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GEOTECHNICAL REPORT

Chateau Road Reconstruction
5-999 (036), PCN 24246

MEDORA, NORTH DAKOTA

SHANNON & WILSON

February 6, 2025

Shannon & Wilson No: 113316-002

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Submitted To: KLJ Engineering LLC
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Attn: Adam McGill

Subject: GEOTECHNICAL REPORT, CHATEAU ROAD RECONSTRUCTION
5-999 (036), PCN 24246, MEDORA, NORTH DAKOTA

Shannon & Wilson prepared this revised report and participated in this project as a subconsultant to KLJ Engineering, LLC (KLJ). Our scope of services was specified in Task Order Number 2402-00545-SW1 with KLJ dated June 5, 2024, and Amendments 1, 2, 3, and 4 dated July 27, September 23, November 6, and December 23, 2024, respectively. This report presents our revised geotechnical design recommendations and was prepared by the undersigned.

We appreciate the opportunity to be of service to you on this project. If you have questions concerning this report, or we may be of further service, please contact us.

Sincerely,

SHANNON & WILSON, INC.

Gregory R. Fischer, PhD, PE
President

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Associate

DKM:CPR:GRF/ajg

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1 INTRODUCTION

1.1 General

The North Dakota Department of Transportation (NDDOT) intends to reconstruct and realign Chateau Road to support increased traffic and to improve access for emergency vehicles. The increase in traffic is a result of the growth of the Medora Musical, additional use of the Burning Hills Amphitheater (BHA), and construction of the proposed Theodore Roosevelt Presidential Library (TRPL). The proposed roadway improvements will involve a widened roadway section and the addition of a pedestrian/bicycle path to support year-round traffic to the above-mentioned facilities.

This report presents the results of our subsurface exploration and laboratory testing program and provides geotechnical design recommendations and construction considerations for the proposed improvements to Chateau Road (the Project) in Medora, North Dakota. Our services were completed in general accordance Task Order Number 2402-00545-SW1 with KLJ dated June 5, 2024, and Amendments 1, 2, and 3 dated July 27, September 23, and November 6, 2024, respectively.

1.2 Scope of Services

Shannon & Wilson's scope of services for the Project included:

- Reviewing existing data available within the Project area.
- Completing a field reconnaissance with geological mapping of the proposed alignment.
- Coordinating a subsurface exploration program consisting of drilling and sampling 17 geotechnical borings to characterize the subsurface conditions along the proposed alignment. Spacing and sampling of the borings was selected to meet the requirements of a NDDOT Linear Soil Survey as described in Chapter 7 of the NDDOT Design Manual.
- Completing a laboratory testing program to characterize index and engineering properties of the soil and bedrock units within the Project.
- Evaluating global stability of proposed cut slopes.
- Evaluating global stability of proposed temporary and permanent fill slopes.
- Analyzing settlement of proposed embankments.
- Providing earthwork and subgrade preparation recommendations for embankment and roadway construction.

- Preparing this geotechnical report.

1.3 Summary of Report Revisions

Shannon & Wilson submitted a final geotechnical report for this project to KLJ on December 23, 2024. Thereafter, NDDOT and KLJ requested revisions to our final report as the design has progressed from 90% to final. This revised report supersedes our December 23, 2024 geotechnical report. Requested revisions include the following:

- Modification of recommended settlement monitoring instrumentation to settlement plates to be installed prior to embankment fill placement in Section 9.1.5.
- Clarification of anticipated self-weight settlement of embankments in Section 9.1.6.
- Inclusion of station ranges where bedrock is anticipated to be encountered in embankment foundation materials and subgrade preparation is not expected to be required in Section 10.2.
- Revision to the type of geogrid specified if subgrade improvements are required to pass a proof-roll in Section 10.4.

2 SITE AND PROJECT DESCRIPTION

2.1 Existing Conditions

Chateau Road is the primary access route from Pacific Avenue to the Theodore Roosevelt Medora Foundation BHA and the site of the TRPL currently under construction. It is located approximately 0.5 miles northwest of the City of Medora (See Figure 1). The roadway is approximately 0.85 mile in length, with the lower 0.29-mile-long segment being owned and operated by the NDDOT, and the upper 0.56-mile-long segment being owned and operated by Billings County. The primary goals of the Project are to decrease grades along the alignment, include pedestrian/bicycle access, and achieve completion of construction by July 4, 2026, when the TRPL is set to open.

Chateau Road is currently a 26-to-28-foot-wide two-lane roadway. The initial 870 feet of the road, beginning with its intersection with Pacific Avenue, is surfaced with asphalt pavement. The remainder of the road up to the BHA parking lot is surfaced with concrete pavement. The existing road climbs approximately 235 feet from its intersection with Pacific Avenue up to BHA parking lot. The road is relatively straight for the first 0.25-mile-long stretch. Thereafter, the road quickly rises in elevation and traverses upward through segments with 90-to-180-degree curves and grades of up to 15%. The alignment traverses through a dissected plateau composed of sedimentary bedrock of the Bullion Creek

Formation (Gonzalez and Biek, 2003). As Chateau Road traverses and meanders the rising terrain, evidence of shallow slope instability is evident in slopes above and below the road (See Figure 2 and Appendix C).

2.2 Proposed Improvements

Our understanding of the proposed reconstruction effort is based on the most recent alignment plan view and cross sections provided by KLJ, dated October 15, 2024. We have reproduced KLJ's alignment in Figure 2.

KLJ's approach to reconstructing the roadway generally involves construction of an offset alignment within proximity to the existing road. Roadway gradients will be reduced using cuts and fills and by lengthening the 180-degree curve that provides the final approach to the top of the plateau and to the BHA parking lot. The completed roadway will have a total width of 40 feet from pavement edge to pavement edge. A 10-foot-wide shared use bicycle and pedestrian path will be constructed adjacent to the roadway.

Cut slopes being proposed to construct the new alignment will flatten existing slope angles to a range between 2.5-horizontal-to-1-vertical (2.5H:1V) to 4H:1V. The maximum height of the proposed cuts is 110 feet. The highest cuts in the Project alignment will be constructed within existing slopes by flattening and shaping the overall slope angle (see Exhibit 2-1). The actual depth of cuts (thickness of material removed measured perpendicular to the proposed slope face) is 20 feet or less along the alignment.

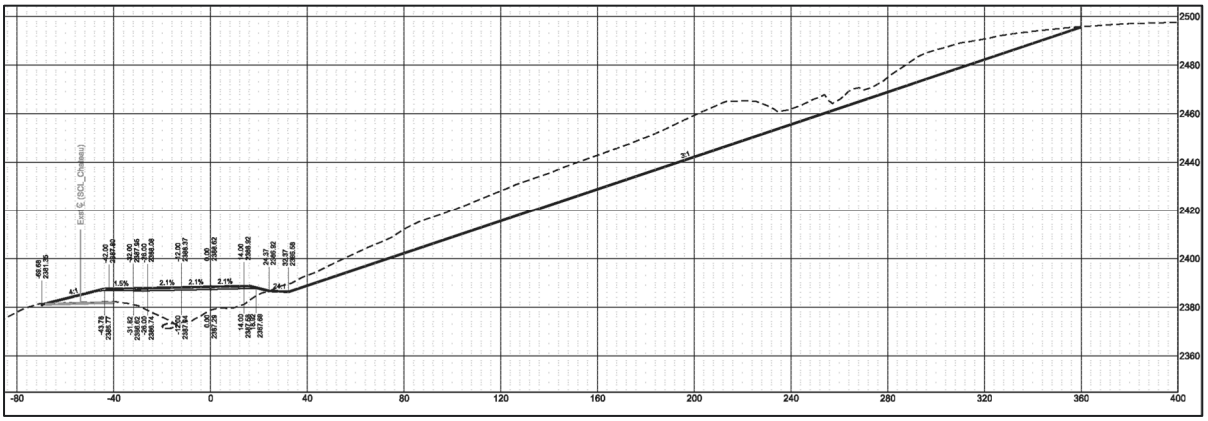

Exhibit 2-1: Maximum Cut Slope Height Proposed for the Project at Station 1020+18

The proposed alignment will require new embankment fill within several segments. Proposed new fill heights / grade raises are up to 20 vertical feet from the existing ground surface (Exhibits are provided in Section 9.1). We understand in several segments of the alignment, construction sequencing will involve building a portion of the permanent

embankments with temporary 2H:1V side slopes. Traffic will be shifted from the existing alignment onto the new embankment, then the remaining portions of the embankments will be constructed with permanent side slopes that vary between 3H:1V and 4H:1V. Flatter side slopes are being implemented in some areas to blend the new embankment fill with surrounding topography.

In addition, we understand that Chateau Road will be reconstructed to the west of the BHA parking lot. The proposed road alignment will generally follow the layout of the northern edge of the existing parking lot. We understand no grade raising or cuts are being proposed in this area. A conceptual illustration of the proposed alignment extension is shown in Figure 2.

3 GEOLOGICAL RECONNAISSANCE

We completed a field reconnaissance on June 11, 2024, to evaluate geological conditions along the proposed alignment. The goal of this reconnaissance effort was primarily to identify potential landslide features that could affect roadway widening or realignment. Our geologist assigned numbers to notable features that were identified during the mapping effort. We also used an unmanned aerial vehicle (UAV) equipped with a camera to collect oblique aerial photographs of the alignment to assist with identification of slope instability. Feature numbers are illustrated in Figure 2. Descriptions and photographs of each feature are provided in Appendix C.

On September 26, 2024, we completed a supplemental reconnaissance to evaluate the geologic conditions of the northern portion of the BHA parking lot where the Chateau Road alignment may be extended approximately 500 feet west of the current entrance to the lot. The goal of this reconnaissance effort was to assess the existing condition of the pavement where the alignment extension is being proposed and to determine if slope instability could impact the extended roadway alignment. Our observations from this reconnaissance effort are also summarized in Appendix C with descriptive photographs of notable features. Additional discussion of landslide features is presented in Section 8.4, and our recommendations regarding slope stability are presented in Section 9.2.

4 FIELD EXPLORATIONS

We conducted a field exploration program between June 18 and 20, 2024, with additional borings drilled on September 26 and November 5, 2024, to explore subsurface conditions

along the existing alignment of Chateau Road. The subsurface exploration plan consisted of drilling and sampling 17 geotechnical borings at the locations shown in Figure 2.

Appendix A presents a discussion of the drilling, sampling, and testing procedures used to complete the borings. Appendix A also presents individual exploration logs and an explanation of the symbols and terminology used.

5 LABORATORY TESTING

Geotechnical laboratory tests were completed on selected samples retrieved from the borings to estimate index and engineering properties. Index and engineering tests included natural water content, unit weight, grain size analysis, hydrometer, and Atterberg limits. Engineering properties tests included corrosion, swell/collapse testing, one-dimensional consolidation, unconsolidated undrained triaxial testing, and compaction testing. The laboratory test results, and a discussion of the testing procedures, are included in Appendix B. The natural water contents, fines content, and Atterberg limits are also shown on the individual boring logs included in Appendix A.

6 REGIONAL GEOLOGY

6.1 Bedrock Geology

We reviewed publicly available geologic mapping in the area by Gonzalez and Biek (2003), which indicates that the Project area is underlain by bedrock of the Paleocene (approximately 66 to 56-million-year-old) Bullion Creek Formation. According to Gonzalez and Biek (2003), this formation consists of variably lithified and interbedded sandstone, siltstone, mudstone, claystone, clinker, and lignite.

We also reviewed a Draft Geotechnical report prepared for design and construction of the TRPL (Braun Intertec Corporation [Braun], 2021). This report identifies the bedrock at the TRPL site as the Sentinel Butte Formation, which has a similar lithology as the Bullion Creek Formation. However, Gonzalez and Biek (2003) illustrate that the Sentinel Butte Formation is located at higher elevation ranges than exist at the Project site. This formation is also typically characterized by deep seated landslides, which were not observed within the Project area. For these reasons, we identified the bedrock in our borings as the Bullion Creek Formation.

6.2 Alluvial Terrace Deposits

Deposits of Pleistocene (approximately 2.6 million to 11,800-year-old) proglacial terrace alluvium are also mapped at the Project site, generally at the top of the plateau (Gonzalez and Biek, 2003). These deposits are derived from the Little Missouri River which is located directly east of the site. We encountered these soils in our borings located between Project Stations 1003+00 and 1015+00 in borings SW-10 through SW-14. Gonzalez and Biek, (2003) describe these deposits as sand and gravel typically between 3 and 10 feet thick.

6.3 Landslide Deposits

Landslide deposits are not mapped by Gonzalez and Biek (2003) in the general vicinity of the roadway alignment. However, we observed several landslide scarps and slumps during our field reconnaissance as discussed in Section 3. Gonzalez and Biek (2003) describe landslide deposits identified in slopes to the northeast of the Project site as a variable mixture of strata that have slid or slumped to the base of steep slopes. The existing ground surfaces are characterized by hummocky topography, numerous arcuate scarps, and chaotic bedding.

7 SUBSURFACE CONDITIONS

Six geologic units were interpreted from our reconnaissance mapping and borings drilled along the alignment: pavement and aggregate base course, fill, alluvium, colluvium, residuum, and bedrock. A summary of each geologic unit is described below. For a complete description of these materials and more detail of the thicknesses of the units at individual boring locations, refer to Appendix A.

7.1 Pavement and Aggregate Base Course

Both asphalt and concrete pavement were observed in our borings in the existing roadway. We measured between 3 and 4 inches of asphalt pavement in borings SW-01 and SW-02. Approximately 1.2 feet of aggregate base course was measured in these borings, which consisted of loose, brown, poorly graded gravel with silt and sand.

Concrete pavement was encountered in borings SW-03 through SW-15 and varied from approximately 4.5 to 8 inches thick. Aggregate base course, between 4 and 10 inches in thickness, was encountered in all of these borings with the exception of boring SW-08. The aggregate base course below the concrete pavement was also identified as poorly graded gravel with silt and sand.

7.2 Embankment Fill

Embankment fill was encountered in four of the borings. Borings SW-08 and SW-12 were drilled through 4 and 17 feet of fill, respectively, that was used to span across an existing drainage channel. Embankment fill up to 2.5 feet thick was also encountered in borings SW-11 and SW-13 where Chateau Road was previously realigned.

The embankment fill composition was variable and consisted of medium stiff to very stiff lean and fat clay with varying amounts of sand; medium dense, well-graded gravel with silt and sand; medium dense, clayey sand with gravel; and very loose to loose, sandy silt.

7.3 Alluvium

Alluvium was encountered in several of our borings along the alignment. Alluvium was observed in the floodplain of the Little Missouri River in borings SW-01 and SW-02, below the embankment at boring SW-08, and in borings SW-10 through SW-15 drilled near the top of the plateau where Pleistocene proglacial alluvial terrace soils were deposited as discussed in Section 6.2.

The alluvium in the floodplain of the Little Missouri River consisted of medium stiff lean clay with sand to the maximum depth explored of 10.5 feet in borings SW-01 and SW-02. Alluvium observed in boring SW-08 was characterized by approximately 5 feet of loose, silty sand with gravel overlying 4 feet of soft to medium stiff, lean clay. Alluvium at the top of the plateau within terrace deposits consisted primarily of granular soils, including loose to medium dense, silty sand and poorly-to-well-graded sand and gravel with silt. These granular soils varied in thickness between 3.5 feet and 15 feet in our borings. Cohesive alluvial soils were also encountered in borings SW-14 and SW-15 at the top of the plateau up to 5.4 feet thick and consisted of soft to very stiff lean clay with sand and sandy lean clay.

7.4 Colluvium

Colluvium was observed in several borings located on side slopes of existing drainage channels, generally at lower elevations within the alignment (borings SW-03 through SW-07 and SW-09). In areas where colluvium could not be differentiated from residuum, we used the term “colluvium to residuum” on our boring logs. The majority of the colluvium deposits encountered in our borings were cohesive soils characterized by very soft to stiff, lean to fat clays with varying amounts of sand. Zones of loose to medium dense, clayey sand were also encountered within colluvium. Colluvium deposits varied between 4.5 and 22 feet in thickness, with thicker deposits located at lower elevation ranges.

7.5 Residuum

Residuum (completely weathered bedrock that has not been transported by erosion) was encountered overlying the bedrock contact in several of the borings. Residuum could only be clearly differentiated from colluvium deposits in boring SW-03. This material was classified as very stiff, gravelly lean clay with sand. The gravel fragments were composed of intact pieces of claystone surrounded by a lean clay matrix.

7.6 Bedrock

We identified the bedrock present along the alignment as the Bullion Creek Formation. In borings that were drilled through bedrock, we encountered extremely weak claystone, siltstone, sandstone, and occasional layers of coal.

The claystone varied from brown, tan, to gray; with massive to laminated structure; and varied from slightly to highly weathered. Most of the claystone samples tested were characterized by liquid limits from the 20s to mid-40s (lean clays). Only four samples were characterized by liquid limits above 50 (fat clays) with the highest value obtained being 66. For bedrock samples tested for the TRPL (Braun, 2021), the highest liquid limit value obtained was 65.

Siltstone and sandstone bedrock encountered in the borings had similar color and structure as the claystone, with weathering grades that varied between moderately weathered to fresh.

Coal partings were observed within occasional sandstone layers. Thicker deposits of coal up to at least 4.5 feet were encountered in borings SW-08 (this boring ended in coal so the layer could be thicker than 3 feet), SW-16 (this coal seam had evidence of being previously burned), and SW-17. Coal was not found at consistent elevations in the bedrock between borings, so the layers are not believed to be laterally continuous.

7.7 Groundwater

Groundwater was not observed during drilling within any of the borings. In addition, Braun (2021) indicates that groundwater was not detected over a 7-month monitoring period between May and November of 2021. They used a combination of manual readings and down-hole instrumentation (Solinst Levellogger Junior Edge F30 transducer) within piezometers up to 150 feet in depth at the top of the plateau. We also did not identify evidence of seepage, springs, or flowing water during our field reconnaissance. Fluctuations of groundwater levels beneath the site are still possible and will depend on

many factors, including seasonal variations, local precipitation and runoff, water levels in surrounding streams and creeks, flood events, and regional drought.

7.8 Subsurface Variation

Shannon & Wilson completed the subsurface exploration program indicated herein to evaluate pavement subgrade; embankment foundations; cut slope conditions; and overall soil, bedrock, and groundwater conditions at the site. Our observations are specific to the locations, depths, and times noted on the logs and may not be applicable to all areas of the Project. No amount of exploration or testing can precisely predict the characteristics, quality, or distribution of subsurface and site conditions. If conditions that are different from those described herein are encountered during construction, we should review our description of the subsurface conditions and reconsider our conclusions and recommendations. Potential variations include, but are not limited to:

- The conditions between explorations may be different.
- The passage of time or intervening causes (natural and manmade) may result in changes to site and subsurface conditions.

