STATE OF COLORADO

Cazier - DNR, Tim <tim.cazier@state.co.us>

M1997054 Parkdale Quarry 112 (c) Permit Amendment - Water Quality Consultant's Report - Part 1 of 2

1 message

David Bieber <David.Bieber@martinmarietta.com> Tue, Jul 13, 2021 at 1:51 PM
To: "Cazier - DNR, Tim" <tim.cazier@state.co.us>
Cc: Erin Kunkel <Erin.Kunkel@martinmarietta.com>

David W. Bieber, PG
Manager of Geology/Survey | West Division

Martin Marietta

1627 Cole Blvd Suite 200

Lakewood, CO 80401

t. 720-245-6423 m. 916-870-6635 f. 303-657-4351
e. david.bieber@martinmarietta.com
www.martinmarietta.com

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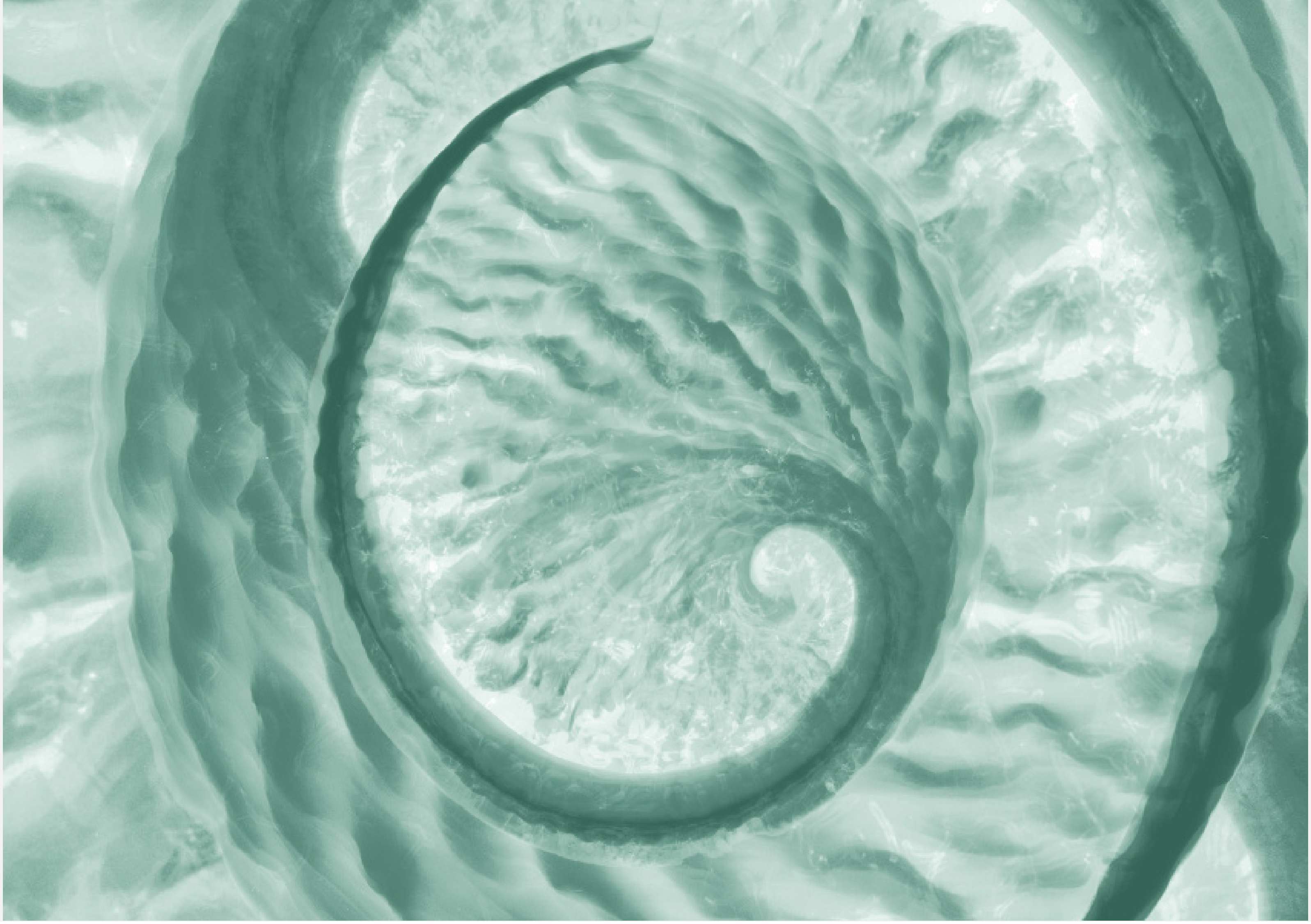

Martin Marietta

Hydrogeologic Assessment

Parkdale Quarry Expansion Area

April 2020

Project No.: 0488586

The business of sustainability

ERM

Signature Page

April 2020

Hydrogeologic Assessment

Parkdale Quarry Expansion Area

Al Trippel Project Director	Fred Marinelli Senior Technical Consultant
Becky Moores Project Manager	Jeremy Stariwat Senior Geologist

ERM-West, Inc.

555 17th Street, Suite 1700

Denver, CO 80202

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Acronyms and Abbreviations

Name	Description
µg/L	Micrograms per liter
amsl	Above mean sea level
bgs	Below ground surface
BLM	Bureau of Land Management
CDPHE	Colorado Department of Public Health & Environment
cm/sec	Centimeters per second
DO	Dissolved oxygen
DWR	Division of Water Resources
EC	Electric conductivity
EPA	Environmental Protection Agency
ERM	ERM-West, Inc.
ft/day	Feet per day
gpm	Gallons per minute
K	Hydraulic conductivity
Kn	Niobrara Formation
mg/L	Milligrams per liter
mrem	Millirem
ORP	Oxidation-reduction potential
pCi/L	Picocuries per liter
pH	Power of hydrogen
psi	Pounds per square inch
SM	Standard Method
TDS	Total dissolved solids
USGS	United States Geological Survey

INTRODUCTION

This report summarizes a hydrogeologic assessment that ERM-West, Inc. (ERM) completed for the area proposed for expansion of the Parkdale Quarry (hereinafter “Site”) located on Bureau of Land Management (BLM) land near Cañon City, Colorado (hereinafter “Project”). ERM understands that the purpose of the investigation is to perform a scoping-level analysis to evaluate if the expanded quarry could affect the quantity and quality of the underlying groundwater system, and most notably, if water levels in existing private water wells near the Site could lower over time. Additionally, it is understood that hydrogeologic monitoring and assessment may be used to support Martin Marietta’s overall permitting process for the Project, including the National Environmental Policy Act review process.

1. BACKGROUND

1.1 Parkdale Quarry Expansion

Martin Marietta is pursuing permits and approvals to expand the Site onto BLM lands located generally north of the current mining operations, as shown on Figure 1. As part of the expansion area investigation, Martin Marietta drilled nine 3.75-inch exploratory boreholes to a depth of 250 feet below ground surface (bgs) and completed three of the borings as 2-inch monitoring wells with screened intervals from approximately 20 to 250 feet bgs (Figure 1). From ground surface downward, these borings generally encountered: several feet of colluvium soil; up to 5 feet of decomposed granite sands; up to 15 feet of weathered and partially weathered granite; and competent fractured granite to the bottom of the borehole. At some locations on Cactus Mountain, bedrock outcrops and is visible at ground surface. Three of the wells were later converted into groundwater monitoring wells: MW-01, MW-03, and MW-10.

1.2 Geologic Setting

The Site lies in the northern extent of the northwest trending Wet Mountains, a sub-range of the Sangre de Cristo Mountains, as part of the Southern Rocky Mountains physiographic region. The gneiss, schist, and granite of the Wet Mountains were exposed during the Wet Mountain uplift as part of the Laramide orogeny (Christman et. al. 1954).

Locally, the Precambrian granite of Cactus Mountain is in fault contact with the Jurassic and Cretaceous sedimentary rocks as part of the larger northwest trending subvertical Ilse fault and the Parkdale fault (Wobus et. al. 1979). The sedimentary rocks, including sequences of limestone, sandstone, and shale, are found immediately south of the proposed excavation and north-northeast of Cactus Mountain (Figure 2). The historical quarry operation excavated coarse alluvium adjacent to the Arkansas River, and the current operation is excavating granite on Martin Marietta owned property north of the Arkansas River. The proposed quarry expansion onto BLM land would continue to excavate granite to be crushed for an aggregate end product.

The Tallahassee Creek Mining District, which historically produced uranium, is approximately 3 miles west of the quarry (Hon 1984), and is drained by Tallahassee Creek.

1.3 Hydrogeologic Settings

The Site is located at the lower end of the Currant Creek and Tallahassee Creek watersheds, near the confluence of Tallahassee Creek and the Arkansas River (Figure 1). Groundwater in the site area is present in four hydrogeologic units: alluvium adjacent to Currant Creek, Tallahassee Creek, and the Arkansas River; sedimentary rocks; decomposed and/or weathered granite; and competent fractured granite. There are mapped faults within the granite body, and fault contacts between the granite and sedimentary rocks (Figure 2).

2. DATA COMPILATION AND REVIEW

ERM conducted a desktop review of relevant publicly available data. The Colorado Division of Water Resources (DWR) well permit database identified wells of other ownership within the project vicinity. The DWR database returned 139 wells within a 4-mile radius of the proposed quarry, shown on Figure 3 and summarized in Table 1. Using this database, ERM determined distances between the proposed quarry excavation and other groundwater users, for use in the analysis.

Table 1: Primary DWR Well Water Use within 4 Miles of the Quarry Expansion

Primary Water Use	Count
Domestic	120
Household use only	8
Stock	6
Commercial	2
Irrigation	2
Other	1
Total	**139**

Available DWR Well Construction and Test Reports for private wells immediately to the north and northeast of Cactus Mountain show that all wells are drilled into Cretaceous sedimentary rocks. However, in some cases, the DWR placed wells above mapped granite. If the United States Geological Survey (USGS) mapped granite and sedimentary rock contact is accurate, this discrepancy may indicate that some of the DWR-reported wells were likely mislocated by the permit applicant or driller, as shown on Figure 4.

Based on the DWR database and a USGS geologic map covering the site area (Wobus et. al. 1979), a geologic cross section (Figure 5) was created to evaluate the underlying bedrock units. The location of the geologic cross section is shown on Figure 3. Potentially mislocated private water wells were not used to develop this geologic interpretation.

3. FIELD INVESTIGATION

ERM conducted five field investigations in 2019 and 2020 at monitoring wells MW-01, MW-03, and MW-10 located within the proposed quarry expansion area. Details on each event are provided below and field notes are included as Appendix A.

3.1 Sampling Event 1 – December 2018

During the initial field investigation from 10-12 December 2018, ERM:

- Conducted groundwater sampling with a Grundfos Redi-Flo 2 submersible pump capable of lifting water from 300 feet.
- Monitored water levels before, during, and after purging using a Level Troll Model 700, 100 pounds per square inch (psi) vented pressure transducer.
- Monitored field water quality parameters throughout the duration of pumping using a YSI flow through cell, including temperature, power of hydrogen (pH), electric conductivity (EC), dissolved oxygen (DO), and oxidation-reduction potential (ORP). Field forms are provided in Appendix A.
- Conducted water quality sampling for common metals, major ions, and radionuclides after water quality parameter stabilization, and delivered samples for laboratory analysis.

3.2 Sampling Event 2 – May 2019

ERM conducted the second field investigation from 13-14 May 2019 similar to that described above for the initial field investigation, but did not include water level monitoring during pumping and recovery (i.e., no pumping test analysis).

3.3 Sampling Event 3 – August 2019

During the third field investigation from 28-29 August 2019, ERM:

- Monitored water levels in wells MW-03 and MW-10, before, during, and after purging, using a transducer as noted above. Access to MW-01 became difficult and it was not possible to get equipment to that site for additional testing.
- Monitored field water quality parameters throughout the duration of pumping using a YSI flow through cell, including temperature, pH, EC, DO, and ORP. Field forms are provided in Appendix A.
- Conducted groundwater sampling at on-site monitoring wells MW-03 and MW-10 for:
    - Isotopic Uranium by Method HASL-300 (Alpha Sepectroscopy)
        - Uranium-233-234
        - Uranium-235/236
        - Uranium-238
    - Gross Alpha and Beta Radioactivity (Total, Suspended, and Dissolved) by Standard Method (SM) 7110 B
    - Radium-226 by SM 7500-Ra B
    - Radium-228 by Environmental Protection Agency (EPA) Ra-05
    - Total Solids by EPA 160.3
- Delivered samples for laboratory analysis.

3.4 Sampling Event 4 – November 2019

During the fourth field investigation from 19-20 November 2019, ERM:

- Monitored water levels in two pumping wells, MW-03 and MW-10, before, during, and after purging, using the same vented pressure transducer as noted above.
- Deployed a permanent DI810 TD-Diver Data Logger transducer and a DI800 Baro-Diver Data Logger to compensate for barometric pressure in monitoring well MW-01 to record a data point for water level every 6 hours. This equipment was installed due to issues with access and the inability to get a pump and generator to the well location.
- Monitored field water quality parameters throughout the duration of pumping using a YSI flow through cell, including temperature, pH, EC, DO, and ORP. Field forms are provided in Appendix A.
- Conducted groundwater sampling at on-site monitoring wells MW-03 and MW-10 for:
  - Isotopic Uranium by Method HASL-300 (Alpha Sepectroscopy)
    - Uranium-233-234
    - Uranium-235/236
    - Uranium-238
  - Gross Alpha and Beta Radioactivity (Total, Suspended, and Dissolved) by SM 7110 B
  - Radium-226 by SM 7500-Ra B
  - Radium-228 by EPA Ra-05
  - Total Solids by EPA 160.3
- Delivered samples for laboratory analysis.

3.5 Sampling Event 5 – February 2020

During the fifth field investigation on 26 February 2020, ERM:

- Measured static water levels at MW-03 by hand using a water level indicator every 5 minutes during the sampling event. Road conditions made vehicle access to MW-10 impossible during this site visit.
- Measured static water levels at MW-01 and MW-10.
- Downloaded transducer data from MW-01 (Appendix C).
- Monitored field water quality parameters throughout the duration of pumping using a YSI flow through cell, including temperature, pH, EC, DO, and ORP. Field forms are provided in Appendix A.

