

Site Investigation and Remediation Workplan

Operator: Highpoint Operating Corporation
Operator Number: 10071
Facility ID: 444359
Well Name/No.: Fox Creek 501-3403H
API No.: 05-123-42583
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The Site Investigation and Remediation Workplan (“Work Plan”) has been prepared following the Colorado Energy and Carbon Management Commission (ECMC) Form 27 instruction documentation for eForm 27 v.1.0 released on December 31, 2016. The proposed Work Plan is being submitted per request of the ECMC following a Notice of Alleged Violation (NOAV) issued on March 13, 2018 with Document Number 401568650.

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B – Structural Contour Map of the Laramie-Fox Hills

Background

Well History¹

Chandler and Associates, Inc. started drilling the Peters Well on August 26, 1973 and completed it on September 7, 1973. Figure 1 shows the location of the Peters Well. The well is an 8,275-foot-deep open hole vertical well completed with a cemented surface casing from ground surface to 230 feet below ground (ft bgl). The well was abandoned the same day as it was completed due to no show in the prospective formations. The prospective formations include the Hygiene member of the Pierre Formation; the D-Sand member of the Graneros Formation², and the J-Sand member of the Dakota Group. Log analysis revealed the J-Sand Formation to be water-bearing. The well was plugged with 15 sacks of cement at the bottom and 10 sacks of cement at the top. The Peters Well passed the well abandonment inspection that was required at the time.

The Fox Creek Well was drilled on November 25, 2016, by Fifth Creek Energy Operating Company, LLC (Fifth Creek) and reached total depth on December 8, 2016. Figure 1 shows the location of the Fox Creek Well. The total measured depth (TMD) of the well is 17,120 ft and the true vertical depth (TVD) is 7,604 ft bgl. The well was stimulated between December 19 and 28, 2016. There are two fracturing fluid disclosures published in the Colorado Energy and Carbon Management Commission (ECMC, formerly Colorado Oil and Gas Conservation Commission or COGCC) database for the same period of well stimulation. On March 11, 2019, HighPoint re-plugged the well consistent with modern well-plugging requirements.

Regulatory Allegations³

HighPoint Operating Corporation (HighPoint)⁴ received a Notice of Alleged Violation (NOAV) from COGCC on March 13, 2018, for four counts of alleged violations in regard to the Fox Creek Well. Among them was an alleged violation of rule 34-60-121(1) CRS-b for not performing offset remediation at the Peters Well prior to completing the Fox Creek Well, as was required by the Form 2 COA.

In a January 3, 2019, email communication to HighPoint, COGCC requested a Site Investigation and Remediation Workplan due to alleged “[..] *impacts to the freshwater aquifer may have occurred through the drilling and completion of the Fox Creek Well.*”

¹ HRS Water Consultants, 2024. Hydrogeology near the Fox Creek 501-340H and Abandoned Peters 16-34 Wells. July 25, 2024 (Attachment A)

² Early publications placed the D-Sand Formation in the Dakota Group (e.g. Bass, 1958; Haun, 1968; and Weimer, 1984). However, more recent publications placed the D-Sand Formation in the Graneros Shale (e.g., Higley and Cox, 2007; Sonnenberg, 2012). For this report, we have relied on the more recent publications.

³ HRS Water Consultants, 2024 (Attachment A)

⁴ The history of ownership is as follows: On March 19, 2018, Bill Barrett Corp and Fifth Creek Energy combined to form HighPoint Resources Corp. The operating entity is now referred to as HighPoint Operating Corp. On April 1, 2021, HighPoint Resources Corp. merged with Bonanza Creek Energy, Inc. On November 1, 2021, Bonanza Creek merged with Extraction Oil & Gas, Inc. to become Civitas Resources, Inc. All legacy companies remain the designated operator of their respective assets.

COGCC indicated the workplan shall include:

- Installation of a monitoring well into the Laramie-Fox Hills Aquifer;
- Developing a groundwater sampling program with parameters listed in the COGCC Model Sampling and Analysis Plan and a full suite of EPA Method 8260 and 8270 constituents as well as stable isotopes of water; and,
- Developing a Laramie-Fox Hills Structural contour map covering an area of at least one-mile radius from the Peters Well.

Site Information

Site Location

The Peters Well (API No.: 05-123-07723) is located in Section 34, Township 12N, Range 63W, 6th P.M. in Weld County, Colorado. Figure 1 shows the location of the well.

Site Conditions

The site consists of a concrete well pad with the plugged and abandoned Peters Well. The well pad is surrounded by native soil with occasional vegetation. The site has a dirt road leading up to the well pad. Within a quarter mile of the Peters Well, there is a methane gas well Elsie #7-34H (API: 05-123) operated by HighPoint. As of the date of this report, the well is currently shut-in⁵.

There are no water wells within a quarter-mile of the Peters Well. The nearest water well (Permit No.: 17021) is 0.5 mile west and is completed at a total depth of 211 feet (ft) in the White River Formation. The static water level in that well was at 31 ft bgl when measured in 1963. The driller noted the first occurrence of water at 190 ft bgl, indicating the screened section of the well is completed in a confined part of the White River Formation. After well completion, the confined water level rose from the water-yielding zone starting at 190 ft bgl up to 31 ft bgl.

The National Hydrography Dataset (NHD) identified two unnamed streams within a quarter mile of Peters Well and they are classified as intermittent streams.

Site Hydrogeology⁶

The Peters Well is located in the Cheyenne Basin, a northern lobe of the Denver-Julesburg Basin. The geology in this area is as follows:

The White River Formation of the High Plains Aquifer is present at the surface, it is composed of claystone and sandstone, and it is the shallowest aquifer in this area. Below the White River Formation lies the Laramie Formation, which is composed of sandstone, claystone, shale, and coal beds. In northern Colorado, the upper part of the Laramie Formation is known as the Upper Laramie Aquifer, while the lower part of the Laramie is combined with the underlying Fox Hills Formation and administered as one hydrogeologic unit known as the Laramie-Fox Hills (LFH) Aquifer. Below the Fox Hills Formation lies the Pierre Shale which contains a siltstone unit known

⁵ <https://ecmc.state.co.us/cogisdb/Facility/FacilityDetail?api=12330631>

⁶ HRS Water Consultants, 2024 (Attachment A)

as the Upper Pierre Aquifer. The White River Formation of the High Plains Aquifer, the Upper Laramie Aquifer, the LFH Aquifer, and the Upper Pierre Aquifer form the Cheyenne Basin Aquifer system. There are 164 permitted water wells within five miles of the Peters Well. Fifty-three water wells are located in Colorado and 111 water wells are located in Wyoming. The Colorado water well permit database provides detailed information regarding well depth, aquifer, date of installation, etc., but the Wyoming water well permit database is less detailed. Based on the available information, most of the water wells within a five-mile radius of the Peters Well were completed in the White River Formation at depths between approximately 35 and 440 ft bgl, with 90 percent of the wells less than 250 feet. There is no known wells completed in the LFH Aquifer within a five-mile radius of the Peters Well.

Site Investigation

The goal of the Site Investigation is to comply with ECMC's NOAV and evaluate if impacts to the LFH Aquifer may have occurred through the drilling and completion of the Fox Creek Well. To accomplish this, it is proposed to install a new groundwater monitoring well near the Peters Well that will be completed and screened in the LFH Aquifer. Groundwater samples will be collected at the new monitoring well and analyzed for parameters requested by the ECMC. There will be no Exploration and Production (E&P) Waste produced from the planned Site Investigation because the total of the investigation will be limited to the LFH Aquifer which is approximately 5,000 feet vertically above potential E&P zones. Groundwater withdrawn from the LFH Aquifer during drilling and completion of the new monitoring well will be temporarily stored in tanks. Laboratory analysis of water samples will verify whether or not the stored groundwater contains hydrocarbons or contaminants. Disposal of the stored water will be determined based on the laboratory analytical results.

Initial remedial action to abate potential groundwater contamination from the Peters Well occurred in 2019 when HighPoint re-entered and re-plugged the Peters Well in accordance with modern well plugging and abandonment procedures. Subsequently, a hydrogeological assessment was performed by HRS Water Consultants, Inc. on behalf of Civitas in 2024 to evaluate the likelihood of groundwater contamination in the LFH Aquifer and potential receptors. Due to generally poor water quality (high TDS concentrations, naturally occurring methane) and the deep depth of the LFH Aquifer, there are no water wells in the LFH within five miles of the Peters Well.

Construction of a New Monitoring Well in the Laramie-Fox Hills Aquifer

A new groundwater monitoring well will be drilled expectedly using direct mud rotary method and will be installed and screened in the LFH Aquifer to obtain representative samples of LFH groundwater. Due to lack of wells completed in the LFH and complex hydrogeology in this area, the groundwater flow direction in the LFH is uncertain. To overcome this uncertainty, it is proposed that the new monitoring well be installed as close as practicable to the Peters Well such that a cone of depression can be created when pumping the new monitoring well during pre-sampling purging. Pre-sampling purging of new monitoring well will create radial flow patterns toward the new monitoring well and result in a cone of depression that intersects the area near the Peters Well, thereby causing groundwater in the LFH to flow from the Peters Well toward the new monitoring

well. Figure 2 shows 50 to 200-foot radial distances from the Peters Well, which is the target area for the new monitoring well. However, the final location of the new monitoring well will be based on land accessibility, buried infrastructure, water supply, and proximity to the drilling equipment staging area.