8 GEOLOGIC HAZARDS

8.1 Corrosive Soil and Bedrock

We completed electro-chemical testing of selected soil and bedrock samples to evaluate the potential for corrosive attack on buried metals and reinforced concrete. Tests included pH, resistivity, and chloride and sulfate concentrations. Results of the corrosion testing are included in Appendix B and summarized in Exhibit 8-1 below.

Exhibit 8-1: Corrosion Test Results

Boring ID	Sample ID	Depth (feet)	Material Type	pH	Resistivity (ohm-cm)	Chlorides (%)	Sulfates (%)
SW-01	G-1	1.5 to 5.0	CL Alluvium	7.5	1,468	0.006	0.04
SW-05	G-1	1.0 to 5.0	CL Colluvium	7.8	1,458	0.008	0.04
SW-09	G-1	0.9 to 2.5	SC/CL Colluvium	6.7	1,812	0.004	0.03
SW-15	G-1	0.9 to 5.0	CL Alluvium	7.7	2,500	0.006	0.01

NOTES:
G-1 refers to “Grab Sample No. 1”
ohm-cm = ohm centimeters

Soil or rock with sulfate concentrations more than 1,000 parts per million (0.1 percent by weight) are indicative of potential degradation based on AASHTO (2020). The

concentrations of water-soluble sulfates measured in the samples from our explorations were no higher than 0.04 percent by weight; therefore, AASHTO would suggest that any concrete design does not need to be sulfate resistant. Similarly, ACI 318-19 (ACI, 2022) classifies these soils as exposure class S0, negligible, on concrete exposed to soil.

AASHTO (2020) indicates soils with a pH less than 5.5, or a pH between 5.5 and 8.5 in highly organic soils should be considered indicative of a potential corrosive environment. The pH values measured from the samples tested were between 6.7 and 7.8, and organic soils were not encountered. Therefore, corrosion potential as a result of soil pH is not considered to be a significant risk for the Project.

Guidelines in AASHTO (2020) indicate that resistivity measured below 2,000 ohm-centimeters should be considered a corrosive environment for metal. Three of the four samples tested were characterized by corrosion values less than this threshold. The fourth sample tested was characterized by a resistivity value of 2,500 ohm-centimeters. Similarly, based on correlations developed by Roberge (2012), the resistivity values obtained by testing all four samples suggest a highly corrosive environment for metal in contact with the subsurface materials.

The test results and the above discussion are provided to assist the designer in the selection of project materials, concrete type, or other features with respect to corrosion. As appropriate, the designer should consider protective measures, such as coatings, upsizing for section loss, or using alternative materials to reduce the corrosion potential.

8.2 Expansive Soils

Cohesive soils and claystone bedrock can often exhibit expansive behavior, depending on the clay minerology. To evaluate the potential for swell within the Project site, we completed one-dimensional swell/collapse tests on soil samples encountered in borings SW-03, SW-09, and SW-15. These tests were performed with an inundation pressure of 250 pounds per square foot (psf) to estimate the expansive properties of the soils under pavement loading conditions. The results are summarized in Exhibit 8-2.

Exhibit 8-2: Swell Testing Results

Boring	Depth (feet)	Material Type	Inundation Pressure (psf)	Swell Pressure (psf)	% Swell/Collapse
SW-03	2.5 to 4.0	CH Colluvium	250	1,200	1.8
SW-09	1.5 to 3.0	SC/CL Colluvium	250	N/A	-0.1
SW-15	2.5 to 4.0	CL Alluvium	250	730	0.1

Swell test results indicated -0.1% collapse to 1.8% swell. The actual magnitude of expansion that could happen in the field is a function of the thickness of a soil zone where the in-situ moisture content can increase (up to full saturation). Based on relationships presented in Nelson and others (2007) between inundation pressure, swell pressure and swell percentage, the expansion potential is considered "low" to "moderate" for the Project site. Using the swell test results obtained from boring SW-03, which was characterized by the highest swell percentage, the upper 5 feet of pavement subgrade would have to experience full saturation to achieve more than 1 inch of heave, which is unlikely to occur in our opinion, provided the pavement subgrade is constructed with a crown and the aggregate base course layer is allowed to drain.

8.3 Dispersive Soils and Sinkholes

We did not complete laboratory testing to characterize soil dispersibility or soil erosion characteristics for the Project. However, we did observe three sinkholes within 20 feet of the edge of pavement on the south side of the existing road between Project Stations 1035+00 and 1036+00. These features measure up to 6 feet in diameter. In addition, there are numerous scarps and slumps located within the side slope of the drainage channel south of the road between Stations 1031+00 and 1036+00 (see Appendix C). Many of these features are believed to be the result of gullying and erosion within the channel and its sidewalls. Additional discussion related to the stability of these slopes is presented in Section 9.2.5, and recommendations to improve the sinkhole conditions are provided in Section 9.3.

8.4 Landslide Considerations

During our field reconnaissance, we identified evidence of shallow slope instability within steep side slopes of drainage channels and drainage basins throughout the Project area. Shallow slope instability was also observed in areas where existing embankment side slopes or cut slopes are over-steepened (generally areas steeper than 1.5H:1V). We did not observe rotational components (e.g., deep longitudinal / transverse cracking, or toe features) in areas of slope instability. Therefore, it is our opinion that unstable slopes in the Project area are characterized by shallow colluvial and/or residual soils moving down slope in a translational mode of failure, similar to soil creep.

For the proposed alignment extension to the west through the BHA parking lot, we identified evidence of shallow slope instability in the steep drainage channels located to the north of the lot. However, we did not observe evidence of slope instability encroaching into the existing parking lot limits. The head of the drainage channel to the north of the proposed roundabout was characterized by shallow slope angles with no observable evidence of slope instability.

For the remainder of the Chateau Road alignment, two conditions exist:

1. Either slope instability was observed in areas that are too far from the proposed alignment to have an impact, or

2. Where shallow slope instability was identified adjacent to and upslope of the proposed roadway, proposed cut slopes are anticipated to remove materials involved in translational down-hill movement. Where slope instability is located downslope of the existing roadway, slope instability is not anticipated to encroach into the proposed pavement.

Additional discussion and recommendations regarding slope stability is provided in Section 9.2 below.

9 GEOTECHNICAL ANALYSES AND RECOMMENDATIONS

9.1 Settlement

There are several segments of the alignment where new embankment fills are being proposed, with maximum new fill heights up to 20 feet. To estimate settlement magnitudes that could occur (and the timeframe over which those settlements could occur) due to new fill placement, we completed settlement analyses at various locations. A summary of our settlement analyses is provided in Exhibit 9-1, with additional detail of the conditions contributing to settlement and our methods of analyses discussed in the following subsections. Output from our settlement analyses is included in Appendix D.

Exhibit 9-1: Estimates of Settlement Magnitudes for New Embankment Fill Placement

Station Range Analyzed	Maximum New Fill Height (feet)	Representative Boring(s)	Settlement Mechanism	Estimated Settlement Magnitude (inches)	Settlement Mitigation Recommended
1008+00 to 1012+50	10	SW-11, SW-12	Short-term Elastic	1	No
1016+50 to 1017+25	20	SW-10	Short-term Elastic	1-2	No
1019+25 to 1020+50	14	SW-08	Short-term Elastic	1	No
1022+75 to 1027+00	16	SW-05, SW-06, SW-07	Long-term Consolidation	3-5	Yes (see Section 9.1.5)

9.1.1 Settlement from Project Stations 1008+00 to 1012+50

The alignment will be constructed on a new embankment between approximate Project Stations 1008+00 and 1012+50 with maximum new fill heights up to 10 feet at Station 1009+50 (see Exhibit 9-2).

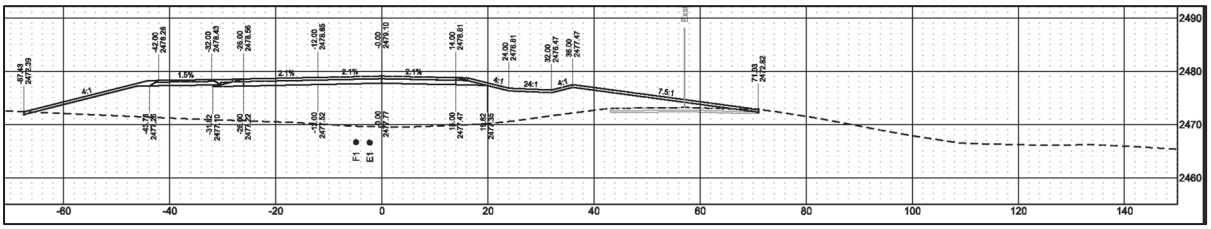

Exhibit 9-2: Maximum new fill height at Station 1009+50 within Project Stations 1008+00 to 1012+50.

Based on our borings drilled within this segment (SW-11 and SW-12), the embankment will be constructed over between 17 and 27 feet of overburden soils characterized by medium dense, clayey sand fill; loose to medium dense, silty sand; and medium dense to dense, well graded sand with silt (boring SW-11); and medium stiff to very stiff, lean clay fill; very loose to loose, sandy silt fill; and medium dense to very dense, poorly graded sand and gravel with silt (boring SW-12).

The majority of the new embankment will be constructed to the north of the existing embankment, and foundation soils are expected to be composed of the granular alluvial soils (i.e., we do not anticipate fill soils). Given these conditions, it is our opinion that settlement behavior will be elastic, and we modeled settlement using a Schmertmann analysis in accordance with AASHTO Section 10.6.2.4.2c (see Appendix D). Elastic modulus values for the soils were selected based on empirical correlations with SPT N values and soil type (Das, 2004). The unit weight for the new embankment material was based on compaction testing results conducted on clayey soils collected from our borings, which resulted in an average maximum dry density of 115 pounds per cubic foot (pcf) (see Appendix B). A wet unit weight of 125 pcf was selected assuming the material would be compacted between 90 and 95 percent of maximum dry density, referencing AASHTO T180, and near optimum moisture content. Settlement beneath the maximum new fill height was analyzed for subsurface conditions encountered in both borings SW-11 and SW-12.

Based on our analyses, settlement magnitudes are estimated to be approximately one inch for this segment of new embankment construction, excluding self-weight embankment settlement (see Section 9.1.6). This settlement is primarily anticipated to occur within 30 days following construction, which we understand can be accommodated by the construction schedule based on discussions with KLJ, with about ½ inch of additional long-term settlement, excluding self-weight embankment settlement. Based on these results,

measures to mitigate settlement are not likely necessary for embankment construction within this segment.

9.1.2 Settlement from Project Stations 1016+50 to 1017+25

Embankment widening to the east is being proposed within this segment of the alignment, with maximum new fill heights up to 20 feet at Station 1016+75 (see Exhibit 9-3). Clayey embankment fill with a wet unit weight of 125 pcf was assumed.

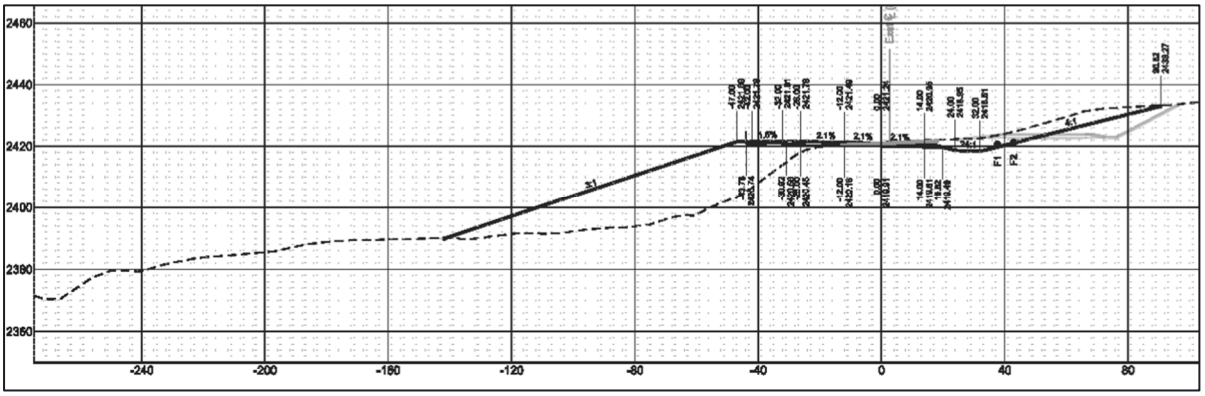

Exhibit 9-3: Maximum new fill height at Station 1016+75 within Project Stations 1016+50 to 1017+25.

Based on borings SW-09 and SW-10 drilled on either side of this segment, the embankment will be constructed over between 5.5 and 12 feet of overburden soils characterized by loose to medium dense, clayey sand (boring SW-9); medium stiff to stiff, sandy lean clay; loose, silty sand; and loose, poorly graded sand with silt (boring SW-10). Below the overburden soils is bedrock.

The cohesive soils at this location are characterized by moisture contents in the teens (and not likely saturated), and the remaining soils are granular in nature. Elastic settlement magnitudes were estimated following the same procedures described above (see Appendix D). Settlement magnitudes beneath the maximum new fill height (below the downhill side of the proposed bike path) are estimated to be between 1 and 2 inches and are anticipated to occur within 30 days following construction with about ½ inch of long-term settlement. Grade raising beneath the proposed roadway is less than 5 feet, and settlement beneath the roadway is expected to be less than one inch. Measures to mitigate settlement are not required for embankment widening within this segment.

9.1.3 Settlement from Project Stations 1019+25 to 1020+50

Grade raising with embankment widening to the west is being proposed over the existing embankment in this segment with maximum new fill heights up to 14 feet at Station 1020+00 (see Exhibit 9-4). Clayey embankment fill with a wet unit weight of 125 pcf was assumed.

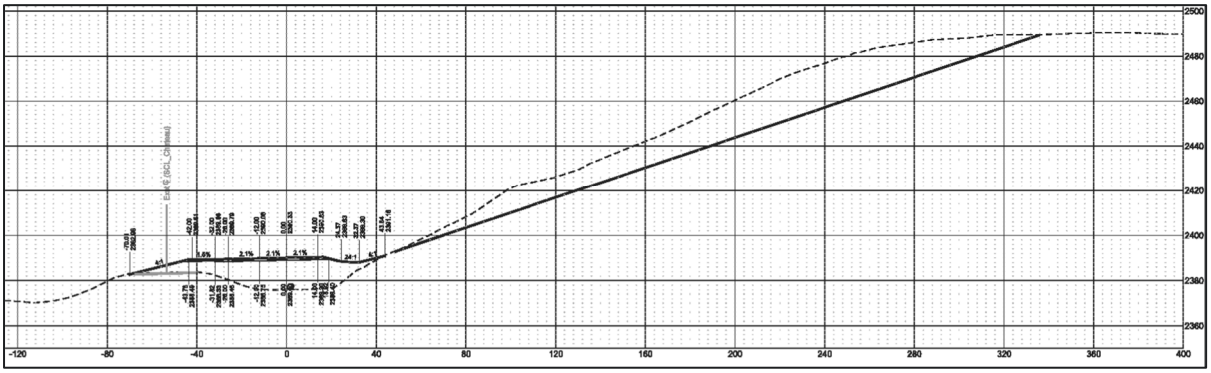

Exhibit 9-4: Maximum new fill height at Station 1020+00 within Project Stations 1019+25 to 1020+50.

Based on boring SW-08 drilled within this segment, the new embankment will be constructed over 13 feet of overburden soils consisting of stiff, lean and fat clay fill; medium dense, gravelly fill; loose, silty sand alluvial soils; and soft to medium stiff, lean clay alluvial soils.

The cohesive soils at this location are characterized by moisture contents in the teens (and not likely saturated), and the other soils are granular in nature. Given these characteristics, it is our opinion that settlement behavior will be elastic, and we modeled settlement using a Schmertmann analysis (see Appendix D). The results indicate approximately one inch of settlement could occur beneath the maximum new fill height (excluding self-weight settlement). Settlement is anticipated to occur within 30 days following construction with about ½ inch of long-term settlement. Measures to mitigate settlement are not required for embankment widening within this segment.

9.1.4 Settlement from Project Stations 1022+75 to 1027+00

Grade raising over the existing road alignment is being proposed in this segment with maximum new fill heights up to 16 feet at Station 1024+50 (see Exhibit 9-5).

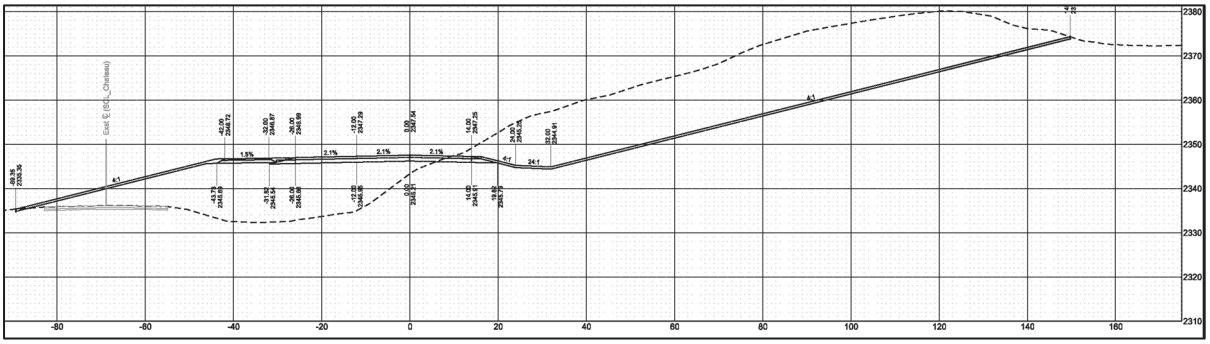

Exhibit 9-5: Maximum new fill height at Station 1024+50 within Project Stations 1022+75 to 1027+00.

Based on borings SW-05 through SW-07 drilled within this segment, the new embankment will be constructed over up to 15 feet of very soft to medium stiff lean clay colluvial soils. The moisture contents of these soils are within the 20s, and the soils appear to be closer to saturation, so the potential for long-term consolidation settlement is present.

Because of the embankment height, we recommend granular alluvial soils be used as embankment fill to reduce the potential for self-weight embankment settlement within this segment (see Section 9.1.6). The unit weight for the new embankment fill was based on compaction testing results conducted on granular alluvial soils collected from our boring SW-11, which resulted in a maximum dry density of 140 pcf (see Appendix B). A wet unit weight of 140 pcf was selected assuming the material would be compacted between 90 and 95 percent of maximum dry density, referencing AASHTO T180, near optimum moisture content.