4. DATA ANALYSIS

Using the collected field data, ERM compiled the laboratory water quality results, evaluated pumping/sampling results to estimate the bulk hydraulic conductivity of granite, and performed scoping-level hydraulic calculations to evaluate the effects of pit development on the groundwater system.

4.1 Water Quality

ERM analyzed water quality samples for field parameters, common metals, major ions, and radionuclides, and then tabulated and presented the results in the laboratory analytical reports provided as Appendix B. Results show pH ranges from 6.64 - 7.71, and total dissolved solids (TDS) ranges from 318 – 814 milligrams per liter (mg/L), generally increasing during the 28 August 2019 sampling event. While not required for compliance purposes, the analytical results were compared to drinking water standards for informational purposes only. Common metals and major ions did not exceed drinking water standards or aquatic life (acute or chronic) limits for the sampling events where collected. The December 2018 sample from well MW-10 was reported to contain 38.2 micrograms per liter (µg/L) of dissolved uranium, in excess of the 30 µg/L drinking water standard. This was the only recorded dissolved uranium exceedance. Isotopic uranium did not exceed the drinking water standard of 30 picocuries per liter (pCi/L) for the four sampling events conducted from December 2018 to November 2019. Gross alpha and beta particles exceeded the drinking water standard of 15 pCi/L and 4 millirems (mrems), respectively, for several sampling events at all wells sampled. Radium 226/228 was detected in all monitoring wells and showed a drinking water standard exceedance of 5 pCi/L at MW-03 in May 2019, and at MW-10 in both December 2018 and August 2019.

Hydrochemical facies, or water types, lie within the magnesium bicarbonate and mixed magnesium bicarbonate/calcium chloride portion of the piper diagram presented as part of Appendix B.

4.2 Hydraulic Conductivity of Granite

Water levels measured during the first investigation (December 2018) at wells MW-01, MW-03, and MW-10 were used to estimate the hydraulic conductivity of granite. The tests generally involved pumping a well as part of the purging process and measuring the associated water-level changes (drawdowns) during both the pumping and recovery periods using a vented pressure transducer and datalogger. These tests are described herein as “pumping tests”, though they were performed opportunistically as part of the well sampling procedure.

Discharge flow rates were measured periodically during the pumping period using the “bucket-and-stopwatch” method, or by recording the total volume of discharged water over time. Hydraulic responses were analyzed using a combination of transient and steady-state analytical solutions appropriate for the testing conditions. Where appropriate, the effects of variable flow rates during the pumping period were considered. The pumping test analyses are presented in Appendix C and summary results are provided in Table 2 below.

Table 2: Pumping Test Results – December 2018

Monitoring Well	Well Total Depth (ft)	Static Depth-to-Water (ft)	Saturated Thickness b (ft)	Transmissivity T (ft^2/day)	Hydraulic Conductivity K (ft/day)	Hydraulic Conductivity K (cm/sec)
MW-01	239	104.13	134.9	0.26	0.0019	6.7E-07
MW-03	249	47.55	201.4	0.63	0.0027	9.5E-07
MW-10	251	9.76	241.2	1.57	0.0065	2.3E-06

Notes:
ft: feet
ft/day: feet per day
ft^2/day: feet squared per day
cm/sec: centimeters per second
T = transmissivity of saturated well completion interval (from static water level to bottom of well)
K = hydraulic conductivity of granite within the saturated interval, K = T / b

The core logs for the site borings are logged as “slightly to intensely fractured.” The hydraulic conductivity (K) values in Table 2 range over a factor of 3.4, which is reasonably consistent for tests conducted in fractured crystalline rock. The best-estimate bulk hydraulic conductivity for competent fractured granite is taken as the arithmetic mean of the three values: 0.0037 ft/day (1.3 x 10^{-6} cm/sec). The best-estimate value is used in subsequent hydraulic analyses to evaluate the effects of pit development on the local groundwater system. Appendix C provides further details on the data and analyses used to evaluate the transmissivity and hydraulic conductivity measured at each of the three tested monitoring wells.

5. SIMULATED CURRENT (PRE-MINING) CONDITIONS

ERM performed a scoping-level analysis of current groundwater conditions at the site using existing information collected during desktop research and the results of pumping tests performed during the first investigation (December 2018), as described in Section 4.2. Groundwater flow through the proposed quarry area was simulated analytically using a modification of the one-dimensional Darcy equation for steady-state groundwater flow in a vertical cross section. The cross-section analysis was based on the interpreted geologic section (Figure 5). The cross section starts at the confluence of Currant Creek and Tallahassee Creek and extends northeast for 17,000 feet, which includes the proposed quarry expansion area, Cactus Mountain, Highway 9, and 3,500 feet past the highway. The orientation of the section is shown on Figure 3.

The analysis is documented in Appendix D and entails the following:

- Dupuit assumption for “essentially” horizontal flow in a system with variably saturated thickness and a water table at the upper boundary.
- Aerially distributed natural recharge.
- A sloping no-flow boundary at the base of what’s assumed to be “permeable” rock. As a first approximation, this conforms to depths where the hydraulic conductivity of fractured granite is expected to become very low. It also conforms approximately to what is assumed to be the base of more permeable sedimentary rock. This boundary is based on professional judgement as there is no known borehole testing to these depths.
- Flow system width (perpendicular to the plane of the section) equal to 3,000 ft.
- The presence of a fault on the northeast side of Cactus Mountain that provides a contact between competent granite to the southwest and sedimentary rock to the northeast.
- Granite hydraulic conductivity (K_g) of 1.3 x 10^{-6} cm/sec based on the results of groundwater pump test events (discussed above).
- An assumed sedimentary rock hydraulic conductivity (K_s) of 1.3 x 10^{-4} cm/sec (100 times K_g). This hydraulic conductivity was not measured, but predicts that the yield to a well with a 100-foot completion interval and 50 feet of drawdown is about 10.5 gallons per minute (gpm), which is reasonable for a typical domestic well.
- A fixed hydraulic head of 5,840 feet above mean sea level (amsl) at the southwest end of the section (confluence of two streams), which conforms to the elevation of the stream channels.
- A target hydraulic head of 6,170 feet amsl at Highway 9, which is similar to water levels measured in private wells where the section crosses the highway (this water level is about 80 feet below ground surface).

The governing differential equation (a general form of the Darcy equation) was evaluated using the Mathcad® computation software based on a point-and-shoot method where both the groundwater flow rate at the southwest end of the section (x=0) and recharge were adjusted iteratively until computed water levels matched the following:

- Water level elevation of 6,170 feet amsl at Highway 9
- Water level elevation of 6,225 feet amsl measured in well MW-10

The results of the calibrated solution are shown graphically on Figure 5-1, below, and additional details are provided in Appendix D. The computed water table profile matches the water level below Highway 9 and the measured head in well MW-10. It does a poor job of matching the water level at well MW-03 because ground surface is well below the computed profile. This could indicate that in the real system, there is groundwater discharge to ground surface southwest of MW-10. However, because the computed flow rates are low (less than 5 gpm), it is unlikely that such discharge would be visually noticeable over a transverse distance of 3,000 feet.

Water table gradients (mounding) in the sedimentary rock are small compared to gradients in the granite portion of the section; an effect that is directly related to the hydraulic conductivity contrast between granite and sedimentary rock (two orders-of-magnitude).

The calibrated recharge rate is surprisingly low; 0.154 inches per year. Sensitivity analyses showed that increasing the recharge rate by small amounts over this value caused the computed water table profile to rise dramatically in the granite, which would conflict with the MW-10 water level and cause the computed water level at Highway 9 to be above ground surface. The dramatic water level rise at higher recharge rates is the result of mounding in the low hydraulic conductivity granite.

As shown on Figure 5-1, ground water flow rates in the system are quite low (less than 6 gpm). At the left (southwest) side of the section, the computed flow rate is 4 gpm to the southwest. Below Highway 9 and at the right (northwest) side of the section, the flow rates are 3 and 5 gpm, respectively, both in the northeast direction. These low flow rates are the direct result of the low hydraulic conductivity of granite and provides an indication that groundwater inflows to the excavated pit of the quarry expansion would be relatively small. Note that the computed water level at the right (northeast) side of the section is 6,150.4 feet amsl. This value is used as a boundary condition in subsequent analyses of the post-mining condition.

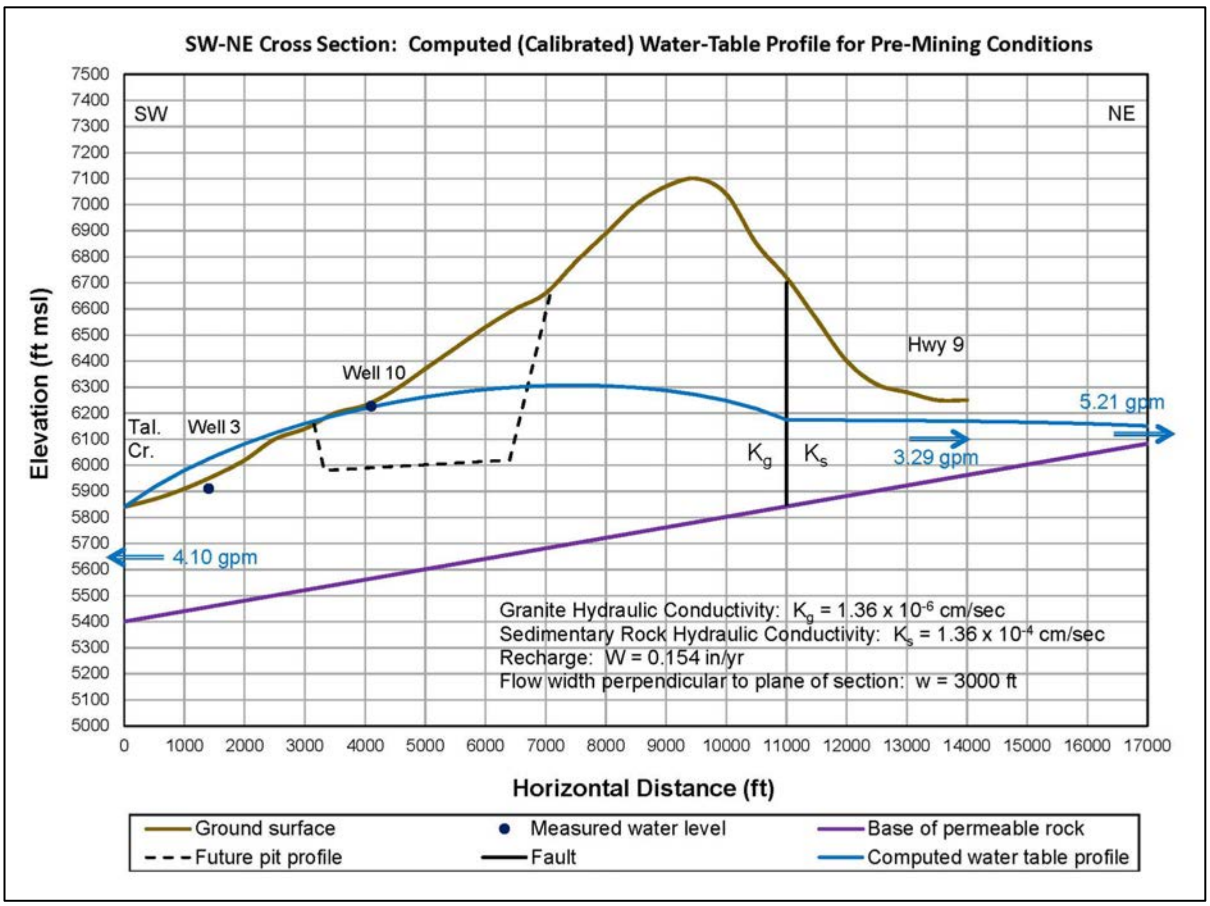

Figure 5-1: Results of Pre-Mining Analysis

6. EVALUATION OF QUARRY EFFECTS ON GROUNDWATER

6.1 Water Quality

Respective of Section 4.1, analytical results indicated drinking water exceedance for dissolved uranium, gross alpha, gross beta, and radium 226/228 in some of the samples analyzed (Appendix B). Radionuclides are generally found as trace elements in most granitic rocks, such as the Precambrian granite housing site groundwater, and are not unusual for the region. The general decline in these analytical parameters could be due to further well development as a result of additional pumping during the sampling. All other common ions and metals are within drinking water quality standards. Based on known rock properties for the area within the proposed quarry expansion area, it is not anticipated that the project will have a negative impact on groundwater quality in the granite or surrounding aquifers where wells of other ownership are completed. Additionally, groundwater discharges to surface waters are not anticipated to change or adversely affect current surface water quality.

The closest formerly sampled stream location is a Colorado Department of Public Health & Environment (CDPHE) well with the identifier 21COL001_WQX-7115, located near the mouth of Tallahassee Creek and southwest of the current quarry and the planned quarry expansion. This location contained dissolved uranium at 26 and 23 µg/L on 12 September 2005 and 20 October 2005, respectively (USGS 2020). The on-site monitoring wells generally showed lower dissolved uranium, between 13.7 and 21.2 µg/L, except for 38.2 µg/L at MW-10 on 12 December 2018, than surface water location 21COL001_WQX-7115.

6.2 Post-Mining Condition

The long-term post-mining effects of the excavated pit were evaluated using the same steady-state one-dimensional approach described in Section 5, with the following modifications:

- The left (southwest) end of the analysis section begins at the pit highwall. At this new boundary, a fixed hydraulic head of 6,020 feet amsl is applied, which conforms to the elevation at the base of the highwall.
- The recharge rate is fixed at 0.154 inches per year, which is a result from the pre-mining analysis.
- The target head at the right (northeast) side of the section is 6,150.4 feet amsl, also a result from the pre-mining analysis. This boundary is about 2 miles northeast of the pit, a distance where the effects of the pit are presumed to be negligible.

For this analysis, the only parameter to be adjusted by iteration was the flow rate at the left side of the section, which was done until the computed water level at the right side of the section matched the target value of 6,150.4 feet amsl.