Figure 3 presents a preliminary construction diagram for the new monitoring well. However, the final dimensions of the new monitoring well such as borehole diameter, casing and screen diameter, and pump size will be determined during discussions with potential well drillers during the pre-bidding process. A permit to construct the monitoring well will be applied with the DWR up to four weeks before starting well construction as well as notifying the ECMC 72 hours prior to construction activities. An as-built well construction diagram, geologist's lithologic log, and geophysical log will be submitted to ECMC as part of the Site Investigation report. A copy of these documents will also be submitted to the Colorado Department of Water Resources (DWR) as required for the construction of a groundwater monitoring well.

Groundwater Sampling Plan

LFH groundwater samples will be analyzed for parameters listed in the COGCC Model Sampling and Analysis Plan (SAP) Version 3 published in January 2021 following Rule 615.e in addition to concentrations of volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and stable isotopes of water. Table 1 summarizes the LFH groundwater parameters to be measured in the field during sampling and Table 2 lists the parameters to be analyzed in laboratories.

The COGCC SAP also describes sampling procedures. First, an LFH groundwater sample will be collected after the new monitoring well is completed and developed. Three subsequent LFH groundwater samples will be collected quarterly following well purging and stabilization of water quality parameters (i.e., pH, temperature, and electrical conductivity). A total of four LFH groundwater samples will be collected as part of this site investigation within approximately one year after completion of the new monitoring well.

During LFH groundwater sampling, a flow-through cell will be connected to the pump discharge pipe so that a YSI meter (or similar) can be used to measure water quality parameters and monitor for parameter stabilization in the field. After the field-measured water quality parameters have stabilized, unfiltered and filtered LFH groundwater samples will be collected. For dissolved metals, a field-filtered sample is required by the laboratory. Field-filtered LFH groundwater samples will be collected using an in-line disposable 0.45-micron glass-fiber filter.

Sampling personnel will be required to wear safety glasses, long-sleeved protective clothing, and new, disposable, powder-free nitrile gloves to prevent contamination of the sample. LFH groundwater samples will be properly labeled before and during sampling. Appropriate chain of custody (COC) forms provided by the laboratory will be completed prior to storing and delivering the samples to the laboratory. All laboratory instructions for storing and shipping of the samples will be followed.

Table 1. Groundwater Sampling – Field Parameters

Field Parameters	Field Equipment
Volume Water Purged Prior to Sampling	Flow meter
Odor	Observation
Water Color	Observation
Bubbles	Observation
Effervescence	Observation
Sediment	Observation
pH	6 Parameter YSI Device with Flowthrough Cell
Specific Conductance	6 Parameter YSI Device with Flowthrough Cell
Temperature (water)	6 Parameter YSI Device with Flowthrough Cell
Dissolved Oxygen (DO)	6 Parameter YSI Device with Flowthrough Cell
Turbidity	6 Parameter YSI Device with Flowthrough Cell
Oxygen Reduction Potential (ORP)	6 Parameter YSI Device with Flowthrough Cell

Table 2. Groundwater Sampling – Laboratory Parameters

Laboratory	Method	Analytes
Eurofins	9040C	pH
Eurofins	9050A	Specific Conductance
Eurofins	SM 2540C	Solids, Total Dissolved
Eurofins	SM 2320B	Alkalinity - Total, Carbonate, Bicarbonate
Eurofins	300	Bromide, Chloride, Fluoride, Sulfate. Nitrate, Nitrite, and Nitrate-Nitrite
Eurofins	353.2	Nitrogen, Nitrate-Nitrite
Eurofins	365.1	Phosphorus, Total
Eurofins	6010D	Dissolved Metals (Ba, B, Ca, Fe, Mg, Mn, K, Na, Se, Sr), Field Filtered
Eurofins	8260D	BTEX
Eurofins	8015D	TPH-GRO (C6-C10), TPH-DRO (C10-C36)
Eurofins	8260D	VOCs
Eurofins	8270E	SVOCs
Isotech	RSK-175	Dissolved Gases (Methane, Ethane, Propane)
Isotech	Lab specific	Fixed Gases (C1-C6)
Isotech	Lab specific	mass spectrometric determination of $\delta^{13}\text{C}$ of CH_4 , and δD of CH_4 and $\delta^{13}\text{C}$ of C_2H_6 , and $\delta^{13}\text{C}$ of C_3H_8
Isotech	Lab specific	Stable Isotopes of water ($\delta^{18}\text{O}$ and $\delta^2\text{H}$)
EMSL	BART	Bacterial Activity Reaction Test (Iron Related Bacteria, Slime Producing Bacteria, and Sulfur Reducing Bacteria)

Laramie-Fox Hills Structural Contour Map

ECMC requested the development of an LFH structural contour map for an area of at least one mile around the Peters Well. Civitas prepared structural maps of the top and the base of the LFH and submitted them to the ECMC in September-October of 2023 in response to the NOAV. The structural contour maps are included in Attachment B.

Reporting

There will be a total of four quarterly LFH groundwater monitoring reports to be submitted to the ECMC on a quarterly basis during the site investigation phase.

After the first (i.e., initial) quarterly LFH groundwater sampling event, Civitas will prepare a Site Investigation (SI) report to be submitted with Form 27 (supplemental) as an attachment. The SI report will discuss the drilling, installation, completion, and development of the new monitoring well; management and disposal of fluids generated during drilling; well construction details; well development procedures; and results of the first LFH groundwater sampling event. The SI report will be submitted within 30 days after receipt of all laboratory analytical results.

Then, results from the second and third quarterly LFH groundwater sampling events will be reported to ECMC within 30 days after receipt of all laboratory results.

The final (i.e., fourth) quarterly LFH groundwater sampling results will be reported to ECMC along with a discussion and interpretation of results, and recommendations on remedial action, if necessary, as an attachment to Form 27 (supplemental).

Remedial Action Plan

If results of the quarterly LFH groundwater sampling events demonstrate that the LFH Aquifer contains hydrocarbons and/or methane, and that the hydrocarbons and methane are not naturally occurring in the LFH, then the need for a remedial action plan and its components will be discussed with ECMC.

Implementation Schedule

Table 3 shows the tentative implementation schedule for this work:

Table 3. Tentative Site Investigation Work Plan Implementation Timeline

Task	Anticipated Estimated Completion Date	Comments
Initial submittal of Work Plan to ECMC (Form 27 Initial)	July 29, 2024	First comments received September 16, 2024
Revision of the Work Plan and approval by the ECMC	TBD in conjunction with ECMC	Anticipated date based upon communication with ECMC
Installation and completion of the monitoring well, geophysical borehole logging, well development and sampling activity	TBD in conjunction with ECMC	Anticipated date based upon hydrogeologists' and driller's availability
Receive Laboratory Results	TBD in conjunction with ECMC	2 weeks turnaround time
Submittal of Site Investigation Report including laboratory results (Form 27 Supplemental)	TBD in conjunction with ECMC	30 days after receipt of lab results
Second groundwater sampling and laboratory analysis	TBD in conjunction with ECMC	Approx. 3 months after first sample
Submittal of laboratory results	TBD in conjunction with ECMC	Within 30 days after receipt of lab results
Third groundwater sampling and laboratory analysis	TBD in conjunction with ECMC	Approx. 3 months after first sample
Submittal of laboratory results	TBD in conjunction with ECMC	Within 30 days after receipt of lab results
Fourth groundwater sampling and laboratory analysis	TBD in conjunction with ECMC	Approx. 3 months after first sample
Submittal of laboratory results with a final remedial action recommendation (Form 27 supplemental)	TBD in conjunction with ECMC	Within 30 days after receipt of lab results