To estimate the anticipated magnitude of settlement from these soils given the load increases expected from the new embankment, we used the software program Settle 3 (Rocscience, 2021) and modeled the proposed embankment geometry (see Appendix D). Values for the compression index (Cc), re-compression index (Cr), and initial void ratio (e_0) were derived from a one-dimensional consolidation test conducted on a sample of the foundation soils (see Exhibit 9-6 and Appendix B). Preconsolidation pressure (σ'_p) and the over-consolidation ratio (OCR) were derived using an empirical correlation with the undrained shear strength obtained from an unconsolidated undrained triaxial shear test conducted on these soils (Terzaghi and others, 1996) and also using the results of the consolidation test (see Exhibit 9-6 and Appendix B). For time-rate calculations, values for the coefficient of consolidation for these soils (Cv) were derived from the consolidation test results. Secondary compression indices (C_a and C_{ar}) were taken to be 0.05 times Cc and Cr, respectively (Terzaghi and others, 1996) (see Exhibit 9-7).

Exhibit 9-6: Consolidation Parameters Used for Settlement Analysis within Project Stations 1022+75 to 1027+00

Representative Borings	Coefficient of Compression (Cc)	Coefficient of Re-Compression (Cr)	Initial Void Ratio (e_0)	Over Consolidation Ratio (OCR)	Pre-Consolidation Pressure (psf)
SW-05; SW-06	0.177	0.030	0.66	0-5 feet: 11 5-15 feet: 3.2	7,500 3,350

Exhibit 9-7: Secondary Compression Indices Used for Settlement Analysis within Project Stations 1022+75 to 1027+00

Representative Borings	Secondary Compression Index (Ca)	Secondary Re-Compression Index (Car)
SW-05; SW-06	0.0089	0.0015

Based on our analyses (see Appendix D), we estimate that between 3 and 5 inches of consolidation settlement is possible beneath the proposed embankment in this segment. We anticipate all but 1 to 2 inches of the consolidation settlement will be complete within 5 to 6 months. The remaining settlement will occur over the following 1 to 2 years with an additional up to 1 inch of secondary compression following this period. Recommendations for settlement mitigation within this segment are provided in Section 9.1.5.

9.1.5 Settlement Mitigation Project Stations 1022+75 to 1027+00

We understand construction sequencing within this segment will involve building the western portion of the embankment with temporary 2H:1V side slopes. Traffic will be shifted from the existing alignment up onto the new embankment, then the remaining eastern portion of the embankment with 4H:1V side slopes will be constructed, followed by installation of the permanent pavement section.

Based on discussions with the Project Team, once the permanent embankment geometry is completed, temporary pavement can be constructed to allow traffic passage for up to 6 months, while implementing settlement monitoring. This will allow settlement to occur over the winter months prior to placing the final pavement section the following spring. Based on our analysis, between 2 and 4 inches of consolidation settlement could occur beneath the proposed roadway following construction of the temporary embankment condition. After construction of the permanent 4H:1V side slopes, up to one additional inch of consolidation settlement could occur beneath the roadway, and up to 1.5 to 2 inches could occur beneath the proposed bike path.

This sequencing provides an opportunity to allow most of the settlement to occur prior to installation of the permanent pavement section. This will reduce the likelihood of long-term consolidation settlement from having impacts to the permanent pavement section post-construction. Our recommendations for the surcharging and settlement monitoring period are as follows:

- We recommend shifting the temporary 2H:1V side slopes of the new embankments as far east as possible, while still maintaining traffic on the existing road alignment. Placing additional fill to the east will increase the load on the underlying soils, increasing settlement during the temporary construction period and thus reducing post-construction settlement.
- We recommend temporary pavement surfacing be placed on the embankment once traffic is initially shifted up onto it, following the construction of the permanent 4H:1V side slopes, and maintained for 6 months during the winter shutdown.
- We recommend monitoring settlement by installing settlement plates following clearing and grubbing and subgrade preparation as described in Section 10.2, prior to any embankment fill placement. The settlement plates should consist of a 12-inch square plate allowing connection of threaded steel pipe. Steel pipe is attached to the settlement plate, and brought up in increments using threaded connections as embankment fill is being placed. The top surface of the steel pipe should be surveyed weekly, making corrections to the survey data for lengths of pipe that are attached. Once final grade is achieved, surveying of the top surface of the pipe should continue weekly during the monitoring period. The settlement plates should be installed on 50-to-100-foot centers in the section of the embankment with the highest fill heights in areas where they will not be disturbed by construction activities, traffic, or snow removal operations during the monitoring period. To reduce the risk of disturbance, we recommend the monuments be protected with a flush-mount well cover.
- Based on our settlement analyses, we anticipate that all but 1 to 2 inches of settlement can be achieved within the segment in approximately 5-6 months, which can be accommodated given the construction sequencing described above.

Other alternatives that we considered, but do not believe to be reasonable for the project include:

- Over-excavation and replacement to reduce the settlement potential – our analyses suggest most of the settlement is occurring in the upper 6 feet of the subsurface. Over-excavation to this depth would exceed the cost of the alternative described above and may negatively impact the construction schedule.
- Surcharging (can be implemented with a combination of wick drains) – KLJ has indicated that because of the need to shift traffic to the upper embankment, given schedule and desired construction sequencing, adding additional surcharge material on

top of the temporary embankment and allowing it to sit through time before shifting traffic may not be an option.

- Use of light-weight fill material such as expanded polystyrene (EPS) geofoam – given size/volume of the embankment fill in this stretch, this alternative would exceed the cost of the other alternatives listed above.

We understand the new roadway will be surfaced with concrete pavement. If delaying permanent pavement operations is not implemented in combination with surcharging and settlement monitoring within these station ranges, NDDOT should expect cracking and differential displacement of concrete panels as settlement occurs following construction. Periodic maintenance such as asphalt overlays or replacement of concrete panels to maintain a smooth roadway profile, especially within the first 2 years following construction, should be expected if settlement mitigation is not implemented.

9.1.6 Self-Weight Embankment Settlement

Soils have a tendency to undergo some long-term self-weight settlement regardless of the level of compaction (although higher compaction levels tends to reduce the magnitude). Clayey soils experience higher long-term self-weight settlement, especially those soils placed wet of optimum moisture content. For embankments constructed of clay soils, the magnitudes of self-weight settlement that can occur is a function of the embankment height. For embankment heights proposed on this project, self-weight settlement of clay embankments can be expected to be between 1 and 1.5 percent (Naval Facilities Engineering Command, 1986; US Bureau of Reclamation, 1987; Sherard and others, 1963).

To reduce the potential for detrimental self-weight settlement post-construction, we recommend prioritizing use of granular materials encountered in cut sections of the alignment for fill materials where embankments exceed 10 feet in height within Project Stations 1022+75 to 1027+00. Granular material is available from the cuts being proposed within Project Stations 1005+00 to 1007+75 and 1012+50 to 1016+25.

Based on discussions with KLJ, we understand there is a volume shortage of granular fill available from these cuts to fully construct the proposed embankments greater than 10 feet in height between Stations 1022+75 and 1027+00. An additional estimated 3,880 cubic yards of granular material will be required. We recommend import granular fill be used to fully construct embankments greater than 10 feet in height within this station range. Alternatively, NDDOT can accept a risk of post-construction self-weight settlement of up to 1.5% of the height for portions of embankments constructed using clayey materials derived from other cuts within the project limits.

9.2 Cut and Fill Slope Global Stability

We completed global stability modeling of proposed cut slopes and embankment side slopes using the commercially available software SlopeW (Geoslope International, 2021). The results of our individual models are included in Appendix E. Geometry of cut slopes and embankments used in our models were derived from cross sections of the proposed alignment provided by KLJ on October 15, 2024. Temporary 2H:1V embankment side slopes were incorporated into the global stability models where appropriate to analyze KLJ's proposed construction sequencing described above. Subsurface conditions (material contacts and elevations of lithologic units) were based on the closest boring(s) drilled to the critical section analyzed. A surcharge load of 250 psf was included in the models within paved limits of the proposed roadway to simulate traffic loading.

The Morgenstern Price method of analysis was used with an entry and exit slip surface that allows the program to identify the critical failure surface. Slip surface search extents were selected in an attempt to avoid "infinite slope failures," characterized by thin slip planes that run parallel to and within close proximity to the ground surface in the models (slide bodies less than 1 or 2 feet in thickness). For fill conditions, entry surfaces were selected to evaluate the graded limits of embankment fills, and exit surfaces were set to evaluate the stability of the full embankment side slope. Infinite slope failures were still produced in some models, but because these were the critical slip surface and were characterized by adequate Factor of Safety (FS) values, the modeling results were accepted and are being reported. Cut slopes were modeled with slip surface search extents to evaluate stability from the crest of the cut to the toe.

9.2.1 Embankment Unit Weights

To model embankments constructed within station ranges between 1022+75 and 1027+00, a unit weight of 140 pcf was assumed for the proposed embankments based on our recommendations of fill material to be used as discussed in Section 9.1.6. Based on volumetric estimates provided to us by KLJ, we understand clayey embankment fill derived from clay overburden soils, siltstone, and claystone bedrock will be required for use as embankment fill in other areas of the project. A unit weight of 125 pcf was assumed for these proposed embankments based on our discussion in Section 9.1.1.

9.2.2 Shear Strength Parameters

We evaluated embankment fill, the foundation soils, and bedrock beneath proposed embankments using both short-term undrained shear strength, where appropriate, and long-term drained shear strength. Cut slopes were modeled using drained shear strength

parameters. A summary of shear strength parameters used in our global stability models is provided in Exhibit 9-8, with additional explanation in the subsections provided below.

Exhibit 9-8: Shear Strength Parameters Used for Global Stability Modeling

Material Type	Condition	Unit Weight (pcf)	Cohesion (psf)	Friction Angle (deg)	Fully Softened / Residual Shear Strength	
					LL	Clay Fraction (%)
Clayey Embankment Fill	Undrained	125	1,500	--	--	--
	Drained		--	Fully Softened	38	30
Granular Embankment Fill	Drained	140	--	32	--	--
Medium Stiff to Very Stiff Lean Clay	Undrained	130	750	--	--	--
	Drained		--	Fully Softened	32 to 39	28
Soft to Medium Stiff Lean Clay	Undrained	120	750	--	--	--
	Drained		--	Fully Softened	32 to 39	28
Loose Sandy Silt, Silty / Clayey Sand	Drained	125	--	28	--	--
Medium Dense Sand and Gravel	Drained	130	--	32	--	--
Dense Poorly to Well Graded Sand	Drained	130	--	35	--	--
Medium Dense Silty / Clayey Sand	Drained	125	--	30	--	--
Medium Stiff to Stiff Fat Clay	Drained	130	--	Fully Softened	56	50
Colluvium Medium Stiff to Stiff Lean Clay	Drained Residual	120	--	Residual	32	28
Claystone Bedrock	Undrained	135	$\geq$ 3,000	--	--	--
	Drained		--	Fully Softened	66	50
Sandstone Bedrock	Drained	140	--	38	--	--
Siltstone Bedrock	Drained	140	--	34	--	--

9.2.2.1 Undrained Shear Strength Parameters

Undrained shear strength parameters in cohesive soils and bedrock were assigned based on empirical correlations given SPT N values (Terzaghi and others, 1996), and also based on results of pocket penetrometer testing in samples collected from these soils (see boring logs in Appendix A). For proposed clay embankment fill, we assumed the material would be compacted to a stiff to very stiff condition (an SPT N value of 15 or greater), and assigned a corresponding cohesion of 1,500 psf.

For alluvial and colluvial clay overburden soils, an unconsolidated undrained triaxial test was conducted on a sample of lean clay soil collected using a Shelby tube from boring SW-06. The results of the test indicated an undrained shear strength for the clay of 1,650 psf. Given SPT N values in the same soil taken from borings SW-05, SW-06, and SW-07, and the results of pocket penetrometer readings, we conservatively assigned an undrained shear strength to lean clay soils throughout the Project of 750 psf.

For undrained conditions in claystone bedrock, the upper 10 feet of the claystone was assigned a cohesion value of 3,000 psf given ranges of SPT N values from our borings. We used a strength function within SlopeW, increasing the cohesion with depth by 1,000 psf per every 10 feet depth given what we observed with overall increase in SPT N values with depth into claystone in our borings.

9.2.2.2 Tension Crack Modeling for Undrained Conditions

We set up our global stability models to allow for the formation of a tension crack in clayey embankments for the undrained condition. The tension crack angle was set to be equal to the angle of an active earth pressure wedge. SlopeW will not permit the formation of a tension crack unless the slip surface angle is equal to or exceeds the angle assigned for the tension crack. Several model outputs did result in the formation of a tension crack (see Appendix E).

9.2.2.3 Drained Shear Strength Parameters

Drained shear strength parameters in granular soils and bedrock were assigned using empirical correlations given SPT N values and soil type (Unified Facilities Criteria, 2022). For granular embankment fill, we assumed material derived from cuts within Project Stations 1005+00 to 1007+75 and 1012+50 to 1016+25 would be used as fill material within Station Range 1022+75 and 1027+00. We assumed the material would be compacted to at least 90% of maximum dry density (AASHTO T180 compaction criteria) and assigned the soil a friction angle of 32 degrees.

Drained shear strength parameters for cohesive soils and bedrock were estimated using empirical correlations presented by Stark and Fernandez (2020), using liquid limits, percent clay fraction determined from hydrometer tests, and overburden stress. These correlations provide an effective stress fully softened shear strength envelope as a function of applied normal stress (which can be applied in SlopeW as a strength function), and zero cohesion is assumed.

For clayey embankments, an average liquid limit and clay fraction was taken from cohesive soils and bedrock encountered within cut areas on the Project, which are anticipated to be reused as fill. For lean and fat clay overburden soils, liquid limit and clay fraction values were selected based on laboratory testing of the nearest boring, or from similar material where testing was absent. For claystone bedrock, the highest liquid limit and clay fraction values obtained from laboratory testing were conservatively assigned to all claystone units for our global stability models.

9.2.2.4 Residual Shear Strength Parameters

Residual shear strength envelopes obtained using the same empirical methods (Stark and Fernandez, 2020) were assigned for one area within the Project where a proposed embankment side slope extends over an area characterized by shallow slope instability (approximate Project Stations 1016+00 to 1018+00).

9.2.2.5 Back Analyses for Drained Shear Strength Parameters

We did not drill a boring within the proposed cut slope located between Project Stations 1024+00 and 1028+75. The shear strength parameters of the bedrock present in the slopes uphill of the roadway in this location were derived using a back analysis assuming the existing slopes are characterized by a FS of 1.1. These shear strength properties were then applied to the cut slopes proposed in this segment.

9.2.3 Global Stability Results of Proposed Embankments and Cut Slopes

The results of our global stability analyses for proposed embankments and cut slopes are presented in Exhibits 9-9 and 9-10, and slope stability outputs are provided in Appendix E. NDDOT does not specify minimum FS values for design of embankment side slopes or cut slopes within the NDDOT Design Manual (2023). We recommend a minimum FS of 1.3 for cut slopes and embankment side slopes in accordance with the Federal Highway Administration (FHWA) Project Development and Design Manual (USDOT, 2024).

Exhibit 9-9: Summary of Global Stability Results for Proposed Embankments

Station Range Analyzed	Critical Section(s) Modeled	Representative Boring(s)	Factors of Safety			
			Temporary Embankment		Final Embankment	
			Drained	Undrained	Drained	Undrained
1008+00 to 1012+25	1009+00	SW-12	N/A	N/A	2.42	6.57
	1011+75	SW-11	N/A	N/A	2.86	5.99
1016+50 to 1017+50	1017+00	SW-09	N/A	N/A	1.50	2.09
1017+50 to 1018+50	1018+50	SW-09 SW-11	2.16	6.45	2.84	11.87
1019+00 to 1020+00 (Lower Embankment)	1019+75	SW-08 SW-17	3.14	5.05	2.33	4.54
1019+00 to 1020+00 (Upper Embankment)	1019+75	SW-08 SW-17	1.41	N/A	N/A	N/A
1020+25 to 1020+50	1020+25	SW-08 SW-17	1.41	5.20	1.90	6.49
1020+75 to 1021+25	1021+25	SW-08 SW-17	N/A	N/A	1.99	9.63
1023+00 to 1024+00	1023+25	SW-07	1.43	1.43	2.60	2.29
1024+25 to 1028+50	1024+25	SW-05	1.60	1.60	2.56	2.56
	1026+00 (Pre Cut)	SW-05	1.42	1.53	2.11	2.11
	1026+00 (Post-cut)	SW-05	1.48	1.48	2.11	2.11

Exhibit 9-10: Summary of Global Stability Results for Proposed Cut Slopes

Station Range Analyzed	Critical Section(s) Modeled	Proposed Cut Slope Angle	Representative Boring(s)	Factor of Safety
1005+50 to 1007+25	1007+00	4H:1V	SW-13	2.38
1012+50 to 1012+75	1012+50	4H:1V	SW-11	2.38
1015+00 to 1016+00	1016+00	4H:1V	SW-10	2.29
1017+50 to 1018+50	1018+50	4H:1V	SW-09, SW-11	2.12
1020+25 to 1020+50	1020+25	3H:1V	SW-08, SW-17	1.40
1020+75 to 1021+25	1020+75	3H:1V	SW-08, SW-17	1.70
1024+25 to 1028+50	1024+25	3H:1V	Back-Analysis of Existing Cut	1.60
1030+75 to 1039+75	1038+00	2.5H:1V	SW-02, SW-16	1.40
	1039+75	2.5H:1V	SW-02, SW-16	1.40

9.2.4 Recommended Cut Slope Angles

Based on our global stability modeling, the cut slope angles proposed in the cross sections provided by KLJ on October 15 will meet global stability requirements. Per KLJ's request, we modeled steeper cut slopes than illustrated in the cross sections at two locations, to determine if cut volumes on the project can be reduced as a cost savings. We make the following recommendations:

- Cut slopes from Stations 1024+00 to 1028+75 can be constructed at 3H:1V rather than at 4H:1V, as originally proposed, and will meet global stability requirements.
- For cuts between Stations 1030+25 and 1037+75, we recommend the cut slope angles be no steeper than 3H:1V. East of Station 1037+75, cut slopes can be constructed at 2.5H:1V through Station 1041+00.

9.2.5 Global Stability Results of Existing Slopes Stations 1032+00 to 1036+00

We also conducted global stability modeling for the existing slopes located down-slope and south of the proposed Chateau Road alignment between Project Stations 1032+00 and 1036+00. Many of the existing slopes within this station range are currently in a failing condition. We set up the models to check whether or not slope failures have the potential to encroach into the proposed roadway alignment. Slip surface search extents were modeled to evaluate the FS for the existing slopes in their current condition, the FS for a failure that could encroach into the proposed grading limits, and the FS for a failure that could encroach into the proposed pavement. The results of these analyses are summarized in Exhibit 9-11, and individual models are included in Appendix E.