The results are shown graphically on Figure 6-1, below, where the post-mining water level profile (red) is compared to the pre-mining profile (blue dashed). The pit creates a drawdown of some 300 feet at the highwall, which has a significant long-term effect on the water levels in granite. Yet the water levels in the sedimentary rock (containing wells) are minimally affected. The lowering of the water table below Highway 9 is predicted to be only 6 feet. A conceptual explanation of this result is as follows. Granite has very low hydraulic conductivity so the changes in system flows at the pit are relatively small (on the order of several gpm). If these changes in flow are propagated into the sedimentary rock, the water level effects are almost negligible because this unit has much higher hydraulic conductivity. This concept can be applied in a more general sense to consider that water levels in any water bearing geologic unit in contact with the granite will not likely experience significant long-term dewatering due to excavation of the pit. Conceptually, the low hydraulic conductivity of the granite “insulates” higher permeability geologic units from experiencing the effects of drawdown at the pit walls.

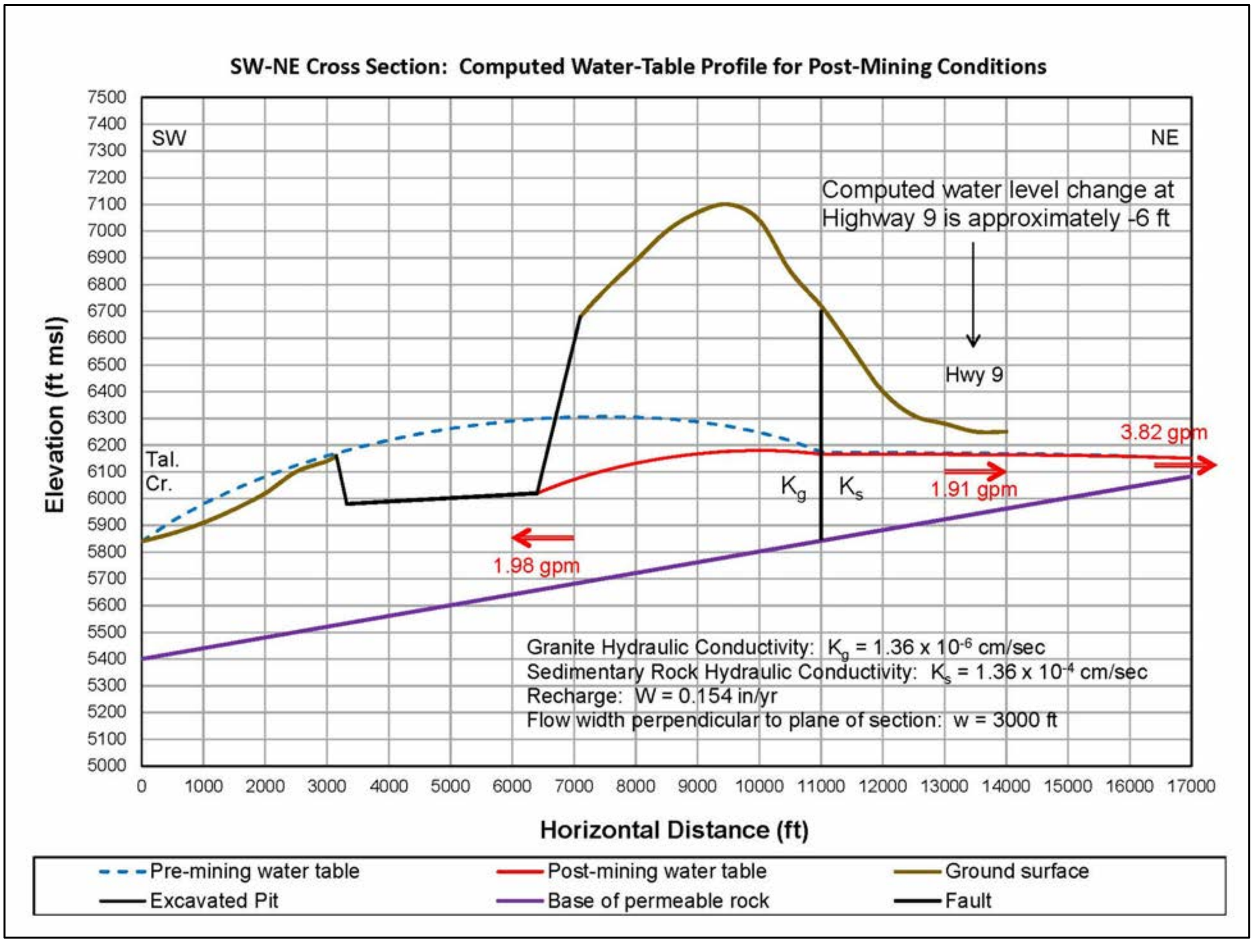

Figure 6-1: Results of Post-Mining Analysis Considering Recharge

6.3 Transient Drawdown Analysis

ERM performed a scoping-level analysis of the change in granite water levels due to pit excavation, using a one-dimensional transient analytical solution for linear flow towards the highwall. The analysis was based on current conditions and did not account for future mining operations currently permitted at the existing Parkdale Quarry and the potential impacts to groundwater that could result from those activities. Details of the analytical solution are provided in Appendix E. The solution assumed the following:

- The pit is instantaneously excavated to full depth at time zero.
- Granite hydraulic conductivity is 1.36 x 10^{-6} cm/sec.
- Storage coefficient of 0.01, which is reasonable for the specific yield of fractured granite.
- Hydraulic drawdown at the quarry wall is 300 feet.
- Thickness of permeable fractured bedrock is 450 feet.
- Groundwater flow towards the quarry is strictly horizontal.

The results of this calculation are provided in Appendix E. The premise of this analysis is that drawdowns cannot occur in the sedimentary rock unit until there is a significant drawdown at the fault, which provides the contact between granite and sedimentary rock. The plot of "Time - Drawdown at Fault" in Appendix E predicts that it would take 20 years for the drawdown at the fault to reach 1 foot. It would therefore take a minimum of two decades for the effects of the pit to be experienced in the sedimentary rock unit. This suggests that if measurable drawdowns were to ever occur in wells completed at Highway 9, the process would be very slow and there would be ample time to monitor and understand the effects so that mitigation measures could be initiation (if needed).

6.4 Quarry Inflows

The drawdown analysis also provides an estimate of transient groundwater inflow at the pit highwall. As shown in Appendix E, the plot of “Time - Flow Rate at Pit High-Wall” indicates relatively high inflow rates during the first several years of operations, but these values drop off after 10 to 15 years and begin to approach flow rates similar to the post-mining steady-state analysis in Section 6.2. The relatively high inflow rates at early times are the result of water released from storage at the water table, not induced flow from the sedimentary rock unit. It is also the consequence of assuming instantaneous excavation of the final pit. In reality, the pit would be excavated gradually over time, so the actual early inflow rates are likely to be much lower than what the analysis shows. The expectation of low inflow rates is consistent with observations at the current granite quarry operated by Martin Marietta. While the current highwall has a height of approximately 270 feet, little to no water is observed at the pit bottom except after precipitation events. For the proposed quarry, it is likely that water volumes originating from rainfall, storm runoff, and snowmelt will be much larger than groundwater inflows.

6.5 Geologic Cross Section Interpretation

ERM developed a geologic cross section to better understand the connection between the domestic drinking water wells and the proposed quarry expansion (Figure 5). The cross section intersects two monitoring wells within the proposed quarry expansion boundary and extends northeast across Cactus Mountain and the Parkdale fault, and ends near Highway 9 (Figure 3). No drinking water wells were identified in the granite southwest of the Parkdale Fault. ERM found that two drinking water wells shown on Figure 4 were mislocated, as the well logs do not show any granite and it is assumed these are northeast of the Parkdale fault in sedimentary rocks. ERM used four wells and a local USGS geologic map to create the geologic cross section, and included two on-site monitoring wells MW-03 and MW-10, and two domestic water wells 215395 and 198713.

The Parkdale fault, a reverse fault, divides the quarry expansion location and the domestic water well users to the northeast. Based on domestic water well depths and the USGS geologic map, the aquifer exploited for water supply is the Carlile Shale, Greenhorn Limestone, and Graneros Shale, Undivided (Kcgg) geologic unit, which contains the water-bearing “Codell Sandstone Member.” The aquifer may be partially confined, as the overlying Niobrara Formation (Kn) consists of mostly shales and limestones. The static water levels in the drinking water wells are approximately 300 feet above the base of the aquifer unit and locally higher than the top of the unit. Furthermore, based on the USGS geologic map, the well users in the area are within a sedimentary syncline.

Based on the topography of the area, it is likely that the recharge zone for the domestic water well users begins at the highest elevation of Cactus Mountain and extends downslope to the northeast. This differs from the likely recharge zone of the proposed quarry expansion, which likely begins at the highest elevation of Cactus Mountain and extends downslope to the southwest.

It is unknown if the Parkdale fault operates as a flow barrier, flow conduit, or simply provides a physical contact between the granite and sedimentary rock units. Groundwater flow in the granite is assuredly fracture controlled and the nature and pervasiveness of fractures has not been investigated. However, pumping tests conducted in three monitoring wells in the quarry area reasonably confirm that the competent fractured granite has very low hydraulic conductivity.

7. DISCUSSION

The scoping-level calculations presented in this memorandum should not be viewed as the results of a formal numerical groundwater model. They are intended to provide a general evaluation of potential groundwater effects resulting from the proposed quarry excavation. The results provide good evidence that groundwater effects at existing wells, while not negligible, will not likely result in abandonment of wells over the many decades of mine operation due to lowering of static (non-pumping) water levels. Existing wells are completed in alluvium and sedimentary rock that have much higher hydraulic conductivity than the granite that will host the proposed quarry. In a conceptual sense, the low hydraulic conductivity of the granite “insulates” higher permeability geologic units from experiencing the effects of drawdown at the pit walls.

Groundwater inflows to the quarry will likely not be of operational consequence when compared to the larger water volumes resulting from rainfall, stormwater runoff, and snow melt. Conceptually, precipitation that does not immediately run off or evapotranspirate is expected to infiltrate into decomposed and weathered granite (0-20 feet thickness), which will likely have a significantly higher hydraulic conductivity than competent granite. This may lead to shallow perched water that could flow downslope towards the quarry highwall. It is possible that perched groundwater may enter the quarry via springs along the top of the highwall. ERM’s evaluation of this process was not considered in the work performed herein, but could be the subject of an additional analysis.

ERM created a geologic cross section to interpret how the geologic units between the proposed quarry and the existing water well users may be hydrologically connected. The Parkdale fault provides a geologic contact between the granite that will host the quarry and sedimentary rock within which the existing wells are completed. For calculations performed herein, the fault is a contact plane between the two rock units and is assumed to provide full hydraulic connectivity, where it is possible that the fault could operate hydrologically as a flow barrier or flow conduit. The extended quarry excavation would not intersect the fault, so the nature of groundwater flow in the fault zone, whether restricted or enhanced, would tend to further reduce the effects of the quarry on groundwater levels in the sedimentary rock unit.

Finally, water quality in the proposed quarry for most analytes tested is generally below drinking water standards (not an applicable regulatory requirement, but for informational purposes only), except for gross alpha and beta particles. Radionuclides are generally found in the granitic rock type of the area and would be expected in baseline conditions. Dissolved uranium was above the drinking water standard for one sampling event at MW-10, but is generally at least 10 µg/L below the standard at most wells, and during most sampling that includes isotopic uranium. One CDPHE water quality stream location showed dissolved uranium between 23 and 26 µg/L in 2005, which is generally higher than that found in the proposed quarry monitoring wells. Therefore, it is unlikely that the surface water proximal to the proposed quarry will be impacted greater than the baseline water quality condition.

Lastly, groundwater in the granite will provide relatively small inflows to the pit, and this mine water will be discharged to surface water. Given the relatively good groundwater quality, no significant impacts to surface water quality are anticipated.

