

**AQUIFER EXEMPTION REQUEST**

# Windy Hill Aquifer Exemption Request

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## EXECUTIVE SUMMARY

This report provides technical information in support of Windy Hill Water Operations, LLC's (Windy Hill) aquifer exemption request for the Dakota J-4 Sandstone (J Sandstone) in the area within one-quarter (0.25) mile of the Windy Hill #3-17D well (API # 05-087-08145). The Windy Hill project is located approximately 2 miles southeast of the City of Brush, in Morgan County, Colorado (**Figure 1**). The Windy Hill #3-17D well is located in the southeast quarter of the northeast quarter of Section 17, Township 3 North, Range 55 West, 6<sup>th</sup> Principal Meridian. The project contemplates use of the Windy Hill #3-17D well as a Class II underground injection control well to dispose of up to 25,000 barrels per day of oil and gas production water into the J Sandstone at a depth of 5,130 to 5,300 feet below ground surface.

The proposed aquifer exemption area and the area of review (AOR) boundaries encompass a 0.25-mile radius around the Windy Hill #3-17D well. A search of the Colorado Division of Water Resources water well database indicated that no drinking water wells are present within the AOR. No source water assessment or protection areas or designated sole source aquifers are present within the AOR.

The Dakota J Sandstone is separated from shallower aquifers by several thousand feet of regionally-continuous, low-permeability shale of the Colorado Group and the Pierre Shale. These units extend from the top of the Dakota J Sandstone up to within about 100 feet of the land surface and serve as an overlying confining layer. The Dakota J Sandstone is confined below by the Morrison and Chugwater Formations, both of which are regionally continuous. No identified faults or fractures occur in the project vicinity.

The Dakota J Sandstone aquifer proposed for exemption is highly unlikely to be developed as a source of drinking water because of the cost of obtaining and treating groundwater from the aquifer. Wells drilled into the aquifer would need to have depths on the order of 5,100 to 5,300 feet. Testing of wells in the project area indicated that 400 to 800 gallons per minute would be available from the Dakota J Sandstone. Water samples from the project area indicate the Dakota J Sandstone groundwater contains between approximately 6,600 and 10,000 milligrams per liter total dissolved solids, consisting primarily of sodium, chloride, and alkalinity.

The nearest public water supply is a well field operated by the City of Brush. The well field is approximately four (4) miles west-southwest of the Windy Hill #3-17D well and obtains water from an alluvial aquifer along Beaver Creek in Section 27, Township 3 North, Range 56 West. During a consultation for the development of this aquifer exemption request, the City indicated that it is unlikely that they would consider obtaining water from the Dakota Sandstone, given the good quality and ready availability of water from the City's current source aquifer, particularly in contrast to the poorer-quality water in the Dakota Sandstone, the high cost of drilling deep wells to access the Dakota Sandstone water, and the high cost and difficulty of treating Dakota Sandstone water to remove excess total dissolved solids. Population growth projections for the City of Brush indicate that future increased water demand could be met by the shallow source aquifer currently in use by the City.

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## **LIST OF ATTACHMENTS**

Attachment 1. Aquifer Exemption Evaluation

Attachment 2. Water Well 3-18WSW Dakota J-4 Sandstone Formation Sampling, 2015

Attachment 3. Unocal J Sand Water Sampling Documentation, 2005

## 1.0 INTRODUCTION

This report provides technical information in support of Windy Hill Water Operations, LLC's (Windy Hill) aquifer exemption request for the Dakota J-4 Sandstone (J Sandstone) in the area within one-quarter (0.25) mile of the Windy Hill #3-17D well (API # 05-087-08145). This information is provided in accordance with the Colorado Oil and Gas Conservation Commission (Commission) Rules 324B.a and 324B.b, a guidance memorandum prepared by the U.S. Environmental Protection Agency (EPA) (EPA 2014; *Enhancing Coordination and Communication with States on Review and Approval of Aquifer Exemption Requests under SDWA [the Safe Drinking Water Act]*), and EPA's Aquifer Exemption Evaluation as adapted by the Commission (a completed evaluation for the Windy Hill project is provided as **Attachment 1**). This report presents the following information:

- A brief description of the project, including identification of the requested aquifer exemption boundary and area of review (AOR) (see Section 2.0);
- A general description of the geology and hydrogeology of the project vicinity, including related information requested on the Aquifer Exemption Checklist (see Section 3.0);
- Demonstration that the J Sandstone in the project vicinity is not used as a drinking water source (see Sections 4.0 and 6.0);
- Demonstration that groundwater in the J Sandstone in the project vicinity contains between 3,000 and 10,000 milligrams per liter (mg/L) total dissolved solids (TDS) (see Section 5.0); and
- Demonstration that the J Sandstone is not reasonably expected to supply a public water system (see Section 6.0).

## 2.0 PROJECT DESCRIPTION

The Windy Hill project is located approximately 2 miles southeast of the City of Brush, in Morgan County, Colorado (**Figure 1**). The Windy Hill #3-17D well is located in the southeast quarter of the northeast quarter of Section 17, Township 3 North, Range 55 West, 6<sup>th</sup> Principal Meridian. The land surface elevation at the well site is approximately 4,404 feet above mean sea level (amsl).

The project contemplates use of the Windy Hill #3-17D well as a Class II underground injection control (UIC) well to dispose of up to 25,000 barrels per day (bpd) of oil and gas production water into the J Sandstone at a depth of 5,130 to 5,300 feet below ground surface (bgs). The water source would be off-site wells (to be identified), and the water would be transported to the site by commercial operators (to be identified). The Commission would permit the project as a Commercial Disposal Well Facility with a Dedicated Injection Well. The proposed disposal well is an existing well that was previously permitted as a Class V UIC well through the EPA for a former project design. While the well was constructed, it was never operated as a disposal well. Upon receipt of a Class II injection permit from the Commission, EPA would release the well from their jurisdiction.

The injection well construction is shown in **Figure 2**. Surface casing of 13.375-inch diameter J-55 steel pipe was installed to a depth of 483 feet in a 17.5-inch diameter borehole. According to the cementing report by Halliburton (2007), the annulus around the surface casing was cemented from the surface to 483 feet with 350 sacks of cement yielding 529.5 cubic feet, completely filling the annular space of 335.5 cubic feet. After the surface casing was set and cemented, a 12.25-inch diameter borehole was drilled to a total depth of 5,431 feet and cased with 8-5/8-inch J-55 steel casing to the total depth. The 8-5/8-inch casing was cemented from the total depth to the surface with 3,130 sacks of cement/pozzolon mixture that yielded 7,259 cubic feet of grout to fill the annular space of 2,278 cubic feet. The grout volume was 320 percent of the annular volume, and cement returns at the surface were reported. The combination of these indicates that the annulus was completely filled. The well was subsequently plugged back with cement to a depth of 5,385 feet, and the casing was perforated with 680 holes in the J Sandstone between the depths of 5,130 feet and 5,300 feet. Tubing of 5-1/2-inch diameter J-55 steel is installed from the surface into a packer set at 5,050 feet. The well is open to the Dakota J-4 Sandstone.

Down-hole pressure measurements in the well indicate that the static water level in the well is approximately 2,518 feet bgs, or at an elevation of approximately 1,900 feet amsl. Injection tests indicate that the well is capable of accepting injectate at a rate of approximately 30,500 bpd without the application of additional pressure at the land surface; additional capacity could theoretically be achieved through injection under pressure. A mechanical integrity test (MIT) performed in April 2015 indicated that the well casing maintained the 350 pounds per square inch (psi) test pressure for the test duration.

## 2.1 Aquifer Exemption Boundary

An aquifer exemption is being requested for the area within a radial distance of one-quarter (0.25) mile of the Windy Hill #3-17D well. The radial distance is based on Commission policy. The 0.25-mile radial distance equates to a surface area of approximately 125.6 acres that includes all or parts of the following quarter-quarter sections within Township 3 North, Range 55 West, 6<sup>th</sup> Principal Meridian:

- Section 17: NENE, NWNE, SWNE, SENE, NESE, NWSE; and
- Section 16: NWNW, SWNW, NWSW.

The pore volume available in the Dakota J-4 Sandstone within that radial distance from the Windy Hill #3-17D well was calculated based on the sandstone thickness and porosity data from geophysical logs of the well. The gamma, resistivity, density, and porosity logs indicate that the thickness of the J-4 Sandstone is 187 feet, with the top and bottom, respectively, occurring at approximately 5,107 feet and 5,294 feet bgs (5,125 feet and 5,312 feet below the log reference point, which was the kelly bushing 18 feet above the ground surface). The average porosity of the J-4 Sandstone is 0.22, as calculated from the digital (.las format) log data. The digital log lists the values of high-resolution thermal neutron porosity, thermal neutron porosity (ratio method), and enhanced thermal neutron porosity for 0.5-foot steps throughout the entire logged interval of 434 feet to 5,407 feet bgs (452 feet to 5,425 feet below the kelly bushing). The average porosity for the J-4 Sandstone was calculated from average of the three values for each step in the interval

from 5,125 feet to 5,312 feet below the log reference point. The total volume of pore space within the 0.25-mile radial distance from the injection well was calculated from the equation:

$$V = \pi r^2 H \theta$$

where:

V = pore space volume (length cubed),

$\pi$  = pi (unitless); 3.14159,

r = radial distance (length); 0.25 mile = 1,320 feet,

H = thickness of the interval (length); 187 feet, and

$\theta$  = average porosity (unitless); 0.22.

Substituting the respective values into the equation gives:

$$V = \pi (1,320 \text{ feet})^2 (187 \text{ feet}) (0.22)$$

$$= 225,196,700 \text{ cubic feet}$$

$$= 40,106,460 \text{ barrels}$$

The volume in cubic feet was converted to barrels by multiplying by 7.48 gallons per cubic foot and dividing by 42 gallons per barrel.

The project contemplates injection rates starting at 5,000 bpd during operating years 1 and 2, increasing to 10,000 bpd during operating years 3 through 5, and further increasing to 25,000 bpd for the remainder of the project life. Calculations indicate that the pore volume within the 0.25-mile radius would be filled after about 7.8 years of continuous injection at the rates just described.

## 2.2 Area of Review

The AOR was calculated using equations from EPA as presented in 40 CFR 146.6 and incorporating project-specific operating plans (injection rate and duration) and site-specific hydraulic properties for the J-4 Sandstone as determined from on-site testing. The equations are:

$$r = \sqrt{\left[ \frac{2.25 K H t}{S 10^x} \right]}$$

where:

$$x = \frac{4 \pi K H [(h_w - h_{bo}) S_p G_b]}{2.3 Q}$$

and:

r = radius of endangering influence from injection well (length); calculated,

$k$  = hydraulic conductivity of the injection zone (length/time); 1.64 feet per day (ft/d) from testing of the Windy Hill #3-17D well,

$H$  = thickness of the injection zone (length); 187 feet, thickness at the Windy Hill #3-17D well,

$t$  = time of injection (time); 7.8 years, equal to 2,847 days,

$S$  = storage coefficient (dimensionless); 0.000187, based on specific storage of  $1 \times 10^{-6}$  per foot times a thickness of 187 feet,

$Q$  = injection rate (volume/time); the total volume injected is 225,196,700 cubic feet over a period of 2,847 days, which gives a time-weighted average  $Q$  of 79,100 cubic ft/d,

$h_{bo}$  = observed original hydrostatic head of injection zone (length) measured from the base of the lowermost underground source of drinking water; 2,794 feet, based on 1,215 psi static pressure at 5,324 feet bgs as measured in the Windy Hill #3-17D well testing,

$h_w$  = hydrostatic head of underground source of drinking water (length) measured from the base of the lowermost underground source of drinking water; 5,270 feet, based on assumption of the water level in the underground source of drinking water being approximately 40 feet bgs,

$S_p G_b$  = specific gravity of fluid in the injection zone (dimensionless); 1.01, based on water with 10,000 mg/L total dissolved solids at the injection zone pressure and temperature, assuming that the waste water to be injected is derived from local wells in the Dakota Sandstone or similar producing zones and 10,000 mg/L is a reasonable average total dissolved solids content, and

$\pi$  = 3.14159 (dimensionless)

The resulting calculations are:

$$x = \frac{4 \cdot \pi \cdot \frac{1.64 \text{ ft}}{d} \cdot 187 \text{ ft} [(5270 \text{ ft} - 2794 \text{ ft}) \cdot 1.01]}{2.3 \cdot 79100 \text{ ft}^3/d} = 52.97$$

$$r = \sqrt{\left[ \frac{2.25 \cdot 1.64 \frac{\text{ft}}{d} \cdot 187 \text{ ft} \cdot 2847 \text{ days}}{0.000187 \cdot 10^{52.97}} \right]} = 1.0 \times 10^{-21} \text{ ft}$$

The calculated AOR is less than 1 foot. The AOR is therefore specified as a radius of 0.25-mile from the Windy Hill #3-17D well.

### 3.0 GEOLOGY AND HYDROGEOLOGY

This section describes the regional geology, the local geology, and the hydrogeologic properties of the Dakota, including groundwater chemical analysis. A detailed description of the injection unit within the Dakota Sandstone is presented. The information presented was derived from publicly available literature; data from Windy Hill wells #3-17D, #1-17D, #7-17S, and #3-18WSW; and other data from wells and geophysical studies in the project vicinity.

### 3.1 Regional Geology

The project site is on the eastern flank of the Denver Basin, one of the largest sedimentary basins formed during the Laramide Orogeny (Rocky Mountain Association of Geologists [RMAG] 1972). **Figure 3** shows a generalized west-to-east cross section through the Denver Basin east of the basin axis. The basin is asymmetric, with its axis close to and paralleling the mountain front. The western side of the basin is bounded by a 5- to 10-mile wide zone of large-displacement faulting parallel to the mountain front, with vertical displacements on some faults exceeding 10,000 feet (Robson and Banta 1987). The western flank dips steeply to the east at 10 degrees or more near the mountain front, while the eastern flank of the basin dips gently to the west at approximately 0.5 to 1 degree (RMAG 1980).

The basin contains up to approximately 13,000 feet of sedimentary rocks above the Precambrian igneous and metamorphic basement rocks (Belitz and Bredehoeft 1988). The sedimentary rocks range in age from Cambrian to Tertiary, with the greatest thickness consisting of Cretaceous-age rocks.

Mississippian-aged rocks consisting of massive grey to brown cherty limestone and dolomite unconformably overlie either Precambrian or Cambrian rocks in the Denver Basin and range from areas of non-deposition or erosion with no Mississippian rocks up to about 350 feet in thickness. They are unconformably overlain by Pennsylvanian-aged rocks consisting of a basal sandstone and overlying thinly-bedded carbonates, sandstones and shales. The rocks of Pennsylvanian age range in thickness from about 800 to about 1,700 feet (RMAG 1980).

Unconformably overlying the Pennsylvanian section are Permian carbonates, sandstones, and evaporites. The thickness of Permian deposits varies from 900 feet in the northern part of the basin to 1,200 feet in the southeastern part of the basin (Momper 1963; RMAG 1972; Robson and Banta 1987).

Triassic-aged rocks are represented by the Lykins Formation, also known as the Chugwater Formation, consisting of red to maroon or purple sandstone, siltstone, and shale. The Lykins/Chugwater overlies the Permian System in the western part of the basin, where it is up to 250 feet thick, but has been removed by erosion in the eastern part of the basin (RMAG 1976).

The Triassic system is unconformably overlain by the Jurassic-aged Morrison Formation, which consists of 50 percent to greater than 80 percent variegated shales and lesser amounts of siltstones, sandstone and minor thin interbeds of limestone. The thickness of the Morrison ranges from approximately 200 to approximately 350 feet. The Morrison formation represents a confining layer with minimal water yields from sandstone lenses (Topper et al. 2003).

The Cretaceous-aged Dakota Group unconformably overlies the Jurassic System. The Dakota consists of a basal member, the Plainview-Lytle sandstone, or its equivalent, a middle marine shale member, the Skull Creek Shale, and upper sandstone members, the "D" and "J" Sandstones (RMAG 1972; Robson and Banta 1987). The Dakota Group is recognized as a regionally extensive unit that outcrops in Kansas, Nebraska, South Dakota, the southeastern portion of the Denver Basin, and along the flank of the Front Range uplift from Colorado Springs north to

Wyoming. The Dakota Group extends throughout the Denver Basin in the subsurface (RMAG 1972). The total Dakota Group thickness is generally about 250 to 350 feet (RMAG 1972; RMAG 1976; Robson and Banta 1987). The proposed groundwater withdrawal zone is within the J Sandstone, the lowermost sandstone of the Dakota. The J Sandstone is composed mainly of deltaic, distributary, and near-shore sandstones (Higley and Schmoker 1989) that are fine- to medium-grained. The Dakota Group is discussed in more detail in Section 3.3 below.

The Dakota Group is overlain by the Upper Cretaceous Colorado Group, which includes, in ascending order, the Graneros Shale, the Greenhorn Limestone, the Carlile Shale, and the Niobrara Formation. These units consist of shale, siltstone and limestone and are confining layers. The aggregate thickness of Colorado Group units ranges from about 700 to about 1,000 feet.

The Niobrara Formation is the thickest unit of the Colorado Group, with thicknesses ranging from approximately 300 feet thick near the mountain front to approximately 600 feet near the Kansas border (RMAG 1976). The Niobrara Formation represents a transgressive marine deposit formed when the Cretaceous Seaway was expanding in the interior of the United States (RMAG 1972). The Niobrara is composed of two members, the basal Fort Hayes Limestone and the overlying Smokey Hill Chalk. The Fort Hayes is the thinner unit, and the contact with the Smokey Hill is gradational (RMAG 1976). The Niobrara was evaluated in the Project area for its reservoir potential (The Discovery Group, Inc. 2003) and found to be composed of chalk and organic-rich shale with high porosity (17 percent average) but very low permeability. The report found that the formation salinity averaged about 24,000 parts per million chlorides and concluded that the Niobrara in this area has “essentially no permeability to fluids” (The Discovery Group, Inc. 2003).

The Niobrara Formation is unconformably overlain by the late-Cretaceous-aged Pierre Shale. The Pierre Shale is a thick, widespread marine shale that consists of calcareous, silty, dense shale containing some thin lenses of siltstone and fine sandstone. The Pierre Shale exceeds 4,000 feet of thickness over much of the Denver Basin (RMAG 1972) and represents a low-permeability confining layer (Topper et al. 2003). The upper part of the Pierre Shale interfingers with regressive shoreline deposits of the Late Cretaceous Fox Hills Sandstone in the western third of the basin (RMAG 1972). The nonmarine Laramie Formation overlies the Fox Hills in the portion of the Denver Basin closest to the mountain front (RMAG 1972). In the Windy Hill project area, the formations overlying the Pierre Shale have been removed by erosion.

The oldest Tertiary rocks present in the eastern portion of the Denver Basin are Oligocene. These rocks are of floodplain origin, and erosion has only left remnant deposits in the eastern part of the Denver Basin just east of the Windy Hill project area (Miller 2000; RMAG 1976; RMAG 1972; Topper et al. 2003).

Unconsolidated Quaternary-aged deposits of alluvial and eolian sediments form the surficial geology over large areas of the Denver Basin (Topper et al. 2003; Scott 1978). In the area of the Windy Hill project, the Pierre Shale is covered with a thin veneer of wind-deposited silt and fine sand (Scott 1978) up to about 100 feet thick.

No identified regional faults occur in the project vicinity. The project is located in an area of low seismicity, and there are no mapped Quaternary-aged faults within Morgan County (Widmann et al. 1998; Colorado Geological Survey 2015).

### 3.2 Local Geology

The local geology within the project area has been documented by studies of logs of oil wells within and surrounding the project area (The Discovery Group, Inc. 2003), including nine wells drilled within the project area boundaries, and a geophysical study of the project area and vicinity (Geostock US, Inc. 2008). The local stratigraphic sequence mimics the regional sequence and is summarized in **Figure 4**. The total thickness of sedimentary rocks beneath the project area is approximately 8,000 feet (Belitz and Bredehoeft 1988). Thus, approximately 2,700 feet of sedimentary rocks are present between the Dakota J-4 Sandstone and the Precambrian-age basement rocks.

The sedimentary strata dip to the northwest at 0.5 to 1 degree. Windy Hill conducted seismic testing in the project area in January 2005, and the results confirmed that there are no expected displacements of the J Sandstone (Sandarusi 2005).

Additional detail on the local geology is provided in Sections 3.3 and 3.4.

### 3.3 Dakota Group and Dakota Sandstone

The Dakota Group is a regional reservoir and aquifer that underlies a large area in the western interior of the United States. The outcrop belt east of the Rocky Mountains extends from the foothills along the Front Range of Colorado, through the southeastern Denver Basin and into Kansas, Nebraska, and South Dakota (RMAG 1972). The Dakota Group is present in the subsurface across the Denver Basin. Throughout the Basin, it is hydraulically underpressured (Gibbons and Self 1973; Robson and Banta 1987).

