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Reclamation Plan

Reclamation of MGP Enterprise A-4 Well Pad
Trinidad, CO
Project #32820182

Prepared for:

BP Remediation Management Services Company
201 Helios Way, Houston, TX 77079

4/8/2021

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4/8/2021

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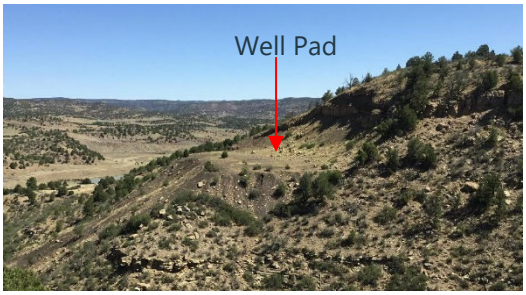
Attachment

Attachment A: Site Visit Technical Memorandum
Attachment B: Geotechnical Data Report
Attachment C: Grading Plans
Attachment D: Hydraulics Report
Attachment E: Stability Analysis
Attachment F: Soil Sample Results and Fertilizer Recommendations

1.0 Introduction

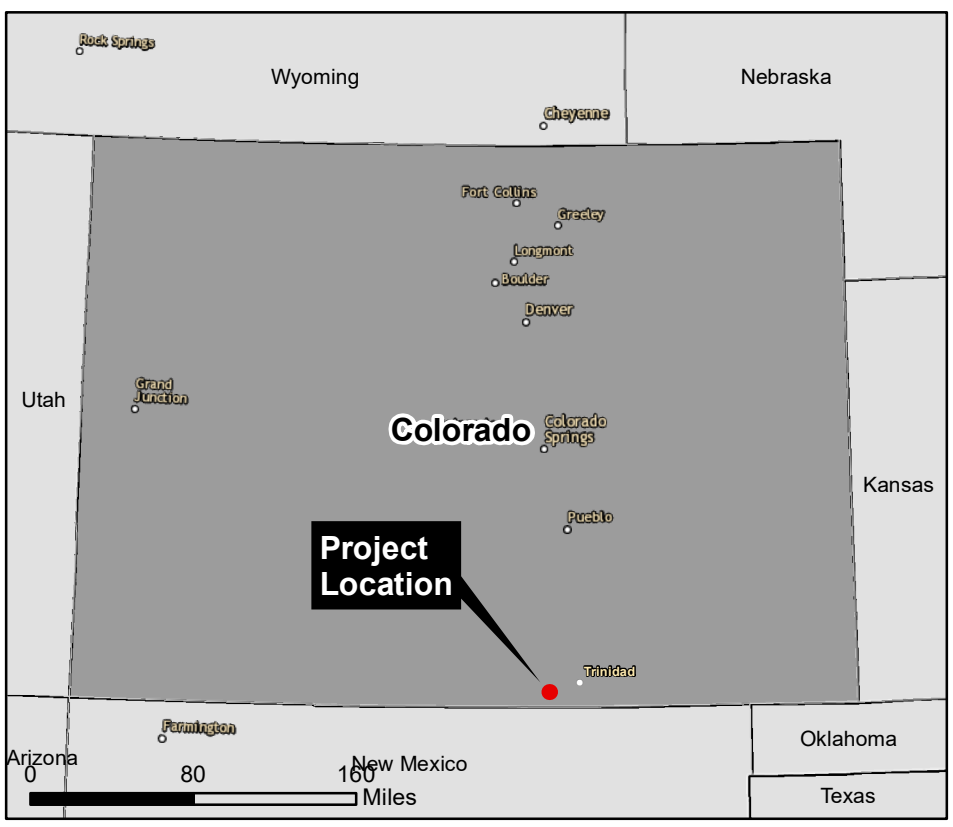
This reclamation plan was developed to address concerns of the Colorado Oil and Gas Conservation Commission (COGCC) regarding the MGP A4 Enterprises (MGP A4) drill pad located in Las Animas County. The MGP A4 drill pad and well were completed in November 1985, with the well closed in 1993. The MGP A4 well pad is located approximately 20 miles west of Trinidad, Colorado in Las Animas County on the privately owned Hall Ranch. Access to the site is via Colorado State Highway 12 to the private Hall Ranch Road to the drill pad access road. The drill pad access road splits from the Hall Ranch Road and is approximately 0.4 miles from the split to the north side of the drill pad. The well pad occupies an approximately one-acre area along the western portion of an undeveloped mountainside. The location of the project is shown on Figure 1.

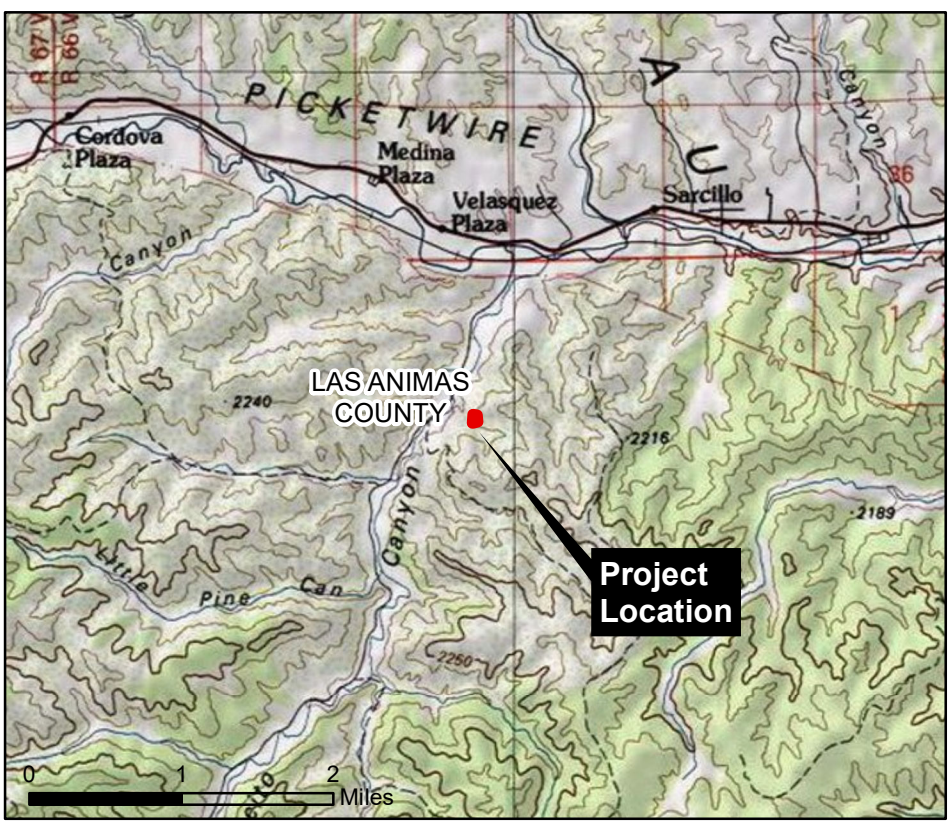


View of the well pad cut into the hillside.

British Petroleum (BP) acquired the well through the acquisition of Amoco Production Company in 1998. As of the acquisition by BP, reclamation of the site has not been completed. The COGCC conducted inspections of the well pad in April and July of 2019 with the inspection reports providing recommendations and requirements for reclamation of the site. COGCC issued a Sundry Notice on December 19, 2019 providing an extension for the completion of the reclamation of the MGP A4 pad.

The reclamation plan provides details on grading the slope, hydrology and erosion controls, and revegetation to successfully reclaim the drill pad and slope. This plan is being submitted to the COGCC for approval prior to the initiation of construction.





0 0.0375 0.075 0.15 Miles

Job No.:	32820182
PM:	RW
Date:	4/14/2021
Scale:	1:2,500

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MGP Enterprise A-4 Reclamation Project
BP
Las Animas County, Colorado

FIGURE 1

Project Overview Map

wood.

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1.1 Purpose of the Reclamation Plan

The MGP Enterprise A-4 well pad has been inactive since 1993. In July of 2019, a site inspection was conducted by the State of Colorado Oil and Gas Conservation Commission (COGCC). During this time, the COGCC established restoration requirements for the site; these included:

1. Regrading the access road;
2. Removal of the cross culvert;
3. Regrading of the well pad to a stable slope;
4. Revegetation of at least 80 percent to pre-disturbance levels;
5. Implement scour countermeasures along the access road where erosion issues have been observed; and
6. Implement erosion control measures to stabilize the seeded soils.

This Reclamation Plan addresses how each component listed above is being completed on the site. Additional technical details will be attached as appendices.

2.0 Environmental Setting

2.1 Climate

Weather data reported by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS 2009) for the nearby City of Trinidad provide a basis for characterizing the climate at the project site. Trinidad is generally characterized by warm summers from June to September and cold, dry, and windy winters between November and February, with mostly clear weather year-round.

The average summer temperature is 70 degrees Fahrenheit (°F) with an average daily maximum temperature of 85°F; the highest recorded temperature of 101°F occurred on June 26, 1994. During winter, the average temperature is 35°F and the average daily minimum temperature is 21°F. The lowest recorded temperature reached -32°F on January 12, 1963.

The average annual total precipitation is 16.1 inches with approximately 64 percent (10.3 inches) as rainfall occurring during the rainy period, which historically is between May and September. The highest recorded single day record for rainfall was 4.2 inches on August 11, 1981. The average seasonal snowfall is 45 inches. On an average, 21 days per year have at least 1 inch of snow cover. The greatest one-day snowfall on record was 14 inches recorded on March 11, 1977.

2.2 Vegetation

Vegetation communities were defined using Southwest Regional Gap Analysis Project (SWReGAP) community descriptions. SWReGAP communities were developed by the USGS and collaborative efforts of state institutions to describe landcover characteristics throughout the southwestern United States. SWReGAP information provides detail on site characteristics, plant communities, management alternatives, and supporting resource information such as broad scale vegetation types (Lowry et al. 2005). The SWReGAP data describes the majority of the well pad area as Southern Rocky Mountain Pinyon-Juniper Woodland with small adjacent areas of Rocky Mountain Ponderosa Pine Woodland and Rocky Mountain Gamble Oak-Mixed Montane Shrubland. These communities are typical of dry sites on mountain slopes, mesas, plateaus, and ridges (SWReGAP 2004).

Vegetation found within the Southern Rocky Mountain Pinyon-Juniper Woodland is typically dominated by Rocky Mountain pinyon (*Pinus edulis*) or oneseed juniper (*Juniperus monosperma*) with an understory of Gamble oak (*Quercus gambelii)*, Arizona fescue (*Festuca arizonica*), and blue grama (*Bouteloua gracilis).*

Vegetation within the Rocky Mountain Ponderosa Pine Woodland is similar to the Rocky Mountain Pinyon-Juniper Woodland with a dominance of Ponderosa pine (*Pinus ponderosa)*. This system typically has soils with better aeration and drainage, an abundance of mineral materials, and periods of drought but typically receive more moisture than the Pinyon-Juniper Woodland.

Vegetation within the Rocky Mountain Gambel Oak-Mixed Montane Shrubland is typically situated above pinyon-juniper woodlands and dominated by Gambel oak or other shrubs such as alderleaf mountain mahogany (*Cercocarpus montanus*), and antelope bitterbush (*Purshia tridentata*).

2.3 Soils

Based on the NRCS Web Soil Survey data, there are two mapped soil types associated with the well pad area (Table 1. Soil Map Units in the Well Pad Revegetation Area). The Saruche-Rombo-Rock outcrop complex, 25 to 50 percent slopes is the dominant soil type (NRCS 2021). This soil along with the Molinaro Loam type are not classified as hydric nor prime farmland (NRCS 2021). These soils naturally have a low water capacity, and a low organic content.

Table 1. Soil Map Units in the Well Pad Revegetation Area

Map Unit Symbol	Map Unit Name	Percent of Revegetation Area	Runoff Class	Drainage Class	Farmland Classification
SR	Saruche-Rombo-Rock outcrop complex, 25 to 50 percent slopes	98	Very high	Well drained	Not prime farmland
Sw	Molinaro loam, 2 to 12 percent slopes	1	Medium	Well drained	Not prime farmland

(NRCS 2021)

2.4 Geology

The Well Pad is located in the Raton Mesa region of south-central Colorado, in an area characterized by flat-topped mesa with steep slopes and separated by deep canyon formations. The Raton Basin is an Upper Cretaceous and Tertiary sedimentary basin with structural formations of rock created by tectonic warping of a previously flat-lying strata. The New Mexico Geological Society (NMGS, 1969) reports that the rocks are comprised of stratigraphic successions (in ascending order) of Pierre Shale, Trinidad Sandstone, Vermejo Formation, and the Raton Formation.

The Well Pad is situated on the Raton Formation, which crops out over most of the Raton Mesa region, with a maximum thickness of 1,700 feet (NMGS, 1969). This formation is comprised of yellow-white (buff), gray, and olive-gray, very fine- to coarse-grained arkose, graywacke, and quartzose sandstone beds; gray to dark gray siltstone and silty shale beds, and numerous coal beds (NMGS 1969).

2.5 Seismicity

The project site is located in an active tectonic province in southern Colorado that is largely influenced by tectonic influences associated with the Rio Grande Rift, which cut north/south across the mountainous, central part of the state. The rift system has contributed to the seismic activity and uplift along faults that

have formed Colorado's high mountainous landscape, which contains over 90 potentially active faults and more than 700 recorded earthquakes of magnitude 2.5 or higher since 1867 (CGS 2013).

The nearest Holocene age fault is the Northern Sangre de Cristo fault which runs along the western foothills of the Sangre De Cristo Mountains approximately 20 miles to the west of the project site. The Northern Sangre de Cristo fault is the boundary between the Sangre de Cristo uplift and the San Luis Basin of the Rio Grande rift. The maximum credible earthquake (MCE) associated with this fault is 7.4 (Widmann et al. 2002). A 5.3 magnitude earthquake, the largest earthquake in Colorado in a half-century, had an epicenter located approximately 5 miles southeast of the project site. The earthquake occurred in a sparsely populated area, but the event caused significant damage to numerous buildings in the City of Trinidad (CGS, 2011). Historically, the Trinidad area of Southern Colorado has a long record of earthquake events ranging from magnitude 3.2 to 4.5 spanning the years between 1973 and 1996 (Kirkham et al. 2012).

Based on the subsurface conditions encountered at Wood's exploration locations, review of laboratory test results, interpretation of soil conditions, and procedures outlined in Chapter 20 of American Society of Civil Engineers (ASCE 2017) Section 7-10, the site is classified as Site Class C, which consists of a "stiff soil profile". On this basis, the mapped and design spectral response accelerations were determined using the Applied Technology Council (ATC) Seismic Design Maps, with hazard loads provided by the U.S. Geological Survey Seismic Design Web Services, in conjunction with the site class and the site coordinates (37.104906° N, -104.780112° W). The resulting peak ground acceleration (PGA) associated with the MCE is 0.124 gravity (g).

3.0 Existing Site Conditions

3.1 Site Reconnaissance

On July 9, 2020, Wood visited the site to conduct visual observations of the well pad. Wood's assessment of the site conditions, including photographs, are documented in the Technical Memorandum dated August 5, 2020 and is presented in Attachment A.

A subsequent aerial survey was performed by Wood on August 13, 2020 to obtain aerial images and topographic data. The aerial survey was conducted using an unmanned aerial vehicle (UAV) capable of surveying and producing photogrammetry models accurate to within 1/10 a foot. The topographic data obtained during the aerial survey was utilized to prepare the reclamation grading plan and provide a basis for hydrological and slope stability analyses.

The geotechnical investigation was performed on February 10, 2021. The full Geotechnical Report is provided in Attachment B. Soil sampling was completed as a component of both the revegetation plan and the geotechnical investigation. These soil results are described in detail below.

3.2 Vegetation and Topography

The existing well pad was constructed by cutting into the existing hillslope with the cut material being deposited on the downslope side of the cut. The elevation at the site ranges from 6,700 ft to 6,900 ft above sea level. The cut and fill construction of the well pad resulted in approximately 10 to 20 feet of fill placed over the natural slope downgradient of the well pad.

Minimal vegetation has established on the pad and fill slope since the well pad was constructed. Small patches of grasses and herbaceous vegetation have established on the site along with a few juniper and gamble oak shrubs. The areas adjacent to the disturbed well pad and slope matches the existing vegetation communities in Section 2.4.

3.3 Well Head

The location of the abandoned well head was identified during the geotechnical investigation performed on February 10, 2021. The geotechnical investigation included subsurface explorations consisting of a geophysical survey to detect ferrous and non-ferrous metals below ground and test pit excavations to uncover the characteristics of the well pad fill materials. The location of the well head is shown on the grading plans in Attachment C.

After a metallic anomaly was identified during the geophysical survey, a test pit excavation was performed, and the top of the well head was visually identified approximately 8 feet below ground surface (ft-bgs) at the western edge of the well pad. The top of the wellhead appeared as a steel pipe that measured roughly 18 inches in diameter. Before exposing the top of the well head during excavation, sparse debris consisting of wood and cylindrical shaped concrete fragments were encountered.

4.0 Hydraulic Analysis

Wood performed hydraulic analyses to evaluate existing erosion along the access road, including areas of localized bend scour and a proposed culvert removal. Wood also performed hydraulic analyses to verify the proposed slope rehabilitation over the existing well pad could withstand the runoff resulting from a 100-year storm event.

For the access road analyses, Wood developed a two-dimensional model using SRH-2D. Model results were used to design riprap countermeasures to mitigate the existing scour and reduce the likelihood of future erosion along the roadway and at the culvert removal. To simplify the construction, the same 9-inch riprap was specified at both the roadway scour and culvert removal locations.

A biodegradable (coconut fiber) erosion control blanket was specified to stabilize seeded soils at the culvert removal location and over the proposed slope rehabilitation. Design flow velocities and bed shear stresses were evaluated over the proposed slope for both the unvegetated blanket and the eventual revegetated slope. For both scenarios, the proposed slope rehabilitation is expected to withstand runoff flows during the 100-year event. The erosion control design is summarized below in Table 2. The full Hydraulic Analysis Report is found in Attachment D.

Table 2. Erosion Control Design Summary

Location	Erosion Potential	Countermeasure
Access Road Bend	Bend Scour	9-inch riprap laid 13.5 inches thick
Culvert Removal	Culvert Outlet Scour	5-ft Riprap Apron 9-inch riprap laid 22 inches thick Erosion control blanket and revegetation downstream of riprap
Rehabilitated Slope over Well Pad	Embankment Erosion	Erosion control blanket and revegetation

5.0 Geotechnical Analysis

Test pit logs, photos, and locations of the excavated test pits are presented in the Wood Geotechnical Data Report in Attachment B of this report.

5.1 Subsurface Exploration

The test pits were strategically located across the surface of the well pad to provide a wide spatial distribution of subsurface conditions and delineate the depth to bedrock. The test pits were excavated by USA Environment, LP (USA Environment) on February 10, 2021. Wood's field engineer was present during the test pit excavation activities to coordinate, supervise, and record geotechnical data. A total of eleven (11) test pits, designated as TP-1 through TP-11, were excavated to depths ranging between approximately 3 to 7 ft-bgs. Test pit excavations were terminated due to encountering excavator refusal conditions. Each test pit was logged and photographed in the field.

5.2 Laboratory Testing

Select soil samples recovered from the test pit excavations were transported to Wood's subconsultant Advanced Terra Testing, Inc. (ATT) in Lakewood, Colorado to further classify and evaluate the material properties of the soils. Laboratory tests were performed in accordance with ASTM International (ASTM) test procedures. A summary of completed laboratory tests are summarized below in accordance with ASTM test procedures.

- Moisture content (ASTM D2216)
- Grain size analyses (ASTM D6913)
- Atterberg limits (ASTM D4318)
- Direct Shear (ASTM D3080)
- Standard Proctor moisture-density relationship (ASTM D698)

5.3 Subsurface Conditions

Based on the subsurface conditions encountered at test pit locations and Wood's understanding of the geological conditions at the project site, the fill materials comprising the well pad consists of native soils derived from the Raton Formation rocks, which consists primarily of clayey sand or clayey gravel with cobbles and boulders. Soils recovered from the test pit excavations typically classify as clayey sand (SC) and clayey gravel (GC) according to the Unified Soil Classification System (USCS) with fine to coarse angular cobble and boulder sized sandstone rock fragments up to 5 feet in diameter.

The thickness of the fill generally tapered to meet the edge of the natural slope on the east and west ends with a maximum thickness ranging from approximately 10 to 17 feet along the northern and southern edge of the Well Pad, respectively. Shallow perennial roots typically contributed small amounts of organic matter within the upper 6 to 12 inches of the soil profile. No groundwater was encountered within the test pits to the maximum depth investigated (17 feet) at the top of bedrock. The apparent firmness and absence of depressions (typically associated with loose/uncompacted underlying soils) along the well pad surface indicate the fill was likely placed in a controlled manner with some degree of compactive effort.

A general subsurface profile that is representative of the conditions encountered within test pit excavations is presented below in Table 3.

Table 3. General Subsurface Profile

Stratum	Material Description (USCS Classification)	Depth to Bottom of Stratum (ft)
Fill	clayey sand and gravel (SC/GC) with cobbles and boulders	1 to 17
Bedrock	weathered sandstone bedrock	17 and greater

6.0 Grading Design Criteria and Basis

6.1 Design Goal

The long-term objective of reclamation is to set the course for eventual ecosystem restoration, including the restoration of the natural vegetation community, hydrology, and wildlife habitats. The reclamation process involves re-contouring of all disturbed surface areas to match or blend with the original landform. To meet long term objectives and develop a self-sustaining landscape, the reclamation design will consist of the following:

- reusing existing fill soil materials
- restoring grade and drainage, to the extent possible
- revegetation
- erosion control and site stability
- control of noxious weeds

6.2 Grading Design Criteria

The major design criteria for the Well Pad reclamation plan are summarized as follows:

Well Pad Fill:

- A cut and fill balance will be achieved by using only existing well pad fill materials.
- The cobble and boulder sized particles comprising the fill were conservatively neglected for stability analyses. However, it should be noted that these oversized materials typically increase the shear resistance of the fill.
- The fill is assumed to be homogenous with uniform material and strength properties for stability analyses.

Well Pad Geometry:

- The final grades will match the natural slopes, to the extent possible.
- A minimum slope of 2.0H:1V (horizontal:vertical) will be maintained to ensure slope stability and proper function of geotextile materials used for erosion protection.
- Cut excavations will not be made at the location of the abandoned well head, to the extent possible.

Well Pad Stability:

The criteria for minimum factors of safety (FS) for stability were adopted from the US Army Corps of Engineers (USACE) engineering and design guidelines provided in Engineering Manual (EM) 1110-2-1902 (USACE 2003) as follows:

- Minimum static loading factor of safety for end of construction stability is 1.3.
- Minimum static loading factor of safety for long-term stability is 1.3.
- Minimum seismic (pseudo-static) loading factor of safety is 1.0.
- Based on the ATC Seismic Design Maps, the PGA associated with the MCE is 0.124 gravity (g).
- A design seismic (pseudo-static) coefficient equal to 0.06, or ½ of the design seismic acceleration per Hynes-Griffin and Franklin (Hynes-Griffin & Franklin 1984).

7.0 Slope Stability Analyses

A slope stability analysis was performed on the critical slope of the grading plan. The purpose of the analysis was to determine the stability of the final slope grades based on Wood's interpretation of topographic data and the results of laboratory testing performed on representative samples of soil material from the Well Pad.

7.1 Modeling Methods

The slope stability analysis was performed utilizing Slide2, a computer-modeling program by Rocscience. Inc. (Rocscience, 2018). Slide2 is a computer software program that uses limit equilibrium theory to compute the factor of safety of earth slopes for either individual slip surfaces or application of search algorithms to calculate the critical failure surface (i.e., lowest deterministic factor of safety) for a given set of soil shear strength properties, geometry, and loading conditions. To find the potential critical slope failure, the "Optimize Surfaces" option was utilized in Slide to search for lower safety factor slip surfaces generated by a non-circular search based on an iterative Monte Carlo technique (Rocscience, 2020).

In accordance with USACE (2003) EM 1110-2-1902 guidelines, slope stability was evaluated using limit equilibrium methods based on Spencer's (Spencer 1967) method, which satisfies both moment and force equilibrium. The resulting stability FS considers the capacity of soils to resist shear stresses resulting from

gravity, seepage, and seismic forces acting on the soil profile. The FS is expressed in terms of the ratio of available shear strength divided by the equilibrium shear stress. Therefore, factors of safety in excess of 1.0 indicate stability and those less than 1.0 indicate instability.

7.2 Stability Criteria

The criteria for the minimum acceptable FS for slope stability, in accordance with USACE (2000) EM 1110-2-1913 guidelines, is presented in Table 4 below. However, a minimum FS for the pseudo-static (seismic) condition is not given by USACE. Therefore, Wood adopted a minimum pseudo-static FS of 1.0, which is a typical accepted industry standard for pseudo-static stability analyses.

Table 4. Slope Stability Requirements

Loading Condition	Applicable Stability Conditions and Minimum Factors of Safety	
	End of Construction	Long-Term Post Construction
Static	1.3	1.5
Pseudo-Static	1.0	1.0

A two-dimensional representation of the Well Pad critical cross section was analyzed to assess its compliance with the specified minimum acceptance criteria for stability.

7.3 Selection of Critical Cross Section

The subsurface conditions were generally consistent throughout the Well Pad. Therefore, the critical cross section evaluated for stability is representative of the Well Pad profile (Cross-Section D) with the greatest thickness of fill that is required to achieve final grades. The upper and lower slopes of Cross-Section D will require up to approximately 16 and 13 feet of fill, respectively. The location of Cross-Section D is shown on the Grading Plans presented in Attachment C. The modeled cross-section is illustrated with the stability analysis results in Attachment B.

7.4 Soil Engineering Parameters

Selected material properties used for slope stability analyses are based on Wood's interpretation of geotechnical data discussed in Attachment B. Samples were obtained from within the existing Well Pad fill for laboratory testing to determine the subsurface material and engineering properties. Where samples could not be obtained, assumed values were utilized. Based on visual observations, the existing fill appears to have been placed in a controlled manner with some degree of compactive effort. Therefore, the soil parameters adopted to model the existing Well Pad conditions are assumed to be similar to those used for final grades.

Moisture density relation curves, developed in accordance with standard Proctor (ASTM D698) tests, were performed on representative samples obtained from the Well Pad. The purpose of the relation curve is to determine the maximum density and optimum moisture content of fill material. The bulk unit weight of the modeled fill soil is based on the dry unit weight and moisture content for a specimen of fill compacted to 90 percent of its maximum dry density as determined by the standard Proctor test.

Remolded direct shear tests (ASTM D3080) were performed on representative samples of fill material. The purpose of this test was to determine the soil resistance to deformation (shear strength), interparticle

attraction (cohesion), and resistance to inter-particle slip (angle of internal friction). Angle of internal friction and cohesion values were utilized from laboratory test results.

As intact rock samples could not be obtained below the Well Pad fill, and excavator refusal conditions were during subsurface test pit explorations, the strength of bedrock was modeled with infinite strength where failure surfaces do not propagate beyond fill materials. The bulk unit weight is based on typical published values for sandstone bedrock.

The material properties used for slope stability modeling are summarized in Table 5 below. The stability models also consider that fill soil behaves as a Mohr-Coulomb material, cohesion of soils is conservatively neglected, the cobble and boulder sized particles comprising the fill were conservatively neglected, and fill is assumed to be homogenous with uniform material and strength properties.

Table 5. Summary of Modeled Material Properties

Material Type	Bulk Unit Weight (pcf)	Effective Stress	
		Friction Angle, Φ' (deg.)	Cohesion, c′ (psf)
Fill	123	36	0
Bedrock	140	n/a	n/a

7.5 Static Loading Conditions

The static stability analysis resulted in a range of values for factor of safety and their respective slip surfaces. The lowest factor of safety value corresponds to the critical slip surface. This critical slip surface does not necessarily result in the largest slip surface.

7.6 Seismic Loading Conditions

The seismic stability analyses were similar to the approach for static loading but utilized a pseudo-static approach. Pseudo-static analyses apply a horizontal body force on the soil mass to approximate equivalent seismic loading on earthfill structures. In an actual seismic event, the peak acceleration would be sustained for only a fraction of a second. Actual seismic time histories are characterized by multiple-frequency attenuating motions. The accelerations produced by seismic events rapidly reverse motion and generally tend to build to a peak acceleration that quickly decays to lesser accelerations. Consequently, the duration that a mass is actually subjected to a unidirectional, peak seismic acceleration is finite, rather than infinite.

The pseudo-static analyses conservatively model seismic events as constant acceleration and direction (i.e., an infinitely long pulse). Therefore, it is customary for geotechnical engineers to take only a fraction of the predicted peak maximum acceleration when modeling seismic events using pseudo-static analyses (Hynes-Griffin and Franklin, 1984). A PGA of 0.124g was adopted for the seismic analyses based on ATC Seismic Design Maps using the latest USGS seismic mapping. Wood utilized a design seismic (pseudo-static) coefficient equal to 0.06g, which is equivalent to half the PGA value.

7.7 Stability Analysis Results

The results of the slope stability analyses resulted in factors of safety exceed the minimum design criterion of 1.3 and 1.5 for end of construction and long-term stability, and the pseudo-static factors of safety are equal to or greater than 1.0 for all scenarios, thereby meeting the design criteria and indicating the final slopes reflect stable conditions for adopted stability criteria. A summary of the slope resultant FS for static

and seismic loading conditions is provided in Table 6. The individual Slide2 stability model outputs and cross section illustrations are included in Attachment E.

Table 6. Summary of Slope Stability Results

Cross Section	Location	Factor of Safety	
		Static Loading	Seismic Loading
Cross Section D	Upper Slope	1.65	1.41
	Lower Slope	1.53	1.31

8.0 Construction Considerations

The following sections discuss earthworks activities and materials for grading. Material take-off quantities are provided in the grading plans presented in Drawing No. 200 of Attachment C.

8.1 Removal of Existing Topsoil and Vegetation

Prior to performing earthwork in the areas of the Well Pad that are to be graded, excavated, or capped with fill material, any vegetation (including the entire root ball), organic topsoil, or debris should be disposed of and/or stockpiled at approved locations outside the construction limits in such a manner as to meet all requirements of State, county and municipal regulations regarding health, safety, and public welfare.

Deep stripping or grubbing will be required where concentrations of organic soils, tree roots, or debris are encountered. Based on the subsurface conditions encountered during test pit excavations, the anticipated thickness of topsoil will vary from 6 to 12 inches across the Well Pad. However, actual conditions in the field may vary. Stripped topsoil and vegetation may be stockpiled and reused to facilitate the growth of vegetation along the final surface grade; however, this material should not be incorporated into any fill used to achieve final grades. Fill should be as free of organic matter as possible since organic matter will decompose creating pockets of empty space within the fill which could result in excessive settling and/or instability.

Where topsoil is being stripped, construction activities should be suspended immediately if soils become excessively wet, or if other field conditions such as high winds may potentially degrade the quality of the existing topsoil. Until topsoil is used, it should be kept separate from fill materials and erosion controls should be implemented to protect the topsoil stockpile from wind and water erosion.

8.2 Abandoned Well Head

The abandoned well head identified during the geophysical utility survey will remain in place and no further cutting or capping will be performed. The grading plan cut and fill slopes were developed to ensure cut excavations will not be made at the location of the abandoned well head. Based on topographic data and approximate measurement identifying the depth to the top of the well head (8 feet), approximately 0.5 feet of fill should cover the well head during site grading. However, care should be taken to identify the location of the well head during earthwork activities to establish a perimeter sufficient to avoid or collisions with construction equipment and traffic.

8.3 Excavation and Grading

The anticipated excavations for the proposed construction will encounter soils that can be managed using conventional earthmoving equipment (e.g., excavators and dozers). The subgrade soil conditions should

be evaluated during the excavation process and the stability of the soils determined at that time by the earthwork contractors' Competent Person. At a minimum, all excavations should be performed in accordance with Occupational Safety and Health Administration (OSHA) 29 CFR, Part 1926, Subpart P, Excavations and in accordance with any applicable local, and/or state regulations. Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations.

The existing fill materials that comprise the Well Pad will be reused to achieve the final grades, which closely match the original contour and blend with the surrounding landform. Based on approximations resulting from test pit excavation data, Wood estimates a cut/fill balance of approximately 21,000 cubic yards (CY) during earthwork operations. The final grades will have slopes that range from 2.6H:1V to 2.8H:1V above the surface of the existing well pad with downgradient slopes ranging between 2.0H:1V to 2.2H:1V. The actual thickness of fill may vary between test pit excavations performed across the Well Pad. Therefore, adjustment based on actual field conditions may be required to achieve a cut and fill balance. Regardless, a minimum slope of 2.0H:1V will be maintained to ensure slope stability and proper function of geotextile materials used for erosion protection. The final grades should be verified to ensure conformance to the required site grading criteria.

8.4 Fill Placement

Prior to placing fill, the base of excavations should be scarified, moisture conditioned, and compacted to achieve a firm, unyielding surface. The fill placed to achieve the final slope grades should be placed and compacted in lifts not exceeding 12-inches in thickness (loose lift thickness). Given the uncertainties associated with measuring in-place density and degree of compaction with oversized particles (e.g., boulders, cobbles, and gravels greater than 1/4 inches in diameter) using conventional methods such as sand cone (ASTM D1556) or nuclear density (ASTM D6938) devices, consideration should be given to visual inspection alone to verify compaction achieves a firm, unyielding surface (USBR, 2006).

The required degree of compaction can be achieved with multiple passes of a large dozer over fill soils. Construction of a small test pad comprised of fill materials is recommended at the beginning of construction to establish the number of dozers passes, and moisture required to achieve proper compaction, which should be reexamined periodically during construction. The dimensions of the test pad should be long enough to allow the compaction equipment to operate at working speed and should be a minimum of three equipment widths wide. An "L" shape trench should be cut along the test pad to facilitate the inspection of the bottom of the lifts and materials for adequate compaction.

Compaction should not be performed on excessively wet or frozen ground and should not be allowed to freeze during moisture conditioning or prior to placing fill. All grades must provide positive drainage during and after construction. The site should be graded to prevent ponding of surface water during the placement of fill. Water collecting over or adjacent to construction areas should be removed.

If site preparation or grading is performed during the winter or spring season, or shortly after significant precipitation, near-surface site soils may be significantly over the optimum moisture content. This condition could impede construction as well as efforts to compact soils to specified levels of compaction. Unstable soils due to excessive moisture can be improved by scarification, mixing with dry soils, and/or other suitable methods. The applicable drying method will depend on the Contractor's capabilities as well as the severity of soil saturation. Therefore, if excessive soil moisture conditions are encountered during construction, the Geotechnical Engineer should review these conditions (as well as the contractor's capabilities) and, if appropriate, provide recommendations for their treatment.

9.0 Revegetation Plan

9.1 Purpose of the Revegetation Plan

The MGP Enterprise A-4 well pad and disturbed hillside has not been actively used in over 20 years. In that time small portions of the well pad have naturally revegetated. However, most of the pad remains sparsely vegetated. The purpose of the Revegetation Plan is to identify effective revegetation practices, identify native species to seed, and describe restoration methods that will restore the disturbed areas and aid in natural vegetation succession processes. The goal and implementation of the plan is to revegetate the well pad with native species (where feasible) that will not require irrigation, will stabilize the soils, and provide forage for wildlife.

9.2 Soil Samples & Results

9.2.1 Soil Samples

Soil samples were collected, and agronomic constituents were analyzed to assist in determining what soil amendments would be needed for successful revegetation of the well pad. Three composite soil samples were taken from a depth of 0-6 inches. One sample was taken from the existing pad, one from the slope area, and one from the drainage at the base of the road. The composite samples were thoroughly mixed. Soil samples were labeled with the sample area and delivered to the Midwest Laboratories testing lab. The lab tested each composite sample for organic matter, available phosphorus, exchangeable potassium, magnesium, calcium and hydrogen, soil pH, buffer index, cation exchange capacity, percent base saturation of cation elements, and carryover nitrogen as nitrate, soluble salts, sodium, excess lime, sulfur, zinc, manganese, iron, copper and boron.

9.2.2 Soil Results

Soils within the well pad are characterized as sandy clay loam and gravel (USDA classification). The soil test results of the well pad area, slope, and drainage indicated inadequate levels of nutrients (Table 7). Based on the soil test results and the purpose of revegetating dryland native grasses, soil amendments are recommended. For the area of the well pad samples (SS-1 PAD), it is recommended that 50 lbs/acre of nitrogen, 80 lbs/acre of P_2O_5 and 55 lbs/acre of K_2O acre added to the soil. For the soil on the slope areas, the laboratory recommends 35lbs/acre of nitrogen, 105 lbs/acre of P_2O_5 and 50 lbs/acre of K_2O. For the drainage area, the laboratory recommends 40lbs/acre of nitrogen, 90 lbs/acre of P_2O_5 and 45 lbs/acre of K_2O. Soil test result details and fertilizer recommendations are in Attachment F.

Table 7. Composite soil sample test results

LAB NUMBER *376*	SAMPLE IDENTIFICATION	ORGANIC MATTER L.O.I. percent	RATE	PHOSPHORUS P_1 (WEAK BRAY) 1:7 ppm	RATE	PHOSPHORUS P_2 (STRONG BRAY) 1:7 ppm	RATE	PHOSPHORUS OLSEN BICARBONATE P ppm	RATE	NEUTRAL AMMONIUM ACETATE (EXCHANGEABLE) POTASSIUM K ppm	RATE	MAGNESIUM Mg ppm	RATE	CALCIUM Ca ppm	RATE	SODIUM Na ppm	RATE	pH SOIL pH 1:1	BUFFER INDEX	CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED) % K	% Mg	% Ca	% H	% Na
09805	SS-1 PAD	3.6	H	5	VL	45	H	8	L	184	M	910	VH	2711	M	29		7.4		21.7	2.2	34.9	62.3	0.0	0.6
09806	SS-2 SLOPE	4.7	VH	2	VL	44	H			187	M	1116	VH	2596	M	23		7.0		22.9	2.1	40.6	56.9	0.0	0.4
09807	SS-3 DRNG	3.3	M	2	VL	34	M	6	L	200	H	963	VH	2938	M	41		7.4		23.4	2.2	34.3	62.7	0.0	0.8

LAB NUMBER *376*	NITRATE-N (FIA) SURFACE ppm	SURFACE lbs/A	SURFACE depth (in)	SUBSOIL 1 ppm	SUBSOIL 1 lbs/A	SUBSOIL 1 depth (in)	SUBSOIL 2 ppm	SUBSOIL 2 lbs/A	SUBSOIL 2 depth (in)	Total lbs/A	SULFUR S ICAP ppm	RATE	ZINC Zn DTPA ppm	RATE	MANGANESE Mn DTPA ppm	RATE	IRON Fe DTPA ppm	RATE	COPPER Cu DTPA ppm	RATE	BORON B SORB. DTPA ppm	RATE	EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm	RATE
09805	5	9	0-6							9	5	VL	1.3	M	2	VL	18	H	0.9	M	0.2	VL	L	0.4	L
09806	10	18	0-6							18	5	VL	1.8	M	2	VL	11	M	1.2	M	0.2	VL	L	0.4	L
09807	11	20	0-6							20	10	L	1.3	M	5	L	10	L	1.2	M	0.3	VL	L	0.4	L

9.3 Site Preparation & Seeding

The well pad totals approximately one acre, the slope area that will also be revegetated is approximately 1.6 acres for a total seeding area of 2.6 acres. The goal is to revegetate and restore pre-disturbance ecological functions on the well pad and slope area.

9.3.1 Site Preparation

Once the slope area and well pad have been graded based on the attached grading plan, undesirable plants (e.g. State Listed A or B noxious weed species or weedy species) growing on the surface should be eradicated before the area is seeded. Once weeds have been eradicated, amend the soil based on soil sampling results in Section 9.2.2. Prior to seeding, the site should be harrowed or raked to relieve residual compaction. Harrowing or raking should be done on the contour (across the slope) and immediately before and after seeding.

9.3.2 Soil Compaction and Amendments

Soil compaction during construction activities can reduce water infiltration and moisture holding attributes of the soil. If compaction occurs due to construction activities, the top 12 to 24 inches of soil should be tilled, and cross ripped for especially compacted areas.

Fertilizer should be added at the rate listed in Attachment F following lab recommendations based on soil samples taken from the site.

9.3.3 Timing Restrictions and Recommendations

Seeding is most successful when temperatures are above freezing, and precipitation is high. The seed mix contains a mix of cool and warm season grasses so seeding can occur in the spring or the fall. Spring seeding should occur after the spring thaw, typically around mid to late April, up through mid-May. Fall seeding should occur between mid-September up until the ground consistently freezes, typically around mid to late October. Typically fall seeding is preferred as it will aid in the dry seeding process and germination with the moisture from the winter and spring. The seed should be applied within 24-hours after seed bed preparation and when the ground is not frozen, snow covered, muddy, nor when the air temperature exceeds 90°F.

9.3.4 Seeding

Due to the steepness of the area to be seeded, hydroseeding is recommended. The addition of a tackifier is recommended if seeding will not occur until fall. It is recommended that the seed and slow-release fertilizer be applied in one operation, followed by the fiber mulch in a second process. The success rate of seeding is decreased when seed and mulch are combined in the same application because the seed attaches to the mulch and doesn't make contact with the soil. It is recommended that seed be certified weed free. The species proposed for reseeding includes the following:

- little bluestem (*Schizachyrium scoparium*),
- blue grama (*Bouteloua gracilis*),
- Sandberg bluegrass (*Poa secunda*),
- western wheatgrass (*Pascopyrum smithii*),
- Indian ricegrass (*Achnatherum hymenoides*), and
- Side Oats Gama (*Bouteloua curtipendula*).

Seeding specifications are included in Table 8. The seed mix was chosen based on existing natural communities adjacent to the area to be restored. Species within this mix are acclimated to the elevation, soil type, and arid ecosystem. The list has a mix of cold season, warm season, and rhizomatous and bunch grasses. This will allow for germination in different seasons, and improved soil stabilization. Overstory vegetation such as Rocky Mountain Juniper, one seed juniper, and Gamble oak will naturally move into the area over time. Once the area is seeded, cover seeded area with a mulch. As mentioned above, it is preferrable to separately apply the seed and mulch when hydroseeding. A Bonded Fiber Matrix (BFM) provides the best moisture and seed germination; however, wood mulch can also be used. Paper mulch is not recommended as the paper mulch tends to crust and can inhibit germination and is not as hardy. With all mulch, care should be taken to ensure the material is not applied too thick as it could prevent penetration of seedling shoots.

Table 8. Seed Specifications

Scientific Name	Common Name	Preferred Variety	Desired Species %	No. of Seeds Per Pound	PLS Planting Rate Per Acre
Native Warm Season Bunch Grasses					
Schizachyrium scoparium	Little bluestem	Pastura	6	130,000	1.5
Bouteloua curtipendula	Side Oats Gama	Butte or Vaughn	20	190,000	13
Native Warm Season Rhizomatous Grasses					
Bouteloua gracilis	Blue grama	CO Native	20	711,000	5
Native Cool Season Bunch Grasses					
Achnatherum hymenoides	Indian ricegrass	Paloma	5	141,000	1.25
Poa secunda	Sandberg bluegrass	Sims Mesa	9	900,000	6.75
Cool Season Rhizomatous Grasses					
Pascopyrum smithii	Western wheatgrass	Arriba	40	113,840	26.0
		Mix Total:	**100**		**64**

Source: Western Native Seed 2021
Note: Western Native Seed has a Pinyon Juniper Grass Seed mix that contains the species listed above (Mutton grass and Squirrel tail removed from Pinyon Juniper Grass Seed mix based on client recommendation). At the time of the report the PLS was 83.55% but may change based on date of mix. The recommended rate of seeding for the mix is 25 lbs/acre, use this rate if using the seed mix from Western Native Seed. The seed is noxious weed free but not certified weed free.

9.4 Post Seeding

Erosion control blankets/mats or geotextiles should be used to secure the slope and prevent erosion. The erosion control measure should have biodegradable netting (e.g. jute, cotton, coir), be toed into the top of the slope, and monitored closely to ensure it maintains contact with the soil.