8. REFERENCES

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FIGURES

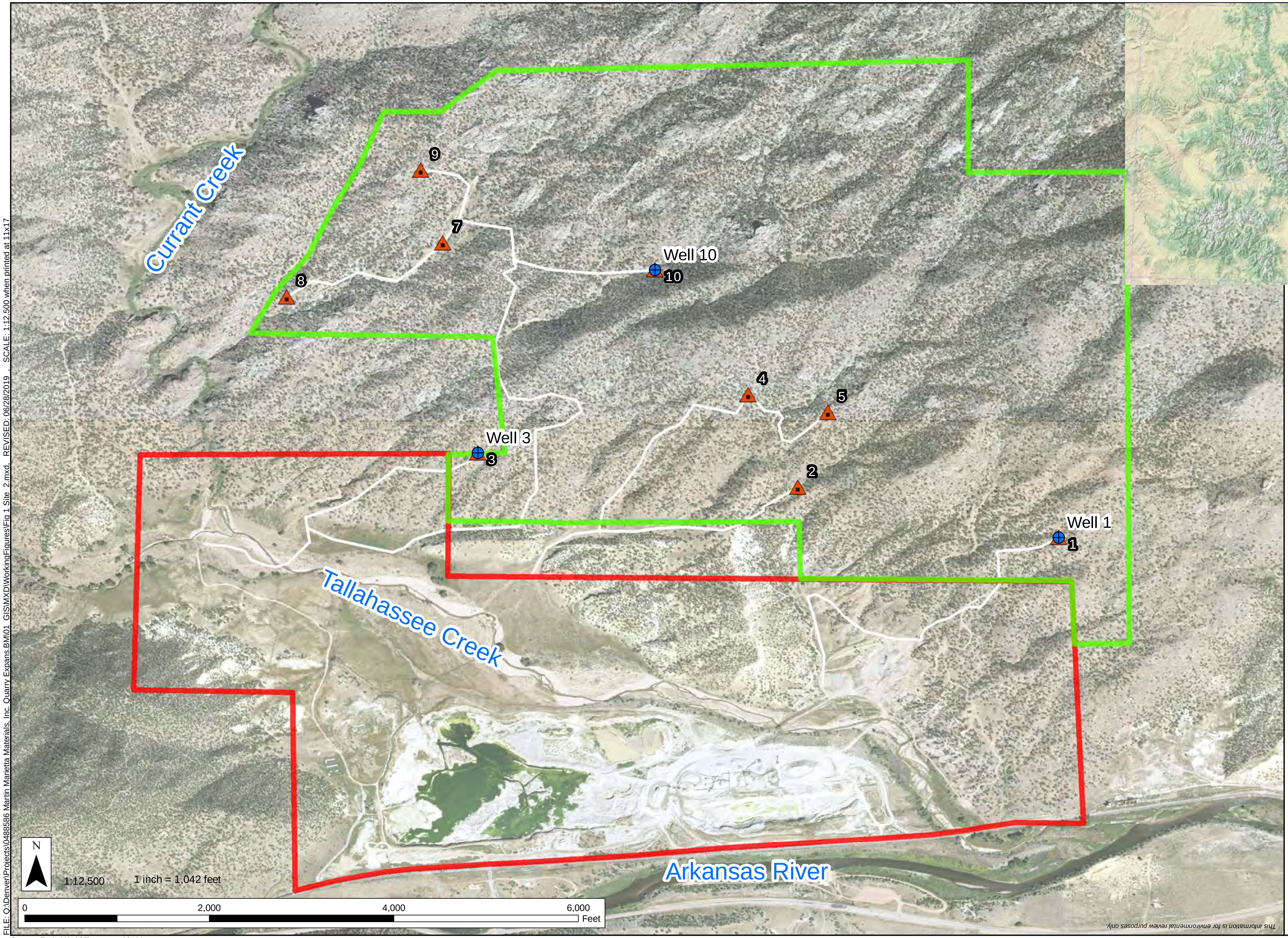
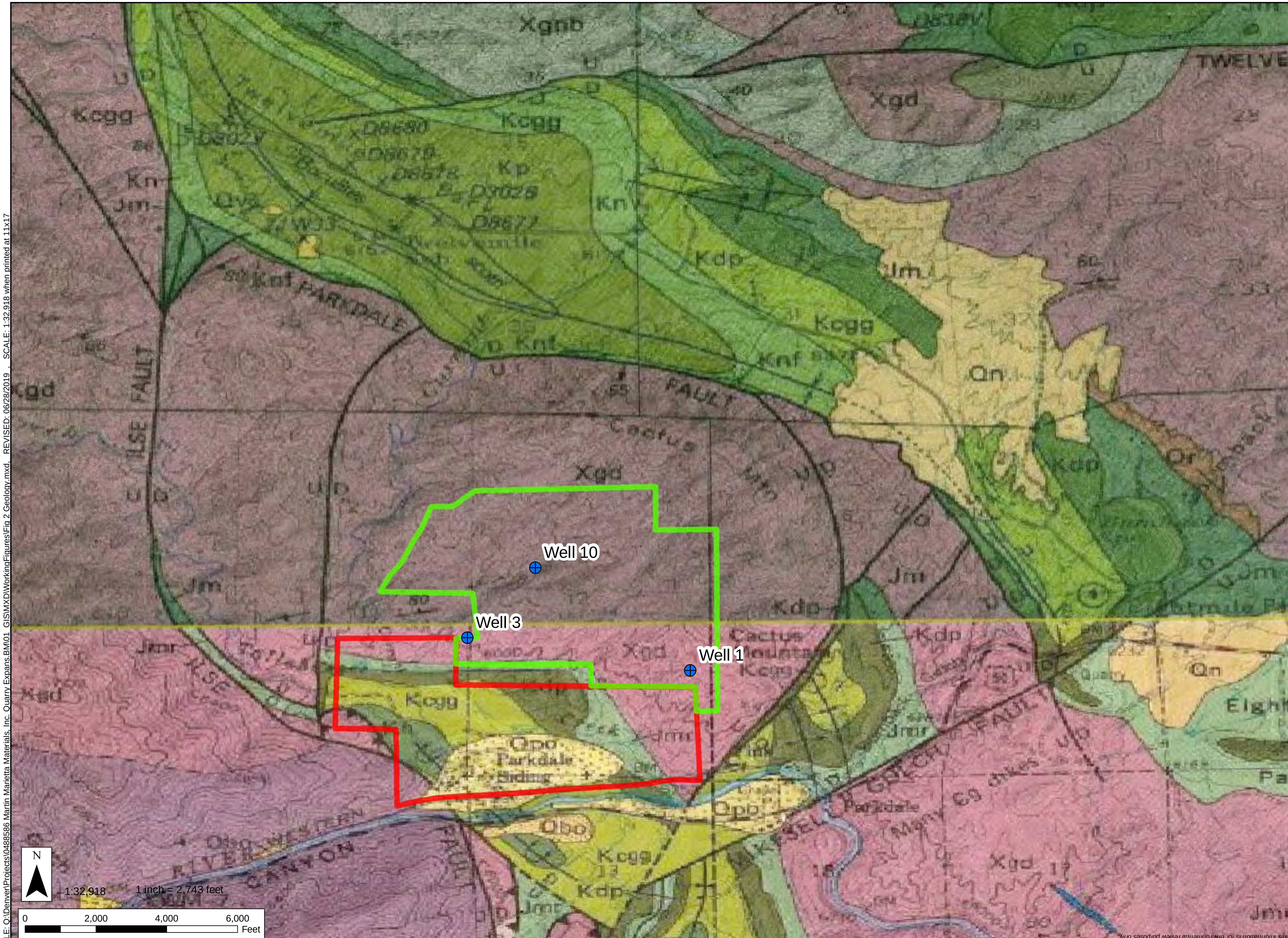


Figure 1
Site Location
Parkdale Quarry Expansion
Martin Marietta
Fremont County, Colorado

ERM West, Inc.
www.erm.com
ERM

FILE: Q:\Denver\Projects\0488586 Martin Marietta Materials, Inc. Quarry Expans.BM01 GIS\MXD\WorkingFigures\Fig 1 Site 2.mxd, REVISED: 06/28/2019 , SCALE: 1:12,500 when printed at 11x17

Source: Esri - World Topoographic Map



Legend

Mine Permit Boundary

Proposed Expansion

Monitoring Well

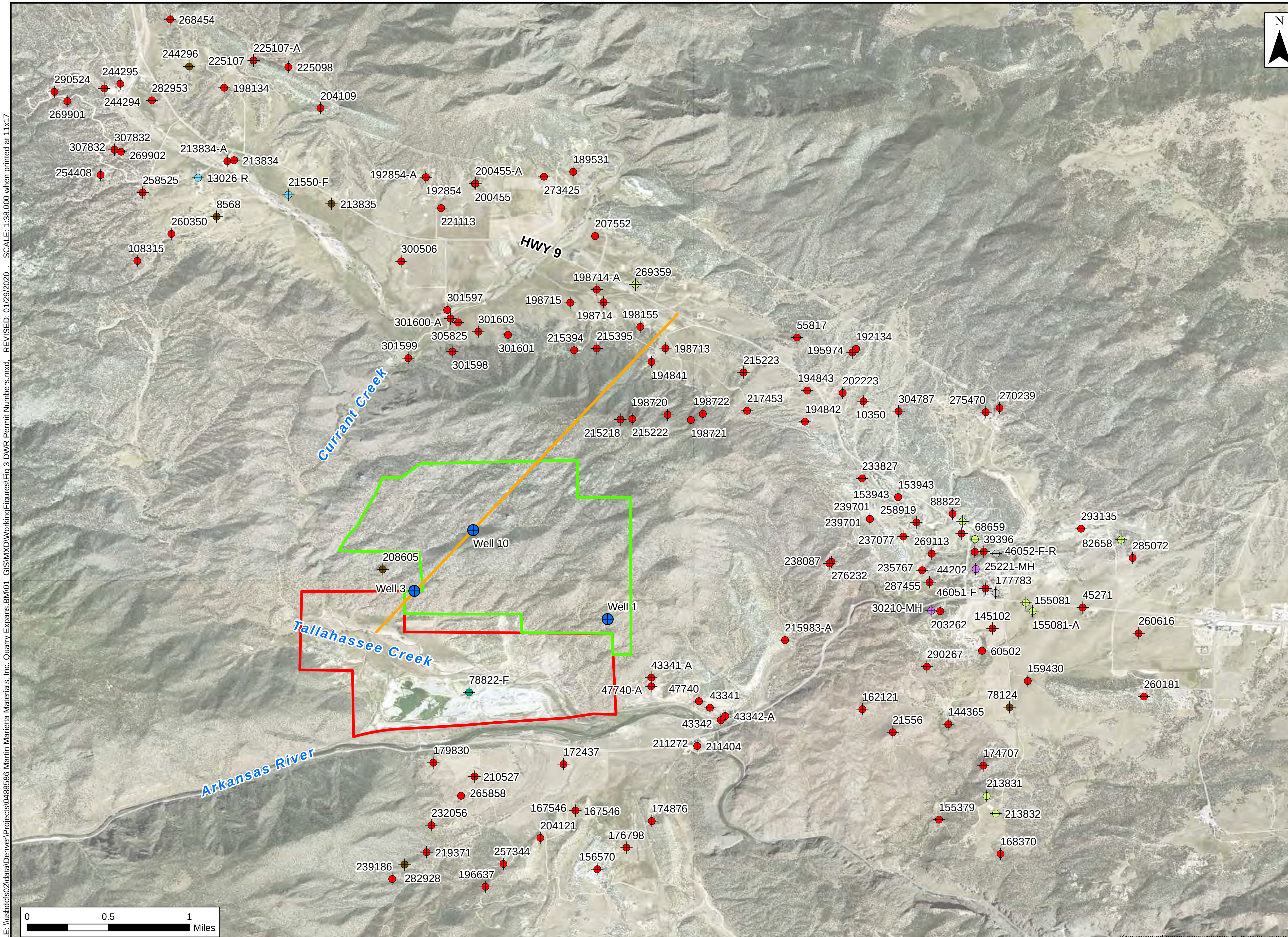
Notes:
Wobus et. al. 1979.
Geologic Map of Cover Mountain Quadrangle, Premont, Park, and Teller Counties, Colorado

Figure 2
Geologic Map
Parkdale Quarry Expansion
Martin Marietta
Fremont County, Colorado

ERM West, Inc.
www.erm.com

Source: Esri - World Topographic Map

FILE: Q:\Denver\Projects\0488586 Martin Marietta Materials, Inc. Quarry Expans.BMI01_GIS\MXD\WorkingFigures\Fig 2 Geology.mxd, REVISED: 06/28/2019 , SCALE: 1:32,918 when printed at 11x17



FILE: \\usbdcfs02\data\Denver\Projects\0488586 Martin Marietta Materials, Inc. Quarry Expans.BM01_GIS\MXD\WorkingFigures\Fig 3 DWR Permit Numbers.mxd REVISED: 01/29/2020 SCALE: 1:38,000 when printed at 11x17

Source: Esri - World Topographic Map

Legend

- Mine Permit Boundary
- Proposed Expansion
- Monitoring Well
- Cross Section A-A'

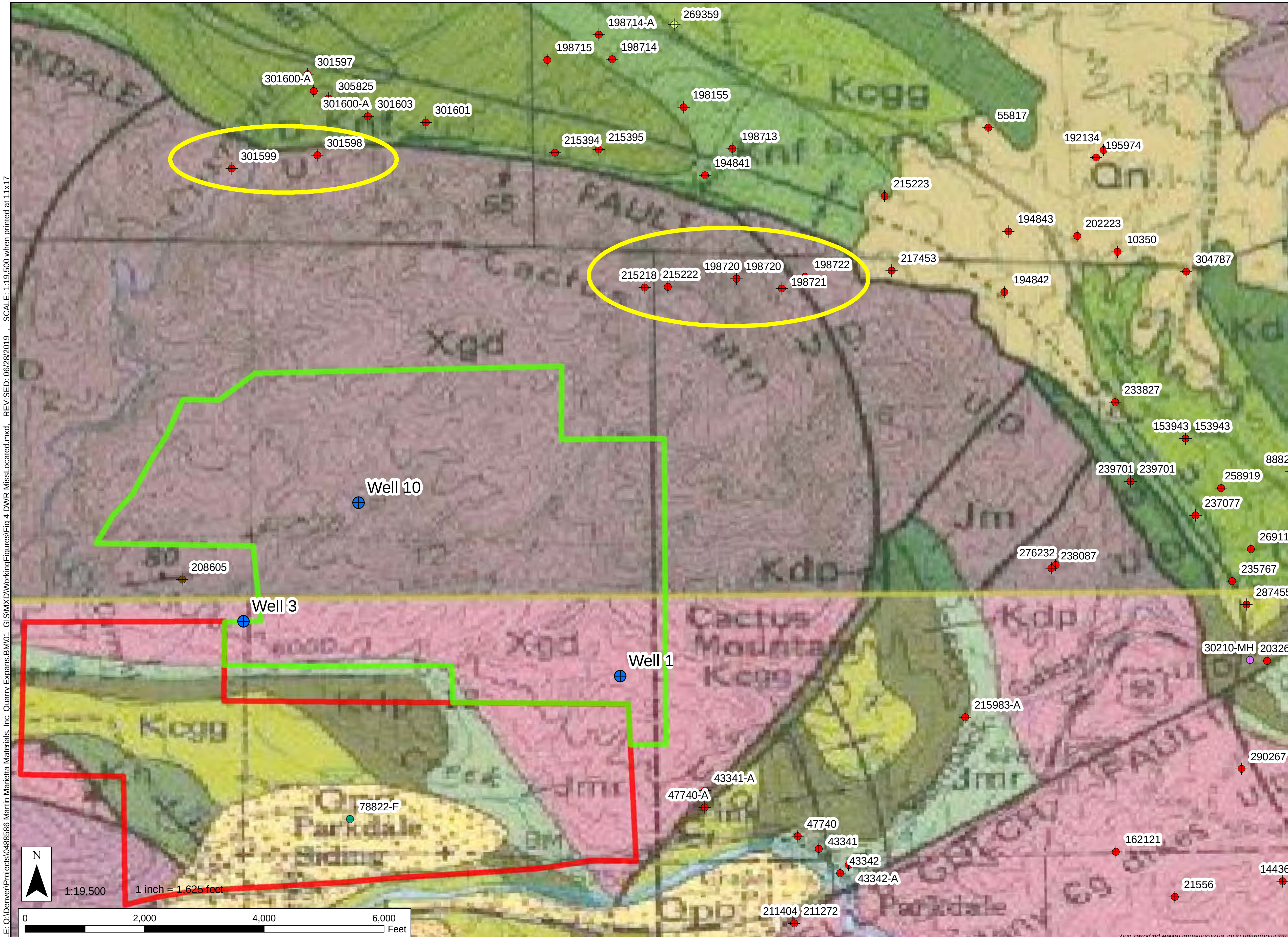
DWR Primary Use

- Commercial
- Domestic
- Household Use
- Irrigation
- Monitoring
- Other
- Stock

Notes:
Numbers are DWR Permit Numbers.