The reason for the subnormal formation pressure is explained by Belitz and Bredehoeft (1988). The hydrodynamic flow of the J Sandstone (Dakota) fluid is generally from west to east. The recharge of the J Sandstone on the western margins of the basin is limited because the outcrops are detached from the main body by faulting along the Front Range. Further into the basin, the J Sandstone is capped by a thick sequence of low-permeability shales which provide isolation from the elevation head of the local water table. Recharge likely occurs at a relatively lower rate than the rate of discharge at the eastern outcrops. The Dakota Group is composed of a basal marine sandstone (the Cheyenne, Plainview-Lytle, Purgatoire or other stratigraphically equivalent sandstones), that is overlain by a widespread marine shale unit (the Skull Creek Shale) that is in turn overlain by a series of erratically-distributed, near-shore-marine, deltaic, and distributary sandstones (**Figure 4**). The lower sandstones are known as the J Sandstone (also called the Muddy), and the upper sandstone is known as the D Sandstone. In Morgan County, as many as four distinguishable sandstone beds (the J-1, J-2, J-3, and J-4) make up the J Sandstone, with the J-1 being the uppermost and the J-4 being the deepest. These sandstones are collectively known as the Dakota Sandstone.

The project area is not structurally complex. The J Sandstone dips to the west-northwest at approximately 1 degree. The top of the J Sandstone is approximately 630 feet below mean sea level at the Windy Hill #3-17D well site. The total J Sandstone thickness in the area ranges between 180 to 210 feet. Over 90 percent of this thickness is represented by the lowermost J-4 layer, based on isopach maps produced from well data (The Discovery Group, Inc. 2003).

The Dakota Sandstone is also known as the Dakota-Cheyenne aquifer in southeastern Colorado, where it provides groundwater to stock, domestic, and irrigation wells (Robson and Banta 1987; Topper et al. 2003). The petroleum industry terminology varies from this, and use of the term Dakota Sandstone is the generally accepted terminology (Higley and Schmoker 1989; Weimer and Sonnenberg 1989). It has been acknowledged that the terminology has varied greatly over the years (Boyd 1993). For the purposes of this document, this unit is referred to as the Dakota Sandstone.

The Dakota Sandstone is an important reservoir for oil and gas production throughout the Denver Basin (Ethridge and Dolson 1989; RMAG 1982), with about two-thirds of the oil and one-half of the gas production in the basin having come from the D and J Sandstones in 355 fields across the basin (Higley and Cox 2007). Historical production from the D and J Sandstones in the project vicinity includes the Pinneo North field, located about 4 miles south of the Windy Hill #3-17D well. Although no historical production is recorded within the aquifer exemption boundary, oil was present in J Sandstone core from the 1 John A Fries et al (L-2768) #1 well (API #05-087-05996) about 3,870 feet (0.73 mile) west of the Windy Hill #3-17D well (Commission 2015a).

### **3.4 Dakota Hydrogeology**

The most complete description of the Dakota Sandstone hydraulic properties is a U.S. Geological Survey Water Resources Investigation (Robson and Banta 1987). The Dakota Group is confined by the underlying Morrison Formation and the overlying Graneros Shale. The Graneros Shale consists of dark gray to black, fissile, noncalcareous shale. The Morrison is composed of mudstones, shales, thin limestones, and sandstones. The permeability of both these units is very low. Also overlying the Dakota Sandstone are the confining units of the Niobrara Formation (greater than 300 feet thick) and the Pierre Shale (approximately 4,300 feet thick) based on the logs of wells in and near the project area. Therefore, the Dakota Sandstone is isolated hydraulically from the surface and any shallow water-bearing units in the AOR.

Pruit (1978) prepared a potentiometric map for the J Sandstone in the Denver Basin. This map showed that the potentiometric surface generally slopes to the north and the northeast, although there are some areas with a pronounced eastward slope to the potentiometric surface (Pearl 1982). In general, Pruit (1978) demonstrated the J Sandstone potentiometric surface is complex and does not have a uniform slope. The potentiometric surface elevation for the Dakota Sandstone in Morgan County is between approximately 2,000 and 2,500 feet asml. The potentiometric surface shows a significant amount of variability regionally (Gibbons and Self 1973). The Gibbons and Self map indicates the Windy Hill project is in a regional potentiometric low with flow generally to the north-northwest. Complex interfingering of sandstones and shales restricts the movement of groundwater in many areas. Additionally, some growth faults in the Cretaceous section may affect groundwater movement. In the Windy Hill project area, the Windy

Hill #3-17D well is located at 4,404 feet amsl, and the hydrostatic level is at approximately 1,900 feet amsl.

The hydraulic conductivity of various units within the Dakota Sandstone ranges from 20 ft/d in the well-sorted sandstones to less than 0.001 ft/d in areas where poorly sorted, clay-rich sediments are prevalent. In Morgan County, the average hydraulic conductivity is estimated to be 0.2 ft/d (Topper et al. 2003). Vertical conductivity in the aquifer is negligible, and very little flow is thought to occur between the overlying and underlying units (Robson and Banta 1987; Topper et al. 2003).

**Table 1** summarizes data from J Sandstone oil wells within and near the project area (The Discovery Group Inc. 2003) and testing of wells #3-17D and #3-18WSW in the project area (Geostock US, Inc. 2007 and 2008). The on-site data indicate hydraulic conductivities with a range of 0.03 ft/d to 2.2 ft/d and an average of 0.89 ft/d.

**Table 1. Summary of Hydraulic Conductivity and Porosity Data for J Sandstone within Project Area.**

Well	Location (T-R-S)	Hydraulic Conductivity (ft/d)	Porosity (percent)
1 Miller	3N-55W-21	0.72	22.9
1 Mitchell	3N-55W-23	0.03	15.8
1 Fries	3N-55W-17	1.0	21.7
1-4 Federal	3N-55W-4	0.40	21.1
1 Chvatal	3N-55W-18	0.09	15.5
1 Bass	3N-55W-29	2.24	24.4
1 Bewley Const	3N-55W-7	0.77	23.3
1-17D	3N-55W-17	0.39	--
3-17D	3N-55W-17	1.64	22.2
3-18WSW	3N-55W-18	1.66	--
		Average = 0.89	Average = 20.7

Data from oil wells within the project area indicate that the J Sandstone has porosities ranging from 15.5 percent to 24.4 percent, with an average of 20.7 percent (**Table 1**) (The Discovery Group, Inc. 2003). Log data from the Windy Hill #3-17D well indicate an average porosity of 22.2 percent for the Dakota J-4 Sandstone.

The complex stratigraphy of the Dakota Group produces highly variable, non-uniform water chemistry regionally. In general, water is of a sodium bicarbonate type in northeastern Colorado (Robson and Banta 1987). Salinity values (as NaCl equivalent) from spontaneous potential and apparent water resistivity calculations for the J Sandstone are as high as 17,000 mg/L (The Discovery Group, Inc. 2003).

The top of the J Sandstone in the Windy Hill #3-17D well encountered at the depth of 5,110 feet bgs and the base of the J Sandstone (top of the Skull Creek Shale) was at 5,312 feet bgs. Only the J-1, J-2, and J-4 Sandstones are present; the J-3 Sandstone is absent. The geophysical logs for Windy Hill #1-17D well indicate that the D-1 Sandstone and the D-2 Sandstone are shaley. The J-1 Sandstone is cleaner sand but thin. The J-4 Sandstone is a thick, clean sandstone in the project area. The gross sand thickness of the J-4 Sandstone is 192 feet.

## 4.0 NEARBY WELLS

Available public records were searched to identify existing wells within the vicinity of Windy Hill #3-17D. The results of the search are described below.

### 4.1 Water Wells

The Colorado Division of Water Resources (DWR) online water wells database (DWR 2015) indicates that there are no permitted water wells within 0.25 mile of Windy Hill #3-17D.

The water well search area was also expanded to a one-half (0.5)-mile radius, which was determined by adding a buffer distance equal to the aquifer exemption boundary radius. There are three constructed water wells within 0.5 mile of Windy Hill #3-17D. The well locations are shown on **Figure 5**, and well details are provided in **Table 2**. All three are monitoring wells associated with the former Windy Hill project and are not permitted for domestic, municipal, or other human-consumption use. Reported well depths range from 60 to 79 feet. All wells listed in **Table 2** are vertically isolated by several thousand feet of low-permeability shale from the Dakota J Sandstone for which the aquifer exemption is requested.

A search of the DWR water wells database indicates that the nearest drinking water well completed in the aquifer proposed for exemption, the Dakota Sandstone, is approximately 54 miles from the proposed aquifer exemption area. This distance is far beyond a distance potentially requiring a capture zone analysis. The database search was conducted screening for wells that are permitted for one of the following uses: domestic, household use only, municipal, other, or all beneficial uses.

**Table 2. DWR Records of Water Wells within One-Half Mile of Windy Hill #3-17D**

Well Name	Permit No.	Twp.	Rng.	Section	Qtr.-Sec.	Qtr.-Qtr.Sec.	Use	Aquifer Name	Date Constructed	Date of First Beneficial Use	Elevation (ft amsl)	Well Depth (ft)	Perforations		Pumping Rate (gpm)	Static Water Level (ft)	Owner Name	Mailing Address
													Top (ft)	Bottom (ft)				
MW-3	46051 MH	3 N	55 W	17	NE	NW	MONITORING WELL	ALL UNNAMED AQUIFERS	4/21/2006		4404	62	50	60			BOSS BRUCE B FAMILY LLP	C/O MFG INC 4900 PEARL EAST CIR, BOULDER, CO 80301
	269978											60					UNOCAL WINDY HILL GAS STORAGE LLC	C/O MFG INC 4900 PEARL EAST CIR, BOULDER, CO 80301
MW-5	269980	3 N	55 W	17	NW	SE	MONITORING WELL	ALL UNNAMED AQUIFERS	4/25/2006		4429	79	69	79			UNOCAL WINDY HILL GAS STORAGE LLC	C/O MFG INC 4900 PEARL EAST CIR, BOULDER, CO 80301
	46055 MH																BOSS BRUCE B FAMILY LLP	C/O MFG INC 4900 PEARL EAST CIR, BOULDER, CO 80301
MW-6	269981	3 N	55 W	17	NW	SE	MONITORING WELL	ALL UNNAMED AQUIFERS	4/25/2006		4429	79	69	79			UNOCAL WINDY HILL GAS STORAGE LLC	C/O MFG INC 4900 PEARL EAST CIR, BOULDER, CO 80301

## 4.2 Other Wells

The Commission's (2015) online database was searched to identify existing permitted oil and gas wells within the 0.25-mile aquifer exemption boundary and AOR. The search results indicate that there are no permitted oil and gas wells within 0.25 mile of Windy Hill #3-17D (**Figure 6**).

## 5.0 J-4 SANDSTONE WATER QUALITY

Two sets of samples have been collected from the Dakota J-4 Sandstone in the Windy Hill project area, as summarized below.

On April 15, 2015, Tetra Tech, Inc. (Tetra Tech) collected water samples from existing well FW-3-18WSW (previously DWR Permit No. 65080-F, currently DWR Permit No. 79176-F) located in the NWSW quarter-quarter of Section 18, Township 3 North, Range 55 West, approximately 9,700 feet west-southwest of the Windy Hill #3-17D well. The intent of this sampling event was to determine the TDS concentration of the Dakota J-4 Sandstone Formation at the site, to identify the permitting requirements for the on-site disposal of oil and gas production water into that formation via a Class II UIC well (a well other than 3-18WSW). Per the Commission's Rule 324B (Exempt Aquifers), permitting requirements are dictated by the TDS results in the following bracketed concentrations: 1) less than 3,000 mg/L, 2) more than 3,000 and less than 10,000 mg/L, and 3) more than 10,000 mg/L. Determining which bracket is applicable to the Windy Hill project was the intended use of the samples that Tetra Tech collected. The samples yielded a measurement of 6,600 mg/L TDS; therefore, Windy Hill is requesting an aquifer exemption and providing supporting materials to meet the evaluation criteria for samples that fall within the second concentration bracket.

As part of the previous Windy Hill project, water samples were collected in February 2005 from existing well Windy Hill #1-17D (API # 05-087-08137), located in the NWNW quarter-quarter of Section 17, Township 3 North, Range 55 West, approximately 4,000 feet west-northwest of Windy Hill #3-17D. The samples yielded a measurement of 10,000 mg/L TDS; therefore, Windy Hill was not required to obtain an aquifer exemption at that time.

### 5.1 April 2015 Sampling Event

Samples were collected in accordance with the April 14, 2015, Sampling and Analysis Plan that Tetra Tech prepared for this sampling event. The sampling event included the collection of two sets of samples, as described below. Field parameters of pH, conductivity, temperature and TDS were measured prior to sample collection and documented in the field notes included in **Attachment 2**.

Prior to sample collection, Tetra Tech obtained information regarding the recent well activities. Based on information provided by Peterson Energy Operating, Inc., the well had been swabbed five times the previous day. At the request of Tetra Tech, Peterson Energy Operating, Inc. swabbed the well four more times prior to sample collection to ensure that representative samples were collected. Water from the well was collected directly from a pipe equipped with a valve located at the wellhead. Water was placed into a new 5-gallon plastic container and then

transferred to pre-cleaned laboratory-supplied sample bottles via disposable tubing and a peristaltic pump. Two water samples, including one parent sample and one blind field duplicate sample, were collected for TDS analysis at ALS Environmental Laboratory (ALS). The samples were placed on ice in a cooler until they were hand-delivered to ALS on April 16, 2015. Appropriate chain-of-custody procedures were implemented during sample collection and delivery.

A copy of the ALS report (Work Order # 1504297) is included in **Attachment 2**. The lab report was corrected at the request of Tetra Tech to document the geologic formation from which the samples were collected (Dakota J-4 Sandstone). Tetra Tech reviewed the analytical data to evaluate whether quality assurance and quality control objectives (QA/QC) were achieved. The data evaluation results are documented in the Data Evaluation Checklist included in **Attachment 2**. The laboratory reported that the sample cooler was received outside specification ( $4\pm 2$  degrees Celsius (C)), at  $7^{\circ}$  C upon receipt. Thus, the sample results are qualified as estimated due to sample preservation being outside specifications. No other QA/QC deficiencies were identified, and the laboratory analytical results are considered suitable for the intended use.

Tetra Tech requested additional laboratory analyses for the two samples on April 27, 2015. The additional analyses included the following parameters:

- Anions: bromine, chloride, fluoride, nitrite, nitrate, and sulfate;
- Cations (total): calcium, potassium, magnesium, sodium, and iron;
- Total alkalinity

Analytical results for both analysis requests are summarized in **Table 3**. The laboratory report indicates that both sample results for TDS are 6,600 mg/L. Based on the relative proportions of the major ions, the water type is sodium chloride.

**Table 3. Summary of Laboratory Analytical Results for April 2015 Samples**

Parameter	Sample Results (mg/L)	
	FW-3-18WSW-01	FW-3-18WSW-02
TDS	6600	6600
Total Alkalinity	1700	1700
Bromide	30	30
Fluoride	2.7	2.7
Nitrate as N	<2	<2
Nitrite as N	<1	<1
Sulfate	<10	<10
Chloride	3100	3100
Calcium	11	11
Iron	89	78
Magnesium	2.9	2.9
Potassium	24	24
Sodium	2200	2200

The ALS report of these additional analyses is included in **Attachment 2**. Per the Data Evaluation Checklist included in **Attachment 2**, the analyses for nitrate and nitrite were performed outside

the recommended hold time for Method 300.0. This deviation is not expected to significantly affect the reported results for these parameters. No other QA/QC deficiencies were identified, and the laboratory analytical results are considered suitable for the intended use.

## 5.2 February 2005 Sampling Event

Well testing was conducted on well UWHGS #1-17D in February 2005. The UWHGS #1-17D well was drilled to a total depth of 6,508 feet, plugged back to 5100 feet, and perforated in the Dakota J-4 Sand from 5,150 to 5,300 feet. The well was swabbed for 19.5 hours over the course of 3 days. On the third day of swabbing, the static water level was measured every half hour for 3 hours and was consistently at 2,200 feet. The surface elevation at the well is approximately 4,412 feet amsl. The potentiometric surface confirms a subnormal pressure regime in the area of review (The Discovery Group, Inc. 2003). **Attachment 3** includes the sampling and analysis documentation that is available to Windy Hill at this time.

On February 7, 2005, on the last swab run, a water sample and a duplicate water sample were collected for TDS analysis. The laboratory reported the TDS data to two significant figures; the result for both samples was 10,000 mg/L. Data validation review of the raw data calculated the TDS as 10,343 and 10,176 mg/L for samples Well #1 and Well #1 Duplicate, respectively. The pH was 7.6 and 7.7 standard units, respectively. Specific gravity was measured at 1.01 for both samples. These and other data on inorganic and organic analyses are presented in **Table 4**. The concentrations of benzene, toluene, ethylbenzene, and xylene are interpreted as residual from petroleum migration in the reservoir.

**Table 4. Summary of Laboratory Analytical Results for February 2005 Samples**

Parameter	Sample Results (mg/L unless noted otherwise)	
	Sample Well #1	Duplicate Sample Well #1
Bromide	2.5	
Calcium	8.9	
Chloride	8.8	
Fluoride	6.9	
Magnesium	1.4	
Nitrate (as N)	<0.028	
Potassium	24	
Total dissolved solids	10,000	10,000
Conductance (µmhos/cm)	13,000	13,000
Specific Gravity	1.01	1.01
pH (s.u.)	7.6	7.7
Antimony	<0.00030	
Arsenic	<0.00030	
Barium	0.180	
Beryllium	<0.00010	
Cadmium	<0.00020	
Chromium	0.00324	
Cobalt	0.00145	
Copper	0.0560	
Iron	24	
Lead	0.0418	
Manganese	0.361	
Molybdenum	0.0133	
Nickel	0.00884	

Parameter	Sample Results (mg/L unless noted otherwise)	
	Sample Well #1	Duplicate Sample Well #1
Selenium	<0.00010	
Silver	<0.00030	
Thallium	<0.00010	
Vanadium	<0.00030	
Zinc	0.0599	
1,1,1-Trichloroethane	<0.00015	
1,1,2-Trichloroethane	<0.00013	
1,1-Dichloroethene	<0.00012	
1,2-Dichlorobenzene	<0.00012	
1,2-Dichloroethane	<0.00013	
1,2-Dichloropropane	<0.00012	
1,2,4-Trichlorobenzene	<0.000083	
1,4-Dichlorobenzene	<0.000036	
Benzene	0.098	
Carbon Tetrachloride	<0.00011	
Chlorobenzene	<0.00003	
Cis-1,2-Dichloroethene	<0.0001	
Ethylbenzene	0.00072	
Methylene Chloride	<0.00016	
M&P Xylenes	0.110	
O-Xylene	0.0063	
Styrene	<0.000062	
Tetrachloroethene	<0.000084	
Toluene	0.016	
Trans-1,2-Dichloroethene	<0.000084	
Trichloroethene	<0.00011	
Vinyl Chloride	<0.000080	
Xylenes, Total	0.130	

## 6.0 PUBLIC WATER SUPPLIES

The City of Brush, Colorado, approximately 2 miles northwest of the Windy Hill project area, is the closest incorporated population center. The city obtains its municipal water supply from a well field in the alluvial aquifer along Beaver Creek in Section 27, Township 3 North, Range 56 West, about 3 miles south of the city and about 4 miles west-southwest of the Windy Hill #3-17D well. Don Marymee (personal communication 2015), Water Superintendent with the City of Brush Public Utilities Department, indicated that the city maintains 11 wells in the system and pumps between 600,000 and 3 million gallons per day, depending on the season. The wells are drilled to the top of the Pierre Shale at depths of about 150 feet, depending on location and land surface elevation, and produce water from unconsolidated (alluvial and eolian) deposits. The water reportedly contains between 108 and 327 mg/L TDS. The only treatment applied by the city is chlorination. Mr. Marymee indicated that it is unlikely that the city would consider obtaining municipal water from the Dakota Sandstone, given the good quality and ready availability of water from the city's current source aquifer, in contrast to the poorer quality of water available from the Dakota Sandstone, the high cost of drilling deep wells to access the Dakota Sandstone, and the high cost and difficulty of treating Dakota Sandstone water to remove excess TDS. The alluvium within the Beaver Creek valley is oriented approximately north-south, and the closest point of the Beaver Creek alluvium to the Windy Hill #3-17D well is approximately 2.6 miles west-southwest of the well. The Beaver Creek alluvium joins the South Platte River alluvium approximately 3.5 miles northwest of the Windy Hill #3-17D well. Both alluvial aquifers are hydrologically isolated

from the Dakota J Sandstone by about 3,000 vertical feet of Pierre Shale and between 700 and 1,000 feet of deeper, low-permeability shale formations within the Colorado Group.