Exhibit 9-11: Summary of Global Stability Results for Existing Slopes

Station Limits	Critical Sections Modeled	Factor of Safety Given Slip Surface Search Extents		
		Existing Slope	Edge of Grading Limits	Edge of Pavement
1032+00 to 1036+00	1032+50	1.11	1.19	1.40
	1032+75	0.80	0.99	1.33
	1033+75	1.07	1.28	1.60
	1034+75	0.80	0.89	1.25
	1035+50	0.74	1.05	1.45
	1036+00	1.28	1.36	1.64

NOTES:
From Stations 1032+00 to 1032+75 and 1034+00 to 1035+50, slope instability could encroach inside of proposed grading limits.

Based on our modeling, there is a potential for slope instability to have impacts inside of the proposed grading limits within several station ranges. Given current slope geometry, the FS values for potential slip surfaces taken to the edge of the pavement are adequate (FS of 1.3 or greater), and slope stability impacts are not anticipated to affect the proposed pavement in the short term, especially given that the roadway is being shifted to the north. In our opinion, if a long-term slope of 2H:1V taken from the existing toe of the slope can be maintained, slope instability should not impact the roadway.

We looked at aerial photography of these slopes spanning the previous 15 years, and did not observe measurable changes in the distance between head scarps and the existing roadway. While global stability is not an immediate problem within pavement limits in this segment, we expect that erosion will continue over time at the toe of these slopes. If erosion continues and failures progressively migrate to the north, mitigation may be required in the future in the form of slope buttressing such as placement of riprap, slope fattening, or other measures.

9.3 Sinkholes at Station 1035+00 to 1036+00

We recommend the sinkholes present between Stations 1035+00 and 1036+00 be backfilled with flow fill, compaction grout, or a low-strength concrete mix (less than 500 psi 28-day compressive strength) with a maximum slump of 3 inches or less. These sinkholes and an erosional / slope stability scarp are located in an area where a drainage channel that flows from the north is disrupted by the existing Chateau Road alignment (see Appendix C, Feature 8). There is no culvert present at this location, and we believe infiltration and subsequent erosion/piping could be contributing to the formation of sinkholes and slope instability on the south side of the road at this location.

We understand KLJ will be improving roadside drainage on the north side of the road at this location, and ditching will be provided to promote water flow to the east parallel to the new Chateau Road alignment.

10 EARTHWORK CONSIDERATIONS

The applicability of our geotechnical recommendations is contingent on good construction practice. Poor construction techniques may alter conditions from those upon which our recommendations are based, and therefore result in poor performance. We assume this project will be constructed according to NDDOT 2024 Standard Specifications. The following sections provide additional construction considerations for this project.

Earthwork, including placement of embankment fill and pavement subgrade preparation, should conform to the requirements provided in the NDDOT 2024 Standard Specifications and the recommendations provided in the following sections. All surface and subsurface structures associated with current development of the site, including pavement, utility poles, fence poles, underground utilities and other deleterious material, should be removed from any areas to be graded. Any existing surficial topsoil and soil containing visible organics should be stripped and removed from all areas to be graded.

10.1 Excavation

We anticipate excavation within the Project limits can be achieved using conventional construction equipment (dozers, scrapers, excavators) and blasting will not be required. Portions of excavations within bedrock for the Project will classify as "Shale Excavation" per NDDOT Section 203.01D and will likely require heavy duty dozer mounted rippers and/or dozer blades to break the material down for removal. Exhibit 10-1 provides a summary of cut slopes proposed on the project that are within bedrock, and anticipated depths where shale processing will be required. These estimates are based on SPT N values and weathering grades of the bedrock encountered in our borings drilled adjacent to or within the proposed cuts.

Exhibit 10-1: Anticipated Required Shale Excavation for Cut Slopes

Cut Slope Approx. Station Range	Representative Borings	Material to be Excavated	Depth of Material Requiring Shale Processing [1]
1017+25 to 1018+75	SW-10, SW-11	Claystone, Siltstone, Sandstone	5 feet
1019+70 to 1022+00	SW-17	Claystone, Siltstone	15 feet
1024+25 to 1028+75	SW-05, SW-06	Claystone	10 feet
1037+00 to 1040+75	SW-16	Claystone, Siltstone	20 feet

NOTE:

1. Depth to material anticipated to require shale processing is to be measured perpendicular to existing ground surface or to existing slope faces.

10.2 Embankment Foundation and Roadway Subgrade Preparation

Following clearing and grubbing, we recommend in all areas of new embankment construction on the Project (unless in bedrock), that the upper 12 inches of the embankment foundation and roadway subgrade be scarified, moisture conditioned, and compacted following the requirements of Compaction Control, Type A per NDDOT Section 203.04G. Embankment foundations and all subgrade areas should be compacted to a dense/firm and

unyielding condition. Bedrock is anticipated to be encountered within portions of the proposed embankment foundations within the following station ranges:

- The approximate western half of the roadway width from Station 1017+75 to 1018+60
- The approximate western third of the roadway width from Station 1020+40 to 1020+50
- The approximate western half of the roadway width from Station 1020+50 to 1021+50
- The approximate southwestern third of the roadway width from Station 1024+60 to 1028+60
- The approximate western third of the roadway width from Station 1037+50 to 1038+75

These anticipated areas are an estimate only and based on limited subsurface information from our borings. We recommend that exposed embankment foundation materials be observed during construction to determine if soil / bedrock is encountered and whether subgrade preparation needs to be implemented.

10.3 Embankment Fill Placement

Exhibit 10-2 provides a summary of all cut locations on the project, anticipated materials to be encountered, and shrink/swell factors that were estimated for the materials to be used as fill.

We recommend prioritizing use of granular materials encountered in cuts from Project Stations 1005+00 to 1007+75 and 1012+50 to 1016+25 as embankment fill to be placed between Stations 1022+75 and 1027+00 where new fill heights exceed 10 feet to address settlement concerns (see Section 9.1.6).

Bedrock materials will be required from other cuts for embankment fill in other areas of the project. We recommend these materials be broken down until 90% of the particles are smaller than 1 inch in all dimensions, with no particle being larger than 3 inches in any dimension. This is to be achieved through pulverizing, using a disc, or manipulating the material with construction equipment. We recommend an engineer make a visual determination if this requirement is met at the time of fill placement.

We recommend all materials being used as embankment fill be placed and compacted following Compaction Control Type A, ND T 180 methods per NDDOT Section 203.04G. We recommend that loose lift thicknesses do not exceed 8 inches.

Exhibit 10-2: Summary of Materials to be Excavated from Cuts with Shrink / Swell Factors

Cut Slope Approx. Station Range	Representative Borings	Material to be Excavated	Shrink / Swell Factors [1,2]
1005+00 to 1007+75	SW-12, SW-13	Loose SM, Medium Stiff CL	0.8
1012+50 to 1016+25	SW-10, SW-11	Loose to Medium Dense SM, SC, SP Medium Stiff CL	0.8
1017+25 to 1018+75	SW-10, SW-11	Claystone, Siltstone, Sandstone	1.0 (upper 5 feet) 1.2 (below 5 feet)
1019+70 to 1022+00	SW-17	Claystone, Siltstone	1.0 (upper 15 feet) 1.2 (below 15 feet)
1024+25 to 1028+75	SW-05, SW-06	Claystone	1.0 (upper 10 feet) 1.2 (below 10 feet)
1030+00 to 1037+00	SW-03, SW-04	Soft to Medium Stiff CL and CH	1.0
1037+00 to 1040+75	SW-16	Claystone, Siltstone	1.0 (upper 20 feet) 1.2 (below 20 feet)

NOTE:

1. Shrink/Swell Factor = original in situ density divided by compacted embankment density. Numbers < 1.0 represent shrinkage. Numbers > 1.0 represent swell.
2. Depths provided for variable shrink/swell factors for bedrock represent transition from highly weathered material to moderately weathered, higher strength material. Depth is to be taken perpendicular to existing ground surfaces or existing slope faces.

Based on the results of our compaction testing on bulk samples collected from the borings, optimum moisture contents for cohesive soils vary from approximately 14% to 15%. Optimum moisture content for the granular alluvial soils was approximately 9%. Cohesive soils encountered between Project Station 1023+00 to the intersection with Pacific Avenue are characterized by in-situ moisture contents of approximately 20%. These soils will have to be scarified and dried to achieve proper compaction. Moisture contents encountered in claystone bedrock layers were also typically in the high teens to low 20s; these materials will also have to be dried to achieve proper compaction. Granular soils encountered in areas of cuts were characterized by in-situ moisture contents typically dry of optimum; moisture conditioning is expected to achieve compaction for these soil types.

For construction of embankments on existing slopes, and when constructing the final slopes against interim slopes, we recommend benching in accordance with NDDOT Section 203.04G.

10.4 Proof Rolling

Following placement and compaction of the aggregate base course (ABC) portion of the pavement section over completed embankments and prepared subgrade areas, we recommend proof rolling the top surface of the ABC using a fully loaded, tandem-axle, 10-yard dump truck or equivalent. Areas that are identified as being soft, loose, or yielding during proof rolling should be addressed on a case-by-case basis considering the following alternatives:

1. Removal of ABC layer, scarify, moisture condition, recompact the subgrade to a dense and unyielding condition, and replace ABC layer with proper compaction control.

2. If subgrade cannot be recompacted to a dense and unyielding condition, consider overexcavation to a maximum depth of either 2 feet, or no deeper than the bottom of adjacent roadside ditching (whichever is encountered first), followed by installation of a biaxial geogrid meeting the requirements of Type G (Geogrid) in accordance with NDDOT Section 858. Replace over-excavated material with Class 5 aggregate per NDDOT Section 816, Table 816-01. Ensure that roadside ditching extends to an adequate depth to provide drainage (by daylighting) for the overexcavation.

11 LIMITATIONS

This report was prepared for the exclusive use of KLJ and the NDDOT for the purpose of providing geotechnical recommendations for the Chateau Road reconstruction project. It should be made available to prospective contractors and/or the Contractor for information on factual data only, and not as a warranty of subsurface conditions.

This report should not be used without our approval if any of the following occurs:

- Conditions change due to natural forces or human activity under, at, or adjacent to the site.
- Assumptions stated in this report have changed.
- Project details change or new information becomes available such that our analyses, conclusions, and recommendations may be affected.
- More than 5 years has passed since the date of this report.

If any of these occur, we should be retained to review the applicability of our analyses, conclusions, and recommendations.

Within the limitations of scope, schedule, and budget, the analyses, conclusions, and recommendations presented in this report were prepared in accordance with generally accepted professional geotechnical and geological principles and practice in this area at the time this report was prepared. We make no other warranty, either express or implied.

Shannon & Wilson has prepared the attached document, "Important Information about Your Geotechnical Report," to assist you and others in understanding the use and limitations of our reports.

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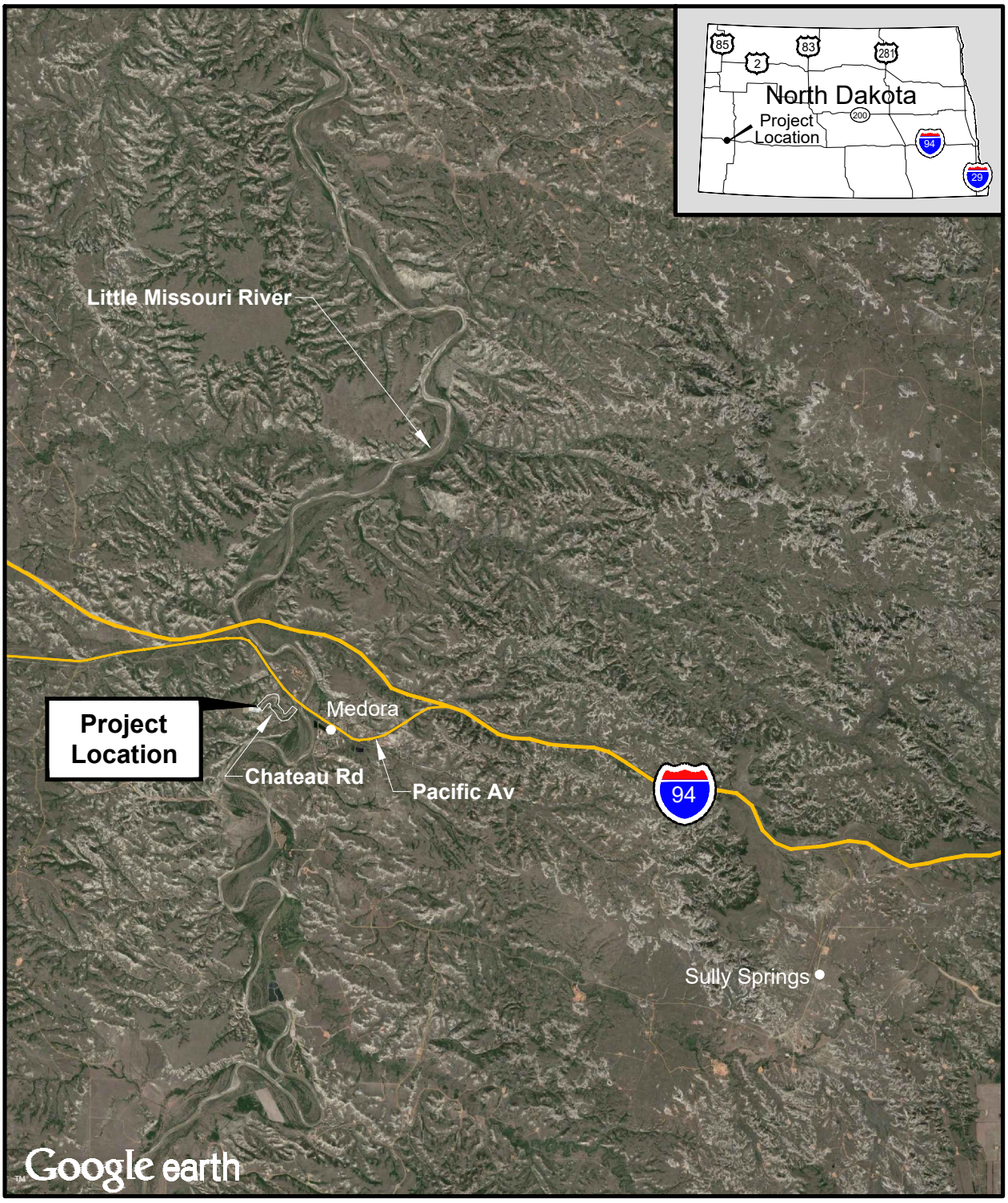

0 2 4

Approximate Scale in Miles

N

NOTE

Map adapted from aerial imagery provided by Google Earth Pro, reproduced by permission granted by Google Earth ™ Mapping Service.

Chateau Road Reconstruction
5-999(036) PCN, 24246
Medora, North Dakota

VICINITY MAP

February 2025 113316-002

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FIG. 1

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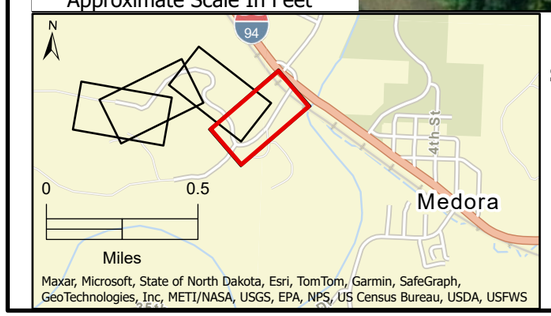

LEGEND

- **SW-10** S&W Boring Designation and Approximate Location
- 5 Reconnaissance Points
- Landslide Scarps
- Approximate Culvert Location
- Proposed Chateau Rd Extension and Roundabout
- Proposed Roadway Centerline and Project Stationing
- Approximate Sinkhole Location

NOTES

1. Boring locations were estimated using recreational grade GPS and measurements from existing site features.
2. Proposed roadway alignment, project stationing, and roundabout location provided by KLJ on 10/15/2024.
3. Reconnaissance points are described in Appendix C.

Chateau Road Reconstruction
5-999(036) PCN, 24246
Medora, North Dakota

SITE AND EXPLORATION PLAN

February 2025 113316-002

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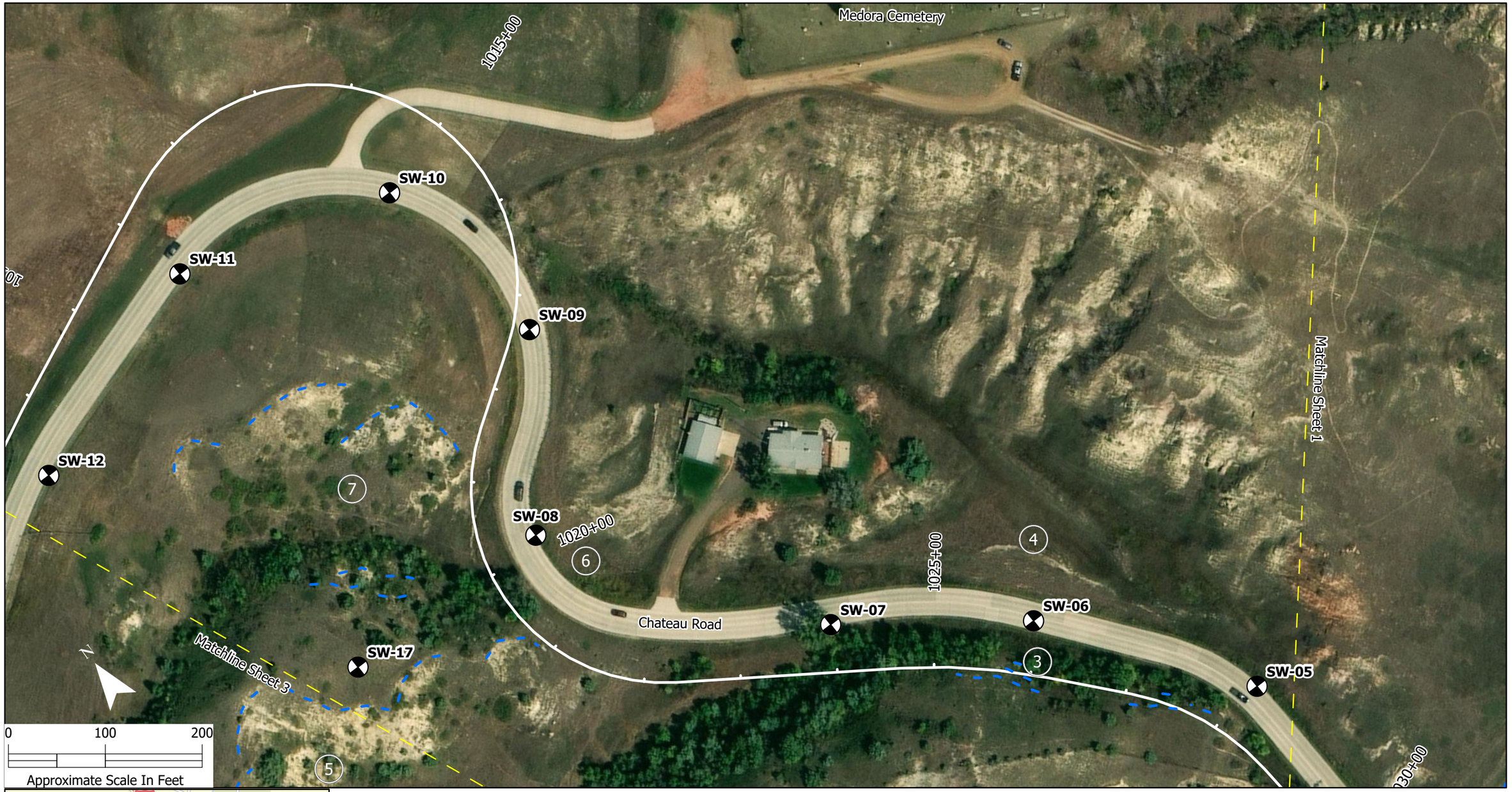
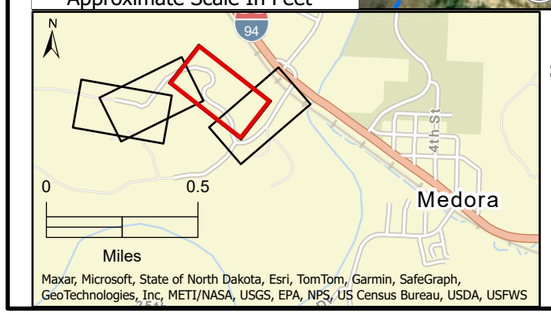
FIG. 2
Sheet 1 of 4