9.5 Monitoring and Success Criteria

The area should be monitored frequently following seeding and erosion control. Early, frequent monitoring will enable detection of potential issues early allowing for proactive correction. Potential issues that arise after initial restoration include:

- Establishment or re-establishment of invasive species, inhibiting native species.
- Erosion from heavy wind, rain, or snow events.
- Foraging of the seedbank by wildlife.
- Adverse amounts of moisture or drought.

If seeded in the spring, monitoring is recommended two weeks following seeding and mulching, monthly for three months, and annually for two years. If seeded in the fall, monitoring should be conducted in the spring when the seeds should begin germinating, following the above schedule. Monitoring reports should include a list of species observed on the site, percent cover (absolute) of vegetation, list of noxious weeds and their abundance, and site observations such as abnormal wildlife/insect herbivory, erosion, and abnormal climate conditions (e.g. drought, wind, rain).

The areas should be considered permanently stabilized when a uniform 70% vegetative ground cover of perennial species has been achieved. Should this not be attainable then the area should be considered successful when the total ground cover (absolute) is within 5% of the total ground cover at a reference site(s). Noxious weed growth of A and B State listed species should be below 5% cover.

9.5.1 Maintenance

Noxious weed growth of A and B State listed species should be actively eradicated using a herbicide. Areas not successfully revegetated should be monitored for weed infestation and erosion and reseeded the following season if necessary. Erosion should be mitigated where feasible to prevent futher degradation. Erosion control measures such as fiber blankets and fiber rolls should be applied to the site if seeding does not take and needs to occur months down the road. Unchecked erosion could further impeed revegetation success.

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Attachment A: Site Visit Technical Memorandum

Technical Memorandum

To: Michael Jackson, Remediation Management

From: Richard Weber, Wood Environment & Infrastructure Solutions, Inc. (Wood)

Date: August 4, 2020

Ref: **MGP Enterprise A-4 Well Pad**

Introduction

This memo provides the observations from a site visit conducted at the MGP Enterprise A-4 well pad located approximately 20 miles west of Trinidad, Colorado. Wood staff conducted the site visit on 9 July 2020 to visually assess the geotechnical, hydrologic and vegetation conditions of the well pad. This technical memorandum also provides general approaches to reclamation of the well pad to provide long-term stability. In addition to the photos provided in the body of this technical memoranda, there are additional photos from the site visit provided in Attachment 1.

Attendees

The following people were present during the site visit

- Richard Weber, Principal Scientist and Project Manager
- Chris Ide, Senior Water Resources Engineer
- Alexander Vega, Geotechnical Engineer
- Mike Powell, Ranch Manager

Site Description

The project site is located approximately 20 miles west of Trinidad, Colorado in Las Animas County. The MGP Enterprise A-4 well pad is located on the Hall Ranch and is accessed by a private road from Colorado State Highway 12. An approximately 0.4-mile long unimproved road provides access to the north side of the well pad. The well pad occupies an approximately 1-acre area along the western portion of an undeveloped mountainside. The location of the project is shown in Figures 1 and 2.

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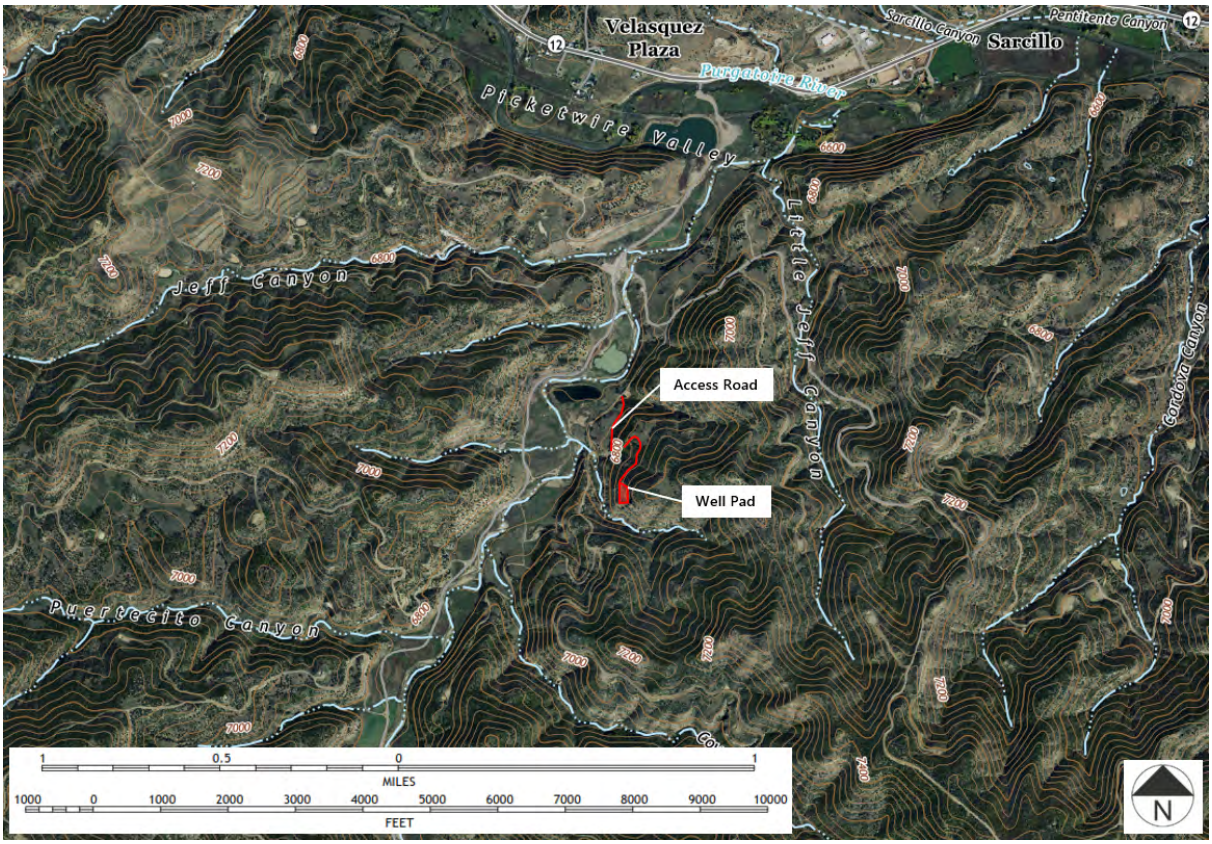

Figure 1 – Site Access

Figure 2 – Site Location

General Observations

The well pad and access road appear to have been constructed by cut and fill balance. Based on visual observations, the well pad and access road appear to have slopes as steep as 2.5H:1V (horizontal:vertical). The cut and fill construction of the well pad resulted in approximately 20 to 50 feet of fill placed over the natural slope downgradient of the well pad. The fill tapers from east to west to match the natural slopes. The surface of the well pad appears relatively flat with most of the well pad having a shallow grade to the north and west. A small portion of the southern end of the pad appears to slope towards the south.

Due to dry conditions, much of the herbaceous vegetation was dormant. The flatter areas tended to have denser vegetation with the slopes having vegetation cover ranging from sparse to completely bare. The access road tended to have better vegetation cover except in steeper areas where erosion is occurring. Several trees and larger bushes are present on the fill slope below the well pad, and flat areas of the well pad but are sparse across the project area.

There are a number of large erosion channels that have formed on the western and southern fill slopes below the well pad area. These erosion channels tend to start at the top of slopes and get larger on the steeper parts of the fill area. The largest channels are located on the southern half of the west slope. Smaller erosional channels are also present on the slope on the south end of the well pad.

There is one culvert in the access road approximately 300 feet from the well pad. The flatter portions of the road appear to be stable with no signs of instability or erosion. Erosion channels are present on the steeper portions of the road. A sediment control structure appears to have been constructed downgradient of the road toward the lower end.

Geotechnical Assessment

The following sections provide the results of the visual geotechnical assessment of the project area.

Geotechnical Conditions

The well pad is located in the Raton Mesa region (Figure 3) of south-central Colorado in an area characterized by flat-topped mesa with steep slopes and separated by deep canyon formations. The Raton Basin is an Upper Cretaceous and Tertiary sedimentary basin with structural formations of rock created by tectonic warping of a previously flat-lying strata. The New Mexico Geological Society (NMGS, 1969) reports that the rocks are comprised of stratigraphic successions (in ascending order) of Pierre Shale, Trinidad Sandstone, Vermejo Formation, and the Raton Formation.

The well pad is situated above the Raton Formation, which crops out over most of the Raton Mesa region, with a maximum thickness of 1,700 feet (NMGS, 1969). This formation is comprised of buff, gray, and olive-gray, very fine- to coarse-grained arkose, graywacke, and quartzose sandstone beds; gray to dark gray siltstone and silty shale beds, and numerous coal beds (NMGS, 1969).

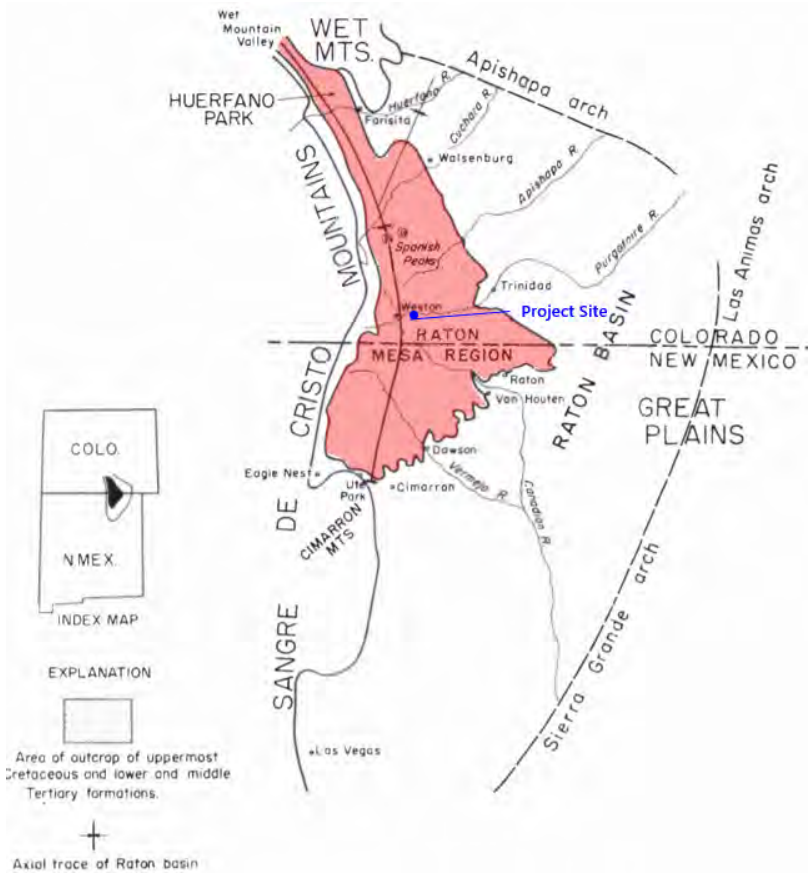

Figure 3 - Map of the Structural Raton Basin of New Mexico and Colorado (NMGS, 1969)

Geotechnical Observations

Based on visual observations and the reported NMGS (1969) geological data, the fill materials along the surface of the well pad and access road appear to consist of native soils derived from the Raton Formation rocks, which include silty, clayey, sandy soils with rock fragment particle sizes ranging from fine-grained gravel (0.25 inches in diameter) to boulders up to three feet in diameter. As evident from the apparent firmness, abundance of bare areas without vegetation, and absence of depressions (typically associated with loose/uncompacted underlying soils) along the well pad surface, the fill appears to have been placed in a controlled manner with some degree of compactive effort.

During Wood's site visit, no deep-seated slides, sloughs, cracking, or depressions associated with slope instability were evident along the well pad and access road areas, including the slopes and toes. However, erosion was observed along the south and west well pad slopes and steeper areas of the access road surface. Where observable, the erosion depth typically measured up to two feet with isolated cases of significant erosion measuring up to four feet along the southwestern facing slope. The erosion appears to be associated with uncontrolled stormwater runoff.

Hydrologic Assessment

The drainage area contributing to the well pad and primary areas of scour appears to be approximately 2 acres. This means that short duration and high intensity storms will cause the most amount of scour, as the stormwater

will concentrate quickly, and infiltration will be minimal. On the well pad itself, there is minimal evidence of scour, likely due to the minimal drainage area leading to primarily sheet and shallow concentrated flow, and the vegetation which has established in the area. At the northwest corner of the pad, there is an area where stormwater noticeably concentrates, and creates a larger channel down the west embankment where scour is evident.

Figure 4 - West embankment scour

Figure 5 - Debris channel downstream of west embankment

There is considerable scour evident on the west slope, which contains the cut material from the well pad (Figure 4). These scour channels are primarily straight, allowing for fast velocities and a quick concentration of flow. There is minimal vegetation in these scour channels showing that flows occur frequently, inhibiting vegetation from establishing. This material appears to be collecting at the base of the slope and continues north of the base approximately 1,000-feet along a local drainage path. This was evident by the non-compacted material, also with minimal vegetation (Figure 5).

The roadway access to the pad appears to have minimal scour present. There are numerous areas tributary to the roadway, of varying sizes, but in most appear to be small enough to allow for sheet or shallow concentrated flow across the roadway. There is one culvert (Figure 6) that was identified at a larger concentrated flow path with approximately three acres of tributary area. This appears to have stabilized vegetation at the inlet and upstream of the culvert. There is no evidence of overtopping of the roadway at this location, which means the culvert is likely adequately sized. There is some minor scour evident at the outlet of the culvert, which could benefit from the addition of riprap.

One primary area of scour was noticed along the roadway where water concentrates between the roadway and hillside (Figure 7). In this area, vegetation has not established, and appears to have rocky debris, indicating fast moving concentrated flow is able to be established flowing parallel to the roadway. This debris appears to spread out as the roadway travels north and does not appear to impact any primary drainageway but is mitigated in naturally vegetated areas as the slope levels off.

Figure 6 - Culvert outlet

Figure 7 - Roadway scour flowing south to north

Vegetative Assessment

Vegetation varies significantly across the project areas with flatter areas having a higher density of vegetation and slopes having less dense or no vegetation. Due to dry conditions, much of the grasses and herbaceous species have become dormant. Thus, it is difficult to fully assess the vegetation cover of the area.

The well pad is relatively flat and appears to have had good grass and herbaceous growth on the majority of the pad area. Several woody shrubs and trees were present on edge of the well pad and at the base of the cut slope (east side of pad). The one exception was in the center of the well pad where there was little to no vegetation present and no evidence of previous vegetation (Figure 8). It is not apparent why the area was void of vegetation as there was no sign of significant erosion or other factors that would limit vegetation growth.

Figure 8 - Area in center of well pad void of vegetation

Vegetation growth on the fill slope below the well pad lacked vegetation on the steeper slopes where soils showed signs of erosion. Flatter areas had grasses and some herbaceous species, but even area with vegetation tended to be scattered (Figure 9(a)). Erosion channels down the slope had little to no vegetation. Some volunteer woody vegetation has become established, primarily along the edges of the slope where the depth of the fill material is less than in the middle of slope (Figure 9(b)).

(a)

(b)

Figure 9 - Photos showing vegetation on the slopes below the well pad

Vegetation along the road is well established consisting of grasses and herbaceous species, most of which has become dormant due to dry conditions (Figure 10(a)). Steeper areas that have previously eroded to rock and actively eroding areas have little to no vegetative growth (Figure 10(b)).

(a)

(b)

Figure 10 - Vegetation growth on the access road

Conclusions and Recommendations

Based on Wood's observations, the fill comprising the well pad appears stable and suitable for supporting heavy earth-moving equipment. However, a geotechnical study is recommended to evaluate the stability of any proposed change to the existing slope geometry needed to achieve reclamation of the site. The proposed study will involve test pit excavations and laboratory testing to collect information on the well pad subsurface materials (e.g., lithology, material classification, moisture-density relationship, shear strength) for geotechnical analyses. Slope stability analyses would include computer-aided modeling to evaluate potential failure slope surfaces for a given set of soil properties, geometric, and loading conditions.

Wood also recommends that a topographic survey be performed to establish the elevation and geometry of the well pad for use in development of the reclamation design. The topographic data can be used to develop cut and fill plans for any proposed well pad reclamation plan. The slope of the project area is steep and unsafe for conventional survey land methods; therefore, Wood recommends using an aerial drone with LiDAR capability to collect sufficient data for development of a one-foot contour topographic map.

In addition to the conclusion and recommendation for a geotechnical study, the following are also preliminary reclamation approaches to assess for final reclamation to meet the stated requirements of the Colorado Oil and Gas Commission.

- Grading and vegetating the erosion channels on the lower slopes of the fill material to minimize future scour. Use of a geotextile fabric is recommended, as erosion control blankets would not be sufficient to prevent continued erosion and allow for vegetation to be established in this area.
- Remove the upper slope fill material and place on the well pad to flatten the angle on the upper slope and reestablish a slope across the well pad.
- If necessary, create slope breaks or small benches on the fill slope below the well pad to reduce velocities of runoff during precipitation and snowmelt events.
- Seed the reestablished slope and install either a geotextile fabric or erosion control blanket to minimize erosion and allow plant establishment.
- Regrade eroded areas along the road and install scour countermeasures such as water bars along the road to reduce velocity of runoff.

Sincerely,
Wood Environment & Infrastructure Solutions, Inc.

Richard Weber
Project Manager

Christopher Ide
Senior Water Engineer

Alexander Vega
Geotechnical Engineer

Attachment 1: Photos

Photo 1: View of well pad profile facing north.

Photo 2: View of outcrop / cut face along eastern end of well pad.

Photo 3: View of well pad slope facing east.

Photo 4: View of well pad slope facing southeast

Photo 5: View of well pad surface facing north.

Photo 6: View of well pad surface facing south.

Photo 7: View of western edge of well pad facing north.

Photo 8: View of southern edge of well pad facing west.

Photo 9: View of upper west slope of well pad facing north.

Photo 10: View of upper west slope of well pad facing south.

Photo 11: View of upper south slope of well pad facing west.

Photo 12: View of upper west slope of well pad facing north.

Photo 13: View of middle west slope of well pad facing north.

Photo 14: View of middle west slope of well pad facing southwest.

Photo 15: View of well pad western slope toe facing south.

Photo 16: View of well pad western slope toe facing north.

Photo 17: View along upper portion on access road facing north.

Photo 18: View along upper portion on access road facing south.

Photo 19: View of culvert outfall along the upper portion access road facing north.

Photo 20: View along upper portion of access road facing north.

Photo 21: View along middle portion of access road facing north.

Photo 22: View along middle portion of access road facing south.

Photo 23: View along middle portion of access road facing south.

Photo 24: View of slope along middle portion of access road facing southwest.

Photo 25: View along lower portion of access road facing south.

Photo 26: View along lower portion of access road facing east.

Attachment B: Geotechnical Data Report

Geotechnical Data Report

Reclamation of MGP Enterprises A-4 Well Pad
Trinidad, Colorado
Project # 32820182

Prepared for:

BP Remediation Management Services Company
201 Helios Way, Houston, Texas

4/8/2021

Geotechnical Data Report

Reclamation of MGP Enterprises A-4 Well Pad
Trinidad, CO
Project # 32820182

Prepared for:

BP Remediation Management Services Company
201 Helios Way, Houston, Texas

Prepared by:

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USA
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4/8/2021

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Appendix D: Test Pit Logs
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1.0 Introduction

1.1 Project Overview

The MGP Enterprise A-4 Well Pad located in Las Animas County, Colorado, approximately 20 miles east of the City of Trinidad (see Figure 1). The well pad occupies an approximately 1-acre area that was constructed by cut and fill placement along a natural mesa formation. The well pad also features an approximately 0.35-mile-long reclaimed access road. The general layout of the well pad is shown in Figure 2 below.

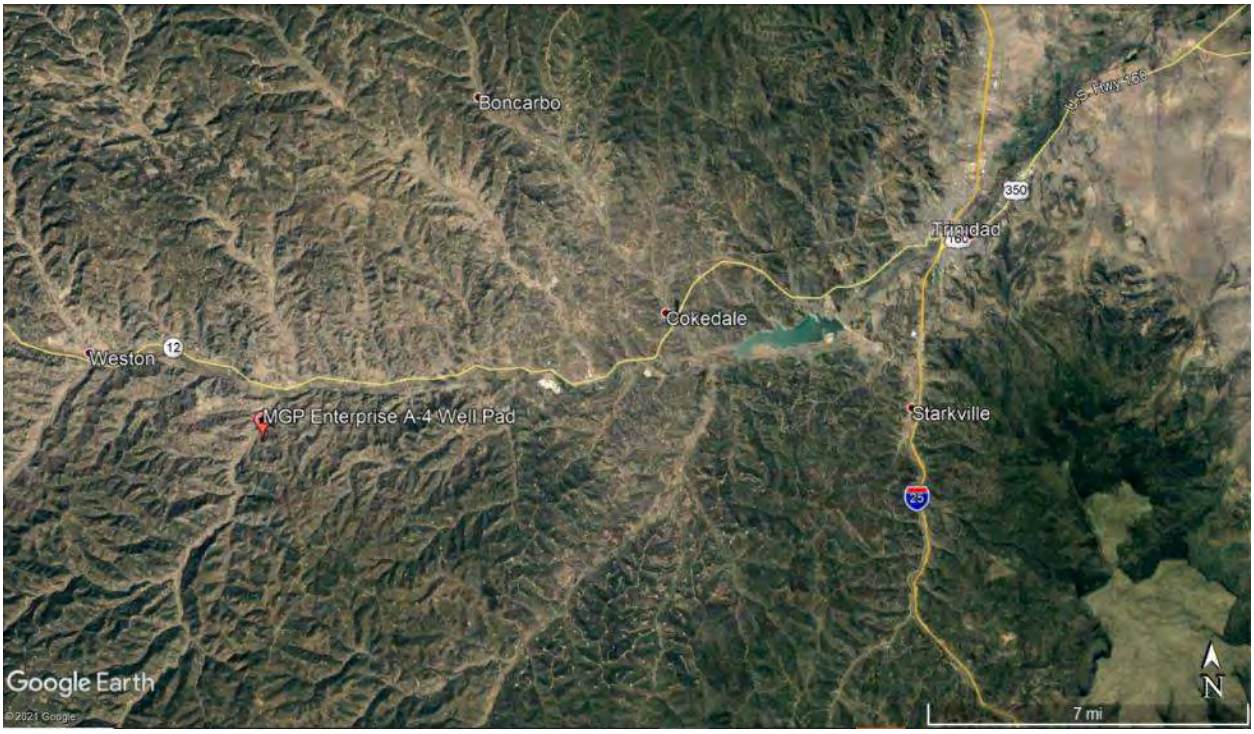


Figure 1. Project Location (Google Earth, 2021)

Wood Environment & Infrastructure Solutions, Inc. (Wood) is developing a reclamation plan to address concerns of the Colorado Oil and Gas Conservation Commission's (COGCC) regarding the MGP A4 Enterprises Well Pad. Phase I of Wood's approach to reclamation included an initial site reconnaissance visit on July 9, 2020 to observe existing surface conditions and features at the project site. Phase I also included an aerial drone survey that was performed on August 13, 2020 to obtain aerial images and topographic data. Based on the results of Phase I and the extent of reclamation required, Wood performed a geotechnical investigation as part of Phase II to evaluate the subsurface conditions well pad and support the develop of the reclamation plan.

This report presents the results of geotechnical subsurface exploration and laboratory testing performed to support of the MGP Enterprises A-4 Reclamation project. The data presented in this report will be used to characterize the subsurface conditions at the locations explored across the well pad. Additionally, the geotechnical data presented in this report will be used to support stability analyses and the reclamation design discussed in the main report.

Figure 2. General Site Layout (Wood, 2020)

Our proposal dated January 2021 defines the scope of services for this project. This report has been prepared as part of the Phase II, Task 1 - Geotechnical Investigation, which includes the following tasks:

- Reviewed and summarized available geological and subsurface information relative to the project site.
- Visited the site to observe existing surface conditions and features.
- Contracted a private utility locator to identify and mark the location of private utilities or anomalies that may be associated with utilities.
- Executed a subsurface exploration program consisting of test pits excavated across the well pad.
- Performed geotechnical laboratory testing on representative soil samples
- Prepared a written report summarizing the subsurface exploration, laboratory testing, and providing descriptions of the subsurface conditions encountered.

Aspects including the well pad reclamation design and stability analyses are discussed in other sections of the main report.

2.0 Geotechnical Investigation

2.1 Subsurface Exploration

On February 10, 2021, Wood performed a subsurface exploration consisting of test pit excavations to evaluate the subsurface conditions below the well pad. A total of eleven (11) test pits designated as TP-1 through TP-11 were excavated to depths ranging between approximately 3 to 17 feet below ground surface (ft-bgs). The test pits were excavated by Wood's subconsultant, USA Environment, LP (USA Environment) from Deer Park, Texas.

The test pits were located across the surface of the well pad to provide a wide spatial distribution of subsurface conditions and delineate the depth to bedrock. The approximate locations and excavated depths of the test pit are summarized in Table 1 and shown in the subsurface exploration plan provided in Appendix A. Details of the subsurface exploration are provided in the sections below. Additionally, the subsurface exploration photos in Appendix B are provided to show the surface, subsurface, and other site features encountered during the geotechnical investigation.

Table 1: Summary of Test Pit Locations and Depths

Test Pit ID [1]	Latitude (deg.)	Longitude (deg.)	Depth (ft-bgs)
TP-1	37.10530	-104.78039	17
TP-2	37.10527	-104.78034	10
TP-3	37.10524	-104.78025	1.5
TP-4	37.10506	-104.78016	3
TP-5	37.10500829	-104.7803467	10.5
TP-6	37.10489	-104.78012	3
TP-7	37.10481	-104.78021	9
TP-8	37.10473	-104.78021	9.5
TP-9	37.10469	-104.78038	16
TP-10	37.10469	-104.78002	5
TP-11	37.10458	-104.78016	12

Notes

1. With the exception of Test Pit No. TP-5, the GPS coordinates for test pits locations were obtained using a handheld device accurate to within +/- 15 feet. The location of the TP-5 was surveyed by Earth Measurement Corporation on February 10, 2021.

2.2 Utility Locates

Prior to performing the subsurface investigation, USA Environment notified the Utility Notification Center of Colorado (UNCC) of the intent to excavate test pits and dispatch utility locators to identify and mark any potential public utilities at the project site. Additionally, USA Environment contracted Earth Measurement Corporation (EMC) to perform private utility locates to identity the location of the well head and any associated utility well pad infrastructure.

EMC performed a geophysical survey consisting of metal detection methods using a Geonics Ltd. EM61 metal detector capable of detecting both ferrous and non-ferrous metal up to a depth of approximately 20 feet. The EMC geophysical survey identified the location of the well head, which was visually conformed with Test Pit Excavation No. 5. Additionally, other metallic anomalies we observed by EMC near the southern end of the well pad that were identified during test pit excavations as a studded steel T-post and a metal 2-inch diameter pipe segment measuring approximately 3-foot long. The location of the well head and detected anomalies are shown on the EMC (2021) geophysical survey color contour utility locate maps provided in Appendix C.

2.3 Test Pit Excavation Procedures

The excavations were performed by USA Environment using a Caterpillar (CAT) 336E track mounted hydraulic excavator. Wood's field representative was present during the test pit excavation activities to coordinate, supervise, and record geotechnical data.

Wood observed each test pit to identify the composition of soil/rock materials, stratification boundaries, and groundwater levels or zones of perched groundwater. Representative grab samples of soils were obtained from excavation spoils for visual classification in accordance with the Unified Soil Classification System (USCS) (ASTM D2488). Recovered soil samples were placed and sealed in 5-gallon sized plastic containers and later transported to the laboratory for further evaluation. A field log was prepared for each exploration, including sampling depths, visual soil classifications, and identification of other relevant subsurface information. The test pit logs are provided in Appendix D. Stratification lines shown on the test pit log represent the approximate boundaries between material types and the actual transitions may be gradual and vary with location.

All test pit excavations were backfilled with the excavated materials immediately upon completion. The test pits were backfilled using the excavator bucket to place and mechanically tamp materials in lifts measuring no greater than approximately 2 feet to achieve a relatively flat surface that closely matches the existing site conditions.

2.4 Laboratory Tests

Select soil samples recovered from the test pit excavations were transported to Wood's subconsultant Advanced Terra Testing, Inc. (ATT) in Lakewood, Colorado to further classify and evaluate the material properties of the soils. A summary of completed laboratory tests are summarized below in accordance with ASTM International (ASTM) test procedures.

- Moisture content (ASTM D2216)
- Grain size analyses (ASTM D6913)
- Atterberg limits (ASTM D4318)
- Direct Shear (ASTM D3080)
- Standard Proctor moisture-density relationship (ASTM D698)

Individual laboratory test results reported by ATT are provided in Appendix E and referenced in subsequent sections below.

3.0 Site Conditions

3.1 Surface Conditions

The well pad and associated access road appear to have been constructed by cut and fill balance. Based on survey data, the cut made to develop the well pad measures approximately 50 feet high with a 1.1H:1V (Horizontal to Vertical slope ratio) westward slope along the side of a mesa formation. The cut transitions to a relatively flat well pad surface measuring approximately 300 feet long and 150 feet wide with a shallow grade to the north-west. The downgradient slope west of the well pad ranged from 1.4H:1V to 1.8H:1V. The cut and fill construction of the well pad resulted in approximately 17 feet of fill placed over the natural slope downgradient of the well pad, which tapers from east to west to match the natural slopes. Elevations

across the project site range from approximately 6,750 feet above sea level (FASL) along the well pad toe-slope to 6,885 FASL on the flat well pad surface.

During Wood's site visit, no deep-seated slides, sloughs, cracking, or depressions associated with slope instability were evident along the well pad and access road areas, including the slopes and toes. However, numerous large erosion channels were observed along the south and west well pad slopes. These erosion channels tend to start at the top of slopes and get larger on the steeper parts of the fill area. The largest channels are located on the southern half of the west slope. Smaller erosional channels are also present on the slope on the south end of the well pad.

Apart from the flat well pad area, flat areas across the site typically have dense herbaceous vegetation. The slopes downgradient of the well pad have herbaceous vegetation cover that range from sparse to completely bare. The access road typically exhibited moderate herbaceous vegetation cover except in steeper areas with erosion. Several trees and larger bushes are present on the slope and flat areas of the well pad but are sparse across the project site.

A corrugated steel culvert pipe crosses perpendicular to the access road approximately 300 feet north of the well pad. The culvert outlet appeared to be partially armored against erosive flows with cobble sized sandstone rock fragments that appear to resemble native rock outcrops. The flatter portions of the road appear to be stable with no signs of instability or erosion. Erosion channels are present on the steeper portions of the road. A sediment control berm structure appears to have been constructed downgradient of the access road approximately 300 feet southwest the road entrance.

3.2 Geological Conditions

The well pad is located in the Raton Mesa region of south-central Colorado, in an area characterized by flat-topped mesa with steep slopes and separated by deep canyon formations. The Raton Basin is an Upper Cretaceous and Tertiary sedimentary basin with structural formations of rock created by tectonic warping of a previously flat-lying strata. The New Mexico Geological Society (NMGS, 1969) reports that the rocks are comprised of stratigraphic successions (in ascending order) of Pierre Shale, Trinidad Sandstone, Vermejo Formation, and the Raton Formation.

The well pad is situated on the Raton Formation, which crops out over most of the Raton Mesa region, with a maximum thickness of 1,700 feet (NMGS, 1969). This formation is comprised of yellow-white (buff), gray, and olive-gray, very fine- to coarse-grained arkose, graywacke, and quartzose sandstone beds; gray to dark gray siltstone and silty shale beds, and numerous coal beds (NMGS, 1969).

3.3 Geotechnical Conditions

The general subsurface conditions encountered at the test pits are summarized in Table 2. The subsurface conditions discussed in the following sections and shown on the attached test pit logs in Appendix D represent an estimate of the subsurface conditions based on Wood's interpretation of geotechnical field and laboratory test data. The transitions between different soil strata may be less distinct than those shown on the test pit logs. Although individual test pits are representative of the subsurface conditions encountered at the explored locations, they are not necessarily indicative of subsurface conditions at other locations or at other times.

Table 2: General Subsurface Profile

Stratum	Material Description (USCS Classification)	Depth to Bottom of Stratum (ft)
Fill	clayey sand and gravel (SC/GC) with cobbles and boulders	1 to 17
Bedrock	weathered sandstone bedrock	17 and greater

3.3.1 Fill

Based on the subsurface conditions encountered at test pit locations and Wood's understanding of the geological conditions at the project site, the fill materials comprising the well pad consists of native soils derived from the Raton Formation rocks, which consists primarily of clayey sand or clayey gravel with cobbles and boulders. Soils recovered from the test pit excavations have a Unified Soil Classification System (USCS) designation of SC and GC and consists of clayey sand and gravel with fine to coarse angular cobble and boulder sized sandstone rock fragments up to 5 feet in diameter. Shallow perennial roots typically contributed small amounts of organic matter within the upper 6 to 12 inches of the soil profile.

The thickness of the fill generally tapered to meet the edge of the natural slope on the east and west ends with a maximum thickness ranging from approximately 10 to 17 feet along the northern and southern edge of the well pad, respectively. The clayey sand soils were brown to dark brown, moist (moisture content of 10 to 15 percent), and possess a medium plasticity (plasticity index of 17 to 18), and a fines content ranging from 26 to 35 percent (percentage of soils passing the No. 200 sieve). The color of gravel, cobble, and boulder sized rock fragments were typically buff-colored.

Based on the results of standard Proctor tests (ASTM D698) performed on a mixture of representative soils recovered from the north and south end of the well pad (Test Pit No. 1, 5, and 11), the optimal moisture content at which the fill soil will become most dense and achieve its maximum dry density is at 111.6 pounds per cubic foot (lb/ft^3) with a moisture content of 16.2 percent. A direct shear test (ASTM D3080) was performed on remolded samples of bulk (disturbed) fill soil samples recovered from the test pit excavations. The samples were compacted to 90 percent of their maximum dry density as determined by the standard Proctor test. Direct shear tests performed on a specimen of fill soil void of gravel particle size greater than ¼ inch and all cobble and boulder, which is likely to produce conservative results due to the removal of large particles that may interlock and increase shearing resistance. ATT's laboratory reported a friction angle of 36.1 degrees with a cohesion value of 68 psf resulting from the direct shear test.

Due to the presence of numerous cobble and boulder size rock fragments, conventional drilling methods were not feasible to facilitate borehole drilling and estimations of in-situ soil density based on Standard Penetration Test (SPT) methods (ASTM D1586). However, the apparent firmness and absence of depressions (typically associated with loose/uncompacted underlying soils) along the well pad surface, indicated that fill was likely to have been placed in a controlled manner with some degree of compactive effort.

3.3.2 Well Head

The top of the well head was located in Test Pit No. 5 approximately 8 feet below the at the western edge of the well pad. The top of the well head appeared as a steel pipe that measured roughly 18 inches in diameter. Before exposing the top of the head during, sparse debris consisting of wood and cylindrical shaped concrete fragments were encountered during the excavation. The location of the well head was surveyed by EMC during the test pit excavation. The GPS coordinates reported by EMC for the well head location are provided in Appendix C.

3.3.3 Bedrock

Weathered bedrock consisting of Raton Formation sandstone underlies the fill at depths ranging from approximately 3 to 17 ft-bgs. Test pit observations and the performance of the excavator indicates that the upper 2 to 7 feet of bedrock are highly weathered and rippable. The rock below the upper weathered zone also appeared weathered and fractured to a lesser degree but excavator refusal conditions were encountered. Weathering characteristics consist of intense fracturing, alteration of primary minerals to clays and oxides (such as iron oxide), dislocation from creep, and the filling of fractures with sand, silt, and clay.

3.3.4 Groundwater

Wet soils or other evidence of groundwater was not observed during the test pits excavations. However, it is Wood's opinion that the fill is susceptible to developing perched or trapped groundwater within the clayey soil matrix during or immediately following precipitation events.

4.0 Limitations

This Geotechnical Data Report has been prepared in accordance with generally accepted engineering practices for use by Wood and BPRM for design purposes. The data provided in this Report result from Wood's interpretation of the geotechnical conditions existing at the site. Actual subsurface conditions may vary. Therefore, experienced geotechnical engineers should evaluate earthwork during construction to verify that the conditions anticipated in design actually exist.

Subsurface information shown on the test pit logs represent conditions encountered at the locations indicated and at the time of the subsurface explorations. No warranty is offered, either express or implied, that confirms that the actual conditions will conform exactly to the assessments contained in this Report. Where data supplied by BPRM or other external sources have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by Wood for incomplete or inaccurate data supplied by others. If conditions appear to be different from those described herein, notification should be given so that a re-evaluation of the recommendations can be made.

This Report has been prepared to assist the Wood design team and BPRM in the design process and is only applicable to the design of the well pad Reclamation Plan. This Report is provided for sole use by BPRM and is confidential to BPRM and its professional advisers. No responsibility whatsoever for the contents of this Report will be accepted to any person other than the BPRM. Any use which a third party makes of this Report, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Wood accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this Report.

5.0 References

Earth Measurement Corporation (EMC), 2021, "Geophysical Investigation Survey, MGP Enterprises A4 Site, Interpretive Map, issued to Remediation Management Services Company (BPRM) on February 11, 2021.

Earth Measurement Corporation (EMC), 2021, "Geophysical Investigation Survey, MGP Enterprises A4 Site, EM-61 Differential Map, issued to Remediation Management Services Company (BPRM) on February 11, 2021.

Google Earth (Google), 2021, aerial image of well pad, earth.google.com/web/, Imagery dated October 18, 2016, Accessed on March 2021.

R. B. Johnson, G. H. Dixon, and A. A. Wanek - New Mexico Geological Society (NMGS), 1969, "Late Cretaceous and Tertiary stratigraphy of the Raton basin of New Mexico and Colorado", 1966, pp. 88-98.

US Geological Survey (USGS, 2019, "Little Pine Canyon Quadrangle, Colorado - Las Animas County, 7.5 Minute Series", 2019.

Wood Environment & Infrastructure Solutions, Inc. (Wood), 2020, "Plan View and Well Pad Section", issued to Remediation Management Services Company (BPRM) on September 3, 2020.

Appendix A: Subsurface Exploration Plan

Note: The figure is based on a Google Earth aerial image of the project site dated October 18, 2016. The locations are approximate and intended for illustration purposes only.

Legend:

TP-1 Approximate location of test pits (TP-1 to TP-11)

SUBSURFACE EXPLORATION PLAN

wood.

MGP ENTERPRISES A-4 RECLAMATION PROJECT
LAS ANIMAS COUNTY, COLORADO

DATE: 03/25/2021		REV. 0
BY: A.V.	CHECKED: D.S.	

Appendix B: Photography Logs

Surface Conditions
Photographs No. 1 through 27

Photo 1: View of the mesa formations within the vicinity of the project site facing south near the entrance at Highway 12 and Hill Rach Road.

Photo 2: View of the northwestern well pad profile facing southeast.

Photo 3: View of the northwestern well pad slope facing southeast.

Photo 4: View of the northwestern well pad slope and toe facing southeast.

Photo 5: View of the northwestern well pad slope facing southeast.

Photo 6: View of the western well pad slope facing east.

Photo 7: View of the southwestern well pad slope facing northeast.

Photo 8: View of the southwestern well pad profile facing north.

Photo 9: View of the northern well pad surface and access road facing north.

Photo 10: View of the northern well pad surface and access road facing southeast.

Photo 11: View of the northeastern well pad surface facing north.

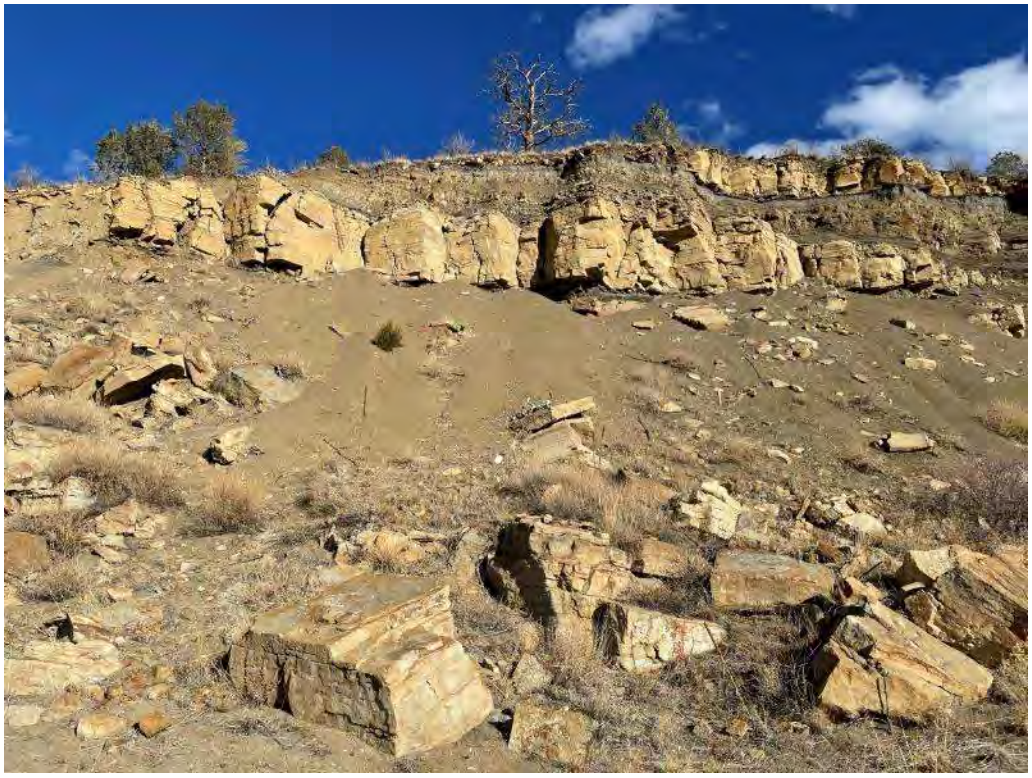


Photo 12: View of the central-east well pad cut facing east.

Photo 13: View of the southeastern well pad surface and cut facing southeast.

Photo 14: View of the southeastern well pad surface and cut facing northeast.

Photo 15: View of the southeastern well pad surface and cut facing northeast.

Photo 16: View of the southeastern well pad surface and cut facing northeast.

Photo 17: View from the top of the southeastern well pad slope facing southeast.

Photo 18: View from the top of the southern well pad slope facing west.

Photo 19: View of the southwestern well pad surface facing northeast.

Photo 20: View from the top of the southwestern well pad slope facing southwest.

Photo 21: View from the top of the southwestern well pad slope facing north.

Photo 22: View from the top of the southwestern well pad slope facing northwest.

Photo 23: View of the central-west well pad surface facing north.

Photo 24: View from the top of the central-west well pad slope facing south.

Photo 25: View from the top of the central-west well pad slope facing west.

Photo 26: View from the top of the central-west well pad slope facing northwest.

Photo 27: View from the top of the northwestern well pad slope facing southwest.

Test Pit Excavations

Photographs No. 28 through 74

Photo 28: View of the excavated materials at Test Pit No. TP-1 facing southeast.

Photo 29: View of the excavated materials at Test Pit No. TP-1 facing east.

Photo 30: View within the excavation at Test Pit No. TP-1.

Photo 31: View within the excavation at Test Pit No. TP-1.

Photo 32: View of the excavated materials at Test Pit No. TP-2 facing north.

Photo 33: View of the excavated materials at Test Pit No. TP-2 facing east.

Photo 34: View within the excavation at Test Pit No. TP-2.

Photo 35: View within the excavation at Test Pit No. TP-2.

Photo 36: View of the excavated materials at Test Pit No. TP-3 facing north.

Photo 37: View within the excavation at Test Pit No. TP-3.

Photo 38: View of the excavated materials at Test Pit No. TP-4 facing north.

Photo 39: View of the excavated materials at Test Pit No. TP-4 facing northeast.