The population of the City of Brush was 5,465 in 2013, based on records from the Colorado Department of Local Affairs, State Demographer's Office (SDO 2015a). SDO (2015b) population projections show an annual growth rate for Morgan County (projections are available only on a county level) ranging from approximately 0.9 percent to 1.3 percent and averaging approximately 1.1 percent through the year 2040. Applying the Morgan County projection rates to the 2013 population for Brush suggests that the population of Brush will grow to approximately 7,341 by 2040, for an increase of 34 percent. The municipal water demand can be anticipated to grow at a rate approximately equal to the population increase, which would result in a water demand ranging seasonally from 800,000 to 4 million gallons per day by the year 2040. This demand could be met by the shallow source aquifer currently in use by the City of Brush.

No source water assessment or protection, or designated sole-source aquifers, were identified within the AOR or the boundary for which Windy Hill is requesting the aquifer exemption.

The Dakota Sandstone is a water bearing formation within the Windy Hill project area, based on testing performed on wells there. Test results and calculations using those results indicate that well yields could be on the order of 500 to 800 gallons per minute (gpm). However, it is unlikely that the Dakota Sandstone will be tapped to supply water for municipal, domestic, stock or agricultural use in the area, due to the poor-quality water available from the Dakota Sandstone, the high cost of drilling deep wells to access the Dakota Sandstone at depths on the order of 5,000 feet, and the high cost and difficulty of treating Dakota Sandstone water to remove excess TDS.

For example, given the high TDS of approximately 6,600 mg/L (**Table 3**) and the fact that most of the TDS is comprised of sodium, chloride, and alkalinity (most likely as bicarbonate), the most inexpensive commercially viable water treatment technology to remove sodium, chloride, and bicarbonate to below the secondary maximum contaminant level standard of 500 mg/L for TDS (EPA 2015a) in the Dakota Sandstone water would be brackish water reverse osmosis (BWRO). For a design flowrate of 800 gpm, the capital cost estimate for a new water treatment plant (WTP) housing a microfiltration (MF) system to protect the BWRO membranes from particulate matter, along with the BWRO system, would cost approximately \$7.8 million to design and construct. This estimate is equivalent to an Association for the Advancement of Cost Engineering Class IV capital cost estimate of +50 percent/-30 percent and includes direct costs such as the cost of the mechanical equipment, installation, and delivery, the WTP building, piping within the WTP, electrical and instrumentation, as well as indirect costs such as startup and commissioning, spares, and engineering and procurement. The estimated annual operating cost for the BWRO WTP is approximately \$880,000, which includes chemicals (antiscalant, membrane cleaning chemicals), consumables, labor, and electricity and assumes that the WTP would operate 95 percent of the time. The cost of electricity used for the estimate is \$0.10/kilowatt-hour (kWh) according to data about the current commercial electricity rates in Brush (Electricity Local 2015). Labor was included in the cost estimate under the assumption that a BWRO WTP will require more manpower to operate than the existing WTP that only requires chlorination, so that

additional staff would be required. These capital and operating cost estimates match well with published data on BWRO WTPs (Wittholz et al. 2008; Lapuente 2012; Karagiannis and Soldatos 2008). In addition to the WTP, a pipeline approximately 2 miles long with 8-inch diameter piping would also be necessary to convey either the raw or treated water to the City of Brush, depending on whether the BWRO WTP would be located by the aquifer or in the City of Brush. At approximately \$50 per foot of 8 inch ductile iron piping to convey 500-800 gpm of water, it would cost approximately \$500,000 to lay the pipeline. This estimate does not include the costs of easements or potential road or railroad crossings of the pipeline.

The estimated costs stated in the preceding paragraph are based on the assumption that no other pre-treatment process besides microfiltration would be necessary for the BWRO system. However, it is possible that other pre-treatment processes may be necessary, because the total iron concentrations of 78 and 89 mg/L (**Table 4**) are considered too high for reverse osmosis (RO) membranes to handle and can pose a risk for membrane scaling if most of the iron is initially dissolved and would not be removed by the MF system prior to entering the BWRO system (Wilf 2001). An iron-removal pre-treatment system, such as manganese greensand filtration, would add approximately \$900,000 to the capital costs and approximately \$130,000 to the annual operating costs.

Besides the costs stated above, another potential issue that may increase the estimated capital and operating costs for treating the Dakota Sandstone water for potable use is brine management and disposal. Reverse osmosis membrane treatment processes generate a brine waste stream, and the preceding capital and operating cost estimates assume that the RO brine can be discharged either to the City of Brush's wastewater treatment plant (WWTP) or directly to the South Platte River. However, because the RO brine stream would not only contain high TDS (approximately 26,000 mg/L TDS) but also potentially high concentrations of metals that may inhibit the biological treatment process at the City of Brush's WWTP (EPA 1987), the WWTP may not be able to accept RO brine waste from a BWRO WTP without first treating the brine to remove metals. Furthermore, the EPA has opposed the direct discharge of RO brine from potable WTPs in Milliken and Cottonwood in Colorado into nearby streams (EPA 2015b). Therefore, it is likely that an RO brine treatment system would also need to be implemented, in addition to a pipeline to convey the treated RO brine to either the WWTP or to the South Platte River. Because the exact degree of brine waste stream treatment that would be necessary to discharge either to the WWTP or to the South Platte River is unknown without more detailed data collection and analyses of water chemistry parameters and discussions with regulators, it is impossible to conduct capital or operating cost estimates for brine waste treatment except to state that these are components that are likely to add further costs to building and operating a BWRO WTP to treat the Dakota Sandstone water for potable use.

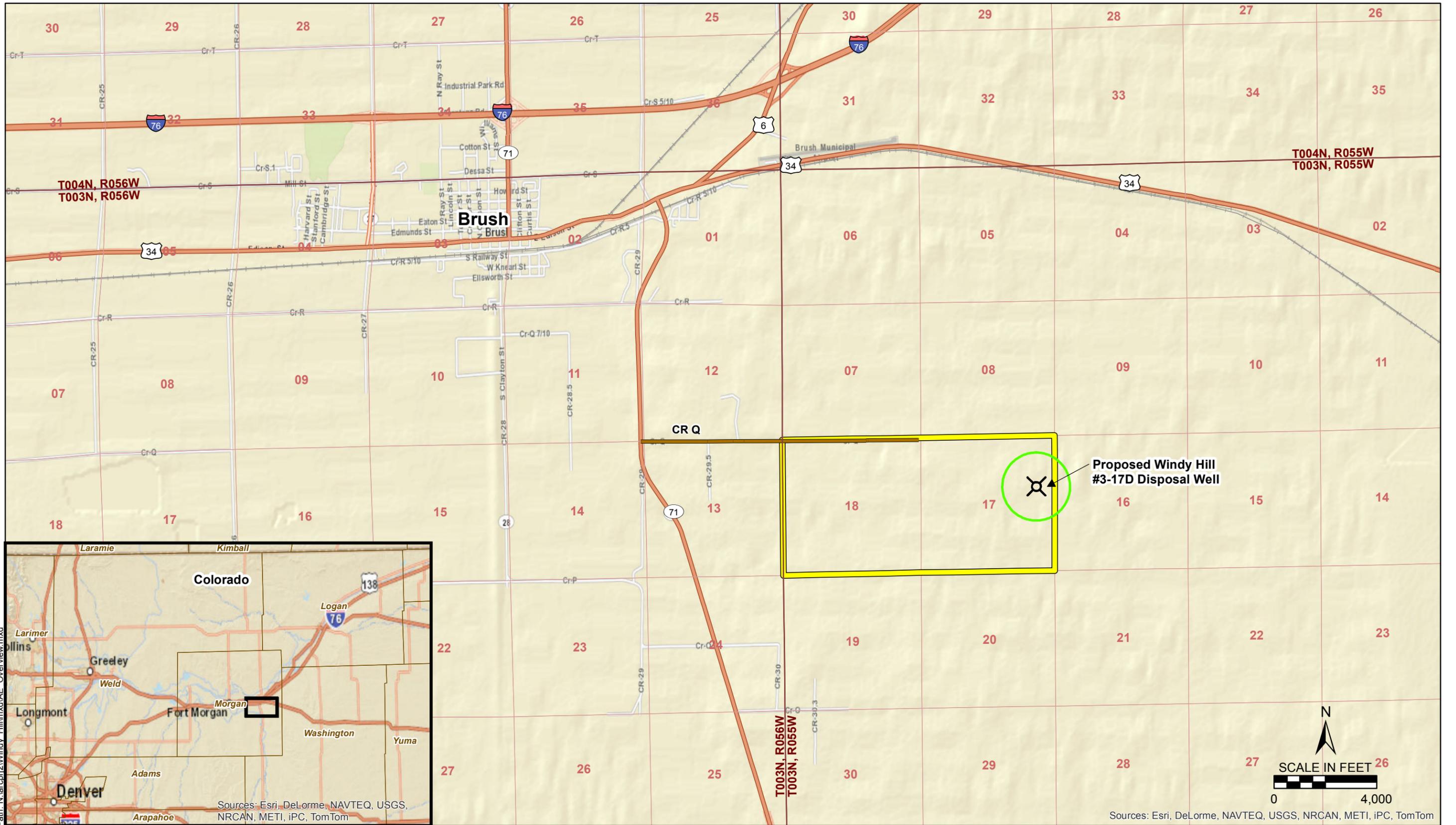
Some industrial uses may be viable despite the high TDS concentrations; the potential for industrial use would depend on the water quality requirements of the user.

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**Legend**

-  Windy Hill #3-17D Disposal Well
-  Aquifer Exemption Boundary (1/4-mile radius)
-  Project Area Boundary

November, 2015

**Figure 1**

**Project Location Map**

Windy Hill Water Operations, LLC  
114-910338

Windy Hill Water Operations, LLC  
 Windy Hill 3-17D  
 SENE Sec 17 T3N R55W  
 Morgan County, Colorado  
 API # 05-087-08145-00

6/29/2015  
 ASP  
 (info from previous operator's file)

KB = 4,499' (18 FT above GL)  
 GL elevation = 4,481'

NOTE: 11" 3,000 WP tubing head w/ 4 1/2" valves.  
 13 5/8" 3M SOW casing head

17 1/2" hole

ID: 12.615" Drift: 12.459"  
 Burst: 2,730 psi Collapse: 1,130 psi

13-3/8" 54.5 # J-55 STC @ 485'

13-3/8" casing cmt'd with 350 sx  
 Halliburton 7/27/2007

**Logs Run:**  
 SWS 8 5/8" CBL run 8/15/2007  
 SWS 12 1/4" openhole log suite @ 5433' run 8/12/2007

12 1/4" hole

5 1/2" 17# J-55 BTC tubing, 119 jts.  
 anchor assembly, stung into packer at 5050'

5050'

Baker Model DA 8 5/8" x 4 1/2" drillable packer

9/26/2007

**J-SAND PERFORATIONS**  
 5,130 FT to 5,300 FT (170 FT)  
 680 holes  
 TCP perf on BJ coil 9/29/07

Top perf 5130'

Btm perf 5300'

ID = 7.921" ; Drift = 7.875"  
 Burst: 5,360 psi; Collapse: 2,950 psi

PBTD: ± 5,385'  
 8 5/8" 32# LS-80 BTC @ 5,431'

TD 5,433' MD / TVD

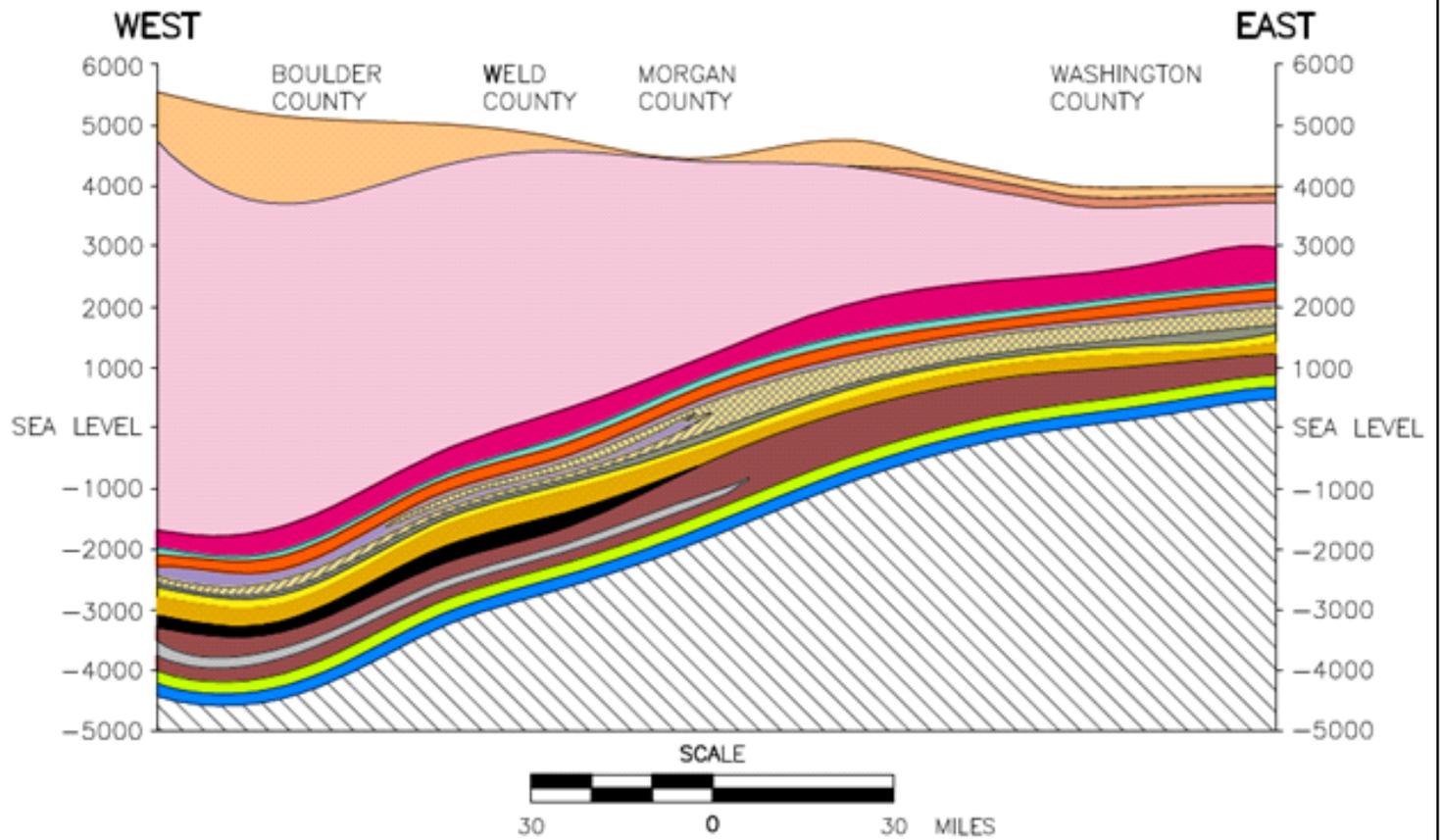
8-5/8" casing primary cemented with 1,830 sx  
 Halliburton 8/14/2007  
 Top job, cemented to surface  
 Halliburton 8/15/2007



Figure 2

Windy Hill #3-17D Construction Details  
 Windy Hill Water Operations, LLC  
 114-910338

10/7/2015 N:\arcpri2\Windy Hill.mxd\Geologic Cross Section.mxd



**LEGEND:**

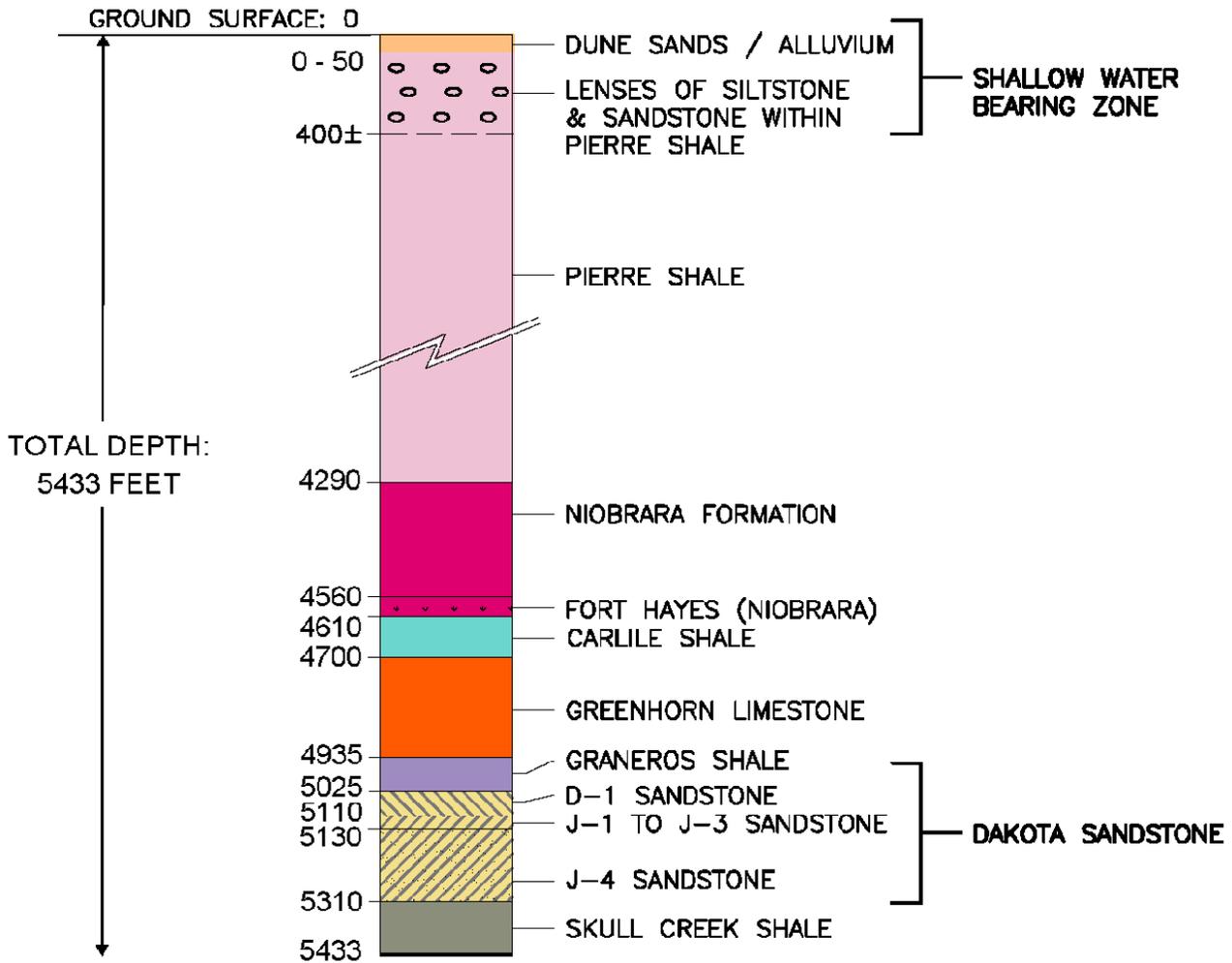
- |   |  |
|---|--|
|  SURFACE DEPOSITS                  |  SKULL CREEK SHALE                  |
|  TERTIARY ROCKS (UNDIFFERENTIATED) |  PLAINVIEW-LYTTLE SANDSTONE         |
|  PIERRE SHALE                      |  MORRISON FORMATION                 |
|  NIOBRARA FORMATION                |  TRIASSIC                           |
|  CARLILE SHALE                     |  PERMIAN SYSTEM                     |
|  GREENHORN LIMESTONE               |  LYONS SANDSTONE (PERMIAN)          |
|  GRANEROS SHALE                    |  FOUNTAIN FORMATION (PENNSYLVANIAN) |
|  D SANDSTONE                       |  LOWER PALEOZOIC (UNDIFFERENTIATED) |
|  J SANDSTONE                       |  PRECAMBRIAN                        |
|  D & J SANDSTONE MERGED            |  |

SOURCE: RMAG 1976.