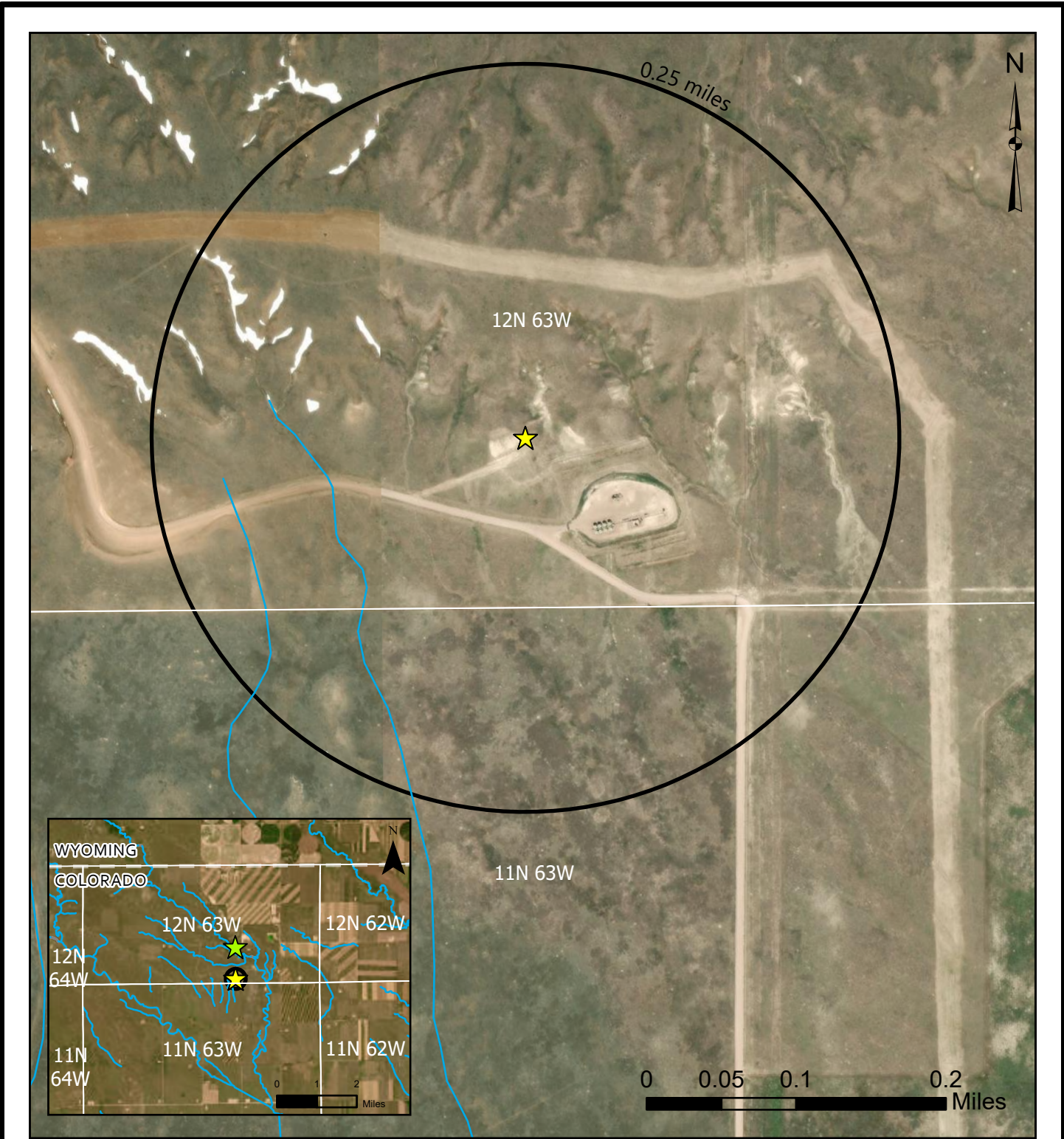





Figure 1 - Surface Water near Peters Well

Legend

-  Peters 16-34
-  Fox Creek 501-3403H
-  NHD classified Intermittent Streams

HRS WATER CONSULTANTS, INC.

Project No.: 24-06

Date: July 2024

Draft by: KL

Projection: NAD 1983 UTM Z13N

File name: PetersWell-SI Workplan.aprx



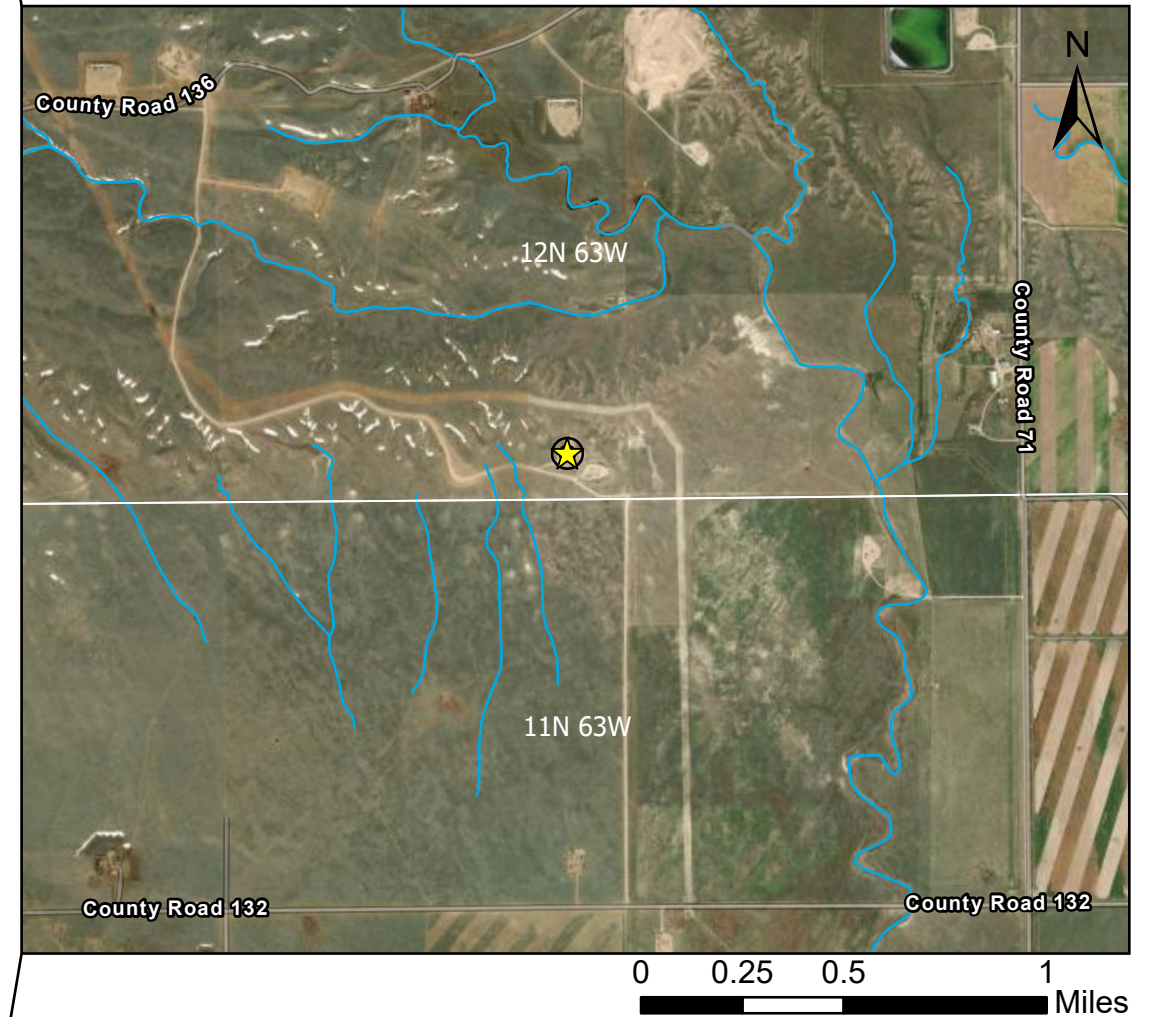
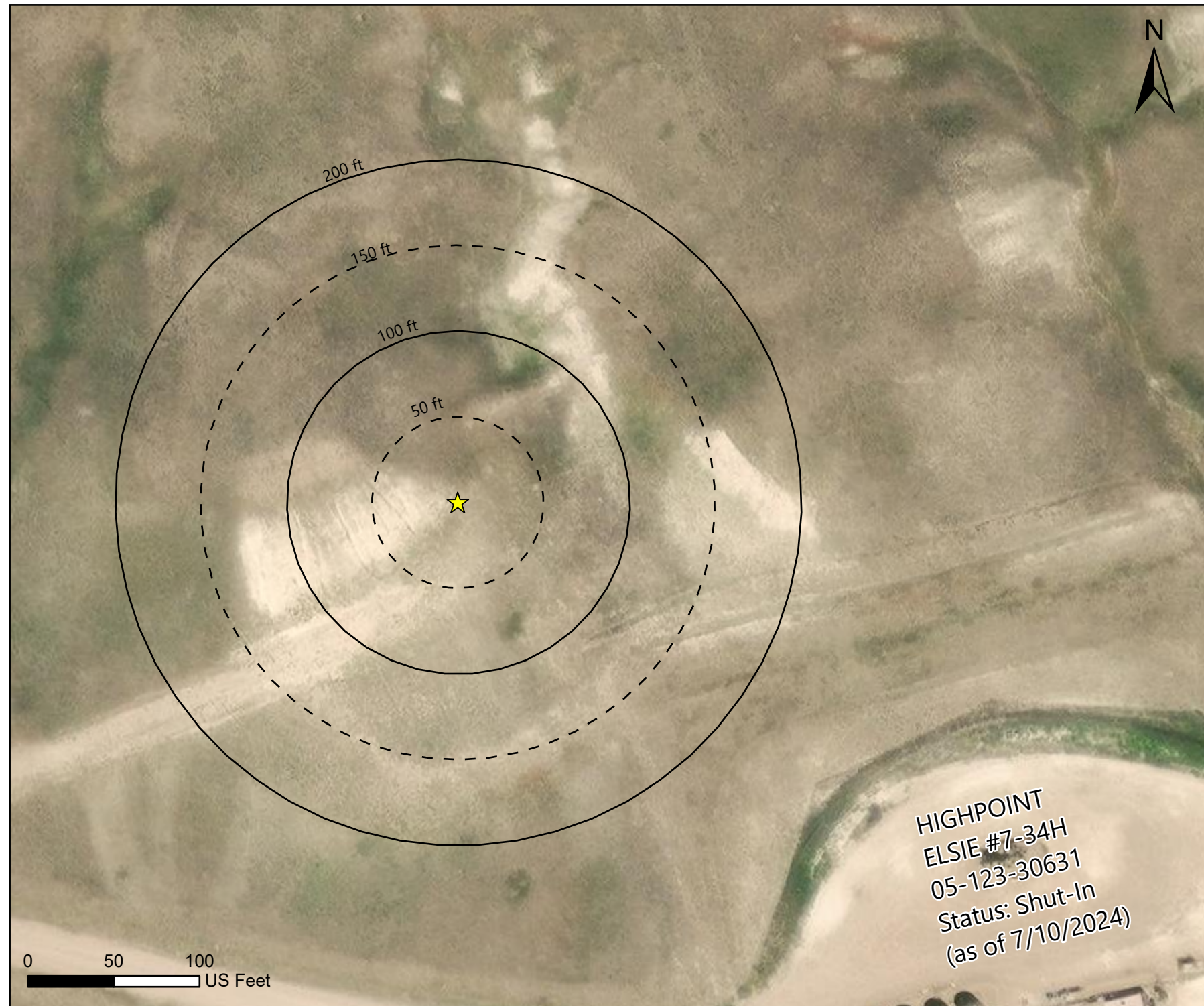


Figure 2. Peters Well - Monitoring Well Siting

Civitas Resources
 Peters Well Site Investigation Work Plan

★ Peters 16-34

HRS WATER CONSULTANTS, INC.