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SITE AND EXPLORATION PLAN

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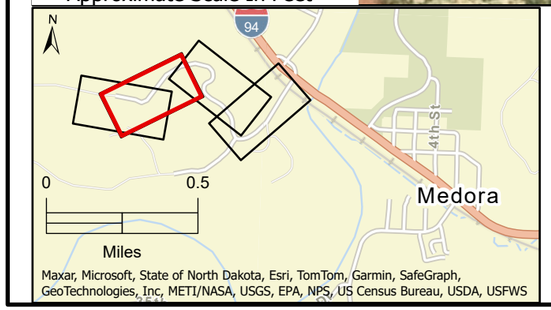
FIG. 2
Sheet 2 of 4



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Chateau Road Reconstruction
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SITE AND EXPLORATION PLAN

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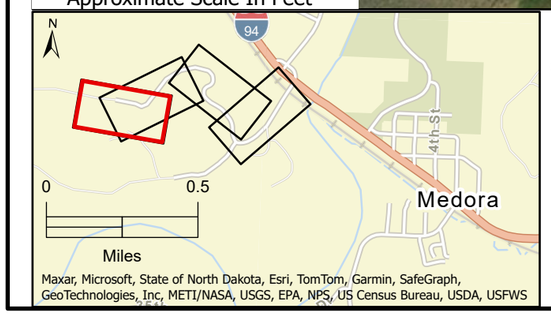
FIG. 2
Sheet 3 of 4



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Chateau Road Reconstruction
5-999(036) PCN, 24246
Medora, North Dakota

SITE AND EXPLORATION PLAN

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FIG. 2
Sheet 4 of 4

APPENDIX A: SUBSURFACE EXPLORATIONS

Appendix A

Subsurface Explorations

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Enclosures

Log Key
Boring Logs

APPENDIX A: SUBSURFACE EXPLORATIONS

A.1 INTRODUCTION

Shannon & Wilson's field exploration program for the project was conducted from June 18 to 20, 2024, September 26, 2024, and November 5, 2024, which consisted of drilling 17 borings at the locations shown on Figure 2. A representative from Shannon & Wilson observed the drilling and sampling, retrieved representative samples, and prepared descriptive field logs of the borings. The methods used to conduct the field exploration program are described below.

A.2 EXPLORATIONS

The borings were coordinated (including subcontractor coordination, site access, and utility locates) and observed by Shannon & Wilson. The enclosed boring logs represent our interpretation of the contents of the field logs and results of select laboratory testing.

Interstate Drilling Services, LLP (IDS) of Grand Forks, North Dakota (under subcontract to Shannon & Wilson) used a Diedrich D-50 turbo diesel truck-mounted drill rig from June 18 to 20, 2024, to drill borings SW-01 through SW-15, and a Diedrich D-70 turbo diesel track-mounted drill rig on September 26, 2024, and November 5, 2024 to drill borings SW-17 and SW-16 respectively. The borings were advanced to depths of approximately 10.5 to 91.0 feet using 7-inch outside diameter (O.D.) and 3.25-inch inside diameter (I.D.) hollow-stem augers and 3.125-inch air rotary techniques.

Borings SW-01 through SW-15 also served to meet the requirements of the North Dakota Department of Transportation (NDDOT) Linear Soil Survey requirements. These borings were drilled within the existing roadway alignment and spaced on 200-to-500-foot centers. Samples were conducted on 2.5-foot intervals in the upper 10 feet from the borings following the methods described in the subsections below, and a bulk sample was also collected from the upper 5 feet of each boring. These sampling requirements were discussed and agreed upon with the NDDOT prior to our subsurface investigation.

The drilling location coordinates were surveyed using a recreational grade GPS unit and offsets from existing site features. Boring elevations were not surveyed in the field but were estimated based on project plans containing topographic survey data provided by KLJ.

A.2.1 Soil Classification System

During drilling, our representative collected samples and prepared field logs of the explorations. Soil classification for this project was based on ASTM International (ASTM) Designation: D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System), and ASTM Designation: D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). The Unified Soil Classification System (USCS) is enclosed. The Shannon & Wilson representative classified rock samples in general accordance with the International Society of Rock Mechanics (ISRM) classification method. According to this system, rocks are classified based on the stratigraphic structure, rock strength, degree of weathering, and other properties. The rock classification system is also enclosed.

The bedrock encountered in the borings was found to be medium stiff to hard and dense to very dense when considered as a lithified soil material. However, when compared with other types of bedrock using the ISRM classification of rock strength, the material resembles a very low strength rock. Therefore, for completeness, the boring logs enclosed in Appendix A contain dual descriptions of the bedrock using the Unified Soil Classification System and the ISRM classification system.

A.2.2 Standard Penetration Test (SPT)

Disturbed samples were obtained in general accordance with the Standard Penetration Test (SPT) (ASTM Designation: D1586). The SPT consists of driving a 2-inch outside diameter (O.D.), 1.375-inch inside diameter split-spoon sampler a distance of 18 inches with a 140-pound hammer free-falling a distance of 30 inches. An automatic hammer system was used to advance the samplers. During sampling, the Shannon & Wilson field representative recorded the number of blows for each 6-inch increment of penetration and summed the blow counts for the last two 6-inch increments. This sum is recorded as the penetration resistance number, or N-value. If high penetration resistance prevented driving the total length of the sampler, the Shannon & Wilson field representative recorded the partial penetration depth and blow count. The N-values provide a means for evaluating the relative density or compactness of cohesionless (granular) soils and consistency or stiffness of cohesive (fine-grained) soils (see the USCS enclosed below). The N-values are shown in the individual boring logs. Representative portions of the split-spoon sample obtained in conjunction with the SPT were placed in a screw-top plastic jar and transported to our laboratory.

A.2.3 Modified California (MC) Test and Sampling

Samples were also obtained using a modified California (MC) barrel sampler. The MC test procedure is similar to the SPT, except a larger diameter barrel sampler (2½-inch O.D.) filled with brass liners is used and also driven 18 inches. During sampling, the Shannon & Wilson field representative recorded the number of blows for each 6-inch increment of penetration. As a result of the larger diameter, the MC sampler yields slightly higher raw blow count numbers when compared to SPT N-values for similar soils. Because the difference in blow counts does not significantly impact our evaluation, we used the field MC blow counts over the last two 6-inch increments to define the relative density and consistency/stiffness of the subsurface materials following SPT terminology. Representative samples retained in the brass liners were sealed with plastic end caps and transported to our laboratory.

A.2.4 Shelby Tube Sampling

Relatively undisturbed soil samples were obtained using Shelby tube samplers in general accordance with ASTM D1587, Standard Practice for Thin-Walled Tube Geotechnical Sampling of Soils. The locations of these samples are shown on the individual boring logs. These samples were collected by using the hydraulic ram of the drill rig to push the thin-walled tube sample into the soil at the bottom of the borehole at the desired depth. The thin-walled tube was connected to the drill rods via a rigid sampling head. After pushing, the drill rods were retracted, and the tube was detached from the sampling head. The Shelby tubes were then sealed and transported to our office for laboratory testing.

A.2.5 Pocket Penetrometer

Select cohesive soil samples were also tested in the field using a pocket penetrometer. The penetrometer estimates the unconfined compressive strength of clay soil samples by penetrating the clay with a 1/4-inch-diameter penetrometer and measuring the resistance (in units of tons per square foot [tsf]) with a calibrated spring. Measurements can be taken to the nearest 0.25 tsf increment. The field measurements from the pocket penetrometer are included on the boring logs.

A.2.6 Bulk Sampling and NDDOT Linear Soil Survey

A bulk soil sample was obtained from the upper 5 feet from borings SW-01 through SW-15 by collecting the drill cuttings to meet the requirements for a Linear Soils Survey per Chapter 7 of the NDDOT Design Manual. Approximately 20 to 30 pounds of cuttings from each location were placed in a 5-gallon bucket and transported to our laboratory. The samples were shipped to our laboratory for testing. The bulk samples are composite

samples sometimes spanning over several soil layers. The USCS classification of the composite bulk samples has not been incorporated into the boring logs for this reason.

SOIL CLASSIFICATION

Shannon & Wilson uses a soil identification system modified from the Unified Soil Classification System (USCS) as described on this Key. Soil descriptions are based on visual-manual procedures (ASTM D2488) and available laboratory index test results (ASTM D2487).

Exhibit A: Unified Soil Classification System (USCS)[1]

Major Divisions			Symbol	Graphic	Typical Identifications (USCS Group Names)[2,4]
COARSE-GRAINED SOILS *(> 50% of soil is retained on the No. 200 sieve[3])*	**GRAVELS** *(> 50% of coarse fraction retained on the No. 4 sieve[3])*	**Gravel** *(< 5% fines[3])*	GW		Well-graded Gravel; Well-Graded Gravel with Sand
			GP		Poorly Graded Gravel; Poorly Graded Gravel with Sand
		Silty or Clayey Gravel *(> 12% fines[3])*	GM		Silty Gravel; Silty Gravel with Sand
			GC		Clayey Gravel; Clayey Gravel with Sand
	SANDS *(≥ 50% of coarse fraction passes the No. 4 sieve[3])*	**Sand** *(< 5% fines[3])*	SW		Well-graded Sand; Well-graded Sand with Gravel
			SP		Poorly Graded Sand; Poorly Graded Sand with Gravel
		Silty or Clayey Sand *(> 12% fines[3])*	SM		Silty Sand; Silty Sand with Gravel
			SC		Clayey Sand; Clayey Sand with Gravel
FINE-GRAINED SOILS *(≥ 50% of soil passes the No. 200 sieve[3])*	**SILTS AND CLAYS** *(liquid limit < 50)*	**Inorganic**	ML		Silt; Silt with Sand or Gravel; Sandy or Gravelly Silt
			CL		Lean Clay; Lean Clay with Sand or Gravel; Sandy or Gravelly, Lean Clay
		Organic	OL		Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly, Organic Silt or Clay
	SILTS AND CLAYS *(liquid limit ≥ 50)*	**Inorganic**	MH		Elastic Silt; Elastic Silt with Sand or Gravel; Sandy or Gravelly, Elastic Silt
			CH		Fat Clay; Fat Clay with Sand or Gravel; Sandy or Gravelly, Fat Clay
		Organic	OH		Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly, Organic Silt or Clay
HIGHLY ORGANIC SOILS	*Primarily organic matter, dark in color, and organic odor*		PT		Peat or other Highly Organic Soils (see ASTM D4427)

NOTE: *For gravels and sands with 5 to 12% fines[3], the following are added to the Group Name:* with Silt and/or Clay or Silty Clay. *Dual Symbols are used:* GW-GM, GP-GM, SW-SM, SP-SM GW-GC, GP-GC, SW-SC, SP-SC

EXHIBIT A NOTES:
1. Adapted, with permission, from USACE Tech Memo 3-357, ASTM D2487, and ASTM D2488.
2. Borderline symbols (symbols separated by a slash) indicate that the soil characteristics are close to the defining boundary between two groups (e.g., CL/ML = Lean Clay to Silt; SP-SM/SM = Sand with Silt to Silty Sand).
3. No. 4 size = 4.75 millimeters (mm) = 0.187 inch; No. 200 sieve size = 0.075 mm = 0.003 inch. Particles smaller 0.075 mm are termed "fines".
4. Poorly graded indicates a narrow range or missing grain sizes. Well-graded indicates a full-range and even distribution of grain sizes.
5. If cobbles and/or boulders are observed, "with cobbles" or "with boulders" or "with cobbles and boulders" is added to the Group Name.

Exhibit B-1: Standard Penetration Test (SPT)

Term	Description
Hammer	140-pound weight with a 30-inch free fall. Hammer types vary (e.g., automatic, rope and cathead). If available, the hammer type and energy ratio (E-ratio) is noted on the boring log.
Sampler	Barrel I.D. / O.D. = 1.5 inches / 2 inches (liner not used) Barrel Length = 30 inches; Shoe I.D. = 1.375 inches
N-Value (N)[1]	Sum of the count of hammer blows to penetrate the second and third 6-inch increments in blows per foot (bpf). **Refusal**: 50 blows for 6 inches or less or 10 blows for 0 inch.

EXHIBIT B NOTES:
1. N-values shown on boring logs are as recorded in the field and have not been corrected for hammer energy, overburden, or other factors. Where the hammer E-ratio is available, the N-value normalized to a ratio of 60% (N_{60}) is listed.
2. Based on ASTM Standard D1586. Relative densities/consistencies noted on the boring logs are based on uncorrected N-values.
3. PP = pocket penetrometer; TV = torvane, tsf = tons per square foot. Correlations based on experience and multiple published references.

Exhibit B-2: Relative Consistency of Cohesive Soils

Term	N[2] (bpf)	PP[3] (tsf)	TV[3] (tsf)
Very Soft	0 - 2	0 - 0.25	0 - 0.12
Soft	2 - 4	0.25 - 0.5	0.12 - 0.25
Medium Stiff	4 - 8	0.5 - 1	0.25 - 0.5
Stiff	8 - 15	1 - 2	0.5 - 1
Very Stiff	15 - 30	2 - 4	1 - 2
Hard	> 30	> 4	> 2

Exhibit B-3: Relative Density of Cohesionless Soils

Term	N[2] (bpf)
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	> 50

Exhibit C: Soil Structure[1]

Term	Description
Blocky	Cohesive soil that can be broken down into small angular lumps that resist further breakdown.
Fissured	Breaks along definite planes or fractures with little resistance.
Homogeneous	Same color and appearance throughout.
Interbedded	Alternating layers at least 1/4 inch thick of varying material or color. *Singular: bed*
Laminated	Alternating layers less than 1/4 inch thick of varying material or color. *Singular: lamination*
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay.
Slickensided	Fracture planes appear polished or glossy, sometimes striated.

EXHIBIT C NOTE:
1. Adapted, with permission, from ASTM D2488.

Exhibit D: Soil Plasticity[1]

Term	Description
Nonplastic	Cannot roll a 1/8-inch thread at any water content.
Low Plasticity	A thread can barely be rolled and a lump cannot be formed when drier than the plastic limit.
Medium Plasticity	A thread is easy to roll and not much time in rolling is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. A lump crumbles when drier than the plastic limit.
High Plasticity	It takes considerable time rolling and kneading to reach the plastic limit. A thread can be rerolled several times after reaching the plastic limit. A lump can be formed without crumbling when drier than the plastic limit.

EXHIBIT D NOTE:
1. Adapted, with permission, from ASTM D2488.

Exhibit E: Soil Moisture Content[1]

Term	Description
Dry	Absence of moisture, dusty, dry to the touch.
Moist	Damp but no visible water.
Wet	Visible free water, from below water table.

EXHIBIT E NOTE:
1. Adapted, with permission, from ASTM D2488 (Figure 2).

Exhibit F: Soil Cementation[1]

Term	Description
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

EXHIBIT F NOTE:
1. Adapted, with permission, from ASTM D2488.

Exhibit G: Percentages

Term	Percent[1]
Trace	<5
Few	5 to 10
Little	15 to 25
Some	30 to 45
Mostly	>50

EXHIBIT G NOTE:
1. Percent estimated by weight for sand and gravel, and by volume for cobbles, organics, and other non-soil material (e.g., rubble, debris).

SOIL CLASSIFICATION *(continued)*

See Page 1 for Soil Classification Exhibits A through G

Exhibit H: Particle Angularity and Shape[1]

Term	Description
Angular	Sharp edges and unpolished planar surfaces.
Subangular	Similar to angular, but with rounded edges.
Subrounded	Nearly planar sides with well-rounded edges.
Rounded	Smoothly curved sides with no edges.
Flat	Width to thickness ratio > 3.
Elongated	Width to thickness ratio < 3.

EXHIBIT H NOTE:
1. Adapted, with permission, from ASTM D2488.

Exhibit I: Additional Descriptive Terms

Term	Description
Mottled	Irregular patches of different colors.
Bioturbated	Soil disturbance or mixing by plants or animals.
Diamict	Nonsorted sediment; sand and gravel in silt and/or clay matrix.
Cuttings	Material brought to surface by drilling action.
Slough	Material that caved from sides of borehole.
Sheared	Disturbed texture, mix of strengths.

SOIL CLASSIFICATION REFERENCES:

ASTM International, [current edition], Annual book of standards, v. 04.08, soil and rock (I): D420 - D5876, available: www.astm.org.

U.S. Army Corps of Engineers, 1953, The unified soil classification system: Vicksburg, Miss., Waterways Experiment Station, Technical Memorandum 3-357, 2 v., March.

