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Energy Fuels Resources (USA) Inc.
225 Union Blvd. Suite 600
Lakewood, CO, US, 80228
303 974 2140
www.energyfuels.com

DRC-2022-005541

March 30, 2022

Sent VIA E-MAIL AND EXPEDITED DELIVERY

Mr. Doug Hansen
Director
Division of Waste Management and Radiation Control
Utah Department of Environmental Quality
195 North 1950 West
Salt Lake City, UT 84116

Re: Transmittal of the Plan for the MW-24A, Phase 2 Study, White Mesa Uranium Mill, Blanding Utah

Dear Mr. Hansen:

Enclosed are two copies of the Energy Fuels Resources USA Inc. ("EFRI") Plan for the MW-24A, Phase 2 Study (the "Phase 2 study"). In response to the previously identified exceedances and increasing trends, in 2020, EFRI voluntarily completed a study of MW-24A (collocated with MW-24) to determine what geochemical and hydrogeological influences are present which may be impacting monitoring data collected at these two wells and potentially other wells across the Mill site. The MW-24A study and report included several additional field data collection and analytical activities based on the conclusions of other Mill reports.

The results of the analytical and test data collected during the MW-24A study demonstrated that natural processes unrelated to disposal of materials in the Tailings Management System ("TMS") can account for the behavior of all trace metals of concern, as well as fluoride, in groundwater at MW-24 and MW-24A. Bottle-roll test results indicated that naturally-occurring trace metals can be mobilized at concentrations similar to or greater than in groundwater.

Based on the results of the MW-24A study EFRI has voluntarily agreed to implement a MW-24A Phase 2 study to determine what geochemical and hydrogeological influences are present that may be affecting monitoring data collected at other wells across the Mill site. EFRI is coordinating the Phase 2 study efforts with DWMRC. This Phase 2 study will build on the results of the previous study and will supplement the data using eight other Mill site locations. The procedures that will be used are described in detail in the attached Phase 2 study plan.

If you should have any questions regarding this submittal please contact me at 303-389-4134.

Yours very truly,

A handwritten signature in black ink that reads 'Kathy Weinel'. The signature is written in a cursive, flowing style.

ENERGY FUELS RESOURCES (USA) INC.
Kathy Weinel
Director, Regulatory Compliance

CC: Scott Bakken, David Frydenlund, Garrin Palmer, Logan Shumway, Jordan App
Stewart Smith (HGC)

White Mesa Uranium Mill

MW-24A Phase 2 Plan

**State of Utah
Groundwater Discharge Permit No. UGW370004**

Prepared by:



**Energy Fuels Resources (USA) Inc.
225 Union Boulevard, Suite 600
Lakewood, CO 80228**

March 30, 2022

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1.0 INTRODUCTION

Energy Fuels Resources (USA) Inc. (“EFRI”) operates the White Mesa Uranium Mill (the “Mill”), located near Blanding Utah, under State of Utah Ground Water Discharge Permit UGW370004 (the “Permit” or “GWDP”). Figure 1A is a site map showing well and piezometer locations, fourth quarter, 2021 shallow (perched) groundwater elevations, and other relevant site features, such as the locations of formerly used (unlined) wildlife ponds, the historic pond, and the boundaries of two shallow groundwater plumes (the nitrate/chloride plume and the chloroform plume) which are under active remediation by pumping. Specifically, Figure 1A shows the commingled nitrate and chloride components of the nitrate/chloride plume.

Figure 1B shows the same features as Figure 1A, except that water levels and plume boundaries are as they existed just prior to cessation of water delivery to the wildlife ponds in the fourth quarter of 2011. As shown in Figures 1A and 1B, perched groundwater flows generally to the southwest across the site, and the nitrate/chloride plume extends more than 1,000 feet upgradient of the tailings management system (“TMS”) indicating an upgradient source. As discussed in HGC (2018), the chloroform plume originated from disposal of laboratory wastes to two former sanitary leach fields that were used prior to Mill construction and operation.

Part I.G.2 of the Permit provides that out-of-compliance status exists when the concentration of a constituent in two consecutive samples from a compliance monitoring point exceeds a groundwater compliance limit (“GWCL”) in Table 2 of the Permit. As part of the assessment of exceedances of previous GWCLs, increasing trends in several constituents in MW-24 and other wells were observed as noted in the reports listed below.

In response to the previously identified exceedances and increasing trends, in 2020 EFRI voluntarily completed a study of MW-24A (collocated with MW-24) to determine what geochemical and hydrogeological influences are present which may be impacting monitoring data collected at these two wells and potentially other wells across the Mill site. The MW-24A study and report (EFRI, 2021) included several additional field data collection and analytical activities based on the conclusions of other Mill reports including but not limited to:

- 2008. *Background Groundwater Quality Report: New Wells for Denison Mines (USA) Corp.’s Mill Site*. April 30, 2008. Prepared by INTERA (“New Wells Background Report”).
- 2012. *Source Assessment Report White Mesa Uranium Mill*. October 10, 2012. Prepared by INTERA (“2012 SAR”).
- 2012. *pH Report White Mesa Uranium Mill*. November 9, 2012. Prepared by Intera (“pH Report”).
- 2012. *Investigation of Pyrite in the Perched Zone White Mesa Uranium Mill*. Prepared by Hydro Geo Chem Inc. (“HGC”) (“Pyrite Report”).
- 2016. *Source Assessment Report for MW-18 and MW-24 White Mesa Uranium Mill*. June 24, 2016. Prepared by INTERA (“2016 SAR”).
- 2019. *Source Assessment Report for MW-11 and MW-24 White Mesa Uranium Mill*. June 27, 2019. Prepared by INTERA (“2019 SAR”).

As discussed in EFRI (2021) the Army was present on the Mill site in the 1960s and may have released chemical contaminants that could potentially impact shallow groundwater.

The purpose of the additional data collection during the MW-24A study were as follows:

- To determine if the Army Bivouac resulted in any visible or discernable chemical impacts in the area of MW-24/MW-24A;
- To collect data regarding the oxidation of pyrite and its impact on pH and metals concentrations; and
- To determine if trace metals occur naturally in the formation hosting the perched groundwater, and whether they can be mobilized at concentrations comparable to or greater than as measured in groundwater.

Data collected during the MW-24A study are as follows:

- Groundwater analytical and groundwater field data from MW-24 and MW-24A;
- X-ray fluorescence (“XRF”) and Photoionization Detector (“PID”) data from the core of MW-24A;
- Whole rock analytical data from select intervals of the core of MW-24A;
- Synthetic precipitation leaching procedure (“SPLP”) data from select intervals of the MW-24A core; and
- Bottle roll test data from select intervals of the MW-24A core.

A summary of each type of data as well as the methods used for data collection are included in the MW-24A Report submitted to Division of Waste Management and Radiation Control (“DWMRC”) on June 14, 2021.

The results of the analytical and test data collected during the MW-24A study demonstrated that natural processes unrelated to disposal of materials in the TMS can account for the behavior of all trace metals of concern, as well as fluoride, in groundwater at MW-24 and MW-24A. Bottle-roll test results indicated that naturally-occurring trace metals can be mobilized at concentrations similar to or greater than in groundwater even without a large pH decrease, suggesting that agitation alone, such as would occur during routine purging and sampling of low permeability wells such as MW-24A, could result in metals mobilization.

In addition, simple mass balance calculations that assume increases in water levels at MW-24/MW-24A and MW-29 are due to potential TMS seepage rather than former wildlife pond seepage, indicate that chloride concentrations at MW-24 would need to exceed 11,500 mg/L, and chloride concentrations at MW-29 would need to exceed 4,500 mg/L, rather than the measured values at MW-24 and MW-29 of approximately 45 mg/L and less than 40 mg/L, respectively, thereby demonstrating that increased water levels at those wells are not due to potential TMS seepage.

Furthermore, although the U. S. Army was formerly present at the site, and may potentially have released contaminants that could impact MW-24A soils and groundwater, the results of the MW-24A study suggest that trace metals of concern, and fluoride, in MW-24A groundwater, could result entirely from natural processes triggered by well installation and sampling, and water level increases resulting from former historic and wildlife pond seepage.

Based on the results of the MW-24A study EFRI has voluntarily agreed to implement a MW-24A Phase 2 study (the “Phase 2 study”) to determine what geochemical and hydrogeological influences are present that may be affecting monitoring data collected at other wells across the Mill site. EFRI is coordinating the Phase 2 study efforts with DWMRC. This Phase 2 study will build on the results of the previous study and will supplement the data using eight other Mill site locations. The procedures that will be used are described in detail in the following sections.

1.1 Background

Metals monitored in shallow (perched) groundwater at the Mill occur naturally in the crust of the Earth at concentrations high enough to be mobilized in groundwater at the concentrations detected in perched monitoring wells. For example, Fleisher (1953) reports the following estimated average crustal abundances converted to parts per billion (“ppb”) by weight: cadmium (“Cd”) (100 to 5,000 ppb); beryllium (“Be”) (5,000 to 30,000 ppb); thallium (“Tl”) (0.8 to 600 ppb); cobalt (“Co”) (10,000 to 40,000 ppb); nickel (“Ni”) (80,000 to 200,000 ppb); selenium (“Se”) (30 to 800 ppb); and uranium (“U”) (200 to 9,000 ppb).

There is no compelling reason to suppose that these and other trace elements would not naturally be present in the formations (Burro Canyon Formation and Dakota Sandstone) hosting the perched groundwater monitored at the Mill. Some or all of these metals have been detected in far upgradient and cross-gradient wells that could not have been impacted by the TMS. In addition, the Mancos Shale directly overlying these formations is anomalous in many metals including Se and U (US Department of Energy, 2011). As discussed in Shawe (1976), the Dakota and Burro Canyon are considered ‘altered facies’ rocks primarily as a result of the invasion of pore waters expelled from the overlying Mancos Shale during compaction that caused removal of hematite coatings on sand grains, destruction of detrital black opaque minerals, and the growth of iron sulfide minerals such as pyrite. Not only were the metals contents of the Dakota and Burro Canyon increased by the invasion of Mancos Shale pore waters, the pyrite created as a result of invasion of these solutions is expected to contain significant trace metals including selenium. As discussed in Deditius et al (2011) pyrite commonly contains arsenic (“As”), lead (“Pb”), antimony (“Sb”), bismuth (“Bi”), copper (“Cu”), Co, Ni, zinc (“Zn”), gold (“Au”), silver (“Ag”), Se and tellurium (“Te”). Oxidation of pyrite by oxygen introduced into the formation via wells or wildlife pond seepage, or by nitrate within the nitrate/chloride plume (which originates upgradient of the Mill and TMS, as shown in Figure 1A) is expected to directly release these metals. The potential for enhanced oxidation of pyrite via oxygen introduced through wells is discussed in Sections 1.1.3 and 1.1.4 below.