Project No.: 24-06
 Date: July 2024
 Draft by: KL
 Projection: NAD 1983 UTM Z13N
 File name: Peters Well - SI Workplan.aprx



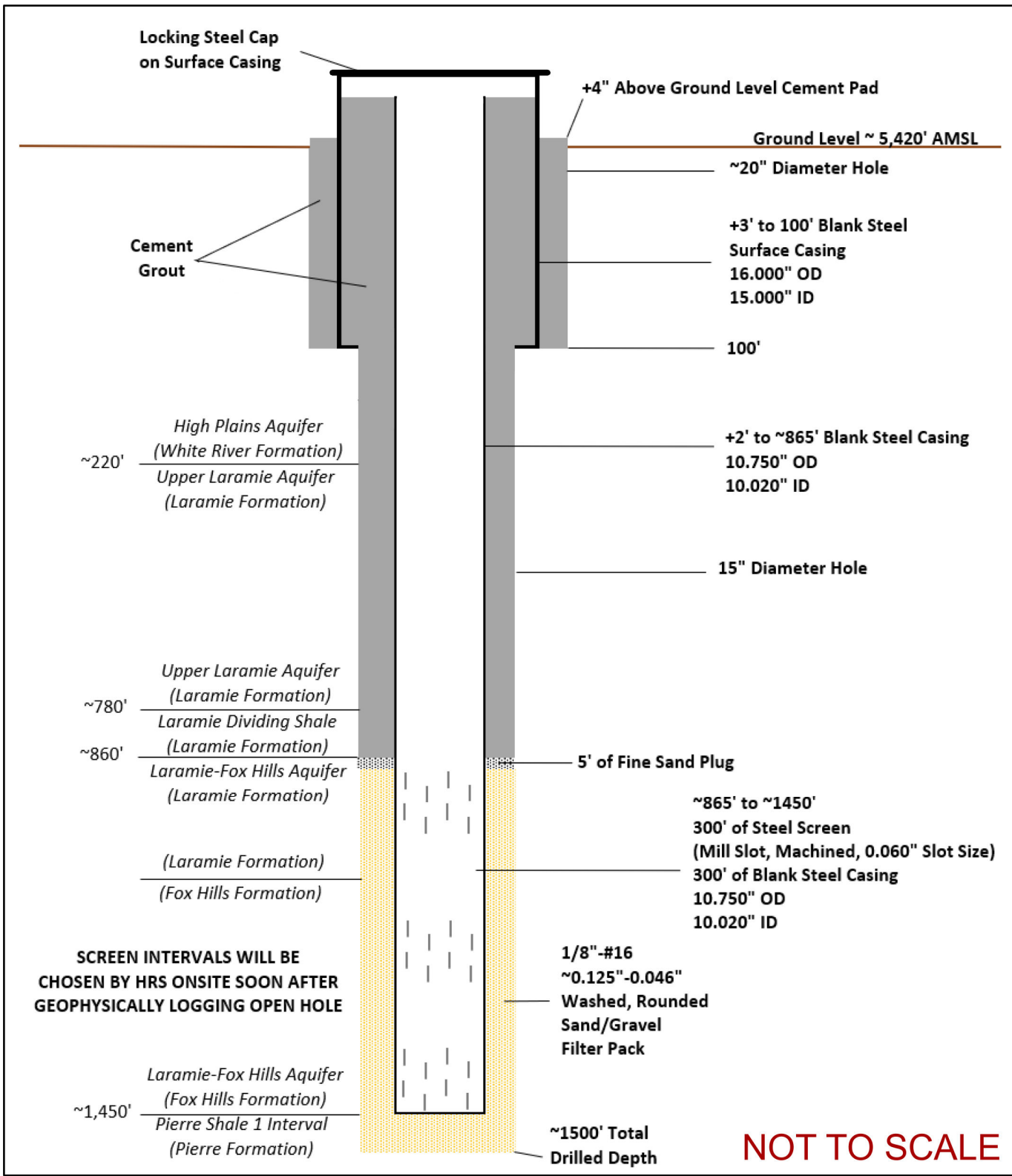


Figure 3. Planned Well Diagram

Notes:
 Borehole diameter, and well casing and screen diameters depends on pump size.
 Possible well casing and screen diameter: 5-10 inches

HRS WATER CONSULTANTS, INC.

Project No.: 24-06
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 Draft by: JMB/KL
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ATTACHMENT A

HRS WATER CONSULTANTS, INC.

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July 25, 2024

Mr. Nathan Bennett
Director, Permitting & Compliance
Civitas Resources
555 17th Street, Suite 3700
Denver, CO 80202

Subject: Hydrogeology Near the Fox Creek 501-340H and Abandoned
Peters 16-34 Wells

Dear Mr. Bennett,

As requested, HRS Water Consultants, Inc. (HRS) appreciates the opportunity to provide HighPoint Operating Corp. (HighPoint), a wholly owned subsidiary of Civitas Resources, Inc. (Civitas) with this report regarding the hydrogeology near the Fox Creek 501-340H well (Fox Creek Well) and the abandoned Peters 16-34 Well (Peters Well). This report was based on a literature review and summarizes the data relied on, analysis, and conclusions.

Background

The Fox Creek Well (API No.: 05-123-42583) and Peters Well (API No.: 05-123-07723) are located in Section 34, Township 12N, Range 63W, 6th P.M. in Weld County, Colorado. Figure 1 shows the location of the two wells.

Well History

Chandler and Associates, Inc. started drilling the Peters Well on August 26, 1973 and completed it on September 7, 1973. The well is an 8,275-foot-deep open hole vertical well completed with a cemented surface casing from ground surface to 230 feet below ground (ft bgl). The well was abandoned the same day as it was completed due to no show in the prospective formations. The prospective formations include the Hygiene member of the Pierre Formation; the

D-Sand member of the Graneros Formation¹, and the J-Sand member of the Dakota Group. Log analysis revealed the J-Sand Formation to be water-bearing. The well was plugged with 15 sacks of cement at the bottom and 10 sacks of cement at the top. The Peters Well passed the well abandonment inspection that was required at the time. On March 11, 2019, HighPoint re-plugged the well consistent with modern well-plugging requirements. The cement plug intervals are depicted in Figure 2.

The Fox Creek Well was drilled on November 25, 2016, by Fifth Creek Energy Operating Company, LLC (Fifth Creek) and reached total depth on December 8, 2016. The total measured depth (TMD) of the well is 17,120 ft and the true vertical depth (TVD) is 7,604 ft bgl. The well was stimulated between December 19 and 28, 2016. There are two fracturing fluid disclosures published in the Colorado Energy and Carbon Management Commission (ECMC, formerly Colorado Oil and Gas Conservation Commission or COGCC) database for the same period of well stimulation.

Legal Allegations

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In a January 3, 2019, email communication to HighPoint, COGCC requested a Site Investigation and Remediation Workplan due to alleged “[...] *impacts to the freshwater aquifer may have occurred through the drilling and completion of the Fox Creek Well.*”

COGCC indicated the workplan shall include:

- Installation of a monitoring well into the Laramie-Fox Hills Aquifer;
- Developing a groundwater sampling program with parameters listed in the COGCC Model Sampling and Analysis Plan and a full suite of EPA Method 8260 and 8270 constituents as well as stable isotopes of water; and,
- Developing a Laramie-Fox Hills Structural contour map covering an area of at least one-mile radius from the Peters Well.

¹ Early publications placed the D-Sand Formation in the Dakota Group (e.g. Bass, 1958; Haun, 1968; and Weimer, 1984). However, more recent publications placed the D-Sand Formation in the Graneros Shale (e.g., Higley and Cox, 2007; Sonnenberg, 2012). For this report, we have relied on the more recent publications.

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Hydrogeologic Setting

The Peters and Fox Creek Wells are located in the Cheyenne Basin, a northern lobe of the Denver-Julesburg Basin. The geology in this area is as follows: The White River Formation is present at the surface, it is composed of claystone and sandstone, and it is the shallowest aquifer in this area. Below the White River Formation lies the Laramie Formation, which is composed of sandstone, claystone, shale, and coal beds. In northern Colorado, the upper part of the Laramie Formation is known as the Upper Laramie Aquifer, while the lower part of the Laramie combined with the underlying Fox Hills Formation is administered as one hydrogeologic unit known as the Laramie-Fox Hills (LFH) Aquifer. Below the Fox Hills Formation lies the Pierre Shale which contains a sandstone unit known as the Upper Pierre Aquifer. The White River Aquifer, the Upper Laramie Aquifer, the LFH Aquifer, and the Upper Pierre Aquifer form the Cheyenne Basin Aquifer system.