Photo 40: View within the excavation at Test Pit No. TP-4.

Photo 41: View within the excavation at Test Pit No. TP-4.

Photo 42: View of the surface at Test Pit No. TP-5 facing south.

Photo 43: View within the excavation at Test Pit No. TP-5.

Photo 44: View within the excavation at Test Pit No. TP-5.

Photo 45: View of concrete debris removed from the excavation at Test Pit No. TP-5.

Photo 46: View of concrete debris removed from the excavation at Test Pit No. TP-5.

Photo 47: View of the well head exposed within the excavation at Test Pit No. TP-5.

Photo 48: View of the well head exposed within the excavation at Test Pit No. TP-5.

Photo 49: View of the excavated materials at Test Pit No. TP-6.

Photo 50: View within the excavation at Test Pit No. TP-6.

Photo 51: View of coal bed observed within the excavation at Test Pit No. TP-6.

Photo 52: View of coal bed observed within the excavation at Test Pit No. TP-6.

Photo 53: View of the excavated materials at Test Pit No. TP-7.

Photo 54: View of the metal pipe segment removed from Test Pit No. TP-7.

Photo 55: View within the excavation at Test Pit No. TP-7.

Photo 56: View within the excavation at Test Pit No. TP-7.

Photo 57: View of the excavated materials at Test Pit No. TP-8.

Photo 58: View within the excavation at Test Pit No. TP-8.

Photo 59: View within the excavation at Test Pit No. TP-8.

Photo 60: View within the excavation at Test Pit No. TP-8.

Photo 61: View of the excavated materials at Test Pit No. TP-9.

Photo 62: View of the excavated materials at Test Pit No. TP-9.

Photo 63: View within the excavation at Test Pit No. TP-9.

Photo 64: View within the excavation at Test Pit No. TP-9.

Photo 65: View of the excavated materials at Test Pit No. TP-10.

Photo 66: View of the studded steel T-post removed from Test Pit No. TP-10.

Photo 67: View within the excavation at Test Pit No. TP-10.

Photo 68: View within the excavation at Test Pit No. TP-10.

Photo 69: View of the excavated materials at Test Pit No. TP-11.

Photo 70: View of the excavated materials at Test Pit No. TP-10

Photo 71: View within the excavation at Test Pit No. TP-11.

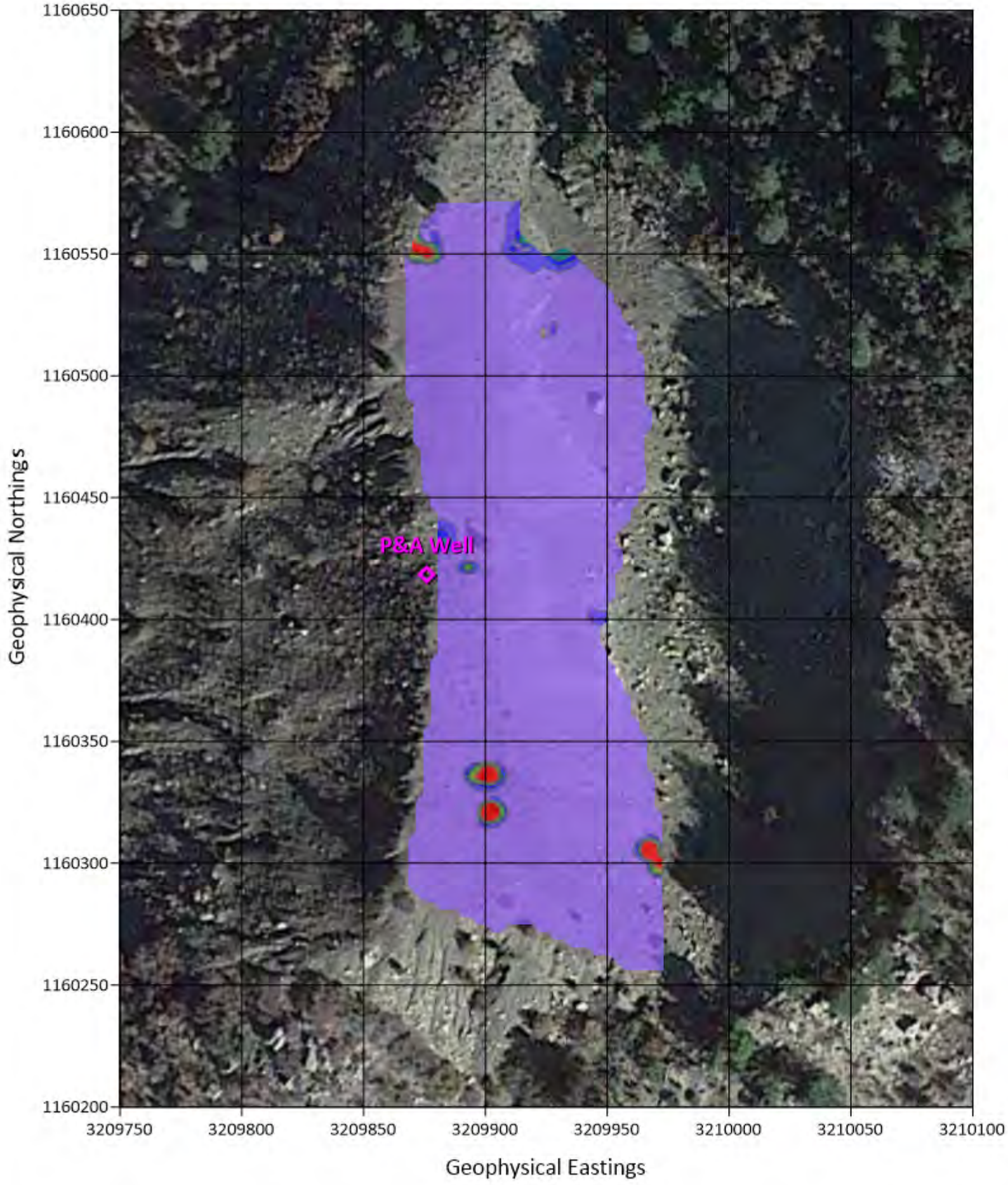
Photo 72: View within the excavation at Test Pit No. TP-11.

Photo 73: View within the excavation at Test Pit No. TP-11.

Photo 74: View within the excavation at Test Pit No. TP-11.

wood.

Appendix C: Geophysical Survey Utility Locate Maps



N
W E
S

Legend

P&A Well

Map Projection Presented in U.S. State Plane NAD83 Colorado South FIPS (0503) U.S. Survey Feet

Notes: **P&A Well Location**
Latitude: 37.1050082
Longitude: -104.7803466
Northing: 1160418.55
Easting: 3209876.10

Measured in Millivolts (mV)

0 10 20 30 40 50 60 70 80 90 100

USA ENVIRONMENT, L.P.

Geophysical Investigation Survey

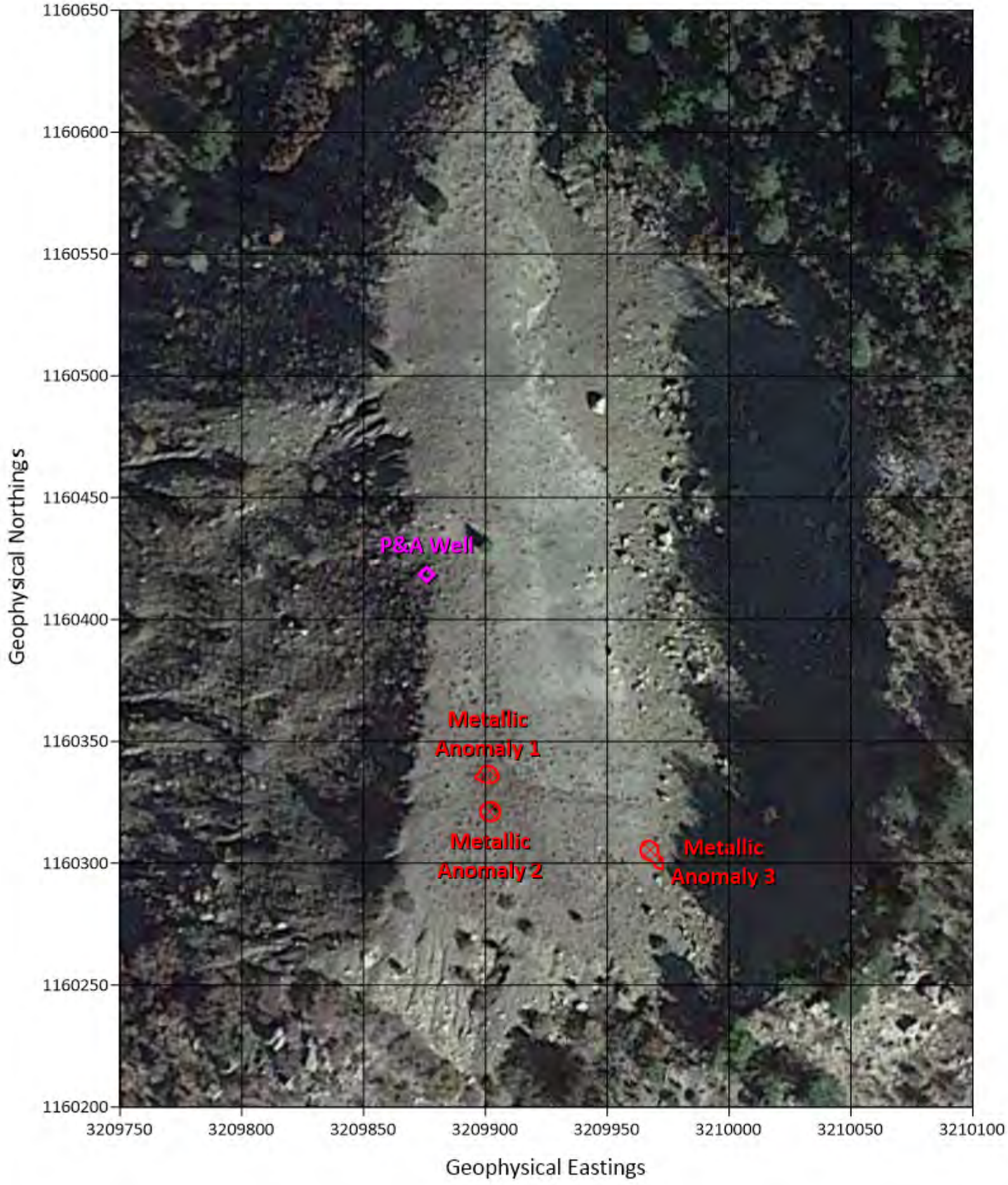
MGP ENTERPRISES A4 SITE
HILL RANCH, COLORADO

EM-61 DIFFERENTIAL MAP
DEPTH OF INVESTIGATION: 0' - 9'

SCALE 1 INCH = 50 FEET
0 50 100

FEB 2021

EMC EARTH MEASUREMENT CORP.
10963 Cutten Road
Houston, Texas 77066
281-829-5700



N
W E
S

Legend

- P&A Well
- Metallic Anomaly

Map Projection Presented in U.S. State Plane NAD83 Colorado South FIPS (0503) U.S. Survey Feet

Notes: **P&A Well Location**

Latitude: 37.1050082
Longitude: -104.7803466
Northing: 1160418.55
Easting: 3209876.10

USA ENVIRONMENT, L.P.

Geophysical Investigation Survey

MGP ENTERPRISES A4 SITE
HILL RANCH, COLORADO

INTERPRETIVE MAP

SHOWING ALL FOUND PIPELINES/ANOMALIES

SCALE 1 INCH = 50 FEET

0 50 100

FEB 2021

EMC EARTH MEASUREMENT CORP.

10963 Cutten Road
Houston, Texas 77066
281-829-5700

Latitude	Longitude	Northing	Easting	Attributes
37.10500829	-104.7803467	1160418.55	3209876.1	P&A Well
37.10477907	-104.7802636	1160336.51	3209900.96	Metallic Anomaly 1
37.10473695	-104.7802608	1160321.18	3209901.91	Metallic Anomaly 2
37.1046900	-104.7800353	1160304.59	3209967.78	Metallic Anomaly 3

Northing/Easting in U.S. State Plane NAD83 Colorado South FIPS (0503) U.S. Survey Feet

Appendix D: Test Pit Logs

Wood Environment & Infrastructure Solutions, Inc.
2000 S Colorado Blvd, Suite 2-1000
Denver, Colorado 80222-7931 USA
Telephone: (303) 935-6505

TEST PIT NO. TP-1

CLIENT BP Remediation Management Services Company
PROJECT NAME MGP Enterprises A-4 Reclamation Project
PROJECT NUMBER 32810245
PROJECT LOCATION Las Animas County, Colorado
DATE STARTED 2/10/21 **COMPLETED** 2/10/21
GROUND ELEVATION 6880 ft 0 **TEST PIT SIZE** 5 ft x 15 ft
EXCAVATION CONTRACTOR USA Environment
GROUND WATER LEVELS:
EXCAVATION METHOD CAT 336E Excavator
AT TIME OF EXCAVATION --- none
LOGGED BY A. Vega **CHECKED BY** D. Servigna
AT END OF EXCAVATION --- none
LOCATION Lat: 37.10530, Long: -104.78039
AFTER EXCAVATION --- none

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0	GB S1	SC		(SC) **CLAYEY SAND and GRAVEL**, some angular cobble sized rock fragment up to 12 inches in diameter, predominately medium grained angular sand and coarse angular gravel, some clay, homogeneous, brown to dark brown, slightly moist to moist, no apparent odor, ***FILL*** - root zone within the upper 12 inches
5	GB S2			
10				
15				
17.0				6863.0

Refusal at 17.0 feet.
Bottom of test pit at 17.0 feet.

Wood Environment & Infrastructure Solutions, Inc.
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Denver, Colorado 80222-7931 USA
Telephone: (303) 935-6505

TEST PIT NO. TP-2

CLIENT BP Remediation Management Services Company
PROJECT NAME MGP Enterprises A-4 Reclamation Project
PROJECT NUMBER 32810245
PROJECT LOCATION Las Animas County, Colorado
DATE STARTED 2/10/21 **COMPLETED** 2/10/21
GROUND ELEVATION 6880 ft 0 **TEST PIT SIZE** 3 ft x 10 ft
EXCAVATION CONTRACTOR USA Environment
GROUND WATER LEVELS:
EXCAVATION METHOD CAT 336E Excavator
AT TIME OF EXCAVATION --- none
LOGGED BY A. Vega **CHECKED BY** D. Servigna
AT END OF EXCAVATION --- none
LOCATION Lat: 37.10527, Long: -104.78034
AFTER EXCAVATION --- none

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0				(SC) **CLAYEY SAND and GRAVEL**, some angular cobbles sized rock fragments up to 12 inches in diameter, predominately medium grained angular sand and coarse angular gravel, some clay, homogeneous, brown to dark brown, slightly moist to moist, no apparent odor, ***FILL***	
	GB S1	SC		- root zone within the upper 12 inches	
5					
				8.0	6872.0
				WEATHERED SANDSTONE, highly weathered, comprised of fine grained sand, yellow-white, with thinly laminated interbeds of dark gray siltstone and silty shale, ***RATON FORMATION***	
10				10.0	6870.0

Refusal at 10.0 feet.
Bottom of test pit at 10.0 feet.

Wood Environment & Infrastructure Solutions, Inc.
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Denver, Colorado 80222-7931 USA
Telephone: (303) 935-6505

TEST PIT NO. TP-3

CLIENT BP Remediation Management Services Company
PROJECT NAME MGP Enterprises A-4 Reclamation Project
PROJECT NUMBER 32810245
PROJECT LOCATION Las Animas County, Colorado
DATE STARTED 2/10/21 **COMPLETED** 2/10/21
GROUND ELEVATION 6880 ft 0 **TEST PIT SIZE** 3 ft x 7 ft
EXCAVATION CONTRACTOR USA Environment
GROUND WATER LEVELS:
EXCAVATION METHOD CAT 336E Excavator
AT TIME OF EXCAVATION --- none
LOGGED BY A. Vega **CHECKED BY** D. Servigna
AT END OF EXCAVATION --- none
LOCATION Lat: 37.10524, Long: -104.78025
AFTER EXCAVATION --- none

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG		MATERIAL DESCRIPTION	
0						
		SC		0.5	(SC) **CLAYEY SAND and GRAVEL**, some angular cobble sized rock fragments up to 12 inches in diameter, predominately medium grained angular sand and coarse angular gravel, some clay, homogeneous, brown to dark brown, slightly moist to moist, no apparent odor, ***FILL***	6879.5
				1.5	- root zone within the upper 6 inches	6878.5
					WEATHERED SANDSTONE, highly weathered, comprised of fine grained sand, yellow-white, with thinly laminated interbeds of dark gray siltstone and silty shale, ***RATON FORMATION***	

Bottom of test pit at 1.5 feet.

Wood Environment & Infrastructure Solutions, Inc.
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Denver, Colorado 80222-7931 USA
Telephone: (303) 935-6505

TEST PIT NO. TP-4

CLIENT BP Remediation Management Services Company
PROJECT NAME MGP Enterprises A-4 Reclamation Project
PROJECT NUMBER 32810245
PROJECT LOCATION Las Animas County, Colorado
DATE STARTED 2/10/21 **COMPLETED** 2/10/21
GROUND ELEVATION 6880 ft 0 **TEST PIT SIZE** 3 ft x 10 ft
EXCAVATION CONTRACTOR USA Environment
GROUND WATER LEVELS:
EXCAVATION METHOD CAT 336E Excavator
AT TIME OF EXCAVATION --- none
LOGGED BY A. Vega **CHECKED BY** D. Servigna
AT END OF EXCAVATION --- none
LOCATION Lat: 37.10506, Long: -104.78016
AFTER EXCAVATION --- none

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0		SC		0.3 (SC) **CLAYEY SAND and GRAVEL**, some angular cobble sized rock fragments up to 12 inches in diameter, predominately medium grained angular sand and coarse angular gravel, some clay, homogeneous, brown to dark brown, slightly moist to moist, no apparent odor, ***FILL***	6879.7
				WEATHERED SANDSTONE, highly weathered, comprised of fine grained sand, yellow-white, with thinly laminated interbeds of dark gray siltstone and silty shale, ***RATON FORMATION***	
				3.0	6877.0

Refusal at 3.0 feet.
Bottom of test pit at 3.0 feet.

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Denver, Colorado 80222-7931 USA
Telephone: (303) 935-6505

TEST PIT NO. TP-5

CLIENT BP Remediation Management Services Company
PROJECT NAME MGP Enterprises A-4 Reclamation Project
PROJECT NUMBER 32810245
PROJECT LOCATION Las Animas County, Colorado
DATE STARTED 2/10/21 **COMPLETED** 2/10/21
GROUND ELEVATION 6880 ft 0 **TEST PIT SIZE** 5 ft x 15 ft
EXCAVATION CONTRACTOR USA Environment
GROUND WATER LEVELS:
EXCAVATION METHOD CAT 336E Excavator
AT TIME OF EXCAVATION --- none
LOGGED BY A. Vega **CHECKED BY** D. Servigna
AT END OF EXCAVATION --- none
LOCATION Lat: 37.10500829, Long: -104.7803467
AFTER EXCAVATION --- none

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0				
	GB S1	SC		(SC) **CLAYEY SAND and GRAVEL**, some angular cobble sized rock fragments up to 12 inches in diameter, predominately medium grained angular sand and coarse angular gravel, some clay, homogeneous, brown to dark brown, slightly moist to moist, no apparent odor, ***FILL*** - root zone within the upper 12 inches
5				
10				
10.5				6869.5

Refusal at 10.5 feet.
Bottom of test pit at 10.5 feet.

Wood Environment & Infrastructure Solutions, Inc.
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Denver, Colorado 80222-7931 USA
Telephone: (303) 935-6505

TEST PIT NO. TP-6

CLIENT BP Remediation Management Services Company
PROJECT NAME MGP Enterprises A-4 Reclamation Project
PROJECT NUMBER 32810245
PROJECT LOCATION Las Animas County, Colorado
DATE STARTED 2/10/21 **COMPLETED** 2/10/21
GROUND ELEVATION 6880 ft 0 **TEST PIT SIZE** 3 ft x 10 ft
EXCAVATION CONTRACTOR USA Environment
GROUND WATER LEVELS:
EXCAVATION METHOD CAT 336E Excavator
AT TIME OF EXCAVATION --- none
LOGGED BY A. Vega **CHECKED BY** D. Servigna
AT END OF EXCAVATION --- none
LOCATION Lat: 37.10489, Long: -104.78012
AFTER EXCAVATION --- none

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0					
		SC		(SC) **CLAYEY SAND and GRAVEL**, some angular cobble sized rock fragments up to 8 inches in diameter, predominately medium grained angular sand and coarse angular gravel, some clay, homogeneous, brown to dark brown, slightly moist to moist, no apparent odor, ***Fill***	6879.5
0.5				**WEATHERED SANDSTONE**, highly weathered with oxidation, comprised of fine grained sand, yellow-white, with thinly laminated interbeds of dark gray siltstone and silty shale, ***RATON FORMATION*** - a thick bed of black coal was encountered between 0.5 and 2.5 feet	
3.0					6877.0

Refusal at 3.0 feet.
Bottom of test pit at 3.0 feet.

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Telephone: (303) 935-6505

TEST PIT NO. TP-7

CLIENT BP Remediation Management Services Company
PROJECT NAME MGP Enterprises A-4 Reclamation Project
PROJECT NUMBER 32810245
PROJECT LOCATION Las Animas County, Colorado
DATE STARTED 2/10/21 **COMPLETED** 2/10/21
GROUND ELEVATION 6880 ft 0 **TEST PIT SIZE** 3 ft x 12 ft
EXCAVATION CONTRACTOR USA Environment
GROUND WATER LEVELS:
EXCAVATION METHOD CAT 336E Excavator
AT TIME OF EXCAVATION --- none
LOGGED BY A. Vega **CHECKED BY** D. Servigna
AT END OF EXCAVATION --- none
LOCATION Lat: 37.10481, Long: -104.78021
AFTER EXCAVATION --- none

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0				
5		SC		(SC) **CLAYEY SAND and GRAVEL**, some angular cobble sized rock fragments up to 12 inches in diameter, rare cobble sized rock fragments up to 18 inches in diameter, predominately medium grained angular sand and coarse angular gravel, some clay, homogeneous, brown to dark brown, slightly moist to moist, no apparent odor, ***FILL*** - root zone within the upper 12 inches - a 2-inch diameter metal pipe segment measuring approximately 3-foot long was encountered 12 inches beneath the ground surface
9.0				6871.0

Refusal at 9.0 feet.
Bottom of test pit at 9.0 feet.

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Denver, Colorado 80222-7931 USA
Telephone: (303) 935-6505

TEST PIT NO. TP-8

CLIENT BP Remediation Management Services Company
PROJECT NAME MGP Enterprises A-4 Reclamation Project
PROJECT NUMBER 32810245
PROJECT LOCATION Las Animas County, Colorado
DATE STARTED 2/10/21 **COMPLETED** 2/10/21
GROUND ELEVATION 6880 ft 0 **TEST PIT SIZE** 3 ft v 14 ft
EXCAVATION CONTRACTOR USA Environment
GROUND WATER LEVELS:
EXCAVATION METHOD CAT 336E Excavator
AT TIME OF EXCAVATION --- none
LOGGED BY A. Vega **CHECKED BY** D. Servigna
AT END OF EXCAVATION --- none
LOCATION Lat: 37.10473, Long: -104.78021
AFTER EXCAVATION --- none

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0				
5		SC		(SC) **CLAYEY SAND and GRAVEL**, some angular cobble sized rock fragments up to 12 inches in diameter, rare boulder sized rock fragments up to 2 feet in diameter, predominately medium grained angular sand and coarse angular gravel, some clay, homogeneous, brown to dark brown, slightly moist to moist, no apparent odor, ***FILL*** - root zone within the upper 12 inches
9.5				6870.5

Refusal at 9.5 feet.
Bottom of test pit at 9.5 feet.

Wood Environment & Infrastructure Solutions, Inc.
2000 S Colorado Blvd, Suite 2-1000
Denver, Colorado 80222-7931 USA
Telephone: (303) 935-6505

TEST PIT NO. TP-9

CLIENT BP Remediation Management Services Company
PROJECT NAME MGP Enterprises A-4 Reclamation Project
PROJECT NUMBER 32810245
PROJECT LOCATION Las Animas County, Colorado
DATE STARTED 2/10/21 **COMPLETED** 2/10/21
GROUND ELEVATION 6880 ft 0 **TEST PIT SIZE** 5 ft x 15 ft
EXCAVATION CONTRACTOR USA Environment
GROUND WATER LEVELS:
EXCAVATION METHOD CAT 336E Excavator
AT TIME OF EXCAVATION --- none
LOGGED BY A. Vega **CHECKED BY** D. Servigna
AT END OF EXCAVATION --- none
LOCATION Lat: 37.10469, Long: -104.78038
AFTER EXCAVATION --- none

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0				
	GB S1	SC		(SC) **CLAYEY SAND and GRAVEL**, some angular cobble sized rock fragments up to 12 inches in diameter, rare boulder sized rock fragments up to 2 feet in diameter, predominately medium grained angular sand and coarse angular gravel, some clay, homogeneous, brown to dark brown, slightly moist to moist, no apparent odor, ***FILL*** - root zone within the upper 12 inches
5				
	GB S2			
10				
				12.0 — 6868.0
				WEATHERED SANDSTONE, highly weathered, comprised of fine grained sand, yellow-white, with thinly laminated interbeds of dark gray siltstone and silty shale, ***RATON FORMATION***
15				
				16.0 — 6864.0

Refusal at 16.0 feet.
Bottom of test pit at 16.0 feet.

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Denver, Colorado 80222-7931 USA
Telephone: (303) 935-6505

TEST PIT NO. TP-10

CLIENT BP Remediation Management Services Company
PROJECT NAME MGP Enterprises A-4 Reclamation Project
PROJECT NUMBER 32810245
PROJECT LOCATION Las Animas County, Colorado
DATE STARTED 2/10/21 **COMPLETED** 2/10/21
GROUND ELEVATION 6880 ft 0 **TEST PIT SIZE** 3 ft x 7 ft
EXCAVATION CONTRACTOR USA Environment
GROUND WATER LEVELS:
EXCAVATION METHOD CAT 336E Excavator
AT TIME OF EXCAVATION --- none
LOGGED BY A. Vega **CHECKED BY** D. Servigna
AT END OF EXCAVATION --- none
LOCATION Lat: 37.10469, Long: -104.78002
AFTER EXCAVATION --- none

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0					
		SC		(SC) **CLAYEY SAND and GRAVEL**, some angular cobble sized rock fragments up to 8 inches in diameter, predominately medium grained angular sand and coarse angular gravel, some clay, homogeneous, brown to dark brown, slightly moist to moist, no apparent odor, ***FILL***	6879.0
				- root zone within the upper 6 inches - a studded steel T-post was encountered 6 inches beneath the ground surface	
1.0				**WEATHERED SANDSTONE**, highly weathered with oxidation, comprised of fine grained sand, yellow-white, with thinly laminated interbeds of dark gray siltstone and silty shale, ***RATON FORMATION***	
5					6875.0
5.0					

Refusal at 5.0 feet.
Bottom of test pit at 5.0 feet.

Wood Environment & Infrastructure Solutions, Inc.
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Denver, Colorado 80222-7931 USA
Telephone: (303) 935-6505

TEST PIT NO. TP-11

CLIENT BP Remediation Management Services Company
PROJECT NAME MGP Enterprises A-4 Reclamation Project
PROJECT NUMBER 32810245
PROJECT LOCATION Las Animas County, Colorado
DATE STARTED 2/10/21 **COMPLETED** 2/10/21
GROUND ELEVATION 6880 ft 0 **TEST PIT SIZE** 5 ft x 15 ft
EXCAVATION CONTRACTOR USA Environment
GROUND WATER LEVELS:
EXCAVATION METHOD CAT 336E Excavator
AT TIME OF EXCAVATION --- none
LOGGED BY A. Vega **CHECKED BY** D. Servigna
AT END OF EXCAVATION --- none
LOCATION Lat: 37.10458, Long: -104.78016
AFTER EXCAVATION --- none

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0				(SC) **CLAYEY SAND and GRAVEL**, some angular cobble sized rock fragments up to 12 inches in diameter, occasional boulder sized rock fragments up to 4 feet in diameter, predominately medium grained angular sand and coarse angular gravel, some clay, homogeneous, brown to dark brown, slightly moist to moist, no apparent odor, ***FILL*** - root zone within the upper 12 inches	
	GB S1				
5		SC			
	GB S2				
10				10.0	6870.0
				WEATHERED SANDSTONE, highly weathered, comprised of fine grained sand, yellow-white, with thinly laminated interbeds of dark gray siltstone and silty shale, ***RATON FORMATION***	
				12.0	6868.0
15					

Refusal at 17.0 feet.
Bottom of test pit at 17.0 feet.

Appendix E: Laboratory Test Results

Advanced Terra Testing
833 Parfet Street Unit A
Lakewood, Co 80215
303-232-8308

ATT Job No.: 3098-003

Date: March 20, 2021

Company: WOOD

Address:

RE: Soil Testing

Dear Alex Vega ,

With this letter you will find a report on soil samples from the MGP Enterprise A-4 Reclamation project. Samples were received at our laboratory on Thursday, February 18, 2021 and testing was performed in accordance with standardized test methods, accepted industry practices as well as specific instructions received from you, our client. Advanced Terra Testing accepts no responsibility and makes no claims to the use or purpose of the material being tested. Furthermore, the results herein are based solely on the material received and tested. **Please note that all material will be disposed of after sixty days unless other arrangements are made.**

We respectfully request that sample reports be considered proprietary information and are not to be reproduced, except in full and only with prior written approval of Advanced Terra Testing. We are pleased to have been given the opportunity to perform the highest quality laboratory testing industry can offer. We sincerely hope the results herein provide you with all the information required. If you have questions or need anything further, please reach out and we will be happy to assist you.

Respectfully,

Kerry Repola, Soils Division Manager & Owner

Moisture
ASTM D 2216

CLIENT	Wood	JOB NO.	3098-003
PROJECT	MGP Enterprise A-4 Reclamation Plan Development	LOCATION	--
PROJECT NO.	32820182		

BORING NO.	TP-1	TP-5	TP-11
DEPTH			
SAMPLE NO.	S1	S1	S2
DATE SAMPLED	2/10/21	2/10/21	2/10/21
DATE TESTED	03/04/21	03/04/21	03/04/21
TECHNICIAN	BDF	BDF	BDF
DESCRIPTION			
Mass of Wet Soil and Pan (g):	776.17	1132.80	1660.60
Mass of Dry Soil and Pan (g):	676.79	1015.25	1536.30
Mass of Pan (g):	14.30	114.49	248.55
Moisture (%):	**15.0**	**13.1**	**9.7**

BORING NO.	
DEPTH	
SAMPLE NO.	
DATE SAMPLED	
DATE TESTED	
TECHNICIAN	
DESCRIPTION	
Mass of Wet Soil and Pan (g):	
Mass of Dry Soil and Pan (g):	
Mass of Pan (g):	
Moisture (%):	

BORING NO.	
DEPTH	
SAMPLE NO.	
DATE SAMPLED	
DATE TESTED	
TECHNICIAN	
DESCRIPTION	
Mass of Wet Soil and Pan (g):	
Mass of Dry Soil and Pan (g):	
Mass of Pan (g):	
Moisture (%):	

NOTES	

Data entry by:	KMS	Date:	3/16/2021
Checked by:	KR	Date:	03/16/21
File name:	3098003__Moisture ASTM D2216_0.xlsm		

ADVANCED TERRA TESTING

Grain Size Analysis
ASTM D 6913

CLIENT	Wood	BORING NO.	TP-1
JOB NO.	3098-003	DEPTH	--
PROJECT	MGP Enterprise A-4 Reclamation Plan Development	SAMPLE NO.	S1
PROJECT NO.	32820182	DATE SAMPLED	02/10/21
LOCATION	--	DESCRIPTION	--
DATE TESTED	03/09/21		
TECHNICIAN	LOG		

Hygroscopic Moisture of Fines

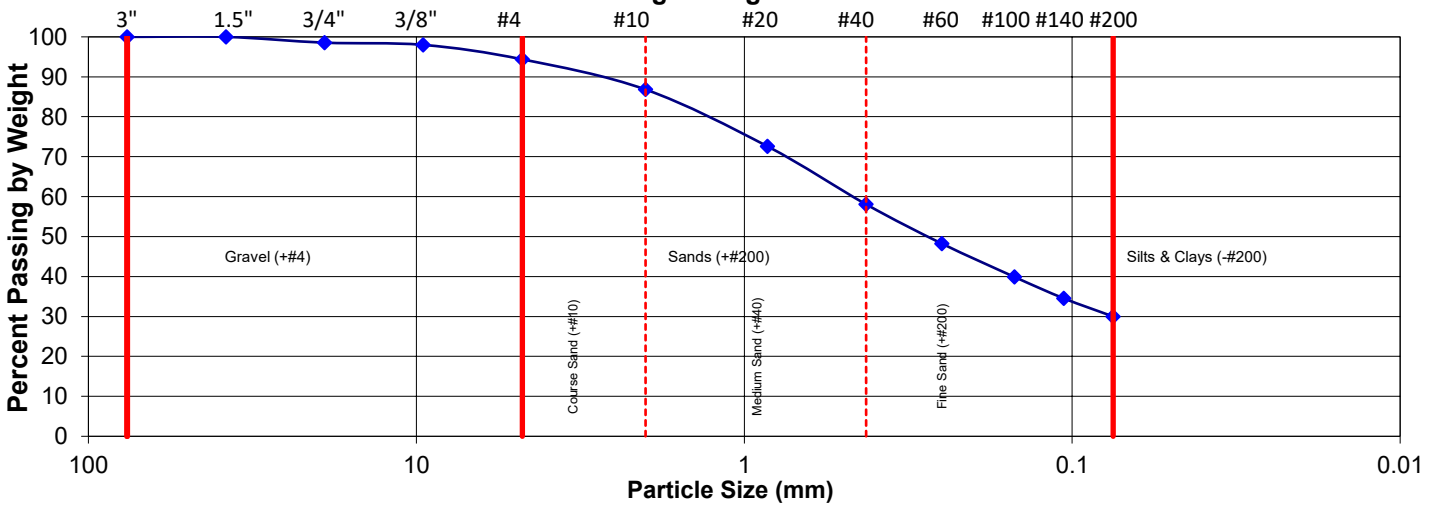
Mass Wet Pan and Soil (g): 787.24
Mass Dry Pan and Soil (g): 711.12
Mass of Pan (g): 163.89
Moisture (%): **13.9**

Sample Data

Total Wet Mass of Sample (g): 20440.2
Total Dry Mass of Sample (g): 17988.3
Split Fraction: 3/8"
Mass of Sub-Sample Fraction (g): 623.35

Sieve Number	Sieve Size (mm)	Mass of Pan and Soil (g)	Mass of Pan (g)	Mass of Individual Retained Soil (g)	Correction Factor	Percent Passing by Weight (%)
3"	76.2	--	--	--	--	**--**
1.5"	38.1	--	--	--	--	**--**
3/4"	19.05	261.6	--	261.6	1.00	**98.5**
3/8"	9.53	99.2	--	99.2	1.00	**98.0**
#4	4.75	20.2	--	20.2	0.98	**94.4**
#10	2.00	42.2	--	42.2	0.98	**86.8**
#20	0.850	79.4	--	79.4	0.98	**72.6**
#40	0.425	81.1	--	81.1	0.98	**58.1**
#60	0.250	54.8	--	54.8	0.98	**48.3**
#100	0.150	46.8	--	46.8	0.98	**39.9**
#140	0.106	30.0	--	30.0	0.98	**34.5**
#200	0.075	25.3	--	25.3	0.98	**30.0**

Percent Passing vs Log of Particle Size



USCS Classification ASTM D 2487

Atterberg Classification: CL
Group Symbol: SC
USCS Classification: Clayey Sand

Coefficient of Curvature - C_c: --
Coefficient of Uniformity - C_u: --

Data entry by:	BDF	Date:	03/16/21
Checked by:	LOG	Date:	03/16/21
File name:	3098003__Grain Size Analysis ASTM D6913_3.xlsm		

ADVANCED TERRA TESTING

Grain Size Analysis
ASTM D 6913

CLIENT	Wood	BORING NO.	TP-5
JOB NO.	3098-003	DEPTH	--
PROJECT	MGP Enterprise A-4 Reclamation Plan Development	SAMPLE NO.	S1
PROJECT NO.	32820182	DATE SAMPLED	02/10/21
LOCATION	--	DESCRIPTION	--
DATE TESTED	03/09/21		
TECHNICIAN	LOG		

Hygroscopic Moisture of Fines

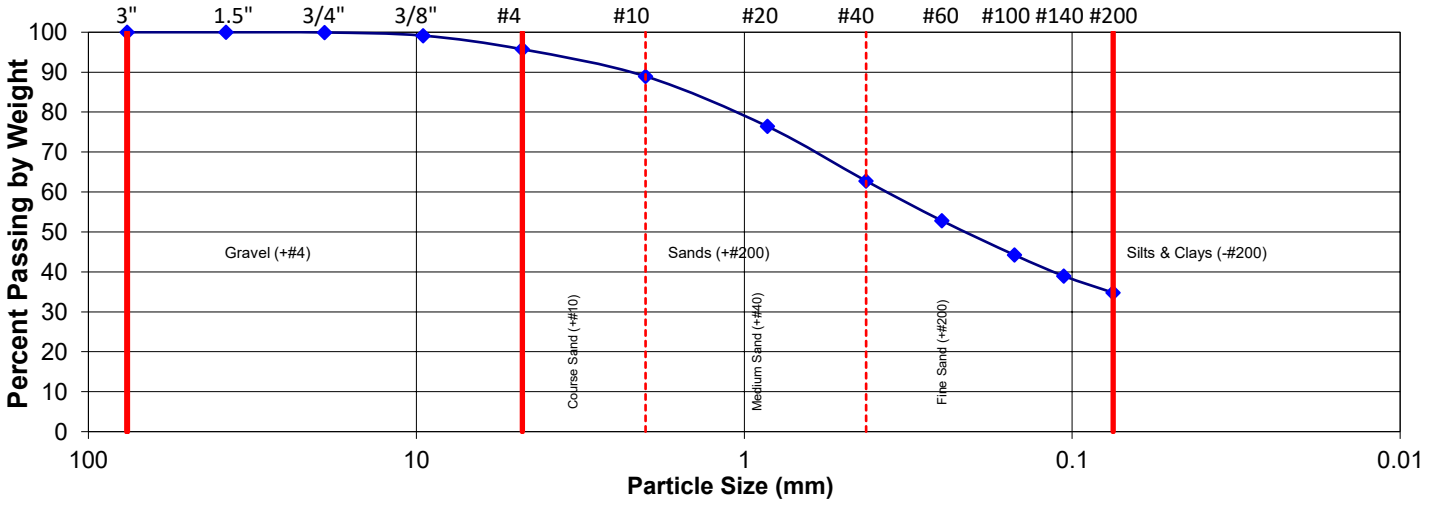
Mass Wet Pan and Soil (g): 942.82
Mass Dry Pan and Soil (g): 866.09
Mass of Pan (g): 221.44
Moisture (%): **11.9**

Sample Data

Total Wet Mass of Sample (g): 19243.1
Total Dry Mass of Sample (g): 17212.0
Split Fraction: 3/8"
Mass of Sub-Sample Fraction (g): 721.38

Sieve Number	Sieve Size (mm)	Mass of Pan and Soil (g)	Mass of Pan (g)	Mass of Individual Retained Soil (g)	Correction Factor	Percent Passing by Weight (%)
3"	76.2	--	--	--	--	**--**
1.5"	38.1	0.0	--	--	--	**--**
3/4"	19.05	9.5	--	9.5	1.00	**99.9**
3/8"	9.53	138.3	--	138.3	1.00	**99.1**
#4	4.75	22.2	--	22.2	0.99	**95.7**
#10	2.00	44.0	--	44.0	0.99	**89.0**
#20	0.850	81.5	--	81.5	0.99	**76.4**
#40	0.425	88.9	--	88.9	0.99	**62.8**
#60	0.250	64.5	--	64.5	0.99	**52.8**
#100	0.150	56.0	--	56.0	0.99	**44.2**
#140	0.106	34.3	--	34.3	0.99	**39.0**
#200	0.075	27.3	--	27.3	0.99	**34.8**

Percent Passing vs Log of Particle Size



USCS Classification ASTM D 2487

Atterberg Classification: CL
Group Symbol: SC
USCS Classification: Clayey Sand

Coefficient of Curvature - C_c: --
Coefficient of Uniformity - C_u: --

Data entry by:	LOG	Date:	03/12/21
Checked by:	BDF	Date:	03/16/21
File name:	3098003__Grain Size Analysis ASTM D6913_1.xlsm		

ADVANCED TERRA TESTING

Grain Size Analysis
ASTM D 6913

CLIENT	Wood	BORING NO.	TP-11
JOB NO.	3098-003	DEPTH	--
PROJECT	MGP Enterprise A-4 Reclamation Plan Development	SAMPLE NO.	S2
PROJECT NO.	32820182	DATE SAMPLED	02/10/21
LOCATION	--	DESCRIPTION	--
DATE TESTED	03/09/21		
TECHNICIAN	LOG		

Hygroscopic Moisture of Fines

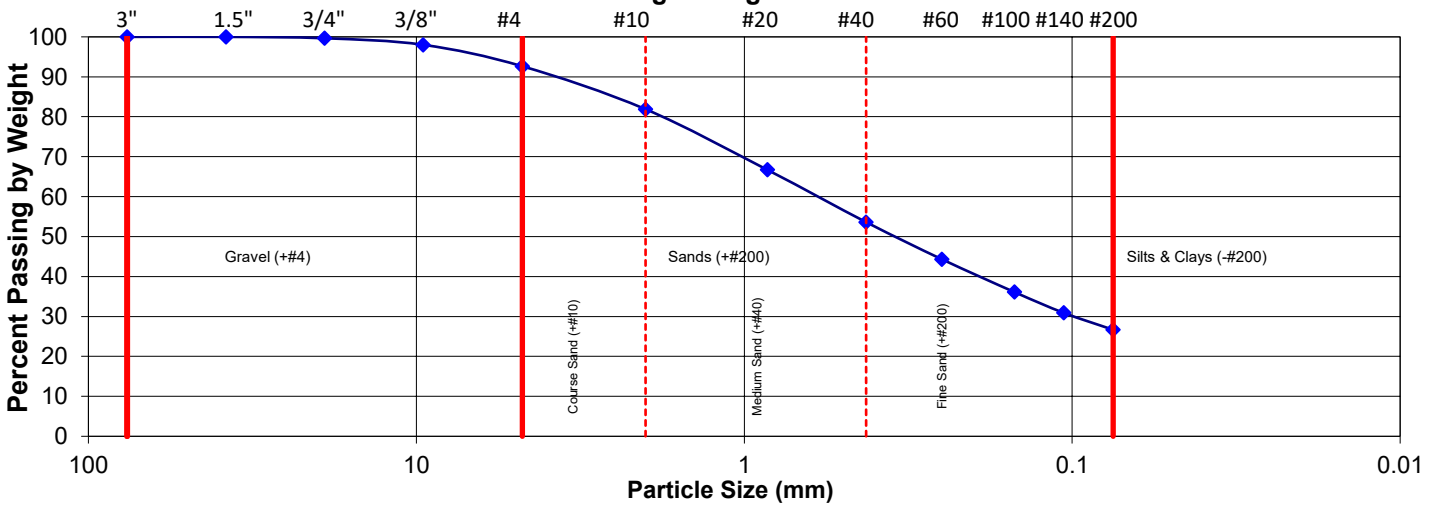
Mass Wet Pan and Soil (g): 771.56
Mass Dry Pan and Soil (g): 724.52
Mass of Pan (g): 172.43
Moisture (%): **8.5**

Sample Data

Total Wet Mass of Sample (g): 22492.4
Total Dry Mass of Sample (g): 20758.9
Split Fraction: 3/8"
Mass of Sub-Sample Fraction (g): 599.13