Furthermore, the Dakota Sandstone and Burro Canyon Formation host naturally-occurring uranium mineralization (Craig, 1982; Pierson, 1980) that is expected to be mobilized in the presence of oxygen and/or nitrate. Rose and Wright (1980) indicate that elements associated with sandstone-type uranium deposits include sulfur (“S”), vanadium (“V”), molybdenum (“Mo”), Se, As, Cu, Ag, chromium (“Cr”), Pb, Zn, Ni, Co, rhenium (“Re”), Be, phosphorous (“P”), manganese (“Mn”) and rare earths.

Overall, considering that the Dakota Sandstone and Burro Canyon Formation have been impacted by the Mancos Shale, and that uranium mineralization with associated elements occurs naturally within these formations, it is possible that the concentrations of many or all of these metals may exceed average crustal abundances.

Considering that the trace metals of concern are likely to be naturally present in the hosting formations at concentrations that could result in the concentrations measured in perched groundwater, changes in conditions unrelated to disposal of materials to the TMS could act to cause changes in concentrations of metals in groundwater. Currently the perched groundwater system hosted by the Burro Canyon Formation and Dakota Sandstone does not approach steady state over much of the monitored area. A large part of the site perched water system is in a transient state and affected by long-term changes in water levels due to past and current activities unrelated to the disposal of materials to the TMS. Changes in water levels have historically been related to seepage from the unlined wildlife ponds; however, past impacts related to the historical pond, and to a lesser extent the sanitary leach fields, are also expected, as discussed in HGC (2018). Water levels have decreased at some locations due to chloroform and nitrate pumping and reduced recharge from the wildlife ponds.

As discussed above, Figure 1B shows the same features as Figure 1A, except that water levels and plume boundaries are as they existed just prior to cessation of water delivery to the wildlife ponds. A comparison between Figure 1A and Figure 1B shows the substantial changes in water levels that have occurred in less than 10 years due to pumping and cessation of water delivery to the wildlife ponds. Currently, although water levels have declined substantially in the center of the perched groundwater mound associated with the northern wildlife ponds, water levels have not returned to pre-pond seepage conditions, and consequently the groundwater mound is still expanding. For example, water levels at relatively distant wells MW-24 and MW-29, which are approximately the same distance from the ponds, have risen approximately 3 feet since the fourth quarter of 2011.

The transient status of a large portion of the perched water system, manifested in long-term changes in saturated thicknesses and rates of groundwater flow, is expected to result in trends in pH and in the concentrations of many dissolved constituents that are unrelated to site operations. Changes in saturated thicknesses and rates of groundwater flow can result in changes in concentrations of dissolved constituents (or pH) for many reasons. For example, as discussed in HGC (2012), groundwater rising into a vadose zone having a different chemistry than the saturated zone can result in changes in pH and groundwater constituent concentrations. If the rise in groundwater represents a long-term trend, long-term changes in groundwater constituent concentrations (or pH) may result.

The following list of previously submitted reports provide background information as well as conclusions and data used in the design of the Phase 2 study. The conclusions from these reports as summarized below were used during the design and implementation of the Phase 2 study.

- 2008. *Background Groundwater Quality Report: New Wells for Denison Mines (USA) Corp.'s Mill Site*. April 30, 2008. Prepared by INTERA ("New Wells Background Report").
- 2012. *Source Assessment Report White Mesa Uranium Mill*. October 10, 2012. Prepared by INTERA ("2012 SAR").
- 2012. *pH Report White Mesa Uranium Mill*. November 9, 2012. Prepared by Intera ("pH Report").
- 2012. *Investigation of Pyrite in the Perched Zone White Mesa Uranium Mill*. Prepared by Hydro Geo Chem Inc. ("HGC") ("Pyrite Report").
- 2020. *MW-24A Report*. June 14, 2021. Prepared by Energy Fuels Resources (USA) Inc. ("EFRI").

1.1.1 New Wells Background Report

The New Wells Background Report noted a downward trend of pH in all perched groundwater wells (both existing and new wells) across the Mill site, including those far upgradient, cross-gradient and far downgradient of the Mill site. The site-wide decreasing pH trends are indicative of a site-wide process impacting the site as a whole including far upgradient, far downgradient and cross-gradient areas that could not possibly have been impacted by site operations, such as potential TMS seepage. The process was initially attributed to natural and/or regional changes and has since been attributed to the oxidation of naturally-occurring pyrite in the formation hosting perched groundwater. As noted in the University of Utah study conducted in 2008 and as referenced in the New Wells Background Report, isotopic and age dating analyses (Hurst 2008) demonstrate that groundwater in site monitoring wells represents natural background conditions because site groundwater predates uranium milling operations.

1.1.2 2012 SAR

The 2012 SAR noted a statistically significant decreasing pH trend and significantly increasing constituent concentration trends in multiple wells. The 2012 SAR concluded that the statistically significantly increasing constituent trends (as wells as non-statistically significant increasing trends) were the result of the decreasing pH trend.

Specifically, chloride dissolved in groundwater is not expected to sorb onto or react with formation materials and is therefore expected to migrate at about the same rate as the groundwater; however pH, which is a measure of the hydrogen ion concentration, is expected to attenuate substantially compared to chloride due to chemical reaction. Naturally-occurring carbonate minerals in the subsurface and carbonate dissolved in groundwater would neutralize the pH in any potential TMS seepage, thereby increasing the pH of the seepage as it percolated through the vadose zone, subsequently mixed with perched groundwater, and was then carried

downgradient. As a result, any decrease in pH associated with potential TMS seepage cannot be detected faster than chloride. Regardless of whether or not pH is decreasing, stable (or decreasing) chloride demonstrates that a particular well has not been impacted by potential TMS seepage. In addition, other factors such as migration of the nitrate/chloride plume, which extends approximately 1,000 feet upgradient of the TMS, could cause increases in chloride in many wells that are unrelated to disposal of materials to the TMS.

1.1.3 pH Report

The primary conclusion from the activities conducted during the pH investigation is that the historical trend of decreasing pH, which was noted in the Background Study Reports, appears to be present in nearly all wells throughout the Mill site area, including upgradient, downgradient, and cross-gradient wells in the groundwater monitoring program. As discussed above, the widespread nature of the decrease in pH in upgradient, downgradient, and cross-gradient wells suggests that the pH decreases result from a natural phenomenon unrelated to Mill operations, which is also confirmed by the indicator parameter analysis in all wells completed as part of the pH investigation. The most likely cause of declining pH across the site appears to be the oxidation of pyrite in the formations hosting perched groundwater (Burro Canyon Formation and overlying Dakota Sandstone).

As discussed in the pyrite report (Section 1.1.4 below), wells which have substantial portions of their screens extending into the vadose zone, can conduct substantial amounts of oxygen to the groundwater which is then available to oxidize pyrite. Mixing of oxygen into groundwater is enhanced by the inevitable agitation caused during routine purging and sampling, a condition that is exacerbated by the low permeability of the perched groundwater zone. In addition, oxygen transport will be enhanced by increased sampling frequency; and by water level increases that mix groundwater into an oxygen-rich vadose zone.

As noted above, prior to about 2016, increased pyrite oxidation resulted in a decrease in pH in nearly all wells throughout the Mill site area, including upgradient, downgradient, and cross-gradient wells in the groundwater monitoring program. However, since 2016, pH has been stable to increasing in nearly all wells throughout the Mill site area, suggesting that if pyrite oxidation is still occurring, any associated acid production must occur in areas localized enough that mixing with surrounding groundwater does not result in an overall pH decrease. In addition, for wells impacted by the nitrate/chloride plume, pyrite can be oxidized by nitrate via a mechanism that consumes rather than produces acid, leading to an increase in pH.

1.1.4 Pyrite Report

The Pyrite Report describes an investigation into the occurrence of naturally-occurring pyrite in the perched water zone at the Mill. The pyrite investigation was completed to address dual exceedances of pH in ten perched groundwater monitoring wells at the Mill and to provide information related to the overall decline in groundwater pH that has been observed in upgradient, downgradient and cross-gradient wells.

The Pyrite Report concluded that the oxidation of pyrite will be enhanced in the vicinities of perched wells because they provide a direct conduit for oxygen to dissolve in the perched water and to react with any pyrite present in the formation near the wells. As discussed above, oxygen transport to groundwater in the vicinities of perched wells is enhanced by the presence of vadose screens; by the low permeability of the perched zone which increases residence time of groundwater in the wells and causes inevitable agitation during routine purging and sampling; and by water level increases that mix groundwater into an oxygen-rich vadose zone (made richer by diffusion of air into the vadose zone via screens extending into the vadose zone). In addition, perched groundwater near formerly used wildlife ponds is expected to have increased oxygen through mixing of oxygen-rich seepage from the ponds. Because of its site-wide influence, and because it is consistent with most of the site data, enhanced pyrite oxidation through increased oxygen transport is a likely mechanism for the formerly decreasing trends in pH measured in most of the wells at the site, including up-gradient, cross-gradient, and downgradient wells.

Pyrite (“FeS₂”) oxidizes in the presence of oxygen according to the following equation, producing Iron (II), hydrogen ions and sulfate in the process:



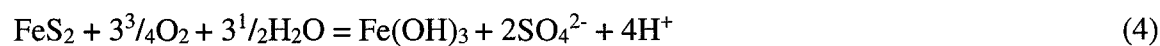
Iron(II) then reacts with oxygen and hydrogen ion according to the following reaction:



Iron(III) then reacts with water according to the following reaction:



Combining the above yields the following reaction (Hartog et al 2001; HGC, 1989):



Oxidation of 1 mole of pyrite therefore yields 4 moles of hydrogen ions. The resulting increase in hydrogen ions lowers the pH (defined as the negative log of the concentration [or activity] of hydrogen ion in moles per liter). The laboratory measured concentrations of pyrite in drill cuttings and/or core samples from three representative wells (MW-3A, MW-24, and MW-27) is more than sufficient to account for measured pH declines and increases in sulfate concentrations at these wells (at least, prior to 2012 when the pyrite report was prepared). The former pH decreases also resulted in changes in concentrations of analytes sensitive to pH such as metals.

Specifically (at the time the report was prepared, when pH was decreasing site-wide), the Pyrite Report noted that screening level calculations (pH-sulfate mass balance) for both pH and sulfate support pyrite oxidation as the mechanism for measured pH decrease and sulfate increase across the site.