SYMBOLOGY AND GRAPHICS

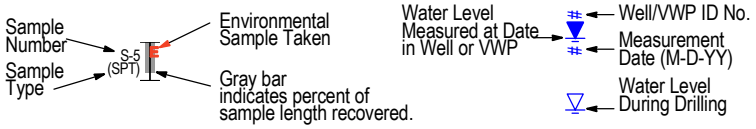
Exhibit J: Sample and Run Graphics

Graphic	Description	Graphic	Description	Graphic	Description
	SPT split spoon (2-inch OD)		Split spoon (SS) (diameters vary)		Core run (typically rock)
	Grab (GB) from cuttings or excavation		Modified California (MC) sampler		Sheath (SH) (used for geoprobes)
	Tube (TB) (e.g., Shelby, piston)		Sonic core (SC) run (typically soil)		

Exhibit K: Hole Backfill and Instrument Graphics

Graphic	Description	Graphic	Description	Graphic	Description
	Bentonite-cement grout		Cement Seal		Blank pipe or instrument casing
	Bentonite grout		Sand filter pack		Perforated or slotted pipe
	Bentonite chips		Slough *(hole caved)*		VWP and electric lead

Exhibit L: Other Log Symbols



ROCK CLASSIFICATION

Shannon & Wilson uses a rock classification system modified from the system recommended by the International Society for Rock Mechanics (ISRM). Copyright limitations prevent us from reproducing summary tables from the ISRM system on this Key. General descriptions are provided in Exhibit M.

Exhibit M: General Rock Descriptive Terms - ISRM

Term	General Description
Strength	Ranges from extremely weak (q_u = 36 to 135 psi) to extremely strong (q_u > 36,250 psi), and is based on the ability to break the rock with a hammer or scrape the rock with a knife.
Weathering	Ranges from fresh (no visible signs of weathering) to completely weathered, based on observed degree of discoloration, decomposition, and/or disintegration. When the rock material has completely converted to soil, it is termed a residual soil.
Fabric	Describes the rock structure based on observed layering, tendency to break, and distribution of minerals (e.g., massive, bedded, foliated).
Roughness	For discontinuities: Includes rough, smooth, and slickensided, and includes other descriptive terms (e.g., stepped, undular, irregular, planar).
Spacing	For discontinuities: Ranges from extremely close (< 1 inch) to extremely wide (> 20 feet).
Persistence	For discontinuities: Ranges from very low to very high.
Other	Description of discontinuities (joints, fractures, bedding planes, etc.), observations of potential displacement, gouge, shear, etc.

REFERENCE: Brown, E. T., ed., 1981, Rock characterization, testing & monitoring: International Society of Rock Mechanics (ISRM) suggested methods: Oxford, Pergamon Press, 211 p.

Exhibit N: Rock Name Graphics

Graphic	Description	Graphic	Description
	Claystone		Coal
	Siltstone		Klinker
	Sandstone		

Exhibit O: Recovery and RQD Equations[1]

Term	Equation
Core Recovery (REC) in %	$100\% \times \frac{\text{Length of Core Recovered}}{\text{Length of Core Run}}$
Rock Quality Designation (RQD) in %	$100\% \times \frac{\text{Length of Core in Pieces} > 4 \text{ in}}{\text{Length of Core Run}}$

REFERENCE: Loehr, J. E.; Lutenegger, A.; Rosenblad, B.; and Boeckmann, A., 2016, Geotechnical site characterization: U.S. Federal Highway Administration Report FHWA NHI-16-072, Geotechnical Engineering Circular no. 5, 1 v.

ACRONYMS AND ABBREVIATIONS

ATD	at time of drilling	N	field (uncorrected) SPT N-value	REF	refusal
bpf	blows per foot	N_{60}	SPT N-value corrected for 60% ETR	RQD	rock quality designation (ASTM D6032)
dia, diam	diameter	NA, n/a	not applicable or not available	SC	sonic core
Elev.	elevation	NE	northeast	SE	southeast
ENV	environmental sample	NP	nonplastic	SPT	Standard Penetration Test (ASTM D1586)
ETR	energy transfer ratio (hammer)	NR	no recovery	SW	southwest
FC	fines content (< 0.075 mm)	NW	northwest	TP	test pit
FeO	iron oxide	OC	organic content	tsf	tons per square foot
ft or '	foot or feet	OD	outside diameter	TV	tor vane reading
gal	gallons	OW	observation well	UCS, q_u	unconfined compressive strength
GP	geoprobe	pcf	pounds per cubic foot	USCS	Unified Soil Classification System
GWT	groundwater table	PI	plasticity index	VST	vane shear test
HSA	hollow-stem auger	PID	photoionization detector	VWP	vibrating wire piezometer
ID	inside diameter or identification	PL	plastic limit	WC	natural water content
in or "	inch	PMT	pressuremeter test	WOH	weight of hammer
incl	inclinometer	PP	pocket penetrometer reading	WOR	weight of rods
ksf	kips per square foot	ppm	parts per million		
lbs	pounds	psi	pounds per square inch		
LL	liquid limit	PT	nonstandard penetration test N-value		
mm	millimeter	REC	recovery		

SHANNON & WILSON

BORING LOG

Chateau Road Reconstruction
Medora, North Dakota

SW-01
Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	*10.5 feet*
Top Elevation:	*~2282 feet*
Vertical Datum:	*NAVD88*
Latitude:	*~ 46.9163 degrees*
Longitude:	*~ -103.5338 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*June 18, 2014*
Hole Finish Date:	*June 18, 2024*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Interstate Drilling Services*
Drill Rig Equipment:	*Diedrich D-50 Truck*
Hole Size:	*7 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*~80% (estimated)*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling: ▽

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
2280	0	***ASPHALT;*** 4" Asphalt Pavement		0.3					0
		Loose, brown, ***POORLY GRADED GRAVEL WITH SILT AND SAND*** (GP-GM); moist. [A-2-4] Base Course		1.5					
		Medium stiff, brown and tan, ***LEAN CLAY*** *(CL)* to ***LEAN CLAY WITH SAND*** *(CL);* moist; trace gravel. [A-6] Alluvium			S-1 (SPT)	N = 8,5,3 (8 bpf)	WC=6% FC=83% LL/PI=36/19 pH=7.5 RES=1468 OhmCm		
					G-1 (GB)				
					S-2 (SPT)	N = 2,2,3 (5 bpf) PP = 1.25 tsf	WC=22%		
					S-3 (MC)	PT = 2,2,4 (6 bpf) PP = 0.75 tsf	WC=24%		
2275	5								5
					S-4 (SPT)	N = 3,2,3 (5 bpf) PP = 0.75 tsf	WC=25%		
					S-5 (SPT)	N = 2,2,3 (5 bpf) PP = 1.25 tsf	WC=22%		
	10			10.5					10
	10.5	BOTTOM OF HOLE AT 10.5 FEET							

No Observed Groundwater

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
- Groundwater level, if indicated above, is for the date specified and may vary.
- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	DKM
Review by:	GRF
Version:	1

Job#: 113316 | Template Ver:1 | File: 113316(12-11-24).GPJ | Rpt: BORING LOG | Library: SW GINT LIBRARY.GLB | Date: 12/11/24

SHANNON & WILSON

BORING LOG

Chateau Road Reconstruction
Medora, North Dakota

SW-02

EXPLORATION INFORMATION

Total Depth:	*10.5 feet*
Top Elevation:	*~2285 feet*
Vertical Datum:	*NAVD88*
Latitude:	*~ 46.9151 degrees*
Longitude:	*~ -103.5348 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*June 18, 2014*
Hole Finish Date:	*June 18, 2024*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Interstate Drilling Services*
Drill Rig Equipment:	*Diedrich D-50 Truck*
Hole Size:	*7 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*~80% (estimated)*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling: ▽

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted (see bottom legend on Page 1)	Depth (feet)
		ASPHALT; 3" Asphalt Pavement		0.3					
		Loose, brown, ***POORLY GRADED GRAVEL WITH SILT AND SAND*** (GP-GM); moist. [A-2-4] Base Course		1.5					
2280	5	Medium stiff, brown and tan, ***LEAN CLAY*** *(CL)* to ***LEAN CLAY WITH SAND*** *(CL);* moist. [A-6] Alluvium			*No Observed Groundwater*			0 50 100	5
					S-1 (SPT)	N = 3,2,3 (5 bpf) PP = 0.25 tsf	WC=19% FC=84% LL/PI=34/15		
					G-1 (GB) S-2 (MC) S-3 (SPT)	PT = 2,3,3 (6 bpf) PP = 0.5 tsf N = 2,2,3 (5 bpf) PP = 0.75 tsf	WC=23% WC=21%		
2275	10				S-4 (SPT)	N = 2,3,3 (6 bpf) PP = 0.75 tsf	WC=21%		10
	10.5			10.5	S-5 (SPT)	N = 2,3,3 (6 bpf) PP = 0.5 tsf	WC=19%		

BOTTOM OF HOLE AT 10.5 FEET

NOTES:
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	DKM
Review by:	GRF
Version:	1

Job#: 113316 | Template Ver:1 | File: 113316(12-11-24).GPJ | Rpt: BORING LOG | Library: SW GINT LIBRARY.GLB | Date: 12/11/24

Chateau Road Reconstruction
Medora, North Dakota

SW-03
Page 1 of 2

EXPLORATION INFORMATION

Total Depth:	*45.4 feet*
Top Elevation:	*~2288 feet*
Vertical Datum:	*NAVD88*
Latitude:	*~ 46.9143 degrees*
Longitude:	*~ -103.5358 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*June 18, 2014*
Hole Finish Date:	*June 18, 2024*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Interstate Drilling Services*
Drill Rig Equipment:	*Diedrich D-50 Truck*
Hole Size:	*7 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*~80% (estimated)*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data
2285	0	***CONCRETE;*** 5.5" of Concrete Pavement		0.5			
		Brown, ***POORLY GRADED GRAVEL WITH SILT AND SAND*** (GP-GM); moist. [A-2-4] Base Course		1.0			
	5	Medium stiff to stiff, brown and tan, ***FAT CLAY*** (CH); moist; trace to few sand, coal, and bedrock fragments. [A-7-6] Colluvium			S-1 (SPT)	N = 2,3,3 (6 bpf) PP = 1 tsf	WC=20%
					G-1 (GB)	PT = 4,6,7 (13 bpf)	WC=24% FC=100% LL/PI=56/37
					S-2 (MC)		WC=16%
					S-3 (SPT)	N = 2,2,3 (5 bpf) PP = 0.75 tsf	
2280					S-4 (SPT)	N = 3,3,3 (6 bpf) PP = 1 tsf	WC=15%
	10				S-5 (MC)	PT = 5,6,6 (12 bpf) PP = 0.75 tsf	WC=15%
2275							
	15				S-6 (SPT)	N = 4,3,4 (7 bpf) PP = 0.75 tsf	WC=14%
2270		Loose, brown, ***CLAYEY SAND*** (SC); moist; trace to few fragments of coal. Colluvium		17.3	S-7 (SPT)	N = 3,2,3 (5 bpf)	WC=17%
2265	20						
		Very stiff, brown and reddish brown, ***GRAVELLY LEAN CLAY WITH SAND*** (CL); moist. Residuum		22.3	S-8 (SPT)	N = 6,7,14 (21 bpf)	WC=18% FC=60% LL/PI=33/16
	25	***CLAYSTONE***: extremely weak, brown and gray, slightly weathered; laminated to slightly fissle. Bullion Creek Formation [Hard, Lean Clay (CL); moist.]		25.0			
2260					S-9 (SPT)	N = 12,25,31 (56 bpf)	WC=16%
	30						
2255					S-10 (MC)	PT = 30,50/5.5" (50/5.5" bpf)	WC=16% FC=98% LL/PI=47/28
	35						

No Observed Groundwater

Multiple Items Plotted *(see bottom legend on Page 1)*
0 50 100

NOTES:
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- Groundwater level, if indicated above, is for the date specified and may vary.
- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	DKM
Review by:	GRF
Version:	1

Chateau Road Reconstruction
Medora, North Dakota

SW-03
Page 2 of 2

See Page 1 for Hole Information and Notes

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
2250	40	***SANDSTONE***: extremely weak, gray, slightly weathered to fresh; massive to laminated with coal partings. Bullion Creek Formation [Very dense, *Silty Sand (SM)* to *Sandy Silt (ML)*; moist.]		37.0	S-11 (SPT)	N = 18,25,34 (59 bpf)	WC=28%		40
2245	45				S-12 (SPT)	N = 18,43,50/5" (93/11" bpf)	WC=20%	>>	45
	45.4	BOTTOM OF HOLE AT 45.4 FEET		45.4					

SHANNON & WILSON

BORING LOG

Chateau Road Reconstruction
Medora, North Dakota

SW-04

EXPLORATION INFORMATION

Total Depth:	*45.5 feet*
Top Elevation:	*~2298 feet*
Vertical Datum:	*NAVD88*
Latitude:	*~ 46.9140 degrees*
Longitude:	*~ -103.5365 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*June 18, 2014*
Hole Finish Date:	*June 18, 2024*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Interstate Drilling Services*
Drill Rig Equipment:	*Diedrich D-50 Truck*
Hole Size:	*7 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*~80% (estimated)*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data
2295	0	***CONCRETE;*** 6.5" of concrete pavement		0.5	G-2 (GB)	N = 1,1,1 (2 bpf) PP = 0.5 tsf	FC=72% LL/PI=30/15
		Brown, ***POORLY GRADED GRAVEL WITH SILT AND SAND*** (GP-GM); moist. [A-2-4] Base Course		1.0	S-1 (SPT)		WC=19%
					G-1 (GB)		WC=17%
		Very soft to stiff, brown and tan, ***LEAN CLAY*** *(CL) to* ***SANDY LEAN CLAY****(CL) ;* moist. [A-6] Colluvium to Residuum			S-2 (MC)	PT = 2,2,2 (4 bpf) PP = 0.5 tsf	WC=15%
2290	5	*-Trace to few carbonaceous fragments from 3.5 to 17.0 feet.*			S-3 (SPT)	N = 2,2,2 (4 bpf) PP = 1.25 tsf	WC=16%
		-Trace bedrock fragments and interbedded sand layers less than 6 inches thick from 6.0 to 17.3 feet.			S-4 (SPT)	N = 2,3,2 (5 bpf) PP = 0.75 tsf	WC=16% FC=67% LL/PI=27/14
2285	10						
	15				S-5 (MC)	PT = 4,4,6 (10 bpf)	WC=18%
2280	20				S-6 (SPT)	N = 4,3,3 (6 bpf) PP = 0.75 tsf	WC=15%
2275	25	***CLAYSTONE***: extremely weak, brown and red-brown, massive; highly to moderately weathered; iron oxide stains. Bullion Creek Formation [Very stiff to hard, Fat Clay (CH); moist.]		22.3	S-7 (SPT)	N = 8,12,18 (30 bpf)	WC=18%
2270	30	***CLAYSTONE***: extremely weak, brown and gray, slightly weathered; thinly bedded to massive. Bullion Creek Formation [Very stiff to hard, Fat Clay (CH); moist.]		27.3	S-8 (SPT)	N = 6,12,18 (30 bpf)	WC=16%
2265	35				S-9 (MC)	PT = 16,36,50/5" (86/11" bpf)	WC=16%

No Observed Groundwater

Multiple Items Plotted *(see bottom legend on Page 1)*: 0 — 50 — 100

NOTES:
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	DKM
Review by:	GRF
Version:	1

Chateau Road Reconstruction
Medora, North Dakota

SW-04
Page 2 of 2

See Page 1 for Hole Information and Notes

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
2260	40	***CLAYSTONE***: extremely weak, brown and gray, slightly weathered; thinly bedded to massive. Bullion Creek Formation [Very stiff to hard, Fat Clay (CH); moist.] *(starts on previous page)*			S-10 (SPT)	N = 9,15,24 (39 bpf)	WC=14%		40
2255	45	***SANDSTONE***: extremely weak, gray, massive; slightly weathered; poorly cemented. Bullion Creek Formation [Very dense, Silty Sand (SM); moist.]		42.3	S-11 (SPT)	N = 30,43,50/5" (93/11" bpf)	WC=18%	>>	45
	45.5	BOTTOM OF HOLE AT 45.5 FEET		45.5					

SHANNON & WILSON

BORING LOG

Chateau Road Reconstruction
Medora, North Dakota

SW-05
Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	*20.5 feet*
Top Elevation:	*~2315 feet*
Vertical Datum:	*NAVD88*
Latitude:	*~ 46.9149 degrees*
Longitude:	*~ -103.5373 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*June 20, 2024*
Hole Finish Date:	*June 20, 2024*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Interstate Drilling Services*
Drill Rig Equipment:	*Diedrich D-50 Truck*
Hole Size:	*7 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*~80% (estimated)*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type → S-5 (SPT) ← Gray bar indicates percent of sample length recovered.