Sieve Number	Sieve Size (mm)	Mass of Pan and Soil (g)	Mass of Pan (g)	Mass of Individual Retained Soil (g)	Correction Factor	Percent Passing by Weight (%)
3"	76.2	--	--	--	--	**--**
1.5"	38.1	--	--	--	--	**--**
3/4"	19.05	72.1	--	72.1	1.00	**99.7**
3/8"	9.53	341.1	--	341.1	1.00	**98.0**
#4	4.75	30.3	--	30.3	0.98	**92.6**
#10	2.00	60.5	--	60.5	0.98	**81.9**
#20	0.850	85.6	--	85.6	0.98	**66.7**
#40	0.425	73.7	--	73.7	0.98	**53.6**
#60	0.250	52.2	--	52.2	0.98	**44.3**
#100	0.150	46.4	--	46.4	0.98	**36.1**
#140	0.106	29.4	--	29.4	0.98	**30.9**
#200	0.075	23.8	--	23.8	0.98	**26.7**

Percent Passing vs Log of Particle Size



USCS Classification ASTM D 2487

Atterberg Classification: CL
Group Symbol: SC
USCS Classification: Clayey Sand

Coefficient of Curvature - C_c: --
Coefficient of Uniformity - C_u: --

Data entry by:	DPM	Date:	03/12/21
Checked by:	ALH	Date:	03/12/21
File name:	3098003__Grain Size Analysis ASTM D6913_2.xlsm		

ADVANCED TERRA TESTING

Grain Size Analysis
ASTM D 6913

CLIENT	Wood	BORING NO.	TP-1 S1, TP-5 S1, TP-11 S1&S2
JOB NO.	3098-003	DEPTH	Composite
PROJECT	MGP Enterprise A-4 Reclamation Plan Development	SAMPLE NO.	--
PROJECT NO.	32820182	DATE SAMPLED	02/10/21
LOCATION	--	DESCRIPTION	--
DATE TESTED	03/10/21		
TECHNICIAN	LOG		

Hygroscopic Moisture of Fines

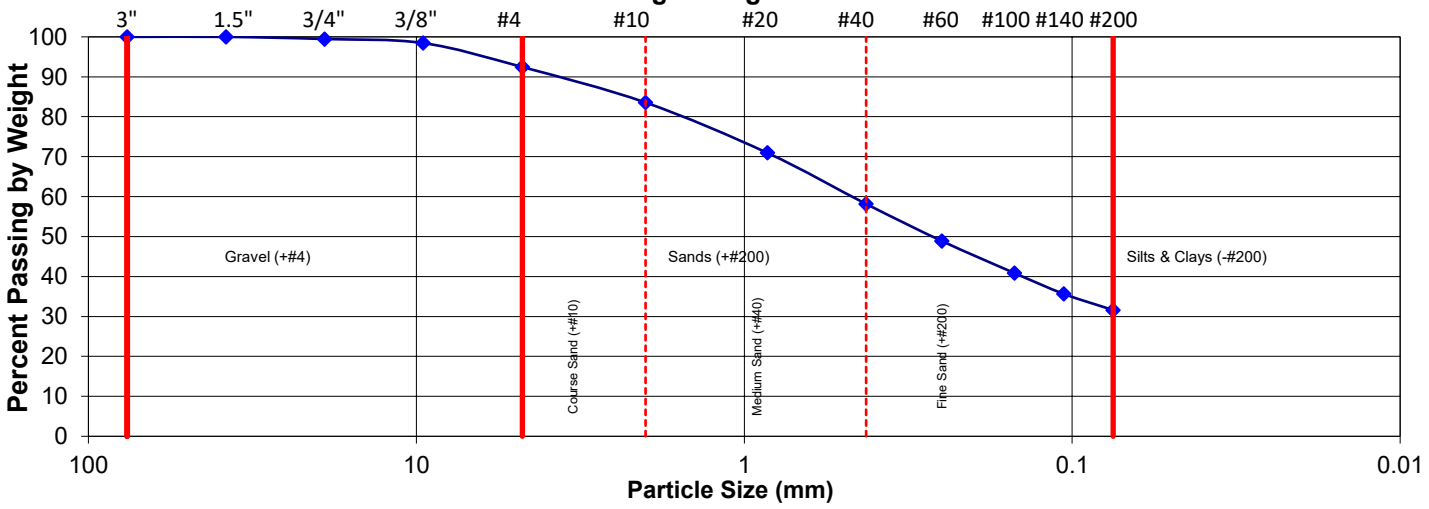
Mass Wet Pan and Soil (g): 781.76
Mass Dry Pan and Soil (g): 724.17
Mass of Pan (g): 171.20
Moisture (%): **10.4**

Sample Data

Total Wet Mass of Sample (g): 85491.0
Total Dry Mass of Sample (g): 77541.2
Split Fraction: 3/8"
Mass of Sub-Sample Fraction (g): 610.56

Sieve Number	Sieve Size (mm)	Mass of Pan and Soil (g)	Mass of Pan (g)	Mass of Individual Retained Soil (g)	Correction Factor	Percent Passing by Weight (%)
3"	76.2	--	--	--	--	**--**
1.5"	38.1	--	--	--	--	**--**
3/4"	19.05	417.9	--	417.9	1.00	**99.5**
3/8"	9.53	791.3	--	791.3	1.00	**98.4**
#4	4.75	33.7	--	33.7	0.98	**92.4**
#10	2.00	49.9	--	49.9	0.98	**83.6**
#20	0.850	70.8	--	70.8	0.98	**70.9**
#40	0.425	71.8	--	71.8	0.98	**58.2**
#60	0.250	52.1	--	52.1	0.98	**48.9**
#100	0.150	45.1	--	45.1	0.98	**40.9**
#140	0.106	29.3	--	29.3	0.98	**35.6**
#200	0.075	22.8	--	22.8	0.98	**31.6**

Percent Passing vs Log of Particle Size



USCS Classification ASTM D 2487

Atterberg Classification: CL
Group Symbol: SC
USCS Classification: Clayey Sand

Coefficient of Curvature - C_c: --
Coefficient of Uniformity - C_u: --

Data entry by:	DPM	Date:	03/12/21
Checked by:	LOG	Date:	03/16/21
File name:	3098003__Grain Size Analysis ASTM D6913_0.xlsm		

ADVANCED TERRA TESTING

Atterberg Limits
ASTM D 4318

CLIENT	Wood	BORING NO.	TP-1
JOB NO.	3098-003	DEPTH	--
PROJECT	MGP Enterprise A-4 Reclamation Plan Development	SAMPLE NO.	S1
PROJECT NO.	32820182	DATE SAMPLED	02/10/21
LOCATION	--	SAMPLED BY	--
DATE TESTED	03/11/21	DESCRIPTION	--
TECHNICIAN	ALH		

Plastic Limits

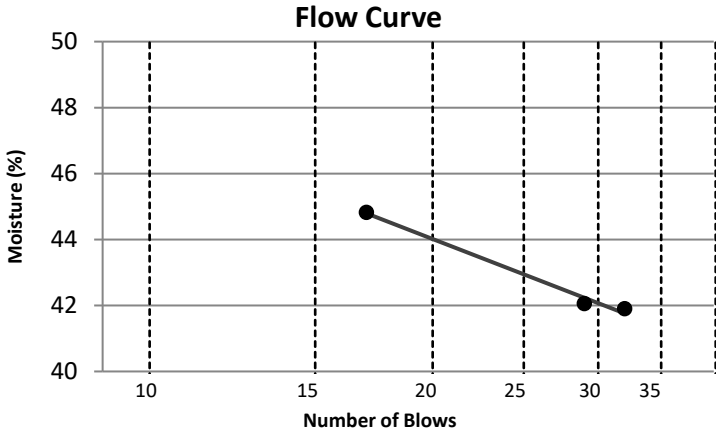
Mass of Wet Pan and Soil (g):	8.58	8.61
Mass of Dry Pan and Soil (g):	7.05	7.11
Mass of Pan (g):	1.04	1.14
Moisture (%)	**25.4**	**25.0**

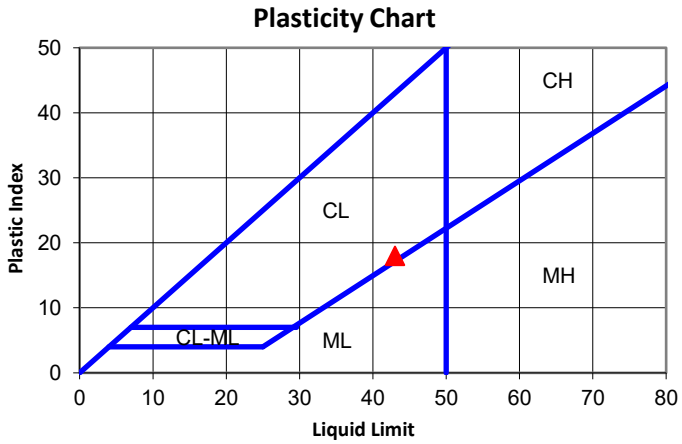
Liquid Limits

Number of Blows	17	29	32
Mass of Wet Pan and Soil (g):	9.29	9.96	9.67
Mass of Dry Pan and Soil (g):	6.75	7.33	7.13
Mass of Pan (g):	1.08	1.09	1.08
Moisture (%)	**44.8**	**42.1**	**41.9**

Plastic Index

Plastic Limit:	**25**	Atterberg Classification:	CL
Liquid Limit:	**43**	Method:	A
Plastic Index:	**18**		





NOTES

Data entry by:	ALH	Date:	03/12/21
Checked by:	LOG	Date:	03/12/21
File name:	3098003__Atterberg ASTM D4318_0.xlsm		

ADVANCED TERRA TESTING

Atterberg Limits
ASTM D 4318

CLIENT	Wood	BORING NO.	TP-5
JOB NO.	3098-003	DEPTH	--
PROJECT	MGP Enterprise A-4 Reclamation Plan Development	SAMPLE NO.	S1
PROJECT NO.	32820182	DATE SAMPLED	02/10/21
LOCATION	--	SAMPLED BY	--
DATE TESTED	03/11/21	DESCRIPTION	--
TECHNICIAN	ALH		

Plastic Limits

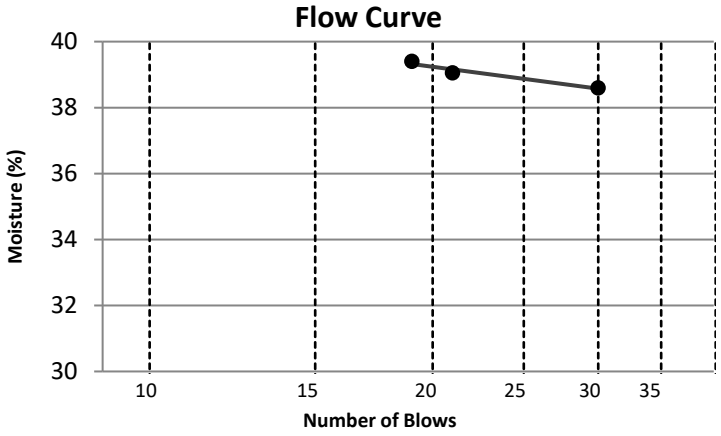
Mass of Wet Pan and Soil (g):	8.61	8.71
Mass of Dry Pan and Soil (g):	7.23	7.34
Mass of Pan (g):	1.09	1.15
Moisture (%)	**22.4**	**22.1**

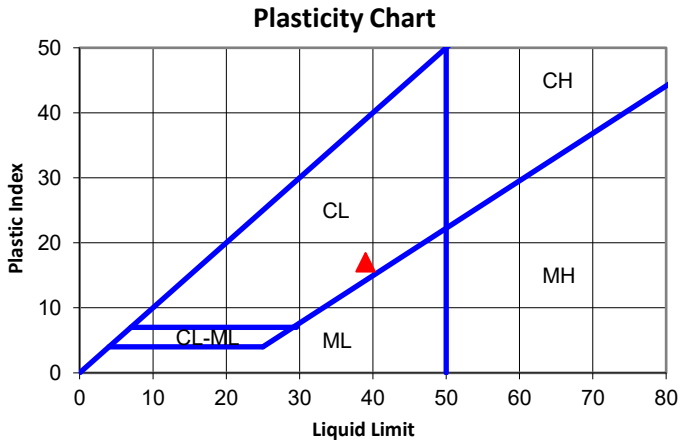
Liquid Limits

Number of Blows	19	21	30
Mass of Wet Pan and Soil (g):	11.99	11.64	11.82
Mass of Dry Pan and Soil (g):	8.93	8.68	8.84
Mass of Pan (g):	1.15	1.10	1.10
Moisture (%)	**39.4**	**39.1**	**38.6**

Plastic Index

Plastic Limit:	**22**	Atterberg Classification:	CL
Liquid Limit:	**39**	Method:	A
Plastic Index:	**17**		





NOTES

Data entry by:	ALH	Date:	03/12/21
Checked by:	LOG	Date:	03/12/21
File name:	3098003__Atterberg ASTM D4318_3.xlsm		

ADVANCED TERRA TESTING

Atterberg Limits
ASTM D 4318

CLIENT	Wood	BORING NO.	TP-11
JOB NO.	3098-003	DEPTH	--
PROJECT	MGP Enterprise A-4 Reclamation Plan Development	SAMPLE NO.	S2
PROJECT NO.	32820182	DATE SAMPLED	02/10/21
LOCATION	--	SAMPLED BY	--
DATE TESTED	03/11/21	DESCRIPTION	--
TECHNICIAN	ALH		

Plastic Limits

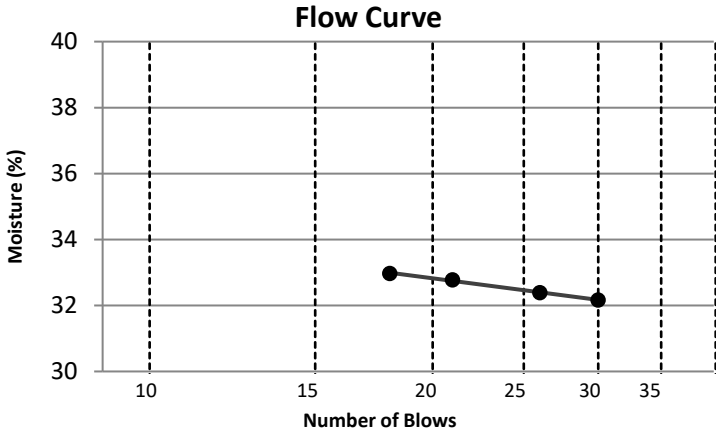
Mass of Wet Pan and Soil (g):	8.68	8.40
Mass of Dry Pan and Soil (g):	7.35	7.13
Mass of Pan (g):	1.11	1.00
Moisture (%)	**21.3**	**20.8**

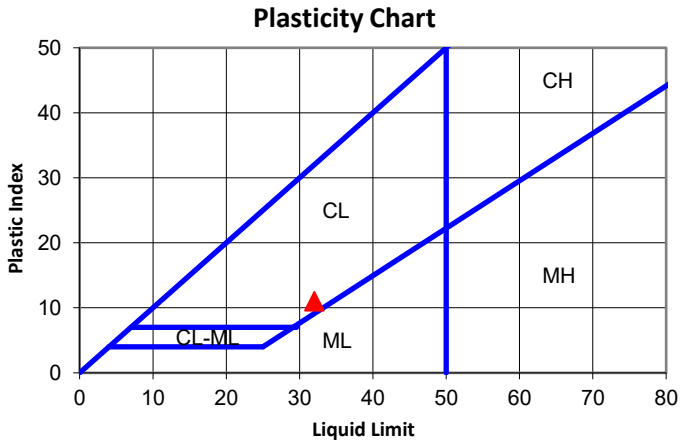
Liquid Limits

Number of Blows	18	21	26	30
Mass of Wet Pan and Soil (g):	9.13	9.05	9.28	9.75
Mass of Dry Pan and Soil (g):	7.14	7.09	7.29	7.65
Mass of Pan (g):	1.13	1.09	1.14	1.14
Moisture (%)	**33.0**	**32.8**	**32.4**	**32.2**

Plastic Index

Plastic Limit:	**21**	Atterberg Classification:	CL
Liquid Limit:	**32**	Method:	A
Plastic Index:	**11**		





NOTES

Data entry by:	LOG	Date:	03/12/21
Checked by:	ALH	Date:	03/12/21
File name:	3098003__Atterberg ASTM D4318_4.xlsm		

ADVANCED TERRA TESTING

Atterberg Limits
ASTM D 4318

CLIENT	Wood	BORING NO.	TP-1 S1, TP-5 S1, TP-11 S1 & S2
JOB NO.	3098-003	DEPTH	Composite
PROJECT	MGP Enterprise A-4 Reclamation Plan Development	SAMPLE NO.	--
PROJECT NO.	32820182	DATE SAMPLED	02/10/21
LOCATION	--	SAMPLED BY	--
DATE TESTED	03/11/21	DESCRIPTION	--
TECHNICIAN	ALH		

Plastic Limits

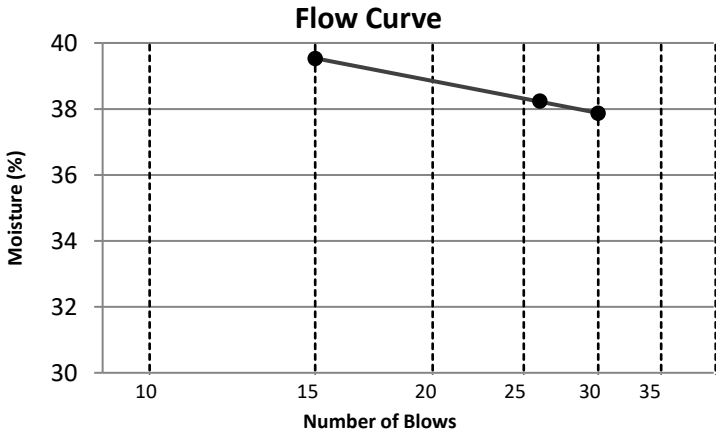
Mass of Wet Pan and Soil (g):	8.71	8.69
Mass of Dry Pan and Soil (g):	7.35	7.35
Mass of Pan (g):	1.10	1.10
Moisture (%)	**21.7**	**21.5**

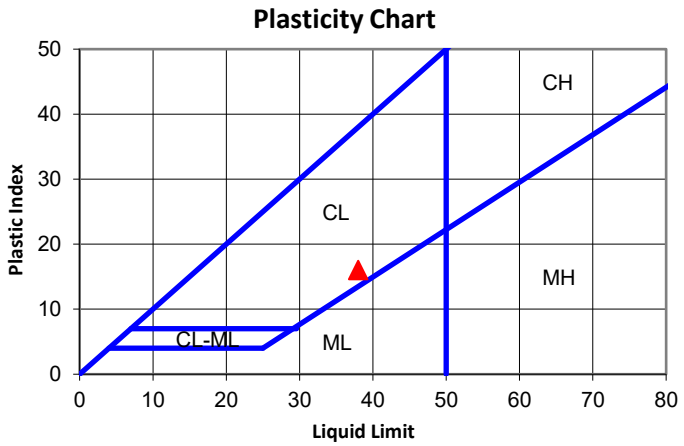
Liquid Limits

Number of Blows	15	26	30
Mass of Wet Pan and Soil (g):	11.28	10.77	10.84
Mass of Dry Pan and Soil (g):	8.40	8.09	8.16
Mass of Pan (g):	1.13	1.08	1.10
Moisture (%)	**39.5**	**38.2**	**37.9**

Plastic Index

Plastic Limit:	**22**	Atterberg Classification:	CL
Liquid Limit:	**38**	Method:	A
Plastic Index:	**16**		





NOTES

Data entry by:	LOG	Date:	03/12/21
Checked by:	ALH	Date:	03/12/21
File name:	3098003__Atterberg ASTM D4318_2.xlsm		

Laboratory Compaction Characteristics

ASTM D698

CLIENT	Wood	BORING NO.	TP-1 S1, TP-5 S1, TP-11 S1 & S2
JOB NO.	3098-003	DEPTH	Composite
PROJECT	MGP Enterprise A-4 Reclamation Plan Development	SAMPLE NO.	-
PROJECT NO.	32820182	DATE SAMPLED	02/10/21
LOCATION	--	DESCRIPTION	--
DATE TESTED	03/10/21		
TECHNICIAN	JL, BDF		

Laboratory Compaction Characteristics

Hygroscopic Moisture

Mass of Wet Pan and Soil (g):	781.76
Mass of Dry Pan and Soil (g):	724.17
Mass of Pan (g):	171.20
Moisture (%):	10.4

Rock Correction ASTM D 4718

Method:	B
Course Fraction (%):	2.0
Rock Correction Applied:	NO
Mass of Dry Aggregate (g):	--
Mass of SSD Aggregate (g):	--
Mass of Aggregate in Water (g):	--
Rock Specific Gravity:	N/A
Zero Air Voids Specific Gravity:	2.65

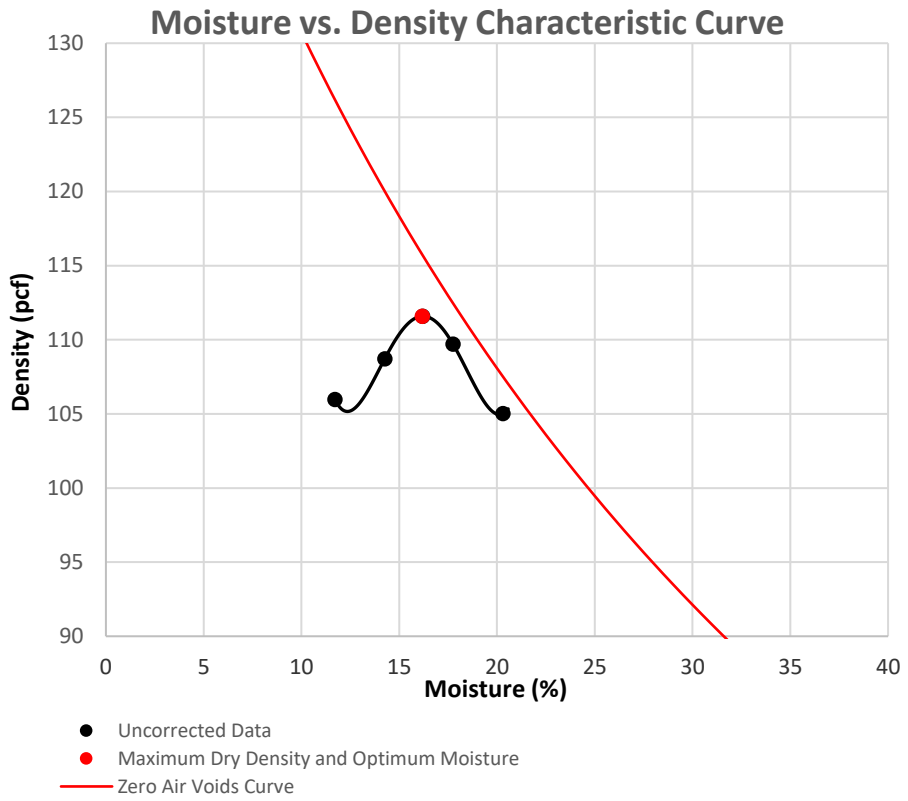
Optimum Dry Density and Moisture

Uncorrected

Dry Density (pcf):	**111.6**
Dry Density (kg/m³):	**1787**
Moisture (%):	**16.2**

Corrected

Dry Density (pcf):	**N/A**
Dry Density (kg/m³):	**N/A**
Moisture (%):	**N/A**



Sample Number:	1	2	3	4	5
Mass of Wet Pan and Soil (g):	205.76	260.54	237.78	235.02	442.16
Mass of Dry Soil and Pan (g):	178.02	222.29	208.94	196.47	396.48
Mass of Pan (g);	6.69	6.76	6.69	6.69	6.68
Moisture (%):	16.2	17.7	14.3	20.3	11.7
Mass of Wet Soil and Mold (g):	6534.3	6527.2	6452.1	6484.4	6363.9
Mass of Mold (g):	4574.0	4574.0	4574.0	4574.0	4574.0
Wet Density (pcf):	129.7	129.2	124.2	126.4	118.4
Dry Density (pcf):	111.6	109.7	108.7	105.0	106.0
Wet Density (kg/m³):	2077	2069	1990	2024	1896
Dry Density (kg/m³):	1787	1757	1741	1682	1697

Data entry by: JL Date: 03/11/21
Checked by: BDF Date: 03/11/21
File name: 3098003__compaction ASTM D698 D1557_0.xlsm

ADVANCED TERRA TESTING

Direct Shear

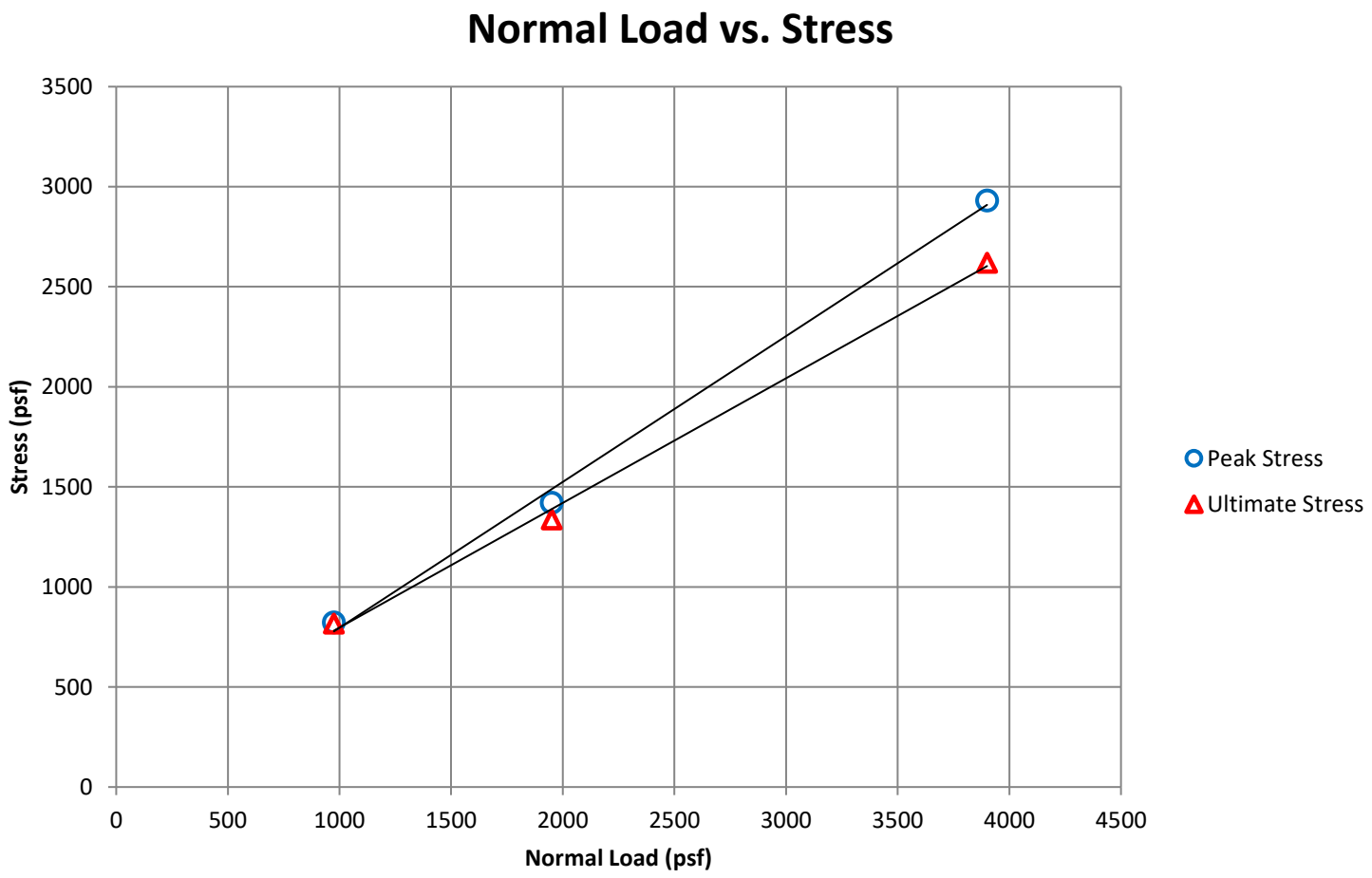
ASTM D 3080

CLIENT	Wood	BORING NO.	TP-1 S1, TP-5 S1, TP-11 S1 & S2
JOB NO.	3098-003	DEPTH	Composite
PROJECT	MGP Enterprise A-4 Reclamation	SAMPLE NO.	--
PROJECT NO.	32820182	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	Remolded 4X4 Box
DATE TESTED	03/17/21		
TECHNICIAN	DPM		

Direct Shear Results

Point:	A	B	C
Normal Load (psf):	3900	1950	975
Normal Load (kPa):	186.7	93.4	46.7
Peak Strength (psf):	2931	1421	823
Ultimate Strength (psf):	2620	1337	816
Peak Strength (kPa):	140.4	68.0	39.4
Ultimate Strength (kPa):	125.5	64.0	39.1

Peak Strength		Ultimate Strength	
Friction Angle:	36.1	Friction Angle:	31.9
Cohesion (psf):	68	Cohesion (psf):	174
Cohesion (kPa):	3.2	Cohesion (kPa):	8.4



Data entry by:	WAR	Date: 03/20/21
Checked by:	MLM	Date: 03/20/21
File name:	3098003__Direct Shear ASTM D3080_0.xlsm	Page 1 of 2

ADVANCED TERRA TESTING

Direct Shear

ASTM D 3080

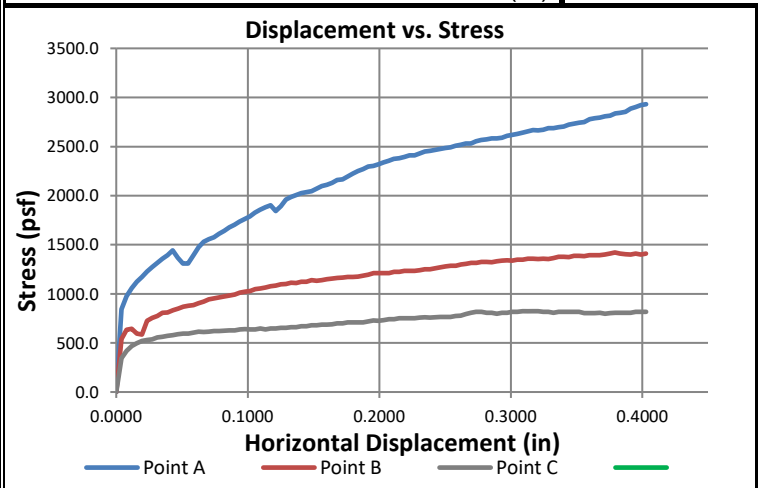
CLIENT	Wood	BORING NO.	TP-1 S1, TP-5 S1, TP-11 S1 & S2
JOB NO.	3098-003	DEPTH	Composite
PROJECT	MGP Enterprise A-4 Reclamation	SAMPLE NO.	--
PROJECT NO.	32820182	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	Remolded 4X4 Box
DATE TESTED	03/17/21		
TECHNICIAN	DPM		

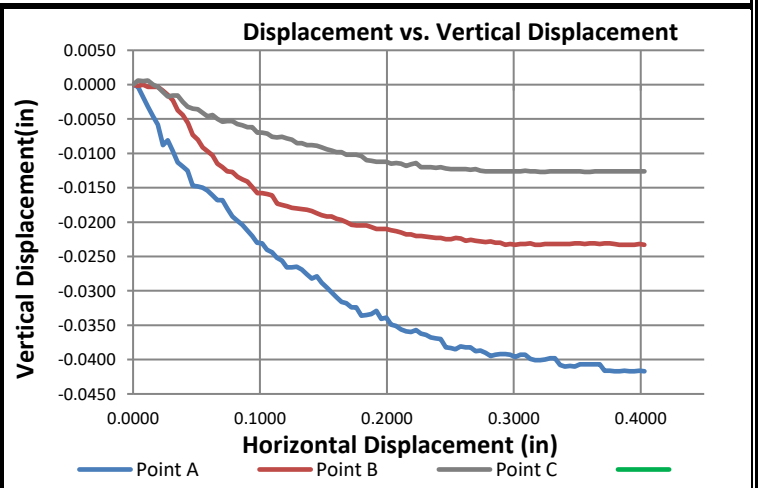
Test Parameters

Displacement Rate (in/min): 0.003 Displacement Rate (cm/min): 0.00762

Raw Data Files: Wood_DS_TP-151-451-_Comp__A.txt, Wood_DS_TP-151-451-1051-1052_Comp__B.txt, Wood_DS_tp-151-451-1051-1052_comp__c.txt,

Before Test Mass of Wet Soil and Ring (g):	3690.90	2936.70	2935.70
After Test Mass of Wet Soil and Pan (g):	1224.81	1243.24	1248.56
Mass of Dry Soil and Pan (g):	1078.33	1084.61	1076.32
Mass of Ring (g):	2709.00	1955.60	1954.40
Mass of Pan (g):	227.81	232.86	232.58
Diameter (in):	4"X4" Box	4"X4" Box	4"X4" Box
Initial Height (in):	2.00	2.00	2.00
Height Change (in):	0.0969	0.0403	0.0179
Area (in²):	16.00	16.00	16.00
Initial Wet Density (pcf):	116.9	116.8	116.8
Initial Dry Density (pcf):	101.3	101.4	100.4
Initial Wet Density (kg/m³):	1872	1871	1871
Initial Dry Density (kg/m³):	1622	1624	1609
Initial Moisture (%):	15.4	15.2	16.3
Final Wet Density (pcf):	124.7	122.8	122.0
Final Dry Density (pcf):	106.4	103.5	101.4
Final Wet Density (kg/m³):	1998	1966	1955
Final Dry Density (kg/m³):	1705	1658	1624
Final Moisture (%):	17.2	18.6	20.4





NOTES: Ultimate strength taken at 0.3" of displacement

File name: 3098003__Direct Shear ASTM D3080_0.xlsm

Direct Shear Data
ASTM D3080

CLIENT	Wood	BORING NO.	TP-1 S1, TP-5 S1, TP-11 S1 & S2
JOB NO.	3098-003	DEPTH	Composite
PROJECT	MGP Enterprise A-4 Reclamation	SAMPLE NO.	--
PROJECT NO.	32820182.0000	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	Remolded 4X4 Box
DATE TESTED	03/17/21		
TECHNICIAN	DPM		

Point A			Point B			Point C		
Displacement (in)	Stress (psf)	Vertical Displacment (in)	Displacement (in)	Stress (psf)	Vertical Displacment (in)	Displacement (in)	Stress (psf)	Vertical Displacment (in)
0.0000	0.0	0.0000	0.0000	0.0	0.0000	0.0000	0.0	0.0000
0.0039	843.2	-0.0003	0.0039	539.2	-0.0002	0.0039	343.3	0.0006
0.0078	975.2	-0.0018	0.0078	632.9	0.0000	0.0078	419.9	0.0005
0.0117	1056.9	-0.0032	0.0117	643.0	-0.0003	0.0117	469.4	0.0006
0.0156	1123.4	-0.0046	0.0156	594.4	-0.0003	0.0156	495.9	0.0000
0.0196	1173.4	-0.0058	0.0196	586.7	-0.0003	0.0195	519.4	-0.0003
0.0235	1226.1	-0.0088	0.0235	724.5	-0.0009	0.0234	529.5	-0.0010
0.0274	1272.7	-0.0081	0.0274	753.2	-0.0015	0.0273	537.1	-0.0017
0.0313	1316.5	-0.0097	0.0313	774.7	-0.0023	0.0313	554.4	-0.0016
0.0352	1357.2	-0.0113	0.0352	805.9	-0.0037	0.0352	562.2	-0.0016
0.0391	1393.9	-0.0119	0.0391	811.5	-0.0044	0.0391	571.5	-0.0025
0.0430	1442.3	-0.0125	0.0431	833.0	-0.0056	0.0430	579.7	-0.0032
0.0469	1368.6	-0.0147	0.0470	849.2	-0.0073	0.0469	587.7	-0.0035
0.0508	1309.1	-0.0148	0.0509	870.1	-0.0080	0.0509	594.7	-0.0036
0.0547	1309.1	-0.0150	0.0548	880.1	-0.0091	0.0548	595.6	-0.0041
0.0586	1393.8	-0.0154	0.0587	884.0	-0.0097	0.0587	604.0	-0.0046
0.0625	1476.6	-0.0161	0.0626	905.7	-0.0103	0.0626	614.0	-0.0044
0.0665	1529.6	-0.0168	0.0665	921.9	-0.0115	0.0665	612.7	-0.0050
0.0704	1556.3	-0.0168	0.0704	942.6	-0.0120	0.0704	613.4	-0.0054
0.0743	1575.2	-0.0180	0.0743	953.6	-0.0126	0.0743	621.9	-0.0053
0.0782	1613.3	-0.0192	0.0783	963.3	-0.0127	0.0782	622.1	-0.0053
0.0821	1640.2	-0.0198	0.0822	974.7	-0.0134	0.0821	622.8	-0.0057
0.0860	1677.2	-0.0204	0.0861	984.2	-0.0138	0.0860	628.8	-0.0059
0.0899	1704.2	-0.0212	0.0900	991.4	-0.0141	0.0900	628.8	-0.0062
0.0938	1737.4	-0.0220	0.0939	1010.7	-0.0149	0.0939	638.6	-0.0062
0.0977	1761.0	-0.0230	0.0978	1021.1	-0.0158	0.0978	639.2	-0.0070
0.1016	1789.0	-0.0231	0.1017	1027.4	-0.0158	0.1017	638.3	-0.0070
0.1055	1826.4	-0.0240	0.1056	1047.2	-0.0159	0.1056	637.8	-0.0071
0.1094	1855.0	-0.0244	0.1096	1056.0	-0.0161	0.1095	645.8	-0.0076
0.1134	1883.0	-0.0252	0.1135	1064.7	-0.0173	0.1134	638.0	-0.0077
0.1173	1901.1	-0.0256	0.1174	1076.4	-0.0175	0.1173	646.8	-0.0076
0.1212	1843.8	-0.0266	0.1213	1084.1	-0.0177	0.1212	646.6	-0.0078
0.1251	1892.5	-0.0266	0.1252	1095.8	-0.0179	0.1251	653.6	-0.0080
0.1290	1961.8	-0.0265	0.1291	1101.0	-0.0180	0.1291	653.6	-0.0085
0.1329	1987.0	-0.0269	0.1330	1111.7	-0.0181	0.1330	661.3	-0.0085
0.1369	2007.5	-0.0276	0.1369	1111.1	-0.0182	0.1369	661.8	-0.0088
0.1408	2025.0	-0.0282	0.1408	1121.5	-0.0184	0.1408	670.6	-0.0088
0.1447	2035.3	-0.0279	0.1447	1122.6	-0.0187	0.1447	669.9	-0.0089
0.1486	2044.4	-0.0288	0.1486	1138.6	-0.0190	0.1486	679.0	-0.0091
0.1525	2069.9	-0.0295	0.1525	1131.6	-0.0192	0.1525	679.3	-0.0094
0.1564	2097.1	-0.0302	0.1564	1138.9	-0.0192	0.1564	687.4	-0.0096
0.1603	2111.4	-0.0309	0.1603	1150.3	-0.0195	0.1603	687.0	-0.0098
0.1642	2128.8	-0.0316	0.1643	1155.0	-0.0197	0.1642	691.2	-0.0098

Direct Shear Data
ASTM D3080

CLIENT	Wood	BORING NO.	TP-1 S1, TP-5 S1, TP-11 S1 & S2
JOB NO.	3098-003	DEPTH	Composite
PROJECT	MGP Enterprise A-4 Reclamation	SAMPLE NO.	--
PROJECT NO.	32820182.0000	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	Remolded 4X4 Box
DATE TESTED	03/17/21		
TECHNICIAN	DPM		

Point A			Point B			Point C		
Displacement (in)	Stress (psf)	Vertical Displacment (in)	Displacement (in)	Stress (psf)	Vertical Displacment (in)	Displacement (in)	Stress (psf)	Vertical Displacment (in)
0.1681	2160.5	-0.0318	0.1682	1163.3	-0.0200	0.1681	698.8	-0.0102
0.1720	2165.5	-0.0324	0.1721	1164.2	-0.0204	0.1720	699.1	-0.0102
0.1759	2195.4	-0.0324	0.1760	1172.4	-0.0205	0.1759	710.0	-0.0102
0.1798	2223.5	-0.0336	0.1799	1173.4	-0.0205	0.1798	709.9	-0.0104
0.1838	2250.6	-0.0335	0.1838	1174.7	-0.0205	0.1838	709.7	-0.0110
0.1877	2269.9	-0.0334	0.1877	1185.1	-0.0207	0.1877	709.3	-0.0111
0.1916	2298.0	-0.0329	0.1916	1195.6	-0.0210	0.1916	717.5	-0.0112
0.1955	2301.5	-0.0341	0.1956	1211.9	-0.0210	0.1955	727.3	-0.0112
0.1994	2319.6	-0.0339	0.1995	1212.7	-0.0210	0.1994	726.6	-0.0112
0.2033	2337.7	-0.0349	0.2034	1212.5	-0.0212	0.2033	732.2	-0.0115
0.2072	2354.3	-0.0351	0.2073	1211.9	-0.0213	0.2073	741.2	-0.0114
0.2111	2374.4	-0.0356	0.2112	1223.7	-0.0215	0.2112	741.1	-0.0115
0.2151	2382.8	-0.0359	0.2151	1224.2	-0.0218	0.2151	750.5	-0.0118
0.2190	2392.8	-0.0360	0.2190	1232.8	-0.0218	0.2190	751.7	-0.0116
0.2229	2411.0	-0.0357	0.2230	1234.4	-0.0220	0.2229	751.4	-0.0114
0.2268	2411.0	-0.0362	0.2269	1233.5	-0.0220	0.2268	750.8	-0.0120
0.2307	2428.5	-0.0364	0.2308	1240.6	-0.0221	0.2307	759.2	-0.0120
0.2346	2449.5	-0.0368	0.2347	1248.9	-0.0222	0.2346	759.9	-0.0120
0.2385	2456.9	-0.0369	0.2386	1248.9	-0.0223	0.2385	759.5	-0.0121
0.2424	2466.8	-0.0370	0.2425	1258.5	-0.0223	0.2424	759.7	-0.0120
0.2463	2477.2	-0.0382	0.2464	1270.4	-0.0225	0.2463	765.2	-0.0122
0.2502	2484.6	-0.0383	0.2504	1280.0	-0.0225	0.2503	764.8	-0.0123
0.2541	2491.1	-0.0385	0.2543	1285.9	-0.0223	0.2542	765.1	-0.0123
0.2580	2509.8	-0.0381	0.2582	1285.7	-0.0224	0.2581	775.9	-0.0123
0.2620	2516.5	-0.0382	0.2621	1298.3	-0.0227	0.2620	776.2	-0.0123
0.2659	2532.0	-0.0382	0.2660	1307.2	-0.0226	0.2659	793.4	-0.0124
0.2698	2532.6	-0.0388	0.2699	1315.8	-0.0227	0.2698	806.4	-0.0123
0.2737	2555.2	-0.0387	0.2738	1315.2	-0.0228	0.2737	815.6	-0.0125
0.2776	2566.6	-0.0390	0.2777	1323.5	-0.0229	0.2777	816.7	-0.0126
0.2816	2574.2	-0.0395	0.2816	1325.5	-0.0228	0.2816	806.2	-0.0126
0.2855	2582.0	-0.0393	0.2855	1321.6	-0.0230	0.2855	805.8	-0.0126
0.2894	2583.7	-0.0392	0.2894	1330.6	-0.0230	0.2894	797.1	-0.0126
0.2933	2590.8	-0.0392	0.2933	1337.0	-0.0233	0.2933	806.2	-0.0126
0.2972	2610.1	-0.0393	0.2972	1340.2	-0.0232	0.2972	806.4	-0.0126
0.3012	2620.4	-0.0396	0.3012	1337.0	-0.0233	0.3012	815.9	-0.0126
0.3051	2628.5	-0.0393	0.3051	1346.9	-0.0232	0.3051	816.8	-0.0126
0.3090	2642.9	-0.0393	0.3090	1346.5	-0.0232	0.3090	822.2	-0.0125
0.3129	2653.3	-0.0399	0.3129	1356.8	-0.0231	0.3129	822.7	-0.0126
0.3168	2666.4	-0.0401	0.3168	1356.8	-0.0233	0.3168	822.0	-0.0126
0.3208	2665.6	-0.0401	0.3207	1355.3	-0.0233	0.3207	822.2	-0.0127
0.3247	2671.7	-0.0400	0.3246	1356.8	-0.0232	0.3247	815.2	-0.0127
0.3286	2686.1	-0.0398	0.3285	1354.9	-0.0232	0.3286	815.7	-0.0126
0.3325	2686.6	-0.0398	0.3324	1363.1	-0.0232	0.3325	805.4	-0.0126