Figure 3 shows a published geologic cross-section of the Cheyenne Basin Aquifer system in the area near the Peters and Fox Creek Wells (Topper, et. al., 2017). From this information, the hydrostratigraphy near the Peters and Fox Creek Wells is summarized in Table 1.

Table 1. Hydrostratigraphy near the Peters and Fox Creek Wells

Formation	Elevation* (ft msl)	Depth* (ft bgl)	Thickness* (ft)	Hydrostratigraphy
White River	5,390 – 5,200	0 – 190	190	Aquifer
Laramie	5,200 – 4,340	190 – 1,050	860	Aquifer (Upper and Lower)
Fox Hills	4,340 – 3,960	1,050 – 1,430	380	Aquifer
Pierre Shale 1	3,960 – 3,600	1,430 – 1,790	360	Confining Unit
Upper Pierre Aquifer	3,600 – 2,960	1,790 – 2,430	640	Aquifer
Pierre Shale 2	2,960 to < 2,600	2,430 – 2,790	> 360	Confining Unit

*All dimensions are approximate. ft msl = feet above mean sea level

As shown, the White River, Laramie, Fox Hills, and Upper Pierre Formations are considered potential drinking water sources. The Pierre Shale 1 and Pierre Shale 2 are considered confining units. The geophysical log at station A07/G15 (Figure 3) shows the LFH Aquifer may occur at a depth between approximately 1,093 and 1,508 ft bg.

Figure 4 shows a published groundwater elevation contour map for the LFH in the area near the Peters and Fox Creek Wells (Robson and Banta, 1987). As shown, the hydraulic gradient in the LFH near the Peters and Fox Creek Wells was toward the southeast in 1987. Please note that, although the Peters and Fox Creek Wells are located near the area studied by Robson and Banta in 1987, the Robson and Banta (1987) dataset stopped approximately five miles southwest of the wells.

Figure 5 shows the location of permitted water wells within a five-mile radius of the Peters and Fox Creek Wells. As shown, there are 164 permitted water wells within five miles of the Peters and Fox Creek Wells. 53 water wells are located in Colorado and 111 water wells are located in Wyoming. The Colorado water well permit database provides some detailed information regarding

well depth, aquifer, date of installation, etc., but the Wyoming water well permit database is less detailed. Based on the available information, most of the water wells within a five-mile radius of the Peters and Fox Creek wells were completed in the White River Aquifer at depths between approximately 35 and 440 feet below ground, with 90-percent of the wells not deeper than 250 feet. We could find no water wells completed in the LFH Aquifer within a five-mile radius of the Peters and Fox Creek Wells.

Figure 5 also shows the location of water wells within a five-mile radius for which water quality data are available. These wells are summarized in Table 2.

Table 2. Water Wells Within Five Mile Radius of the Peters and Fox Creek Wells With Data

Well ID	Depth (ft bg)	Aquifer	Data Provider	Number of Samples	Sampling Dates
USGS-405403104213101	NA	NA	USGS	1	1978
USGS-405546104222801	NA	NA	USGS	1	1978
USGS-405708104210701	132	White River	USGS	0	1962
USGS-405923104200101	NA	NA	USGS	1	1978
USGS-410050104224401	NA	NA	USGS	1	1990
USGS-410108104223501	NA	NA	USGS	1	2014
USGS-410156104242901	100	White River	USGS	1	1999
760441	320	Upper Laramie	ECMC	1	2019
755340	169	White River	ECMC	2	2016, 2018

Notes: ft bg = feet below ground. NA = not available in the database.

Groundwater Quality

Water Quality Data Near Peters and Fox Creek Wells

Published water quality data for wells within a five-mile radius of Peters and Fox Creek Wells were retrieved from the ECMC and United States Geological Survey (USGS) on-line databases for the locations shown in Figure 5. Table 3 summarizes the available water quality data.

As shown, the amount of water quality data near the Peters and Fox Creek Wells is limited to a total of seven locations within a five-mile radius, with only one to three water quality samples available in the White River and Laramie Aquifers. No water quality data were available for the LFH Aquifer within a five-mile radius of the Peters and Fox Creek Wells. Four of the water quality samples in the database did not have an aquifer identification. The data are summarized in Table 3.

Table 3. Average Water Quality of Aquifers within Five Miles of the Peters Well

Water Quality Parameter	Units	White River Aquifer (n = 3)	Laramie Aquifer (n = 1)	Unspecified Aquifers (n = 4)
Total Dissolved Solids (TDS)	mg/L	387	NA	318
Calcium	mg/L	62	41.2	61
Magnesium	mg/L	12	6.3	11
Sodium	mg/L	14	28.4	33
Potassium	mg/L	4	6.1	6
Bicarbonate	mg/L	177	164	NA
Sulfate	mg/L	14	22.6	29
Chloride	mg/L	13	2.0	31
Fluoride	mg/L	0.4	0.53	0.5
Iron	mg/L	ND	ND	0.05
Selenium	ug/L	1.9	ND	2
Uranium	ug/L	14	NA	11
Methane	mg/L	0.8	ND	NA

Notes: n = number of samples in database. ND = not detected above the laboratory method detection limit. NA = not available in the database. mg/L = milligrams per liter. ug/L = micrograms per liter.

The data show that the groundwater in the White River and Laramie Aquifers near the Peters and Fox Creek Wells is generally of good quality as indicated by concentrations of total dissolved solids (TDS) below 500 milligrams per liter (mg/L) and relatively low concentrations of the other water quality parameters. None of the water quality results in this dataset were found to exceed a US Environmental Protection Agency (EPA) primary or secondary maximum contaminant level (MCL). Methane was detected in only one sample at a concentration of 0.8 mg/L; however, methane does not pose any known health risk from ingestion.

The data are inconclusive regarding ECMC’s assertion that either the Peters or Fox Creek Wells have impacted water quality in the LFH Aquifer.

Water Quality Data in the LFH Aquifer in Weld County, Colorado

To provide additional context regarding potential water quality in the LFH Aquifer, we retrieved water quality data from the online databases mentioned above within all of Weld County, Colorado. Results are summarized in Table 4.

Table 4. Average Water Quality in the LFH Aquifer in Weld County, Colorado

Parameters	Units	Laramie-Fox Hills Aquifer (n = 8 to >2,000)
Total Dissolved Solids (TDS)	mg/L	970
Calcium	mg/L	23
Magnesium	mg/L	8.1
Sodium	mg/L	529
Potassium	mg/L	2.6
Bicarbonate	mg/L	454
Sulfate	mg/L	456
Chloride	mg/L	98.6
Fluoride	mg/L	2.0
Iron	mg/L	1.0
Selenium	ug/L	17.4
Arsenic	ug/L	14.5
Lead	ug/L	3.2
Uranium	ug/L	14.0
Bromide	ug/L	915.4
Chromium	ug/L	3.3
Nickel	ug/L	2.1
Mercury	ug/L	ND
Methane	mg/L	21.4

Notes: n = number of samples in database. ND = not detected above the laboratory method detection limit. NA = not available in the database. mg/L = milligrams per liter. ug/L = micrograms per liter.

The data show that groundwater in the LFH Aquifer in Weld County can be highly variable but is chiefly classified as sodium-bicarbonate or calcium-bicarbonate type water, although magnesium- and sulfate-type waters may also occur. The data also show that the average TDS concentration in this dataset was approximately 970 mg/L, which indicates there are many locations in Weld County where TDS in the LFH may exceed the EPA secondary drinking water MCL of 500 mg/L.

Sodium is another important water quality indicator because EPA recommends sodium levels in drinking water between 30 and 60 mg/L for general purposes, but they recommend a sodium level of 20 mg/L or lower for people on a restricted diet. The average sodium concentration in this dataset was approximately 529 mg/L and, thus, there are many locations in Weld County where sodium may exceed the EPA health advisory.

Iron is another key water quality indicator because EPA's secondary drinking water MCL for iron is 0.3 mg/L. The average iron concentration in this dataset was approximately 1.0 mg/L and, thus, there are many locations in Weld County where iron may exceed the EPA standard.

Methane is an important water quality indicator because, although methane has no known health effects, it may accumulate in enclosed spaces and create an explosive hazard. The primary source of methane in the LFH Aquifer is naturally occurring coal seams which generate coal-bed methane, also known as biogenic methane. However, orphan wells may create pathways for deeper methane sourced in oil and gas deposits, known as thermogenic methane, to migrate vertically upward into the LFH. The average methane concentration in this dataset was approximately 21.4 mg/L and, thus, there are many locations in Weld County where methane is present in the LFH Aquifer. Methane is known to be widespread throughout the LFH.

Conclusions

The following may be concluded based on the results of this study:

1. There is no data indicating that the abandoned Peters Well ever was a transport pathway for deep-seated hydrocarbons below the Pierre Formation to migrate vertically upward into the LFH.
2. The Peters Well is considered low risk for gas migration into the LFH because it was properly plugged and abandoned in 2019.
3. There is no data indicating that drilling and completion of the Fox Creek Well has directly or indirectly impacted the LFH.
4. Shallow groundwater in the White River and Laramie Aquifers is the primary source of water near the Peters and Fox Creek Wells because it is of generally good quality, and it is relatively inexpensive to complete water wells in these aquifers due to their shallow depth.
5. The LFH does not appear to be a source of water near the Peters and Fox Creek Wells because regional water quality in the LFH is known to be poor, and better water quality can be obtained from shallower aquifers.