1.1.5 MW-24A Report

As previously stated, the MW-24A Report concluded that the analytical and test data demonstrate that natural processes unrelated to disposal of materials in the TMS account for the behavior of all trace metals of concern, as well as fluoride, in groundwater at MW-24 and MW-24A. Bottle-roll test results indicate that naturally-occurring trace metals can be mobilized at concentrations similar to or greater than in groundwater even without a large pH decrease, suggesting that agitation alone, such as would occur during routine purging and sampling of low permeability wells such as MW-24A, could result in metals mobilization.

One mechanism that likely increases mobilization of trace metals without a significant pH drop, is reactivation of passivated mineral surfaces by agitation. Reactivation is expected to enhance the solubility of metals derived directly from reactive minerals such as pyrite. In addition, mechanical agitation may enhance desorption of trace metals sorbed onto iron or manganese oxides. Such mechanisms are likely to impact both the solids in the test bottles and in the formation in the immediate vicinity of MW-24A during purging and sampling.

The pH behavior of bottle-roll solutions was generally consistent with expectations based on the mineralogy of the samples, as the largest pH drops were measured in the bottles containing only “generic” pyrite; and the next largest pH drops occurred in bottles containing core samples in which pyrite but no obvious carbonate minerals were present. pH in bottles containing core having both pyrite and carbonate minerals either increased slightly; remained about the same; or decreased slightly. pH in the uncrushed (solid) pure pyrite samples dropped by approximately 3 pH units; pH in the uncrushed (solid) 77.5-77 ft bls core sample (where pyrite but no carbonate was noted) dropped by approximately 0.7 pH units; and pH in the remaining uncrushed (solid) core samples (containing carbonate minerals) either decreased slightly; stayed about the same; or increased.

While the MW-24A Report noted increased trace metals concentrations without a significant pH drop, the results of the MW-24A study corroborated the conclusions noted in both the pH Report and the Pyrite Report. The “generic” pyrite control sample included in the MW-24A study showed a significant pH drop (as described above) which demonstrates that oxidation of the naturally-occurring pyrite in the formation is likely the cause of the declining pHs noted across the Mill site prior to 2016. Previous reports have attributed the statistically significant increasing trends (as well as non-statistically significant increasing trends) to the decreasing pH trend. The MW-24A Report concluded that trace metals will leach from the formation in the absence of a declining pH trend; however, the MW-24A study does not definitively determine if the concentrations of trace metals leached increases when a decreasing pH trend is present. It is likely that a decreasing pH trend will increase the trace metals concentrations in groundwater; however, based on the MW-24A study findings, leaching without a significant pH decrease can yield concentrations greater than those noted in the groundwater. Therefore no further investigation regarding the effect of a decreasing pH trend is necessary at this time.

2.0 GEOLOGY/HYDROGEOLOGY

The following discussion is based primarily on TITAN (1994) and HydroGeoChem (2018).

The Mill has an average elevation of approximately 5,600 feet above mean sea level (“ft. amsl”) and is underlain by unconsolidated alluvium and indurated sedimentary rocks. The indurated rocks consist primarily of sandstone and shale and are relatively flat lying with dips generally less than 3°. The alluvial materials consist primarily of aeolian silts and fine-grained aeolian sands with a thickness varying from a few feet to as much as 25 to 30 feet across the site. The alluvium is underlain by the Dakota Sandstone and Burro Canyon Formation, and where present, the Mancos Shale. The Dakota and Burro Canyon are sandstones having a total thickness ranging from approximately 55 to 140 feet, and, because of their similarity, are typically not distinguished in lithologic logs at the site. Beneath the Burro Canyon Formation lies the Morrison Formation, consisting, in descending order, of the Brushy Basin Member, the Westwater Canyon Member, the Recapture Member, and the Salt Wash Member. The Brushy Basin and Recapture Members of the Morrison Formation, classified as shales, are very fine-grained, have a very low permeability, and are considered aquicludes. The Brushy Basin Member is primarily composed of bentonitic mudstones, siltstones, and claystones. The Westwater Canyon and Salt Wash Members also have a low average vertical permeability due to the presence of interbedded shales.

Beneath the Morrison Formation lies the Summerville Formation, an argillaceous sandstone with interbedded shales, and the Entrada Sandstone. Beneath the Entrada lies the Navajo Sandstone. The Navajo and Entrada Sandstones constitute the primary aquifer in the vicinity of the site. The Entrada and Navajo Sandstones are separated from the Burro Canyon Formation by approximately 1,000 to 1,100 feet of materials having a low average vertical permeability. Groundwater within this system is under artesian pressure in the vicinity of the site, is of generally good quality, and is used as a secondary source of water at the site. Although the water quality and productivity of the Navajo/Entrada aquifer are generally good, the depth (approximately 1,200 feet below land surface [“ft. bls”]) makes access difficult.

The shallowest groundwater beneath the site occurs within the Dakota Sandstone and Burro Canyon Formation. This groundwater is referred to as the ‘perched’ groundwater and is used on a limited basis to the north (upgradient) of the site because it is more easily accessible than the Navajo/Entrada aquifer. Although perched groundwater extends into the overlying Dakota Sandstone within areas having greater saturated thicknesses, perched groundwater at the site is hosted primarily by the Burro Canyon Formation, which consists of a relatively hard to hard, fine- to medium-grained sandstone containing siltstone, shale and conglomeratic materials. Perched groundwater originates mainly from precipitation and local recharge sources such as unlined reservoirs (Kirby, 2008) and is supported within the Burro Canyon Formation by the underlying aquiclude (Brushy Basin Member of the Morrison Formation). Saturated thicknesses at the site range from less than 1 foot along the downgradient edge of the tailings management system to approximately 80 feet in upgradient wells located near formerly used unlined wildlife ponds.

Perched water quality is generally poor due to high total dissolved solids (“TDS”) in the range of approximately 1,100 to 7,900 milligrams per liter (“mg/L”), and is used primarily for stock watering and irrigation. The saturated thickness of the perched water zone generally increases to the north of the site, increasing the yield of the perched zone to wells installed north of the site. Perched water flow across the site is generally from northeast to southwest. This general flow pattern has been consistent based on perched water level data collected beginning with the initial site investigation described in Dames and Moore (1978). Perched water discharges in seeps and springs located to the west, southwest, east, and southeast of the site.

The perched zone has generally low permeability. Hydraulic conductivity ranges from approximately 2×10^{-8} to 0.01 cm/s and has a geometric average (based on slug tests) of approximately 3×10^{-5} cm/s. MW-24 and MW-24A have relatively low hydraulic conductivities of approximately 4×10^{-5} and 1.4×10^{-5} cm/s, respectively.

The generally low permeability of the perched zone limits well yields. Although sustainable yields of as much as 4 gallons per minute (“gpm”) have been achieved in site wells penetrating higher transmissivity zones near unlined wildlife ponds, yields are typically low (<0.5 gpm) due to the generally low permeability of the perched zone. Even site wells that yielded as much as 4 gpm during the first few months of pumping eventually saw yields drop to about 1 gpm or less. Total achievable pumping from the 16 wells used to remediate chloroform and nitrate plumes at the site is less than 7 gpm. In addition, many of the perched monitoring wells purge dry and take several hours to more than a day to recover sufficiently for groundwater samples to be collected. During a well redevelopment effort during 2010 and 2011, many of the perched wells went dry during surging and bailing and required several sessions on subsequent days to remove the proper volumes of water (HGC, 2011).

3.0 PROCEDURES AND DATA TO BE COLLECTED AS PART OF THIS INVESTIGATION

As stated in Section 1.0 the results of the analytical and test data collected during the MW-24A study demonstrated that natural processes unrelated to disposal of materials in the TMS can account for the behavior of all trace metals of concern, as well as fluoride, in groundwater at MW-24 and MW-24A. Bottle-roll test results indicated that naturally-occurring trace metals can be mobilized at concentrations similar to or greater than in groundwater even without a large pH decrease, suggesting that agitation alone, such as would occur during routine purging and sampling of low permeability wells such as MW-24A, could result in metals mobilization.

As noted above, the perched groundwater system hosted by the Burro Canyon Formation and Dakota Sandstone does not approach steady state over much of the monitored area. A large part of the site perched water system is in a transient state and affected by long-term changes in water levels due to past and current activities unrelated to the disposal of materials to the TMS. Based on the results of the MW-24A study EFRI has voluntarily agreed to implement a Phase 2 study to determine what geochemical and hydrogeological influences are present that may be affecting monitoring data collected at other wells across the Mill site.

The MW-24A study was used as the basis for the data collection activities to be implemented during the Phase 2 study. Some data collection activities that were implemented during the MW-24A study have been modified, enhanced or omitted based on the results of the MW-24A study.

During discussions with DWMRC regarding this investigation, DWMRC requested the installation of another groundwater monitoring well down gradient of MW-24/MW-24A. The new well will be installed as part of this investigation and the core material from well drilling will be used in this study. The well (MW-41) is shown on Figure 2. MW-41 will be installed down gradient from MW-24/MW-24A (in closer proximity to MW-24 than MW-2) and will be completed using a shorter well screen to eliminate open well screen above the water table. –

The primary purpose of eliminating open screen above the water table is to minimize transport of air into the vadose zone in the vicinity of the well to in turn minimize oxygen transport to groundwater. As discussed in HGC (2012), enhanced oxygen transport to groundwater near monitoring wells increases pyrite oxidation, lowers pH, and mobilizes trace metals contained in pyrite as well as pH sensitive metals that occur naturally in the formation hosting perched groundwater.

Oxygen transport from a well screened in the vadose zone occurs via diffusion of air enhanced by barometric pumping. The mechanism for barometric pumping is discussed in Rossabi and Falta (2002) and You et al (2011). Barometric pumping via wells screened in the vadose zone can be significant enough to remediate VOC plumes in the vadose zone as discussed in Rossabi et al (1993); and Bosze et al (2001). ESTCP (2006) specifically discusses enhancing oxygen transport to the vadose zone via barometric pumping using vadose wells to stimulate aerobic biodegradation of vadose hydrocarbon contamination. Because barometric pumping relies on wells screened in the vadose zone, transport of air (and oxygen) to the vadose zone, where it is in direct contact with groundwater, can therefore be minimized by eliminating vadose screen and keeping the top of the well screen below the water table.

The procedures used for each data collection activity are summarized below. Detailed procedures, for each activity, that will be used by the field and bottle roll laboratory personnel are included in Tab A.