Water Level During Drilling →

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)*	Depth (feet)
		CONCRETE; 4.5" concrete pavement		0.4					
		Brown, ***POORLY GRADED GRAVEL WITH SILT AND SAND*** (GP-GM); moist. [A-2-4] Base Course		1.0					
2310	5	Soft to stiff, brown, ***LEAN CLAY*** *(CL)* to ***LEAN CLAY WITH SAND*** *(CL);* moist; trace to few gravel. [A-6] Colluvium to Residuum			S-1 (MC) G-1 (GB) S-2 (SPT) S-3 (SPT) *No Observed Groundwater*	PT = 5,6,5 (11 bpf) PP = 0.75 tsf N = 3,2,2 (4 bpf) PP = 0.5 tsf N = 2,2,2 (4 bpf) PP = 0.25 tsf	WC=14% FC=76% LL/PI=33/16 pH=7.8 RES=1458 OhmCm WC=20% WC=19%	0 50 100	5
2305	10				S-4 (TB)	PP = 0.5 tsf	WC=22% FC=78% LL/PI=33/18		10
2300	15	***CLAYSTONE***: extremely weak, brown and gray, highly to moderately weathered; blocky to thinly bedded; trace carbonaceous fragments. Bullion Creek Formation [Stiff to hard, *Fat Clay(CH);* moist.]		15.0	S-5 (SPT)	N = 2,3,5 (8 bpf)	WC=28%		15
2295	20 20.5	BOTTOM OF HOLE AT 20.5 FEET		20.5	S-6 (SPT)	N = 11,16,21 (37 bpf)	WC=21%		20

NOTES:
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	DKM
Review by:	GRF
Version:	1

Job#: 113316 | Template Ver:1 | File: 113316(12-11-24).GPJ | Rpt: BORING LOG | Library: SW GINT LIBRARY.GLB | Date: 12/11/24

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BORING LOG

Chateau Road Reconstruction
Medora, North Dakota

SW-06
Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	*20.5 feet*
Top Elevation:	*~2322 feet*
Vertical Datum:	*NAVD88*
Latitude:	*~ 46.9155 degrees*
Longitude:	*~ -103.5379 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*June 20, 2024*
Hole Finish Date:	*June 20, 2024*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Interstate Drilling Services*
Drill Rig Equipment:	*Diedrich D-50 Truck*
Hole Size:	*7 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*~80% (estimated)*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted (see bottom legend on Page 1)	Depth (feet)
2320	0	***CONCRETE;*** 6.5" of concrete pavement		0.5					
		Brown, ***POORLY GRADED GRAVEL WITH SILT AND SAND*** (GP-GM); moist. [A-2-4] Base Course		1.1	S-1 (MC) / G-1 (GB) / S-2 (SPT)	PT = 5,6,7 (13 bpf) PP = 0.5 tsf	WC=16%		
		Very soft to stiff, brown, ***LEAN CLAY*** *(CL)* to ***LEAN CLAY WITH SAND*** *(CL);* moist. [A-6] Colluvium to Residuum			S-8 (TB) / S-3 (SPT)	N = 2,2,2 (4 bpf) PP = 0.25 tsf	WC=20%		
	5					PP = 0.75 tsf N = 1,1,1 (2 bpf)	WC=19% FC=95% LL/PI=39/21		5
2315						PP = 0.25 tsf	WC=17%		
					S-4 (SPT)	N = 1,2,1 (3 bpf) PP = 0.5 tsf	WC=20%		
	10				S-5 (SPT)	N = 3,2,2 (4 bpf) PP = 0.5 tsf	WC=16%		10
2310									
	15	***CLAYSTONE***: gray-brown and black, highly weathered; disturbed texture. Bullion Creek Formation [Medium stiff, *Fat Clay (CH);* moist.]		14.5	S-6 (SPT)	N = 2,3,4 (7 bpf)	WC=27%		15
2305		**SILTSTONE TO CLAYSTONE**: extremely weak, tan; massive; slightly weathered. Bullion Creek Formation [Dense to hard, *Silt (ML)* to *Lean Clay (CL);* moist.]		17.3					
	20				S-7 (SPT)	N = 10,13,18 (31 bpf)	WC=22%		20
	20.5	BOTTOM OF HOLE AT 20.5 FEET		20.5					

No Observed Groundwater

Multiple Items Plotted (see bottom legend on Page 1): 0 — 50 — 100

NOTES:
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	DKM
Review by:	GRF
Version:	1

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BORING LOG

Chateau Road Reconstruction
Medora, North Dakota

SW-07

EXPLORATION INFORMATION

Total Depth:	*10.5 feet*
Top Elevation:	*~2345 feet*
Vertical Datum:	*NAVD88*
Latitude:	*~ 46.9158 degrees*
Longitude:	*~ -103.5386 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*June 20, 2024*
Hole Finish Date:	*June 20, 2024*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Interstate Drilling Services*
Drill Rig Equipment:	*Diedrich D-50 Truck*
Hole Size:	*7 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*~80% (estimated)*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)*	Depth (feet)
		CONCRETE; 4.5" of concrete pavement		0.4					
		Brown, ***POORLY GRADED GRAVEL WITH SILT AND SAND*** (GP-GM); moist. [A-2-4] Base Course		0.9					
2340	5	Soft to stiff, brown and tan, ***LEAN CLAY*** *(CL)* to ***LEAN CLAY WITH SAND*** *(CL);* moist; trace gravel. [A-6] Colluvium			*No Observed Groundwater*				5
2335	10				S-1 (SPT)	N = 5,4,6 (10 bpf) PP = 1.75 tsf	FC=76% LL/PI=32/17	0 50 100	
	10.5			10.5	G-1 (GB)	PT = 4,5,5 (10 bpf)	WC=12%		
					S-2 (MC)		WC=9%		
					S-3 (SPT)	N = 3,3,3 (6 bpf) PP = 0.75 tsf	WC=14%		
					S-4 (SPT)	N = 2,2,2 (4 bpf) PP = 0.5 tsf	WC=17%		
					S-5 (SPT)	N = 2,3,3 (6 bpf) PP = 0.75 tsf	WC=16% FC=84% LL/PI=27/13		10

BOTTOM OF HOLE AT 10.5 FEET

NOTES:
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	DKM
Review by:	GRF
Version:	1

Job#: 113316 | Template Ver:1 | File: 113316(12-11-24).GPJ | Rpt: BORING LOG | Library: SW GINT LIBRARY.GLB | Date: 12/11/24

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BORING LOG

Chateau Road Reconstruction
Medora, North Dakota

SW-08
Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	*26.0 feet*
Top Elevation:	*~2388 feet*
Vertical Datum:	*NAVD88*
Latitude:	*~ 46.9165 degrees*
Longitude:	*~ -103.5393 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*June 20, 2024*
Hole Finish Date:	*June 20, 2024*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Interstate Drilling Services*
Drill Rig Equipment:	*Diedrich D-50 Truck*
Hole Size:	*7 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*~80% (estimated)*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted (see bottom legend on Page 1) 0 50 100	Depth (feet)
2385	0	***CONCRETE;*** 8" concrete pavement		0.7					0
		Stiff, brown, ***LEAN CLAY WITH SAND*** *(CL)* to ***FAT CLAY WITH SAND*** *(CH);* moist, few gravel. [A-6 & A-7-6] Fill		2.3	S-1 (MC) G-1 (GB) S-2 (MC)	PT = 5,8,6 (14 bpf) PP = 0.75 tsf PT = 4,4,6 (10 bpf) PP = 1.25 tsf	WC=15% WC=14%		
	5	Medium dense, red, ***WELL-GRADED GRAVEL WITH SILT AND SAND*** (GW-GM); moist. [A-2-4] Fill		3.5 4.4	S-3 (SPT)	N = 3,2,3 (5 bpf)	WC=11%		5
2380		Stiff, brown, ***LEAN CLAY*** *(CL)* to ***FAT CLAY*** *(CH);* moist, sand layers up to 6 inches in thickness. [A-6 & A-7-6] Fill			S-4 (SPT)	N = 3,3,3 (6 bpf)	WC=9% FC=27% LL/PI=NP/NP		
	10	Loose, red-brown, ***SILTY SAND WITH GRAVEL*** (SM); moist; clayey sand layers up to 6 inches in thickness. [A-2-4 & A-2-6] Alluvium		9.3	S-5 (SPT)	N = 2,2,2 (4 bpf) PP = 0.25 tsf	WC=15%		10
2375		Soft to medium stiff, brown, ***LEAN CLAY*** (CL); moist; trace gravel; trace sand. Alluvium		13.0	S-6 (SPT)	N = 3,3,5 (8 bpf) PP = 1.75 tsf	WC=21%		
	15	***CLAYSTONE***: extremely weak, brown and tan, highly weathered; thinly bedded to laminated. Bullion Creek Formation [Medium stiff to very stiff, *Fat Clay (CH);* moist.]							15
2370					S-7 (SPT)	N = 4,6,11 (17 bpf)	WC=26%		
2365	20	***COAL***: extremely weak, black. Bullion Creek Formation		22.8					20
	25				S-8 (SPT)	N = 7,9,12 (21 bpf)	WC=86%		25
	26	BOTTOM OF HOLE AT 26 FEET		26.0					

No Observed Groundwater

NOTES:
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	DKM
Review by:	GRF
Version:	1

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BORING LOG

Chateau Road Reconstruction
Medora, North Dakota

SW-09

EXPLORATION INFORMATION

Total Depth:	*35.5 feet*
Top Elevation:	*~2416 feet*
Vertical Datum:	*NAVD88*
Latitude:	*~ 46.9170 degrees*
Longitude:	*~ -103.5389 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*June 20, 2024*
Hole Finish Date:	*June 20, 2024*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Interstate Drilling Services*
Drill Rig Equipment:	*Diedrich D-50 Truck*
Hole Size:	*7 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*~80% (estimated)*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data
2415	0	***CONCRETE;*** 6" of concrete pavement		0.5			
		Brown, ***POORLY GRADED GRAVEL WITH SILT AND SAND*** (GP-GM); moist. [A-2-4] Base Course		0.9	S-1 (MC) / G-1 (GB) / S-2 (SPT)	PT = 8,7,7 (14 bpf) PP = 3.5 tsf N = 2,3,4 (7 bpf) PP = 0.5 tsf	FC=53% LL/PI=31/14 pH=6.7 RES=1812 OhmCm WC=11% FC=46% LL/PI=25/9
2410	5	Loose to medium dense, brown to gray, ***CLAYEY SAND*** *(SC)* to medium stiff to stiff, ***SANDY LEAN CLAY*** *(CL);* moist, few gravel. [A-6] Colluvium		5.5	S-3 (SPT)	N = 1,3,6 (9 bpf) PP = 3.5 tsf	WC=20% WC=24%
		CLAYSTONE: extremely weak, gray and brown, highly weathered; blocky to massive. Bullion Creek Formation [Stiff to very stiff, *Fat Clay (CH);* moist.]			S-4 (MC)	PT = 5,11,15 (26 bpf)	WC=22% FC=100% LL/PI=52/33
2405	10				S-5 (SPT)	N = 6,10,13 (23 bpf)	WC=21%
		SILTSTONE: extremely weak, tan, moderately weathered; laminated. Bullion Creek Formation [Dense, *Silt with Sand (ML);* moist.]		13.0			
2400	15				S-6 (SPT)	N = 15,43,50/4" (93/10" bpf)	WC=16%
		CLAYSTONE: extremely weak, gray and red-brown, thinly bedded to laminated. Bullion Creek Formation [Hard, *Fat Clay (CH);* moist.]		18.3			
2395	20				S-7 (SPT)	N = 10,17,23 (40 bpf)	WC=17%
2390	25	*-Light blue gray from 28.3 to 34.5*			S-8 (SPT)	N = 10,13,22 (35 bpf)	WC=13%
2385	30				S-9 (SPT)	N = 10,16,24 (40 bpf)	WC=16%
		-Green-gray and massive from 34.7 to 35.5 feet					
2380	35	***COAL***: from 34.5 to 34.7 feet		34.7	S-10 (SPT)	N = 13,20,29 (49 bpf)	WC=20%
2380	35.5	BOTTOM OF HOLE AT 35.5 FEET		35.5			

No Observed Groundwater

Multiple Items Plotted *(see bottom legend on Page 1)*

0 — 50 — 100

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

NOTES:
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FINAL

Logged by:	DKM
Review by:	GRF
Version:	1

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BORING LOG

Chateau Road Reconstruction
Medora, North Dakota

SW-10

EXPLORATION INFORMATION

Total Depth:	*45.5 feet*
Top Elevation:	*~2439 feet*
Vertical Datum:	*NAVD88*
Latitude:	*~ 46.9175 degrees*
Longitude:	*~ -103.5390 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*June 19, 2024*
Hole Finish Date:	*June 19, 2024*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Interstate Drilling Services*
Drill Rig Equipment:	*Diedrich D-50 Truck*
Hole Size:	*7 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*~80% (estimated)*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data
		CONCRETE; 6" of concrete pavement		0.5			
		Brown, ***POORLY GRADED GRAVEL WITH SILT AND SAND*** (GP-GM); moist. [A-2-4] Base Course		1.0			
2435	5	Medium stiff to stiff, ***SANDY LEAN CLAY*** (CL); moist; trace gravel. [A-6] Colluvium		4.0	S-1 (SPT)	N = 2,2,3 (5 bpf)	WC=13%
					G-1 (GB)	PP = 0.5 tsf	
					S-2 (MC)	PT = 5,5,6 (11 bpf)	WC=15%
		Loose, brown, ***SILTY SAND*** (SM); moist. [A-2-4] Alluvium		6.3		PP = 0.5 tsf	
					S-3 (SPT)	N = 4,3,4 (7 bpf)	WC=6%
2430	10	Loose, red-brown, ***POORLY GRADED SAND WITH SILT*** (SP-SM); moist; few gravel. Alluvium		12.3	S-4 (SPT)	N = 6,3,3 (6 bpf)	WC=5% FC=7%
					S-5 (SPT)	N = 2,1,4 (5 bpf)	WC=8%
2425	15	***CLAYSTONE***: extremely weak, brown and red-brown, highly weathered; blocky. Bullion Creek Formation [Stiff to very stiff, *Fat Clay (CH);* moist.]			S-6 (SPT)	N = 11,7,8 (15 bpf)	WC=21%
		SILTSTONE: extremely weak, gray and brown, massive; slightly weathered. Bullion Creek Formation [Very dense, *Silt (ML);* moist; few sand.]		17.3	S-7 (SPT)	N = 17,22,31 (53 bpf)	WC=18% FC=94% LL/PI=NP/NP
2420	20						
		CLAYSTONE: extremely weak, gray and brown, slightly weathered; laminated to thinly bedded. Bullion Creek Formation [Hard, *Lean Clay (CL);* moist; trace sand.]		22.3	S-8 (SPT)	N = 9,17,29 (46 bpf) PP = 0.25 tsf	WC=20% FC=99% LL/PI=32/15
2415	25						
2410	30				S-9 (SPT)	N = 15,27,41 (68 bpf)	WC=19%
		SILTSTONE: extremely weak, gray, massive; fresh. Bullion Creek Formation [Very dense, *Silt with Sand (ML);* moist.]		32.3			
2405	35				S-10 (SPT)	N = 23,37,45 (82 bpf)	WC=16%

No Observed Groundwater

Multiple Items Plotted *(see bottom legend on Page 1)*

0 50 100

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
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- Group symbol is based on visual-manual identification and selected lab testing.
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FINAL

Logged by:	DKM
Review by:	GRF
Version:	1

Chateau Road Reconstruction
Medora, North Dakota

SW-10
Page 2 of 2

See Page 1 for Hole Information and Notes

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
2400	40	***CLAYSTONE***: extremely weak, light blue gray and gray, fresh; laminated to thinly bedded; trace carbonaceous fragments. Bullion Creek Formation [Hard, *Fat Clay (CH);* moist.]		37.3	S-11 (SPT)	N = 12,24,34 (58 bpf)	WC=20%		40
2395	45	***COAL***: from 44.5 to 44.6 feet		44.6	S-12 (SPT)	N = 17,29,50 (79 bpf)	WC=20%		45
	45.5	***COAL***: from 45.3 to 45.5 feet BOTTOM OF HOLE AT 45.5 FEET		45.5					

SHANNON & WILSON

BORING LOG

Chateau Road Reconstruction
Medora, North Dakota

SW-11

EXPLORATION INFORMATION

Total Depth:	*45.5 feet*
Top Elevation:	*~2464 feet*
Vertical Datum:	*NAVD88*
Latitude:	*~ 46.9177 degrees*
Longitude:	*~ -103.5399 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*June 19, 2024*
Hole Finish Date:	*June 19, 2024*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*IDS*
Drill Rig Equipment:	*Diedrich D-50 Truck*
Hole Size:	*7 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*~80% (estimated)*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted (see bottom legend on Page 1) 0 50 100	Depth (feet)
2460	0	**CONCRETE;** 6" of concrete pavement		0.5					0
		Brown, ***POORLY GRADED GRAVEL WITH SILT AND SAND*** (GP-GM); moist. [A-2-4] Base Course		0.9	G-1 (GB)	N = 9,9,8 (17 bpf)	FC=15% LL/PI=27/8		
					S-1 (SPT)	N = 5,7,6 (13 bpf)	WC=7%		
				2.5	S-2 (SPT)		WC=7%		
	5	Medium dense, red-brown, ***CLAYEY SAND WITH GRAVEL*** (SC); moist. [A-2-4] Fill			S-3 (SPT)	N = 3,4,6 (10 bpf)	WC=5%		5
2455		Loose to medium dense, brown, ***SILTY SAND*** (SM); moist; trace to few gravel. [A-2-4] Alluvium			S-4 (SPT)	N = 4,4,5 (9 bpf)	WC=2%		
	10				S-5 (SPT)	N = 3,4,6 (10 bpf)	WC=5%		10
2450		Medium dense to dense, red-brown, ***WELL-GRADED SAND WITH SILT*** (SW-SM); moist; trace gravel. Alluvium		12.3					
	15				S-6 (SPT)	N = 6,11,19 (30 bpf)	WC=8%		15
2445		***SANDSTONE***: extremely weak, light brown tan, massive; slightly weathered. Bullion Creek Formation [Dense to very dense, *Silty Sand (SM) to Sandy Silt (ML);* moist.]		17.3	S-7 (SPT)	N = 10/0" (10/0" bpf) NR		>>	
	20								20
2440					S-8 (SPT)	N = 44,50/5" (50/5" bpf)	WC=8%	>>	
	25								25
2435					S-9 (SPT)	N = 18,28,37 (65 bpf)	WC=7%		
	30								30
2430					S-10 (SPT)	N = 20,22,26 (48 bpf)	WC=10%		
	35								35

No Observed Groundwater

NOTES:
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	DKM
Review by:	GRF
Version:	1

Chateau Road Reconstruction
Medora, North Dakota

SW-11
Page 2 of 2

See Page 1 for Hole Information and Notes

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
2425	40	***CLAYSTONE***: extremely weak, gray, slightly weathered; thinly bedded. Bullion Creek Formation [Hard, *Lean Clay (CL);* moist.]		37.3	S-11 (SPT)	N = 11,18,24 (42 bpf)	WC=18% FC=100% LL/PI=42/22		40
2420	45 45.5	***SILTSTONE***: extremely weak, gray, massive; slightly weathered. Bullion Creek Formation [Very dense, *Silt with Sand (ML);* moist to wet.]		42.3 45.5	S-12 (SPT)	N = 24,34,50 (84 bpf)	WC=22%		45

BOTTOM OF HOLE AT 45.5 FEET

SHANNON & WILSON

BORING LOG

Chateau Road Reconstruction
Medora, North Dakota

SW-12
Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	*35.5 feet*
Top Elevation:	*~2488 feet*
Vertical Datum:	*NAVD88*
Latitude:	*~ 46.9174 degrees*
Longitude:	*~ -103.5408 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*June 19, 2024*
Hole Finish Date:	*June 19, 2024*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Interstate Drilling Services*
Drill Rig Equipment:	*Diedrich D-50 Truck*
Hole Size:	*7 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*~80% (estimated)*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data
2485	0	***CONCRETE;*** 6.5" concrete pavement		0.5			
		POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM); moist. [A-2-4] Base Course		0.9	S-1 (MC)	PT = 6,7,8 (15 bpf)	FC=57% LL/PI=28/11
					G-1 (GB)	N = 4,4,9 (13 bpf)	WC=15% WC=16%
					S-2 (SPT)		
		Stiff to very stiff, brown, ***LEAN CLAY*** *(CL)* to ***SANDY LEAN CLAY*** *(CL);* moist, trace bedrock fragments. [A-6] Fill			S-3 (SPT)	N = 6,8,10 (18 bpf) PP = 2.25 tsf	WC=14%
2480	5						
					S-4 (SPT)	N = 4,3,2 (5 bpf) PP = 0.75 tsf	WC=13%
				8.8			
	10	Very loose to loose, brown, ***SANDY SILT*** (ML); moist; trace gravel. Fill			S-5 (SPT)	N = 2,2,2 (4 bpf)	WC=10% FC=54% LL/PI=NP/NP
2475				12.3			
		Medium stiff, brown, ***LEAN CLAY*** (CL); moist. Fill			S-6 (SPT)	N = 3,3,3 (6 bpf) PP = 0.75 tsf	WC=18%
	15						
2470				17.8			
		Medium dense, red-brown, ***POORLY GRADED GRAVEL WITH SILT AND SAND*** *(GP-GM)* to ***POORLY GRADED SAND WITH SILT AND GRAVEL*** *(SP-SM):* moist; inferred from very low sample recovery. Alluvium			S-7 (SPT)	N = 4,8,10 (18 bpf) NR	
	20						
2465							
					S-8 (SPT)	N = 9,8,7 (15 bpf)	WC=7%
	25						
2460				27.3			
		CLAYSTONE: extremely weak, brown, highly weathered; blocky to thinly bedded. Bullion Creek Formation [Very stiff, *Lean Clay (CL);* moist.]			S-9 (SPT)	N = 8,9,16 (25 bpf)	WC=18%
	30						
2455				32.3			
		SILTSTONE: extremely weak, brown, moderately to slightly weathered; laminated. Bullion Creek Formation [Very dense, *Silt with Sand (ML);* moist.]			S-10 (SPT)	N = 15,25,33 (58 bpf)	WC=16% FC=79% LL/PI=NP/NP
	35						
	35.5			35.5			