Please note this evaluation was based on public and private data available to us at the time of this report. We believe the available data is robust and provide a reasonable basis to support the findings. Should new or additional information become available, we reserve the right to review such information, perform additional analyses, and modify our findings.

Thank you very much for the opportunity to be of assistance. Please contact us if you have any questions or require additional information.

Sincerely,
HRS WATER CONSULTANTS, INC.



Katharina Lowe, P.G.
Staff Hydrogeologist



David S. Lipson, Ph.D., C.P.G.
Principal Hydrogeologist



Attachments

Figures

Figure 1 – Location of Peters Well and Fox Creek Well

Figure 2 – Peters Well Wellbore and Plugging Diagram

Figure 3 – Geologic Cross Section A-A' (Topper et al., 2017)

Figure 4 – Water Level Contour in the Laramie-Fox Hills Aquifer (Robson and Banta, 1987)

Figure 5 – Map of Water Wells and Water Quality Sampling within 5 miles of the Peters Well

Appendix

Appendix A - References

Appendix A - References

- ECMC Oil and Gas Well Database
 - Peters Well
 - <https://ecmc.state.co.us/cogisdb/Resources/Docs?classid=07~08&id=12307723>
 - Well Completion or Recompletion Report and Log (Document No.: 279194)
 - Geological Well Report (Document No.: 98140)
 - Well Abandonment and Plugging 1973 (Document No.: 37596)
 - Field Inspection 1998 (Document No.: 33885)
 - Well Bore Diagram before 2019 replugging (Document No.: 55510)
 - Well Bore Diagram after 2019 replugging (Document No.: 58389)
 - Cement Job Report for 2019 plugging (Document No.: 680732)
 - Fox Creek Well
 - <https://ecmc.state.co.us/cogisdb/Resources/Docs?classid=07~08&id=12342583>
 - Drilling Completion Report (Document No.: 167881)
 - Well Bore Diagram (Document No.: 121729)
 - CDWR Water Well Database
 - Colorado Decision Support System (CDSS) Map Viewer
 - <https://maps.dnrgis.state.co.us/dwr/Index.html?viewer=mapviewer>
 - Wyoming Oil & Gas Well Locations
 - Interactive Oil and Gas Map of Wyoming
 - <https://portal.wsgs.wyo.gov/arcgis/apps/webappviewer/index.html?id=d42f571b87fa4234b03d66ca7ae311a4>
 - Wyoming Water Well Database
 - Groundwater Atlas of Wyoming
 - <https://portal.wsgs.wyo.gov/arcgis/apps/webappviewer/index.html?id=181c32a872a346bfae3579a62230a65a>
 - ECMC Water Quality Data
 - Water Well Data
 - <https://ecmc.state.co.us/documents/data/downloads/environmental/WaterWellDownload.html>
 - USGS Water Quality Data
 - National Water Quality Monitoring Council: <https://www.waterqualitydata.us/>

Hydraulic Fracturing Fluid Composition disclosures for the Fox Creek Well

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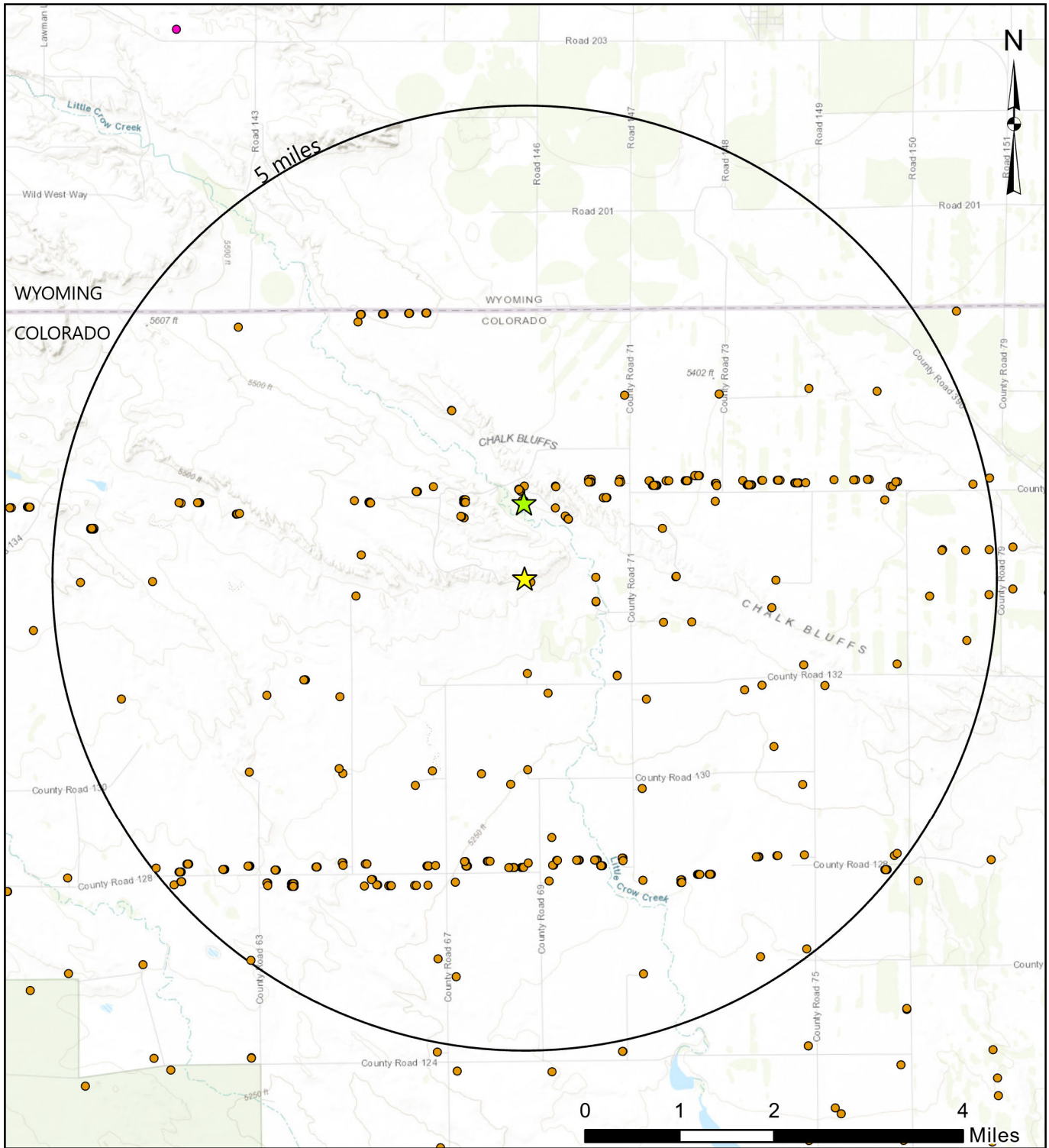


Figure 1 - Location of Peters Well and Fox Creek Well

Legend

- ★ Peters 16-34
- ★ Fox Creek 501-3403H
- WY Oil and Gas Wells
- CO Oil and Gas Wells