3.1 Locations

In order to collect data that are representative of the Mill site, locations far upgradient, far downgradient and far cross-gradient of the TMS have been chosen. The locations to be included in this study are as follows:

- MW-3A (downgradient)
- MW-18 (upgradient)
- MW-22 (far cross-gradient)
- MW-24A (downgradient)
- MW-32 (cross-gradient)
- MW-39 (far cross-gradient)

- MW-40 (far cross-gradient)
- MW-41 (far cross-gradient)

No boring will be drilled at MW-24A during this investigation. Core collected during well installation activities in 2019 will be used for the Phase 2 study.

Data collected during this investigation are as follows:

- Lithologic data of the core material from the borings (in the case of MW-41, from well installation and in the case of MW-24A data from the 2019 installation will be used)
- Groundwater analytical and groundwater field data;
- XRF and PID data from the core material;
- Whole rock analytical data from select intervals of the core material;
- SPLP data from select intervals of the core material; and
- Bottle roll test data from select intervals of the core material.

3.2 Borings

The MW-24A study was conducted using core material collected during well installation. For the Phase 2 study, EFRI will drill borings in close proximity to the above wells and collect core material from the borings. MW-41 core material will be collected during well installation and therefore there will not be a separate boring drilled.

It was noted by Mill field personnel that following the installation and development of MW-24A, the water in MW-24 (which is 16 feet cross gradient) became more turbid and a visual difference in the quality of the water in MW-24 was apparent. EFRI will strive to place the borings as close to the wells listed above as possible; however, for wells with GWCLs, EFRI will attempt to locate the boring downgradient (in the case of MW-32, cross-gradient) and outside of the zone of influence of the wells, if at all possible.

Lithologic information, PID readings and XRF data will be collected during the boring activities as noted in Section 3.2.1 below. Immediately following the field data collection activities, the borings will be abandoned in accordance with State of Utah Administrative Rules for Water Wells R655-4-14. Core materials will be labeled, boxed and stored in a secure location on the Mill site.

3.2.1 Methods

During the installation of MW-41 and other borings, core will be collected from the top of the boring to the bottom to the extent possible. The core will be logged and quartered at the time of collection. Particular attention will be paid to identifying the presence of pyrite during the logging. Field PID data using a RAE Systems instrument and XRF data using an Olympus Vanta C-Series instrument (or equivalent) will be collected to provide information regarding the presence of any organic constituents and metals data content respectively. The XRF data will be

used to assist in identifying sampling intervals for submission for whole rock analyses based on any high metals readings detected by the XRF.

During core collection the following field analysis procedures were implemented:

- 1) The entire length of core will be scanned with the PID. If there were any PID readings above background, the core section will be photographed, and samples collected for full suite laboratory analyses (total volatile organic compounds ["VOCs"], total semi-volatile organic compounds ["SVOCs"], total metals, and total inorganics).
- 2) The entire length of core was analyzed in the field using a portable, hand-held XRF.
- 3) Elements of interest during the XRF analysis = iron, sulfur, trace metals. Areas with higher concentrations of these elements, if present, will be noted. Elevated iron or manganese, if present, will also be noted: elevated iron may indicate pyrite or relatively abundant iron oxides; and elevated manganese may indicate relatively abundant manganese oxides.
- 4) If VOC samples are collected based on a PID reading above background, a pre-preserved VOC sample jar will be submitted to the analytical laboratory for analysis. If an SVOC sample is collected based on a PID reading above background, an aliquot of each core will be removed from the whole core section by AWAL prior to crushing and grinding to prevent the loss of any SVOCs present. The remainder of the core samples will be crushed and ground prior to analytical testing of the whole rock samples for total metals, and total inorganics. Specialized EPA methods for the collection of VOCs in soils will be followed as directed by AWAL. All sampling materials for VOCs (hermetically sealed jars etc.) will be provided by AWAL.

The XRF and PID will be calibrated and operated in accordance with the manufacturer's specifications

The XRF samples will be named for the core box number and the core interval in the box. For example, sample B8-76 would be a 5 shot average of the 76 feet bgs. interval in core box 8.

3.3 Groundwater Data

Groundwater data from routine sampling activities specified in the GWDP will be used for this Phase 2 study.

3.3.1 Methods

Groundwater sampling, field data collection and reporting, analytical methods, and data review procedures are described in the DWMRC-approved Quality Assurance Plan ("QAP") that was current at the time of the sampling. Data review results are described in each routine quarterly groundwater report.

3.4 Whole Rock Analytical Sample Collection

After the field analysis of the core by XRF and PID, whole rock samples will be collected from the quartered core for submission to the analytical laboratory. The whole rock core analyses will be completed to characterize the analytical composition of the formation to determine what analytes are present. The specific analytical list is included in Table 3.4-1. A fraction of each crushed and ground sample will be leached using SPLP and analyzed for total metals and inorganics. The SPLP analyses are discussed below.

3.3.1 Methods

Whole rock samples will be selected for analytical testing using the following criteria:

- One metals and inorganics analytical sample will be collected every 5 feet above the saturated zone and every 2 feet within the saturated zone.
- Sample names will reflect the interval of the sample (e.g. 24A 112 – 114 is the interval from 112 feet to 114 feet bgs).
- As noted above the core will be quartered. One quarter of the core for the interval chosen will be submitted to AWAL for analysis. AWAL will crush/grind the core prior to whole rock analysis.
- Note that sample locations may be moved or adjusted to locations with high concentrations of iron, sulfur, trace metals based on the XRF data, visible pyrite, or PID readings above background.

3.5 SPLP Samples

As noted above, a fraction of the crushed and ground whole rock samples will be analyzed following SPLP leaching. SPLP was chosen because it is a United States Environmental Protection Agency (“USEPA”) SW-846 test method that can be used with soil samples to estimate the site-specific adsorption-desorption potential of a constituent that may impact groundwater. SPLP uses a mild acid (5.0 SU west of the Mississippi) as an extraction fluid.

The list of analytes for the SPLP analyses is included in Table 3.4-1. Note that sulfate and nitrate are included in the whole rock analytical list but are omitted from the SPLP analyte list. Because nitric acid and sulfuric acid are used to adjust the pH of the extraction fluid for SPLP, it is not possible to measure these constituents during SPLP analyses.

3.5.1 Methods

Split samples will be collected from the crushed and ground whole rock samples submitted to AWAL. No field procedures were necessary for this this data collection activity.

3.6 Bottle Roll Testing

A rolling bottle leach test is a common analytical test used in determining if a constituent can be extracted from a solid. As an analytical tool, a solution contacted with a solid in a rolling bottle leach test is one of the first tests an analytical chemist might utilize to determine the type and amount of leachable metals or other constituents present in a naturally occurring or by-product material. The application of this analytical test type is widely used in a variety of analytical, environmental and geochemical/metallurgical laboratories.

Simply said, a rolling bottle test consists of a bottle filled with known amounts of solid material and a liquid. The solid material can be either a naturally occurring material or a man-made product that is sized according to the needs of the test work. The liquid can have either an acid, neutral or basic pH and will typically contain a specific constituent intended to enhance the leaching. In the simplest case, neutral water is used as the leaching solution. The sealed bottle is then rolled on laboratory rolls for a specific period of time. The test leach period can be short or long. At designated time intervals and/or at the end of the leaching period the solution is sampled and analyzed for the constituents of interest. The final solid residue material can be assayed as well for the constituents of interest so that a mass balance can be formulated and an extraction can be calculated.

Environmental characterization test work may employ a variety of leach conditions in rolling bottle tests to examine the possibility that a constituent might migrate from the solid into the surrounding soils, rocks or aquifers.

3.6.1 Methods

Bottle roll tests will be completed at the Mill by laboratory staff. The bottle roll test will consist of bottles filled with known amounts of solid core material (approximately 3 to 4 inches of core), and a “pure” pyrite sample (solid) used as the control (in two of the four tests). All samples will be covered with laboratory grade deionized (“DI”) water.

The core samples that will be selected for inclusion in the bottle roll test will be the core with the highest visible pyrite. Some of the intervals chosen will be located above the saturated zone and some will be located below the saturated zone. The pyrite sample will be purchased from a rock shop.

Specific Procedures for the core material selection are as follows:

- 1) As discussed above, select intervals having visible pyrite.
- 2) If visible pyrite is not present, select intervals having high iron (and sulfur) concentrations (based on screening with a portable XRF) that are also ‘reduced looking’, ie, have a color that is white to grayish to greenish.
- 3) In addition, select intervals having notable trace metals concentrations (beryllium, cadmium, etc.) based on screening with a portable XRF; and intervals that are ‘oxidized

looking' and have relatively large amounts of iron or manganese oxides to which naturally-occurring trace metals may have sorbed.

Screening with a portable XRF is discussed in Section 4.

Bottles with sufficient volume to accommodate a 3 to 4-inch segment of solid core material will be selected. The bottles will have enough space to allow sufficient DI water to cover sample and allow for evaporation and sampling during the testing period; and air space at least double the volume of sample + water. A pyrite sample will be included as a control in two of the four bottle roll tests.

A summary of the procedures that will be employed for the core material bottle roll test are as follows:

1. One bottle will be opened for 15 minutes weekly, closed and then rolled for 15 minutes.
2. One bottle will be opened for 15 minutes weekly (no rolling or agitation).
3. One bottle will have core and water and never be opened or rolled.
4. One bottle will be opened and air will be bubbled in the liquid for 15 minutes weekly. No rolling or agitation.

The control leachability tests performed using solid 'generic' pyrite will consist of pyrite covered with lab-grade water. The two bottles having pyrite and water will be treated as follows:

1. One bottle will have pyrite and water and never be opened or rolled.
2. One bottle having pyrite and water will be opened and air will be bubbled in the liquid for 15 minutes weekly. No rolling or agitation.

4.0 QUALITY ASSURANCE/QUALITY CONTROL ("QA/QC")

Data collected during this investigation will include groundwater data, PID and XRF data from the core material, metals and inorganic data for select intervals of core material (whole rock analysis), SPLP metals and inorganic data for select intervals of core material, and metals data from the bottle roll test.

Analytical laboratory methods specified in the Groundwater Monitoring QAP will be used when possible. Where it was not possible to use the Groundwater Monitoring QAP methods due to matrix differences (i.e., whole rock solid samples), the most comparable methods will be employed.

4.1 Groundwater Data

The Director, Regulatory Compliance (i.e. the "Mill QA Manager") performs a QA/QC review each quarter of the groundwater data collected, to confirm compliance of the monitoring program with requirements of the Groundwater Monitoring QAP and the GWDP. The results of the reviews for the groundwater samples are included in the routine quarterly groundwater reports

and will not be repeated. The data included will have been previously reviewed and deemed usable for their intended purpose.

4.2 Field Data

PID and XRF data will be collected by scanning the core material. PID readings above background will be recorded if noted. XRF data will be included in the report generated after the completion of this Phase 2 study.