October, 2015

Figure 3



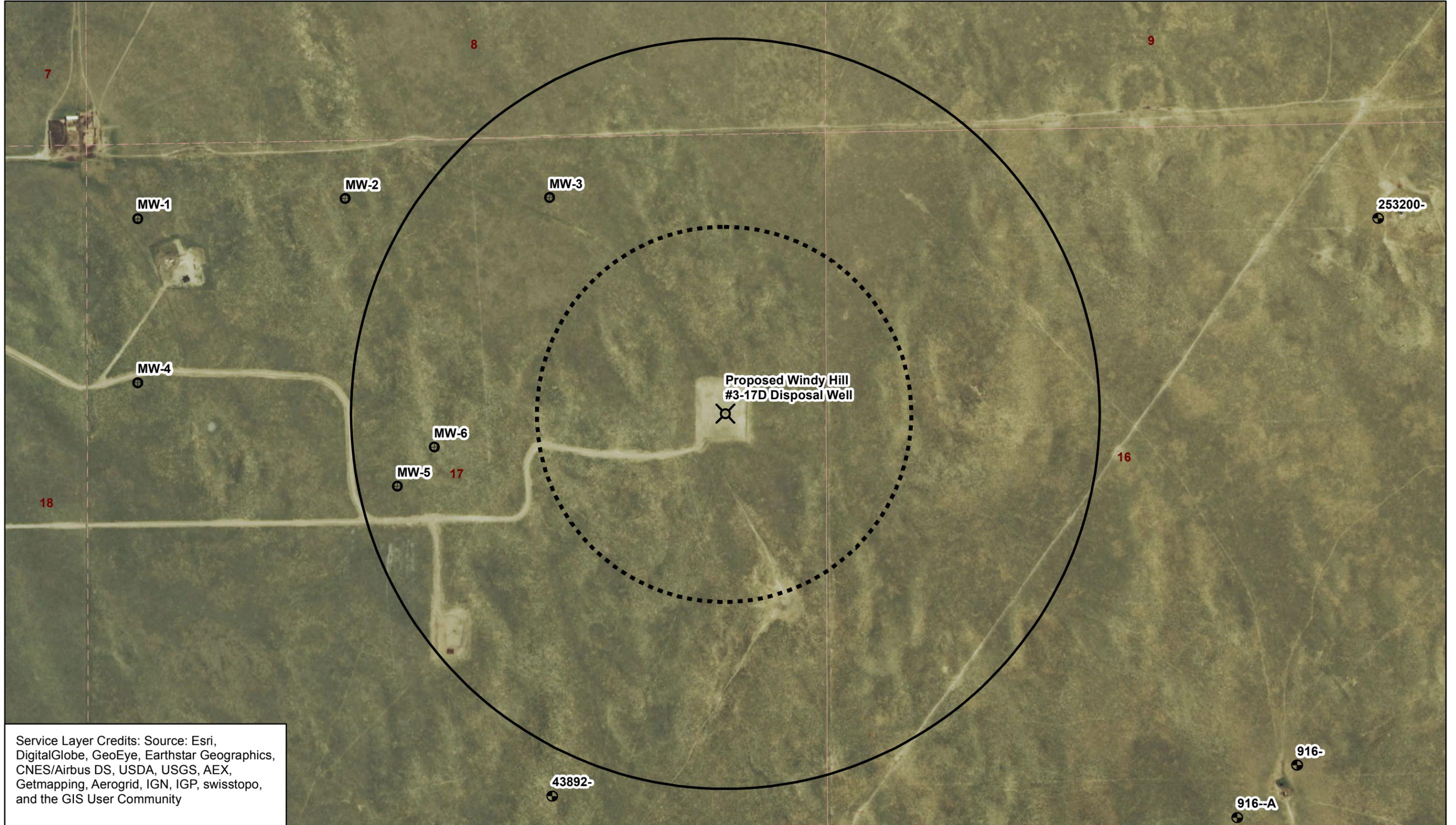


October, 2015

Figure 4



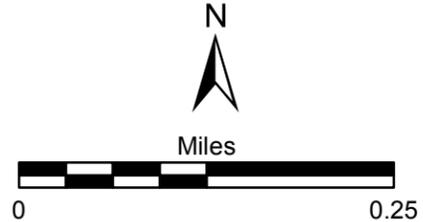
Path: N:\arcp12\Windy\_Hill\mxd\Wells\_one\_mile\_317D.mxd



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



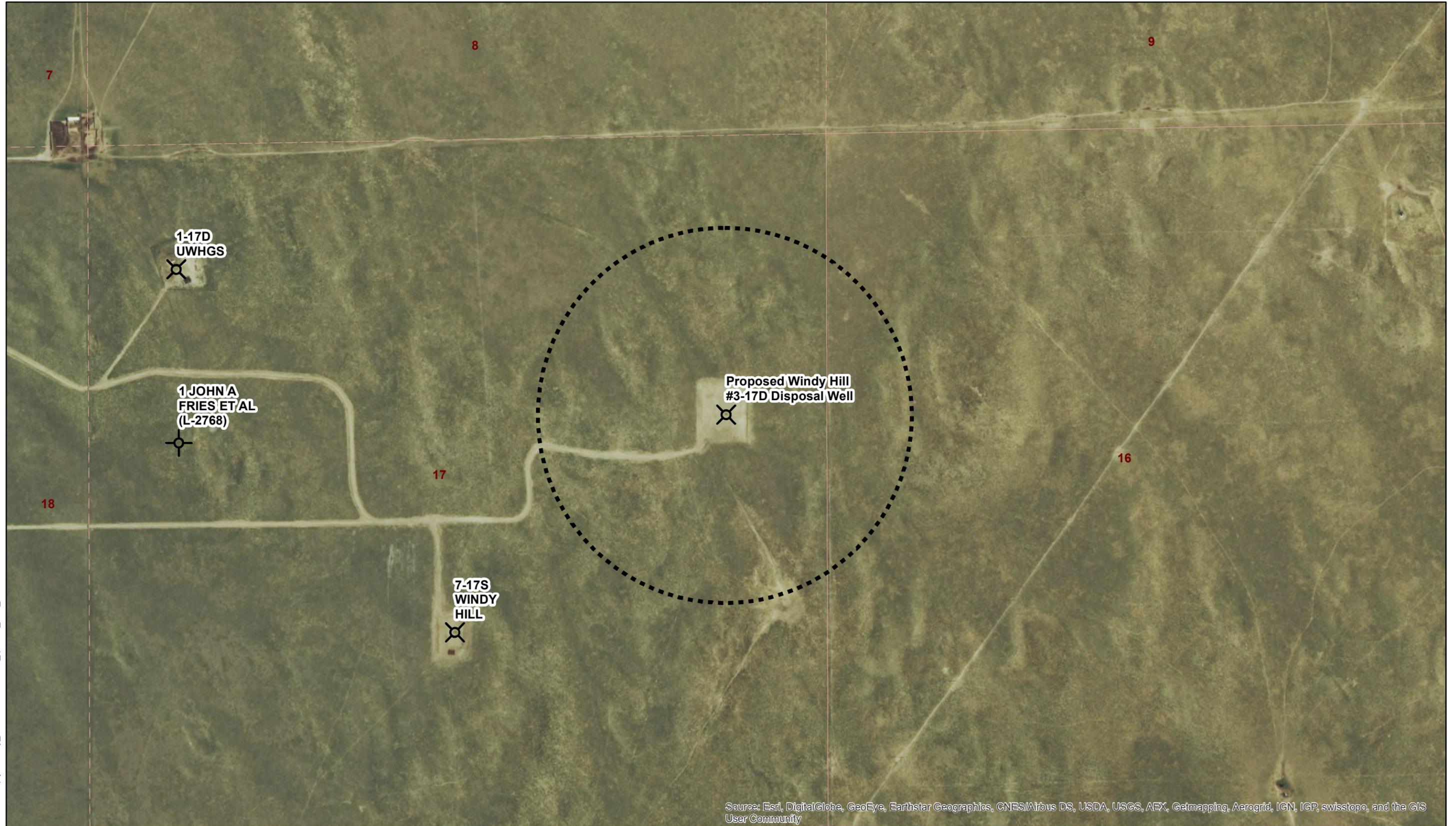
- Legend**
- Windy Hill #3-17D Disposal Well
  - Water well
  - Monitoring well
  - Aquifer Exemption Boundary (1/4-mile radius)
  - 1/2-mile radius



November, 2015  
Figure 5

**Water Wells within 1/4-Mile and 1/2-Mile of Windy Hill #3-17D**  
Windy Hill Water Operations, LLC  
114-910338

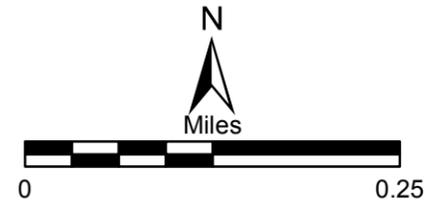
Path: N:\arcpj2\Windy\_Hill\mxd\O&GWells\_quarter\_mile\_317D.mxd



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

**Legend**

-  Drilled and abandoned well
-  Inactive injection well
-  Aquifer Exemption Boundary (1/4-mile radius)



November, 2015

**Figure 6**

**Oil & Gas Wells within 1/4-Mile of Windy Hill #3-17D**

**Windy Hill Water Operations, LLC**  
114-910338

**ATTACHMENT 1**  
**AQUIFER EXEMPTION EVALUATION**

## Aquifer Exemption Evaluation

**Regulatory Agency:** Colorado Oil and Gas Conservation Commission (COGCC) 1425 Program

**Date of Aquifer Exemption Request:** November 5, 2015

**Substantial or Non-Substantial Program Revision:** Non-Substantial

**Basis for Substantial or Non-Substantial Determination:** This AE request is considered non-substantial, consistent with EPA Guidance 34.

**Operator:** Windy Hill Water Operations, LLC

**Well Class/Type:** Class II UIC Well

**Well/Project Name:** Windy Hill #3-17D

**Well/Project Permit Number:** N/A

**Well API number:** 05-087-08145-00

**Field:** Unnamed

**Tribal Reservation:** None

**Well/Project Location:** Qtr: SENE Section: 17 Township: 3N Range: 55W

**Footage Call:** 1974 feet from (NS) line 715 feet from (EW) line

**County:** Morgan

**State:** CO

**Latitude:** 40.22796

**Longitude:** -103.54932 (decimal degree, 5-decimals)

### **DESCRIPTION OF PROPOSED AQUIFER EXEMPTION (depths are approximate values at the well bore)**

**Aquifer to be Exempted:** Dakota J4 Sandstone **Top:** 5128 feet bgs (-647 ft msl) **Bottom:** 5300 feet bgs (-819 ft msl)

**Lithology:** Sandstone

**Water Quality – TDS (mg/L):** 6,600 mg/L to 10,000 mg/L **Source of WQ Data:** Analysis of 4/15/2015 sample from Windy Hill #3-18WSW well and 2/7/2005 sample from Windy Hill #1-17D well

### **Areal Extent and Description of Exempted Aquifer (i.e. radial distance, encompassed TSR)**

**Total Area of Aquifer to be Exempted:** 125.6 Acres

**Description:** The area within a radial distance of one-quarter (0.25) mile from Windy Hill #3-17D, which includes all or parts of the following quarter-quarter sections in Township 3 North, Range 55 West, 6th Principal Meridian:

Section 17: NENE, NWNE, SWNE, SENE, NESE, NWSE; and

Section 16: NWNW, SWNW, NWSW.

### **Confining Zone(s):**

**Upper: Lithology:** Colorado Group and Pierre Shale: shale, limestone **Top:** Approx. 100 feet bgs **Bottom:** 5125 feet bgs

**Lower: Lithology:** Morrison Fm.: shale, sandstone **Top:** 5312 feet bgs **Bottom:** 5550 feet bgs

### **BACKGROUND**

**USDW(s):** Unconsolidated Eolian deposits, land surface to approximately 100 feet bgs

**Injectate Characteristics:** Oil & Gas Exploration & Production wastes

## **BASIS FOR DECISION**

### **Regulatory Criteria under which the exemption is requested**

146.4:  (a) Not currently used as a drinking water source and:

- How far from the AE boundary to review drinking water wells and how was this determined?
  - AE boundary is 0.25-mile radius; water well search area boundary was 0.5-mile radius. Water well search area boundary was determined by adding a buffer distance equal to the AE boundary radius.
- Identify drinking water wells in area of review, their depths, and provide source of information.
  - The Colorado Division of Water Resources water well database was searched to identify water wells within the area of review. No drinking water wells were identified as present within the area of review.
- Identify any source water assessment and/or protection areas and designated sole source aquifers
  - No source water assessment or protection areas or designated sole source aquifers are present within the area of review.
- Identify nearest public water supply (PWS).
  - The nearest PWS is a well field operated by the City of Brush. The well field is approximately four (4) miles west-southwest of the Windy Hill #3-17D well and obtains water from an alluvial aquifer along Beaver Creek in Section 27, Township 3 North, Range 56 West.
- What is the distance of the nearest drinking water well utilizing the aquifer proposed for exemption. If so, is it in close enough proximity to require a capture zone analysis?
  - A search of the Colorado Division of Water Resources water well database indicated that the nearest drinking water well completed in the aquifer proposed for exemption, the Dakota Sandstone, is approximately 54 miles from the proposed aquifer exemption area. This distance is far beyond a distance potentially requiring a capture zone analysis. The database search was conducted screening for wells that are permitted for one of the following uses: domestic, household use only, municipal, other, or all beneficial uses.
- Provide map of AE boundary and location of drinking water wells.
  - See Figure 5 of the Windy Hill Aquifer Exemption Request report.

(b)(1) It is mineral, hydrocarbon, or geothermal energy producing, or can be demonstrated by a permit applicant as part of a permit application for a Class II or Class II operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible; or

- Projections on future use of the proposed aquifer.

#### ***Hydrocarbon Production Data:***

- Demonstrate historical production having occurred in the project area or field.
  - Hydrocarbon production from the Dakota Sandstone has occurred within about 4 miles of the proposed aquifer exemption area, based on COGCC data.
- Demonstrate existence hydrocarbon (logs, core data, etc) and estimation of the quantity of the hydrocarbon potential.
  - Oil was present in Dakota J Sandstone core from the John A Fries et al (L-2768) #1 well (API #05-087-05996) about 3,870 feet (0.73 mile) west of Windy Hill #3-17D, based on data from the COGCC.

**Mineral Resources Available:**

- A summary of logging which indicates that commercially producible quantities of minerals are present, a description of the mining method to be used, general information on the mineralogy and geochemistry of the mining zone, and a development timetable.

**(b)(2)** It is situated at a depth or location which makes recovery of water for drinking water purposes economically or technologically impractical; or

- Projections on future use of the proposed aquifer.
- Current sources of water supply in the area of the proposed exempted aquifer.
- Availability, quantity and quality of alternative water supply source(s) to meet present and future needs.
- Population trends in the area and analysis of future water supply needs within the general area.
- Well construction and water transportation and/or treatment costs to develop aquifer proposed for exemption compared to costs to develop alternative resource(s).

**(b)(3)** It is so contaminated that it would be economically or technologically impractical to render that water fit for human consumption; or

- Projections on future use of the proposed aquifer.
- Concentrations, types, and source of contaminants in the aquifer.
- If contamination is a result of a release, extent of contaminated area and whether contamination source has been abated.
- Ability of treatment to remove contaminants from ground water.
- Current sources of water supply in the area of the proposed exempted aquifer.
- Availability, quantity and quality of alternative water supply source(s) to meet present and future needs.
- Population trends in the area and analysis of future water supply needs within the general area.
- Well construction and water transportation and/or treatment costs to develop aquifer proposed for exemption compared to costs to develop alternative resource(s).

**(c)** TDS is more than 3,000 and less than 10,000 mg/l and it is not reasonably expected to supply a public water system.

- Projections on future use of the proposed aquifer.
  - The Dakota J Sandstone is a water bearing zone in the vicinity of the proposed aquifer exemption area. The aquifer proposed for exemption is highly unlikely to be developed as a source of drinking water because of the cost of obtaining and treating groundwater from the aquifer. Theoretically, groundwater from the aquifer could be used for other purposes for which water quality is relatively unimportant.
- Include information about the quality and availability of water from the aquifer proposed for exemption.
  - The aquifer proposed for exemption is a water bearing zone. Wells drilled into the aquifer would need to have depths on the order of 5,100 to 5,300 feet. Testing of wells in the project area indicated that 400 to 800 gallons per minute would be available from the Dakota J Sandstone. Water samples from the site indicate the Dakota J Sandstone groundwater contains between approximately 6,600 and 10,000 mg/L total dissolved solids consisting primarily of sodium, chloride, and alkalinity.
- Analysis of the potential for public water supply use of the aquifer. This may include: a description of current sources of public water supply in the area, a discussion of the adequacy of current water supply sources to supply future needs, population projections, economy, future technology, and a discussion of other available water supply sources within the area.

- The nearest population center, the City of Brush, obtains its public water supply from wells approximately 150 feet deep that are drilled into a shallow alluvial aquifer several miles west of the proposed aquifer exemption area. The alluvial aquifer does not cross through the proposed aquifer exemption area. During consultation with the City regarding this aquifer exemption request, the City indicated that it is unlikely that they would consider obtaining water from the Dakota Sandstone, given the good quality and ready availability of water from the City's current source aquifer, particularly in contrast to the poorer-quality water in the Dakota Sandstone, the high cost of drilling deep wells to access the Dakota Sandstone water, and the high cost and difficulty of treating Dakota Sandstone water to remove excess total dissolved solids. Population growth projections for the City of Brush indicate that future increased water demand could be met by the shallow source aquifer currently in use by the City.

**Describe what assurance exist to confine fluids within the AE boundary:**

- Discuss injection rate or volume limitation
  - Injection rates are anticipated to be up to 5,000 barrels per day during years 1 and 2 of operation, up to 10,000 barrels per day during years 3 through 5 of operation, and up to 25,000 barrels per day for the remainder of the project life. The maximum permissible injection rate is expected to be specified by the COGCC.
- Discuss existence and quality of confining zone(s). (Is the confining zone continuous, are there known fractures?)
  - The Dakota J Sandstone is separated from shallower aquifers by several thousand feet of regionally-continuous, low-permeability shale of the Colorado Group and the Pierre Shale. These units extend from the top of the Dakota J Sandstone up to within about 100 feet of the land surface and serve as an overlying confining layer. The Dakota J Sandstone is confined below by the Morrison and Chugwater Formations, both of which are regionally continuous. No identified faults or fractures occur in the project vicinity.

**Public Comment**

Public Comment Conducted?  Yes  No

Results of Public Comment Process:

**Checklist of Questions to Consider**

- Are there deeper aquifers with poorer quality water that can be used for injection (disposal wells)?**
  - Not determined. No deeper aquifers that may exist in the area are developed.
- Proximity to other jurisdictional boundaries?**
  - The proposed aquifer exemption area is near the Morgan County border but lies entirely within Morgan County and the State of Colorado.
- Is seismicity a concern in the area?**
  - Seismicity is not a concern in the area. The proposed aquifer exemption area is in an area of low seismicity. No identified faults or fractures occur in the vicinity.
- Will injection of fluids cause any original formation fluid or injectate to migrate to any known USDW?**
  - No.
- Are all wells within the AE boundary and AOR properly cemented to prevent preferential flow paths?**
  - There are no wells within the 0.25-mile AE boundary and AOR.

**Provide other considerations to support aquifer exemption approval:**

**ATTACHMENT 2**

**WATER WELL 3-18WSW DAKOTA J-4 SANDSTONE FORMATION  
SAMPLING, 2015**

**MEMORANDUM**

**TO:** Lee Robinson, Windy Hill Gas Storage LLC

**FROM:** Nikki Scheinost and Elaine Porter, Tetra Tech, Inc.

**SUBJECT:** Water Well 3-18WSW Dakota J-4 Sandstone Formation Sampling

**DATE:** May 15, 2015

**PROJECT:** 114-910338

---

On April 15, 2015, Tetra Tech, Inc. (Tetra Tech) collected water samples from the Dakota J-4 Sandstone Formation in an existing well identified as FW-3-18WSW located at the Windy Hill project site near Brush, Colorado. The intent of this sampling event was to determine the total dissolved solids (TDS) concentration of the Dakota J-4 Sandstone Formation at the site, to identify the permitting requirements for the on-site disposal of exploration and production (E&P) waste into that formation via a Class II underground injection control (UIC) well (a well other than 3-18WSW). Per Colorado Oil and Gas Conservation Commission (COGCC) Rule 324B (Exempt Aquifers), permitting requirements are dictated by the TDS results in the following bracketed concentrations: 1) less than 3,000 milligrams per liter (mg/L), 2) more than 3,000 and less than 10,000 mg/L, and 3) more than 10,000 mg/L. Determining which bracket is applicable to the Windy Hill project was the intended use of the samples that Tetra Tech collected.

Samples were collected in accordance with the April 14, 2015, Sampling and Analysis Plan that Tetra Tech prepared for this sampling event. The sampling event included the collection of two sets of samples, as described below. Field parameters were collected prior to sample collection and documented in the field notes that are included in **Attachment 1**.