Figure 3
DWR Well Database
Parkdale Quarry Expansion
Martin Marietta
Fremont County, Colorado

ERM West, Inc.
www.erm.com



Legend

Mine Permit Boundary

Proposed Expansion

Possibly Mislocated

Monitoring Well

DWR

Primary Use

Commercial

Domestic

Household Use

Irrigation

Monitoring

Other

Stock

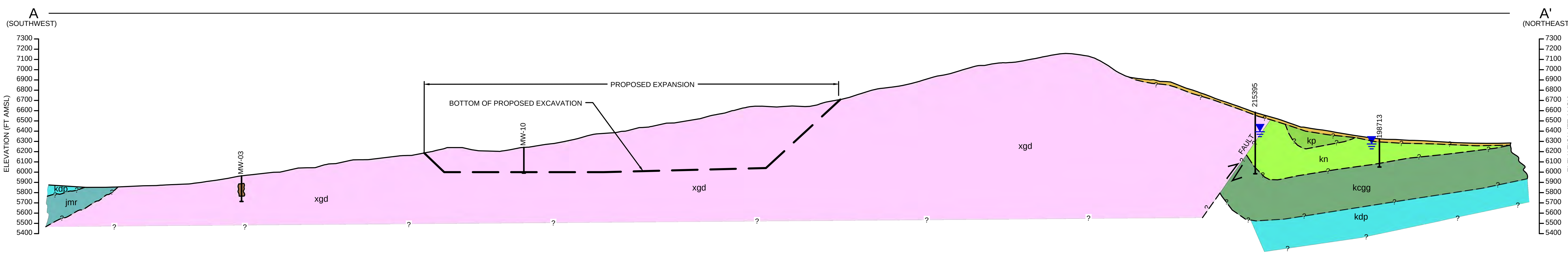
Notes:
Numbers are DWR Permit Numbers.

Figure 4
DWR Mislocated Wells
Parkdale Quarry Expansion
Martin Marietta
Fremont County, Colorado

ERM West, Inc.
www.erm.com
ERM

Source: Esri - World Topographic Map

FILE: Q:\Denver\Projects\0488586 Martin Marietta Materials, Inc. Quarry Expans.BM01_GIS\MXD\WorkingFigures\Fig 4 DWR MissLocated.mxd, REVISED: 06/28/2019 , SCALE: 1:19,500 when printed at 11x17



LEGEND

Top Soil/Fill

Clayey Fracture Fill

kp - Pierre Shale

kn - Niabara Formation

kcgg - Carlile Shale, Greenhorn Limestone, and Graneros Shale

kdp - Dakota Sandstone and Purgatoire Formation

jmr - Morrison and Ralston Creek Formation

xgd - Granodiorite

MW-03

Well

Water Level

Bottom of Proposed Excavation

Fault Movement

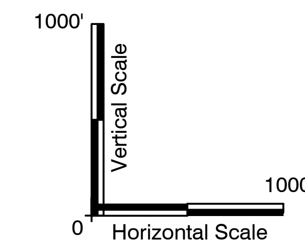


Figure 5
Cross Section A-A'
Parkdale Quarry Expansion
Martin Marietta
Fremont County, Colorado

Environmental Resources Management
www.erm.com
ERM

J. Estrada 4/08/2020 0488586.05 G:\DWGS\0488586 Parkdale Quarry\05\04885605-01.dwg

APPENDIX A FIELD WATER QUALITY FORMS

Project Parkdale Quarry

Location Cañon City, CO

Purpose

Well Name Well 1

Sample ID

Date	Time	Temperature	pH	EC	DO	ORP	Notes
		[unit] °C		[unit] µS/cm²	[unit] mg/L	[unit]	Vol
12/11/18	12:14	13.57	6.42	622	7.32	52.2	1 gallon, Cloudy
	12:20	14.00	6.93	622	6.11	75.0	2.4 gal, Cloudy
	12:26	13.91	7.42	624	6.09	58.8	3.3 gal, Cloudy
	12:33	13.74	7.19	616	5.93	78.5	4.5 gal, Cloudy
	12:40	13.84	7.51	619	6.01	74.8	5.5 gal, Cloudy
	13:10	13.55	7.39	617	6.24	93.5	9.2 gal Cloudy
	13:49	12.67	7.41	627	7.10	105.3	13.8 gal, Sl. Cloudy
	1358	13.45	7.51	616	5.87	102.0	14 gal

Well Development / Purge Form

Project	Parkdale Quarry	Total Depth		Depth Ind. S/N	
Project No.		Depth to Water (DTW)		Weather	
Location		Water Column (ft. h.)			
Date	12/11/18	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)		3 vols =	
Well Number	Well 1	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)			
Method	Redi Flo 3	Total Gallons Removed			
Field Personnel	PM & ZW	Sample Number & Time			
Setup time:	09:45				

Time	Duration (Minutes)			Volume	Temp	DO	Spec. Cond.	pH	ORP/ REDOX	Turbidity	DTW	Remarks
	Surge	Pump	Bail	(gallons)	(°C)	(mg/L)	(µs/ms)		(ReL.	(NTU)	(ft btoc)	
10:12		0		0								114.39' static @ 09:20
11:28				1	14.68	4.37	587	7.71	127.0	743	—	
												Original Field Form blew in the wind & not recovered. This was the final Field parameters after stabalization

Sample Analytes: VOCs (8260)
Semi-Volatiles (8270)
Dissolved Fe and Mn (6020) (lab filtered)
Total Alkalinity as $CaCO_3$ (SM 2320B)
Sulfate, Nitrite, Nitrate, and Chloride (EPA 300.0)
Sulfide (SM 4500S2)
Ferric and Ferrous Iron (SM3500 Fe; Hach 8146)
Dissolved Methane, Ethane, and Ethene (RSK175)

Ferrous Iron (field test) =_______ mg/L

Well Development / Purge Form

Project	Parkdale Quarry	Total Depth	249.0
Project No.	0488586	Depth to Water (DTW)	47.55
Location	Canon City, CO	Water Column (ft. h.)	
Date	12/11/18	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)	3 vols =
Well Number	Well 3	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)	
Method	Red. Flo 2 Pump	Total Gallons Removed	
Field Personnel	RM & ZW	Sample Number & Time	
Setup time:	14:00		

Depth Ind. S/N:

Weather:

Time	Duration (Minutes)			Volume	Temp	DO	Spec. Cond.		ORP/ REDOX	Turbidity	DTW	
	Surge	Pump	Bail	(gallons)	(°C)	(mg/L)	(µs/ms)	pH	(ReL.	(NTU)	(ft btoc)	Remarks
14:45:15				1.0	14.50	1.81	516	6.19	125.7	Sl. Cloudy	—	
14:46:50				2.0								
14:48:00				3.0	14.72	0.50	497	6.72	106.2	Cloudy	—	
14:49:20				4.0								↑ Pump rate
14:50:47				5.0	14:88	0.53	480	6.97	99.8	Sl. Cloudy	—	
14:52:13				6.0								↑ Pump rate
14:53:37				7.0	15:01	0.61	475	7.12	97.0	Sl. Cloudy	—	
14:54:53				8.0								↑ Pump rate ~~(125 Hz)~~
14:55:50				9.0	15.18	0.65	475	7.21	94.0			
14:56:53				10.0								
14:58:06				11.0	15.25	0.66	476	7.26	94.7			↑ Pump rate (250 Hz)
14:58:08				12.0								
15:00:06				13.0								

Sample Analytes: VOCs (8260)
Semi-Volatiles (8270)
Dissolved Fe and Mn (6020) (lab filtered)
Total Alkalinity as $CaCO_3$ (SM 2320B)
Sulfate, Nitrite, Nitrate, and Chloride (EPA 300.0)
Sulfide (SM 4500S2)
Ferric and Ferrous Iron (SM3500 Fe; Hach 8146)
Dissolved Methane, Ethane, and Ethene (RSK175)

Ferrous Iron (field test) =_______ mg/L

Well Development / Purge Form

Project		Total Depth		Depth Ind. S/N
Project No.		Depth to Water (DTW)		Weather
Location		Water Column (ft. h.)		
Date		Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)		3 vols =
Well Number		Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)		
Method		Total Gallons Removed		
Field Personnel		Sample Number & Time		
Setup time:				

Time	Duration (Minutes) Surge	Pump	Bail	Volume (gallons)	Temp (°C)	DO (mg/L)	Spec. Cond. (µs/ms)	pH	ORP/ REDOX (ReL.	Turbidity (NTU)	DTW (ft btoc)	Remarks
15:01:10				14.0	15.33	0.68	475	7.36	92.7	—	—	
15:02:22				15.0	—	—	—	—	—	—	—	↑ pump rate
15:03:34				16.0	—	—	—	—	—	—	—	
15:04:40				17.0	15.45	0.71	475	7.42	92.1	—	—	
15:05:54				18.0	—	—	—	—	—	—	—	↑ pump rate
15:07:02				19.0	15.52	0.72	475	7.45	92.3	550	—	
15:08:13				20.0	—	—	—	—	—	—	—	
15:09:16				21.0	15.58	0.76	475	7.50	90.6	—	—	
15:10:27				22.0	—	—	—	—	—	571	—	↑ Pump rate
15:11:37				23.0	15.64	0.78	475	7.51	91.2	—	—	↑ Pump rate
15:12:46				24.0	~~15~~ —	—	—	—		629	—	
15:13:49				25.0	15.79	0.81	475	7.56	89.3	—	—	
15:14:53	15:14:53			26.0	—	—	—	—	—	638	—	
15:16:03	15:16:03			27.0	15.86	0.90	477	7.56	90.7	63	—	

Sample Analytes: VOCs (8260)
Semi-Volatiles (8270)
Dissolved Fe and Mn (6020) (lab filtered)
Total Alkalinity as $CaCO_3$ (SM 2320B)
Sulfate, Nitrite, Nitrate, and Chloride (EPA 300.0)
Sulfide (SM 4500S2)
Ferric and Ferrous Iron (SM3500 Fe; Hach 8146)
Dissolved Methane, Ethane, and Ethene (RSK175)

Ferrous Iron (field test) =_______ mg/L

Well Development / Purge Form

Project		Total Depth		Depth Ind. S/N	/
Project No.	0488586	Depth to Water (DTW)		Weather	
Location	Canon City, CO	Water Column (ft. h.)			
Date	12/11/18	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)		3 vols =	
Well Number	Well 3	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)			
Method		Total Gallons Removed			
Field Personnel		Sample Number & Time	Well 3 : Parkdale @ 15:35		
Setup time:					

Time	Duration (Minutes)			Volume	Temp	DO	Spec. Cond.	pH	ORP/ REDOX	Turbidity	DTW	Remarks
	Surge	Pump	Bail	(gallons)	(°C)	(mg/L)	(µs/ms)		(ReL.	(NTU)	(ft btoc)	
15:17:15				28.0	—	—	—	—	—	—	—	
~~15:~~				~~29.0~~								No readings / time
15:19:23				30.0	15.85	1.04	478	7.59	89.3	—	—	
15:20:25				31.0	—	—	—	—	—	549	—	
15:21:28				32.0	—	—	—	—	—	—	—	
15:22:34				33.0	16.23	1.09	482	7.64	86.9	—		
15:23:50				34.0	—	—	—	—	—	—	—	
15:24:52				35.0	16.27	1.05	481	7.60	88.5	422	—	
15:26:16				36.0	—	—	—	—	—	—	—	
15:27:20				37.0	16.35	0.99	480	7.63	88.6	635	—	
15:28:26				38.0	—	—	—	—	—	—	—	
15:29:34				39.0	16.40	0.95	480	7.65	88.5	>1000		
15:30:46				40.0	—	—	—	—	—	—		
15:32												↓ Rate for sampling

Sample Analytes: VOCs (8260)
Semi-Volatiles (8270)
Dissolved Fe and Mn (6020) (lab filtered)
Total Alkalinity as $CaCO_3$ (SM 2320B)
Sulfate, Nitrite, Nitrate, and Chloride (EPA 300.0)
Sulfide (SM 4500S2)
Ferric and Ferrous Iron (SM3500 Fe; Hach 8146)
Dissolved Methane, Ethane, and Ethene (RSK175)

Ferrous Iron (field test) =______ mg/L

Well Development / Purge Form

Project		Total Depth	
Project No.		Depth to Water (DTW)	
Location	Canon City, CO	Water Column (ft. h.)	
Date	12/11/18	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)	3 vols =
Well Number	Well 3	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)	
Method		Total Gallons Removed	
Field Personnel		Sample Number & Time	
Setup time:			

Depth Ind. S/N:

Weather:

Time	Duration (Minutes) Surge	Pump	Bail	Volume (gallons)	Temp (°C)	DO (mg/L)	Spec. Cond. (µs/ms)	pH	ORP/ REDOX (ReL.	Turbidity (NTU)	DTW (ft btoc)	Remarks
15:57:00				48.5	(+ sample x2)							~~Ramped Q~~ ↑↑ Rat
15:58				50	(+ Sample volume)							Stopped

Sample Analytes: VOCs (8260)
Semi-Volatiles (8270)
Dissolved Fe and Mn (6020) (lab filtered)
Total Alkalinity as $CaCO_3$ (SM 2320B)
Sulfate, Nitrite, Nitrate, and Chloride (EPA 300.0)
Sulfide (SM 4500S2)
Ferric and Ferrous Iron (SM3500 Fe; Hach 8146)
Dissolved Methane, Ethane, and Ethene (RSK175)

Ferrous Iron (field test) =_______ mg/L

Well Development / Purge Form

Project	Parkdale Quarry	Total Depth	251'	Depth Ind. S/N	
Project No.	0488586	Depth to Water (DTW)	static 11.28'	Weather	Mostly Sunny / 36 F
Location	Cañon City, CO	Water Column (ft. h.)			
Date	12/12/18	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)		3 vols =	
Well Number	Well 10	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)			
Method	Grundos Redi Flo 2	Total Gallons Removed			
Field Personnel	PM & ZW	Sample Number & Time		@10:52	
Setup time:	09:20				