The XRF and PID will be calibrated and operated in accordance with the manufacturer's specifications. No further QA/QC data reviews for the PID or XRF data are required.

4.3 Whole Rock Data

Sample intervals for laboratory analysis may be moved to reflect geology noted during the logging and core recovery. Any changes to this plan will be discussed in detail in the report generated after the completion of this Phase 2 study.

The Mill QA Manager will perform a QA/QC review to confirm compliance of the monitoring program with requirements of the laboratory method requirements. The Groundwater Monitoring QAP and the GWDP will not be used as the basis for the data review because the QAP and GWDP specify requirements for water samples and the whole rock analyses will be performed on a solid matrix. The solid data QA review will include an evaluation of laboratory preparation and analysis of QC samples, and QC review of laboratory data and methods. The steps and tests applied to check laboratory data QA/QC will be discussed in the report generated after the completion of this Phase 2 study.

4.3.1 Analytical Data Validation

The Analytical Laboratories will provide summary reports of the analytical QA/QC measurements necessary to maintain conformance with National Environmental Laboratory Accreditation Conference certification and reporting protocol. The analytical laboratory QA/QC Summary Reports, including copies of the Mill's Chain of Custody ("COC") and Analytical Request Record forms for each set of Analytical Results, will be included in the report generated after the completion of this Phase 2 study.

In addition to reviewing the laboratory QA/QC data, the Mill QA Manager will also complete the following evaluations: a receipt temperature check, a holding time check, and a review of the laboratory's reported QA/QC information.

4.4 SPLP Data

The Mill QA Manager will perform a QA/QC review to confirm compliance of the SPLP data with requirements of the Groundwater Monitoring QAP and the GWDP. While the SPLP samples are not groundwater, the QAP will be used as the starting point to the data assessment

due to the similarities of the SPLP and groundwater matrices. As specified in the Mill QAP, data QA includes an analyte completeness review, and quality control review of laboratory data methods and data, and an analytical completeness review.

4.5 Bottle Roll Data

The Mill QA Manager will perform a QA/QC review to confirm compliance of the analytical data with requirements of the Groundwater Monitoring QAP and the GWDP. While the bottle roll fluid samples are not groundwater, the QAP will be used as the starting point to the data assessment due to the similarities of the bottle roll fluids and groundwater matrices. As specified in the Mill QAP, data QA includes an analyte completeness review, and quality control review of laboratory data methods and data, and an analytical completeness review.

The QAP and GWDP identify the data validation steps and data quality control checks required for the groundwater monitoring program. Consistent with these requirements, the Mill QA Manager will complete the following evaluations: a field data QA/QC evaluation, a receipt temperature check, a holding time check, a reporting limit check, and a review of each laboratory's reported QA/QC information.

5.0 SCHEDULE

The Phase 2 study drilling will begin in July 2022 if DWMRC approval has been received. DWMRC will be provided with a 14-day notice specifying the exact start date for drilling activities.

After approval of the Phase 2 study plan by DWMRC, EFRI will apply for Utah Division of Water Rights Start cards (as necessary), and provide additional notifications to DWMRC as described below. EFRI will have laboratory contracts in place prior to sample shipment.

EFRI anticipates the drilling and MW-41 well installation/completion/development may take several weeks depending on weather and drilling contractor schedules. After core materials are collected, and samples are shipped to the analytical laboratory, EFRI will review the field data to determine what intervals of core material will be used for the bottle roll tests. EFRI anticipates that a minimum of three intervals will be selected from each boring/well for inclusion, but more or fewer intervals may be used based on the field data collected during drilling.

After the core material intervals are selected, EFRI anticipates that it will take approximately 5 working days to set up the bottle roll tests. DWMRC will be notified of the start date for the bottle roll testing set up as described below. The bottle roll testing will continue for one year. At the end of six months, liquid samples will be withdrawn from the bottles and submitted for inorganic and metals analyses. At the end of one year, liquid samples will be withdrawn from the bottles and submitted for inorganic and metals analyses.

A report will be prepared and submitted to DWMRC on or before 90 days after the receipt of the analytical data from the one year liquid sample analyses.

5.1 Notifications to DWMRC

EFRI will provide 14 days notice to DWMRC prior to the commencement of drilling activities.

Pursuant to a request from DWMRC, EFRI will also provide 14 days notice prior to the bottle roll test set up.

5.2 Reports

A report summarizing the data collected during the Phase 2 study, any deviations from the plan, a QA/QC assessment of the analytical data collected, data analysis, and conclusions will be prepared in accordance with the schedule in Section 5.0 above. The MW-24A Report will be used as the basis for the final Phase 2 study report.

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7.0 SIGNATURE AND CERTIFICATION

This document was prepared by Energy Fuels Resources (USA) Inc.
Energy Fuels Resources (USA) Inc.

By:

Scott

Bakken

Digitally signed by Scott
Bakken
Date: 2022.03.30
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 3/30/22 Date

Scott A. Bakken
Vice President, Regulatory Affairs

Certification:

I certify, under penalty of law, that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Scott Bakken

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Date: 2022.03.30 15:47:15
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Scott A. Bakken
Vice President, Regulatory Affairs
Energy Fuels Resources (USA) Inc.

TABLES

Table 3.4-1 Analytical Constituents

Analyte	Maximum Holding Times	Sample Temperature/Preservation Requirements
SVOCs – Whole Rock*		
1,2,4-Trichlorobenzene	14 days	≤6°C
1,2-Dichlorobenzene	14 days	≤6°C
1,3-Dichlorobenzene	14 days	≤6°C
1,4-Dichlorobenzene	14 days	≤6°C
1-Methylnaphthalene	14 days	≤6°C
2,4,5-Trichlorophenol	14 days	≤6°C
2,4,6-Trichlorophenol	14 days	≤6°C
2,4-Dichlorophenol	14 days	≤6°C
2,4-Dimethylphenol	14 days	≤6°C
2,4-Dinitrophenol	14 days	≤6°C
2,4-Dinitrotoluene	14 days	≤6°C
2,6-Dinitrotoluene	14 days	≤6°C
2-Chloronaphthalene	14 days	≤6°C
2-Chlorophenol	14 days	≤6°C
2-Methylnaphthalene	14 days	≤6°C
2-Methylphenol	14 days	≤6°C
2-Nitrophenol	14 days	≤6°C
3&4-Methylphenol	14 days	≤6°C
3,3'-Dichlorobenzidine	14 days	≤6°C
4,6-Dinitro-2-methylphenol	14 days	≤6°C
4-Bromophenylphenyl ether	14 days	≤6°C
4-Chloro-3-methylphenol	14 days	≤6°C
4-Chlorophenyl phenyl ether	14 days	≤6°C
4-Chlorophenol	14 days	≤6°C
4-Nitrophenol	14 days	≤6°C
Acenaphthene	14 days	≤6°C
Acenaphthylene	14 days	≤6°C
Anthracene	14 days	≤6°C
Azobenzene	14 days	≤6°C
Benz(a)anthracene	14 days	≤6°C
Benzo(a)pyrene	14 days	≤6°C
Benzo(b)fluoranthene	14 days	≤6°C
Benzo(g,h,i)perylene	14 days	≤6°C
Benzo(k)fluoranthene	14 days	≤6°C
Bis(2-hloroethoxy)methane	14 days	≤6°C
Bis(2-chloroethyl) ether	14 days	≤6°C
Bis(2-ethylhexyl) phthalate	14 days	≤6°C
Butyl benzyl phthalate	14 days	≤6°C
Chrysene	14 days	≤6°C
Dibenz(a,h)anthracene	14 days	≤6°C
Diethyl phthalate	14 days	≤6°C
Dimethyl phthalate	14 days	≤6°C
Di-n-butyl phthalate	14 days	≤6°C
Di-n-octyl phthalate	14 days	≤6°C
Fluoranthene	14 days	≤6°C
Fluorene	14 days	≤6°C
Hexachlorobenzene	14 days	≤6°C

Table 3.4-1 Analytical Constituents

Analyte	Maximum Holding Times	Sample Temperature/Preservation Requirements
Hexachlorobutadiene	14 days	≤6°C
Hexachlorocyclopentadiene	14 days	≤6°C
Hexachloroethane	14 days	≤6°C
Indeno(1,2,3-cd)pyrene	14 days	≤6°C
Isophorone	14 days	≤6°C
Naphthalene	14 days	≤6°C
Nitrobenzene	14 days	≤6°C
N-Nitrosodimethylamine	14 days	≤6°C
N-Nitrosodi-n-propylamine	14 days	≤6°C
N-Nitrosodiphenylamine	14 days	≤6°C
Pentachlorophenol	14 days	≤6°C
Phenanthrene	14 days	≤6°C
Phenol	14 days	≤6°C
Pyrene	14 days	≤6°C
Pyridine	14 days	≤6°C
VOCs – Whole Rock*		
1,1,1-Trichloroethane	14 days	≤6°C
1,1,2,2-Tetrachloroethane	14 days	≤6°C
1,1,2-Trichloro-1,2,2-trifluoroethane	14 days	≤6°C
1,1,2-Trichloroethane	14 days	≤6°C
1,1-Dichloroethane	14 days	≤6°C
1,1-Dichloroethene	14 days	≤6°C
1,2,3-Trichlorobenzene	14 days	≤6°C
1,2,4-Trichlorobenzene	14 days	≤6°C
1,2-Dibromo-3-chloropropane	14 days	≤6°C
1,2-Dibromoethane	14 days	≤6°C
1,2-Dichlorobenzene	14 days	≤6°C
1,2-Dichloroethane	14 days	≤6°C
1,2-Dichloropropane	14 days	≤6°C
1,3-Dichlorobenzene	14 days	≤6°C
1,4-Dichlorobenzene	14 days	≤6°C
1,4-Dioxane	14 days	≤6°C
2-Butanone	14 days	≤6°C
2-Hexanone	14 days	≤6°C
4-Methyl-2-pentanone	14 days	≤6°C
Acetone	14 days	≤6°C
Benzene	14 days	≤6°C
Bromochloromethane	14 days	≤6°C
Bromodichloromethane	14 days	≤6°C
Bromoform	14 days	≤6°C
Bromomethane	14 days	≤6°C
Carbon disulfide	14 days	≤6°C
Carbon tetrachloride	14 days	≤6°C
Chlorobenzene	14 days	≤6°C
Chloroethane	14 days	≤6°C
Chloroform	14 days	≤6°C
Chloromethane	14 days	≤6°C
cis-1,2-Dichloroethene	14 days	≤6°C