Direct Shear Data
ASTM D3080

CLIENT	Wood	BORING NO.	TP-1 S1, TP-5 S1, TP-11 S1 & S2
JOB NO.	3098-003	DEPTH	Composite
PROJECT	MGP Enterprise A-4 Reclamation	SAMPLE NO.	--
PROJECT NO.	32820182.0000	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	Remolded 4X4 Box
DATE TESTED	03/17/21		
TECHNICIAN	DPM		

Point A			Point B			Point C		
Displacement (in)	Stress (psf)	Vertical Displacment (in)	Displacement (in)	Stress (psf)	Vertical Displacment (in)	Displacement (in)	Stress (psf)	Vertical Displacment (in)
0.3364	2696.0	-0.0408	0.3363	1376.5	-0.0232	0.3364	816.0	-0.0126
0.3403	2704.4	-0.0410	0.3402	1377.5	-0.0232	0.3403	815.3	-0.0126
0.3442	2723.3	-0.0409	0.3441	1375.5	-0.0232	0.3442	816.2	-0.0126
0.3481	2733.7	-0.0410	0.3481	1386.1	-0.0231	0.3481	816.1	-0.0126
0.3520	2743.8	-0.0407	0.3520	1386.4	-0.0231	0.3520	817.2	-0.0126
0.3559	2750.2	-0.0407	0.3559	1385.3	-0.0232	0.3559	805.1	-0.0127
0.3599	2779.8	-0.0407	0.3598	1393.5	-0.0231	0.3598	803.2	-0.0127
0.3638	2787.0	-0.0407	0.3637	1393.5	-0.0231	0.3638	805.1	-0.0126
0.3677	2796.0	-0.0407	0.3676	1393.5	-0.0232	0.3677	805.8	-0.0126
0.3716	2806.7	-0.0416	0.3715	1400.3	-0.0231	0.3716	797.1	-0.0126
0.3755	2815.1	-0.0416	0.3754	1410.6	-0.0231	0.3755	803.8	-0.0126
0.3794	2836.1	-0.0417	0.3793	1421.2	-0.0232	0.3794	805.9	-0.0126
0.3833	2845.1	-0.0417	0.3832	1410.8	-0.0233	0.3833	805.9	-0.0126
0.3872	2854.3	-0.0416	0.3872	1402.0	-0.0233	0.3872	805.7	-0.0126
0.3911	2886.8	-0.0417	0.3911	1400.2	-0.0233	0.3911	805.4	-0.0126
0.3950	2902.7	-0.0417	0.3950	1410.6	-0.0233	0.3951	816.4	-0.0126
0.3990	2923.4	-0.0416	0.3989	1401.0	-0.0232	0.3990	815.7	-0.0126
0.4029	2931.4	-0.0417	0.4028	1410.4	-0.0233	0.4029	815.2	-0.0126

ADVANCED TERRA TESTING

DS Shear Rate

ASTM D 2435

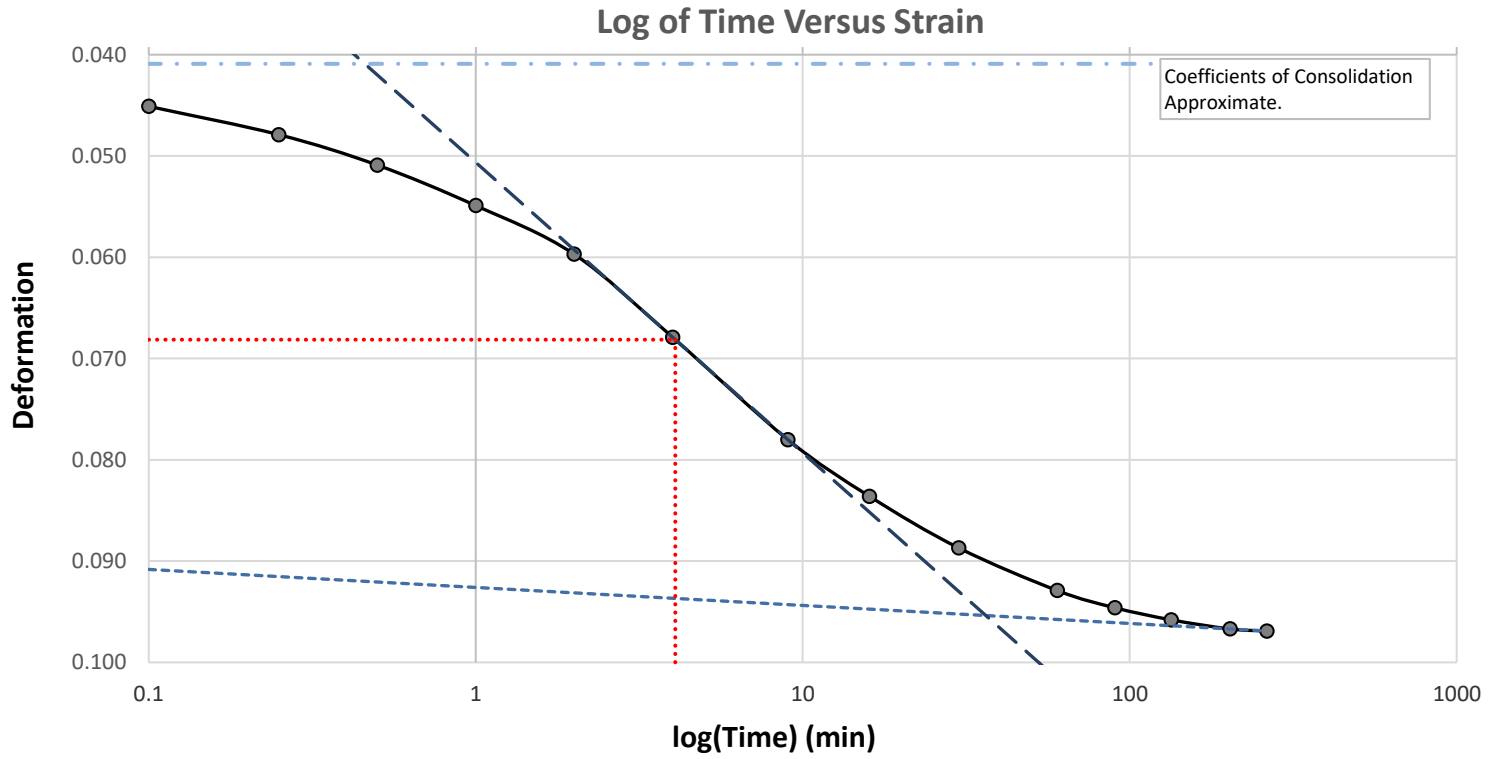
CLIENT	Wood	BORING NO.	TP-1 S1, TP-5 S1, TP-11 S1 & S2
JOB NO.	3098-003	DEPTH	Composite
PROJECT	MGP Enterprise A-4 Reclamation	SAMPLE NO.	--
PROJECT NO.	32820182	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	Remolded 4X4 Box
DATE TESTED	03/17/21		
TECHNICIAN	DPM	STANDARD	ASTM D3080

Coefficient of Consolidation (cm²/s)	Shear Rate (in/min)	Load (psf)
0.005	0.0010	3900

T50 (min)	T90 (min)	Distance to Failure (in):
4.076	7.337	0.20

NOTES:

Elapsed Time (min)	Elapsed Time log(min)	Dial Reading (in)	Deformation (in)	Strain (%)
0.1	-1.00	0.2315	0.0451	2.3
0.25	-0.60	0.2343	0.0479	2.4
0.5	-0.30	0.2373	0.0509	2.5
1	0.00	0.2413	0.0549	2.7
2	0.30	0.2461	0.0597	3.0
4	0.60	0.2543	0.0679	3.4
9	0.95	0.2644	0.0780	3.9
16	1.20	0.2700	0.0836	4.2
30	1.48	0.2751	0.0887	4.4
60	1.78	0.2793	0.0929	4.6
90	1.95	0.2810	0.0946	4.7
134	2.13	0.2822	0.0958	4.8
203	2.31	0.2831	0.0967	4.8
263	2.42	0.2833	0.0969	4.8



Data entry by:	WAR	Date: 03/20/21
Checked by:	MLM	Date: 03/20/21

Consolidated Undrained Triaxial Compression
ASTM D4767
(Point A Before Picture)

CLIENT	Wood	BORING NO.	TP-1 S1, TP-5 S1, TP-11 S1 & S2
JOB NO.	3098-003	DEPTH	Composite
PROJECT	MGP Enterprise A-4 Reclamation	SAMPLE NO.	--
PROJECT NO.	32820182	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	Remolded 4X4 Box
DATE TESTED	03/17/21		
TECHNICIAN	DPM		

NOTES	Ultimate strength taken at 0.3" of displacement

Picture File: DSCF3003.JPG
File name: 3098003__Direct Shear ASTM D3080_0.xlsm

Consolidated Undrained Triaxial Compression
ASTM D4767
(Point A After Picture)

CLIENT	Wood	BORING NO.	TP-1 S1, TP-5 S1, TP-11 S1 & S2
JOB NO.	3098-003	DEPTH	Composite
PROJECT	MGP Enterprise A-4 Reclamation	SAMPLE NO.	--
PROJECT NO.	32820182	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	Remolded 4X4 Box
DATE TESTED	03/17/21		
TECHNICIAN	DPM		

NOTES	Ultimate strength taken at 0.3" of displacement

Picture File: DSCF3006.JPG
File name: 3098003__Direct Shear ASTM D3080_0.xlsm

Consolidated Undrained Triaxial Compression
ASTM D4767
(Point B Before Picture)

CLIENT	Wood	BORING NO.	TP-1 S1, TP-5 S1, TP-11 S1 & S2
JOB NO.	3098-003	DEPTH	Composite
PROJECT	MGP Enterprise A-4 Reclamation	SAMPLE NO.	--
PROJECT NO.	32820182	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	Remolded 4X4 Box
DATE TESTED	03/17/21		
TECHNICIAN	DPM		

NOTES	Ultimate strength taken at 0.3" of displacement

Picture File: DSCF3007.JPG
File name: 3098003__Direct Shear ASTM D3080_0.xlsm

Consolidated Undrained Triaxial Compression
ASTM D4767
(Point B After Picture)

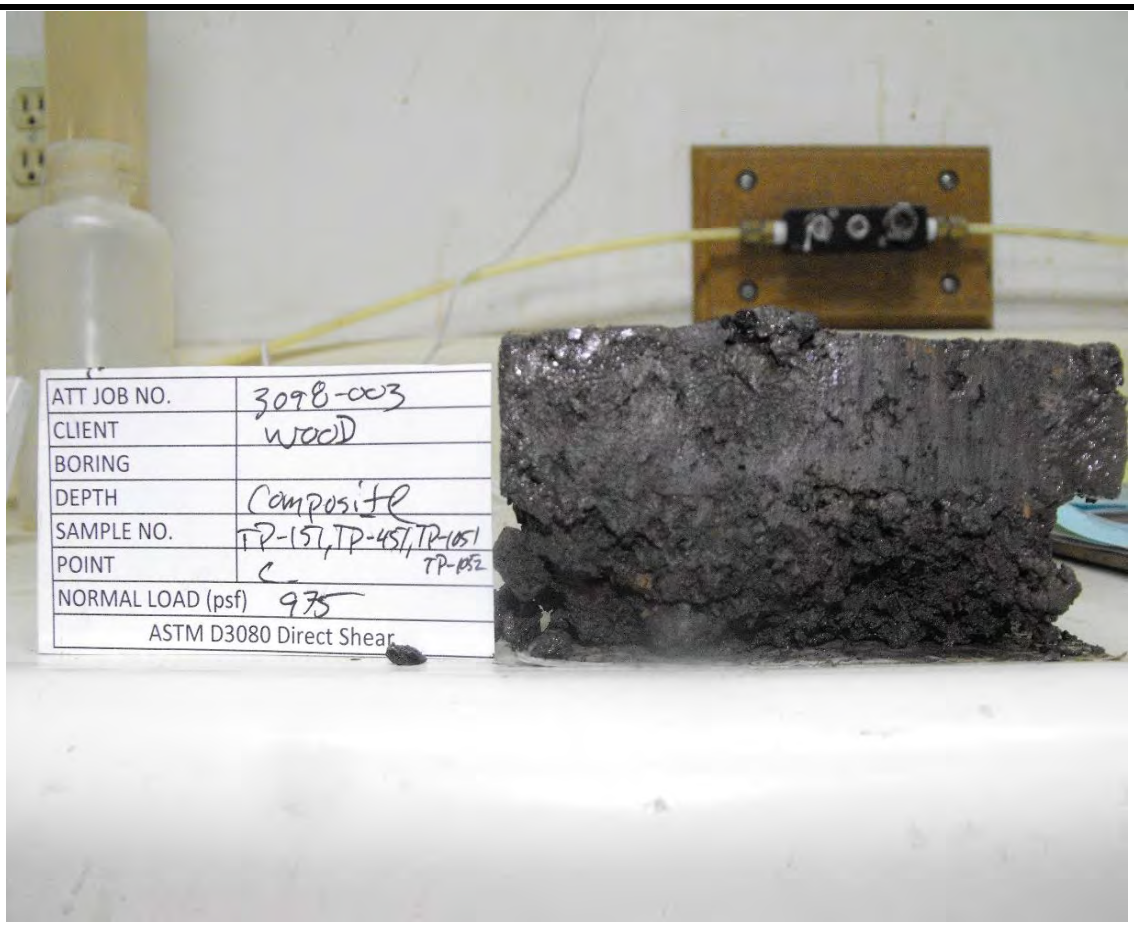
CLIENT	Wood	BORING NO.	TP-1 S1, TP-5 S1, TP-11 S1 & S2
JOB NO.	3098-003	DEPTH	Composite
PROJECT	MGP Enterprise A-4 Reclamation	SAMPLE NO.	--
PROJECT NO.	32820182	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	Remolded 4X4 Box
DATE TESTED	03/17/21		
TECHNICIAN	DPM		

NOTES	Ultimate strength taken at 0.3" of displacement

Picture File: DSCF3008.JPG
File name: 3098003__Direct Shear ASTM D3080_0.xlsm

Consolidated Undrained Triaxial Compression
ASTM D4767
(Point C Before Picture)

CLIENT	Wood	BORING NO.	TP-1 S1, TP-5 S1, TP-11 S1 & S2
JOB NO.	3098-003	DEPTH	Composite
PROJECT	MGP Enterprise A-4 Reclamation	SAMPLE NO.	--
PROJECT NO.	32820182	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	Remolded 4X4 Box
DATE TESTED	03/17/21		
TECHNICIAN	DPM		



NOTES	Ultimate strength taken at 0.3" of displacement

Picture File: DSCF3011.JPG
File name: 3098003__Direct Shear ASTM D3080_0.xlsm

Consolidated Undrained Triaxial Compression
ASTM D4767
(Point C After Picture)

CLIENT	Wood	BORING NO.	TP-1 S1, TP-5 S1, TP-11 S1 & S2
JOB NO.	3098-003	DEPTH	Composite
PROJECT	MGP Enterprise A-4 Reclamation	SAMPLE NO.	--
PROJECT NO.	32820182	DATE SAMPLED	--
LOCATION	--	DESCRIPTION	Remolded 4X4 Box
DATE TESTED	03/17/21		
TECHNICIAN	DPM		

NOTES	Ultimate strength taken at 0.3" of displacement

Picture File: DSCF3012.JPG
File name: 3098003__Direct Shear ASTM D3080_0.xlsm

Attachment C: Grading Plans

MGP ENTERPRISE A-4 RECLAMATION
TRINIDAD, COLORADO

Sheet Number	Sheet Title	Rev.
000	COVER	A
100	GENERAL SITE PLAN EXISTING CONDITIONS	A
120	GEOTECHNICAL INVESTIGATION LOCATIONS	A
150	GENERAL SITE PLAN PROPOSED IMPROVEMENTS	A
160	PROPOSED HYDROLOGY IMPROVEMENTS DETAILS	A
200	PROPOSED WELL PAD REGRADING PLAN VIEW	A
210	PROPOSED WELL PAD REGRADING SECTIONS	A

ISSUED FOR CLIENT AND AGENCY REVIEW
APRIL 13, 2021

PREPARED FOR:

bp

PREPARED BY:

wood.

2000 South Colorado Bouldevard
Suite 2-1000
Denver, CO 80222
Phone: 303-935-6505
Fax: 303-935-6575

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LEGEND:

2400 EXISTING GROUND SURFACE CONTOUR EL, FEET (NOTE 1)

EXISTING ROADS

NOTES:

1. EXISTING TOPOGRAPHIC CONTOURS WERE GENERATED FROM AERIAL SURVEYS CONDUCTED ON AUGUST 13, 2020 AND WERE PROVIDED BY WOOD ASSET SOLUTIONS, AMERICA (WOOD ASA) IN THE FOLLOWING COORDINATE SYSTEM: NAD83, COLORADO STATE PLANE, SOUTH ZONE, US FOOT.

DRAWING No.	REFERENCES	REV	DATE	DESCRIPTION
		A	04/13/21	ISSUED FOR CLIENT AND AGENCY REVIEW

ENGR / CADD: RW / SS

CLIENT: BP AMERICA PRODUCTION COMPANY

DISCLAIMER

WOOD PRODUCED THE INFORMATION PRESENTED ON THIS DRAWING THROUGH THE USE OF TECHNICAL INFORMATION AND PRACTICAL EXPERIENCE SPECIFIC TO ITS EFFORTS. RECEIVING THIS DRAWING DOES NOT GUARANTEE ANY RIGHTS TO SUCH TECHNICAL INFORMATION AND PRACTICAL EXPERIENCE. ANY ALTERATION OR ADAPTATION OF THE DATA OR CONTENTS OF THIS DRAWING SHALL BE AT USER'S SOLE RISK AND WITHOUT ANY LIABILITY OR LEGAL RESPONSIBILITY TO WOOD.

PROVIDED FOR: bp

PROVIDED BY: wood.

ISSUED FOR: REVIEW

PROJECT: MGP ENTERPRISE A-4 RECLAMATION

ISSUED DATE: 04/13/21

DRN BY: SS

DSN BY: SS

CHK BY: DS

APR BY: RW

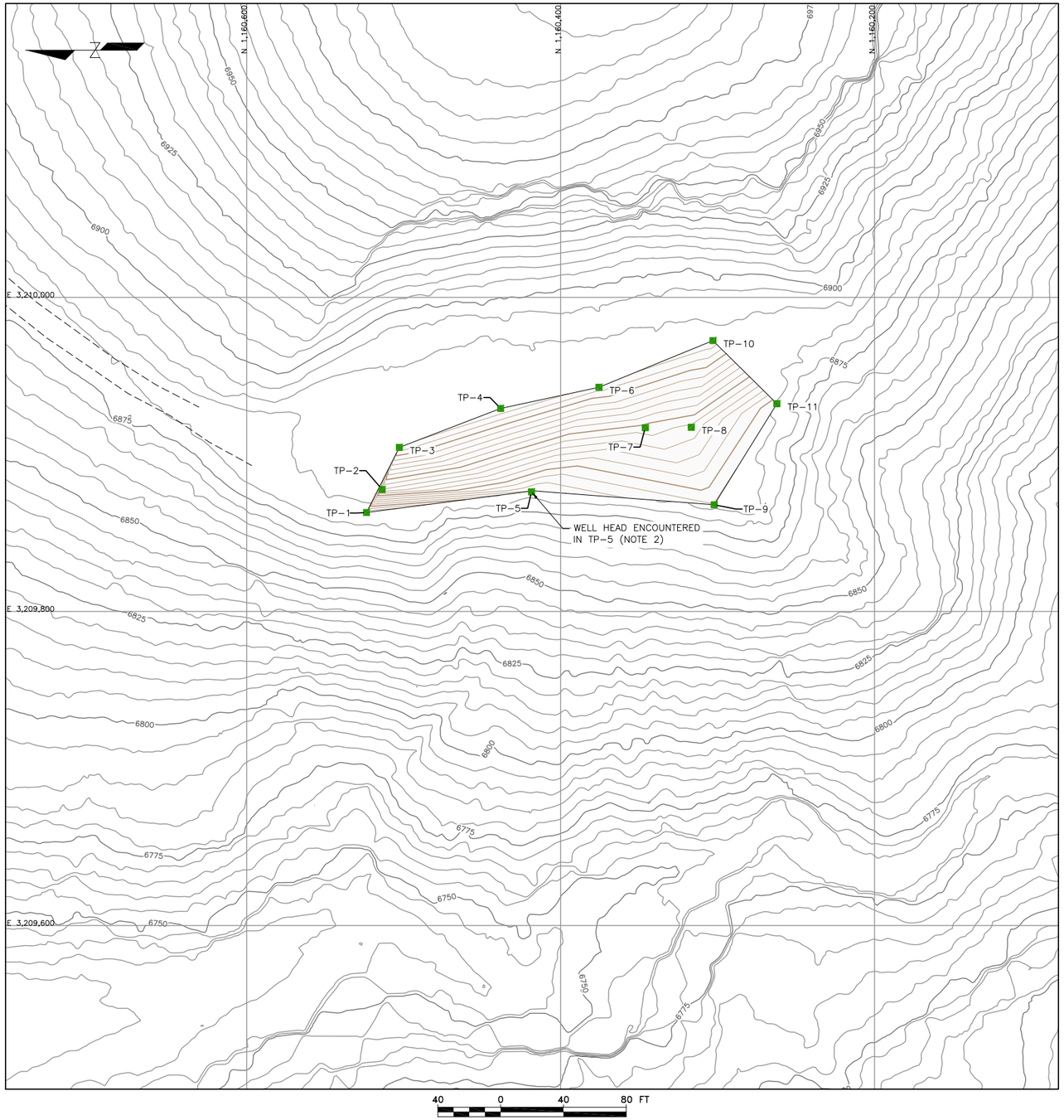
TITLE: GENERAL SITE PLAN EXISTING CONDITIONS

PROJECT No.: 32820182

DRAWING No.: 100

REV: A

C:\Users\samantha.steritz\OneDrive – Wood PLC\Projects\BP\CADD\1_Sheet Sets\1_Well Pad Reclamation_IFC_Rev0\General Site Plan_Existing Conditions.dwg-4/8/2021 4:54 PM



LEGEND:

- 2400 — EXISTING GROUND SURFACE CONTOUR EL, FEET (NOTE 1)
- 2400 — INTERPOLATED BEDROCK SURFACE CONTOUR EL, FEET (NOTE 2)
- EXISTING ROADS
- TP-1 — TEST PITS (WOOD, 2021)

NOTES:

1. EXISTING TOPOGRAPHIC CONTOURS WERE GENERATED FROM AERIAL SURVEYS CONDUCTED ON AUGUST 13, 2020 AND WERE PROVIDED BY WOOD ASSET SOLUTIONS, AMERICA (WOOD ASA) IN THE FOLLOWING COORDINATE SYSTEM: NAD83, COLORADO STATE PLANE, SOUTH ZONE, US FOOT.
2. THE TOP OF THE WELL HEAD ENCOUNTERED IN TP-5 IS LOCATED APPROXIMATELY 8FT BELOW THE GROUND SURFACE. THE LOCATION OF THE WELL HEAD WAS SURVEYED BY EARTH MEASUREMENT CORPORATION (EMC) ON FEBRUARY 10, 2021.

WELL PAD AREA TEST PITS

Point ID	Northing	Easting	Bedrock Elevation (ft)
TP-1	1,160,523.7	3,209,863.0	6867.10
TP-2	1,160,513.7	3,209,877.6	6877.96
TP-3	1,160,502.7	3,209,904.5	6886.75
TP-4	1,160,438.2	3,209,929.3	6887.95
TP-5	1,160,418.6	3,209,876.1	6872.01
TP-6	1,160,375.6	3,209,942.7	6886.56
TP-7	1,160,346.1	3,209,917.0	6879.58
TP-8	1,160,316.7	3,209,917.2	6878.67
TP-9	1,160,302.2	3,209,867.9	6873.93
TP-10	1,160,303.0	3,209,972.4	6887.84
TP-11	1,160,262.2	3,209,932.2	6874.12

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PROJECT: MGP ENTERPRISE A-4 RECLAMATION

ISSUED DATE: 04/13/21

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TITLE: GEOTECHNICAL INVESTIGATION LOCATIONS

PROJECT No.: 32820182

DRAWING No.: 120

REV: A

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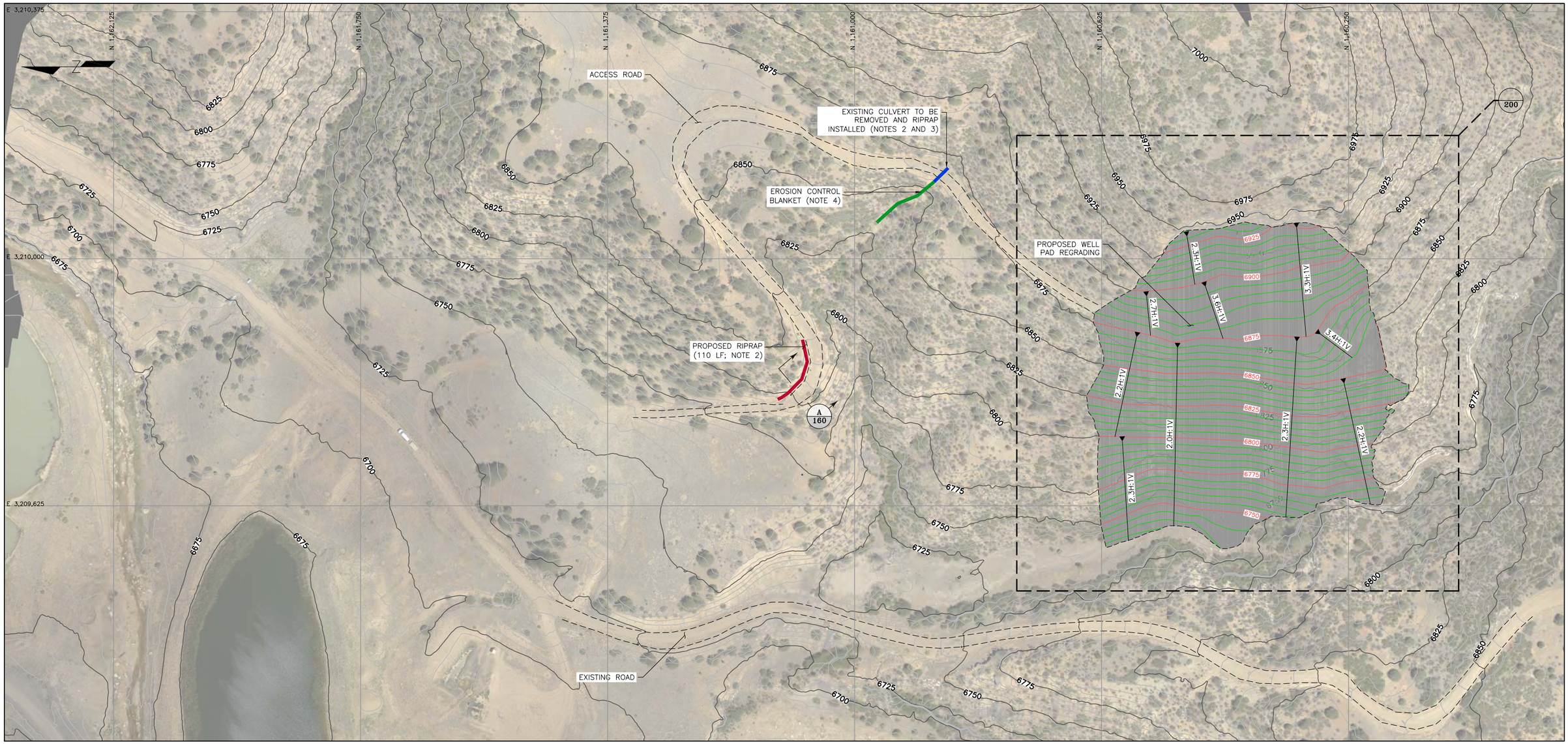

LEGEND:

- 2400 EXISTING GROUND SURFACE CONTOUR EL, FEET (NOTE 1)
- 2400 PROPOSED GROUND SURFACE CONTOUR EL, FEET
- EXISTING ROADS
- EXISTING CULVERT
- PROPOSED RIPRAP ARMORING
- PROPOSED EROSION CONTROL BLANKET

NOTES:

1. EXISTING TOPOGRAPHIC CONTOURS WERE GENERATED FROM AERIAL SURVEYS CONDUCTED ON AUGUST 13, 2020 AND WERE PROVIDED BY WOOD ASSET SOLUTIONS, AMERICA (WOOD ASA) IN THE FOLLOWING COORDINATE SYSTEM: NAD83, COLORADO STATE PLANE, SOUTH ZONE, US FOOT.
2. PLACE RIPRAP AS REQUIRED PER CDOT SPECIFICATION 506.
3. DETAIL OF RIPRAP PLACEMENT WILL BE PROVIDED IN CONSTRUCTION DRAWING SET.
4. THE BIONET C125BN EROSION CONTROL BLANKET SHALL BE ANCHORED TO THE SLOPES FOLLOWING MANUFACTURER/VENDOR RECOMMENDATIONS

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PROJECT: MGP ENTERPRISE A-4 RECLAMATION

ISSUED DATE: 04/13/21

DRN BY: SS
DSN BY: SS
CHK BY: DS
APR BY: RW

TITLE: GENERAL SITE PLAN PROPOSED IMPROVEMENTS

PROJECT No.: 32820182

DRAWING No.: 150

REV: A

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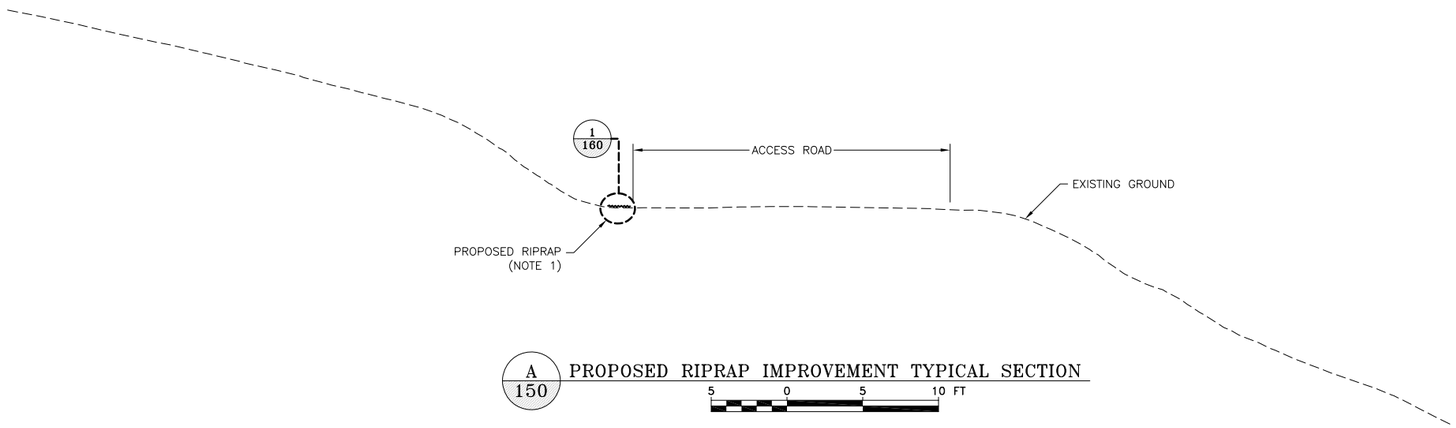
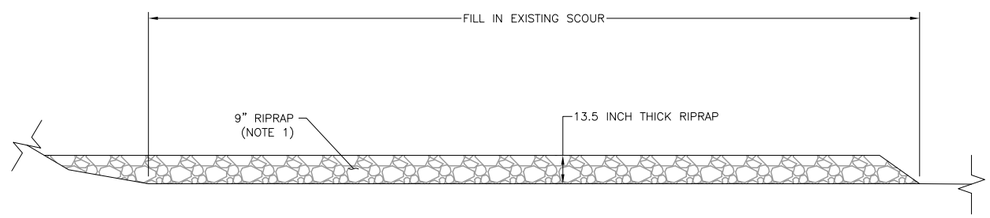


A / 150 PROPOSED RIPRAP IMPROVEMENT TYPICAL SECTION

5 0 5 10 FT

NOTE:

1. PLACE RIPAP AS REQUIRED PER CDOT SPECIFICATION 506.



1 / 160 TYPICAL RIPRAP ARMORING DETAIL

NOT TO SCALE

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PROJECT: MGP ENTERPRISE A-4 RECLAMATION

ISSUED DATE: 04/13/21

DRN BY: SS

DSN BY: SS

CHK BY: DS

APR BY: RW

TITLE: PROPOSED HYDROLOGY IMPROVEMENTS DETAILS

PROJECT No.: 32820182

DRAWING No.: 160

REV: A

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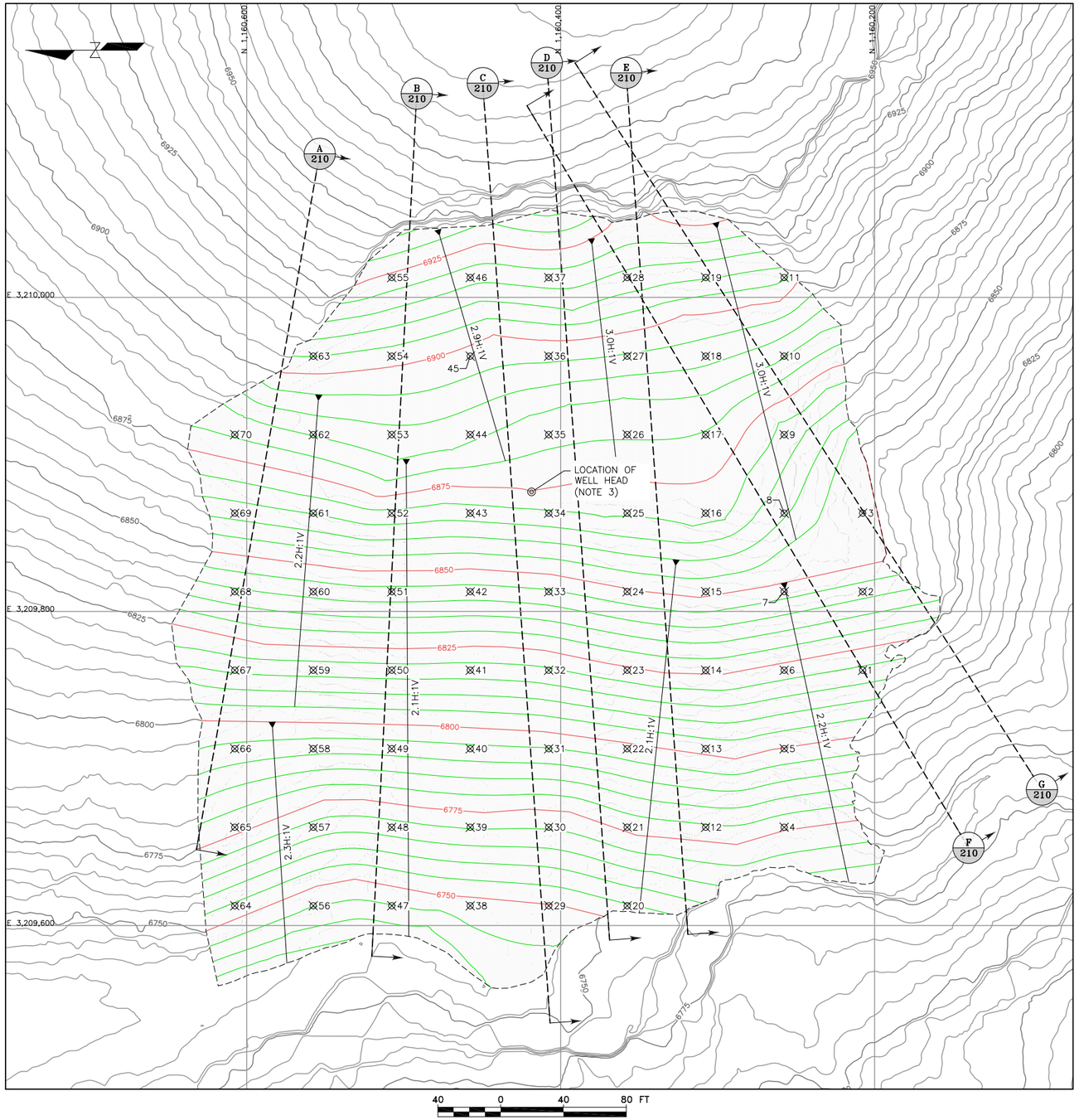

LEGEND:

- 2400 — EXISTING GROUND SURFACE CONTOUR EL, FEET (NOTE 1)
- 2400 — PROPOSED GROUND SURFACE CONTOUR EL, FEET (NOTE 2)
- EXISTING ROADS

NOTES:

1. EXISTING TOPOGRAPHIC CONTOURS WERE GENERATED FROM AERIAL SURVEYS CONDUCTED ON AUGUST 13, 2020 AND WERE PROVIDED BY WOOD ASSET SOLUTIONS, AMERICA (WOOD ASA) IN THE FOLLOWING COORDINATE SYSTEM: NAD83, COLORADO STATE PLANE, SOUTH ZONE, US FOOT.
2. THE FINAL CONSTRUCTED SURFACE MAY DEVIATE FROM WHAT IS PRESENTED ON THESE DRAWINGS BASED ON SITE CONDITIONS ENCOUNTERED DURING CONSTRUCTION. FIELD FIT AS NECESSARY UNDER THE GUIDANCE OF THE ON-SITE ENGINEER.
3. THE PROPOSED GRADING IS DESIGNED TO BURY THE EXISTING WELL HEAD. THE TOP OF THE WELL HEAD IS ESTIMATED TO BE AT ABOUT 6874 FT AND THE PROPOSED FINAL GRADE ELEVATION AT THIS LOCATION IS 6875 FT. THE CONTRACTOR SHALL TAKE EXTRA PRECAUTION WHEN WORKING AROUND THIS EXISTING WELL HEAD AND MAY NEED TO HAND PLACE MATERIAL TO MEET FINAL GRADE.