Time	Duration (Minutes) Surge	Pump	Bail	Volume (gallons)	Temp (°C)	DO (mg/L)	Spec. Cond. (µs/ms)	pH	ORP/ REDOX (ReL.	Turbidity (NTU)	DTW (ft btoc)	Remarks
09:49		0		0								Start pump
09:50:14				1	12.42	1.19	669	8.05	-15.6	Cloudy	—	silty
09:51:24				2							—	
09:52:44				3							—	↑ Pump rate
09:53:26				4	12.73	0.30	646	7.96	-34.5	Cloudy	—	
09:55:20				5								↑ Pump rate
09:56:25				6	12.90	0.29	627	7.91	-38.0	Cloudy	—	
09:57:29				7								
09:58:34				8	13.01	0.60	617	7.88	-37.8	Cloudy	—	
09:59:35				9								
10:00:36				10								
10:01:40				11	13.21	1.35	613	7.83	-32.0	Cloudy	—	
10:02:33				12								
10:03:20				13	13.24	1.70	611	7.81	-28.1	Cloudy	—	

Sample Analytes: VOCs (8260)
Semi-Volatiles (8270)
Dissolved Fe and Mn (6020) (lab filtered)
Total Alkalinity as $CaCO_3$ (SM 2320B)
Sulfate, Nitrite, Nitrate, and Chloride (EPA 300.0)
Sulfide (SM 4500S2)
Ferric and Ferrous Iron (SM3500 Fe; Hach 8146)
Dissolved Methane, Ethane, and Ethene (RSK175)

Ferrous Iron (field test) =_______ mg/L

Well Development / Purge Form

Project		Total Depth		Depth Ind. S/N
Project No.	0488586	Depth to Water (DTW)		Weather
Location	Canon City, CO	Water Column (ft. h.)		
Date	12/12/18	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)		3 vols =
Well Number	Well 10	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)		
Method	Grundfos Redi flow 2 ~1 gal/min	Total Gallons Removed		
Field Personnel	PM + ZW	Sample Number & Time		
Setup time:				

Time	Duration (Minutes) Surge	Pump	Bail	Volume (gallons)	Temp (°C)	DO (mg/L)	Spec. Cond. (µs/ms)	pH	ORP/ REDOX (ReL.	Turbidity (NTU)	DTW (ft btoc)	Remarks
10:04:15				14								
10:05:13				15	13.25	2.00	607	8.03	-26.1	Cloudy	—	
10:06:14				16								
10:07:18				17	13:28	2.21	585	7.74	-15.1	Cloudy	—	
10:08:18				18								
10:09:19				19	13.30	2.25	568	7.72	-9.9	Cloudy	—	
10:10:29				20								
10:11:29				21	13.29	2.36	604	7.70	-3.4	Cloudy	—	
10:12:30				22								
10:13:36				23								↑ Pump rate
10:14:38				24	13.34	2.52	602	7.66	-4.9	Cloudy	—	
10:15:38				25								
10:16:40				26	1337	2.77	603	7.66	9.0	Cloudy	—	
10:17:39				27								

Sample Analytes: VOCs (8260)
Semi-Volatiles (8270)
Dissolved Fe and Mn (6020) (lab filtered)
Total Alkalinity as $CaCO_3$ (SM 2320B)
Sulfate, Nitrite, Nitrate, and Chloride (EPA 300.0)
Sulfide (SM 4500S2)
Ferric and Ferrous Iron (SM3500 Fe; Hach 8146)
Dissolved Methane, Ethane, and Ethene (RSK175)

Ferrous Iron (field test) =_______ mg/L

Well Development / Purge Form

Project		Total Depth		Depth Ind. S/N	
Project No.		Depth to Water (DTW)		Weather	
Location		Water Column (ft. h.)			
Date	12/12/18	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)		3 vols =	
Well Number	Well 10	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)			
Method		Total Gallons Removed			
Field Personnel		Sample Number & Time			
Setup time:					

Time	Duration (Minutes) Surge	Pump	Bail	Volume (gallons)	Temp (°C)	DO (mg/L)	Spec. Cond. (µs/ms)	pH	ORP/ REDOX (ReL.	Turbidity (NTU)	DTW (ft btoc)	Remarks
10:18:40				28	13.41	3.02	584	7.66	13.4	Cloudy	—	
10:19:40				29	—	—	—	—	—	—	—	
10:20:37				30	13.44	3.04	570	7.65	17.2	Cloudy	—	
10:22:00				31	—	—	—	—	—	—	—	
10:23:10				32	13.45	3.15	579	7.64	21.8	Cloudy	—	
10:25:10				34	13.46	3.29	576	7.62	24.8	>1000	—	
10:27:10				36	13.49	3.47	575	7.60	27.4	>1000	—	
10:29:10				38	13.48	3.69	574	7.60	29.9	>1000	—	
10:31:22				40	13.51	3.96	587	7.59	32.5	>1000	—	
10:34:10				43	13.59	4.26	591	7.58	34.3	>1000	—	
10:36:09				45	13.63	4.46	594	7.57	36.3	>1000	—	
10:37:55	—	—	—	—	—	—	—	—	—	—		↓ Pump rate
10:38:22				47	13.56	4.48	596	7.59	36.8	>1000	—	
10:40:07				48	13.36	4.48	597	7.57	39.2	>1000	—	

Sample Analytes: VOCs (8260)
Semi-Volatiles (8270)
Dissolved Fe and Mn (6020) (lab filtered)
Total Alkalinity as $CaCO_3$ (SM 2320B)
Sulfate, Nitrite, Nitrate, and Chloride (EPA 300.0)
Sulfide (SM 4500S2)
Ferric and Ferrous Iron (SM3500 Fe; Hach 8146)
Dissolved Methane, Ethane, and Ethene (RSK175)

Ferrous Iron (field test) =_______ mg/L

Well Development / Purge Form

Project		Total Depth		Depth Ind. S/N	
Project No.		Depth to Water (DTW)		Weather	
Location	Canon City, CO	Water Column (ft. h.)			
Date	12/12/18	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)		3 vols =	
Well Number	Well 10	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)			
Method		Total Gallons Removed			
Field Personnel	Pm + Zw	Sample Number & Time	@ 10:52		
Setup time:					

Time	Duration (Minutes) Surge	Pump	Bail	Volume (gallons)	Temp (°C)	DO (mg/L)	Spec. Cond. (µs/ms)	pH	ORP/ REDOX (ReL.	Turbidity (NTU)	DTW (ft btoc)	Remarks
10:41:45				49	13.33	4.47	597	7.49	44.2	>1000	—	
10:43:21				50	—	—	—	—	—	>1000	—	
10:44:49				51	13.39	4.35	600	7.52	45.0	>1000	—	
10:46:23				52	13.40	4.29	601	7.52	46.4	>1000	—	
10:47:52				53	13.41	4.23	602	7.55	47.6	>1000	—	
10:49:12				54	13.43	4.20	602	7.55	48.7	>1000	—	Very Turbid
10:52				—	—	—	—	—	—	—	—	COLLECT SAMPLE
11:09:00				63.5	(+ Sample		volume x 2)					
11:10:30				65								↑↑ Rate
11:12:12				67								
11:13:38				69								↑ Rate
11:14:11				70								
11:17:15				75								
11:20:14				80								

Sample Analytes: VOCs (8260)
Semi-Volatiles (8270)
Dissolved Fe and Mn (6020) (lab filtered)
Total Alkalinity as $CaCO_3$ (SM 2320B)
Sulfate, Nitrite, Nitrate, and Chloride (EPA 300.0)
Sulfide (SM 4500S2)
Ferric and Ferrous Iron (SM3500 Fe; Hach 8146)
Dissolved Methane, Ethane, and Ethene (RSK175)

Ferrous Iron (field test) = _______ mg/L

Well Development / Purge Form

Project	MM Spring GW Sampling	Total Depth	239	Depth. Ind. S/N
Project No.		Depth to Water	123.99	Weather: Sunny, Slight breeze
Location	~~Well 4~~, Parkdale Quarry	Water Column (ft. h.)	115.01	
Date	5/14/2019	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)	18 gal	
Well Number	well-1	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)		
Method	pumping	Total Gallons Removed		
Field Personnel	Zeek Walter Morgan Farmer	Sample Number & Time		

Time	Duration (Minutes)			Volume (gallons)	Temp (°C)	DO (mg/L)	Spec Cond. ms/cm ~~(µs/ms)~~	pH	ORP/ REDOX (ReL. mV)	Turbidity (NTU)	Remarks
	Surge	Pump	Bail								
1215				2	15.61	13.55	.484	7.49	178	—	very turbid water
1233				4	15.30	12.53	.489	7.51	165	—	pump technical difficulties
1253				6	17.01	6.02	.485	7.3	158	—	more technical difficults
1305				8	18.99	4.71	.482	7.16	~~8~~ 147	530	
1313				10	18.88	4.89	.483	7.13	137	701	
1319				12	19.74	4.50	.480	7.13	131	626	
1325				14	19.58	4.52	.481	7.14	125	780	since tubing was exposed to sunlight when pump was pulled up, temp maybe off.

Sample Analytes: BTEX | Napthalene (8020) | TVPH (gas) 8015mod | TEPH (diesel) 8015 mod | Napthalene (8270) | PAHs (610)

Nitrate | Glycols | RCRA Metals F N/F | VOC (8260) | Semi-Volatiles (8270)

General Water Chemistry (cations plus manganese, anions, chloride, sulfate, bicarbonate, and total alkalinity)

Well Development / Purge Form

Project	MM Spring GW Sampling	Total Depth	239
Project No.		Depth to Water	123.99
Location	Pancake Quarry	Water Column (ft. h.)	115.01
Date	5/14/2019	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)	19 gal
Well Number	well-1	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)	
Method	pumping	Total Gallons Removed	
Field Personnel	Zack Walter, Morgan Farmer	Sample Number & Time	

Depth. Ind. S/N:

Weather:

Time	Duration (Minutes)			Volume (gallons)	Temp (°C)	DO (mg/L)	Spec Cond ms/cm ~~(µs/ms)~~	pH	ORP/ REDOX (ReL. ~~MV~~ mV)	Turbidity (NTU)	Remarks
	Surge	Pump	Bail								
1330				16	19.97	4.19	.479	7.15	126	845	
1338				18	20.26	3.98	.475	7.16	127	920	

Sample Analytes: BTEX; Napthalene (8020); TVPH (gas) 8015mod; TEPH (diesel) 8015 mod; Napthalene (8270); PAHs (610); Nitrate; Glycols; RCRA Metals F N/F; VOC (8260); Semi-Volatiles (8270)

General Water Chemistry (cations plus manganese, anions, chloride, sulfate, bicarbonate, and total alkalinity)

Well Development / Purge Form

Project	Martin Marieta Springs GW Sampling	Total Depth	N/A 249 - Sall field day	Depth. Ind. S/N	
Project No.		Depth to Water	38.38ft	Weather	sunny / slight breeze
Location	Canyon City	Water Column (ft. h.)	249 - 38.38 = ft		
Date	5/13/2019	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)	(249.0 - 38.38) * .16 = 33.7 gal		
Well Number	MW-3	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)			
Method		Total Gallons Removed			
Field Personnel	Zack Walter, Morgan Farmer	Sample Number & Time			

Time	Duration (Minutes) Surge	Pump	Bail	Volume (gallons)	Temp (°C)	DO (mg/L)	Spec Cond (ms/cm)	pH	ORP/ REDOX (ReL. MV)	Turbidity (NTU)	Remarks
1218				1	14.80	20.36	.380 mS/cm	7.39	162	315	
1220				3	14.97	14.43	.381 mS/cm	7.07	113	89.1	
1222				5	15.13	12.47	.380	6.84	109	175	
1224				7	15.23	11.20	.380	6.73	124	92.7	
1227				9	15.30	10.30	.379	6.68	132	80.0	
1229				11	15.39	9.72	.379	6.66	132	92.5	
1231				13	15.47	9.23	.379	7.51	88	96.1	

Sample Analytes: BTEX Napthalene (8020) TVPH (gas) 8015mod TEPH (diesel) 8015 mod Napthalene (8270) PAHs (610)

Nitrate Glycols RCRA Metals F N/F VOC (8260) Semi-Volatiles (8270)

General Water Chemistry (cations plus manganese, anions, chloride, sulfate, bicarbonate, and total alkalinity)

Well Development / Purge Form

Project	Martin Marieta Spring GW Sampling	Total Depth	249.
Project No.		Depth. Ind. S/N	
Location	Canyon City	Depth to Water	38.38
Date	5/13/2009	Weather	
Well Number	MW-3	Water Column (ft. h.)	
Method		Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)	33.7 gal
Field Personnel	Morgan Farmer, Zack Walter	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)	
		Total Gallons Removed	
		Sample Number & Time	

Time	Duration (Minutes) Surge	Pump	Bail	Volume (gallons)	Temp (°C)	DO (mg/L)	Spec Cond (ms/cm)	pH	ORP/ REDOX (ReL. mV)	Turbidity (NTU)	Remarks
12:34	un-			15	15.56	8.90	.380	7.53	89	95.0	
12:37				17	15.66	8.67	.380	7.52	89	101	
12:40				19	15.80	8.36	.380	7.53	86	110	
1243				21	15.88	8.12	.380	7.54	82	117	
1247				23	15.85	8.04	.381	7.26	89	138	
1253				25	16.08	8.36	.381	7.07	98	157	
				27	16.04	~~7.8~~ 8.00	.381	7.07	99	153	

Sample Analytes: BTEX Napthalene (8020) TVPH (gas) 8015mod TEPH (diesel) 8015 mod Napthalene (8270) PAHs (610)

Nitrate Glycols RCRA Metals F N/F VOC (8260) Semi-Volatiles (8270)

General Water Chemistry (cations plus manganese, anions, chloride, sulfate, bicarbonate, and total alkalinity)

Well Development / Purge Form

Project	Martin Marietta Spring GW Sampling	Total Depth	249.0	Depth. Ind. S/N	
Project No.		Depth to Water	38.38	Weather	
Location	Canyon City	Water Column (ft. h.)			
Date		Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)	33.7 gal		
Well Number	MW-3	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)			
Method		Total Gallons Removed			
Field Personnel	Morgan Fame, Zack Walter	Sample Number & Time			