Table 3.4-1 Analytical Constituents

Analyte	Maximum Holding Times	Sample Temperature/Preservation Requirements
cis-1,3-Dichloropropene	14 days	≤6°C
Cyclohexane	14 days	≤6°C
Dibromochloromethane	14 days	≤6°C
Dichlorodifluoromethane	14 days	≤6°C
Ethylbenzene	14 days	≤6°C
Isopropylbenzene	14 days	≤6°C
m,p-Xylene	14 days	≤6°C
Methyl Acetate	14 days	≤6°C
Methyl tert-butyl ether	14 days	≤6°C
Methylcyclohexane	14 days	≤6°C
Methylene chloride	14 days	≤6°C
Naphthalene	14 days	≤6°C
o-Xylene	14 days	≤6°C
Styrene	14 days	≤6°C
Tetrachloroethene	14 days	≤6°C
Toluene	14 days	≤6°C
trans-1,2-Dichloroethene	14 days	≤6°C
trans-1,3-Dichloropropene	14 days	≤6°C
Trichloroethene	14 days	≤6°C
Trichlorofluoromethane	14 days	≤6°C
Vinyl chloride	14 days	≤6°C
Tetrahydrofuran	14 days	≤6°C
Inorganics – Whole Rock		
Chloride	28 days	≤6°C
Phosphate	28 days	≤6°C
Sulfate	28 days	≤6°C
Carbonate as CaCO ₃	28 days	≤6°C
Bicarbonate as CaCO ₃	28 days	≤6°C
Fluoride	28 days	≤6°C
Ammonia (as N)	28 days	≤6°C
Nitrate & Nitrite (as N)	28 days	≤6°C
pH	Analyze Immediately	≤6°C
Conductivity	Analyze Immediately	≤6°C
Metals – Whole Rock		
Arsenic	6 months	None
Beryllium	6 months	None
Cadmium	6 months	None
Chromium	6 months	None
Cobalt	6 months	None
Copper	6 months	None
Iron	6 months	None
Lead	6 months	None
Manganese	6 months	None
Mercury	28 days	None
Molybdenum	6 months	None
Nickel	6 months	None
Selenium	6 months	None

Table 3.4-1 Analytical Constituents

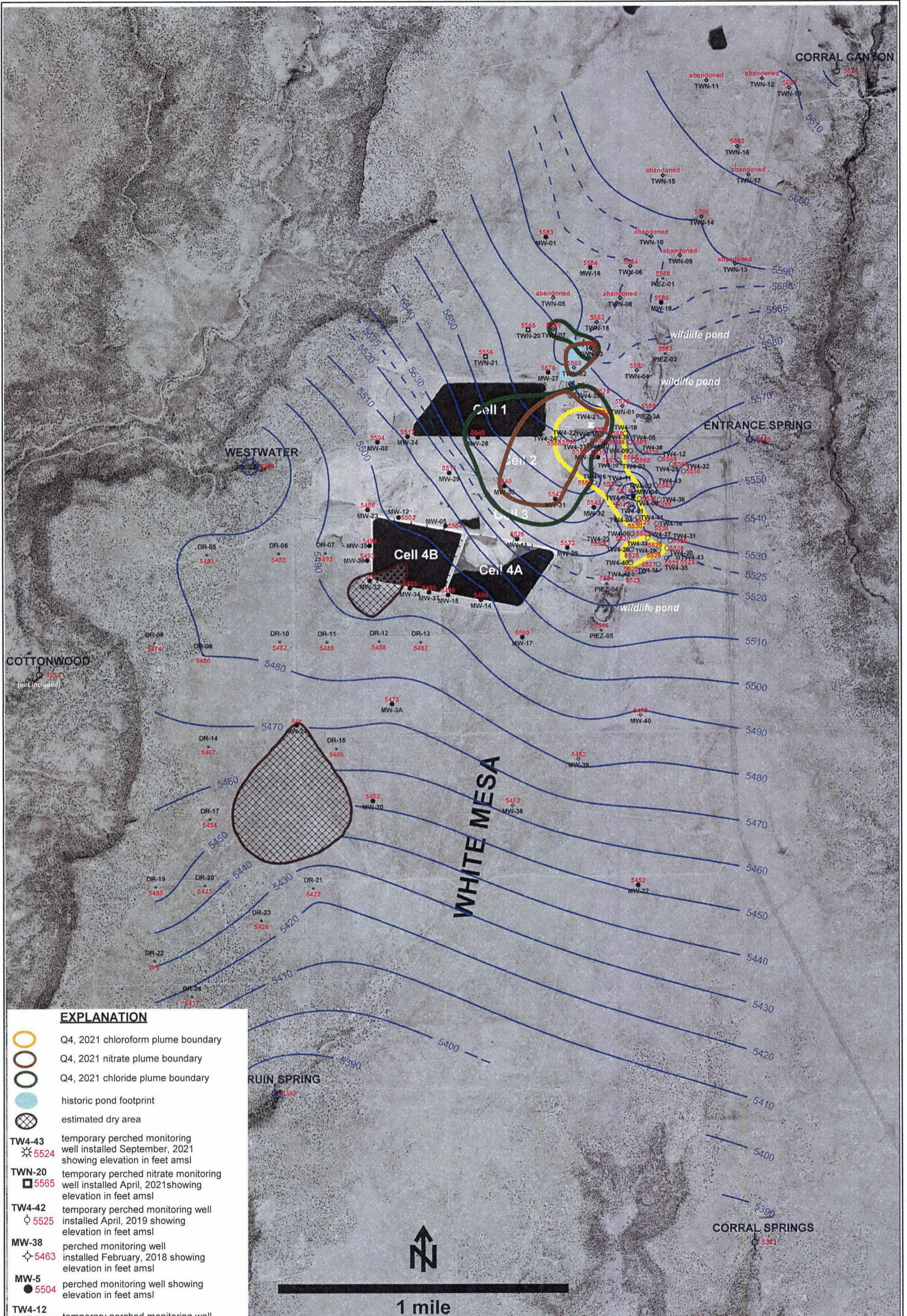
Analyte	Maximum Holding Times	Sample Temperature/Preservation Requirements
Silver	6 months	None
Thallium	6 months	None
Tin	6 months	None
Uranium	6 months	None
Vanadium	6 months	None
Zinc	6 months	None
Sodium	6 months	None
Potassium	6 months	None
Magnesium	6 months	None
Calcium	6 months	None
Metals - SPLP		
Arsenic	6 months	None
Beryllium	6 months	None
Cadmium	6 months	None
Chromium	6 months	None
Cobalt	6 months	None
Copper	6 months	None
Iron	6 months	None
Lead	6 months	None
Manganese	6 months	None
Mercury	28 days	None
Molybdenum	6 months	None
Nickel	6 months	None
Selenium	6 months	None
Silver	6 months	None
Thallium	6 months	None
Tin	6 months	None
Uranium	6 months	None
Vanadium	6 months	None
Zinc	6 months	None
Sodium	6 months	None
Potassium	6 months	None
Magnesium	6 months	None
Calcium	6 months	None
Inorganics - SPLP		
Chloride	28 days	≤6°C
Carbonate as CaCO ₃	28 days	≤6°C
Bicarbonate as CaCO ₃	28 days	≤6°C
Fluoride	28 days	≤6°C
Ammonia (as N)	28 days	≤6°C
Phosphate	28 days	≤6°C
Metals - Bottle Roll		
Arsenic	6 months	None
Beryllium	6 months	None
Cadmium	6 months	None
Chromium	6 months	None
Cobalt	6 months	None
Copper	6 months	None
Iron	6 months	None

Table 3.4-1 Analytical Constituents















Analyte	Maximum Holding Times	Sample Temperature/Preservation Requirements
Lead	6 months	None
Manganese	6 months	None
Mercury	28 days	None
Molybdenum	6 months	None
Nickel	6 months	None
Selenium	6 months	None
Silver	6 months	None
Thallium	6 months	None
Tin	6 months	None
Uranium	6 months	None
Vanadium	6 months	None
Zinc	6 months	None
Sodium	6 months	None
Potassium	6 months	None
Magnesium	6 months	None
Calcium	6 months	None

*VOCs and SVOCs will only be collected if a PID reading above background is measured. Only the interval showing a PID reading above background will be sampled for SVOCs and VOCs.

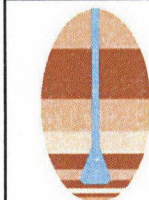
FIGURES



EXPLANATION

-  Q4, 2021 chloroform plume boundary
-  Q4, 2021 nitrate plume boundary
-  Q4, 2021 chloride plume boundary
-  historic pond footprint
-  estimated dry area
- TW4-43**
 temporary perched monitoring well installed September, 2021 showing elevation in feet amsl
- TWN-20**
 temporary perched nitrate monitoring well installed April, 2021 showing elevation in feet amsl
- TW4-42**
 temporary perched monitoring well installed April, 2019 showing elevation in feet amsl
- MW-38**
 perched monitoring well installed February, 2018 showing elevation in feet amsl
- MW-5**
 perched monitoring well showing elevation in feet amsl
- TW4-12**
 temporary perched monitoring well showing elevation in feet amsl
- TWN-7**
 temporary perched nitrate monitoring well showing elevation in feet amsl
- PIEZ-1**
 perched piezometer showing elevation in feet amsl
- RUIN SPRING**
 seep or spring showing elevation in feet amsl