PROPOSED REGRADING QUANTITIES	
PROPOSED REGRADED SURFACE AREA (SF) =	198,000
PROPOSED CUT (CY) =	21,000
PROPOSED FILL (CY) =	21,000

CONTROL POINTS

Point #	Elevation	Northing	Easting
1	6818.83	1,160,207.6	3,209,762.6
2	6842.13	1,160,207.6	3,209,812.6
3	6851.13	1,160,207.6	3,209,862.6
4	6776.01	1,160,257.6	3,209,662.6
5	6799.69	1,160,257.6	3,209,712.6
6	6822.83	1,160,257.6	3,209,762.6
7	6847.25	1,160,257.6	3,209,812.6
8	6860.64	1,160,257.6	3,209,862.6
9	6868.51	1,160,257.6	3,209,912.6
10	6885.33	1,160,257.6	3,209,962.6
11	6905.81	1,160,257.6	3,210,012.6
12	6779.14	1,160,307.6	3,209,662.6
13	6801.82	1,160,307.6	3,209,712.6
14	6826.25	1,160,307.6	3,209,762.6
15	6851.33	1,160,307.6	3,209,812.6
16	6872.27	1,160,307.6	3,209,862.6
17	6879.54	1,160,307.6	3,209,912.6
18	6891.73	1,160,307.6	3,209,962.6
19	6910.40	1,160,307.6	3,210,012.6
20	6754.35	1,160,357.6	3,209,612.6
21	6776.29	1,160,357.6	3,209,662.6
22	6798.33	1,160,357.6	3,209,712.6
23	6823.86	1,160,357.6	3,209,762.6
24	6848.99	1,160,357.6	3,209,812.6
25	6870.52	1,160,357.6	3,209,862.6

CONTROL POINTS

Point #	Elevation	Northing	Easting
26	6880.61	1,160,357.6	3,209,912.6
27	6894.42	1,160,357.6	3,209,962.6
28	6913.36	1,160,357.6	3,210,012.6
29	6749.67	1,160,407.6	3,209,612.6
30	6770.54	1,160,407.6	3,209,662.6
31	6794.77	1,160,407.6	3,209,712.6
32	6819.29	1,160,407.6	3,209,762.6
33	6844.39	1,160,407.6	3,209,812.6
34	6869.18	1,160,407.6	3,209,862.6
35	6881.85	1,160,407.6	3,209,912.6
36	6896.38	1,160,407.6	3,209,962.6
37	6917.77	1,160,407.6	3,210,012.6
38	6748.15	1,160,457.6	3,209,612.6
39	6770.40	1,160,457.6	3,209,662.6
40	6793.73	1,160,457.6	3,209,712.6
41	6817.71	1,160,457.6	3,209,762.6
42	6842.77	1,160,457.6	3,209,812.6
43	6867.45	1,160,457.6	3,209,862.6
44	6886.13	1,160,457.6	3,209,912.6
45	6898.15	1,160,457.6	3,209,962.6
46	6917.05	1,160,457.6	3,210,012.6
47	6744.75	1,160,507.6	3,209,612.6
48	6767.75	1,160,507.6	3,209,662.6
49	6792.23	1,160,507.6	3,209,712.6
50	6817.85	1,160,507.6	3,209,762.6

CONTROL POINTS

Point #	Elevation	Northing	Easting
51	6843.30	1,160,507.6	3,209,812.6
52	6868.77	1,160,507.6	3,209,862.6
53	6888.49	1,160,507.6	3,209,912.6
54	6902.56	1,160,507.6	3,209,962.6
55	6923.67	1,160,507.6	3,210,012.6
56	6745.33	1,160,557.6	3,209,612.6
57	6768.21	1,160,557.6	3,209,662.6
58	6791.88	1,160,557.6	3,209,712.6
59	6817.05	1,160,557.6	3,209,762.6
60	6841.86	1,160,557.6	3,209,812.6
61	6865.29	1,160,557.6	3,209,862.6
62	6885.30	1,160,557.6	3,209,912.6
63	6905.16	1,160,557.6	3,209,962.6
64	6754.01	1,160,607.6	3,209,612.6
65	6776.53	1,160,607.6	3,209,662.6
66	6793.61	1,160,607.6	3,209,712.6
67	6815.87	1,160,607.6	3,209,762.6
68	6838.94	1,160,607.6	3,209,812.6
69	6861.77	1,160,607.6	3,209,862.6
70	6880.67	1,160,607.6	3,209,912.6

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PROJECT: MGP ENTERPRISE A-4 RECLAMATION

ISSUED DATE: 04/13/21

DRN BY: SS
DSN BY: SS
CHK BY: DS
APR BY: RW

TITLE: PROPOSED WELL PAD REGRADING PLAN VIEW

PROJECT No.: 32820182

DRAWING No.: 200

REV: A

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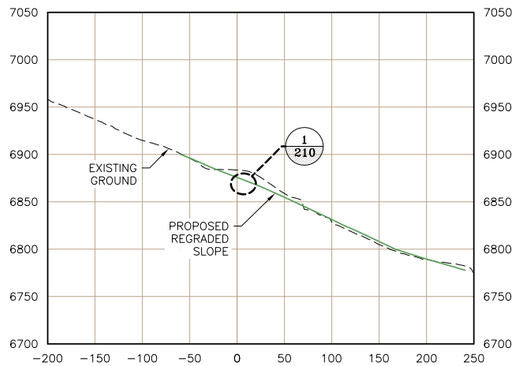

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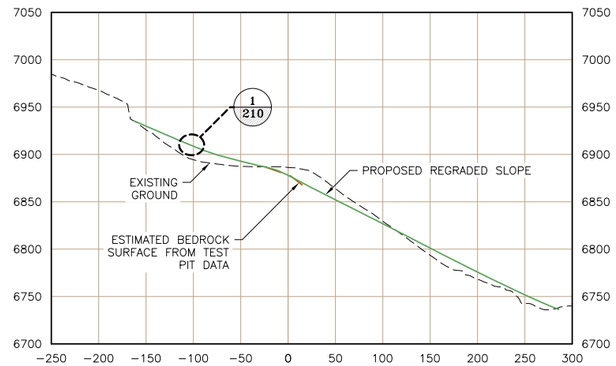

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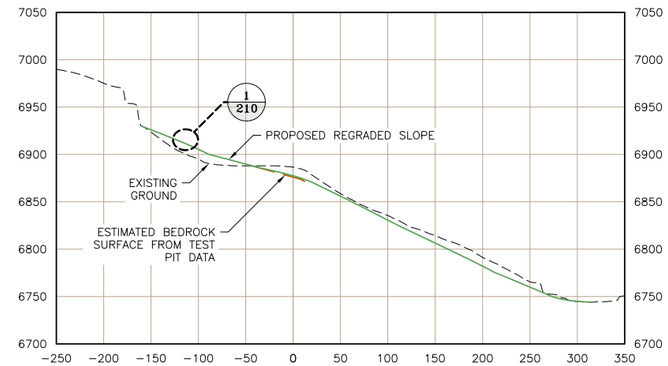

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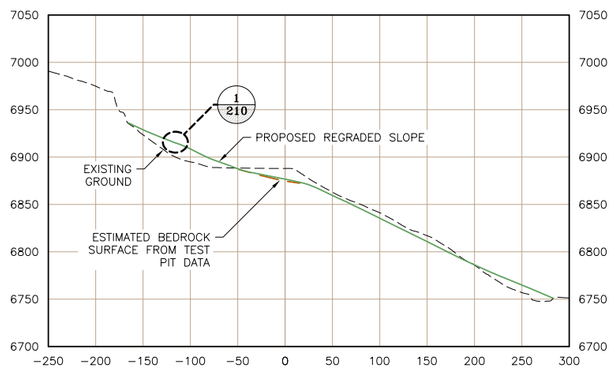

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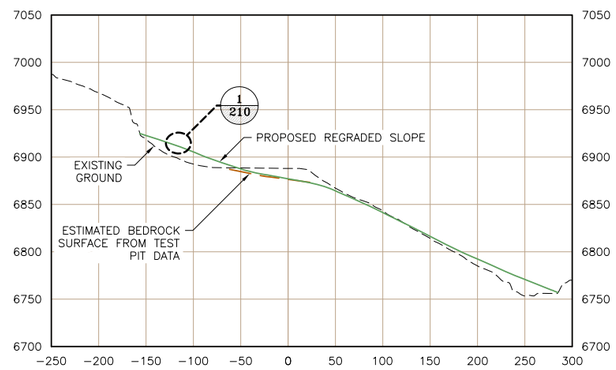

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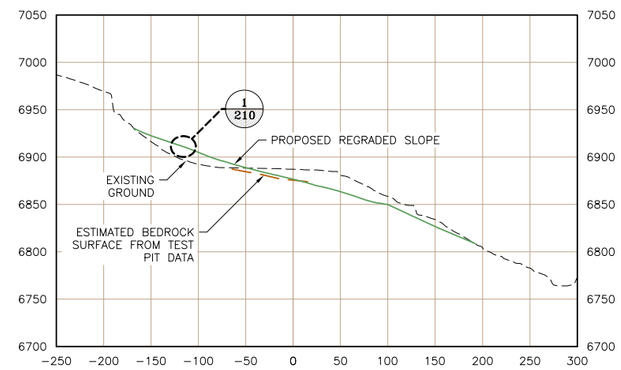

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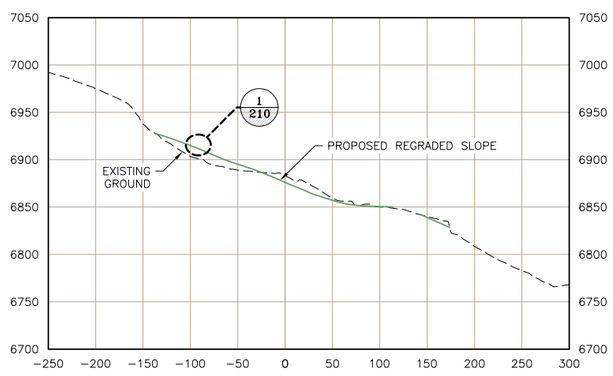

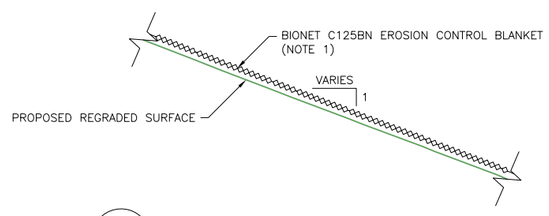

1/210 EROSION CONTROL TYPICAL DETAIL

NTS

NOTES:

1. THE BIONET C125BN EROSION CONTROL BLANKET SHALL BE ANCHORED TO THE SLOPES FOLLOWING MANUFACTURER/VENDOR RECOMMENDATIONS.

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PROJECT: MGP ENTERPRISE A–4 RECLAMATION

ISSUED DATE: 04/13/21

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APR BY: RW

TITLE: PROPOSED WELL PAD REGRADING SECTIONS

PROJECT No.: 32820182

DRAWING No.: 210

REV: A

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Attachment D: Hydraulics Report

Hydraulics Report for the MGP Enterprise A-4 Well Pad Erosion Control

MGP Enterprise A-4 Well Pad
Las Animas County, Colorado
Project # 32820182

Prepared for:

BP Remediation Management Services Company
201 Helios Way, Houston, TX 77079

3/26/2020

Hydraulics Report for the MGP Enterprise A-4 Well Pad Erosion Control

MGP Enterprise A-4 Well Pad
Pagosa Springs, Colorado
Project # 32820182

Prepared for:

BP Remediation Management Services Company
201 Helios Way, Houston, TX 77079

Prepared by:

Wood Environment & Infrastructure Solutions, Inc.
2000 S. Colorado Blvd., Ste. 2-1000
Denver, CO 80222

3/26/2020

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1.0 Introduction

MGP Enterprise A-4 well pad has been inactive since 1993.

A site inspection was conducted by the State of Colorado Oil and Gas Conservation Commission (COGCC) in July of 2019, and restoration requirements were specified for the site, including:

1. Regrading the access road,
2. Removal of the cross culvert,
3. Regrading of the well pad to a stable slope,
4. Revegetation of at least 80 percent of pre-disturbance levels,
5. Implement scour countermeasures along the access road where erosion issues have been observed.
6. Implement erosion control measures to stabilize the seeded soils.

Wood has been asked to design the site grading and erosion countermeasures to address the issues listed above. Grading design for the restored slope and access road, included in Appendix D, was completed to account for geotechnical properties at the site. Due to the steepness of the area to be seeded, a hydroseeding plan was recommended. The seed mix includes a mix of cold season, warm season, and rhizomatous and bunch grasses to allow for germination in different seasons, and improved soil stabilization.

Hydraulic analysis of the proposed conditions was performed to address requirements 2, 5 and 6 and design erosion control measures along the access road and over the restored slope. This report details the hydrologic and hydraulic investigations of the site, the design of scour countermeasures along the access road, and specification of the geotextile necessary to stabilize the seeded soils.

A copy of this inspection report is included in Appendix G.

2.0 Data Review

2.1 Site Location

As shown in Figure 1, the project site is located approximately 20 miles west of Trinidad, Colorado in Las Animas County. The MGP Enterprise A-4 well pad (hereafter well pad) is accessed by a private route, Hill Ranch Road, from Colorado State Highway 12. An approximately 0.4-mile-long unimproved road provides access to the north side of the well pad. The well pad occupies an approximately 1-acre area along the western portion of an undeveloped mountainside.

2.2 Topographic Data

The project area was surveyed by drone in August of 2020. Aerial imagery across the site and a detailed survey dataset with approximately a 1-foot resolution were provided to Wood. This survey dataset was converted to a digital elevation model (DEM) using ArcGIS Version 10.4 (Esri, 2016) and referenced throughout the hydrologic and hydraulic analyses.

All spatial data and model results reference the horizontal North American Datum of 1983 (NAD 83) Colorado State Plane South projection and the North American Vertical Datum of 1988 (NAVD88).

2.3 Drainage Areas

Wood used the survey dataset to delineate the 8.2-acre drainage area contributing to flows along the roadway and the 2.3-acre drainage area contributing to flows over the proposed slope rehabilitation. Both drainage areas are presented in Figure 2.

2.4 Site Reconnaissance

Wood performed a site visit in July of 2020 and noted the area is covered with sparse shrubs and native grasses. Some pinion was encountered, but the trees were relatively small.

2.5 Hydrologic Soil Groups

Soils are classified by the NRCS into four Hydrologic Soil Groups (HSG) based on the soil's runoff potential. The four HSGs are labeled A, B, C and D. Soils within group A generally have the smallest runoff potential whereas soils within group D have the highest runoff potential.

The NRCS reports rock outcropping and Type D soils across the entire drainage area (NRCS, 2015). Wood confirmed rocky soils on their site visit, so Type D soils were verified and assumed for the rational method calculations.

3.0 Determination of Design Flows

The Colorado Oil and Gas Conservation Commission (COGCC) requires ditches to be constructed to accommodate a 100-year, 24-hour storm event and completely contain the water volume from a 25-year, 24-hour storm event (COGCC, 2021). Erosion along the access road leading to the well pad has formed a small ditch that must be remediated. Though a new ditch is not being constructed, both the 25-year and 100-year events will be evaluated to determine the controlling countermeasure design parameters.

The rational method was evaluated to estimate the peak flows along the access road, at the culvert removal location, and over the proposed slope rehabilitation. Necessary parameters to the rational method include soil properties, drainage area, a delineation of the longest flowpath (separated by flow type) and point precipitations depths. See Figure 2 for a presentation of the rational method parameters and Appendix A for a full presentation of rational method calculations.

3.1 Frequency Storm Precipitation Depths

The National Oceanic and Atmospheric Administration (NOAA) has made precipitation depths for many areas across the country, including Colorado, available through their Precipitation Frequency Server (NOAA, 2011). Wood accessed the dataset and extracted point precipitation depths and associated 90 percent confidence intervals for the 25-year and 100-year events near the well pad. These rainfall depths are presented in Table 1.

Table 1 – Point Rainfall Depths for Determination of Design Flows

Recurrence Interval:	25-Year	100-Year
24-Hour Point Rainfall Depth (in)	3.28 (2.64-4.27)	4.51 (3.39-6.15)

The design rainfall depths for the 25-year and 100-year events are 3.28 inches and 4.51 inches, respectively.

3.2 Design Peak Flow Results

The rational method was used to estimate peak flows along the access road, over the proposed slope, and at the culvert removal location. Three drainage basins were delineated as shown in Figure 2. Note the

drainage area to the culvert is essentially a sub-basin to the drainage area contributing to the bend in the access road. To determine the drainage area contributing to flow around the bend, the culvert is conservatively assumed blocked. To estimate flow at the culvert removal location, no blockage is assumed..

As discussed in Section 2.5, natural soils in the area have a low infiltration rate (hydrologic soil group D). Though the proposed slope must be revegetated, the proposed soils were assumed to have a high runoff potential.

The rational method represents a steady inflow-outflow condition of the watershed during the peak intensity of the design storm. This means that a single peak flow rate is estimated for the entire drainage basin without consideration for timing or flow accumulation towards the outlet. The rational method tends to overpredict peak flows but is appropriate for the small drainage areas with relatively uniform coverage evaluated for this project.

The drainage area contributing to side drainage around the access road bend is approximately 8.2 acres and has an average slope of 29.4 percent. The outlet of the side drainage basin is just downstream of the bend in the access road, so the roadway peak flows should well represent flow conditions around the bend.

The drainage area contributing to flow over the proposed slope rehabilitation is approximately 3.2 acres and has an average slope of 36.2 percent. The basin outlet is at the toe of the proposed slope, at its interface with the existing slope.

All relevant rational method parameters are presented in Figure 2 and calculations included in Appendix A.

Design peak flows for the access road, slope rehabilitation, and the culvert removal location are listed in Table 2.

Table 2 – Design Peak Flows

Location:	25-Year Peak Flow (cfs)	100-Year Peak Flow (cfs)
Access Road	11.2	22.0
Proposed Slope	2.8	5.7
Culvert Removal	2.5	5.1

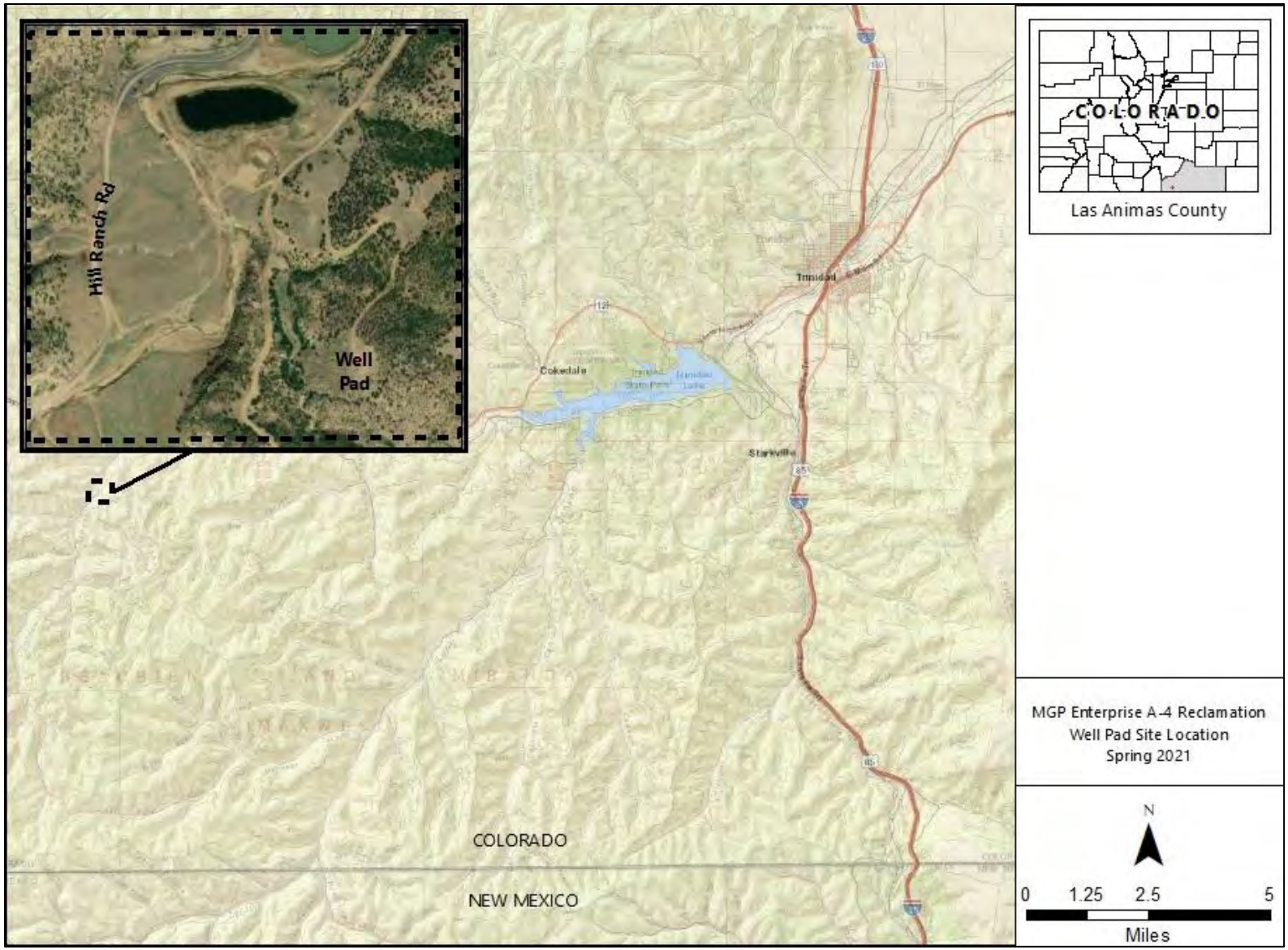

Figure 1 – Well Pad Location

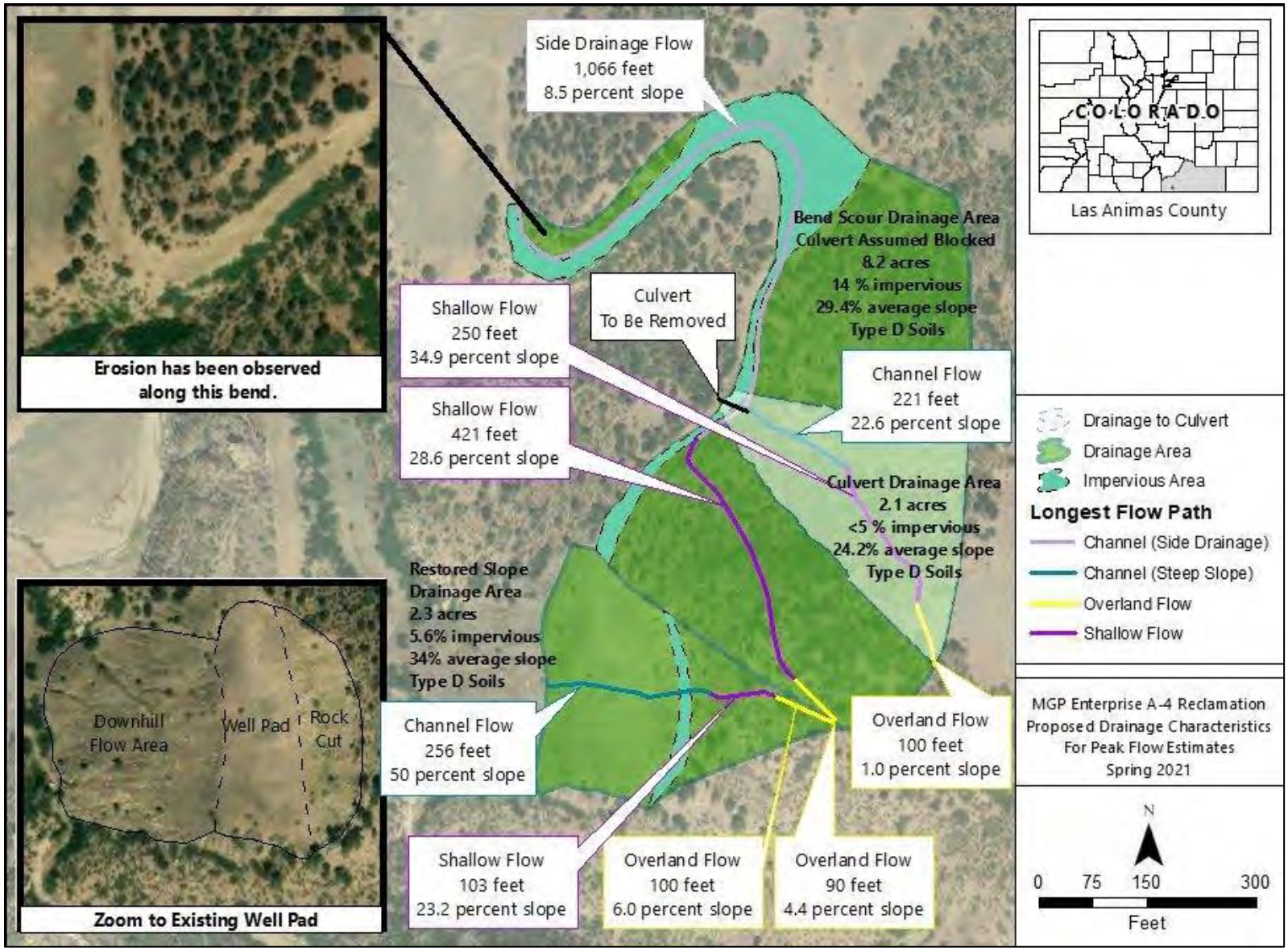

Figure 2 – Rational Method Parameters for Proposed Conditions

4.0 Two-Dimensional Hydraulic Modeling

The Surface-Water Modeling System (SMS) Version 13.0.11 (Aquaveo, 2020) was used to develop a 2-dimensional (2D) hydraulic model to represent the existing conditions of the access road drainage.

SMS allows the user to develop a flexible computational mesh consisting of triangular and quadrilateral elements. The mesh can then be exported to various 2D hydraulic modelers. For this effort, SMS was used in conjunction with the Sedimentation and River Hydraulics – Two-Dimension (SRH-2D) Version 3.2.4 (USBR, 2019) software developed by the U.S. Bureau of Reclamation (USBR) in conjunction with the Federal Highway Administration (FHWA).

4.1 Model Extents

The model extents, delineated in yellow in Figure 3, were drawn to capture the entirety of the roadway drainage, then extended towards the south to account for runoff over the propose slope rehabilitation over the well pad.

4.2 Boundary Conditions

The inflow and outflow conditions for all model scenarios assumed steady flow. At the upstream end, boundary conditions were delineated to encompass the drainage spreadwidth. Each inflow rate was distributed with respect to conveyance along the inflow boundary condition line, as shown by the short blue line towards the western portion of the mesh extents in Figure 3. The downstream boundary conditions were set to allow exit flow. The upstream and downstream boundary condition flow rates, previously estimated using the rational method, are presented in Figure 3.

Given the distance from the access road bend to the downstream model limit, it is not anticipated that altering outflows used as the downstream boundary condition would have an appreciable effect on scour estimates at the bend.

4.1 Computational Mesh

A computational mesh was developed to represent the proposed conditions. The mesh contains approximately 17,700 triangular elements and 800 quadrilateral elements. Element sizes range between about 3 and 50 feet.

To generate a mesh and best represent the topography and survey data, breaklines were delineated along the roadway to add additional refinement and specify quadrilateral elements. Figure 4 shows the portion of the computational mesh containing the roadway bend. Note how the mesh cells are smaller in the area of interest, then increase towards the model edges (delineated in yellow).

4.2 Roughness Coefficients

Roughness coefficients (Manning's n-values) were assigned based on field observations and aerial imagery. Through forested areas and along the dirt road, roughness values were depth-varied. The bend area of interest is completely contained within these two coverages, so the depth-varied refinement was useful for scour estimation. Roughness coefficients for forested areas ranged from 0.15 (shallow flow) to 0.08 (flow above 1 foot). Similarly, roughness coefficients along the dirt road ranged from 0.035 to 0.02.

4.3 Computational Parameters

The models were run by initially setting the model to dry and using a 2-second time step under steady-state flow conditions for an 8-hour simulation time.

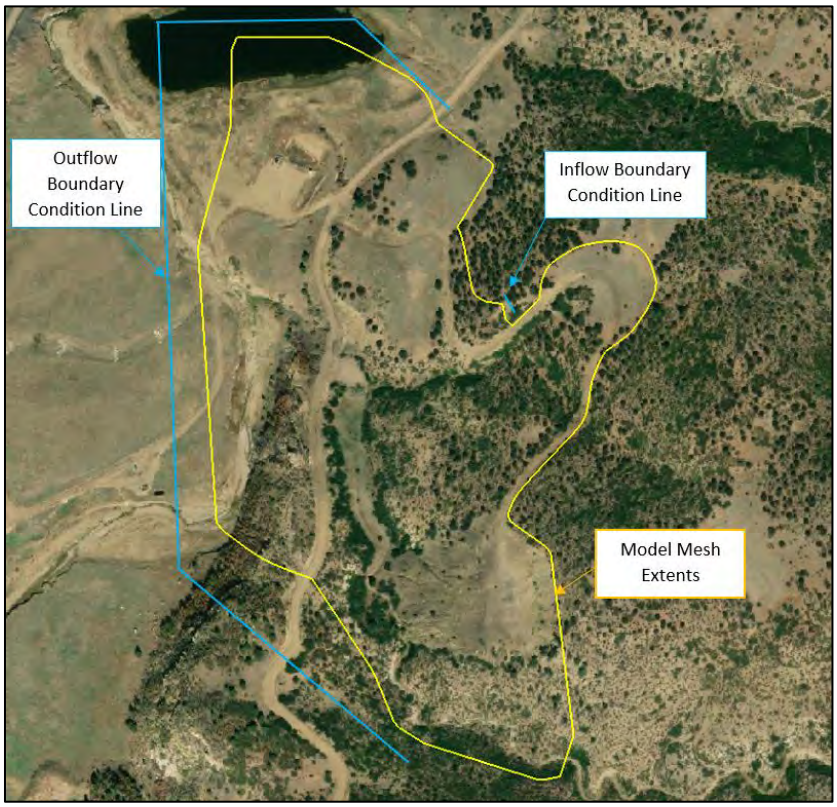

Figure 3 – Model Extents and 100-Year Boundary Condition Lines

Figure 4 – Computational Mesh near the Roadway Bend

5.0 Hydraulic Model Results

Recognizing that relatively frequent flood events can cause erosion along the access road, both the 25-year and 100-year design events were evaluated for their bend scour potential.

Wood evaluated the bend scour using the empirical Maynord relationship (Equation 1), a method developed for natural, sand-bed channels (Maynord, 1996). Though the erosion is occurring due to side drainage rather than a natural channel, Wood determined the Maynord equation to be the most appropriate method for estimating the scour potential around the roadway bend for three reasons:

1. The observed erosion is largely due to mobilization of sandy soils.
2. The Maynord method accounts for the geometry of the bend.
3. The equation is dependent upon flow depth and width rather than flow rate. The design flow rates are relatively small, so comparing changes in flow width are less likely to underpredict the scour potential.

$$\frac{D_{max}}{D_{upstream}} = 1.8 - 0.051\left({R_c}/{W_{upstream}}\right) + 0.0084\left({W_{upstream}}/{D_{upstream}}\right)$$

Equation 1 – Maynord Equation for Bend Scour in Sand-Bed Channels

Where D_{max} is the maximum flow depth around the bend after scour occurs, $D_{upstream}$ is the hydraulic depth upstream of the bend, $W_{upstream}$ is the active channel width upstream of the bend, and R_c is the radius of curvature.

The radius of curvature, R_c, was measured against the velocity mapping as part of the model results. The 10-year event had a R_c of about 300 feet and the remaining events all flowed through the avulsion with a R_c of about 450 feet. The delineation of the bend section was delineated against the survey dataset and was assumed constant for all peak flow rates.

The upstream width and depth ($W_{upstream}$ and $D_{upstream}$) were taken from model results. First, $W_{upstream}$ was delineated to indicate how much of the upstream channel width contributes to flow through the bend section. Velocity mapping, as shown in Figure 5, provides a good indicator of the appropriate upstream width. $D_{upstream}$ was then taken as the hydraulic depth of the upstream section.

For each peak flow rate, the maximum depth along the bend section prior to scour (D_{bend}) was sampled from the model results. When Equation 1 is solved for D_{max}, the scour depth can then be estimated as the difference between the depth before and after scour occurs ($D_{max} - D_{bend}$).

Model results and scour parameters are presented in Table 5. These parameters are presented against the 100-year depth mapping in Figure 5. A detailed presentation of bend scour calculations is included in Appendix B.

Table 3 – Summary of Existing Conditions Scour Potential

Model Inflow (cfs)	Scour Parameters for the Maynord Equation					Scour Depth (D_{max}-D_{bend}) (ft)
	R_c (ft)	D_{bend} (ft)	$D_{upstream}$ (ft)	$W_{upstream}$ (ft)	Calculated D_{max} (ft)	
11.2 (25-Year)	120	0.42	0.46	8.18	0.55	**0.1**
22.0 (100-Year)	120	0.21	0.28	16.48	0.54	**0.3**

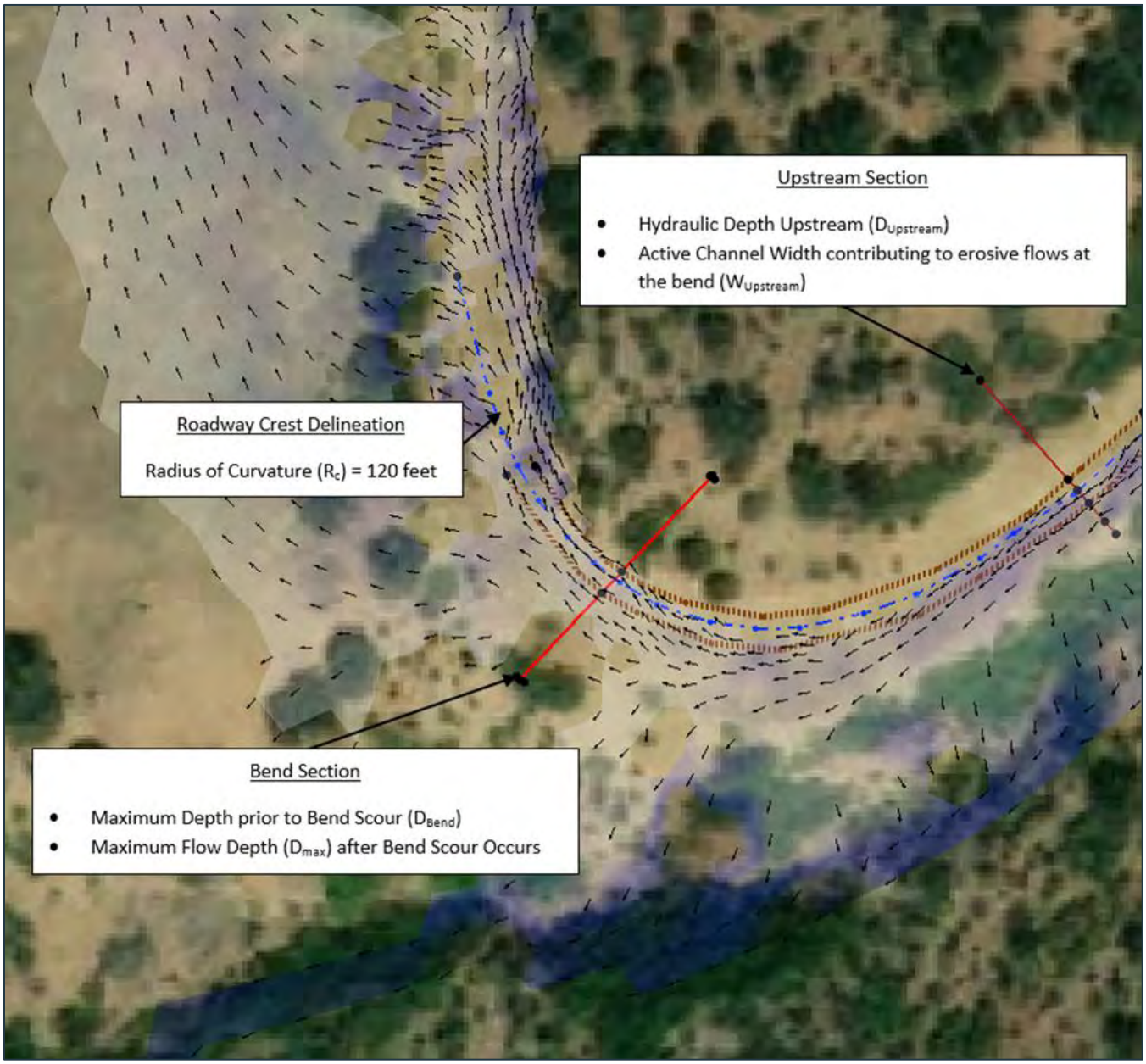

Figure 5 – Definition Sketch for Maynord Bend Scour along the Access Road under Existing Conditions

6.0 Erosion Control Design

The existing conditions analyses indicated that the 25-year and 100-year events have scour potentials of approximately 0.1 and 0.3 feet along the roadway bend, respectively. The proposed design is intended to mitigate this localized scour. The 100-year event is referenced as the design event due to its more intense flow characteristics and higher scour potential.

6.1 General Description of the Mitigation Design

Riprap will be placed around the bend to fill in the existing scoured areas and to provide countermeasures against future erosion. An erosion control blanket is specified to aid in revegetating the proposed slope over the well pad.

6.2 Access Road Scour Protection

Riprap was sized to resist the shear stresses along the side drainage according to the methods of HEC-15 (FHWA, 2005), the FHWA's publication for Design of Roadside Channels with Flexible Linings. Use of this method requires the assumption of a trapezoidal channel; this assumption is reasonable for representing roadside drainage. All riprap calculations are included in Appendix C.

The model results show the maximum bed shear stress along the bend during the 100-year event is approximately 3.0 lb/sf.

The HEC-15 methodology estimates the maximum bed shear stress using Equation 1,

$$\tau_d = \gamma S_0 \; Equation\ 1$$

where τ_d is the shear stress in the channel at maximum depth (lb/sf),
γ is the unit weight of water (62.4 lb/ft^3), and
S_0 is the channel bottom slope (ft/ft).

When Equation 1 is used to estimate the shear stress at maximum depth around the bend, the shear stress at maximum depth is approximately 3.18 ft/sf. This value is greater than the maximum shear stress evaluated by the model, so the Equation 1 estimate was used to size the riprap.

6.2.1 Riprap Sizing

Wood found that angular stones with a D_{50} of 9 inches is the optimal riprap size for the side drainage along the access road. See Appendix C for a presentation of the HEC-15 calculations for riprap sizing.

A geotextile filter, such as AASHTO M-288 geotextile strength class 1 (CDOT, 2017), should be laid underneath the riprap. As summarized inTable 4, 9-inch riprap shall be laid to a depth of 13.5 inches over the filter. Riprap will be tapered down to the existing ground at a 2:1 slope.

Table 4 – Riprap Design Summary

Location	Safety Factor	Riprap D_{50} (inches)	Riprap Thickness (inches)	Calculated Bed Shear Stress (lb/ft^2)
Access Road Bend	1.0	9	13.5	3.18

See the site plan, attached to this report in Appendix D, for the proposed riprap layout.

6.2.2 Design Safety Factor

The HEC-15 documentation includes values for typical permissible shear stresses. 6 and 12-inch rock riprap have permissible shear stresses of 2.4 and 4.8 psf, respectively (See HEC-15 Table 2.3, reproduced below as Figure 6). Interpolating between those values, 9-inch rock riprap should be able to withstand approximately 3.6 psf. The design bed shear stress is 3.18 psf, so the riprap design can withstand the shear stresses imposed by the design event.

Table 2.3. Typical Permissible Shear Stresses for Bare Soil and Stone Linings

Lining Category	Lining Type	Permissible Shear Stress N/m^2	Permissible Shear Stress lb/ft^2
Bare Soil[1] Cohesive (PI = 10)	Clayey sands	1.8-4.5	0.037-0.095
	Inorganic silts	1.1-4.0	0.027-0.11
	Silty sands	1.1-3.4	0.024-0.072
Bare Soil[1] Cohesive (PI $\geq$ 20)	Clayey sands	4.5	0.094
	Inorganic silts	4.0	0.083
	Silty sands	3.5	0.072
	Inorganic clays	6.6	0.14
Bare Soil[2] Non-cohesive (PI < 10)	Finer than coarse sand D_{75}<1.3 mm (0.05 in)	1.0	0.02
	Fine gravel D_{75}=7.5 mm (0.3 in)	5.6	0.12
	Gravel D_{75}=15 mm (0.6 in)	11	0.24
Gravel Mulch[3]	Coarse gravel D_{50} = 25 mm (1 in)	19	0.4
	Very coarse gravel D_{50} = 50 mm (2 in)	38	0.8
Rock Riprap[3]	D_{50} = 0.15 m (0.5 ft)	113	2.4
	D_{50} = 0.30 m (1.0 ft)	227	4.8

[1]Based on Equation 4.6 assuming a soil void ratio of 0.5 (USDA, 1987).
[2]Based on Equation 4.5 derived from USDA (1987)
[3]Based on Equation 6.7 with Shield's parameter equal to 0.047.

Figure 6 – HEC-15 Table 2.3. Typical Permissible Shear Stresses for Bare Soil and Stone Linings

Wood's countermeasure design recognizes that the proposed riprap has a permissible shear stress greater than the maximum design shear stress and that the evaluation of permissible shear stress is conservative. An additional safety factor is not necessary.

6.3 Slope Stabilization over the Well Pad

The proposed slope rehabilitation over the existing well pad is designed to have slopes no steeper than 2:1 (horizontal to vertical). The sloped area is approximately 96,000 square feet and extends approximately 200 feet from its toe elevation up to the base of existing stable rock.

6.3.1 Revegetation

A mix of native vegetation has recommended for hydroseeding against the proposed slope. It is expected that the vegetation will take 2-3 years to fully establish.

6.3.2 Erosion Control Design

A biodegradable erosion control blanket was selected to support revegetation over the proposed slope. To account for the life cycle of the blanket, flow hydraulics were evaluated assuming flow over the unvegetated blanket and over the revegetated slope.

The proposed blanket has a maximum permissible flow velocity of 10 feet per second (See the specification sheet included in Appendix E). Wood used Bentley FlowMaster V8i (Bentley Systems, Inc., 2009) to perform a sensitivity analysis of what concentrated flow width would exceed the 10 feet per second threshold and began to scour the blanket.

Table 5 presents the flow velocities associated with the unvegetated erosion control blanket. During the 25-year event, flow widths can be approximately as narrow as 3 feet before scouring occurs. The narrowest allowable flow width during the 100-year event is approximately 6 feet.

Table 5 – Flow Velocities over the Unvegetated Erosion Control Blanket

Recurrence Interval	Flow Velocity (fps)					
	1-ft Bottom Width	3-ft Bottom Width	5-ft Bottom Width	6-ft Bottom Width	10-ft Bottom Width	50-ft Bottom Width
25-Year Peak Flow (2.8 cfs)	13.39	9.65	7.97	7.43	6.10	3.19
100-Year Peak Flow (5.7 cfs)	16.63	12.66	10.54	9.84	8.07	4.27

After the vegetation is established, the grass mix should contribute to reducing the soil erosion potential. For channel applications, the United States Department of Agriculture (USDA) estimates that grass-lined channels with slopes between 5 and 10 percent can withstand flow velocities of about 3 to 4 feet per second (USDA, 2007). Though the rehabilitated slope is much steeper than a typical open channel, these flow velocities provide some guidance on what sort of flow conditions the proposed grasses could withstand.

Table 6 presents the flow velocities associated with the unvegetated erosion control blanket. During the 25-year event, flow widths can be approximately as narrow as 11 feet before scouring occurs. The narrowest allowable flow width during the 100-year event is approximately 25 feet.

Table 6 – Flow Velocities over the Proposed Revegetated Slope

Recurrence Interval	Flow Velocity (fps)					
	10-ft Bottom Width	11-ft Bottom Width	15-ft Bottom Width	20-ft Bottom Width	25-ft Bottom Width	50-ft Bottom Width
25-Year Peak Flow (2.8 cfs)	4.24	4.09	3.61	3.25	2.96	2.25
100-Year Peak Flow (5.7 cfs)	5.64	5.43	4.82	4.29	3.92	2.98

Peak flows are most likely to spread across the entire length of the embankment rather than concentrate in a single channel as modeled. Based on the results of the flow velocities over the proposed slope, no additional erosion countermeasures or flow diversions will be necessary to protect the unvegetated mat or the eventual revegetated surface.

See Appendix F for screenshots of the FlowMaster results.

6.4 Slope Stabilization at the Culvert Removal

The proposed reclamation plan includes removal of a cross culvert under the access road. Drainage contributing to this culvert flows down a steep slope with a distinct v-shaped gully. Local scour has been observed just downstream of the existing culvert outlet.

Model results for at the culvert removal location are summarized in Table 7.

Table 7 – Hydraulic Conditions at the Culvert Removal Location

Recurrence Interval	Peak Flow (cfs)	Maximum Velocity (fps)	Maximum Bed Shear Stress (psf)
25-Year	2.1	2.17	0.811
100-Year	5.0	2.92	1.24

To reestablish the natural waterway, it is recommended that the existing outlet scour be mitigated by riprap. Downstream of the riprap, the slope should be stabilized using the same erosion control blanket and seed mixture specified for the well pad slope rehabilitation.

A riprap apron is specified to fill in existing scour just downstream of the existing culvert outlet. This riprap apron was designed in accordance with the FHWA's HEC-14, Hydraulic Design of Energy Dissipators for Culverts and Channels (FHWA, 2006).

The same 9-inch rock riprap specified for the access road can also be used on this slope. Table 10.1 in HEC-14, reproduced here as Figure 7, presents the riprap apron as a function of culvert rise and riprap size. Assuming a rise of 12 inches and a rock diameter of 9 inches, the apron length should extend about 5 feet downstream of the existing culvert outlet and riprap should be laid to a depth of about 22 inches.

Table 10.1. Example Riprap Classes and Apron Dimensions

Class	D_{50} (mm)	D_{50} (in)	Apron Length[1]	Apron Depth
1	125	5	4D	$3.5D_{50}$
2	150	6	4D	$3.3D_{50}$
3	250	10	5D	$2.4D_{50}$
4	350	14	6D	$2.2D_{50}$
5	500	20	7D	$2.0D_{50}$
6	550	22	8D	$2.0D_{50}$

[1]D is the culvert rise.

Figure 7 – Example Riprap Classes and Apron Dimensions (FHWA, 2006)

As discussed in Section 6.3.2, the unvegetated erosion control blanket can withstand velocities up to 10 feet per second and shear stresses up to 2.35 pounds per square foot (See specifications in Appendix E). Once established, the proposed vegetation should be able to withstand flow velocities as high as 3 to 4 feet per second. At no point do the proposed conditions velocities or bed shear stresses exceed those threshold values, so the proposed erosion control blanket is well able to protect the slope downstream of the riprap apron.

7.0 Conclusion

Wood was asked to address three key issues in the rehabilitation of the MGP Enterprise A-4 well pad:

1. Implement scour countermeasures along the access road where erosion issues have been observed.
2. Implement erosion control measures to stabilize the culvert removal area.
3. Implement erosion control measures to stabilize the seeded soils over the proposed slope rehabilitation.

Wood developed a two-dimensional model using SRH-2D to determine the bed shear stresses along the access road. Riprap countermeasures were determined to be the most appropriate means of filling in the existing scoured area and reducing the likelihood of additional erosion. The riprap was conservatively designed to withstand the 100-year design event.

A biodegradable (coconut fiber) erosion control blanket was specified to stabilize seeded soils at the culvert removal location and over the proposed slope rehabilitation. The blanket itself will be able to protect the rehabilitated slope during more than the 100-year storm event. After native vegetation is fully reestablished through the blanket, the grass mix will provide the primary erosion control and is expected to withstand runoff flows during the 100-year event.

Finally, an additional riprap apron was specified to protect the area just downstream of the existing culvert. To simplify the construction, the apron was designed assuming same 9-inch riprap required for the roadway countermeasures.

The erosion control design is summarized below in Table 8.