**Sample Set #1**

Prior to sample collection, Tetra Tech obtained information regarding the recent well activities. Based on information provided by Peterson Energy Operating, Inc., the well had been swabbed five times the previous day. At the request of Tetra Tech, Peterson Energy Operating, Inc. swabbed the well four more times prior to sample collection to ensure that representative samples were collected. Water from the well was collected directly from a pipe equipped with a valve located at the wellhead. Water was placed into a new 5-gallon plastic container and then transferred to the pre-cleaned lab-supplied sample bottles via disposable tubing and a peristaltic pump. Two water samples, including one parent sample and one blind field duplicate sample, were collected for TDS analysis at ALS Environmental Laboratory (ALS). The samples were placed on ice in a cooler until they were hand-delivered to ALS on April 16, 2015. Appropriate chain-of-custody (C-O-C) procedures were implemented during sample collection and delivery. The field sampling notes are included in **Attachment 1**.

A copy of the ALS report (Work Order # 1504297) is included in **Attachment 2**. The lab report was corrected at the request of Tetra Tech to document the geologic formation from which the samples were

collected (Dakota J-4 Sandstone). Tetra Tech reviewed the analytical data to evaluate if quality assurance and quality control objectives (QA/QC) were achieved. The data evaluation results are documented in the Data Evaluation Checklist included in **Attachment 3**. The laboratory reported that the sample cooler was received outside specification ( $4\pm 2^\circ$  Celsius (C)), at  $7^\circ$  C upon receipt. Thus, the sample results are qualified as estimated due to sample preservation being outside specifications. No other QA/QC deficiencies were identified and the laboratory analytical results are considered usable for the intended use.

The COGCC Class II UIC permit application requires submittal of the proposed injection formation TDS. The lab report indicates that both sample results for TDS are 6,600 mg/L (**Table 1**).

**Table 1. Total Dissolved Solids Sample Results**

Parameter	Sample Results (mg/L)	
	FW-3-18WSW-01	FW-3-18WSW-02
TDS	6600	6600

Because the TDS results are more than 3,000 and less than 10,000 mg/L: 1) an aquifer exemption will be required for on-site disposal into the Dakota J-4 Sandstone Formation, and 2) in order to obtain an aquifer exemption from the U.S. Environmental Protection Agency, Windy Hill must demonstrate that the formation is not reasonably expected to supply a public water system. Additional analytical laboratory analyses may be useful to further characterize the water samples for use in an aquifer exemption request; therefore, Tetra Tech requested additional laboratory analyses for the two samples on April 27, 2015. The additional analyses included the following parameters:

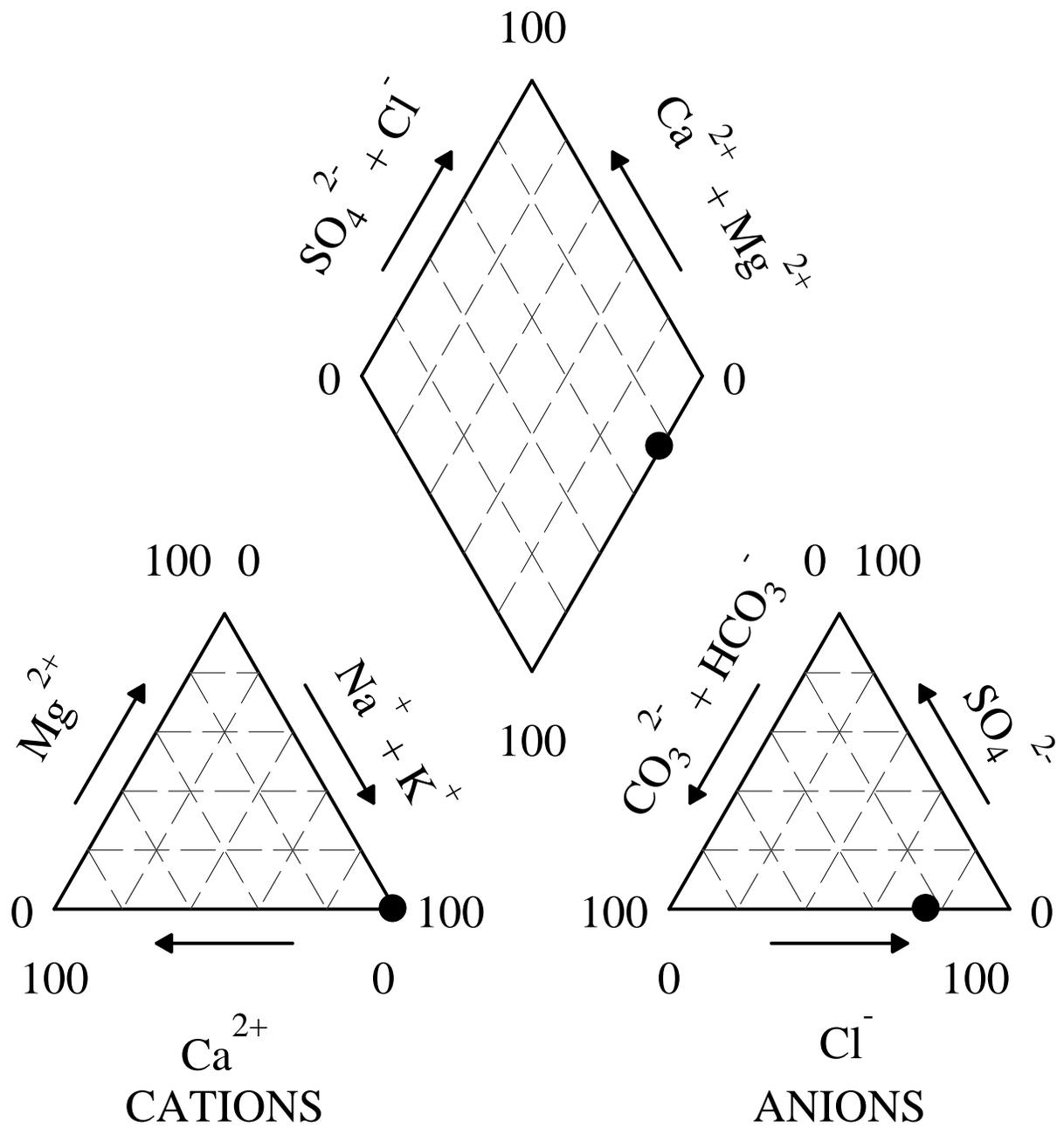
- Anions: bromine, chloride, fluorine, nitrite, nitrate, and sulfate;
- Cations (total): calcium, potassium, magnesium, sodium, and iron;
- Total alkalinity

The results of these additional analyses are presented in **Table 2**, and the ALS report is included in **Attachment 2**. The Piper diagram that follows **Table 2** shows that the water type is sodium chloride. Per the Data Evaluation Checklist included in **Attachment 3**, the analyses for nitrate and nitrite were performed outside the recommended hold time for Method 300.0. This deviation is not expected to significantly affect the reported results for these parameters. No other QA/QC deficiencies were identified and the laboratory analytical results are considered usable for the intended use.

**Table 2. Summary of Anion and Cation Sample Results**

Parameter	Sample Results (mg/L)	
	FW-3-18WSW-01	FW-3-18WSW-02
Total Alkalinity	1700	1700
Bromide	30	30
Fluoride	2.7	2.7
Nitrate as N	<2	<2
Nitrite as N	<1	<1
Sulfate	<10	<10
Chloride	3100	3100
Calcium	11	11
Iron	89	78
Magnesium	2.9	2.9
Potassium	24	24
Sodium	2200	2200

# Windy Hill Water Sample - Dakota J4 Sandstone - April 15, 2015





## **Sample Set #2**

Tetra Tech collected three additional samples in containers provided by Peterson Energy Operating, Inc. Tetra Tech hand-delivered these samples to Baker Hughes Lab in Brighton, Colorado, Halliburton Lab in Fort Lupton, Colorado, and CalFrac Lab in Platteville, Colorado. Tetra Tech was not responsible for evaluating the sample results from these laboratories.

**ATTACHMENT 1**

## Technical Memorandum

**To:** Elaine Porter **From:** Jeff DeTienne  
**Company:** Tetra Tech **Date:** April 17, 2015  
**Re:** Windy Hill 3-18WSW Sampling **Project #:** 114-910338  
**CC:** \_\_\_\_\_

---

- **Tuesday, April 14, 2015**
  - Sampling preparation. Picked up sample bottles from ALS lab in Fort Collins, CO
  - Prepared JSA, HASP
  - Gathered necessary sampling equipment
- **Wednesday, April 15, 2015**
  - TIME 6:00am Traveled to site south of Brush, CO
  - 7:30am met with Bob Kuehn, representing Peterson Energy, to discuss logistics.
  - Reviewed documents provided by Peterson Energy regarding well construction and current activities at the well location.
  - I was informed that the well was swabbed five times on 4/14/15
  - Purged water was being held in a steel tank on site. Appeared to be 1,000 to 1,500 gallons of purged water in tank.
  - Recommended to on-site drilling personnel that they swab it 3-4 additional times prior to sampling to obtain representative samples.
  - **Field parameters after purge #2:**
  - pH 8.07
  - Conductivity 12.86 mS/cm
  - Temp. 28.3°C
  - TDS 8.23 g/L
  - **Field parameters after purge #4:**
  - pH 7.89
  - Conductivity 13.39 mS/cm
  - Temp. 36.7°C
  - TDS 8.58 g/L
  - **9:00am Obtained samples to be submitted to ALS for TDS**
  - **Purge #5:**
  - Obtained (3) 5-gallon buckets to be submitted to other labs requested by Peterson Energy
  - 12pm delivered (1) 5-gallon bucket of water to Baker Hughes lab in Brighton, CO
  - 12:30pm delivered (1) 5-gallon bucket of water to Halliburton lab in Fort Lupton, CO
  - 1pm delivered (1) 5-gallon bucket of water to CalFrac lab in Platteville, CO
  - Spoke with Andy Peterson to let him know that samples were obtained from the well and that buckets were delivered to the appropriate laboratories.
- **Thursday, April 16, 2015**
  - 9:30am delivered two sample bottles to ALS lab in Fort Collins, CO

WINDY HILLS 114-910338

6am - TRAVEL TO BOUSA (4/15/15)  
730am - MET W/ BOB KREW (QUEST MGT)

- DOCUMENT REVIEW  
- HEALTH & SAFETY

- WELL WAS SLABBED 5 TIMES  
ON 4/14/15

- CHECKED PURGE WATER IN SHEL  
TANK FOR CONSISTENCY

- RECORDED 3-4 ADDITIONAL PURGES  
PRIOR TO SAMPLING

FIELD PARAMETERS

PURGE #2  
PH 8.07  
CONDUCTIVITY 12.86 mS/cm  
TEMP 28.3°C  
TDS 8.23 g/L

PURGE #4 (SAMPLES FOR LAB TESTS)  
2-BOTTLES (ICED)

PH 7.89  
COND. 13.39 mS/cm  
TEMP 36.7°C  
TDS 8.58 g/L

PURGES  
COLLECTED (3) 5-GALLON BUCKETS  
OF WATER

12pm-2pm  
DELIVERED BUCKETS TO BAKER HUGHES,  
HARRISBURG, AND CAL-JORDAN

4/16/15 8am DELIVERED 2-BOTTLES  
TO ACS LAB

**ATTACHMENT 2**

Tuesday, April 28, 2015

Elaine Porter  
Tetra Tech  
4900 Pearl East Circle, Suite 300W  
Boulder, CO 80301-6118

Re: ALS Workorder: 1504297  
Project Name: Windy Hill  
Project Number:

Dear Porter:

Two water samples were received from Tetra Tech, on 4/16/2015. The samples were scheduled for the following analysis:

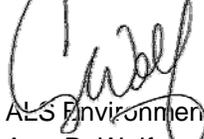
Inorganics

The results for these analyses are contained in the enclosed reports.

The data contained in the following report have been reviewed and approved by the personnel listed below. In addition, ALS certifies that the analyses reported herein are true, complete and correct within the limits of the methods employed.

Thank you for your confidence in ALS Environmental. Should you have any questions, please call.

Sincerely,



ALS Environmental  
Amy R. Wolf  
Project Manager

ARW/mmj  
Enclosure(s):

ALS Environmental – Fort Collins is accredited by the following accreditation bodies for various testing scopes in accordance with requirements of each accreditation body. All testing is performed under the laboratory management system, which is maintained to meet these requirement and regulations. Please contact the laboratory or accreditation body for the current scope testing parameters.

ALS Environmental – Fort Collins	
Accreditation Body	License or Certification Number
Alaska (AK)	UST-086
Alaska (AK)	CO01099
Arizona (AZ)	AZ0742
California (CA)	06251CA
Colorado (CO)	CO01099
Connecticut (CT)	PH-0232
Florida (FL)	E87914
Idaho (ID)	CO01099
Kansas (KS)	E-10381
Kentucky (KY)	90137
L-A-B (DoD ELAP/ISO 170250)	L2257
Maryland (MD)	285
Missouri (MO)	175
Nebraska(NE)	NE-OS-24-13
Nevada (NV)	CO000782008A
New Jersey (NJ)	CO003
New York (NY)	12036
North Dakota (ND)	R-057
Oklahoma (OK)	1301
Pennsylvania (PA)	68-03116
Tennessee (TN)	2976
Texas (TX)	T104704241
Utah (UT)	CO01099
Washington (WA)	C1280



**1504297**

**Inorganics:**

The samples were analyzed following MCAWW procedures for the current revision of the following SOP and method:

<u>Analyte</u>	<u>Method</u>	<u>SOP #</u>
TDS	160.1	1101

All acceptance criteria were met.

# ALS Environmental -- FC

## Sample Number(s) Cross-Reference Table

---

**OrderNum:** 1504297

**Client Name:** Tetra Tech

**Client Project Name:** Windy Hill

**Client Project Number:**

**Client PO Number:**

---

Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
FW-3-18WSW-01 (Dakota J-4 Sa	1504297-1		WATER	15-Apr-15	9:00
FW-3-18WSW-02 (Dakota J-4 Sa	1504297-2		WATER	15-Apr-15	9:00



**ALS Laboratory Group**  
 228 Commerce Drive, Fort Collins, Colorado 80524  
 Tel: (970) 225-4411 Fax: (970) 225-1111 PC: (970) 225-1022

**Chain-of-Custody**

Form 1000

PROJECT NAME WINDY HILLS (NB)		SAMPLER JEFF DREYER (NB)		DATE 4/15/12		WORKORDER 1504297	
PROJECT NO. 14-910338		SITE ID WINDY HILLS (NB)		TURNAROUND		PAGE of	
PURCHASE ORDER		BILL TO COMPANY FETA TECH - SPORT COLLEGE				By Lab or Return to Client	
SEND REPORT TO ELIJK REITER		ADDRESS					
CITY / STATE / ZIP		PHONE					
FAX		E-MAIL					
E-MAIL ELIJK.REITER@FETA.TECH		MATERIALS					
Lab ID	Field ID	Sample Date	Sample Time	Sample Bottle	Pres. QC		
①	(Dakota J4 Sandstone) W FW-3-18NSW-01	4/15/12	9:00	1	-	X	
②	(Dakota J4 Sandstone) W FW-3-18NSW-02 (NB)	4/15/12	9:00	1	-	X	

\*Time Zone (C=Day) EST CBT MST PST MEX. O=rd S=rd NG =non-std test W=week L=hour E=extra F=flat  
 For results or artifacts, please detail analysis below.

Container:	NO PACKAGE (leave blank)
	LEVEL 1 (RM GC)
	LEVEL 2 (RM GC - Heavy)
	LEVEL 3 (RM GC - Heavy - see sheet)
5 of 9	
Preservative Key:	1-HCl 2-HNO3 3-H2SO4 4-HClO4 5-H2SO4 7-Other 8-4 reagent C 9-035

RECEIVED BY	SIGNATURE	PRINTED NAME	DATE	TIME
RECEIVED BY	[Signature]	JEFF DREYER	4/16/12	9:30
RECEIVED BY	[Signature]	Ann Peterson	4/16/12	09:30
RECEIVED BY				
RECEIVED BY				



**ALS Environmental - Fort Collins**  
**CONDITION OF SAMPLE UPON RECEIPT FORM**

Client: Tetra Tech

Workorder No: 1504297

Project Manager: AW

Initials: CDJ Date: 4-16-15

1. Does this project require any special handling in addition to standard ALS procedures?		YES	<input checked="" type="radio"/> NO
2. Are custody seals on shipping containers intact?	<input checked="" type="radio"/> NONE	YES	NO
3. Are Custody seals on sample containers intact?	<input checked="" type="radio"/> NONE	YES	NO
4. Is there a COC (Chain-of-Custody) present or other representative documents?		<input checked="" type="radio"/> YES	NO
5. Are the COC and bottle labels complete and legible?		<input checked="" type="radio"/> YES	NO
6. Is the COC in agreement with samples received? (IDs, dates, times, no. of samples, no. of containers, matrix, requested analyses, etc.)		<input checked="" type="radio"/> YES	NO
7. Were airbills / shipping documents present and/or removable?	<input checked="" type="radio"/> DROP OFF	YES	NO
8. Are all aqueous samples requiring preservation preserved correctly? (excluding volatiles)	<input checked="" type="radio"/> N/A	YES	NO
9. Are all aqueous non-preserved samples pH 4-9?	N/A	<input checked="" type="radio"/> YES	NO
10. Is there sufficient sample for the requested analyses?		<input checked="" type="radio"/> YES	NO
11. Were all samples placed in the proper containers for the requested analyses?		<input checked="" type="radio"/> YES	NO
12. Are all samples within holding times for the requested analyses?		<input checked="" type="radio"/> YES	NO
13. Were all sample containers received intact? (not broken or leaking, etc.)		<input checked="" type="radio"/> YES	NO
14. Are all samples requiring no headspace (VOC, GRO, RSK/MEE, Rx CN/S, radon) headspace free? Size of bubble: ___ < green pea ___ > green pea	<input checked="" type="radio"/> N/A	YES	NO
15. Do any water samples contain sediment? Amount Amount of sediment: ___ dusting ___ moderate ___ heavy	N/A	YES	<input checked="" type="radio"/> NO
16. Were the samples shipped on ice?		<input checked="" type="radio"/> YES	NO
17. Were cooler temperatures measured at 0.1-6.0°C? IR gun used*: <input checked="" type="radio"/> #2 #4 RAD ONLY		YES	<input checked="" type="radio"/> NO
Cooler #: <u>1</u>			
Temperature (°C): <u>7.0</u> <input checked="" type="radio"/>			
No. of custody seals on cooler: <u>0</u>			
External µR/hr reading: <u>NA</u>			
Background µR/hr reading: <u>NA</u>			
Were external µR/hr readings ≤ two times background and within DOT acceptance criteria? YES / NO <input checked="" type="radio"/> NA (If no, see Form 008.)			

**Additional Information:** PROVIDE DETAILS BELOW FOR A NO RESPONSE TO ANY QUESTION ABOVE, EXCEPT #1 AND #16.

Ⓢ proceed with analysis per email from Nikki dated 4/17/15.  
aw 4/17/15

If applicable, was the client contacted?  YES / NO / NA Contact: Nikki Scheinost Date/Time: 4/16/15

Project Manager Signature / Date: [Signature] 4/16/15

**Client:** Tetra Tech  
**Project:** Windy Hill  
**Sample ID:** FW-3-18WSW-01 (Dakota J-4 Sandstone)  
**Legal Location:**  
**Collection Date:** 4/15/2015 09:00

**Date:** 28-Apr-15  
**Work Order:** 1504297  
**Lab ID:** 1504297-1  
**Matrix:** WATER  
**Percent Moisture:**

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
<b>Total Dissolved Solids</b>			<b>EPA160.1</b>		Prep Date: <b>4/17/2015</b>	PrepBy: <b>AJD</b>
TOTAL DISSOLVED SOLIDS	6600		200	MG/L	1	4/20/2015

**Client:** Tetra Tech  
**Project:** Windy Hill  
**Sample ID:** FW-3-18WSW-02 (Dakota J-4 Sandstone)  
**Legal Location:**  
**Collection Date:** 4/15/2015 09:00

**Date:** 28-Apr-15  
**Work Order:** 1504297  
**Lab ID:** 1504297-2  
**Matrix:** WATER  
**Percent Moisture:**

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
<b>Total Dissolved Solids</b>			<b>EPA160.1</b>		Prep Date: <b>4/17/2015</b>	PrepBy: <b>AJD</b>
<b>TOTAL DISSOLVED SOLIDS</b>	<b>6600</b>		<b>200</b>	<b>MG/L</b>	<b>1</b>	<b>4/20/2015</b>

**Explanation of Qualifiers**

**Radiochemistry:**

- U or ND - Result is less than the sample specific MDC.
- Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.
- Y2 - Chemical Yield outside default limits.
- W - DER is greater than Warning Limit of 1.42
- \* - Aliquot Basis is 'As Received' while the Report Basis is 'Dry Weight'.
- # - Aliquot Basis is 'Dry Weight' while the Report Basis is 'As Received'.
- G - Sample density differs by more than 15% of LCS density.
- D - DER is greater than Control Limit
- M - Requested MDC not met.
- LT - Result is less than requested MDC but greater than achieved MDC.
- M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.
- L - LCS Recovery below lower control limit.
- H - LCS Recovery above upper control limit.
- P - LCS, Matrix Spike Recovery within control limits.
- N - Matrix Spike Recovery outside control limits
- NC - Not Calculated for duplicate results less than 5 times MDC
- B - Analyte concentration greater than MDC.
- B3 - Analyte concentration greater than MDC but less than Requested MDC.