Time	Duration (Minutes)			Volume (gallons)	Temp (°C)	DO (mg/L)	Spec Cond. (~~µs/ms~~ ms/cm)	pH	ORP/ REDOX (ReL. ~~MV~~ mV)	Turbidity (NTU)	Remarks
	Surge	Pump	Bail								
1256				29	16.24	8.11	.381	6.95	101	168	
1258				31	16.21	7.90	.381	6.93	103	190	
1301				33	16.30	7.63	.380	6.94	101	190	
1304				35	16.38	7.51	.379	6.97	96	205	
1308				37	16.44	7.28	.380	7.22	85	222	
1311				39	16.50	7.13	.380	7.60	65	216	
1314				41	16.53	7.97	.381	7.35	76	222	

Sample Analytes: BTEX, Napthalene (8020), TVPH (gas) 8015mod, TEPH (diesel) 8015 mod, Napthalene (8270), PAHs (610)

Nitrate, Glycols, RCRA Metals F N/F, VOC (8260), Semi-Volatiles (8270)

General Water Chemistry (cations plus manganese, anions, chloride, sulfate, bicarbonate, and total alkalinity)

Well Development / Purge Form

Project	Martin Marietta Spring GW Sampling	Total Depth	249.0	Depth. Ind. S/N	
Project No.		Depth to Water	38.38	Weather	
Location	Canyon City	Water Column (ft. h.)			
Date	5/13/2019	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)			
Well Number	MW-3	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)			
Method		Total Gallons Removed			
Field Personnel	Zack Walter, Morgan Farmer	Sample Number & Time			

Time	Duration (Minutes)			Volume (gallons)	Temp (°C)	DO (mg/L)	Spec Cond. (~~µs/ms~~) mS/cm	pH	ORP/ REDOX (ReL. ~~M~~V) mV	Turbidity (NTU)	Remarks
	Surge	Pump	Bail								
1316				43	16.76	6.82	.380	7.09	81	209	
1318				45	16.66	7.38	.380	7.01	86	200	
1321				47	16.73	7.02	.380	7.00	87	256	
1324				49	16.90	6.71	.379	7.05	85	429	
1326				51	~~16~~ 17.00	6.41	.379	7.12	70	821	
				59	17.13	6.20	.378	7.71	49	0.0	

Sample Analytes: BTEX | Napthalene (8020) | TVPH (gas) 8015mod | TEPH (diesel) 8015 mod | Napthalene (8270) | PAHs (610)

Nitrate | Glycols | RCRA Metals F N/F | VOC (8260) | Semi-Volatiles (8270)

General Water Chemistry (cations plus manganese, anions, chloride, sulfate, bicarbonate, and total alkalinity)

Well Development / Purge Form

Project	Martin Marietta Spring GW Sampling	Total Depth		Depth. Ind. S/N	
Project No.		Depth to Water	10.17	Weather	
Location	Parkdale quarry	Water Column (ft. h.)			
Date	5/~~18~~ 13/2019	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)			
Well Number	MW-10	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)			
Method	pumping	Total Gallons Removed			
Field Personnel	Morgan Farmer, Zeek Walter	Sample Number & Time			

Time	Duration (Minutes)			Volume (gallons)	Temp (°C)	DO (mg/L)	Spec Cond. (~~µs~~ mS/cm)	pH	ORP/ REDOX (ReL. ~~MV~~ mV)	Turbidity (NTU)	Remarks
	Surge	Pump	Bail								
1611				44	12.93	5.20	.481	6.63	107	503	
1613				46	12.92	5.22	.480	6.62	108	450	
1614				48	12.85	5.12	.480	6.62	109	419	
1616				50	12.86	5.05	.480	6.64	110 ~~11~~	478	

Sample Analytes: BTEX Napthalene (8020) TVPH (gas) 8015mod TEPH (diesel) 8015 mod Napthalene (8270) PAHs (610)
Nitrate Glycols RCRA Metals F N/F VOC (8260) Semi-Volatiles (8270)
General Water Chemistry (cations plus manganese, anions, chloride, sulfate, bicarbonate, and total alkalinity)

Well Development / Purge Form

Project	Martin Marietta Spring Hill Sampling	Total Depth		Depth. Ind. S/N	
Project No.		Depth to Water	10.17	Weather	
Location	Parkdale Quarry	Water Column (ft. h.)			
Date	5/13/2019	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)			
Well Number	MW-10	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)			
Method	pumping	Total Gallons Removed			
Field Personnel	Morgan Farmer, Zack Walter	Sample Number & Time			

Time	Duration (Minutes) Surge	Pump	Bail	Volume (gallons)	Temp (°C)	DO (mg/L)	Spec Cond. ~~(µs/ms)~~ mS/cm	pH	ORP/ REDOX (ReL. ~~MV~~ mV)	Turbidity (NTU)	Remarks
1557				30	13.06	5.93	.408	6.62	108	656	
~~15~~ 16.00				32	13.04	5.72	.491	6.62	105	777	
16.02				34	13.03	5.65	.485	6.63	106	926	
1603				36	13.06	5.48	.482	6.63	105	906	
1605				38	13.9	5.41	.480	6.64	104	779	
~~16.06~~ 16.07				40	13.00	5.41	.480	6.64	105	651	
1609				42	~~13~~ 12.99	5.24	.480	6.62	107	570	

Sample Analytes: BTEX Napthalene (8020) TVPH (gas) 8015mod TEPH (diesel) 8015 mod Napthalene (8270) PAHs (610)

Nitrate Glycols RCRA Metals F N/F VOC (8260) Semi-Volatiles (8270)

General Water Chemistry (cations plus manganese, anions, chloride, sulfate, bicarbonate, and total alkalinity)

Well Development / Purge Form

Project	Martin Marietta Spring GW Sampling	Total Depth	
		Depth. Ind. S/N	
Project No.		Depth to Water	10.17
		Weather	
Location	Parkdale Quarry	Water Column (ft. h.)	
Date	5/13/2019	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)	
Well Number	MW-10	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)	
Method	pumping	Total Gallons Removed	
Field Personnel	zack walter, morgan farmer	Sample Number & Time	

Time	Duration (Minutes) Surge	Pump	Bail	Volume (gallons)	Temp (°C)	DO (mg/L)	Spec Cond. ms/cm (~~µs~~/ms)	pH	ORP/ REDOX (ReL. mV)	Turbidity (NTU)	Remarks
1545				16	13.29	7.79	.502	6.73	102	—	
~~5~~ 1546				18	13.26	7.50	.502	6.71	102	—	
1549				20	13.27	7.12	.502	6.70	100	—	
1551				22	13.22	6.86	.500	6.66	105		
1552				24	13.21	~~6.09~~ 6.38	.498	6.64	105	918	
15 54				26	13.14	6.28	.497	6.64	106	946	
15 56				28	13.09	6.17	.496	6.63	108	691	

Sample Analytes: BTEX | Napthalene (8020) | TVPH (gas) 8015mod | TEPH (diesel) 8015 mod | Napthalene (8270) | PAHs (610)

Nitrate | Glycols | RCRA Metals F N/F | VOC (8260) | Semi-Volatiles (8270)

General Water Chemistry (cations plus manganese, anions, chloride, sulfate, bicarbonate, and total alkalinity)

pump on 15 30

Well Development / Purge Form

Project	Martin Marietta Spring GW Sampling	Total Depth		Depth. Ind. S/N	
Project No.		Depth to Water	10.17 from TOC	Weather	
Location	Parkdale Quarry	Water Column (ft. h.)	
Date	5/13/2019	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)	
Well Number	MW-10	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)	
Method	pumping	Total Gallons Removed	
Field Personnel	Morgan Farmer, Zeek Walter	Sample Number & Time	

Time	Duration (Minutes) Surge	Pump	Bail	Volume (gallons)	Temp (°C)	DO (mg/L)	Spec Cond. ms/cm	pH	ORP/ REDOX (ReL. MV)	Turbidity (NTU)	Remarks
1532				2	13.13	15.21	.512	7.22	32	~~0~~	
1534				4	13.22	12.46	.509	7.05	36	~~N/A~~	
1536				6	13.28	10.43	.504	6.96	33	1000	1000 flashing
1538				8	12.94	9.53	.504	6.87	68	—	moved pump higher in well, very turbid water
1540				10	13.11	8.80	.504	6.81	87	—	
1542				12	13.16	8.10	.505	6.81	94	—	water starting to clear
1543				14	13.20	7.94	.502	6.79	100		

Sample Analytes: BTEX, Napthalene (8020), TVPH (gas) 8015mod, TEPH (diesel) 8015 mod, Napthalene (8270), PAHs (610)
Nitrate, Glycols, RCRA Metals F N/F, VOC (8260), Semi-Volatiles (8270)
General Water Chemistry (cations plus manganese, anions, chloride, sulfate, bicarbonate, and total alkalinity)

Page

Project MM

Location Parkdale

Purpose

Well Name Well 10

Sample ID SWL - 18.69

~~30~~

Date	Time	Temperature	pH	EC	DO	ORP	Notes
8/28		[unit] °C		[unit] mS/cm	[unit] mg/L	[unit] mV	
~~1828~~	Pump on						WL 16.81
~~19:32~~	18:32	13.50	6.81	.493	1.80	107	2.5 G
~~18:38~~	18:38	14.81	6.46	.601	2.32	80	5 G
8/28	18:43	14.24	6.28	.608	2.29	89	7.5 G
8/28	18:46	14.65	6.33	.607	2.31	44	10 G
8/28	18:49	14.73	6.46	.608	2.42	57	12.5 G
8/28	18:52	14.67	6.71	.609	2.59	60	15 G
8/28	18:54	14.66	6.50	.609	2.70	72	17.5 G
8/28	18:58	14.64	6.78	.611	3.60	65	20 G Multiprobe shut down and had to be turned on again
8/28	19:01	14.58	6.71	.613	3.38	78	22.5 G
8/28	19:03	14.59	6.94	.615	3.91	66	25 G
8/28	19:05	14.61	6.70	.617	4.19	72	27.5 G
8/28	19:09	14.66	6.93	.616	4.43	65	30 G
8/28	19:11	14.72	6.89	.616	4.67	64	32.5 G
8/28	19:14	14.71	6.91	.617	4.87	64	35. G *330 NTU*
	19:25	Pump Off					~43 gal total

Project MM

Well Name Well 3

Location Parkdale

Sample ID

Purpose 11:59 SDTW 49.19'

30 gal / well volume

Date	Time	Temperature	pH	EC	DO	ORP	Notes gal Total
		[unit] °C		[unit] mS/cm	[unit] mg/L	[unit] ORP mV	
8/28	12:43						DTW 46.86 after pump install
8/28	14:10	16.14°C	7.29	.445	2.68	-18	1 Gal
8/28	14:15	16.61	6.99	.434	1.70	2	5 Gallons
8/28	14:20	17.27	6.98	.416	1.2	25	10 Gal
8/28	14:33	17.18	7.24	.414	1.19	23	15 Gal (Time delay due to power surge on generator
8/28	14:37	17.17	7.19	.415	1.01	24	17.5 Gal
8/28	14:44	17.45	7.12	.412	.88	25	20 Gal
8/28	14:50	17.50	7.08	.412	.87	23	22.5 Gal
8/28	14:58	17.71	7.09	.412	.79	19	25 Gal
8/28	15:04	17.83	7.08	.412	.73	14	27.5 Gal
8/28	15:11	17.98	7.08	.410	.63	13	30 Gal
8/28	15:18	17.99	7.13	.411	1.18	9	32.5 gal 24.8 NTU ← collecting sample
	15:36	Pump		Off			5+ additional gal durring
	15:50	Transducer		back in			sampling

Project MW

Location Parkdale

Purpose Hydraulic Testing

Well Name Well 1

Sample ID None

Date	Time	Temperature	pH	EC	DO	ORP	Notes
		[unit]		[unit]	[unit]	[unit]	
8/29	12:51						Pump on
							Equipment underpowered; unable to complete pumping

YSI DSS Pro

5 g - 4.75
10 g - 901 20

2 of 2 pg

Well Development / Purge Form

Project	Park Dale Quarry	Total Depth	250
Project No.	0488586	Depth. Ind. S/N	2354 wx meter
Location	Cannon City, CO	Depth to Water	49.90
Date	11/19/19	Weather	60 Sunny
Well Number	Well-3	Water Column (ft. h.)	
Method		Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)	
Field Personnel	Nick Alfino Zack Walters	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)	
		Total Gallons Removed	
		Sample Number & Time	Well-3 960

Time	Duration (Minutes)			Volume (gallons)	Temp (°C)	DO (mg/L)	Spec Cond. (µs/ms)	pH	ORP/ REDOX (ReL. MV)	Turbidity (NTU)	Remarks
	Surge	Pump	Bail								
853		0		0	14.3	4.52	460	8.11	125.1	34.70	
856		3		3	15.5	0.52	479.5	7.64	60.0	26.70	
859		6		7	15.8	0.63	463.0	7.67	30.5	23.47	
902		9		10.5	15.9	0.74	458.8	7.65	27.0	22.68	
905		12		13.5	16.1	0.75	458.8	7.64	25.40	21.62	
908		15		16.5	16.1	0.74	458.0	7.64	29.1	17.43	
911		18		19.5	16.2	0.74	457.5	7.64	30.3	16.12	

Sample Analytes: BTEX, Napthalene (8020), TVPH (gas) 8015mod, TEPH (diesel) 8015 mod, Napthalene (8270), PAHs (610), Nitrate, Glycols, RCRA Metals F N/F, VOC (8260), Semi-Volatiles (8270)

15 g - 90640

General Water Chemistry (cations plus manganese, anions, chloride, sulfate, bicarbonate, and total alkalinity)

2 of 2 pg

20g	912.15
25g	919.00
30g	923.45
35g	931.0
40g	938 20
45	946 20

Well Development / Purge Form

Project	~~BNSF/RSI - 48th and Holly GW~~ Parkdale Quarry	Total Depth	250
Project No.	~~0396407~~ 0488586	Depth to Water (DTW)	49.90
Location	~~Commerce City, CO~~	Water Column (ft. h.)	
Date	11/19/19	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)	3 vols =
Well Number	Well - 3	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)	
Method		Total Gallons Removed	
Field Personnel	Nize Alfonso Zach Walker	Sample Number & Time	Well - 3 950
Setup time:		Depth Ind. S/N	2354
		Weather	