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Project No.: 24-06

Date: March 2024

Draft by: KL

Projection: NAD 1983 UTM Z13N

File name: PetersWell.aprx



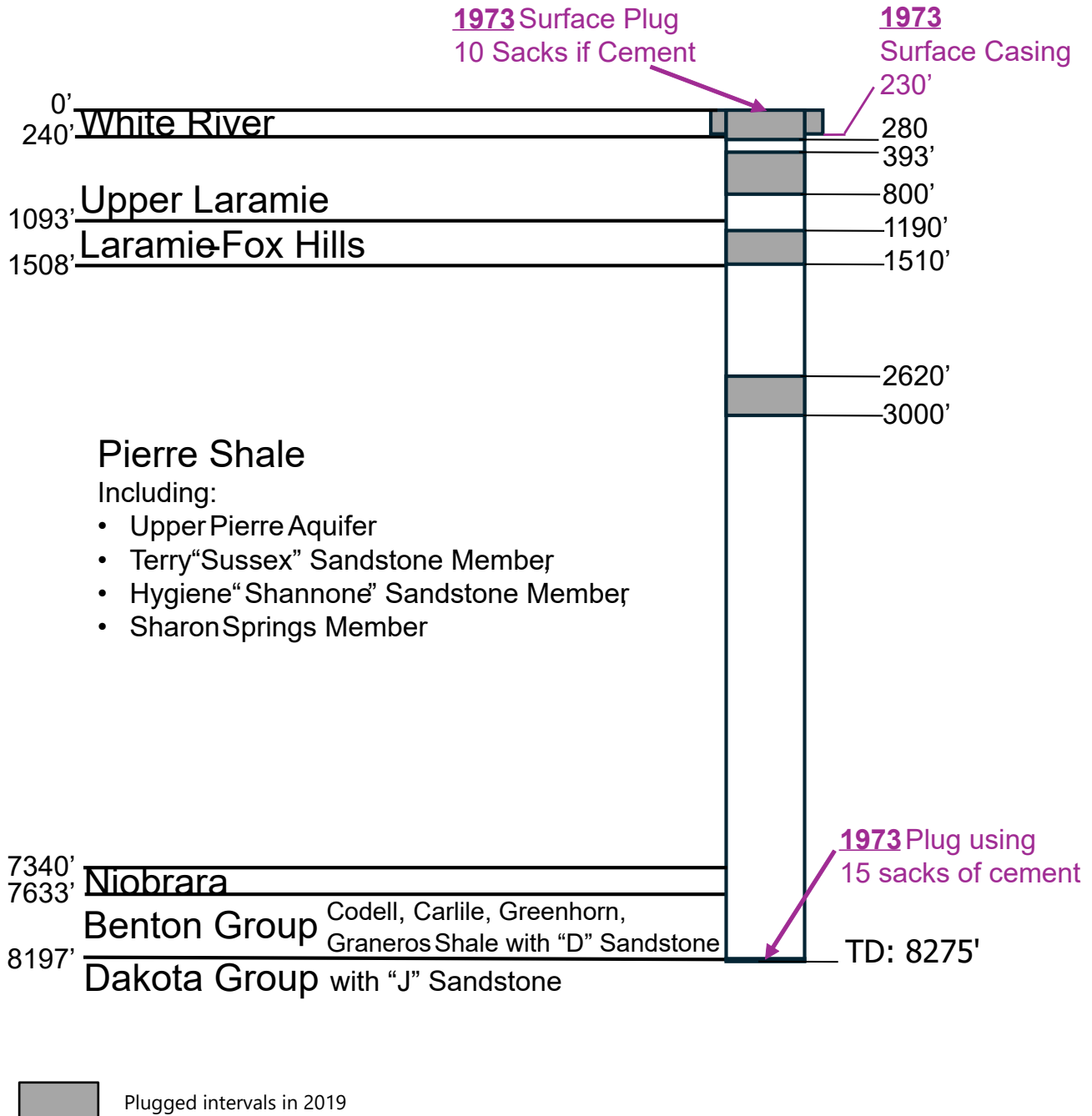


Figure 2 - Peters Well Wellbore Diagram with 2019 Replug and Geologic Formations

Notes:

Depths in feet below ground level.
 Peters Well is an open hole spudded and abandoned in 1973 due to no show in the targeted formation: Hygiene Member of Pierre Shale, the D Sandstone in the Graneros Shale, and the J Sandstone of the Dakota Group.
 Purple notes refers to the well abandonment in 1973.

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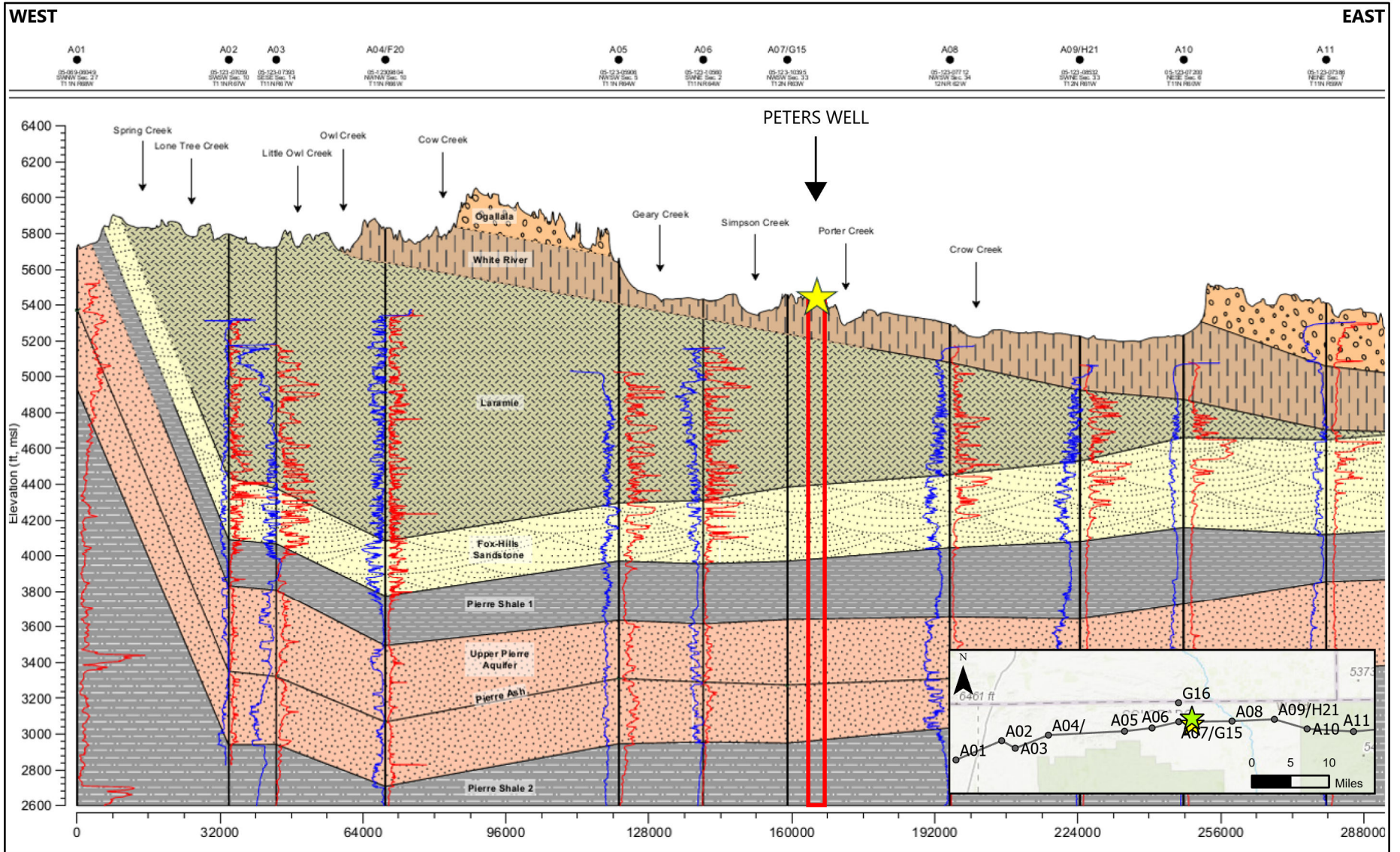


Figure 3 - Geologic Cross Section Near Peters Well

Legend ★ Peters 16-34 ★ Fox Creek 501-3403H • Geophysical Logs — Cross Section Lines

Notes: Peters Well is approx. 1.75 miles ESE of the A07/G15 log location (red box)
Source: Topper et al., 2017

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Projection: NAD 1983 UTM Z13N

File name: PetersWell.aprx





Figure 4 - Water Level Contour in the Laramie-Fox Hills

Source: Robson, S.G., Banta, E.R., 1987. Geology and Hydrology of the Deep Bedrock Aquifers in Eastern Colorado - Plate 3. USGS Water Resources Investigations Report 85-4240

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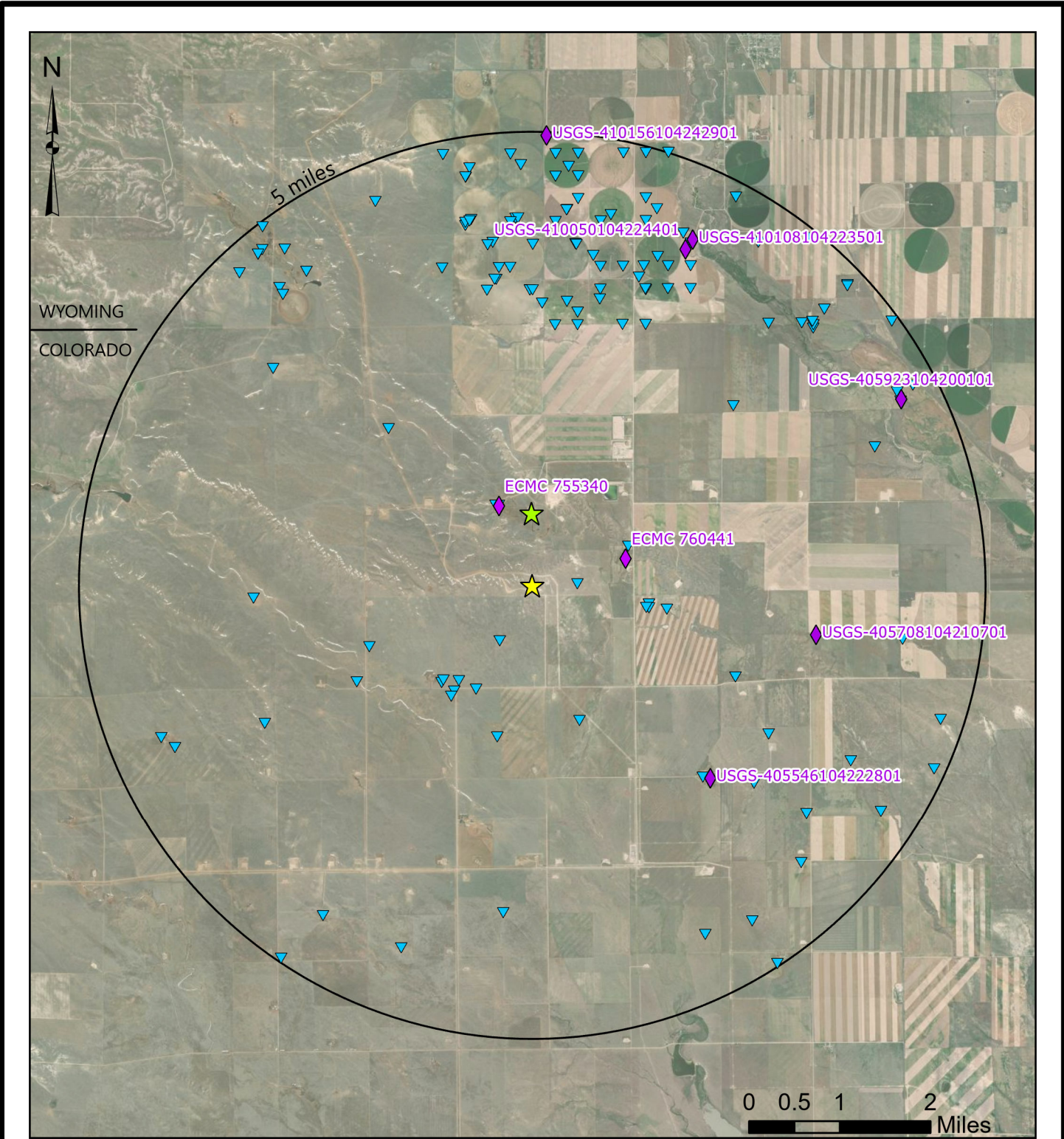