Table 8 – Erosion Control Design Summary

Location	Riprap D_{50} (inches)	Riprap Thickness (inches)	Erosion Control Blanket
Access Road Bend	9	13.5	-
Culvert Removal	9	22	BioNet C125BN
Rehabilitated Slope over Well Pad	-	-	BioNet C125BN

8.0 References

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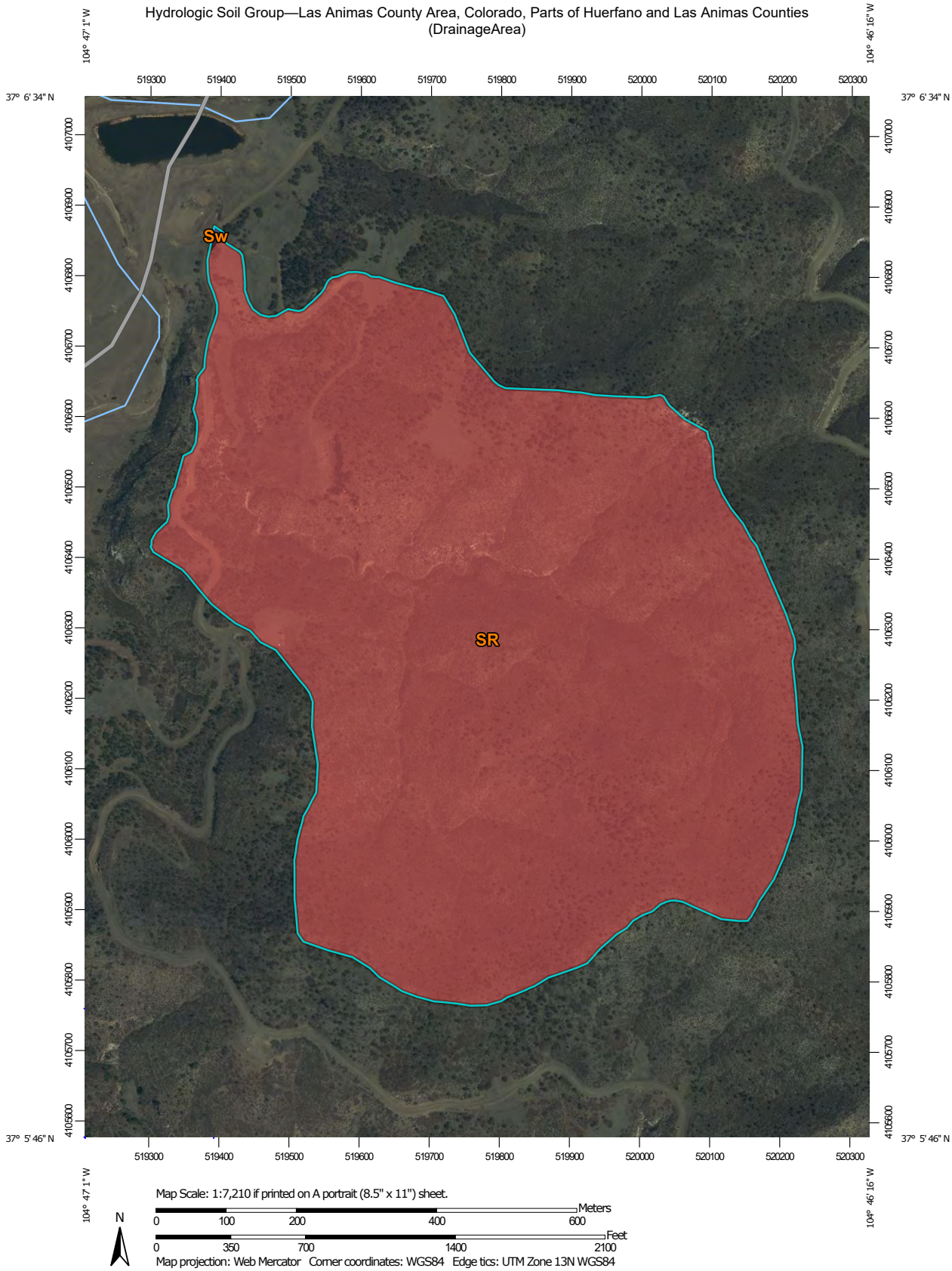
Appendix A: Hydrology

Hydrologic Soil Group—Las Animas County Area, Colorado, Parts of Huerfano and Las Animas Counties
(DrainageArea)



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Las Animas County Area, Colorado, Parts of Huerfano and Las Animas Counties
Survey Area Data: Version 23, Jun 5, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 31, 2020—May 18, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
SR	Saruche-Rombo-Rock outcrop complex, 25 to 50 percent slopes	D	159.7	100.0%
Sw	Molinaro loam, 2 to 12 percent slopes	B	0.1	0.0%
Totals for Area of Interest			**159.7**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

NOAA Atlas 14, Volume 8, Version 2
Location name: Weston, Colorado, USA*
Latitude: 37.1042°, Longitude: -104.7806°
Elevation: 6809.93 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.236 (0.188-0.296)	0.291 (0.232-0.364)	0.383 (0.304-0.482)	0.463 (0.365-0.586)	0.578 (0.440-0.767)	0.670 (0.497-0.904)	0.766 (0.547-1.07)	0.866 (0.591-1.25)	1.00 (0.656-1.50)	1.11 (0.706-1.68)
10-min	0.346 (0.276-0.433)	0.426 (0.339-0.534)	0.561 (0.445-0.706)	0.678 (0.534-0.857)	0.846 (0.644-1.12)	0.981 (0.727-1.32)	1.12 (0.800-1.56)	1.27 (0.865-1.83)	1.47 (0.961-2.19)	1.63 (1.03-2.47)
15-min	0.422 (0.337-0.529)	0.519 (0.413-0.651)	0.684 (0.543-0.860)	0.827 (0.652-1.05)	1.03 (0.786-1.37)	1.20 (0.887-1.62)	1.37 (0.976-1.90)	1.55 (1.06-2.23)	1.79 (1.17-2.67)	1.99 (1.26-3.01)
30-min	0.592 (0.472-0.741)	0.725 (0.578-0.909)	0.952 (0.756-1.20)	1.15 (0.906-1.45)	1.43 (1.09-1.90)	1.66 (1.23-2.24)	1.90 (1.36-2.64)	2.15 (1.47-3.09)	2.49 (1.63-3.71)	2.76 (1.75-4.18)
60-min	0.739 (0.589-0.925)	0.901 (0.718-1.13)	1.18 (0.935-1.48)	1.42 (1.12-1.80)	1.77 (1.35-2.35)	2.05 (1.52-2.77)	2.35 (1.68-3.27)	2.66 (1.81-3.83)	3.09 (2.02-4.60)	3.42 (2.17-5.18)
2-hr	0.886 (0.712-1.10)	1.08 (0.864-1.34)	1.41 (1.12-1.75)	1.69 (1.34-2.12)	2.11 (1.62-2.78)	2.44 (1.83-3.27)	2.79 (2.01-3.86)	3.17 (2.18-4.53)	3.68 (2.43-5.45)	4.09 (2.62-6.14)
3-hr	0.965 (0.779-1.19)	1.16 (0.937-1.44)	1.50 (1.21-1.86)	1.80 (1.44-2.25)	2.25 (1.74-2.95)	2.61 (1.97-3.49)	2.99 (2.17-4.12)	3.40 (2.36-4.85)	3.96 (2.63-5.85)	4.41 (2.84-6.61)
6-hr	1.14 (0.926-1.39)	1.33 (1.08-1.63)	1.68 (1.36-2.06)	2.00 (1.61-2.47)	2.48 (1.95-3.26)	2.90 (2.21-3.86)	3.34 (2.46-4.60)	3.83 (2.69-5.45)	4.53 (3.04-6.66)	5.09 (3.31-7.57)
12-hr	1.37 (1.12-1.66)	1.54 (1.27-1.87)	1.89 (1.54-2.30)	2.23 (1.81-2.73)	2.77 (2.21-3.64)	3.26 (2.52-4.33)	3.79 (2.82-5.21)	4.40 (3.13-6.24)	5.28 (3.60-7.74)	6.01 (3.95-8.88)
24-hr	1.60 (1.33-1.93)	1.81 (1.50-2.17)	2.22 (1.83-2.68)	2.62 (2.15-3.18)	3.28 (2.64-4.27)	3.86 (3.01-5.10)	4.51 (3.39-6.15)	5.24 (3.77-7.40)	6.32 (4.35-9.21)	7.21 (4.79-10.6)
2-day	1.81 (1.51-2.16)	2.11 (1.76-2.52)	2.67 (2.22-3.19)	3.19 (2.64-3.84)	4.01 (3.24-5.15)	4.71 (3.70-6.15)	5.48 (4.15-7.38)	6.33 (4.58-8.82)	7.55 (5.24-10.9)	8.55 (5.74-12.5)
3-day	1.98 (1.66-2.35)	2.30 (1.93-2.73)	2.90 (2.42-3.45)	3.46 (2.87-4.14)	4.33 (3.52-5.53)	5.07 (4.01-6.58)	5.89 (4.48-7.89)	6.79 (4.94-9.42)	8.08 (5.64-11.6)	9.13 (6.17-13.3)
4-day	2.14 (1.80-2.52)	2.46 (2.07-2.91)	3.07 (2.57-3.64)	3.64 (3.03-4.34)	4.52 (3.69-5.76)	5.29 (4.19-6.83)	6.12 (4.67-8.17)	7.03 (5.14-9.73)	8.35 (5.86-12.0)	9.43 (6.41-13.7)
7-day	2.53 (2.15-2.96)	2.88 (2.44-3.37)	3.51 (2.96-4.13)	4.09 (3.44-4.84)	4.99 (4.10-6.28)	5.76 (4.59-7.37)	6.59 (5.07-8.72)	7.50 (5.53-10.3)	8.80 (6.22-12.5)	9.86 (6.75-14.2)
10-day	2.87 (2.45-3.35)	3.25 (2.77-3.79)	3.92 (3.32-4.59)	4.53 (3.82-5.33)	5.44 (4.48-6.79)	6.21 (4.97-7.89)	7.04 (5.44-9.24)	7.93 (5.87-10.8)	9.20 (6.53-13.0)	10.2 (7.04-14.7)
20-day	3.81 (3.28-4.39)	4.31 (3.70-4.97)	5.14 (4.40-5.96)	5.86 (4.99-6.84)	6.88 (5.68-8.42)	7.70 (6.20-9.61)	8.54 (6.64-11.0)	9.42 (7.01-12.7)	10.6 (7.60-14.8)	11.5 (8.04-16.5)
30-day	4.58 (3.96-5.26)	5.19 (4.48-5.96)	6.18 (5.32-7.13)	7.00 (5.99-8.12)	8.13 (6.71-9.83)	8.99 (7.26-11.1)	9.86 (7.69-12.6)	10.7 (8.03-14.3)	11.9 (8.55-16.5)	12.8 (8.94-18.1)
45-day	5.56 (4.83-6.34)	6.31 (5.48-7.20)	7.50 (6.49-8.60)	8.45 (7.27-9.75)	9.71 (8.04-11.6)	10.6 (8.62-13.0)	11.5 (9.03-14.6)	12.4 (9.32-16.4)	13.5 (9.76-18.6)	14.3 (10.1-20.2)
60-day	6.40 (5.58-7.27)	7.27 (6.33-8.27)	8.62 (7.49-9.84)	9.68 (8.36-11.1)	11.1 (9.17-13.1)	12.0 (9.78-14.7)	13.0 (10.2-16.4)	13.8 (10.4-18.2)	14.9 (10.8-20.4)	15.6 (11.1-22.0)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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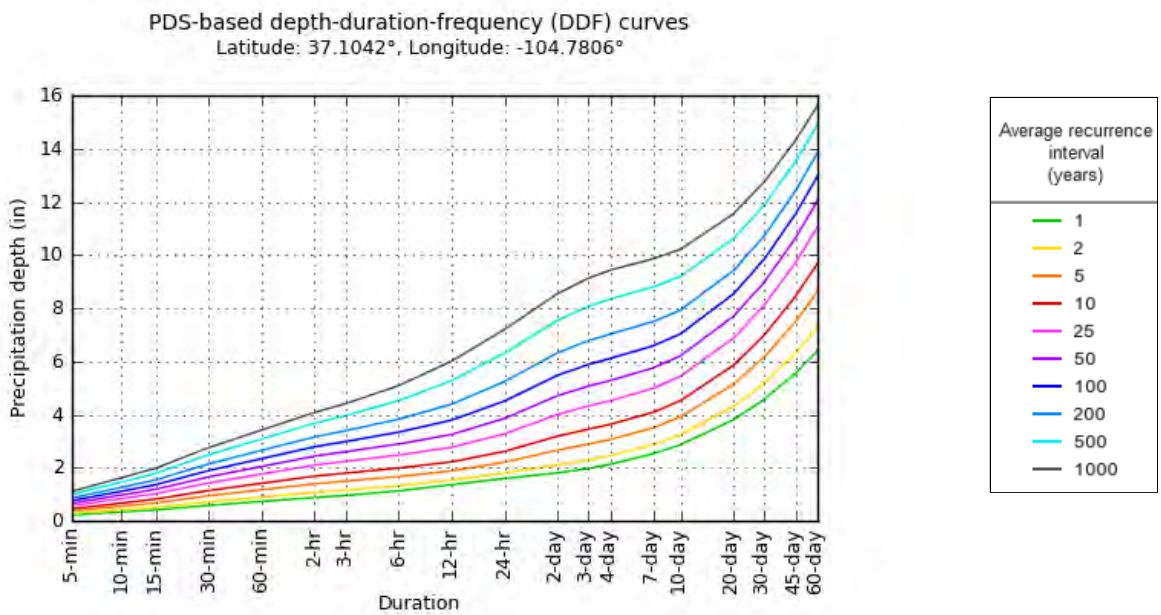
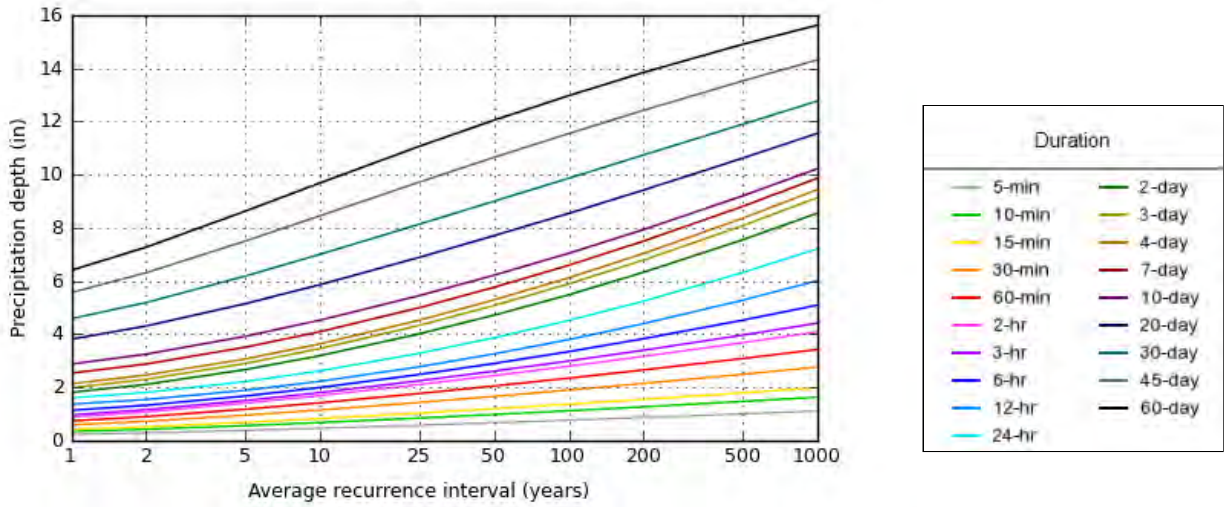
PF graphical





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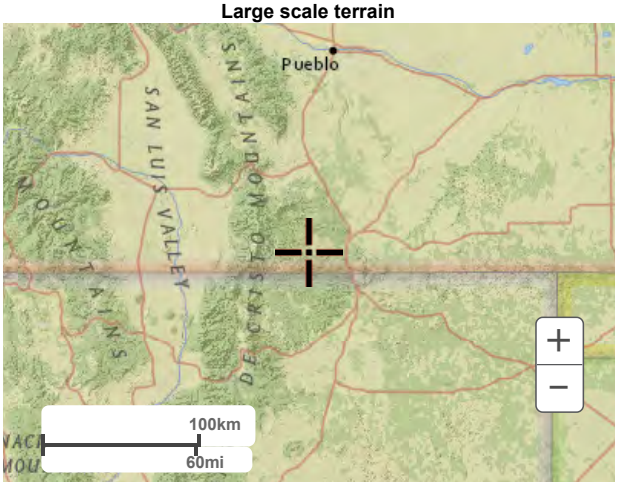
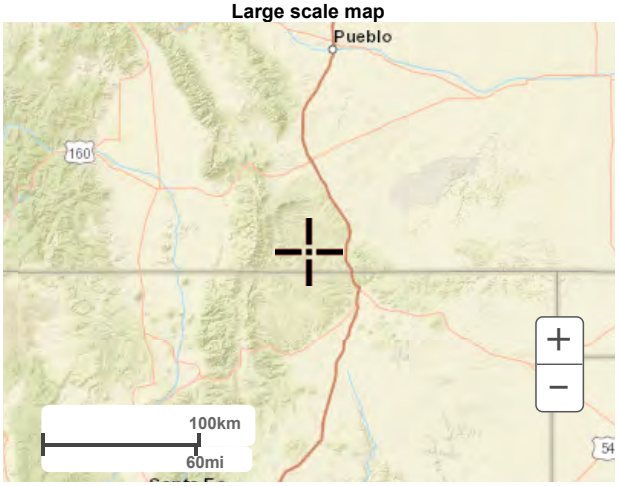
Maps & aerials

Small scale terrain

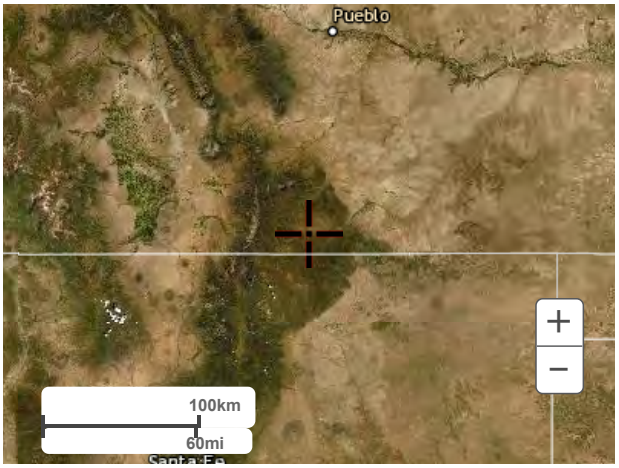
Large scale terrain



Large scale map



Large scale aerial



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National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

Proposed Conditions
Peak Flows Contributing to Bend Scour

Drainage Basin Description

Contributing Drainage Area (A)	8.20	acres
Hydrologic Soil Group [1]	D	
Percent Impervious	15%	
2-Year Runoff Coefficient [2] (C_x)	0.10	
5-Year Runoff Coefficient [2] (C_x)	0.16	
10-Year Runoff Coefficient [2] (C_x)	0.24	
25-Year Runoff Coefficient [2] (C_x)	0.40	
50-Year Runoff Coefficient [2] (C_x)	0.47	
100-Year Runoff Coefficient [2] (C_x)	0.55	
500-Year Runoff Coefficient [2] (C_x)	0.64	

Longest Flowpath Metrics

Overland (Sheet) Flow Longest Path (D)	90.00	feet
Average Slope of the Basin (S)	29	percent
Longest Flow Path (L)	0.30	miles
Channel Flow Change in Elevation (H)	91.00	feet

Calculations

$$\text{Overland (Initial)Flow Time: } T_i = \frac{1.8(1.1 - C_x)D^{1/2}}{S^{1/3}}$$

$$\text{Watershed Flow Time: } T_t = \left(\frac{11.9L^3}{H}\right)^{0.385}$$

$$\text{Computed Time of Concentration: } T_c = T_i + T_t \geq 10\ minutes$$

$$\text{Watershed Lag Time: } T_{lag} = 0.6(T_c)$$

$$\textbf{Rational Method Peak Flow}^{[3]}\textbf{: } \boldsymbol{Q_x = C_x I_{TC} A}$$

Where I_{TC} = Average rainfall intensity in inches per hour for a duration equal to the time of concentration

Return Period:	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
T_i (minutes)	5.54	5.21	4.74	3.86	3.51	3.07	2.57
T_t (minutes)	6.79	6.79	6.79	6.79	6.79	6.79	6.79
T_c (minutes)	12.33	12.00	11.53	10.65	10.29	10.00	10.00
T_{lag} (minutes)	7.40	7.20	6.92	6.39	6.18	6.00	6.00
I_{TC} [4] (inches/hour)	1.54	2.04	2.55	3.39	4.10	4.91	7.04
Q_x (cfs)	**1.25**	**2.64**	**5.07**	**11.20**	**15.69**	**21.96**	**36.72**

[1] Soil Survey Staff. (2015). Natural Resources Conservation Service, United States Department of Agriculture. Retrieved from Web Soil Survey: http://websoilsurvey.nrcs.usda.gov/
[2] Urban Drainage and Flood Control District. (2017). Urban Storm Drainage Criteria Manual V1, Table 6-5. Denver, CO.
[3] Colorado Department of Transportation. (2004). Chapter 7: Hydrology. CDOT Drainage Design Manual. CDOT Staff Hydraulics.
[4] National Oceanic and Atmospheric Administration. (2016). Hydrometeorological Design Studies Center. Retrieved from Precipitation Frequency Data Server: http://hdsc.nws.noaa.gov/hdsc/pfds/

Proposed Conditions
Peak Flows at the Culvert Removal

Drainage Basin Description		
Contributing Drainage Area (A)	2.06	acres
Hydrologic Soil Group [1]	D	
Percent Impervious	5%	
2-Year Runoff Coefficient [2] (C_x)	0.03	
5-Year Runoff Coefficient [2] (C_x)	0.08	
10-Year Runoff Coefficient [2] (C_x)	0.17	
25-Year Runoff Coefficient [2] (C_x)	0.35	
50-Year Runoff Coefficient [2] (C_x)	0.42	
100-Year Runoff Coefficient [2] (C_x)	0.50	
500-Year Runoff Coefficient [2] (C_x)	0.60	

Longest Flowpath Metrics		
Overland (Sheet) Flow Longest Path (D)	100.00	feet
Average Slope of the Basin (S)	24.2	percent
Longest Flow Path (L)	0.14	miles
Channel Flow Change in Elevation (H)	50.00	feet

Calculations

$$\text{Overland (Initial)Flow Time: } T_i = \frac{1.8(1.1 - C_x)D^{1/2}}{S^{1/3}}$$

$$\text{Watershed Flow Time: } T_t = \left(\frac{11.9L^3}{H}\right)^{0.385}$$

$$\text{Computed Time of Concentration: } T_c = T_i + T_t \geq 10\ minutes$$

$$\text{Watershed Lag Time: } T_{lag} = 0.6(T_c)$$

$$\textbf{Rational Method Peak Flow}^{[3]}\textbf{: } \boldsymbol{Q_x = C_x I_{TC} A}$$

Where I_{TC} = Average rainfall intensity in inches per hour for a duration equal to the time of concentration

Return Period:	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
T_i (minutes)	6.67	6.37	5.79	4.69	4.25	3.71	3.09
T_t (minutes)	3.58	3.58	3.58	3.58	3.58	3.58	3.58
T_c (minutes)	10.25	10.00	10.00	10.00	10.00	10.00	10.00
T_{lag} (minutes)	6.15	6.00	6.00	6.00	6.00	6.00	6.00
I_{TC} [4] (inches/hour)	1.62	2.14	2.64	3.44	4.13	4.91	7.04
Q_x (cfs)	**0.10**	**0.34**	**0.92**	**2.46**	**3.55**	**5.10**	**8.76**

[1] Soil Survey Staff. (2015). Natural Resources Conservation Service, United States Department of Agriculture. Retrieved from Web Soil Survey: http://websoilsurvey.nrcs.usda.gov/
[2] Urban Drainage and Flood Control District. (2017). Urban Storm Drainage Criteria Manual V1, Table 6-5. Denver, CO.
[3] Colorado Department of Transportation. (2004). Chapter 7: Hydrology. CDOT Drainage Design Manual. CDOT Staff Hydraulics.
[4] National Oceanic and Atmospheric Administration. (2016). Hydrometeorological Design Studies Center. Retrieved from Precipitation Frequency Data Server: http://hdsc.nws.noaa.gov/hdsc/pfds/

Proposed Conditions

Peak Flows over the Proposed Slope

Drainage Basin Description		
Contributing Drainage Area (A)	2.30	acres
Hydrologic Soil Group [1]	D	
Percent Impervious	5%	
2-Year Runoff Coefficient [2] (C_x)	0.03	
5-Year Runoff Coefficient [2] (C_x)	0.08	
10-Year Runoff Coefficient [2] (C_x)	0.17	
25-Year Runoff Coefficient [2] (C_x)	0.35	
50-Year Runoff Coefficient [2] (C_x)	0.42	
100-Year Runoff Coefficient [2] (C_x)	0.50	
500-Year Runoff Coefficient [2] (C_x)	0.60	
Longest Flowpath Metrics		
Overland (Sheet) Flow Longest Path (D)	100.00	feet
Average Slope of the Basin (S)	34	percent
Longest Flow Path (L)	0.09	miles
Channel Flow Change in Elevation (H)	117.00	feet

Calculations

$$\text{Overland (Initial)Flow Time: } T_i = \frac{1.8(1.1 - C_x)D^{1/2}}{S^{1/3}}$$

$$\text{Watershed Flow Time: } T_t = \left(\frac{11.9L^3}{H}\right)^{0.385}$$

$$\text{Computed Time of Concentration: } T_c = T_i + T_t \geq 10\ minutes$$

$$\text{Watershed Lag Time: } T_{lag} = 0.6(T_c)$$

$$\textbf{Rational Method Peak Flow}^{[3]}\textbf{: } \boldsymbol{Q_x = C_x I_{TC} A}$$

Where I_{TC} = Average rainfall intensity in inches per hour for a duration equal to the time of concentration

Return Period:	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
T_i (minutes)	5.95	5.69	5.17	4.18	3.79	3.31	2.76
T_t (minutes)	1.48	1.48	1.48	1.48	1.48	1.48	1.48
T_c (minutes)	10.00	10.00	10.00	10.00	10.00	10.00	10.00
T_{lag} (minutes)	6.00	6.00	6.00	6.00	6.00	6.00	6.00
I_{TC} [4](inches/hour)	1.63	2.14	2.64	3.44	4.13	4.91	7.04
Q_x (cfs)	**0.11**	**0.37**	**1.03**	**2.75**	**3.97**	**5.70**	**9.78**

[1] Soil Survey Staff. (2015). Natural Resources Conservation Service, United States Department of Agriculture. Retrieved from Web Soil Survey: http://websoilsurvey.nrcs.usda.gov/

[2] Urban Drainage and Flood Control District. (2017). Urban Storm Drainage Criteria Manual V1, Table 6-5. Denver, CO.

[3] Colorado Department of Transportation. (2004). Chapter 7: Hydrology. CDOT Drainage Design Manual. CDOT Staff Hydraulics.

[4] National Oceanic and Atmospheric Administration. (2016). Hydrometeorological Design Studies Center. Retrieved from Precipitation Frequency Data Server: http://hdsc.nws.noaa.gov/hdsc/pfds/

Peak Flows as Estimated by the Rational Method

Runoff Coefficient and Time of Concentration References for Rational Method Calculations

[2] Runoff Coefficients for Rational Method

Table 6-5. Runoff coefficients, *c*

Total or Effective % Impervious	NRCS Hydrologic Soil Group A						
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
2%	0.01	0.01	0.01	0.01	0.04	0.13	0.27
5%	0.02	0.02	0.02	0.03	0.07	0.15	0.29
10%	0.04	0.05	0.05	0.07	0.11	0.19	0.32
15%	0.07	0.08	0.08	0.1	0.15	0.23	0.35
20%	0.1	0.11	0.12	0.14	0.2	0.27	0.38
25%	0.14	0.15	0.16	0.19	0.24	0.3	0.42
30%	0.18	0.19	0.2	0.23	0.28	0.34	0.45
35%	0.21	0.23	0.24	0.27	0.32	0.38	0.48
40%	0.25	0.27	0.28	0.32	0.37	0.42	0.51
45%	0.3	0.31	0.33	0.36	0.41	0.46	0.54
50%	0.34	0.36	0.37	0.41	0.45	0.5	0.58
55%	0.39	0.4	0.42	0.45	0.49	0.54	0.61
60%	0.43	0.45	0.47	0.5	0.54	0.58	0.64
65%	0.48	0.5	0.51	0.54	0.58	0.62	0.67
70%	0.53	0.55	0.56	0.59	0.62	0.65	0.71
75%	0.58	0.6	0.61	0.64	0.66	0.69	0.74
80%	0.63	0.65	0.66	0.69	0.71	0.73	0.77
85%	0.68	0.7	0.71	0.74	0.75	0.77	0.8
90%	0.73	0.75	0.77	0.79	0.79	0.81	0.84
95%	0.79	0.81	0.82	0.83	0.84	0.85	0.87
100%	0.84	0.86	0.87	0.88	0.88	0.89	0.9
Total or Effective % Impervious	**NRCS Hydrologic Soil Group B**						
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
2%	0.01	0.01	0.07	0.26	0.34	0.44	0.54
5%	0.03	0.03	0.1	0.28	0.36	0.45	0.55
10%	0.06	0.07	0.14	0.31	0.38	0.47	0.57
15%	0.09	0.11	0.18	0.34	0.41	0.5	0.59
20%	0.13	0.15	0.22	0.38	0.44	0.52	0.61
25%	0.17	0.19	0.26	0.41	0.47	0.54	0.63
30%	0.2	0.23	0.3	0.44	0.49	0.57	0.65
35%	0.24	0.27	0.34	0.47	0.52	0.59	0.66
40%	0.29	0.32	0.38	0.5	0.55	0.61	0.68
45%	0.33	0.36	0.42	0.53	0.58	0.64	0.7
50%	0.37	0.4	0.46	0.56	0.61	0.66	0.72
55%	0.42	0.45	0.5	0.6	0.63	0.68	0.74
60%	0.46	0.49	0.54	0.63	0.66	0.71	0.76
65%	0.5	0.54	0.58	0.66	0.69	0.73	0.77
70%	0.55	0.58	0.62	0.69	0.72	0.75	0.79
75%	0.6	0.63	0.66	0.72	0.75	0.78	0.81
80%	0.64	0.67	0.7	0.75	0.77	0.8	0.83
85%	0.69	0.72	0.74	0.78	0.8	0.82	0.85
90%	0.74	0.76	0.78	0.81	0.83	0.84	0.87
95%	0.79	0.81	0.82	0.85	0.86	0.87	0.88
100%	0.84	0.86	0.86	0.88	0.89	0.89	0.9

Table 6-5. Runoff coefficients, *c* (continued)

Total or Effective % Impervious	NRCS Hydrologic Soil Group C						
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
2%	0.01	0.05	0.15	0.33	0.40	0.49	0.59
5%	0.03	0.08	0.17	0.35	0.42	0.5	0.6
10%	0.06	0.12	0.21	0.37	0.44	0.52	0.62
15%	0.1	0.16	0.24	0.4	0.47	0.55	0.64
20%	0.14	0.2	0.28	0.43	0.49	0.57	0.65
25%	0.18	0.24	0.32	0.46	0.52	0.59	0.67
30%	0.22	0.28	0.35	0.49	0.54	0.61	0.68
35%	0.26	0.32	0.39	0.51	0.57	0.63	0.7
40%	0.3	0.36	0.43	0.54	0.59	0.65	0.71
45%	0.34	0.4	0.46	0.57	0.62	0.67	0.73
50%	0.38	0.44	0.5	0.6	0.64	0.69	0.75
55%	0.43	0.48	0.54	0.63	0.66	0.71	0.76
60%	0.47	0.52	0.57	0.65	0.69	0.73	0.78
65%	0.51	0.56	0.61	0.68	0.71	0.75	0.79
70%	0.56	0.61	0.65	0.71	0.74	0.77	0.81
75%	0.6	0.65	0.68	0.74	0.76	0.79	0.82
80%	0.65	0.69	0.72	0.77	0.79	0.81	0.84
85%	0.7	0.73	0.76	0.79	0.81	0.83	0.86
90%	0.74	0.77	0.79	0.82	0.84	0.85	0.87
95%	0.79	0.81	0.83	0.85	0.86	0.87	0.89
100%	0.83	0.85	0.87	0.88	0.89	0.89	0.9

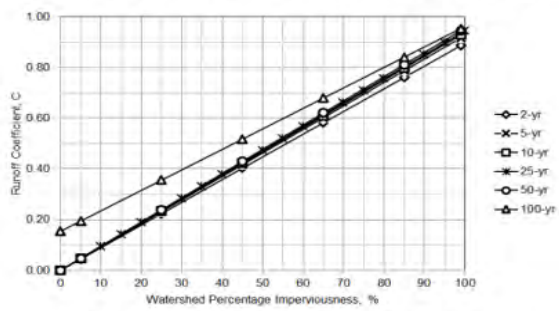


Figure 6-1. Runoff coefficient vs. watershed imperviousness NRCS HSG A

[3] Calculation of the Time of Concentration

7.3.3 Time of Concentration

The time of concentration, T_c, is defined as the time it takes a drop of rain falling on the hydraulically most remote point in the watershed to travel through the watershed to the first design point. It is a very important parameter at which the entire drainage basin is contributing runoff to the design point. The time of concentration usually has two components. The first is the initial time, T_i, which is the time runoff is sheet flowing. The travel time, T_t, is the time runoff is in a channel.

$$T_c = T_i + T_t,$$

For overland flow in a small basin:

$$T_i = \frac{1.8(1.1 - C)D^{0.5}}{S^{0.33}},$$

where: T_i = minutes; C = runoff coefficient as defined in the rational equation; D = distance of flow path in feet (500 ft maximum for non-urban areas, 300 ft maximum for urban areas); S = average slope of basin in percent (see Figure 7.1).

For channel flow:

$$T_t = (11.9\, L^3/H)^{0.385}$$

In urban watersheds, the time of concentration at the first design point (including both channel and overland flow), shall not exceed the following:

$$T_c = (L/180) + 10$$

where: T_c = time of concentration, in minutes, at the first design point; and L =basin length in feet.

A minimum T_c is to be 5 minutes in urban areas and 10 minutes in rural areas.

[2] Urban Drainage and Flood Control District. (2017). Urban Storm Drainage Criteria Manual - Volumes 1, Table RO-5. Denver, CO.

[3] Colorado Department of Transportation. (2004). Chapter 7: Hydrology. CDOT Drainage Design Manual. CDOT Staff Hydraulics.

Appendix B: Bend Scour

Parameters and Estimation of Maynord Bend Scour[3]
for Estimation of Bank Scour along the Avulsion over the Line 41 South Platte River Crossing

Symbol	Units	Description	Source	25-Year	100-Year
Sediment Properties					
D_{50}	mm	Particle size with 50 percent finer	Assumed for Sand	**0.50**	**0.50**
D_m	mm	Effective mean diameter of bed material in the bridge		**0.63**	**0.63**
T	ft/sec	Fall velocity of bed material based on the D_{50}	HEC-18[2] Fig. 6.8	**0.22**	**0.22**
V_c	ft/sec	Critical velocity for mobilization of bed sediment		**1.16**	**1.07**
V_*	ft/sec	Shear velocity in the approach cross-section		**1.47**	**1.15**
		Check for clear-water ($V_1<V_c$) or live-bed ($V_1>V_c$) scour conditions:		**Live-Bed**	**Live-Bed**
SRH-2D Model Output					
Q_1	cfs	Flow in the upstream section transporting sediment	Upstream Section	**11**	**22**
Q_2	cfs	Flow in the bend section	Bend Section over the Avulsion	**12**	**13**
S_1	ft/ft	Slope of the upstream energy grade line	Upstream Section	**0.1450**	**0.1456**
V_1	ft/sec	Average velocity in the upstream cross-section	Upstream Section	**3.43**	**3.84**
Scour Calculation					
$\frac{D_{max}}{D_{upstream}} = 1.8 - 0.051\left({R_c}/{W_{upstream}}\right) + 0.0084\left({W_{upstream}}/{D_{upstream}}\right)$					
R_c	ft	Approximate Radius of Curvature	Measured	**120.00**	**120.00**
$W_{upstream}$	ft	Active channel width contributing to side drainage erosion	Upstream Section	**8.18**	**16.48**
$D_{upstream}$	ft	Average depth of the upstream side drainage	Upstream Section	**0.46**	**0.28**
D_{bend}	ft	Average depth through the eroded side drainage	Bend Section over the Avulsion	**0.42**	**0.21**
D_{max}	ft	Maximum depth over the eroded side drainage	Bend Section over the Avulsion	**0.55**	**0.54**
Scour	**ft**	**Scour Depth over the Pipeline**	**D_{max} - D_{bend}**	**0.1**	**0.3**

[1] Advanced Terra Testing (2020). Grain Size Analysis for Line 41-South Platte River Geohazard

[2] FHWA. (2012). Hydraulic Engineering Circular No. 18 - Evaluating Scour at Bridges, 5th Edition. U.S. Department of Transportation.

[3] Maynord, S. (1996). Toe Scour Estimation in Stabilized Bendways. Journal of Hydraulic Engineering, ASCE, V122, n8, P460.

Appendix C: Riprap Design

HEC-15 Flexible Channel Lining Design - RIPRAP

Project Identification:	**Hydraulics Report for the MGP Enterprise A-4 Well Pad Erosion Control**
Channel Identification:	**Access Road Side Drainage**

Channel Properties - User Input	
Very Angular	
Slope (ft/ft)	0.085
Riprap specific gravity	2.65
Z left	3.0
Z right	3.0
Bottom Width (ft)	8.0

Iterative Properties - User Input	
Initial Q_i (cfs)	22.0
Initial D_{50} (ft)	0.75
Initial flow depth d_i (ft)	0.600

Channel Flow Properties	
T - Flow Top Width (ft)	11.6
A - Wet area (sq ft)	5.9
P - Wetted perimeter (ft)	11.8
R=A/P - hydraulic radius (ft)	0.499
da=A/T - Average flow depth (ft)	0.51
d_a/D_{50}	0.68

Calculated flow and depth -EQ 6.1 - IF d_a/D_{50} >=1.5	
n - Manning's roughness (EQ 6.1)	
Calculated Q_C (cfs)	
Percent Difference between Qi and Qc	
Calculated depth of flow d_i+1 (ft)	

Calculated flow and depth - EQ 6.2 - IF 0.3<da/D50<1.5	
b - (EQ 6.6)	0.240
FR - Froude No. (Q/A)/SQRT(g*d_a)	0.926
f(CG) - (EQ 6.5)	0.472
f(REG) - (EQ 6.4)	6.838
f(Fr) - (EQ 6.3)	1.040
n - Manning's roughness (EQ 6.2)	0.070
Calculated Q_C (cfs)	23.00
Percent Difference between Qi and Qc	4.55%
Calculated depth of flow d_i+1 (ft)	0.589

V_* - Shear Velocity (EQ 6.10)	1.28
R_e - (EQ 6.9)	7.90E+04
SF - Safety Factor	1.11
F* - Sheild's Parameter	0.069

Shear Stress	
τ_S - Channel shear stress (EQ 3.1)	3.18
K_1 - Side to bottom stress ratio (EQ 3.4)	0.868
τ_S - Side shear strees (EQ 3.3)	2.76
h - Stability number (EQ 6.14)	0.523
a - Angle of channel slope (deg)	4.86
f - Angle of repose for riprap (deg) from Figure 6.1	41.5
θ - Angle of side slope (deg) (EQ 6.17)	18.4
β - weight vs drag vector (EQ 6.13)	34.5
Δ -geometry/riprap function (EQ 6.12)	1.141

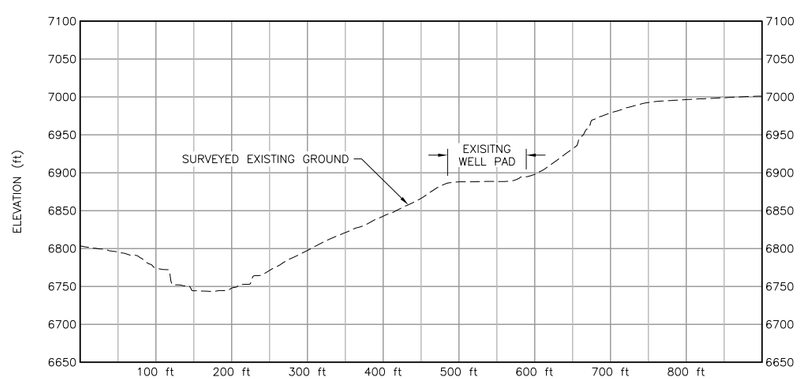
Calculated Min. Bottom Riprap Size	**(ft)**
If slope less than 5%	
Min. D_{50} (EQ 6.8)	0.50
If slope greater than 10%	
Min. D_{50} (EQ 6.11)	0.57
If slope is between 5% and 10%	
Min. D_{50} = Greater of EQ 6.8 or EQ 6.11	0.57

Calculated Min. Side Slope Riprap Size	**(ft)**
θ - Angle of side slope (EQ 6.17)	18.4
K2 - (EQ 6.16)	0.88
$D_{50,S}$ - (EQ 6.15)	0.56

Messages:

The initial D50 is larger than the Min. D50, the calculations are complete

Appendix D: Site Plan



A F01 EXISTING WELL PAD SECTION

100 0 100 200 FT

LEGEND:

2400 EXISTING GROUND SURFACE CONTOUR EL, FEET (NOTE 1)

EXISTING ROADS

NOTES:

1. EXISTING TOPOGRAPHIC CONTOURS WERE GENERATED FROM AERIAL SURVEYS CONDUCTED ON AUGUST 13, 2020 AND WERE PROVIDED BY WOOD ASSET SOLUTIONS, AMERICA (WOOD ASA) IN THE FOLLOWING COORDINATE SYSTEM: NAD83, COLORADO STATE PLANE, SOUTH ZONE, US FOOT.

DRAFT

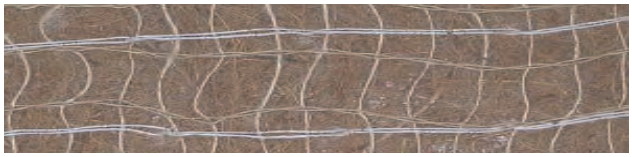
PROVIDED FOR: bp	PROVIDED BY: wood.	CLIENT: BP AMERICA PRODUCTION COMPANY	ISSUED DATE: 03 SEPT 2020
	DRN BY: SS	PROJECT: MGP ENTERPRISE A–4 RECLAMATION	PROJECT No.: 32820182
	DSN BY: JQ	TITLE: PLAN VIEW AND WELL PAD SECTION	
	CHK BY: DS		FIGURE No.: F01 / REV: A
	APR BY: RW		

Z:\SConnor Files\Projects\32820182 – MGP Enterprise A–4 Reclamation\14 CAD\CIV\FIG\2020.09.03 – Plan View and Well Pad Section\Plan View and Well Pad Section.dwg–9/3/2020 11:01 AM

Appendix E: Erosion Control

ROLLMAX™
ROLLED EROSION CONTROL

Specification Sheet
BioNet® C125BN™ Erosion Control Blanket



DESCRIPTION

The long-term double net erosion control blanket shall be a machine-produced mat of 100% coconut fiber with a functional longevity of up to 24 months. *(NOTE: functional longevity may vary depending upon climatic conditions, soil, geographical location, and elevation).* The blanket shall be of consistent thickness with the coconut evenly distributed over the entire area of the mat. The blanket shall be covered on the top and bottom sides with 100% biodegradable woven natural organic fiber netting. The netting shall consist of machine directional strands formed from two intertwined yarns with cross directional strands interwoven through the the twisted machine strands (commonly referred to as Leno weave) to form an approximate 0.50 x 1.0 in (1.27 x 2.54 cm) mesh. The blanket shall be sewn together on 1.50 inch (3.81 cm) centers with degradable thread. The blanket shall be manufactured with a colored thread stitched along both outer edges (approximately 2-5 inches [5-12.5 cm] from the edge) as an overlap guide for adjacent mats.