**Inorganics:**

- B - Result is less than the requested reporting limit but greater than the instrument method detection limit (MDL).
- U or ND - Indicates that the compound was analyzed for but not detected.
- E - The reported value is estimated because of the presence of interference. An explanatory note may be included in the narrative.
- M - Duplicate injection precision was not met.
- N - Spiked sample recovery not within control limits. A post spike is analyzed for all ICP analyses when the matrix spike and or spike duplicate fail and the native sample concentration is less than four times the spike added concentration.
- Z - Spiked recovery not within control limits. An explanatory note may be included in the narrative.
- \* - Duplicate analysis (relative percent difference) not within control limits.
- S - SAR value is estimated as one or more analytes used in the calculation were not detected above the detection limit.

**Organics:**

- U or ND - Indicates that the compound was analyzed for but not detected.
- B - Analyte is detected in the associated method blank as well as in the sample. It indicates probable blank contamination and warns the data user.
- E - Analyte concentration exceeds the upper level of the calibration range.
- J - Estimated value. The result is less than the reporting limit but greater than the instrument method detection limit (MDL).
- A - A tentatively identified compound is a suspected aldol-condensation product.
- X - The analyte was diluted below an accurate quantitation level.
- \* - The spike recovery is equal to or outside the control criteria used.
- + - The relative percent difference (RPD) equals or exceeds the control criteria.
- G - A pattern resembling gasoline was detected in this sample.
- D - A pattern resembling diesel was detected in this sample.
- M - A pattern resembling motor oil was detected in this sample.
- C - A pattern resembling crude oil was detected in this sample.
- 4 - A pattern resembling JP-4 was detected in this sample.
- 5 - A pattern resembling JP-5 was detected in this sample.
- H - Indicates that the fuel pattern was in the heavier end of the retention time window for the analyte of interest.
- L - Indicates that the fuel pattern was in the lighter end of the retention time window for the analyte of interest.
- Z - This flag indicates that a significant fraction of the reported result did not resemble the patterns of any of the following petroleum hydrocarbon products:
  - gasoline
  - JP-8
  - diesel
  - mineral spirits
  - motor oil
  - Stoddard solvent
  - bunker C

Client: Tetra Tech

**QC BATCH REPORT**

Work Order: 1504297

Project: Windy Hill

Batch ID: **TD150417-1-1**

Instrument ID: **Balance**

Method: **EPA160.1**

LCS		Sample ID: <b>TD150417-1</b>			Units: <b>MG/L</b>		Analysis Date: <b>4/20/2015</b>				
Client ID:		Run ID: <b>TD150420-1A1</b>					Prep Date: <b>4/17/2015</b>		DF: <b>1</b>		
Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	RPD Ref	RPD	RPD Limit	Qual
TOTAL DISSOLVED SOLIDS	409	20	400		102	85-115				5	

MB		Sample ID: <b>TD150417-1</b>			Units: <b>MG/L</b>		Analysis Date: <b>4/20/2015</b>				
Client ID:		Run ID: <b>TD150420-1A1</b>					Prep Date: <b>4/17/2015</b>		DF: <b>1</b>		
Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	RPD Ref	RPD	RPD Limit	Qual
TOTAL DISSOLVED SOLIDS	ND	20									

The following samples were analyzed in this batch: 

1504297-1	1504297-2
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## 1504524

This report is a re-log from work order 1504297.

### Metals:

The samples were analyzed following Methods for the Determination of Metals in Environmental Samples – Supplement 1 procedures. Analysis by Trace ICP followed method 200.7 and the current revision of SOP 807.

The samples were shaken prior to analysis.

All acceptance criteria were met.

### Inorganics:

The samples were analyzed following MCAWW and EMSL procedures for the current revisions of the following SOPs and methods:

<u>Analyte</u>	<u>Method</u>	<u>SOP #</u>
Alkalinity	310.1	1106
Bicarbonate	310.1	1106
Carbonate	310.1	1106
Bromide	300.0 Revision 2.1	1113
Chloride	300.0 Revision 2.1	1113
Fluoride	300.0 Revision 2.1	1113
Nitrate as N	300.0 Revision 2.1	1113
Nitrite as N	300.0 Revision 2.1	1113
Sulfate	300.0 Revision 2.1	1113

Nitrate and Nitrite analysis was requested after hold times had expired.

All acceptance criteria were met.

# ALS Environmental -- FC

## Sample Number(s) Cross-Reference Table

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**OrderNum:** 1504524

**Client Name:** Tetra Tech

**Client Project Name:** Windy Hill

**Client Project Number:**

**Client PO Number:**

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Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
FW-3-18WSW-01 (Dakota J-4 Sa	1504524-1		WATER	15-Apr-15	9:00
FW-3-18WSW-02 (Dakota J-4 Sa	1504524-2		WATER	15-Apr-15	9:00





ALS Environmental - Fort Collins  
CONDITION OF SAMPLE UPON RECEIPT FORM

1504524  
1505 aw 4/29/15

Client: Tetra Tech

Workorder No: 1504297

Project Manager: AW

Initials: CDJ Date: 4-16-15

1. Does this project require any special handling in addition to standard ALS procedures?		YES	<input checked="" type="radio"/> NO
2. Are custody seals on shipping containers intact?	<input checked="" type="radio"/> NONE	YES	NO
3. Are Custody seals on sample containers intact?	<input checked="" type="radio"/> NONE	YES	NO
4. Is there a COC (Chain-of-Custody) present or other representative documents?		<input checked="" type="radio"/> YES	NO
5. Are the COC and bottle labels complete and legible?		<input checked="" type="radio"/> YES	NO
6. Is the COC in agreement with samples received? (IDs, dates, times, no. of samples, no. of containers, matrix, requested analyses, etc.)		<input checked="" type="radio"/> YES	NO
7. Were airbills / shipping documents present and/or removable?	<input checked="" type="radio"/> DROP OFF	YES	NO
8. Are all aqueous samples requiring preservation preserved correctly? (excluding volatiles)	<input checked="" type="radio"/> N/A	YES	NO
9. Are all aqueous non-preserved samples pH 4-9?	N/A	<input checked="" type="radio"/> YES	NO
10. Is there sufficient sample for the requested analyses?		<input checked="" type="radio"/> YES	NO
11. Were all samples placed in the proper containers for the requested analyses?		<input checked="" type="radio"/> YES	NO
12. Are all samples within holding times for the requested analyses?		<input checked="" type="radio"/> YES	NO
13. Were all sample containers received intact? (not broken or leaking, etc.)		<input checked="" type="radio"/> YES	NO
14. Are all samples requiring no headspace (VOC, GRO, RSK/MEE, Rx CN/S, radon) headspace free? Size of bubble: ___ < green pea ___ > green pea	<input checked="" type="radio"/> N/A	YES	NO
15. Do any water samples contain sediment? Amount Amount of sediment: ___ dusting ___ moderate ___ heavy	N/A	YES	<input checked="" type="radio"/> NO
16. Were the samples shipped on ice?		<input checked="" type="radio"/> YES	NO
17. Were cooler temperatures measured at 0.1-6.0°C? IR gun used*: <input checked="" type="radio"/> #2 #4 RAD ONLY		YES	<input checked="" type="radio"/> NO
Cooler #: <u>1</u>			
Temperature (°C): <u>7.0</u> <input checked="" type="radio"/>			
No. of custody seals on cooler: <u>0</u>			
External µR/hr reading: <u>NA</u>			
Background µR/hr reading: <u>NA</u>			
Were external µR/hr readings ≤ two times background and within DOT acceptance criteria? YES / NO <input checked="" type="radio"/> NA (If no, see Form 008.)			

Additional Information: PROVIDE DETAILS BELOW FOR A NO RESPONSE TO ANY QUESTION ABOVE, EXCEPT #1 AND #16.

Proceed with analysis per email from Nikki dated 4/17/15  
aw 4/17/15

Re-log of 1504297 to 1504524 for additional testing.  
aw 4/29/15

If applicable, was the client contacted?  YES / NO / NA Contact: Nikki Scheinost Date/Time: 4/16/15  
email

Project Manager Signature / Date: [Signature] 4/16/15

Client: Tetra Tech  
 Project: Windy Hill  
 Sample ID: FW-3-18WSW-01 (Dakota J-4 Sandstone)  
 Legal Location:  
 Collection Date: 4/15/2015 09:00

Date: 04-May-15  
 Work Order: 1504524  
 Lab ID: 1504524-1  
 Matrix: WATER  
 Percent Moisture:

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
<b>Alkalinity as Calcium Carbonate</b>			<b>EPA310.1</b>		Prep Date: <b>4/29/2015</b>	PrepBy: <b>JAC</b>
BICARBONATE AS CaCO3	1700		20	MG/L	1	4/30/2015
CARBONATE AS CaCO3	ND		20	MG/L	1	4/30/2015
TOTAL ALKALINITY AS CaCO3	1700		20	MG/L	1	4/30/2015
<b>Ion Chromatography</b>			<b>EPA300.0</b>		Prep Date: <b>4/29/2015</b>	PrepBy: <b>AJD</b>
BROMIDE	30		2	MG/L	10	4/30/2015 08:29
CHLORIDE	3100		40	MG/L	200	4/30/2015 20:04
FLUORIDE	2.7		1	MG/L	10	4/30/2015 08:29
NITRATE AS N	ND		2	MG/L	10	4/30/2015 08:29
NITRITE AS N	ND		1	MG/L	10	4/30/2015 08:29
SULFATE	ND		10	MG/L	10	4/30/2015 08:29
<b>Total Recoverable Metals by 200.7</b>			<b>EPA200.7</b>		Prep Date: <b>5/1/2015</b>	PrepBy: <b>CDR</b>
CALCIUM	11		1	MG/L	1	5/1/2015 16:04
IRON	89		0.1	MG/L	1	5/1/2015 16:04
POTASSIUM	24		1	MG/L	1	5/1/2015 16:04
MAGNESIUM	2.9		1	MG/L	1	5/1/2015 16:04
SODIUM	2200		100	MG/L	100	5/1/2015 16:19

Client: Tetra Tech  
 Project: Windy Hill  
 Sample ID: FW-3-18WSW-02 (Dakota J-4 Sandstone)  
 Legal Location:  
 Collection Date: 4/15/2015 09:00

Date: 04-May-15  
 Work Order: 1504524  
 Lab ID: 1504524-2  
 Matrix: WATER  
 Percent Moisture:

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
<b>Alkalinity as Calcium Carbonate</b>			<b>EPA310.1</b>		Prep Date: <b>4/29/2015</b>	PrepBy: <b>JAC</b>
BICARBONATE AS CaCO3	1700		20	MG/L	1	4/30/2015
CARBONATE AS CaCO3	ND		20	MG/L	1	4/30/2015
TOTAL ALKALINITY AS CaCO3	1700		20	MG/L	1	4/30/2015
<b>Ion Chromatography</b>			<b>EPA300.0</b>		Prep Date: <b>4/29/2015</b>	PrepBy: <b>AJD</b>
BROMIDE	30		2	MG/L	10	4/30/2015 08:57
CHLORIDE	3100		40	MG/L	200	4/30/2015 20:18
FLUORIDE	2.7		1	MG/L	10	4/30/2015 08:57
NITRATE AS N	ND		2	MG/L	10	4/30/2015 08:57
NITRITE AS N	ND		1	MG/L	10	4/30/2015 08:57
SULFATE	ND		10	MG/L	10	4/30/2015 08:57
<b>Total Recoverable Metals by 200.7</b>			<b>EPA200.7</b>		Prep Date: <b>5/1/2015</b>	PrepBy: <b>CDR</b>
CALCIUM	11		1	MG/L	1	5/1/2015 16:09
IRON	78		0.1	MG/L	1	5/1/2015 16:09
POTASSIUM	24		1	MG/L	1	5/1/2015 16:09
MAGNESIUM	2.9		1	MG/L	1	5/1/2015 16:09
SODIUM	2200		100	MG/L	100	5/1/2015 16:20

**Client:** Tetra Tech  
**Project:** Windy Hill  
**Sample ID:** FW-3-18WSW-02 (Dakota J-4 Sandstone)  
**Legal Location:**  
**Collection Date:** 4/15/2015 09:00

**Date:** 04-May-15  
**Work Order:** 1504524  
**Lab ID:** 1504524-2  
**Matrix:** WATER  
**Percent Moisture:**

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
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**Explanation of Qualifiers**

**Radiochemistry:**

- U or ND - Result is less than the sample specific MDC.
- Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.
- Y2 - Chemical Yield outside default limits.
- W - DER is greater than Warning Limit of 1.42
- \* - Aliquot Basis is 'As Received' while the Report Basis is 'Dry Weight'.
- # - Aliquot Basis is 'Dry Weight' while the Report Basis is 'As Received'.
- G - Sample density differs by more than 15% of LCS density.
- D - DER is greater than Control Limit
- M - Requested MDC not met.
- LT - Result is less than requested MDC but greater than achieved MDC.
- M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.
- L - LCS Recovery below lower control limit.
- H - LCS Recovery above upper control limit.
- P - LCS, Matrix Spike Recovery within control limits.
- N - Matrix Spike Recovery outside control limits
- NC - Not Calculated for duplicate results less than 5 times MDC
- B - Analyte concentration greater than MDC.
- B3 - Analyte concentration greater than MDC but less than Requested MDC.

**Inorganics:**

- B - Result is less than the requested reporting limit but greater than the instrument method detection limit (MDL).
- U or ND - Indicates that the compound was analyzed for but not detected.
- E - The reported value is estimated because of the presence of interference. An explanatory note may be included in the narrative.
- M - Duplicate injection precision was not met.
- N - Spiked sample recovery not within control limits. A post spike is analyzed for all ICP analyses when the matrix spike and or spike duplicate fail and the native sample concentration is less than four times the spike added concentration.
- Z - Spiked recovery not within control limits. An explanatory note may be included in the narrative.
- \* - Duplicate analysis (relative percent difference) not within control limits.
- S - SAR value is estimated as one or more analytes used in the calculation were not detected above the detection limit.

**Organics:**

- U or ND - Indicates that the compound was analyzed for but not detected.
- B - Analyte is detected in the associated method blank as well as in the sample. It indicates probable blank contamination and warns the data user.
- E - Analyte concentration exceeds the upper level of the calibration range.
- J - Estimated value. The result is less than the reporting limit but greater than the instrument method detection limit (MDL).
- A - A tentatively identified compound is a suspected aldol-condensation product.
- X - The analyte was diluted below an accurate quantitation level.
- \* - The spike recovery is equal to or outside the control criteria used.
- + - The relative percent difference (RPD) equals or exceeds the control criteria.
- G - A pattern resembling gasoline was detected in this sample.
- D - A pattern resembling diesel was detected in this sample.
- M - A pattern resembling motor oil was detected in this sample.
- C - A pattern resembling crude oil was detected in this sample.
- 4 - A pattern resembling JP-4 was detected in this sample.
- 5 - A pattern resembling JP-5 was detected in this sample.
- H - Indicates that the fuel pattern was in the heavier end of the retention time window for the analyte of interest.
- L - Indicates that the fuel pattern was in the lighter end of the retention time window for the analyte of interest.
- Z - This flag indicates that a significant fraction of the reported result did not resemble the patterns of any of the following petroleum hydrocarbon products:
  - gasoline
  - JP-8
  - diesel
  - mineral spirits
  - motor oil
  - Stoddard solvent
  - bunker C

Client: Tetra Tech  
 Work Order: 1504524  
 Project: Windy Hill

**QC BATCH REPORT**

Batch ID: **IP150501-4-1** Instrument ID **ICPTrace2** Method: **EPA200.7**

**LCS** Sample ID: **FP150501-4** Units: **MG/L** Analysis Date: **5/1/2015 16:02**  
 Client ID: Run ID: **IT150501-1A5** Prep Date: **5/1/2015** DF: **1**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	RPD Ref	RPD	RPD Limit	Qual
CALCIUM	40.2	1	40		101	85-115				20	
IRON	0.945	0.1	1		94	85-115				20	
MAGNESIUM	40.5	1	40		101	85-115				20	
POTASSIUM	44.9	1	40		112	85-115				20	
SODIUM	39.8	1	40		100	85-115				20	

**MB** Sample ID: **FP150501-4** Units: **MG/L** Analysis Date: **5/1/2015 16:01**  
 Client ID: Run ID: **IT150501-1A5** Prep Date: **5/1/2015** DF: **1**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	RPD Ref	RPD	RPD Limit	Qual
CALCIUM	ND	1									
IRON	ND	0.1									
MAGNESIUM	ND	1									
POTASSIUM	ND	1									
SODIUM	ND	1									

The following samples were analyzed in this batch:

1504524-1	1504524-2
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Client: Tetra Tech  
 Work Order: 1504524  
 Project: Windy Hill

# QC BATCH REPORT

Batch ID: **AK150429-1-2** Instrument ID **Balance** Method: **EPA310.1**

LCS		Sample ID: <b>AK150429-1</b>			Units: <b>MG/L</b>		Analysis Date: <b>4/30/2015</b>				
Client ID:		Run ID: <b>AK150429-1A1</b>			Prep Date: <b>4/29/2015</b>		DF: <b>1</b>				
Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	RPD Ref	RPD	RPD Limit	Qual
TOTAL ALKALINITY AS CaCO3	97.3	5	100		97	85-115				15	

MB		Sample ID: <b>AK150429-1</b>			Units: <b>MG/L</b>		Analysis Date: <b>4/30/2015</b>				
Client ID:		Run ID: <b>AK150429-1A1</b>			Prep Date: <b>4/29/2015</b>		DF: <b>1</b>				
Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	RPD Ref	RPD	RPD Limit	Qual
BICARBONATE AS CaCO3	ND	5									
CARBONATE AS CaCO3	ND	5									
TOTAL ALKALINITY AS CaCO3	ND	5									

The following samples were analyzed in this batch:

1504524-1	1504524-2
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Client: Tetra Tech  
 Work Order: 1504524  
 Project: Windy Hill

# QC BATCH REPORT

Batch ID: **IC150429-1-1** Instrument ID **IC** Method: **EPA300.0**

LCS		Sample ID: <b>IC150429-1</b>			Units: <b>MG/L</b>		Analysis Date: <b>4/29/2015 12:36</b>				
Client ID:		Run ID: <b>IC150429-1A1</b>			Prep Date: <b>4/29/2015</b>		DF: <b>1</b>				
Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	RPD Ref	RPD	RPD Limit	Qual
FLUORIDE	1.92	0.1	2		96	90-110				15	
CHLORIDE	5.06	0.2	5		101	90-110				15	
NITRITE AS N	1.93	0.1	2		96	90-110				15	
BROMIDE	5.16	0.2	5		103	90-110				15	
NITRATE AS N	5.01	0.2	5		100	90-110				15	
SULFATE	19.7	1	20		98	90-110				15	

MB		Sample ID: <b>IC150429-1</b>			Units: <b>MG/L</b>		Analysis Date: <b>4/29/2015 12:50</b>				
Client ID:		Run ID: <b>IC150429-1A1</b>			Prep Date: <b>4/29/2015</b>		DF: <b>1</b>				
Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	RPD Ref	RPD	RPD Limit	Qual
FLUORIDE	ND	0.1									
CHLORIDE	ND	0.2									
NITRITE AS N	ND	0.1									
BROMIDE	ND	0.2									
NITRATE AS N	ND	0.2									
SULFATE	ND	1									

The following samples were analyzed in this batch:

1504524-1	1504524-2
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**ATTACHMENT 3**

## TETRA TECH DATA EVALUATION CHECKLIST

Tetra Tech Project No.: **114-910338, Windy Hill Project**

Event: **Groundwater Sampling Event, Well ID: FW-3-18WSW, Dakota J-4 Sandstone Formation**

Lab: **ALS Environmental – Fort Collins, CO**

Lab Sample Numbers: **1504297-1 and 1504297-2**

Matrix/Analytical Methods: **Groundwater / EPA Method 160.1, total dissolved solids (TDS)**