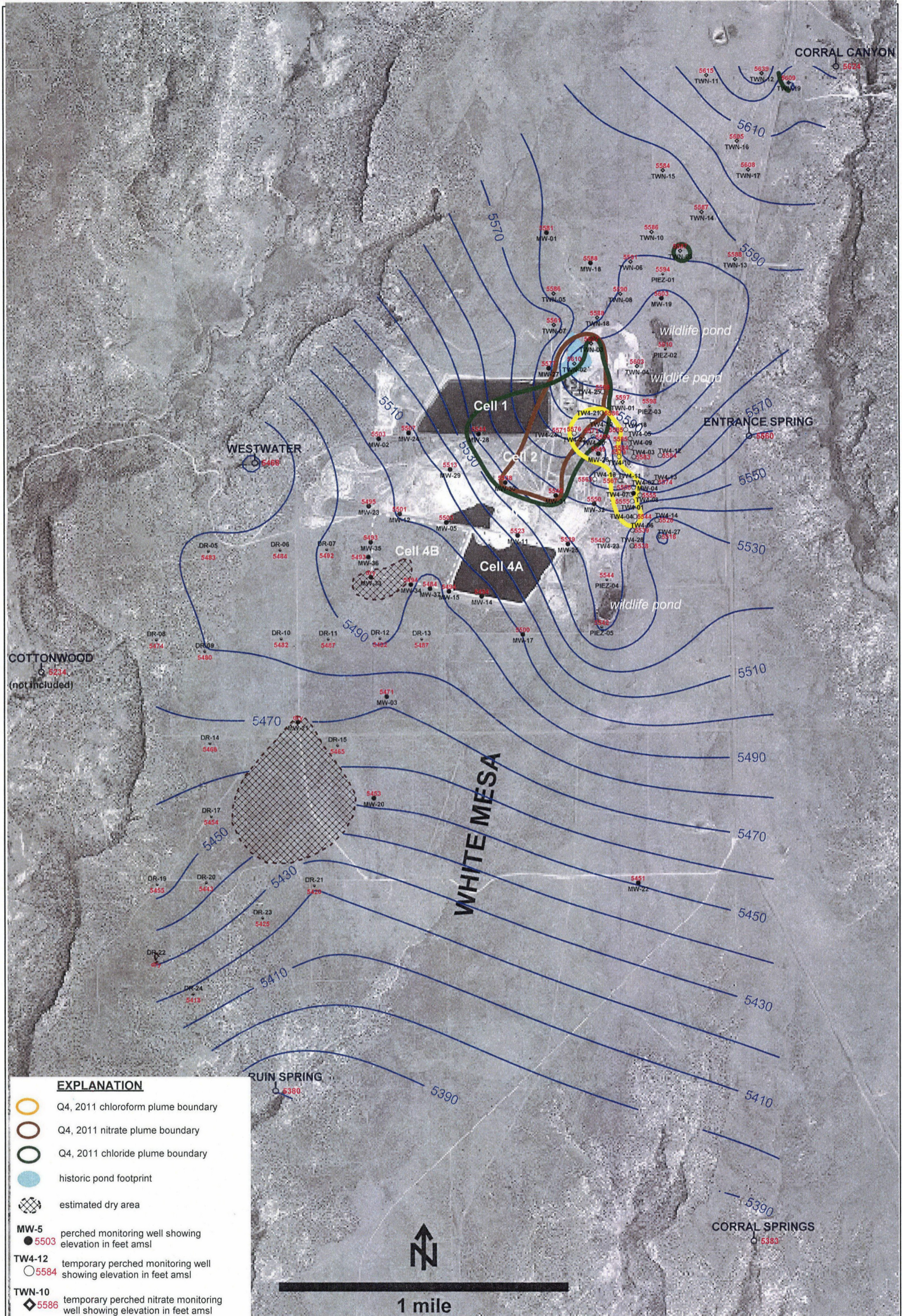
NOTES: MW-4, MW-26, TW4-1, TW4-2, TW4-4, TW4-11, TW4-19, TW4-21, TW4-37, TW4-39, TW4-40 and TW4-41 are chloroform pumping wells; TW4-22, TW4-24, TW4-25 and TWN-2 are nitrate pumping wells; TW4-1, TW4-2 and TW4-11 water levels are below the base of the Burro Canyon Formation














**HYDRO
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**KRIGED 4th QUARTER 2021 WATER LEVELS
AND PLUME BOUNDARIES
WHITE MESA SITE**


APPROVED	DATE	REFERENCE	FIGURE
		H:\718000\MW24A\AdditionalWork\Phase2\WorkPlan\Uw\Plumes4Q21.srf	1A



EXPLANATION

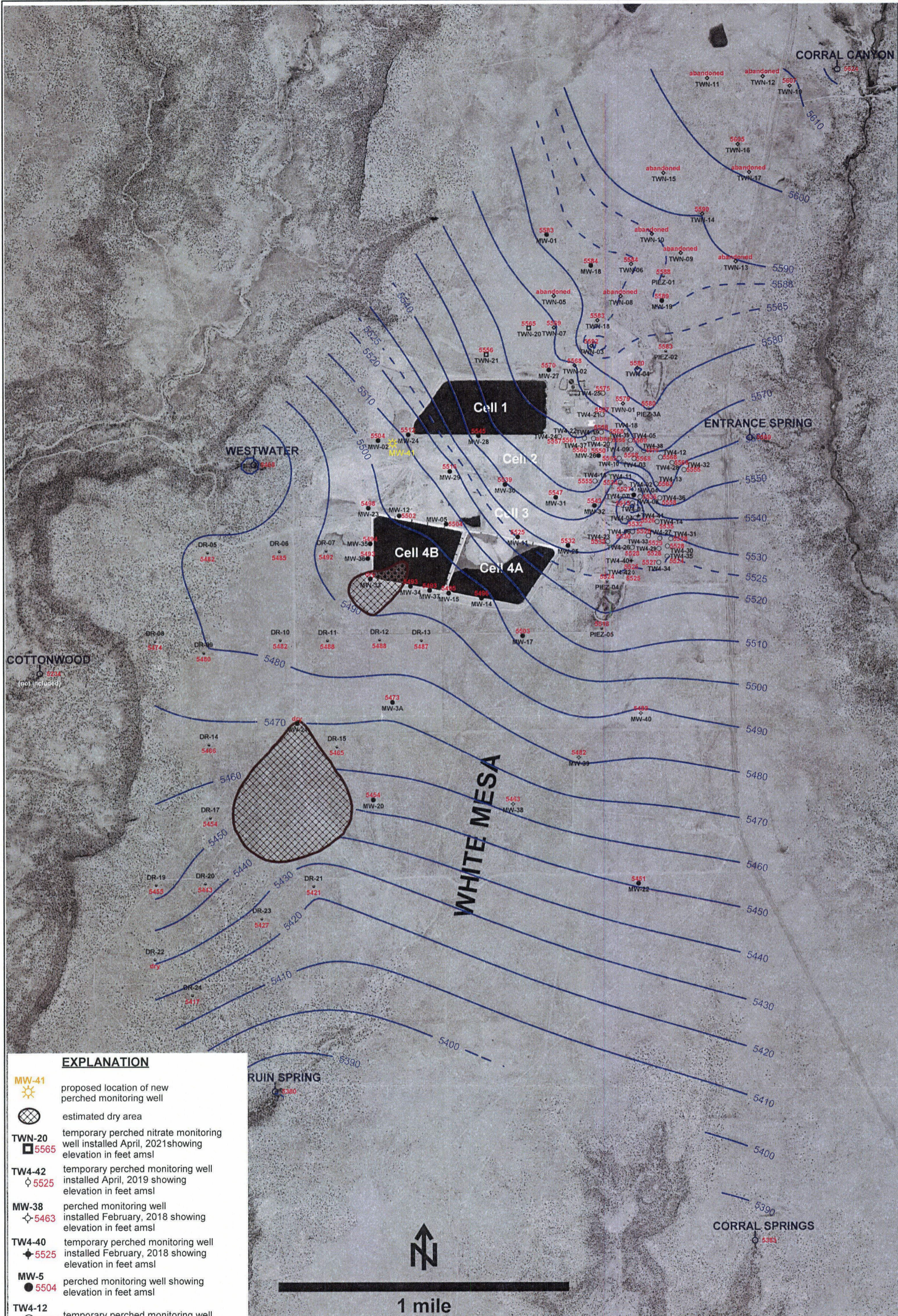
-  Q4, 2011 chloroform plume boundary
-  Q4, 2011 nitrate plume boundary
-  Q4, 2011 chloride plume boundary
-  historic pond footprint
-  estimated dry area
- MW-5**
 perched monitoring well showing elevation in feet amsl
● 5503
- TW4-12**
 temporary perched monitoring well showing elevation in feet amsl
○ 5584
- TWN-10**
 temporary perched nitrate monitoring well showing elevation in feet amsl
◇ 5586
- PIEZ-1**
 perched piezometer showing elevation in feet amsl
● 5594
- TW4-27**
 temporary perched monitoring well installed October, 2011 showing elevation in feet amsl
☆ 5518
- RUIN SPRING**
 seep or spring showing elevation in feet amsl
○ 5380

NOTE: MW-4, MW-26, TW4-4, TW4-19, and TW4-20 are pumping wells



**HYDRO
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KRIGED 4th QUARTER, 2011 WATER LEVELS AND PLUME BOUNDARIES WHITE MESA SITE			
APPROVED	DATE	REFERENCE	FIGURE
		H:/718000/MW24A/ AnalyticalReport/UwINCChl_4Q11.srf	1B



- EXPLANATION**
- MW-41 proposed location of new perched monitoring well
 - estimated dry area
 - TWN-20 temporary perched nitrate monitoring well installed April, 2021 showing elevation in feet amsl
 - TW4-42 temporary perched monitoring well installed April, 2019 showing elevation in feet amsl
 - MW-38 perched monitoring well installed February, 2018 showing elevation in feet amsl
 - TW4-40 temporary perched monitoring well installed February, 2018 showing elevation in feet amsl
 - MW-5 perched monitoring well showing elevation in feet amsl
 - TW4-12 temporary perched monitoring well showing elevation in feet amsl
 - TWN-7 temporary perched nitrate monitoring well showing elevation in feet amsl
 - PIEZ-1 perched piezometer showing elevation in feet amsl
 - RUIN SPRING seep or spring showing elevation in feet amsl

NOTES: MW-4, MW-26, TW4-1, TW4-2, TW4-4, TW4-11, TW4-19, TW4-21, TW4-37, TW4-39, TW4-40 and TW4-41 are chloroform pumping wells; TW4-22, TW4-24, TW4-25 and TWN-2 are nitrate pumping wells; TW4-11 water level is below the base of the Burro Canyon Formation

 HYDRO GEO CHEM, INC.	KRIGED 3rd QUARTER, 2021 WATER LEVELS (and proposed location of new perched well MW-41) WHITE MESA SITE		
	APPROVED	DATE	REFERENCE H:\718000\MW-41\MW41proploc.srf

TAB A

Data Collection and Bottle Roll Laboratory Procedures

Procedure A-1 Boring Procedures, Field Data Collection Procedures and MW-41 Installation Procedures

Background/General Information

- 1) All boring locations and the MW-41 location will be staked prior to the commencement of field work by Mill Environmental Department Personnel.
- 2) As per agreement with DWMRC, MW-41 will be installed down gradient from MW-24/MW-24A (in closer proximity to MW-24 than MW-2) **and will be completed using a shorter well screen to eliminate open well screen above the water table.**
- 3) A boring will not be completed at MW-24A. Existing core from well installation in 2019 will be used for this study.
- 4) Data collection and the associated analyses will be completed as described herein.
- 5) Immediately following the field data collection activities, the borings (except MW-41) will be abandoned in accordance with State of Utah Administrative Rules for Water Wells R655-4-14.
- 6) Full Suite Analyses = Total Metals and Total Inorganics.
- 7) SPLP Analyses = SPLP Metals and SPLP Inorganics.
- 8) VOCs and SVOCs will only be collected if a PID reading above background is recorded. If a PID reading above background is recorded, only sample that interval for VOCs and SVOCs.