The C125BN shall meet Type 4 specification requirements established by the Erosion Control Technology Council (ECTC) and Federal Highway Administration's (FHWA) FP-03 Section 713.17

Material Content		
Matrix	100% Coconut Fiber	0.5 lbs/sq yd (0.27 kg/sm)
Netting	Leno Woven 100% biodegradable jute	9.3 lbs/1000 sq ft (4.5 kg/100 sm)
	100% Biodegradable jute	7.7 lb/1000 sq ft (3.76 kg/100 sm)
Thread	Biodegradable	

Standard Roll Sizes		
Width	6.67 (2.03 m)	8.0 ft (2.4 m)
Length	108 ft (32.92 m)	112 ft (34.14 m)
Weight ± 10%	52.22 lbs (23.69 kg)	65.25 lbs (29.61 kg)
Area	80 sq yd (66.9 sm)	100 sq yd (83.61 sm)
	Leno weave top only	Leno weave top and bottom

Index Property	Test Method	Typical
Thickness	ASTM D6525	0.23 in. (5.84 mm)
Resiliency	ECTC Guidelines	85%
Water Absorbency	ASTM D1117	365%
Mass/Unit Area	ASTM 6475	9.79 oz/sy (333 g/sm)
Swell	ECTC Guidelines	40%
Smolder Resistance	ECTC Guidelines	Yes
Stiffness	ASTM D1388	0.11 oz-in
Light Penetration	ASTM D6567	16.2%
Tensile Strength - MD	ASTM D6818	206.4 lbs/ft (3.06 kN/m)
Elongation - MD	ASTM D6818	15.3%
Tensile Strength - TD	ASTM D6818	145.2 lbs/ft (2.15 kN/m)
Elongation - TD	ASTM D6818	12.9%
Biomass Improvement	ASTM 7322	473%

Design Permissible Shear Stress	
Unvegetated Shear Stress	2.35 psf (112 Pa)
Unvegetated Velocity	10.0 fps (3.05 m/s)

Slope Design Data: C Factors			
	Slope Gradients (S)		
Slope Length (L)	≤ 3:1	3:1 – 2.1	≥ 2:1
≤ 20 ft (6 m)	0.0001	0.018	0.050
20-50 ft	0.003	0.040	0.060
≥ 50 ft (15.2 m)	0.007	0.070	0.070

Roughness Coefficients – Unveg.	
Flow Depth	Manning's n
≤ 0.50 ft (0.15 m)	0.022
0.50 – 2.0 ft	0.022-0.014
≥ 2.0 ft (0.60 m)	0.014

NORTH AMERICAN GREEN®

Western Green
4609 E. Boonville-New Harmony Rd.
Evansville, IN 47725

nagreen.com
800-772-2040

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EC_RMX_MPDS_C125BN_1.19

Appendix F: Hydraulic Model Results

```
*****************************************************************
*                                                               *
*                    SRH-2D Version 3.2.3                       *
*             Sedimentation-River-Hydraulics 2D Model           *
*          with Mobile-Bed and Sediment Transport Module        *
*                                                               *
*        Technical Service Center,  Bureau of Reclamation       *
*        Developer: Yong G. Lai, Ph.D., ylai@usbr.gov           *
*****************************************************************

==> Code Execution Year-Month-Date:  2021  3 25


*************************************************************
*          Summary of Input Parameters and Variables       *
*************************************************************

SRH-2D MODULE USED:
     Module Used: FLOW modeling only
     Temperature Module: not activated
     Bank erosion model activated?  NO
     Turbulence Model: Depth-averaged parabolic zero-equation model

MESH SIZE INFO:
     Total number of cells:              18490
     Total number of mesh points:         9782
     Total number of faces:              28271
     Total number of boundary faces:       307
     NCLVT:                              56235
     Number of Mesh Blocks:                  1
     Mesh Type: Unstructured mesh - SMS-2DM format

UNSTEADY SIMULATION PARAMETERS:
     Unsteady Simulation: YES, it is unsteady
     Initial Condition:   New run from user specified initial condition
     Number of time steps (ntstep):                   -1
     Number of iterations within each time step:       3
     Tstart(s) DT(s) DT_CHAN(s) Total_simu_time(hr):    0.0000E+00   2.0000E+00
2.0000E+00   8.0000E+00
     Laminar kinematic viscosity:                       1.0000E-06
     Turbulent Parabolic Model Constant:                7.0000E-01

MISCELLENEOUS PARAMETERS:

INTERMEDIATE RESULT PRINTOUT CONTROL:


*********************************************************
```

```
*       End of Input Parameters and Variables Summary      *
*************************************************************

==> Mesh Size Info over Solution Domain
    Minimum Mesh Cell Area (m^2)      =   2.664E-01
    Maximum Mesh Cell Area (m^2)      =   1.537E+02
    Total Solution Domain Area (m^2)  =   1.335E+05

==> Smallest Angle between Cell-to-Cell-Base-Vector and Face =   5.088E+01
    Located at Face=    9121;    Between two cells:    5707    5707


****************************************************
*   SIMULATION INFORMATION PRINT OUT               *
****************************************************



*************************************************************
**         SUMMARY OF FINAL RESULT OUTPUT
*************************************************************

** Total Volume of Water and Sediment through all Exits and Monitor Lines

  Water Volume (cubic meter) through Monitor Line # 1:   7.6002E+02

  Water Volume (cubic meter) through Monitor Line # 2:   0.0000E+00

  Water Volume (cubic meter) through Monitor Line # 3:   4.1188E+03

  Water Volume (cubic meter) through Exit # 1:   0.0000E+00

  Water Volume (cubic meter) through Exit # 2:   0.0000E+00

  Water Volume (cubic meter) through Exit # 3:   0.0000E+00

==> CPU-TIME(hours) =    1.424E-01

==> SRH-2D is successfully executed
```

```
*****************************************************************
*                                                               *
*                    SRH-2D Version 3.2.3                       *
*             Sedimentation-River-Hydraulics 2D Model           *
*          with Mobile-Bed and Sediment Transport Module        *
*                                                               *
*        Technical Service Center,  Bureau of Reclamation       *
*        Developer: Yong G. Lai, Ph.D., ylai@usbr.gov           *
*****************************************************************

==> Code Execution Year-Month-Date:  2021  3 25


*************************************************************
*          Summary of Input Parameters and Variables       *
*************************************************************

SRH-2D MODULE USED:
     Module Used: FLOW modeling only
     Temperature Module: not activated
     Bank erosion model activated?  NO
     Turbulence Model: Depth-averaged parabolic zero-equation model

MESH SIZE INFO:
     Total number of cells:              18490
     Total number of mesh points:         9782
     Total number of faces:              28271
     Total number of boundary faces:       307
     NCLVT:                              56235
     Number of Mesh Blocks:                  1
     Mesh Type: Unstructured mesh - SMS-2DM format

UNSTEADY SIMULATION PARAMETERS:
     Unsteady Simulation: YES, it is unsteady
     Initial Condition:   New run from user specified initial condition
     Number of time steps (ntstep):                   -1
     Number of iterations within each time step:       3
     Tstart(s) DT(s) DT_CHAN(s) Total_simu_time(hr):    0.0000E+00   2.0000E+00
2.0000E+00   8.0000E+00
     Laminar kinematic viscosity:                       1.0000E-06
     Turbulent Parabolic Model Constant:                7.0000E-01

MISCELLENEOUS PARAMETERS:

INTERMEDIATE RESULT PRINTOUT CONTROL:


*********************************************************
```

```
*       End of Input Parameters and Variables Summary      *
*************************************************************

==> Mesh Size Info over Solution Domain
    Minimum Mesh Cell Area (m^2)      =   2.664E-01
    Maximum Mesh Cell Area (m^2)      =   1.537E+02
    Total Solution Domain Area (m^2)  =   1.335E+05

==> Smallest Angle between Cell-to-Cell-Base-Vector and Face =   5.088E+01
    Located at Face=    9121;    Between two cells:    5707    5707


****************************************************
*   SIMULATION INFORMATION PRINT OUT               *
****************************************************



*************************************************************
**         SUMMARY OF FINAL RESULT OUTPUT
*************************************************************

** Total Volume of Water and Sediment through all Exits and Monitor Lines

  Water Volume (cubic meter) through Monitor Line # 1:   5.8627E+01

  Water Volume (cubic meter) through Monitor Line # 2:   0.0000E+00

  Water Volume (cubic meter) through Monitor Line # 3:   4.3136E+03

  Water Volume (cubic meter) through Exit # 1:   0.0000E+00

  Water Volume (cubic meter) through Exit # 2:   0.0000E+00

  Water Volume (cubic meter) through Exit # 3:   0.0000E+00

==> CPU-TIME(hours) =    1.348E-01

==> SRH-2D is successfully executed
```

Worksheet : 25-Year Flow over Unvegetated Erosion Control Blanket

Uniform Flow | Gradually Varied Flow | Messages

Solve For: Normal Depth

Friction Method: Manning Formula

Roughness Coefficient:	0.022	
Channel Slope:	0.50000	ft/ft
Normal Depth:	0.10	ft
Left Side Slope:	0.10	ft/ft (H:V)
Right Side Slope:	0.10	ft/ft (H:V)
Bottom Width:	3.00	ft
Discharge:	2.80	ft³/s

Flow Area:	0.29	ft²
Wetted Perimeter:	3.19	ft
Hydraulic Radius:	0.09	ft
Top Width:	3.02	ft
Critical Depth:	0.30	ft
Critical Slope:	0.01315	ft/ft
Velocity:	9.65	ft/s
Velocity Head:	1.45	ft
Specific Energy:	1.54	ft
Froude Number:	5.49	
Flow Type:	Supercritical	

Worksheet : 100-Year Flow over Unvegetated Erosion Control Blanket

Uniform Flow | Gradually Varied Flow | Messages

Solve For: Normal Depth

Friction Method: Manning Formula

Roughness Coefficient:	0.022	
Channel Slope:	0.50000	ft/ft
Normal Depth:	0.10	ft
Left Side Slope:	0.10	ft/ft (H:V)
Right Side Slope:	0.10	ft/ft (H:V)
Bottom Width:	6.00	ft
Discharge:	5.70	ft³/s

Flow Area:	0.58	ft²
Wetted Perimeter:	6.19	ft
Hydraulic Radius:	0.09	ft
Top Width:	6.02	ft
Critical Depth:	0.30	ft
Critical Slope:	0.01180	ft/ft
Velocity:	9.84	ft/s
Velocity Head:	1.51	ft
Specific Energy:	1.60	ft
Froude Number:	5.59	
Flow Type:	Supercritical	

Worksheet : 25-Year Flow over Vegetated Slope

Uniform Flow | Gradually Varied Flow | Messages

Solve For: Normal Depth

Friction Method: Manning Formula

Roughness Coefficient:	0.040	
Channel Slope:	0.50000	ft/ft
Normal Depth:	0.06	ft
Left Side Slope:	0.10	ft/ft (H:V)
Right Side Slope:	0.10	ft/ft (H:V)
Bottom Width:	11.00	ft
Discharge:	2.80	ft³/s

Flow Area:	0.68	ft²
Wetted Perimeter:	11.13	ft
Hydraulic Radius:	0.06	ft
Top Width:	11.01	ft
Critical Depth:	0.13	ft
Critical Slope:	0.04778	ft/ft
Velocity:	4.09	ft/s
Velocity Head:	0.26	ft
Specific Energy:	0.32	ft
Froude Number:	2.89	
Flow Type:	Supercritical	

Calculation Successful.

Worksheet : 100-Year Flow over Vegetated Slope

Uniform Flow | Gradually Varied Flow | Messages

Solve For: Normal Depth

Friction Method: Manning Formula

Roughness Coefficient:	0.040	
Channel Slope:	0.50000	ft/ft
Normal Depth:	0.06	ft
Left Side Slope:	0.10	ft/ft (H:V)
Right Side Slope:	0.10	ft/ft (H:V)
Bottom Width:	25.00	ft
Discharge:	5.70	ft³/s

Flow Area:	1.45	ft²
Wetted Perimeter:	25.12	ft
Hydraulic Radius:	0.06	ft
Top Width:	25.01	ft
Critical Depth:	0.12	ft
Critical Slope:	0.04817	ft/ft
Velocity:	3.92	ft/s
Velocity Head:	0.24	ft
Specific Energy:	0.30	ft
Froude Number:	2.87	
Flow Type:	Supercritical	

Calculation Successful.

Appendix G: Inspection Report

FORM INSP Rev X/15

State of Colorado
Oil and Gas Conservation Commission

1120 Lincoln Street, Suite 801, Denver, Colorado 80203
Phone: (303) 894-2100 Fax: (303) 894-2109

FIELD INSPECTION FORM

Inspection Date: 07/19/2019
Submitted Date: 07/22/2019
Document Number: 689901036

Loc ID	Inspector Name:	On-Site Inspection
386457	COSTA, RYAN	2A Doc Num:

Status Summary:

- [x] THIS IS A FOLLOW UP INSPECTION
- [x] FOLLOW UP INSPECTION REQUIRED
- [ ] NO FOLLOW UP INSPECTION REQUIRED

Findings:

3 Number of Comments
1 Number of Corrective Actions
[x] Corrective Action Response Requested

ANY CORRECTIVE ACTION(S) FROM PREVIOUS INSPECTIONS THAT HAVE NOT BEEN ADDRESSED ARE STILL APPLICABLE

Operator Information:

OGCC Operator Number: 2500
Name of Operator: AMOCO PRODUCTION COMPANY
Address: P O BOX 3092 ROOM 2.554
City: HOUSTON State: TX Zip: 77253-

Contact Information:

Contact Name	Phone	Email	Comment
CAMPBELL, PATRICIA		patti.campbell@bpx.com	
Arthur, Denise		denise.arthur@state.co.us	
Campbell, Patti	(970) 335-3828	patricia.campbell@bp.com	

Inspected Facilities:

Facility ID	Type	Status	Status Date	Well Class	API Num	Facility Name	Insp Status
217318	WELL	DA	01/29/1993	GW	071-06094	MGP ENTERPRISES A 4	RI

General Comment:

Reclamation Inspection for DA Well API#071-06094; Spud 11/20/1985; Abandoned 1/29/1993.
Amoco Production is BP America Production Company #10000 surety bond.

The corrective action of the previous inspection has not been performed.
Previous corrective action date remains for possible enforcement.
Corrective action needs to be performed immediately.

Reclamation - Storm Water - Pit

Interim Reclamation:

Date Interim Reclamation Started: _____ Date Interim Reclamation Completed: _____

Land Use: _____

Comment: _____

1002 SITE PREPARATION AND STABILIZATION

1002a. FENCING _____

Comment _____

Corrective Action _____ Date _____

1002b. SOIL REMOVAL AND SEGREGATION _____

Comment _____

Corrective Action _____ Date _____

1002c. PROTECTION OF SOILS _____

Comment _____

Corrective Action _____ Date _____

1002E. SURFACE DISTRURBANCE MINIMIZATION _____

Comment _____

Corrective Action _____ Date _____

1003a. Waste and Debris removed? _____

Comment _____

Corrective Action _____ Date _____

Unused or unneeded equipment onsite? _____

Comment _____

Corrective Action _____ Date _____

Pit, cellars, rat holes and other bores closed? _____

Comment _____

Corrective Action _____ Date _____

Guy line anchors marked? _____

Comment _____

Corrective Action _____ Date _____

Inspector Name: COSTA, RYAN

1003b. Area no longer in use? _____ Production areas stabilized ? _____

1003c. Compacted areas have been cross ripped? _____

1003d. Drilling pit closed? _____ Subsidence over on drill pit? _____

Cuttings management: _____

1003e. Areas no longer needed for drilling or subsequent operations for have been re-vegetated to 80% of pre-existing? _____

Production areas have been stabilized? _____ Segregated soils have been replaced? _____

RESTORATION AND REVEGETATION

Cropland

Top soil replaced _____ Recontoured _____ Perennial forage re-established _____

Non-Cropland

Top soil replaced _____ Recontoured _____ 80% Revegetation _____

1003e. INTERIM VEGETATION TRANSECT

TRANSECT RESULTS OF DISTURBED AREA% _____

TRANSECT RESULTS OF REFERENCE AREA% _____

TOTAL % OF DESIRABLE VEGETATION COVER _____

VEGETATIVE COVER _____

1003 f. Weeds Noxious weeds? _____

Comment

Corrective Action Date

Overall Interim Reclamation

Final Reclamation/ Abandoned Location:

Date Final Reclamation Started: _____ Date Final Reclamation Completed: _____

Final Land Use: _____

Reminder: _____

Comment:

Well plugged Pass Pit mouse/rat holes, cellars backfilled Pass

Debris removed Pass No disturbance /Location never built _____

Access Roads Regraded Fail Contoured Fail Culverts removed Fail

Gravel removed _____

Location and associated production facilities reclaimed Fail Locations, facilities, roads, recontoured Fail

Compaction alleviation _____ Dust and erosion control Fail

Non cropland: Revegetated 80% Fail Cropland: perennial forage _____

Weeds present _____ Subsidence _____

1004.d. FINAL VEGETATION TRANSECT

TRANSECT RESULTS OF DISTURBED AREA% _____

TRANSECT RESULTS OF REFERENCE AREA% _____

TOTAL % OF DESIRABLE VEGETATION COVER _____

VEGETATIVE COVER _____

Comment: The access road and location have not been recontoured and reclaimed. There is erosion issues along the access road and a culvert remains. There is an estimated 200 ft. unstable cut slope. The fill slope is unstable and has erosion issues. See Attached Photos
The corrective action of the previous inspection has not been performed.

Corrective Action: Date **07/17/2019**

Comply with 1004 Rules.
Recontour and reclaim the access road and location.

Overall Final Reclamation Fail Well Release on Active Location ☐ Multi-Well Location ☐

COGCC Comments

Comment	User	Date
Establish vegetation with total perennial, non-invasive uniform plant cover of at least eighty (80) percent of pre-disturbance or reference area levels. Use a seed mixture requested by the surface owner, or a mixture prescribed by the local county NRCS. Ensure erosion controls are implemented to stabilize the seeded soil, and continue to monitor and manage this site until Final Reclamation has passed	CostaR	07/22/2019

Attached Documents

You can go to COGCC Images (https://cogcc.state.co.us/weblink/) and search by document number:

Document Num	Description	URL
402116605	INSPECTION SUBMITTED	http://ogccweblink.state.co.us/DownloadDocumentPDF.aspx?DocumentId=4885407
689901037	Inspection Photos	http://ogccweblink.state.co.us/DownloadDocumentPDF.aspx?DocumentId=4885406

Inspection Photos

API: 05-071-06094

Operator: AMOCO PRODUCTION COMPANY

Inspection Date: 7/22/2019

COLORADO
Oil & Gas Conservation Commission
Department of Natural Resources

Photo 1. Facing east toward the location from across the canyon. Reclamation has not been performed.

Attachment E: Stability Analysis

Slide Analysis Information

Project Summary

File Name:	X-Sect_D_Final_Grade_Rev.1.slmd
Slide Modeler Version:	9.012
Project Title:	MGP Enterprises A-4 Well Pad
Analysis:	Slope Stability
Author:	A. Vega
Company:	Wood
Date Created:	4/1/2021

Currently Open Scenarios

Group Name	Scenario Name	Global Minimum	Compute Time
Upper Slope	Static Stability	Spencer: 1.646190	00h:00m:43.794s
	Psuedo-Static Stability	Spencer: 1.411920	00h:00m:53.328s
Lower Slope	Static Stability	Spencer: 1.525140	00h:00m:53.584s
	Psuedo-Static Stability	Spencer: 1.308250	00h:00m:59.647s

Analysis Options

All Open Scenarios

Slices Type:	Vertical
Analysis Methods Used	
	Spencer
Number of slices:	50
Tolerance:	0.005
Maximum number of iterations:	75
Check malpha < 0.2:	Yes
Create Interslice boundaries at intersections with water tables and piezos:	Yes
Initial trial value of FS:	1
Steffensen Iteration:	Yes

Materials

Fill	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	123
Cohesion [psf]	0
Friction Angle [deg]	36
Water Surface	Assigned per scenario
Ru Value	0
Bedrock	
Color	
Strength Type	Infinite strength
Unit Weight [lbs/ft3]	140
Allow Sliding Along Boundary	Yes
Water Surface	Assigned per scenario
Ru Value	0

Materials In Use

Material	Static Stability	Psuedo-Static Stability	Static Stability	Psuedo-Static Stability
Fill	✓	✓	✓	✓
Bedrock	✓	✓	✓	✓

Global Minimums

Upper Slope - Static Stability

Method: spencer

FS	1.646190
Axis Location:	162.735, 7000.094
Left Slip Surface Endpoint:	84.262, 6935.387
Right Slip Surface Endpoint:	167.417, 6898.491
Resisting Moment:	1.22283e+06 lb-ft
Driving Moment:	742826 lb-ft
Resisting Horizontal Force:	11892.3 lb
Driving Horizontal Force:	7224.17 lb
Total Slice Area:	158.998 ft2
Surface Horizontal Width:	83.1545 ft
Surface Average Height:	1.91208 ft

Upper Slope - Psuedo-Static Stability

Method: spencer

FS	1.411920
Axis Location:	162.785, 7000.140
Left Slip Surface Endpoint:	84.262, 6935.387
Right Slip Surface Endpoint:	167.474, 6898.470
Resisting Moment:	1.20567e+06 lb-ft
Driving Moment:	853924 lb-ft
Resisting Horizontal Force:	11717.8 lb
Driving Horizontal Force:	8299.2 lb
Total Slice Area:	160.876 ft2
Surface Horizontal Width:	83.2111 ft
Surface Average Height:	1.93335 ft

Lower Slope - Static Stability

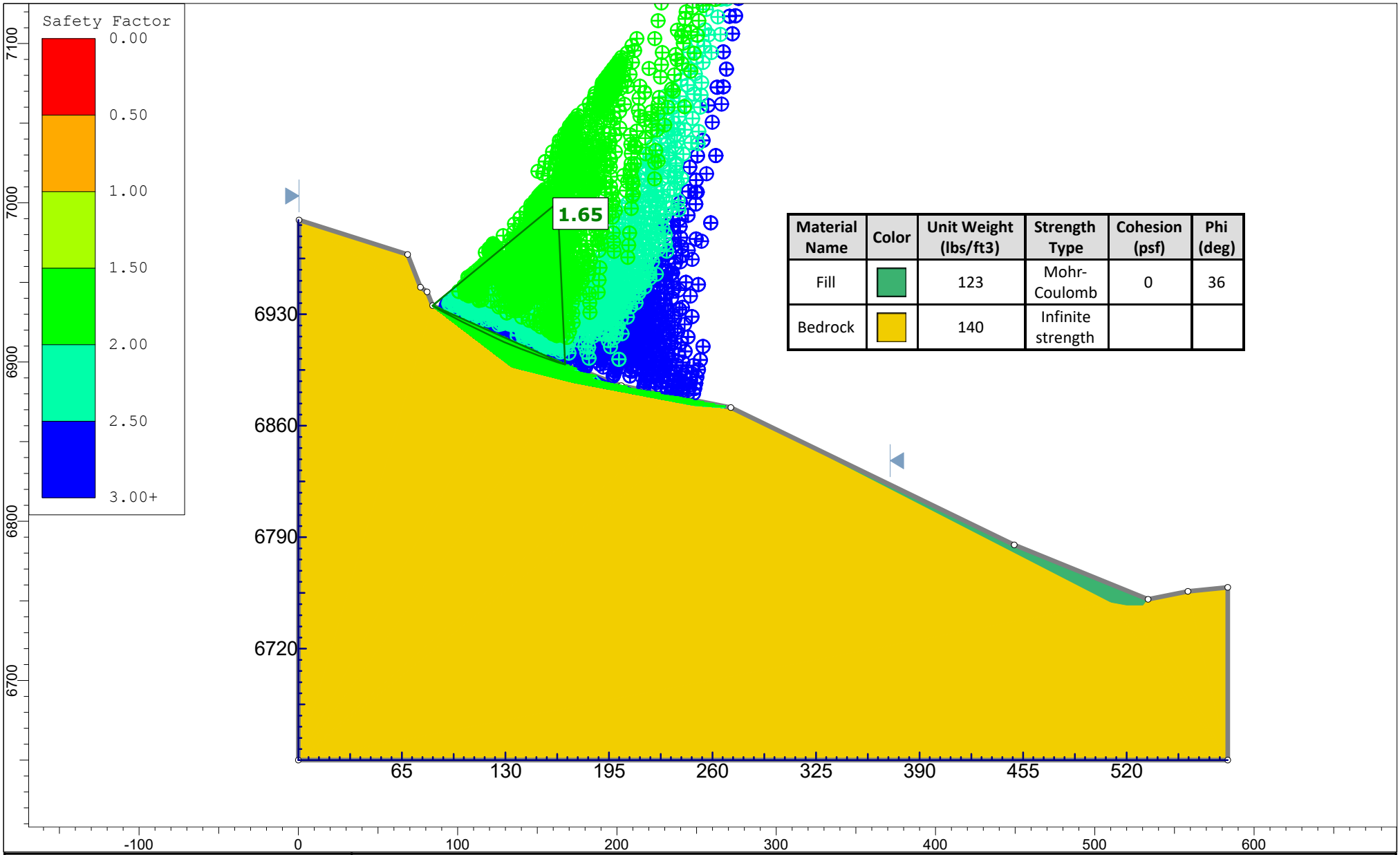
Method: spencer

FS	1.525140
Axis Location:	449.838, 6873.307
Left Slip Surface Endpoint:	379.475, 6818.993
Right Slip Surface Endpoint:	451.071, 6784.429
Resisting Moment:	1.3504e+06 lb-ft
Driving Moment:	885423 lb-ft
Resisting Horizontal Force:	14529.8 lb
Driving Horizontal Force:	9526.85 lb
Total Slice Area:	199.487 ft2
Surface Horizontal Width:	71.5961 ft
Surface Average Height:	2.78629 ft

Lower Slope - Psuedo-Static Stability

Method: spencer

FS	1.308250
Axis Location:	449.435, 6872.954
Left Slip Surface Endpoint:	379.475, 6818.993
Right Slip Surface Endpoint:	450.627, 6784.610
Resisting Moment:	897391 lb-ft
Driving Moment:	685950 lb-ft
Resisting Horizontal Force:	9847.42 lb
Driving Horizontal Force:	7527.2 lb
Total Slice Area:	139.53 ft2
Surface Horizontal Width:	71.152 ft
Surface Average Height:	1.96102 ft

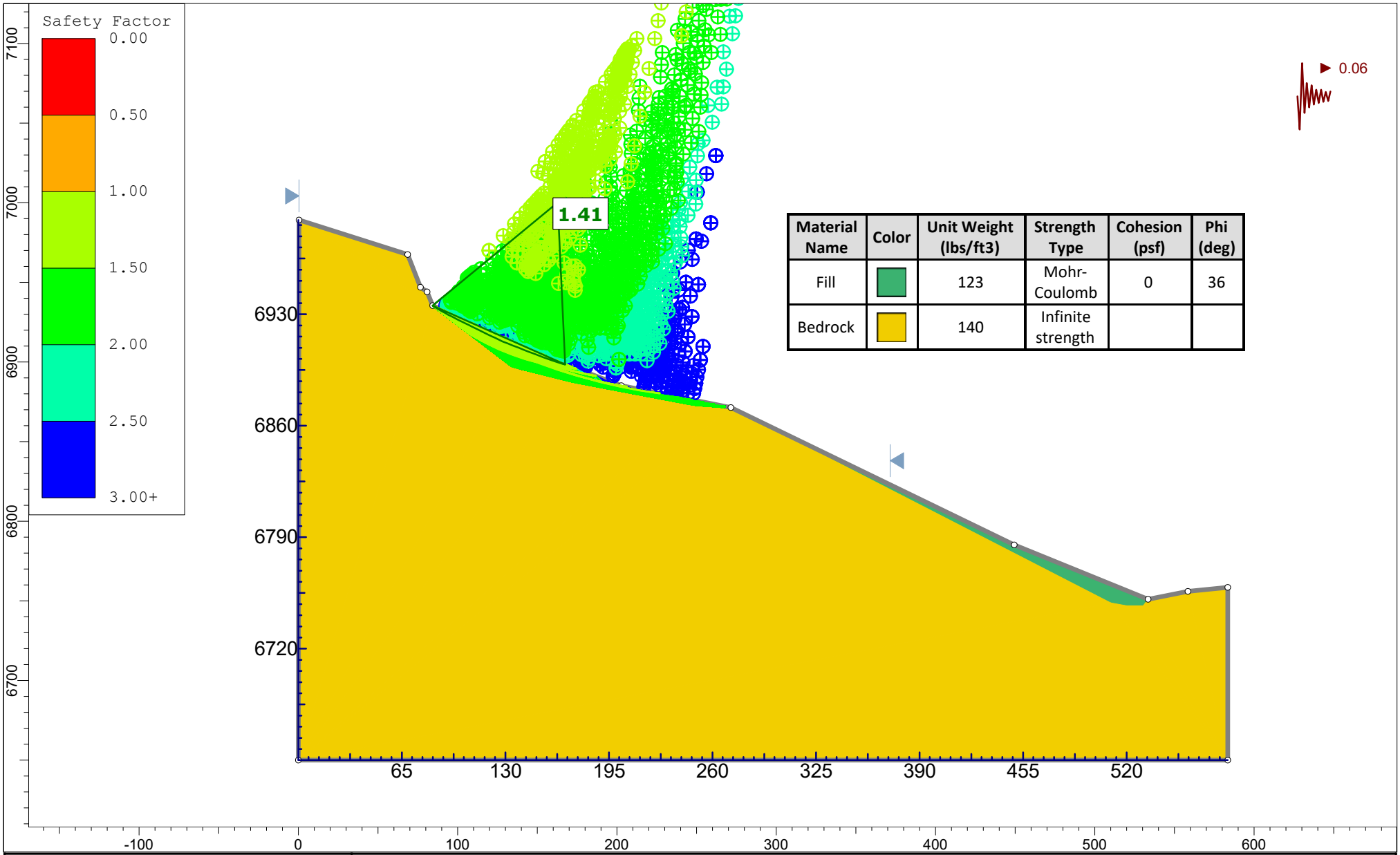


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Fill		123	Mohr-Coulomb	0	36
Bedrock		140	Infinite strength		

wood.

SLIDEINTERPRET 9.012

Project	MGP Enterprises A-4 Well Pad		
Group	Upper Slope	*Scenario*	Static Stability
Drawn By	A. Vega	*Company*	Wood
Date	4/1/2021	*File Name*	X-Sect_D_Final_Grade_Rev.1.slmd

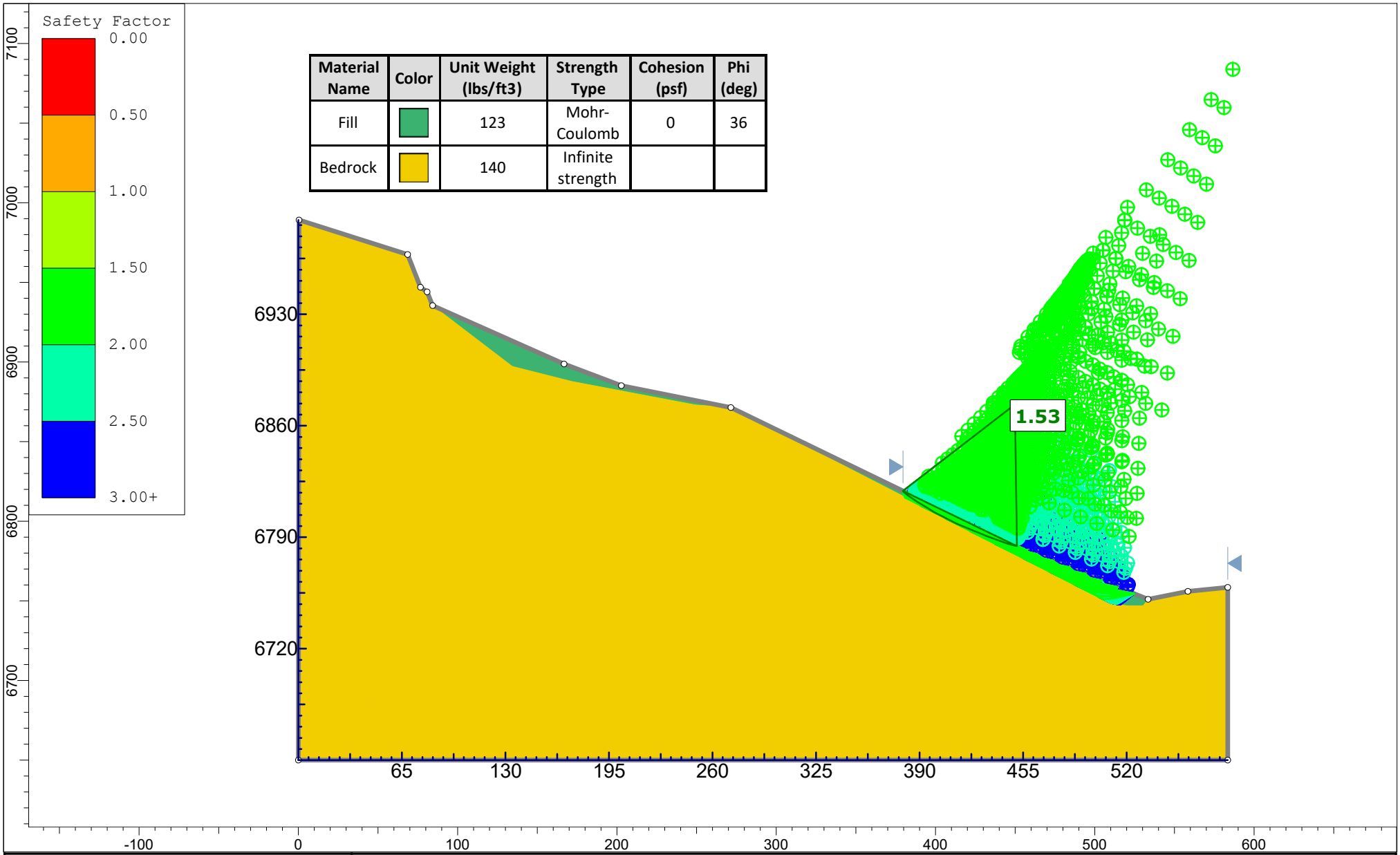


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Fill		123	Mohr-Coulomb	0	36
Bedrock		140	Infinite strength		

wood.

SLIDEINTERPRET 9.012

Project	MGP Enterprises A-4 Well Pad		
Group	Upper Slope	*Scenario*	Psuedo-Static Stability
Drawn By	A. Vega	*Company*	Wood
Date	4/1/2021	*File Name*	X-Sect_D_Final_Grade_Rev.1.slmd

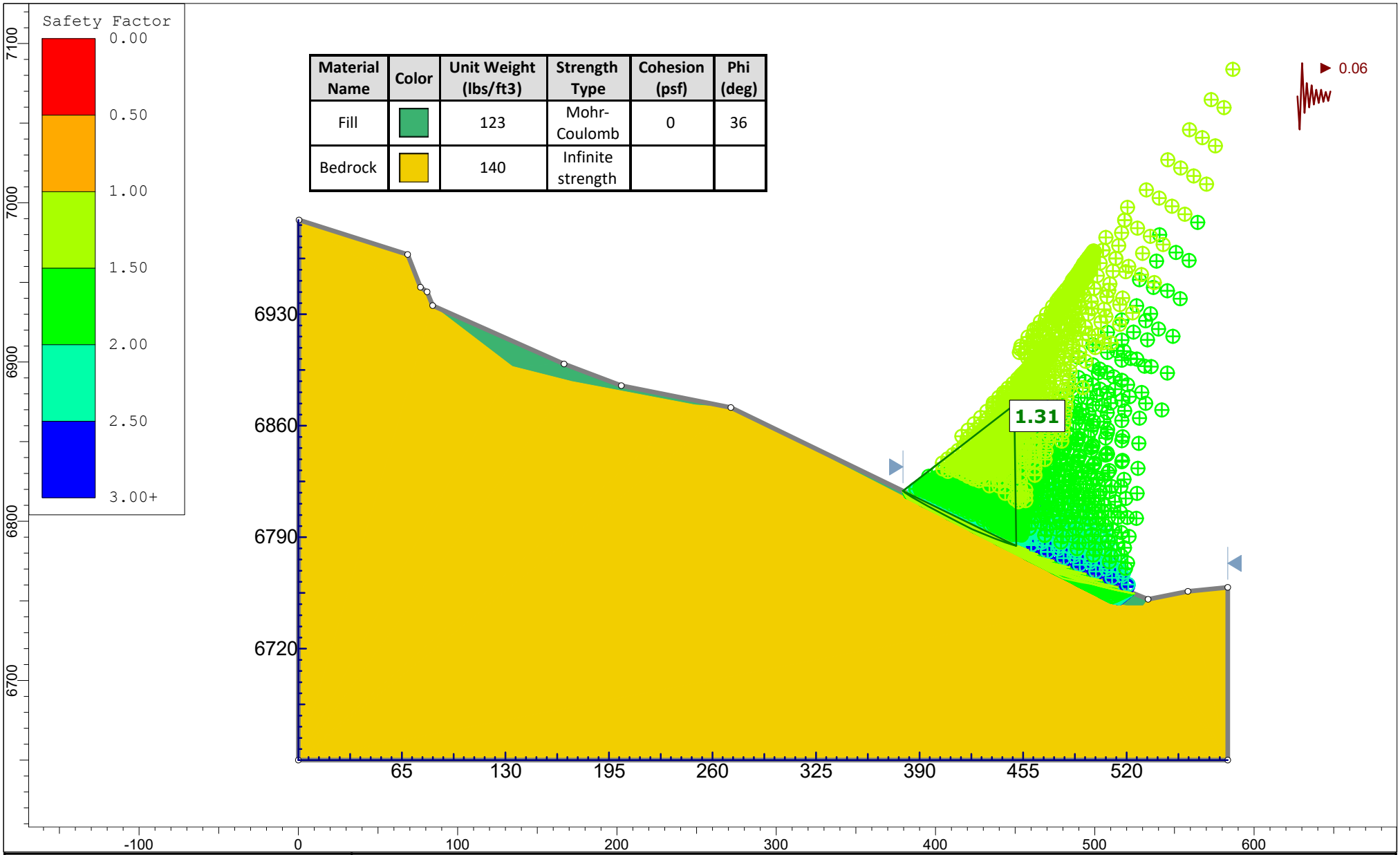


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Fill		123	Mohr-Coulomb	0	36
Bedrock		140	Infinite strength		

wood.

SLIDEINTERPRET 9.012

Project	MGP Enterprises A-4 Well Pad		
Group	Lower Slope	*Scenario*	Static Stability
Drawn By	A. Vega	*Company*	Wood
Date	4/1/2021	*File Name*	X-Sect_D_Final_Grade_Rev.1.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Fill		123	Mohr-Coulomb	0	36
Bedrock		140	Infinite strength		

wood.

SLIDEINTERPRET 9.012

Project	MGP Enterprises A-4 Well Pad		
Group	Lower Slope	*Scenario*	Psuedo-Static Stability
Drawn By	A. Vega	*Company*	Wood
Date	4/1/2021	*File Name*	X-Sect_D_Final_Grade_Rev.1.slmd

Attachment F: Soil Sample Results and Fertilizer Recommendations

REPORT NUMBER
21-046-0018

COMPLETED DATE
Feb 17, 2021

ACCOUNT
33831

RECEIVED DATE
Feb 15, 2021

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www.midwestlabs.com

TODAY'S DATE
Feb 17, 2021

WOOD ENV & INFRASTRUCTURE SOL
PAUL MALLOY
2000 S COLORADO BD STE2-1000
DENVER CO 80222

IDENTIFICATION
PO 32820182 PHASE 2 TASK 3
RECLAMATION SITE

SOIL ANALYSIS REPORT

LAB NUMBER *376*	SAMPLE IDENTIFICATION	ORGANIC MATTER L.O.I. percent	RATE	PHOSPHORUS P1 (WEAK BRAY) 1:7 ppm	RATE	PHOSPHORUS P2 (STRONG BRAY) 1:7 ppm	RATE	PHOSPHORUS OLSEN BICARBONATE P ppm	RATE	NEUTRAL AMMONIUM ACETATE (EXCHANGEABLE) POTASSIUM K ppm	RATE	MAGNESIUM Mg ppm	RATE	CALCIUM Ca ppm	RATE	SODIUM Na ppm	RATE	pH SOIL pH 1:1	BUFFER INDEX	CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED) % K	% Mg	% Ca	% H	% Na
09805	SS-1 PAD	3.6	H	5	VL	45	H	8	L	184	M	910	VH	2711	M	29		7.4		21.7	2.2	34.9	62.3	0.0	0.6
09806	SS-2 SLOPE	4.7	VH	2	VL	44	H			187	M	1116	VH	2596	M	23		7.0		22.9	2.1	40.6	56.9	0.0	0.4
09807	SS-3 DRNG	3.3	M	2	VL	34	M	6	L	200	H	963	VH	2938	M	41		7.4		23.4	2.2	34.3	62.7	0.0	0.8

LAB NUMBER *376*	NITRATE-N (FIA) SURFACE ppm	SURFACE lbs/A	SURFACE depth (in)	SUBSOIL 1 ppm	SUBSOIL 1 lbs/A	SUBSOIL 1 depth (in)	SUBSOIL 2 ppm	SUBSOIL 2 lbs/A	SUBSOIL 2 depth (in)	Total lbs/A	SULFUR S ICAP ppm	RATE	ZINC Zn DTPA ppm	RATE	MANGANESE Mn DTPA ppm	RATE	IRON Fe DTPA ppm	RATE	COPPER Cu DTPA ppm	RATE	BORON B SORB. DTPA ppm	RATE	EXCESS LIME RATE	SOLUBLE SALTS 1:1 mmhos/cm	RATE
09805	5	9	0-6							9	5	VL	1.3	M	2	VL	18	H	0.9	M	0.2	VL	L	0.4	L
09806	10	18	0-6							18	5	VL	1.8	M	2	VL	11	M	1.2	M	0.2	VL	L	0.4	L
09807	11	20	0-6							20	10	L	1.3	M	5	L	10	L	1.2	M	0.3	VL	L	0.4	L

REV.10/17

The above analytical results apply only to the sample(s) submitted. Samples are retained a maximum of 30 days.

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REPORT NUMBER
21-046-0018
COMPLETED DATE
Feb 17, 2021
ACCOUNT
33831
RECEIVED DATE
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TODAY'S DATE
Feb 17, 2021

WOOD ENV & INFRASTRUCTURE SOL
PAUL MALLOY
2000 S COLORADO BD STE2-1000
DENVER CO 80222

IDENTIFICATION
PO 32820182 PHASE 2 TASK 3
RECLAMATION SITE

SOIL FERTILITY RECOMMENDATIONS (POUNDS PER ACRE)

YOUR SAMPLE NUMBER (LAB NUMBER)	INTENDED CROP	YIELD GOAL	PREVIOUS CROP	SOIL AMENDMENTS LIME LBS/A OF	LIME TON	GYPSUM TONS/A	ELEMENTAL SULFUR LBS/A	N NITROGEN	P_2O_5 PHOSPHATE	K_2O POTASH	Mg MAGNE-SIUM	S SULFUR	Zn ZINC	Mn MANGA-NESE	Fe IRON	Cu COPPER	B BORON
SS-1 PAD	INDIAN GRASS	BEST	UNKNOWN					50	60	50	--	11	1.2	2.9	--	--	0.9
	GRASS HAY - ton	4.0	UNKNOWN					125	60	55	--	13	0.5	--	--	--	--
(37609805)	GRAMA GRASS	BEST	UNKNOWN					50	80	55	--	11	1.4	2.9	--	--	1.0
SS-2 SLOPE	INDIAN GRASS	BEST	UNKNOWN					35	80	50	--	11	0.3	2.9	--	--	0.9
	GRASS HAY - ton	4.0	UNKNOWN					110	80	55	--	13	0.1	--	--	--	--
(37609806)	GRAMA GRASS	BEST	UNKNOWN					35	105	50	--	11	0.4	2.9	--	--	1.0
SS-3 DRNG	INDIAN GRASS	BEST	UNKNOWN					40	70	45	--	8	1.2	2.0	--	--	0.8
	GRASS HAY - ton	4.0	UNKNOWN					115	65	45	--	9	0.5	--	--	--	--
(37609807)	GRAMA GRASS	BEST	UNKNOWN					40	90	45	--	8	1.4	2.0	--	--	0.9

REV. 12/03

The above analytical results apply only to the sample(s) submitted. Samples are retained a maximum of 30 days.

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