Field Sample Ids: **FW-3-18WSW-01 and FW-3-18WSW-02 (collected on 4/15/2015).**

**TABLE 1 – DATA EVALUATION**

No.	Data Evaluation Question	YES	NO
1	Is a Work Plan, SAP or QAPP available? <b>Sampling and Analysis Plan (SAP) for Well ID: FW-3-18WSW Dakota J-4 Sandstone Formation prepared by Tetra Tech on 4/14/15. The SAP meet the applicable requirements outlined in the Colorado Oil and Gas Conservation Commission (COGCC) Quality Assurance Plan (Plan) for the underground injection control (UIC) Program.</b>	<b>X</b>	
2	Chain of Custody (“C-O-C”) Records:	<b>X</b>	
	Are the C-O-Cs present?	<b>X</b>	
	Are the C-O-Cs complete and signed off?	<b>X</b>	
	Were the samples received at or below 4±2 °C <b>Samples were received at the lab at 7°C which is slightly above the method specification of 4±2 °C. The lab contacted Tetra Tech upon sample receipt and confirmed that the lab should proceed with analysis. The sample results are qualified as estimated (J) due to sample preservation being outside specifications.</b>		<b>X</b>
	Were all samples on the C-O-C analyzed? <b>Per the SAP, the field sample IDs were to include the sample formation (Dakota J-4 Sandstone); however, this was inadvertently omitted by the field sampler on the C-O-C form. Tetra Tech submitted a corrected C-O-C form to the lab and the report was revised accordingly.</b>	<b>X</b>	
	Were any problems noted?		<b>X</b>
3	Was a project narrative available from the lab?	<b>X</b>	
	Were any problems noted?		<b>X</b>
4	Were all holding times met?	<b>X</b>	
5	Was the frequency stated in the Work Plan or SAP for field duplicates, equipment rinsate and trip blanks met?	<b>X</b>	

No.	Data Evaluation Question	YES	NO
	<b>One field duplicate was collected (FW-3-18WSW-02). Equipment trip blanks and trip blanks were not required.</b>		
6	Were all equipment rinsate blank, trip blank, field blanks, and method blank results non-detect (ND)? <b>The lab QC report includes one method blank. The method blank results are non-detect. Equipment rinsate blanks, trip blanks and field blanks were not required.</b>	X	
7	Were all matrices, units and detection limits reported correctly? <b>Results are reported in mg/L. The detection limit was 200 mg/L.</b>	X	
8	Were all surrogate recoveries within lab control limits? <b>NA</b>	NA	
9	Were all LCS spike recoveries within lab control limits? <b>The LCS recovery was 102% which is within the acceptable lab control limit range of 85-115%.</b>	X	
10	Were all LCDS RPDs within lab control limits? <b>LCDS RPDs were not reported.</b>	NA	
11	Were all MS/MSD spike recoveries within lab control limits? <b>MS/MSDs were not reported.</b>	NA	
12	Were all MSD RPDs within lab control limits? <b>MS/MSDs were not reported.</b>	NA	
13	Were analytical duplicate RPDs within lab control limits? <b>Analytical duplicates were not reported.</b>	NA	
14	Were all field duplicate RPDs within specified control limits? <b>One field duplicate was collected (Field ID: FW-3-18WSW-02). The parent sample and field duplicate results were the same; therefore, the RPD was 0% which meets the QAPP requirements.</b>	X	
15	Was the project completeness goal met?	X	

TABLE 2 – FIELD DUPLICATES

FIELD SAMPLE IDs	ANALYTE	UNITS	SAMPLE RESULT	DUPLICATE RESULT	RPD%
FW-3-18WSW-01	TDS	mg/L	6600 mg/L	6600 mg/L	0
FW-3-18WSW-02					

TABLE 3 – DATA QUALIFICATIONS

Field Sample ID	Analyte	Result (mg/L)/ Qualification	Reason for Qualification
FW-3-18WSW-01	Total dissolved solids	6600 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
FW-3-18WSW-02	Total dissolved solids	6600 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)

J - The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.

**TABLE 4 – DATA EVALUATION SUMMARY**

Data Evaluation Summary	
	<p>Sample Collection, Transfer and Handling:  <b>One parent sample and one field duplicate sample were collected on April 15, 2015 and hand delivered to ALS Environmental in Fort Collins, Colorado on April 16, 2015. Samples were collected in pre-cleaned containers provided by the laboratory using disposable equipment. The samples were analyzed within the required holding time for total dissolved solids (TDS) via EPA Method 160.1. The laboratory reported that the sample cooler was received outside specification (4±2 °C) at 7°C upon receipt. The laboratory contacted Tetra Tech and received confirmation to proceed with the analysis. The sample results are qualified as estimated (J) due to sample preservation being outside specifications (Table 3).</b>  <b>The frequency of QC field sample collection met the requirements outlined in the Sampling and Analysis Plan (SAP), which included the collected of one field duplicate sample.</b></p>
	<p>Accuracy:  <b>Accuracy is a measure of the system bias. The level of accuracy is determined by examination of blank contamination, laboratory control sample (LCS) and matrix spike/spike duplicate (MS/MSD) recoveries, laboratory calibration verification sample recoveries, and surrogate recoveries.</b>  <b>The laboratory reported one LCS and one method blank sample in the QC batch. The LCS recovery was within laboratory control limits and the method blank result was non-detect; therefore, the data is acceptable without qualification.</b></p>
	<p>Precision:  <b>Precision is a measure of agreement among replicate measurements of a sample under similar conditions. Precision is monitored by the examination of field and laboratory duplicate results.</b>  <b>One field duplicate was collected (Field ID: FW-3-18WSW-02). The parent sample and field duplicate results were the same; therefore, the RPD was 0% which meets the QAPP requirements.</b>  <b>Analytical duplicates were not reported.</b></p>
	<p>Data Qualifications based on Data Evaluation:  <b>The laboratory analytical results are considered usable for the intended use with the exception of the qualifications noted in Table 3.</b></p>

Data Validation by: Nikki Scheinost  
 Date: April 21, 2015

## TETRA TECH DATA EVALUATION CHECKLIST

Tetra Tech Project No.: **114-910338, Windy Hill Project**

Event: **Groundwater Sampling Event, Well ID: FW-3-18WSW, Dakota J-4 Sandstone Formation**

Lab: **ALS Environmental – Fort Collins, CO**

Lab Sample Numbers: **1504524-1 and 1504524-2**

Matrix/Analytical Methods: **Groundwater / Metals via EPA Method 200.7 and Inorganics via EPA Methods 300.0 and 310.1**

Field Sample Ids: **FW-3-18WSW-01 and FW-3-18WSW-02 (collected on 4/15/2015).**

**TABLE 1 – DATA EVALUATION**

No.	Data Evaluation Question	YES	NO
1	Is a Work Plan, SAP or QAPP available? <b>Sampling and Analysis Plan (SAP) for Well ID: FW-3-18WSW Dakota J-4 Sandstone Formation prepared by Tetra Tech on 4/14/15. The SAP meets the applicable requirements outlined in the Colorado Oil and Gas Conservation Commission (COGCC) Quality Assurance Plan (Plan) for the underground injection control (UIC) Program.</b>	<b>X</b>	
2	Chain of Custody (“C-O-C”) Records:	<b>X</b>	
	Are the C-O-Cs present?	<b>X</b>	
	Are the C-O-Cs complete and signed off?	<b>X</b>	
	Were the samples received at or below 4±2 °C <b>Samples were received at the lab at 7°C which is slightly above the method specification of 4±2 °C. The lab contacted Tetra Tech upon sample receipt and confirmed that the lab should proceed with analysis. The sample results are qualified as estimated (J and UJ) due to sample preservation being outside specifications.</b>		<b>X</b>
	Were all samples on the C-O-C analyzed? <b>Per the SAP, the field sample IDs were to include the sample formation (Dakota J-4 Sandstone); however, this was inadvertently omitted by the field sampler on the C-O-C form. Tetra Tech submitted a corrected C-O-C form to the lab and the report was revised accordingly.</b>	<b>X</b>	
Were any problems noted? <b>The C-O-C only designates TDS analysis was requested; however, Tetra Tech contacted the lab on 4/27/15 and requested additional analyses be performed (major anions and cations, and total alkalinity) on the two samples with the remaining sample volume. The lab report was prepared under a new Work Order number.</b>		<b>X</b>	

No.	Data Evaluation Question	YES	NO
3	Was a project narrative available from the lab? Were any problems noted?	X	X
4	Were all holding times met? <b>The lab noted that the nitrate and nitrite analyses were completed after hold times had expired. This is not expected to significantly affect the analytical results.</b>		X
5	Was the frequency stated in the Work Plan or SAP for field duplicates, equipment rinsate and trip blanks met? <b>One field duplicate was collected (FW-3-18WSW-02). Equipment trip blanks and trip blanks were not required.</b>	X	
6	Were all equipment rinsate blank, trip blank, field blanks, and method blank results non-detect (ND)? <b>The lab QC report includes a method blank for each of the three methods. The method blank results are non-detect. Equipment rinsate blanks, trip blanks and field blanks were not required.</b>	X	
7	Were all matrices, units and detection limits reported correctly? <b>Results are reported in mg/L. Specific detection limits were not requested.</b>	X	
8	Were all surrogate recoveries within lab control limits? <b>NA</b>	NA	
9	Were all LCS spike recoveries within lab control limits? <b>The LCS recoveries were within lab control limits for each method.</b>	X	
10	Were all LCDS RPDs within lab control limits? <b>LCDS RPDs were not reported.</b>	NA	
11	Were all MS/MSD spike recoveries within lab control limits? <b>MS/MSDs were not reported.</b>	NA	
12	Were all MSD RPDs within lab control limits? <b>MS/MSDs were not reported.</b>	NA	
13	Were analytical duplicate RPDs within lab control limits? <b>Analytical duplicates were not reported.</b>	NA	
14	Were all field duplicate RPDs within specified control limits? <b>One field duplicate was collected (Field ID: FW-3-18WSW-02). The field duplicate results are acceptable without qualification (Table 2).</b>	X	
15	Was the project completeness goal met?	X	

**TABLE 2 – FIELD DUPLICATES**

FIELD SAMPLE IDs	ANALYTE	SAMPLE RESULT mg/L	DUPLICATE RESULT mg/L	RPD%
FW-3-18WSW-01	bicarbonate as CaCO <sub>3</sub>	1700	1700	0
	carbonate as CaCO <sub>3</sub>	ND	ND	NA
	total alkalinity	1700	1700	0
	bromide	30	30	0
	chloride	3100	3100	0
	fluoride	2.7	2.7	0
FW-3-18WSW-02 (duplicate)	nitrate as N	ND	ND	NA
	nitrate as N	ND	ND	NA
	sulfate	ND	ND	NA
	calcium	11	11	0
	iron	89	78	13.2
	potassium	24	24	0
	magnesium	2.9	2.9	0
	sodium	2200	2200	0

ND – Not detected at the lab reporting limit.

NA – Not applicable.

**TABLE 3 – DATA QUALIFICATIONS**

Field Sample ID	Analytes	Result (mg/L)/ Qualification	Reason for Qualification
FW-3-18WSW-01	bicarbonate as CaCO <sub>3</sub>	1700 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	carbonate as CaCO <sub>3</sub>	ND / UJ	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	total alkalinity	ND / UJ	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	bromide	1700 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	chloride	30 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	fluoride	3100 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	nitrate as N	2.7 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	nitrate as N	ND / UJ	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	sulfate	ND / UJ	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	calcium	ND / UJ	Sample preservation; cooler temperature measured outside specifications (4±2 °C)

Field Sample ID	Analytes	Result (mg/L)/ Qualification	Reason for Qualification
FW-3-18WSW-01	iron	11 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	potassium	89 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	magnesium	24 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	sodium	2.9 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
FW-3-18WSW-02	bicarbonate as CaCO <sub>3</sub>	1700 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	carbonate as CaCO <sub>3</sub>	ND / UJ	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	total alkalinity	1700 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	bromide	30 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	chloride	3100 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	fluoride	2.7 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	nitrate as N	ND / UH	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	nitrate as N	ND / UJ	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	sulfate	ND / UJ	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	calcium	11 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	iron	78 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	potassium	24 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	magnesium	2.9 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)
	sodium	2200 / J	Sample preservation; cooler temperature measured outside specifications (4±2 °C)

ND – Indicates the compound was not detected at the lab reporting limit.

J - The detected result is an estimated quantity; the associated numerical value is the approximate concentration of the analyte in the sample.

UJ – Not detected estimated value; the reported result is an estimate.

**TABLE 4 – DATA EVALUATION SUMMARY**

Data Evaluation Summary	
	<p>Sample Collection, Transfer and Handling:</p> <p><b>One parent sample and one field duplicate sample were collected on April 15, 2015 and hand delivered to ALS Environmental in Fort Collins, Colorado on April 16, 2015. Samples were collected in pre-cleaned containers provided by the laboratory using disposable equipment. The samples were initially analyzed for total dissolved solids (TDS) via EPA Method 160.1. On April 27, 2015, Tetra Tech requested additional laboratory analyses be conducted with the remaining sample volume, including major anions and cations and total alkalinity.</b></p> <p><b>The laboratory reported that the sample cooler was received outside specification (4±2 °C) at 7°C upon receipt. The laboratory contacted Tetra Tech and received confirmation to proceed with the analysis. The sample results are qualified as estimated (J and UJ for detected and not detected results, respectively) due to sample preservation being outside specifications (Table 3).</b></p> <p><b>The lab noted that the nitrate and nitrite analyses were completed after hold times had expired. This is not expected to significantly affect the analytical results.</b></p> <p><b>The frequency of QC field sample collection met the requirements outlined in the Sampling and Analysis Plan (SAP), which included the collected of one field duplicate sample.</b></p>
	<p>Accuracy:</p> <p><b>Accuracy is a measure of the system bias. The level of accuracy is determined by examination of blank contamination, laboratory control sample (LCS) and matrix spike/spike duplicate (MS/MSD) recoveries, laboratory calibration verification sample recoveries, and surrogate recoveries.</b></p> <p><b>The laboratory reported one LCS and one method blank sample in the QC batch for each of the three method. The LCS recovery was within laboratory control limits and the method blank result was non-detect; therefore, the data is acceptable without qualification.</b></p>
	<p>Precision:</p> <p><b>Precision is a measure of agreement among replicate measurements of a sample under similar conditions. Precision is monitored by the examination of field and laboratory duplicate results.</b></p> <p><b>One field duplicate was collected (Field ID: FW-3-18WSW-02). The parent sample and field duplicate results were acceptable without qualification.</b></p> <p><b>Analytical duplicates were not reported.</b></p>
	<p>Data Qualifications based on Data Evaluation:</p> <p><b>The laboratory analytical results are considered usable for the intended use with the exception of the qualifications noted in Table 3.</b></p>

Data Validation by: Nikki Scheinost  
 Date: May 12, 2015

**ATTACHMENT 3**

**UNOCAL J SAND WATER SAMPLING DOCUMENTATION, 2005**

**UNDERGROUND INJECTION CONTROL  
PERMIT APPLICATION**

**FOR**

**NON-HAZARDOUS CLASS I DISPOSAL  
AT THE WINDY HILL GAS STORAGE FACILITY**

**MORGAN COUNTY, COLORADO**

**SUBMITTED TO**

**U.S. ENVIRONMENTAL PROTECTION AGENCY  
REGION 8  
GROUNDWATER PROGRAM**



**BY**

**UNOCAL WINDY HILL GAS STORAGE, LLC**

**UNOCAL** 

**AND**

**MFG, INC.**



**G**  
consulting  
scientists and  
engineers

**JUNE 13, 2005**

**Table F-1**  
**Results of Water Quality Tests for UWHGS 1-17**

Parameter	Units	Minimum Detection Level	Value Sample Well #1	Value Duplicate Sample Well #1
<b>General Chemistry</b>				
Bromide	mg/L	0.087	2.5	
Calcium	mg/L	0.013	8.9	
Chloride	mg/L	0.042	8.8	
Flouride	mg/L	0.031	6.9	
Magnesium	mg/L	0.012	1.4	
Nitrate (as N)	mg/L	0.028	ND	
Potassium	mg/L	0.31	24	
Total dissolved solids	mg/L	8.2	10,000	10,000
Conductance	µmhos/cm	100	13,000	13,000
Specific Gravity	NA	0.010	1.01	1.01
pH	std	0.10	7.6	7.7
<b>Metals</b>				
Antimony	mg/L	0.00030	ND	
Arsenic	mg/L	0.00030	ND	
Barium	mg/L	0.00010	0.180	
Beryllium	mg/L	0.00010	ND	
Cadmium	mg/L	0.00020	ND	
Chromium	mg/L	0.00040	0.00324	
Cobalt	mg/L	0.00010	0.00145	
Copper	mg/L	0.00010	0.0560	
Iron	mg/L	0.0027	24	
Lead	mg/L	0.00010	0.0418	
Manganese	mg/L	0.00010	0.361	
Molybdenum	mg/L	0.00010	0.0133	
Nickel	mg/L	0.00010	0.00884	
Selenium	mg/L	0.00010	ND	
Silver	mg/L	0.00030	ND	
Thallium	mg/L	0.00010	ND	
Vanadium	mg/L	0.00030	ND	
Zinc	mg/L	0.00080	0.0599	

Organics				
1,1,1-Trichloroethane	µg/L	0.15	ND	
1,1,2-Trichloroethane	µg/L	0.13	ND	
1,1-Dichloroethene	µg/L	0.12	ND	
1,2 Dichlorobenzene	µg/L	0.12	ND	
1,2 Dichloroethane	µg/L	0.13	ND	
1,2 Dichloropropane	µg/L	0.12	ND	
1,2,4-Trichlorobenzene	µg/L	0.083	ND	
1,4 Dichlorobenzene	µg/L	0.036	ND	
Benzene	µg/L	0.52	98	
Carbon Tetrachloride	µg/L	0.11	ND	
Chlorobenzene	µg/L	0.030	ND	
Cis-1,2-Dichloroethene	µg/L	0.10	ND	
Ethylbenzene	µg/L	0.086	0.72	
Methylene Chloride	µg/L	0.16	ND	
M&P Xylenes	µg/L	0.75	110	
O-Xylene	µg/L	0.10	6.3	
Styrene	µg/L	0.062	ND	
Tetrachloroethene	µg/L	0.084	ND	
Toluene	µg/L	0.060	16	
Trans-1,2-Dichloroethene	µg/L	0.084	ND	
Trichloroethene	µg/L	0.11	ND	
Vinyl Chloride	µg/L	0.080	ND	
Xylenes, Total	µg/L	0.25	130	

Notes:

µg/L – micrograms per liter  
µmhos/cm – micromhos per centimeter  
mg/L – milligrams per liter  
ND – Not Detected

**From:** Shugarts, Cathy -- MFG Inc  
**Sent:** Tuesday, March 22, 2005 10:18 AM  
**To:** Schuller, Tisha -- MFG, Inc.  
**Subject:** Unocal Data evaluation

**Attachments:** Unocal B0502051.DOC  
Tisha,

Attached is the data evaluation of the Unocal J Sand data.

As an FYI: The lab reported the TDS data to two significant figures and reported the results for both samples at 10, 000 mg/L. The raw data calculates out to 10,343 and 10,176 for Well # 1 and Well # 1 Dup, respectively. Please realize that not all the numbers in the raw results are significant figures. The lab reported the results using standard conventions for significant figures.

Note due to 0% recoveries for the nitrite, the field sample results for nitrite are rejected.

