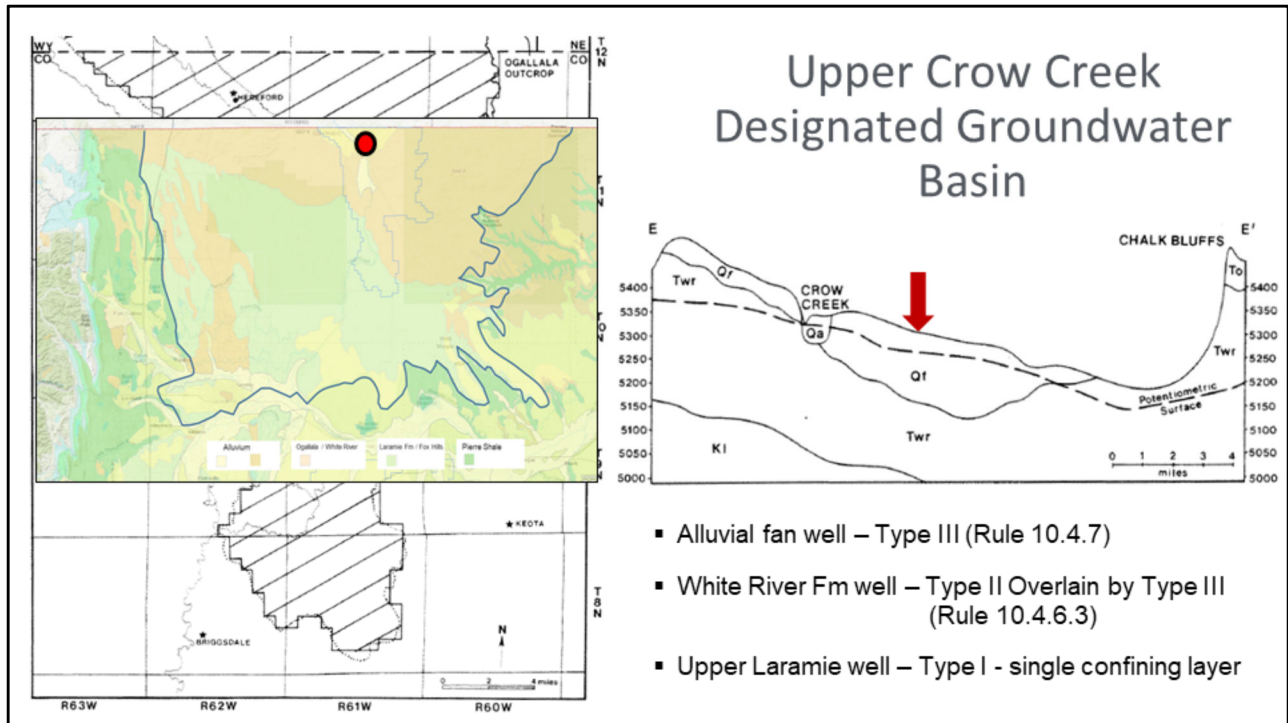
- This is the situation in much of the Cheyenne Basin – Laramie Fm is at the surface
- In some areas it will be covered with a veneer of alluvium, usually 0-50 thick.

Well Construction in the Cheyenne Basin



Well on “Older Alluvium” SW part of basin:

- Alluvial well
 - ✓ Type III (Rule 10.4.7)
- Laramie Fm well
 - ✓ Type II Overlain by Type III (Rule 10.4.6.3)
- Laramie-Fox Hills well?
 - ✓ Laramie-Fox Hills (Rule 10.4.8)



- Aquifers: Crow Ck Alluvium, Alluvial Fan Aquifer, White River, Upper Laramie, Laramie-Fox Hills, Upper Pierre
- Aquifers in Designate Basins are distinctly regulated — Look at your permit carefully!
- Alluvial Fan deposits (Qf) can be up to 150 ft thick!
- Rule 10.4.6.3 applies - Type III above Type II – isolation of alluvium. -more than 150 ft alluvium above Type II can request variance for an alternate construction method
- Policy 2017-2 – Type III above Type I – must fully isolate alluvium.

Resources

- Colorado Groundwater Atlas – Online:
 - Text & Figures - <https://coloradogeologicalsurvey.org/water/colorado-groundwater-atlas/>
 - GIS Map - linked at the top of the page
- Upper Pierre Aquifer of the Cheyenne Basin, Geologic Cross-Sections:
(DWR Water Resources Investigation 2017-1a)
 - https://dnrweblink.state.co.us/dwr/0/edoc/3207851/DWR_3207851.zip?searchid=0bd68dfc-0ebf-4e59-ad96-7a01e961b582
- The Pawnee Aquifer, Denver-Julesburg Basin, Northeastern CO
Theresa Jehn-Dellaport & Tammi Renninger, The Mountain Geologist January 2017, Vol. 54, No.1, p. 15-32.
- Water Resources of Upper Crow Creek, CO Colorado Geological Survey SP-29
 - <https://coloradogeologicalsurvey.org/publications/water-resources-upper-crow-creek-colorado/>