Boring Location Selection Procedure

Boring locations are selected based on the following:

- 1) Borings will be drilled as close to the collocated well as practical without causing any undue disruption to the collocated well.
- 2) The MW-32 boring will be located due east of MW-32 beyond the overhead and underground power lines within that area. Safety distances will be maintained at all times, but the boring will be as close as reasonable achievable given the safety distances required for energized power lines.
- 3) The boring for well MW-3A will be downgradient of the collocated well to minimize disturbances in the routine groundwater sampling conducted for GWDP compliance.
- 4) Unless noted in bullet points 1 – 3 above, borings will be located prior to the start of field work and positioned approximately 15 feet downgradient of the existing co-located well.

Drilling and Logging Procedures

- 1) Core will be collected in all borings and MW-41, to the extent practical, from the surface to total depth. Total depth for the borings will be the same completion depth as the collocated well. As much of the material above the Dakota contact as possible will be collected, as this material may largely consist of weathered Mancos Shale.
- 2) Completion depths for the collocated wells is included in Table 1 below.
- 3) Log and quarter the core samples. Rinse splitter between each use to minimize potential cross-contamination. Particularly note any visible pyrite during logging.
- 4) Quartered core should be stored in the same core boxes to minimize the volume of cores that need to be archived.
- 5) Photograph core after it is placed in core boxes.
- 6) Bag and archive any drill cuttings.

MW-41 Installation Procedure

The location of MW-41 was determined based on discussions with DWMRC. MW-41 will be installed down gradient from MW-24/MW-24A (in closer proximity to MW-24 than MW-2) and will be completed using a shorter well screen to eliminate open well screen above the water table.

The primary purpose of eliminating open screen above the water table is to minimize transport of air into the vadose zone in the vicinity of the well to in turn minimize oxygen transport to groundwater. As discussed in HGC (2012), enhanced oxygen transport to groundwater near monitoring wells increases pyrite oxidation, lowers pH, and mobilizes trace metals contained in pyrite as well pH sensitive metals that occur naturally in the formation hosting perched groundwater.

Oxygen transport from a well screened in the vadose zone occurs via diffusion of air enhanced by barometric pumping. The mechanism for barometric pumping is discussed in Rossabi and Falta (2002) and You et al (2011). Barometric pumping via wells screened in the vadose zone can be significant enough to remediate VOC plumes in the vadose zone as discussed in Rossabi et al (1993); and Bosze et al (2001). ESTCP (2006) specifically discusses enhancing oxygen transport to the vadose zone via barometric pumping using vadose wells to stimulate aerobic biodegradation of vadose hydrocarbon contamination. Because barometric pumping relies on wells screened in the vadose zone, transport of air (and oxygen) to the vadose zone, where it is in direct contact with groundwater, can therefore be minimized by eliminating vadose screen and keeping the top of the well screen below the water table.

The procedure for determining screen placement is described below. Screen lengths of 5 feet and 10 feet must be available. It is assumed that, similar to other perched zone wells at the site, the MW-41 boring will be drilled approximately 2 to 3 feet into the Brushy Basin Member of the Morrison Formation; and that, if drilled more than 3 feet into the Brushy Basin Member that the boring will be backfilled to a depth of approximately 2 to 3 feet below the Brushy Basin Member contact. **However, the decision to backfill should be delayed until the static water level in the boring can be obtained.**

- 1) Allow sufficient time after completion of the boring for the water level to recover from the impacts of drilling and for a reasonably accurate static water level to be measured.
- 2) Measure the static water level using an electric water level meter and calculate the saturated thickness (difference between depth to water and depth to upper contact of Brushy Basin Member).
- 3) Screen from approximately 2 feet below the static water level to just below the Brushy Basin Member contact.

Based on saturated thicknesses at MW-2 and MW-24 (which bracket the position of proposed well MW-41), the saturated thickness at MW-41 is anticipated to be approximately 10 feet. Under these conditions, MW-41 would be screened from approximately 2 feet below the water table to 2 feet below the Brushy Basin Member contact, using 10 feet of screen. If the saturated thickness is less than approximately 7 feet, then 5 feet of screen should be used and placed from approximately 2 feet below the water table to at or just below the Brushy Basin Member contact, depending on the measured saturated thickness. If the saturated thickness is between 7 and 10 feet, 10 feet of screen can be used provided the boring is deep enough to allow the top of the screen to be placed approximately 2 feet below the water table.

Data Collection/Sampling

NOTE 1: If any portion of the core appears unusual (color, odor,) sample that for full suite analytical (Total Metals, Total Inorganics).

NOTE 2: Both 'reduced-looking' and 'oxidized-looking' core will be of interest. Pyrite that may be present in 'reduced-looking' core (having a light gray or white to light greenish color and a relatively high Fe content) may contain metals besides iron as contaminants. Iron or manganese oxides present in 'oxidized-looking' core may have sorbed metals. Metal contaminants in pyrite or metals sorbed to iron/manganese oxides have the potential to impact groundwater.

NOTE 3: In addition to the full suite (total) analyses listed above, samples will also be submitted for SPLP Metals and SPLP Inorganics.

Field Data Collection

- 1) Scan the entire length of core with the PID.
 - a. If there are any PID readings above background, photograph the core section with the elevated PID reading, and collect samples for VOCs, SVOCs and total metals and total inorganics analyses.
 - b. If there are no PID readings above background, proceed with sample collection at the routine intervals (every 2 feet or every 5 feet) .
- 2) Analyze entire length of core in the field using a portable XRF.
- 3) Elements of interest during the XRF = iron, sulfur and trace metals. Areas with higher concentrations of these elements should be noted.
- 4) Elevated Fe or Mn should especially be noted: elevated Fe may indicate pyrite or relatively abundant Fe oxides; and elevated Mn may indicate relatively abundant Mn oxides.
- 5) Analytical samples will be collected as follows:
 - General concept for the sampling is 1 analytical sample every 5 feet above the saturated zone and every 2 feet within the saturated zone.
 - Note that sample locations can/should be moved or adjusted to locations with high concentrations of iron, sulfur and trace metals based on the XRF data and/or visible pyrite.
- 6) Note sampling interval and the reason for the sample location if it is other than the general location. Photograph each location as needed, i.e. if a general location is moved/adjusted for data, color or presence of pyrite etc.
- 7) Sample volumes have been set by the laboratory. Submit a 2-foot section of quarter core for each location.
- 8) For VOCs, the lab needs approximately 5 grams per vial (2 vials are provided). A scale is available to weigh a few samples to visually get an idea of what 5 grams looks like. **DO NOT PUT LABELS ON THE VOC VIALS.**
- 9) Wrap the quartered core in foil and put the foil wrapped core into a Ziploc bag. Label the bags. Sample names reflect the interval of the sample (e.g. 24A 112 – 114 is the interval from 112 feet to 114 feet bgs).
- 10) Samples for VOCs and SVOCs (if collected) and Inorganics should be stored cold. Mill Environmental Department Personnel can store those samples in the environmental sample refrigerator.
- 11) Note samples with the highest visible pyrite for bottle roll tests.

Table 1 Well Depth Information

Monitor Well Name	Monitor Well Completion Depth or Depth to Brushy Basin (Feet Below Ground Surface [bgs.])
MW-3A	95
MW-18	139
MW-22	120
MW-24A	NA
MW-32	130.6
MW-39	102.5
MW-40	120
MW-41	TBD

NA – A boring will not be completed at MW-24A. Existing core from well installation in 2019 will be used for this study.

TBD – Core material will be collected from this location during well installation.

Procedure A-2 Bottle Roll Interval Selection Procedures

The core samples that will be selected for inclusion in the bottle roll test will be the core with the highest visible pyrite. Some of the intervals chosen will be located above the saturated zone and some will be located below the saturated zone. The "generic" pyrite sample will be purchased from a rock shop.

As discussed in Procedure A-1 Boring Procedures, Field Data Collection Procedures and MW-41 Installation Procedures, if visible pyrite is not present, select intervals having high iron (and sulfur) concentrations (based on screening with a portable XRF) that are also 'reduced looking', ie, have a color that is white to grayish to greenish. In addition, select intervals having notable trace metals concentrations (beryllium, cadmium, etc.) based on screening with a portable XRF; and intervals that are 'oxidized looking' and have relatively large amounts of iron or manganese oxides to which naturally-occurring trace metals may have sorbed.

Procedure A-3 Bottle Roll Tests

Test sample material will be solid, core material determined to contain pyrite and solid 'pure' ("generic") pyrite sample.

- 1) Select bottles with sufficient volume to accommodate a 3 to 4-inch segment of core sample; sufficient DI water to cover sample and allow for evaporation and sampling during testing period; and air space at least double the volume of sample + water.
- 2) Tests will be run on four samples of intact core from each interval and one sample of solid pyrite. At least 3 intervals will be chosen from each of 8 borings. It is anticipated that at least 96 core material samples (excluding the 2 pyrite controls) will be included in this study.
- 3) EFRI Environmental Department Personnel will provide core sample material.
- 4) During test set up, label sample bottles using indelible marker, labels or a method to assure label remain intact for the year-long study.
- 5) Label the samples using the well name and interval depth. For example:

➤ MW-32-75.5 – 75.75

Where: MW-32 is monitor well MW-32 and the depth interval is 75.5 – 75.75 feet bgs. Well names and interval information will be provided by Mill Environmental Department Personnel

- 6) Label, mark, color code or in some manner, physically differentiate the bottles to plainly illustrate what bottles are not opened, opened, rolled, and aerated (see steps 7a through 7d below).
 - 7) Weekly treat the marked bottles as follows:
 - a) One bottle will be opened for 15 minutes weekly, closed and then rolled for 15 minutes.
 - b) One bottle will be opened for 15 minutes weekly (no rolling or agitation).
 - c) One bottle will have core and water and never be opened or rolled.
 - d) One bottle will be opened and air will be bubbled in the liquid for 15 minutes. No rolling or agitation.
- Note: Ambient air will be used for the weekly aeration.
- 8) The control leachability tests performed using solid 'generic' pyrite will consist of pyrite covered with lab-grade DI water. The two bottles having pyrite and water will be treated as follows:
 - a. One bottle will have pyrite and water and never be opened or rolled.
 - b. One bottle having pyrite and water will be opened and air will be bubbled in the liquid for 15 minutes. No rolling or agitation.
 - 9) Keep weekly notes in a bound notebook. Note any color changes, any observations, issues or deviations from the above procedures. Provide notes to K. Weinel in Lakewood as requested.