Let me know if you have any questions.  
Cathy



Unocal  
B0502051.DOC (50 |

**MFG, INC.**  
**DATA EVALUATION CHECKLIST**

MFG Project No.: **P010195 – Unocal J Sand**

Lab: **Analytica Environmental Laboratories - Thornton, Colorado**  
**Analytica International Inc. - Fairbanks, Alaska**

Lab Sample Numbers: **B0502051-01 through B0502051-03**

Matrix/Analytical Methods: **Water / Specific Conductance by EPA 120.1; pH by EPA 150.1; TDS by EPA 160.1; Total Metals (Ca, Fe, Mg, K and Na) by EPA 200.7; Total Metals (Sb, As, Ba, Be, Cd, Cr, Co, Cu, Pb, Mn, Mo, Ni, Se, Ag, Tl, V and Zn) by EPA 200.8; Specific Gravity by SM2710F; Mercury by EPA 245.1; Volatile Organic Compounds by EPA DW (specific method not provided) and Inorganic Ions (Br, F, NO<sub>3</sub>, NO<sub>2</sub>, ortho-PO<sub>4</sub>, SO<sub>4</sub> and Cl) by EPA 300.0A.**

Field Sample Ids: **Well #1, Well #1 Dup and Trip Blank (Collected on 02/06/05)**

	<u>YES</u>	<u>NO</u>
1. Is a Work Plan, SAP, or QAPP available?		N
2. Chain of Custody Records:		
Are the COCs present?		N
<b>A copy of the original COC was reviewed. The COC used to transfer custody to the Alaska lab was not provided.</b>		
Are the COCs complete and signed off?		N
<b>Trip blank was not listed on COC.</b>		
Were the samples received at or below 4 ± 2°C?		N
<b>The sample temperature upon receipt at the Thornton laboratory was 4.3°C. The sample temperature upon receipt at the Fairbanks laboratory was 6.7 °C; however, properly-preserved samples for metals analytes and samples specific gravity are not subject to the EPA temperature recommendations. Documentation summarized in case narrative. Specific documentation not provided.</b>		
Were all samples on the COCs analyzed?	Y	
Were any problems noted?	Y	
<b>Mercury was requested by Method 200.8 on the COC.</b>		
3. Was a project narrative available from the laboratory?	Y	
Were any problems noted?	Y	
<b>TDS was detected in the method blank at a concentration greater than PQL. The MS and MSD recoveries for TDS were outside lab control limits, but the parent sample was not associated with this project.</b>		
<b>The MS and MSD recoveries for nitrite were outside lab control limits.</b>		
4. Were all holding times met?	Y	
<b>The analyses were performed within holding time.</b>		

	<u>YES</u>	<u>NO</u>
5. Was the frequency stated in the Work Plan or SAP for field duplicates, equipment rinsate, and trip blanks met?	NA	
6. Were all equipment rinsate blank, trip blank, and method blank results ND? <b>Equipment rinsate blanks were not submitted. TDS was detected in the method blank at a concentration greater than the PQL.</b>		N
7. Were all matrices, units, and detection limits reported correctly? <b>Some detection limits were elevated due to dilutions prior to analysis.</b>	Y	
8. Were all surrogate recoveries within control limits? <b>Surrogate recoveries for VOCs ranged from 100% to 123% (lab control limits 70-130%).</b>	Y	
9. Were all LCS spike recoveries within control limits? <b>Information summarized in case narrative. Specific documentation not provided for all analytes.</b>	Y	
10. Were all MS spike recoveries and RPDs within control limits? <b>The MS and MSD recoveries for nitrite were 0% (lab control limits 70-130%).</b>		N
11. Were all analytical duplicate RPDs within control limits? <b>Information summarized in case narrative. Specific documentation not provided for all analytes.</b>	Y	
12. Were all field duplicate RPDs within control limits? <b>Project control limits were not established for field duplicates.</b>	NA	
13. Was the project completeness goal met? <b>Project completeness goals were not established.</b>	NA	

**Comments:**

Sample Collection and Transfer

One water sample and one field duplicate were collected on February 6, 2005 and submitted along with one trip blank to Analytica Environmental Laboratories in Thornton, Colorado for the analysis of metals, mercury, anions, pH, specific conductance, TDS and volatile organic compounds. Specific gravity and metals by ICP/MS analyses were performed by Analytica International Inc. in Fairbanks, Alaska.

The samples were properly preserved. The temperature of the samples upon receipt at the Colorado laboratory was within the EPA recommended range for proper sample transport and storage ( $4 \pm 2^{\circ}\text{C}$ ). The analytes requested on the samples submitted to the Alaska laboratory were not subject to the EPA recommended temperature requirements for standards transport and storage. The chain of custody form used to transfer custody to the Alaska laboratory was not provided in the data package.

#### Sample Analysis and Reporting

Analytical results were reported for all samples included in this sample set. All samples were analyzed within the EPA recommended holding times for the specific method. Project required quantitation limits (PRQL) were not established.

The laboratory quality control (QC) results were summarized in the case narrative. The specific information required to verify QC results was not provided in the data package.

#### Accuracy

The accuracy of the data was evaluated based on extraction efficiencies, matrix spike and matrix spike duplicate recoveries, laboratory method blank results and trip blank results.

Extraction efficiencies are monitored by including samples with known analyte concentrations, lab control samples (LCS), in each sample batch. The LCS recoveries were within the laboratory control limits for all analytes.

The matrix spike (MS) and matrix spike duplicates (MSD) monitor potential analytical interferences related to the sample matrix. The reported matrix spike and matrix spike duplicate results were within project or laboratory control limits for all analytes less than four times the spike concentration except for TDS and nitrite. The sample selected for the MS and MSD for TDS was not associated with this project; therefore, the TDS results for this project are not affected. The nitrite MS and MSD recoveries were 0%. Due to the lack of specific information from the laboratory related to the analytical run for nitrite, the nitrite results for the project samples are rejected due to possible matrix interferences.

Total dissolved solids (TDS) were detected at a concentration greater than the reporting limit in the laboratory preparation blank; however, all TDS results for field samples were greater than five times the laboratory preparation blank concentration.

Serial dilution results were not reported for metals.

#### Precision

Laboratory precision was evaluated based on the relative percent differences (RPD) calculated from laboratory matrix spike/matrix spike duplicates, analytical duplicates and field duplicates. The RPDs were within lab control limits.

Field sample Well #1 Dup is a field duplicate of sample Well #1. Project control limits were not established for field duplicates.

#### Completeness

Analytical results were reported for analytes requested on the field samples submitted to the laboratory for analysis. The analytical results are considered usable with the exception of the rejected nitrite results.



**Preparation Report**  
**Main Batch:ST050215011**

Preparation Date: 2/12/2005 12:00:00AM  
 Prepared By: cm  
 Preparation Method:160.1

Batch Comments:

SubBatch Number: T050215011      Analysis Method: Residue, Filterable, Gravimetric, Dried at 180C (TDS)

<u>Sample Number</u>	<u>Due Date</u>	<u>Initial Vol./Weight</u>	<u>Final Extract Vol.</u>	<u>Spike ID</u>	<u>Spike Name</u>	<u>Spike Vol.</u>	<u>Comments</u>
T050215011-MB		100.00 ml	1.00				
B0502051-01E	2/18/05	100.00 ml	1.00				
B0502051-02B	2/18/05	100.00 ml	1.00				
B0502058-03B	3/1/05	100.00 ml	1.00				
T050215011-LCS		100.00 ml	1.00	3013	TDS liquid std	68,933.83 ul	
T050215011-LCSD		100.00 ml	1.00	3013	TDS liquid std	68,933.83 ul	
B0502058-03B-DUP		100.00 ml	1.00				
B0502058-03B-MS		100.00 ml	1.00	3013	TDS liquid std	68,933.83 ul	

Spike Details

Standard ID: 3,013  
Standard Name: TDS liquid std  
Expiration Date: 9/1/2005 12:00:00AM

<u>Analyte Name</u>	<u>CAS Number</u>	<u>Concentration</u>
Total Dissolved Solids		1,088.00 mg/L

SampleNumber	Run Date
<b>B0502058-03B</b>	<b>2/15/2005 3:20:56 PM</b>
B0502058-03B-MS	2/15/2005 3:20:56 PM

Analyte	Sp RR	MSD rr	SampRes	SpkRes	SpLevel	MSD level	Recov	MSD Rec	LIMITS
<b>Total Dissolved Solids</b>	<b>1</b>		<b>3440</b>	<b>3900</b>	<b>750</b>		<b>61.6</b>		<b>70 - 130</b>



**UNOCAL - GULF REGION USA**  
**DAILY - DRILLING / WORKOVER / COMPLETION REPORT**

WELL NAME	Windy Hill Gas Storage Unit # 1 Well 1-17	DATE	02/04/05	REPORT NO	4		
LEASE	Windy Hill Gas Storage Unit # 1	AFE Number	162582	COST EST (Dry Hole)			
WELL NUMBER	1-17	Net Interest %		Orig & Eval (incl. P&A) Est			
PROSPECT				AFE AMOUNT (Total)			
AREA NAME							
FIELD	n/a Section						
WORK TYPE	Evaluate J-Sand	CASING PROGRAM					
WELL CLASS	Exploratory CATEGORY	SIZE	TYPE	MD BTM	TVD BTM	COND	LOT or FIT
CITY / PARISH OR CO. / STATE	Morgan County, Colorado	13-3/8	Surface	355	355	cemented	
RIG NAME / RIG TYPE	Patterson-UTI Rig 190	8.625	Long String	5,997	5,997	cemented	
TD (PROPOSED / PRESENT)	6,500						
TVD (PROPOSED / PRESENT)	6,500						
OBJECTIVE SAND(S)	J Sand						
GROUND ELEV.	4,412' RKB 16.0'						
PERFORATIONS (Proposed)	5150' to 5230'; 5,270' to 5300'						

RPT. DATE 02/04/05 FOREMAN W.F. "GUS" Gustafson MUD WEIGHT 0.0 PPG

DEPTH @ 0600 HRS 5,900' ETD / PSTD / TOF 5,900' FOOTAGE DRILLED DRLG HOURS AVERAGE ROP

PRESENT OPERATION (0700 HRS.) Finish rig up to swab test J-Sand.

From	To	PLU	Hrs.	Remarks
7:00	16:30	P	9.50	Held pre job safety meeting on picking up pressure gauge assembly, packer tail assembly, Model EA Retrievmatic packer. Well on slight vacuum. Picked up pressure gauge assembly ( 2-7/8" ported bull plug, 8' pup joint with 3 pressure gauges, 6' pup joint, seating nipple, perforated nipple with 22 holes (0.75" ID), 2-7/8" by 3-1/2" collar, six (6) joints 3-1/2" 9.3 lb/ft J-55 EUE tubing, Model EA Retrievmatic Packer, 6' 3-1/2" pup joint. Tripped in hole rotary and pick up 161 joints of 3-1/2" 9.3 lb/ft J-55 EUE J-55 tubing. Set packer at 5,086.29 FT with 20K set down weight. Loaded annulus with 75 BBLs fresh water and tested packer to 500 PSI. Held okay. Nipped up to swab test well. Connected lines to 210 BBL swab tank. Installed 3,000 PSI WP Valve in top of tubing and closed in. Shut in BOP secured well. NOTE: The 75 BBLs to fill annulus to test packer indicates fluid level is at 1,529 FT. Fluid level on last per gun run was 770 FT. Fluid dropped an additional 759 FT.
16:30	7:00		14.50	Shut down for night.
			24.0	TOTAL HRS.

DAILY INTANGIBLE	\$ 10,038	CUMULATIVE COST	\$ 61,397
DAILY TANGIBLE	\$ -	DAILY COST	\$ 10,038
CAPITALIZED ENGINEERING	\$ -	PRIOR CUM. COST	\$ 51,359

FLUID PROPERTIES	MW	MO @ MW	VIS	PV - YP	Gel 10 S	Gel 10 Min	API Filtrate	Filtrate HTHP	Oil / Water Ratio	Exc. Stability	Excess Lime	Water Phase Salinity
% LGS	% Sand	% Solids	HST	pH	PF / MF	Chlorides	Calcium	LCM (PPB)	600 RPM	300 RPM	6 RPM	3RPM

PRODUCT USAGE / FLUID INFO.						
Product Name	Quantity	Product Name	Quantity	Fluid Company	Quality Dng Fluids	PRIOR CUM. FLUID LOSS
				Fluid Type	BRINE	Daily Fluid Loss - Hole
				Fluid System	SALT WATER	Cum Fluid Loss - Hole
						0 bbl
						Prior Cum. Fluid Cost
						Daily Fluid Cost
						Cumulative Fluid Cost

BIT INFORMATION												
Report Jet Nozzle sizes on Page 2 below the BHA section.												
NO.	SIZE	MAKE	SERIAL #	TYPE	DEPTH IN	DEPTH OUT	FOOTAGE	HOURS	ROP	WOB	TFA	IADC BIT GRADE
							0				0.9204	
							0					

HYDRAULICS INFORMATION													
PUMP	MAKE	MODEL	STROKE	UNER	SPM	EFF. %	BBUSTK	PUMP PRESS	GPM	DP AV	DC AV	JET VEL	HHP
1									0				
2													
3													

**UNOCAL - GULF REGION USA**  
**DAILY - DRILLING / WORKOVER / COMPLETION REPORT**

WELL NAME	Windy Hill Gas Storage Unit # 1 Well 1-17			DATE	02/05/05	REPORT NO	5
LEASE	Windy Hill Gas Storage Unit # 1			AFE Number	162582	COST EST (Dry Hole)	
WELL NUMBER	1-17			Net Interest %		Orig & Eval (incl. P&A) Est.	
PROSPECT						AFE AMOUNT (Total)	
AREA NAME							
FIELD	n/a	Section					
WORK TYPE	Evaluate J-Sand			CASING PROGRAM			
WELL CLASS	Exploratory	CATEGORY		SIZE	TYPE	MD BTM	TVD BTM
CITY / PARISH OR CO. / STATE	Morgan County, Colorado			13-3/8	Surface	355	355
RIG NAME / RIG TYPE	Patterson-UTI Rig 190			8.625	Long String	5,987	5,987
TD (PROPOSED / PRESENT)	6,500						
TVD (PROPOSED / PRESENT)	6,500						
OBJECTIVE SAND(S)	J Sand						
GROUND ELEV.	4,412'	RKB	16.0'				
PERFORATIONS (Proposed)	5150' to 5230'; 5,270' to 5300'						

RPT. DATE 02/05/05 FOREMAN W.F. "GUS" Gustafson MUD WEIGHT 0.0 PPG

DEPTH @ 0800 HRS 5,500' ETD / PBDT / TOF 5,900' FOOTAGE DRILLED DRLG HOURS AVERAGE ROP

PRESENT OPERATION (0700 HRS.) Rig up additional frac tank to hold swabbed fluid and continue swabbing J-Sand.

From	To	PLA	Hrs.	Remarks
7:00	18:00	P	11.00	Held pre job safety meeting on swabbing well. Shut in tubing on vacuum. No pressure on casing tubing annulus.
				Finished hooking up lines to swab tank. Swab well on test 9.5 hours. Initial fluid level 2,400 FT with final fluid level 2,200 FT. Monitor Chlorides of water
				Swab results listed below
				Time fluid level BBL/HR Total BBL Chlorides
				9:00 2250 19.38 19.38 — sample not tested
				10:00 2350 19.38 38.76 76,000
				11:00 2250 14.82 53.58 — sample not tested
				12:00 2250 20.52 74.10 37,500
				13:00 2200 11.40 85.50 36,000
				14:00 2300 23.94 109.44 30,000
				15:00 2200 25.48 134.92 25,000
				16:00 2200 27.36 162.28 25,000
				17:00 2200 25.06 187.34 — sample not tested
				17:30 2200 9.04 196.38 15,300
				Secured well for night close master valve.
18:00	7:00		0.54	Shut down for night.
				NOTE: We will continue swabbing until chlorides of recovered fluid represent known level of produced J-Sand water. Anticipated chlorides range of 2000-3000 to 7000 ppm.
			11.5	TOTAL HRS.

DAILY INTANGIBLE	\$ 3,840	CUMULATIVE COST	\$ 65,236
DAILY TANGIBLE	\$ -	DAILY COST	\$ 3,840
CAPITALIZED ENGINEERING	\$ -	PRIOR CUM. COST	\$ 61,396

FLUID PROPERTIES	MW	MD @ MW	VIS	PV - YP	Gel 10 S	Gel 10 Mn	API Filtrate	Filtrate HTHP	Oil / Water Ratio	Elec. Stability	Excess Lime	Water Phase Satiny
% LGS	% Sand	% Solids	MBT	pH	PF / MF	Chlorides	Calcium	LCM (PPB)	600 RPM	300 RPM	0 RPM	3RPM

PRODUCT USAGE / FLUID INFO.												
Product Name	Quantity	Product Name	Quantity	Fluid Company	Quality Dry Fluids	PRIOR CUM. FLUID LOSS						
				Fluid Type	BRINE	Daily Fluid Loss - Hole						
				Fluid System	SALT WATER	Cum Fluid Loss - Hole						
						0 bbl						
						Prior Cum. Fluid Cost						
						Daily Fluid Cost						
						Cumulative Fluid Cost						

BIT INFORMATION												
Report Jet Nozzle sizes on Page 2 below the BHA section.												
NO.	SIZE	MAKE	SERIAL #	TYPE	DEPTH IN	DEPTH OUT	FOOTAGE	HOURS	ROP	WOB	TFA	WDC BIT GRADE
							0				0.9204	
							0					

HYDRAULICS INFORMATION												
PUMP	MAKE MODEL	STROKE	LINER	SPM	EFF. %	BBL/STK	PUMP PRESS	CPM	DP AV	OC AV	JET VEL	HHP
1								0				
2											BIT PRESS DROP	IMP FORCE
3												





**UNOCAL - GULF REGION USA**  
**DAILY - DRILLING / WORKOVER / COMPLETION REPORT**

WELL NAME	Windy Hill Gas Storage Unit # 1 Well 1-17	DATE	02/08/05	REPORT NO	8		
LEASE	Windy Hill Gas Storage Unit # 1	AFE Number	162582	COST EST (Dry Hole)			
WELL NUMBER	1-17	Net Interest %		Drig & Eval (incl. P&A) Est.			
PROSPECT				AFE AMOUNT (Total)			
AREA NAME							
FIELD	n/a Section						
WORK TYPE	Evaluate J-Sand	CASING PROGRAM					
WELL CLASS	Exploratory CATEGORY	SIZE	TYPE	MD BTM	TVD BTM	COND	LOT or FIT
CITY / PARISH OR CO. / STATE	Morgan County, Colorado	13-3/8	Surface	355	355	cemented	
RIG NAME / RIG TYPE	Patterson-UTI Rig 190	8.625	Long String	5,987	5,987	cemented	
TD (PROPOSED / PRESENT)	6,500						
TVD (PROPOSED / PRESENT)	6,500						
OBJECTIVE SAND(S)	J Sand						
GROUND ELEV.	4,412' RKB 16.0'						
PERFORATIONS (Proposed)	5150' to 5230'; 5,270' to 5300'						

RPT. DATE 02/08/05 FOREMAN W.F. "GUS" Gustafson MUD WEIGHT 8.0 PPG

DEPTH @ 6600 HRS 5.900 ETD / P&TD / TOF 5.900 FOOTAGE DRILLED DRLG HOURS AVERAGE ROP

PRESENT OPERATION (0700 HRS.) Trip in hole and hang off 3-1/2" tubing in well. Load hole with fresh water and corrosion inhibitor. Pressure test cement retainer to 250 psi.

From	To	PUA	Hrs.	Remarks
7:00	9:00	P	2.00	Frack tank empty from gravity feed of swabbed water. Held pre job safety meeting on releasing packer and tripping 3-1/2" tubing and rigging up pump lines.
				Rehooked up lines to tubing & inject swabbed water out of the swab tank. Pumped a total of 197 BBLS swabbed water. Rig down pump lines.
9:00	13:00		4.00	Rigged down 3-1/2" 3K isolation valve. Removed stripping head, rigged up floor to trip tubing. Released packer. Pulled out of hole racking back 80 doubles of 3-1/2" tubing. Laid down packer, 6 joints of tail pipe tubing.
13:00	14:00		1.00	Breakdown perf nipple / gauge assembly. Remove pressure gauges and download pressure gauges. Recovered good data.
14:00	16:00		2.00	Wait on ASAP Perforators to run cement retainer.
16:00	17:00		1.00	Rigged up ASAP Perforators electric line unit. Make up cement retainer and run in hole. Set Baker Cement Retainer at 5,100 FT.
				Pulled out of hole with e-line tools and rigged down ASAP Perforators. NOTE: Fluid level in hole prior to setting Cement Retainer was 2580 FT.
17:00	17:30		0.50	Secured well Shut down for night.
17:30	7:00		13.50	Shut down for night.
			24.00	TOTAL HRS.

DAILY INTANGIBLE	\$ 10,079	CUMULATIVE COST	\$ 128,914
DAILY TANGIBLE	\$ -	DAILY COST	\$ 10,079
CAPITALIZED ENGINEERING	\$ -	PRIOR CUM. COST	\$ 118,835

FLUID PROPERTIES	MW	MD @ MW	VIS	PV - YP	Gel 10 S	Gel 10 Min	API Filtrate	Filtrate HT/HP	Cl / Water Ratio	Elec. Stability	Excess Lime	Water Phase Salinity
% LGS	% Sand	% Solids	MBT	pH	PF / MF	Chlorides	Calcium	LCM (PPG)	800 RPM	300 RPM	6 RPM	3RPM

PRODUCT USAGE / FLUID INFO.		Product Name		Quantity	Fluid Company	Quality Orig. Fluids	PRIOR CUM. FLUID LOSS
					Fluid Type	BRINE	Daily Fluid Loss - Hole
					Fluid Systems	SALT WATER	Cum Fluid Loss - Hole
							0 bbl
							Prior Cum. Fluid Cost
							Daily Fluid Cost
							\$ 350
							Cumulative Fluid Cost
							\$ 350

BIT INFORMATION												
Report Jet Nozzle sizes on Page 2 below the BHA section.												
NO.	SIZE	MAKE	SERIAL #	TYPE	DEPTH IN	DEPTH OUT	FOOTAGE	HOURS	ROP	WOB	TFA	IADC BIT GRADE
							0				0.9204	
							0					

HYDRAULICS INFORMATION												
PUMP	MAKE MODEL	STROKE	LINER	SPM	EFF. %	BS/STK	PUMP PRESS	GPM	DP AV	DC AV	JET VEL	HHP
1								0				
2												
3												

BIT PRESS DROP IMP FORCE