Figure 5 - Water Wells and Water Quality Sampling near Peters Well

Legend

- ★ Peters 16-34
- ★ Fox Creek 501-3403H
- ▼ Permitted Water Wells
- ◆ Wells with Water Quality Data

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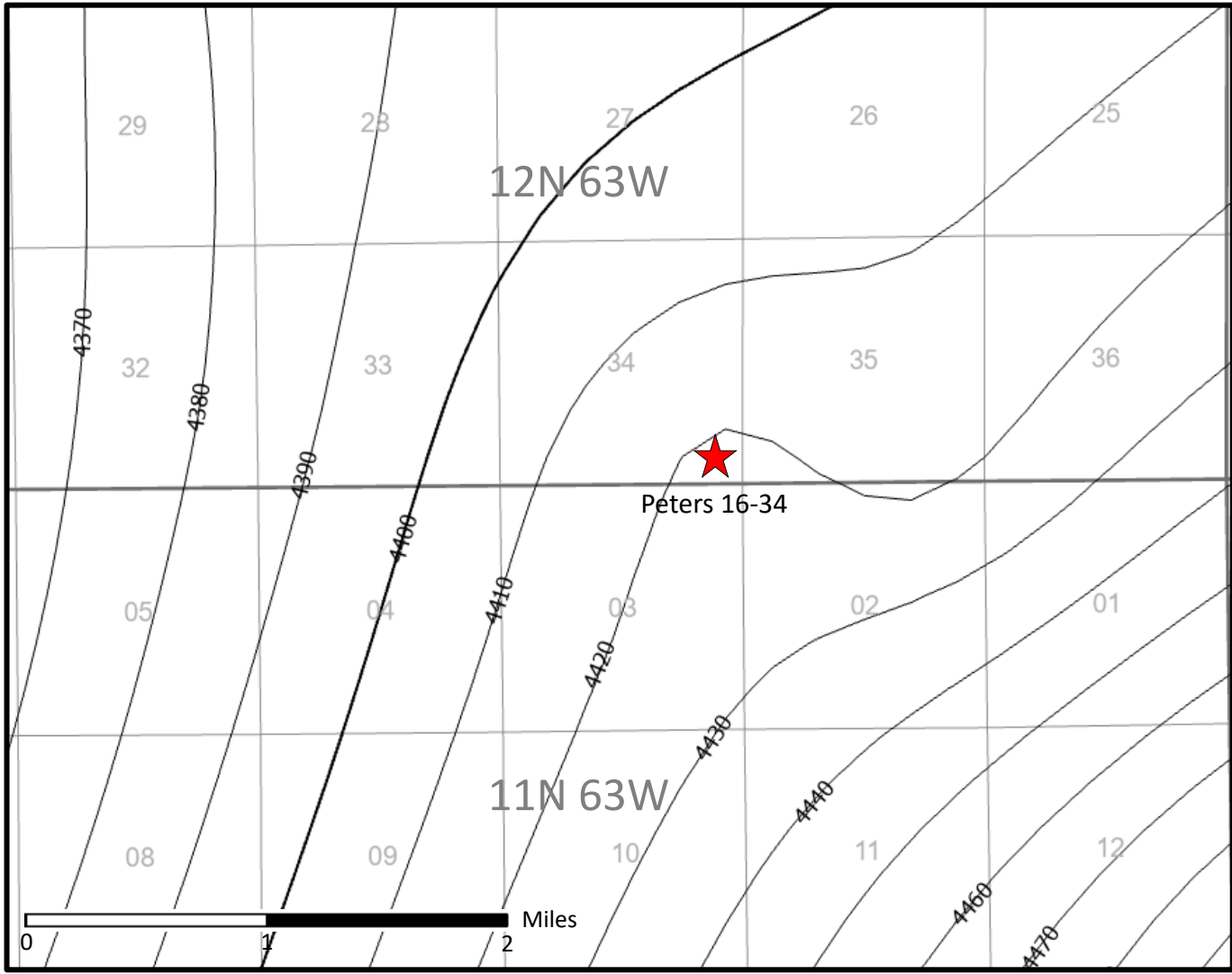
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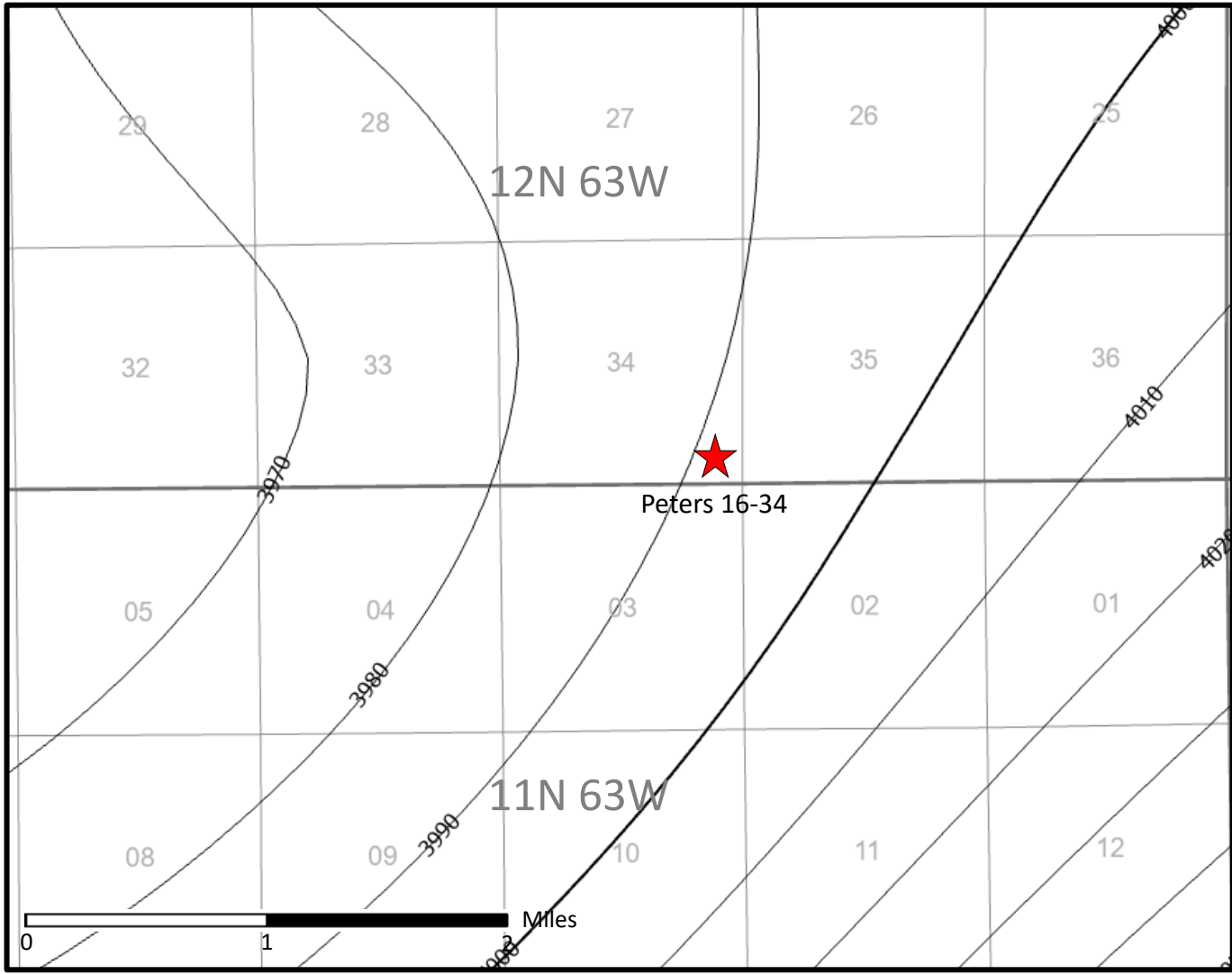


ATTACHMENT B



CIVITAS

Structure Map of Fox Hills
Top
Contour Interval 10 feet



CIVITAS

Structure Map of Fox Hills
Base
Contour Interval 10 feet