Time	Duration (Minutes) Surge	Pump	Bail	Volume (gallons)	Temp (°C)	DO (mg/L)	Spec. Cond. (µs/ms)	pH	ORP/ REDOX (ReL.	Turbidity (NTU)	DTW (ft btoc)	Remarks
914		21		21.5	16.3	0.74	457.4	7.64	31.7	14.56		
917		24		29.5	16.3	0.74	457.4	7.64	30.6	15.34		Increase Pump rate
920		27		26.0	16.4	0.75	457.4	7.64	29.3	13.38		
923		30		28.0	16.5	0.75	457.3	7.64	29.1	15.24		
925		33		29.5	16.7	0.76	458.6	7.64	27.3	13.38		
928		36		32.5	16.67	0.83	459.6	7.63	29.7	10.33		
931		39		35.0	16.8	0.97	462.1	7.62	32.3	12.16		
934		42		37.5	16.9	1.13	466.5	7.60	32.9	11.32		
937		45		39.0	17.0	1.14	467.0	7.59	35.1	11.92		
940		48		41.5	17.1	1.09	466.1	7.59	34.0	12.30		
943		51		43.0	17.1	1.04	464.1	7.60	34.2	13.60		
946		54		45.0	17.2	0.96	462.1	7.61	32.3	15.03		
949		57		47.0	17.3	0.90	461.2	7.62	30.5	10.2		
950				50	Sample		950					

Sample Analytes: VOCs - Site Specific (8260B)
Dissolved Fe (200.7) (field filtered)

Notes: Pump off @ 10:03

Well Development / Purge Form

Pg 1 of 2

Project	~~BNSF/RSI - 48th and Holly GW~~ Parkdale Quarry	Total Depth	250' ~~4.28~~
Project No.	~~0396407~~ 04885866	Depth Ind. S/N	NA 2354
Location	~~Commerce City~~, Canon City, CO	Depth to Water (DTW)	14.28
Date	11/19/19	Weather	
Well Number	Well - 10	Water Column (ft. h.)	
Method		Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)	3 vols =
Field Personnel	Nick Akins Zack Walter	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)	
Setup time:		Total Gallons Removed	
		Sample Number & Time	Well-10 1255

Time	Duration (Minutes) Surge	Pump	Bail	Volume (gallons)	Temp (°C)	DO (mg/L)	Spec. Cond. (µs/ms)	pH	ORP/ REDOX (ReL.	Turbidity (NTU)	DTW (ft btoc)	Remarks
1203		0		0	13.9	5.85	725	7.38	155.7	841.2		
1206		3		4	14.2	4.17	720	6.96	122.3	763.4		
1209		6		7	14.2	4.15	721	6.93	117.3	597.4		
12:12		9		10.5	14.2	4.21	720	6.92	114.5	387.6		
1215		12		13.5	14.2	4.27	722	6.90	112.2	295.6		
1218		15		16	14.2	4.43	722	6.89	111.6	286.5		
1221		18		18.5	14.2	4.56	723	6.89	111.3	212.4		
1224		21		21	14.3	4.84	725	6.89	111.1	195.6		
1227		24		23.5	14.2	5.04	726	6.88	112.6	141.9		
1230		27		26	14.2	5.08	724	6.88	113.5	125.2		
1233		30		29	14.2	4.98	721	6.89	109.0	115.4		
1236		33		31.5	14.2	5.00	722	6.88	104.1	111.7		
1239		36		34	14.2	5.16	724	6.89	100.9	120.2		
1242		39		36.5	14.3	5.33	727	6.89	99.7	78.4		

Sample Analytes: VOCs - Site Specific (8260B)
Dissolved Fe (200.7) (field filtered)

Notes:

5 gal - 1207 10
10 gal - 1212 00
15 gal 1217 15
20 gal 1223 00
25 gal - 1228.30
30 gal - 1234.00
35 gal 1240.00

Well Development / Purge Form

Project	~~BNSF/RSI - 48th and Holly GW~~ Parkdale Quarry	Total Depth	250	Depth Ind. S/N	2354
Project No.	~~0396407~~ 04885	Depth to Water (DTW)	14.28	Weather	
Location	~~Commerce City, CO~~ Canon city CO	Water Column (ft. h.)			
Date	11/12/19	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)		3 vols =	
Well Number	Well-10	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)			
Method		Total Gallons Removed			
Field Personnel	Nick Alfono Zach Walker	Sample Number & Time	Well-10 1255		
Setup time:					

Time	Duration (Minutes)			Volume (gallons)	Temp (°C)	DO (mg/L)	Spec. Cond. (µs/ms)	pH	ORP/ REDOX (ReL.	Turbidity (NTU)	DTW (ft btoc)	Remarks
	Surge	Pump	Bail									
1245		42		39	14.3	5.54	728	6.89	99.1	20.8		
1248		45		42.0	14.3	5.72	731	6.89	99.5	47.1		
1251		48		44.5	14.3	5.83	733	6.89	96.2	36.4		
1254		51		47.5	14.3	5.91	735	6.89	98.9	28.5		
1255				50		Collect	Sample					

NA 2

Sample Analytes: VOCs - Site Specific (8260B)
Dissolved Fe (200.7) (field filtered)

1302 pump off

40 gal - 1245 45
50 gal - 1251 30

Notes:

Well Development / Purge Form

Project	M M Parkdale Quarry	Total Depth		Depth. Ind. S/N	
Project No.	0488596	Depth to Water	49.35'	Weather	50 Sunny
Location	Parkdale CO	Water Column (ft. h.)			
Date	2-26-20	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)			
Well Number	Well-3	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)			
Method		Total Gallons Removed			
Field Personnel	Nick Claire	Sample Number & Time			

Time	Duration (Minutes)			Volume (gallons)	Temp (°C)	DO (mg/L)	Spec Cond. (µs/ms)	pH	ORP/ REDOX (ReL. MV)	Turbidity (NTU)	Remarks
	Surge	Pump	Bail								
11:07 ~~11:04~~		0		0							Start Pumping
11:11				5	15.7	3.3	.501	7.38	148.0		250 mL = 4 sec
11:16					16.1	1.79	.482	7.50	127.9		reduced flow
11:18											Stop pumping
											83.1 dtw @ 14:59

Sample Analytes: BTEX Napthalene (8020) TVPH (gas) 8015mod TEPH (diesel) 8015 mod Napthalene (8270) PAHs (610)

Nitrate Glycols RCRA Metals F N/F VOC (8260) Semi-Volatiles (8270)

General Water Chemistry (cations plus manganese, anions, chloride, sulfate, bicarbonate, and total alkalinity)

Well Development / Purge Form

Project	MM Parkdale QuaRRY	Total Depth		Depth. Ind. S/N	
Project No.	0488596	Depth to Water	52.6	Weather	50°F Sunny
Location	Parkdale CO	Water Column (ft. h.)			
Date	2/26/20	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)			
Well Number	Well-3	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)			
Method		Total Gallons Removed			
Field Personnel	Nick Alfino & Claire O'Donnell	Sample Number & Time			

Time	Duration (Minutes) Surge	Pump	Bail	Volume (gallons)	Temp (°C)	DO (mg/L)	Spec Cond. (µs/ms)	pH	ORP/ REDOX (ReL. MV)	Turbidity (NTU)	Remarks
12:17		0		0	—	—	—	—	—	—	
12:21				5	15.5	0.33	.475	7.65	-85.1		water level at 72.65 at 12:24
12:27				9	16.1	.38	.455	7.59	-25.2		250 mL = 7 sec; 10 gallons @ 12:28; water level 77.15 ft
12:32				13	16.5	0.40	.450	7.59	-7.7		250 mL = 6 sec; water level 81.29 ft
12:37				16	16.5	0.48	.451	7.58	6.2		250 mL = 6 sec; 15 gallons @ 12:35; water level = 87.00 ft
12:42				19	16.7	0.53	.450	7.58	14.8		250 mL = 8 sec; 20 gallons @ 12:45; water level = 91.82 ft
12:47				21	16.8	0.53	.450	7.58	17.0		250 mL = 9.5 sec; water level = 94.92

Sample Analytes: BTEX Napthalene (8020) TVPH (gas) 8015mod TEPH (diesel) 8015 mod Napthalene (8270) PAHs (610)

Nitrate Glycols RCRA Metals F N/F VOC (8260) Semi-Volatiles (8270)

General Water Chemistry (cations plus manganese, anions, chloride, sulfate, bicarbonate, and total alkalinity)

Well Development / Purge Form

Project	MM Parkdale Quarry	Total Depth	
		Depth. Ind. S/N	
Project No.	0488596	Depth to Water	
		Weather	
Location	Parkdale CO	Water Column (ft. h.)	
Date	2/26/20	Casing Volume (gal) (2″ = 0.16h, 4″ = 0.66h)	
Well Number	Well 3	Borehole Volume (gal) (2″ = 0.73h, 4″ = 1.15h)	
Method		Total Gallons Removed	
Field Personnel	Nick Alfino & Claire	Sample Number & Time	

Time	Duration (Minutes)			Volume (gallons)	Temp (°C)	DO (mg/L)	Spec Cond. (µs/ms)	pH	ORP/ REDOX (ReL. MV)	Turbidity (NTU)	Remarks
	Surge	Pump	Bail								
12:52				24	16.9	0.51	0.449	7.58	18.3		250 mL = 9.5 sec water level: 95.67
12:57				25.5	17.4	.48	.449	7.59	17.7		250 mL = 6 seconds @ 12:54 increased rate 25 gallons @ 12:56 250 mL = 16 seconds dtw = 98 ft
~~13:02~~											12:59 pump down 13:09 pump on & set back to original setting
13:14				29	17.6	.51	0.451	7.61	1.9		waterlevel 87.17 @ 13:12 250 ml = 7 sec waterlevel 90.08 @ 13:14
13:19				33	17.2	.49	0.454	7.60	11.4		250 mL = 9.5 sec 30 gallons @ 13:18 dtw = 94.8 ft
13:24				34	17.1	.43	0.449	7.61	17.5		250 mL = 10.5 sec. dtw = 96.4 ft
13:29				35	17	.44	.447	7.61	20.5		250 mL = 12 sec dtw = 97.5 ft

Sample Analytes: BTEX Napthalene (8020) TVPH (gas) 8015mod TEPH (diesel) 8015 mod Napthalene (8270) PAHs (610)

Nitrate Glycols RCRA Metals F N/F VOC (8260) Semi-Volatiles (8270)

General Water Chemistry (cations plus manganese, anions, chloride, sulfate, bicarbonate, and total alkalinity)

Well Development / Purge Form

Project	MM Parkdale Quarry	Total Depth		Depth. Ind. S/N	
Project No.	0488596	Depth to Water		Weather	
Location	Parkdale CO	Water Column (ft. h.)			
Date	2/26/20	Casing Volume (gal) (2" = 0.16h, 4" = 0.66h)			
Well Number	Well 3	Borehole Volume (gal) (2" = 0.73h, 4" = 1.15h)			
Method		Total Gallons Removed			
Field Personnel	Nick Alfino & Claire O'Donnell	Sample Number & Time			

Time	Duration (Minutes)			Volume (gallons)	Temp (°C)	DO (mg/L)	Spec Cond. (µs/ms)	pH	ORP/ REDOX (ReL. MV)	Turbidity (NTU)	Remarks
	Surge	Pump	Bail								
13:34				38	17.0	.48	.447	7.61	23.6		dtw= 98.4 ft 250mL = 12 sec
13:39				39	17.0	.52	.448	7.61	26.1		dtw= 99.42 40gall @ 13:43 250mL = 12 sec
13:44				41	17.0	.55	.448	7.61	30.5		dtw =100.42 250 mL = 12 sec
13:49				43	16.9	.57	.448	7.61	33		dtw = 100.9 250 mL = 12 sec
13:54				44	17.1	.59	.448	7.61	36		dtw = 101.27 45gal@ 13:57 250 mL = 12 sec
13:59				46	17.1	.62	.448	7.61	38.3		dtw = 101.5 250 mL = 12 sec
14:04				47	17.1	.65	.449	7.61	41.3		dtw = 102 250mL = 13 sec

Sample Analytes: BTEX Napthalene (8020) TVPH (gas) 8015mod TEPH (diesel) 8015 mod Napthalene (8270) PAHs (610)

Nitrate Glycols RCRA Metals F N/F VOC (8260) Semi-Volatiles (8270)

General Water Chemistry (cations plus manganese, anions, chloride, sulfate, bicarbonate, and total alkalinity)

Well Development / Purge Form

Project	MM Parkdale Quarry	Total Depth	
		Depth. Ind. S/N	
Project No.	0488596	Depth to Water	
		Weather	
Location	Parkdale CO	Water Column (ft. h.)	
Date	2/26/20	Casing Volume (gal) (2″ = 0.16h, 4″ = 0.66h)	
Well Number	Well 3	Borehole Volume (gal) (2″ = 0.73h, 4″ = 1.15h)	
Method		Total Gallons Removed	
Field Personnel	Nick Alfino & Claire O'Donnell	Sample Number & Time	

Time	Duration (Minutes) Surge	Pump	Bail	Volume (gallons)	Temp (°C)	DO (mg/L)	Spec Cond. (µs/ms)	pH	ORP/ REDOX (ReL. MV)	Turbidity (NTU)	Remarks
14:08				49	17	.67	.449	7.62	43.7		dtw = 102.45 250 mL = 13 sec
14:12				50	16.9	.66	.448	7.62	44.6		dtw = -102.45. 250 mL =
											pump off at 14:29 on In Situ DTW 102.45 14:30 actual
											DTW 90.00 2:42 pm DTW 88.00 2:45 PM
											Pull pump

Sample Analytes: BTEX Napthalene (8020) TVPH (gas) 8015mod TEPH (diesel) 8015 mod Napthalene (8270) PAHs (610)

Nitrate Glycols RCRA Metals F N/F VOC (8260) Semi-Volatiles (8270)

General Water Chemistry (cations plus manganese, anions, chloride, sulfate, bicarbonate, and total alkalinity)