No Observed Groundwater

Multiple Items Plotted *(see bottom legend on Page 1)*: 0 — 50 — 100

BOTTOM OF HOLE AT 35.5 FEET

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	DKM
Review by:	GRF
Version:	1

Job#: **113316** | Template Ver:1 | File: 113316(12-11-24).GPJ | Rpt: BORING LOG | Library: SW GINT LIBRARY.GLB | Date: **12/11/24**

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BORING LOG

Chateau Road Reconstruction
Medora, North Dakota

SW-13
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EXPLORATION INFORMATION

Total Depth:	*25.5 feet*
Top Elevation:	*~2510 feet*
Vertical Datum:	*NAVD88*
Latitude:	*~ 46.9170 degrees*
Longitude:	*~ -103.5417 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*June 19, 2024*
Hole Finish Date:	*June 19, 2024*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Interstate Drilling Services*
Drill Rig Equipment:	*Diedrich D-50 Truck*
Hole Size:	*7 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*~80% (estimated)*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling: ▽

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data
		CONCRETE; 6.5" concrete pavement		0.5			
		Dark brown, ***POORLY GRADED GRAVEL WITH SILT AND SAND*** (GP-GM); moist. [A-2-4] Base Course		1.1	S-1 (MC)	PT = 2,3,5 (8 bpf)	WC=20%
					G-1 (GB)		
				2.5	S-2 (SPT)	N = 3,3,3 (6 bpf)	WC=12%
2505	5	Medium stiff to stiff, brown, ***LEAN CLAY*** (CL); moist; few sand. [A-6] Fill		4.0	S-3 (SPT)	N = 3,4,5 (9 bpf)	WC=6% FC=8%
		Loose, brown, ***SILTY SAND*** (SM); moist; trace gravel. [A-2-4] Alluvium		7.5	S-4 (SPT)	N = 3,2,3 (5 bpf)	WC=30%
2500	10	Loose, red-brown to brown, ***POORLY GRADED SAND WITH SILT AND GRAVEL*** *(SP-SM)* to ***SILTY SAND*** *(SM);* moist. Alluvium			S-5 (SPT)	N = 4,5,5 (10 bpf) NR	
		CLAYSTONE: extremely weak, dark brown gray, highly weathered; blocky. Bullion Creek Formation [Medium stiff to stiff, *Fat Clay (CH);* moist.]		12.0	S-6 (MC)	PT = 6,15,23 (38 bpf)	WC=20% FC=100% LL/PI=37/16
2495	15	***CLAYSTONE***: extremely weak, brown gray, moderately to slightly weathered; thinly bedded to laminated. Bullion Creek Formation [Very stiff to hard, *Lean Clay (CL);* moist.] *-Massive, with manganese staining on joint faces from 17.3 feet to 22.3 feet.*					
2490	20				S-7 (SPT)	N = 8,12,15 (27 bpf)	WC=21%
2485	25				S-8 (SPT)	N = 7,10,15 (25 bpf)	WC=22%
	25.5	BOTTOM OF HOLE AT 25.5 FEET		25.5			

No Observed Groundwater

Multiple Items Plotted *(see bottom legend on Page 1)*: 0 — 50 — 100

NOTES:
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- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	DKM
Review by:	GRF
Version:	1

Job#: 113316 | Template Ver:1 | File: 113316(12-11-24).GPJ | Rpt: BORING LOG | Library: SW GINT LIBRARY.GLB | Date: 12/11/24

SHANNON & WILSON

BORING LOG

Chateau Road Reconstruction
Medora, North Dakota

SW-14
Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	*10.5 feet*
Top Elevation:	*~2515 feet*
Vertical Datum:	*NAVD88*
Latitude:	*~ 46.9165 degrees*
Longitude:	*~ -103.5424 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*June 19, 2024*
Hole Finish Date:	*June 19, 2024*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Interstate Drilling Services*
Drill Rig Equipment:	*Diedrich D-50 Truck*
Hole Size:	*7 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*~80% (estimated)*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling: ▽

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
		CONCRETE; 7.5" of concrete pavememt		0.6					
		Dark brown, ***POORLY GRADED GRAVEL WITH SILT AND SAND*** (GP-GM); moist. [A-2-4] Base course		1.4					
2510	5	Stiff to very stiff, brown, ***LEAN CLAY WITH SAND*** *(CL)* to ***SANDY LEAN CLAY*** *(CL);* moist. [A-6] Alluvium		4.5	S-1 (MC) G-1 (GB) S-2 (SPT)	PT = 2,3,7 (10 bpf) PP = 2.25 tsf N = 4,6,12 (18 bpf)	FC=60% LL/PI=32/16 WC=21% WC=20%		5
		Medium dense, red-brown, ***POORLY GRADED SAND WITH SILT AND GRAVEL*** (SP-SM); moist. [A-2-4] Alluvium		8.0	S-3 (SPT)	N = 7,6,9 (15 bpf) PP = 3.25 tsf	WC=11%		
2505	10	***CLAYSTONE***: extremely weak, brown gray, highly weathered; blocky. Bullion Creek Formation			S-4 (MC)	PT = 3,3,7 (10 bpf) PP = 1.25 tsf	WC=34% FC=99% LL/PI=66/40		10
	10.5	[Stiff to very stiff, *Fat Clay (CH);* moist; trace sand.]		10.5					

No Observed Groundwater

BOTTOM OF HOLE AT 10.5 FEET

NOTES:
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	DKM
Review by:	GRF
Version:	1

Job#: 113316 | Template Ver:1 | File: 113316(12-11-24).GPJ | Rpt: BORING LOG | Library: SW GINT LIBRARY.GLB | Date: 12/11/24

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BORING LOG

Chateau Road Reconstruction
Medora, North Dakota

SW-15
Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	*10.5 feet*
Top Elevation:	*~2514 feet*
Vertical Datum:	*NAVD88*
Latitude:	*~ 46.9160 degrees*
Longitude:	*~ -103.5430 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*June 19, 2024*
Hole Finish Date:	*June 19, 2024*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Interstate Drilling Services*
Drill Rig Equipment:	*Diedrich D-50 Truck*
Hole Size:	*7 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*~80% (estimated)*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted (see bottom legend on Page 1) 0 50 100	Depth (feet)
		CONCRETE; 7" of concrete pavement		0.6					
		Brown, ***POORLY GRADED GRAVEL WITH SILT AND SAND*** (GP-GM); moist. [A-2-4] Base Course		0.9					
2510		Soft to stiff, brown and gray, ***LEAN CLAY WITH SAND*** *(CL)* to ***SANDY LEAN CLAY*** *(CL);* moist; few gravel. [A-6] Alluvium -*Clayey sand layer from 3.8 to 4.0 feet*		6.3	*No Observed Groundwater*				
2505	10	***CLAYSTONE***: extremely weak, gray and red-brown, moderately to slightly weathered; thinly bedded, iron oxide stains. Bullion Creek Formation [Stiff to very stiff, *Lean Clay (CL); moist; trace sand.]*		10.5					

S-1 (SPT): N = 1,2,1 (3 bpf); PP = 0.5 tsf; PT = 4,5,9 (14 bpf)
G-1 (GB), S-2 (MC), S-3 (SPT): N = 3,4,6 (10 bpf); PP = 0.5 tsf
S-4 (SPT): N = 5,6,9 (15 bpf); PP = 2.5 tsf
S-5 (SPT): N = 5,6,8 (14 bpf)

Lab Data: FC=64%; LL/PI=34/16; pH=7.7; RES=2500 OhmCm; WC=20%; WC=21%; FC=80%; LL/PI=34/14; WC=17%; WC=22%; WC=20%; FC=99%; LL/PI=37/20

BOTTOM OF HOLE AT 10.5 FEET

NOTES:
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	DKM
Review by:	GRF
Version:	1

Job#: 113316 | Template Ver:1 | File: 113316(12-11-24).GPJ | Rpt: BORING LOG | Library: SW GINT LIBRARY.GLB | Date: 12/11/24

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BORING LOG

Chateau Road Reconstruction
Medora, North Dakota

SW-16

EXPLORATION INFORMATION

Total Depth:	*75.5 feet*
Top Elevation:	*~2345 feet*
Vertical Datum:	*NAVD88*
Latitude:	*~ 46.9157 degrees*
Longitude:	*~ -103.5351 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*November 5, 2024*
Hole Finish Date:	*November 5, 2024*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Interstate Drilling Services*
Drill Rig Equipment:	*Diedrich D-50 Truck*
Hole Size:	*7 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*~80% (estimated)*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data
		Medium dense, tan, ***SILT WITH SAND*** (ML); moist. Residuum					
2340	5	***CLAYSTONE***: extremely weak, brown and gray, massive to blocky; highly weathered. Bullion Creek Formation [Stiff to very stiff, *Lean Clay (CL);* moist.]		4.5	S-1 (SPT)	N = 6,7,8 (15 bpf)	WC=22%
2335	10				S-2 (SPT)	N = 5,8,12 (20 bpf)	WC=22%
2330	15	***SILTSTONE***: extremely weak, tan, massive; highly weathered. Bullion Creek Formation [Medium dense, *Silt (ML);* moist; few sand.]		12.3	S-3 (MC)	PT = 5,5,8 (13 bpf)	WC=9% FC=87% LL/PI=23/1
2325	20	***CLAYSTONE***: extremely weak, red and red-brown, laminated; highly to moderately weathered. Bullion Creek Formation [Stiff, *Lean Clay (CL);* moist; trace sand.]		17.3	S-4 (SPT)	N = 6,8,6 (14 bpf)	WC=21% FC=98% LL/PI=38/17
2320	25	**KLINKER**		24.0	S-5 (SPT)	N = 2,2,4 (6 bpf)	S-5A : WC=8% S-5B : WC=53% FC=57% LL/PI=56/12
		COAL: extremely weak, light gray; laminated; coal layer reduced to ash due to previous coal fire - inferred from color, low density, and presence of klinker above and below. [Medium stiff, *Elastic Silt with Sand (MH);* moist.]		24.5			
2315	30	**KLINKER**		29.0	S-6 (SPT)	N = 10,25,29 (54 bpf)	WC=17%
		CLAYSTONE: extremely weak, brown light brown gray, massive to laminated; moderately weathered. Bullion Creek Formation [Hard, *Lean Clay (CL);* moist; trace sand.]		29.3			
2310	35				S-7 (MC)	PT = 22,48,50/4" (98/10" bpf)	WC=16% FC=98% LL/PI=24/9

Multiple Items Plotted *(see bottom legend on Page 1)*: 0 — 50 — 100

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	DKM
Review by:	GRF
Version:	1

Chateau Road Reconstruction
Medora, North Dakota

SW-16
Page 2 of 2

See Page 1 for Hole Information and Notes

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data
2305	40	***CLAYSTONE***: extremely weak, brown light brown gray, massive to laminated; moderately weathered. Bullion Creek Formation [Hard, *Lean Clay (CL);* moist; trace sand.] *(starts on previous page)*			S-8 (SPT)	N = 7,16,27 (43 bpf)	WC=15%
				42.3			
2300	45	***SANDSTONE***: extremely weak, tan, massive; moderately weathered. Bullion Creek Formation [Very dense, *Silty Sand (SM);* moist.]			S-9 (SPT)	N = 18,28,40 (68 bpf)	WC=7% FC=45% LL/PI=NP/NP
				47.3			
2295	50	***CLAYSTONE***: extremely weak, gray to brown, thinly bedded to laminated; moderately weathered to slightly weathered; trace to few carbonaceous fragments. Bullion Creek Formation [Very stiff to hard, *Lean and Fat Clay (CL and CH);* moist; trace to few sand.]			S-10 (SPT)	N = 5,9,16 (25 bpf)	WC=18%
2290	55				S-11 (MC)	PT = 16,43,50/3" (93/9" bpf)	WC=17%
2285	60				S-12 (SPT)	N = 14,25,39 (64 bpf)	WC=16%
2280	65				S-13 (SPT)	N = 15,22,35 (57 bpf)	WC=16% FC=95% LL/PI=42/27
2275	70				S-14 (MC)	PT = 22,45,50/3" (95/9" bpf)	WC=18%
2270	75	*-Interbedded sand layer from 74.3 to 74.5 feet.*			S-15 (SPT)	N = 15,23,37 (60 bpf)	WC=17%
	75.5			75.5			

Multiple Items Plotted *(see bottom legend on Page 1)*
0 50 100

BOTTOM OF HOLE AT 75.5 FEET

SHANNON & WILSON

BORING LOG

Chateau Road Reconstruction
Medora, North Dakota

SW-17

EXPLORATION INFORMATION

Total Depth:	*91.0 feet*
Top Elevation:	*~2487 feet*
Vertical Datum:	*NAVD88*
Latitude:	*~ 46.9166 degrees*
Longitude:	*~ -103.5407 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*September 26, 2024*
Hole Finish Date:	*September 26, 2024*

DRILLING INFORMATION

Drilling Method:	*Air Rotary*
Drilling Company:	*Interstate Drilling Services*
Drill Rig Equipment:	*Diedrich D-70 Track*
Hole Size:	*3.125 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*~80% (estimated)*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data
2485	0	Brown, ***POORLY GRADED SAND WITH SILT AND GRAVEL*** (SP-SM); moist; inferred from drill cuttings. Alluvium					
		SILTSTONE: extremely weak, tan, laminated; highly weathered. (Bullion Creek Formation) [Loose, *Silt (ML);* moist.]		3.0	S-1 (SPT)	N = 2,3,4 (7 bpf)	WC=12%
2480	5	***CLAYSTONE***: extremely weak, brown to tan, laminated to thinly bedded; highly weathered. (Bullion Creek Formation) [Very stiff, *Lean Clay (CL);* moist.]		7.0	S-2 (SPT)	N = 6,9,12 (21 bpf)	WC=19%
2475	10						
2470	15			17.8	S-3 (SPT)	N = 10,11,15 (26 bpf)	WC=20%
2465	20	***SILTSTONE***: extremely weak, tan, laminated to thinly bedded; moderately weathered. (Bullion Creek Formation) [Dense to very dense, *Silt (ML);* moist; trace sand.]			S-4 (MC)	PT = 15,23,36 (59 bpf)	WC=10% FC=96% LL/PI=26/3
	25					N = 16,23,27	WC=15%

Multiple Items Plotted *(see bottom legend on Page 1)*: 0 — 50 — 100

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
- Groundwater level, if indicated above, is for the date specified and may vary.
- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

DRAFT

Logged by:	DKM
Review by:	GRF
Version:	1

Chateau Road Reconstruction
Medora, North Dakota

SW-17
Page 2 of 3

See Page 1 for Hole Information and Notes

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted (see bottom legend on Page 1) 0 50 100	Depth (feet)
2460		***SILTSTONE***: extremely weak, tan, laminated to thinly bedded; moderately weathered. (Bullion Creek Formation) [Dense to very dense, *Silt (ML);* moist; trace sand.] *(starts on previous page)*			S-5 (SPT)	(50 bpf)			
	30				S-6 (SPT)	N = 16,29,34 (63 bpf)	WC=12%		30
2455									
	35				S-7 (SPT)	N = 20,39,47 (86 bpf)	WC=11% FC=99% LL/PI=25/3		35
2450									
	40				S-8 (MC)	PT = 8,20,26 (46 bpf)	WC=18%		40
2445		**CLAYSTONE/SILTSTONE**: extremely weak, tan, laminated; moderately weathered. (Bullion Creek Formation). [Hard, *Silty Clay (CL-ML);* moist; trace sand.]		40.3					
	45				S-9 (SPT)	N = 14,27,29 (56 bpf)	WC=15% FC=97% LL/PI=26/6		45
2440									
	50				S-10 (SPT)	N = 11,24,50/5.5" (74/11.5" bpf)	WC=12% FC=95% LL/PI=25/1		50
2435		***SILTSTONE***: extremely weak, tan, laminated; moderately weathered. (Bullion Creek Formation) [Very dense, *Silt (ML);* moist; trace to few sand.]		50.5					
		CLAYSTONE: extremely weak, tan, laminated; moderately weathered; interbedded siltstone layers. (Bullion Creek Formation) [Hard, *Lean Clay (CL);* moist; trace sand.]		53.0					
	55				S-11 (SPT)	N = 10,14,20 (34 bpf)	WC=17% FC=98% LL/PI=29/11		55
2430									
	60				S-12 (MC)	PT = 10,16,29 (45 bpf)	WC=18%		60
2425									

Chateau Road Reconstruction
Medora, North Dakota

SW-17

See Page 1 for Hole Information and Notes

Approx. Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data
				62.8			
2420	65	***CLAYSTONE***: extremely weak, brown to gray, massive; moderately to slightly weathered. (Bullion Creek Formation) [Hard, *Lean Clay (CL);* moist.]			S-13 (SPT)	N = 10,16,25 (41 bpf)	WC=20% FC=88% LL/PI=43/21
2415	70				S-14 (SPT)	N = 9,15,24 (39 bpf)	WC=19%
				72.8			
2410	75	***SANDSTONE***: extremely weak, massive; slightly weathered; interbedded claystone layers. (Bullion Creek Formation) [Dense, *Silty Sand (SM);* moist.]			S-15 (SPT)	N = 9,16,24 (40 bpf)	WC=12% FC=41% LL/PI=20/NP
				77.8			
2405	80	***CLAYSTONE***: extremely weak, gray to brown, laminated; slightly weathered; interbedded siltstone layers. (Bullion Creek Formation) [Hard, *Sandy Lean Clay (CL);* moist.]			S-16 (MC)	PT = 13,27,50/3" (77/9" bpf)	WC=14% FC=65% LL/PI=26/9
2400	85	***COAL***: extremely weak, black. (Bullion Creek Formation)		85.5	S-17 (SPT)	N = 15,26,50/5.5" (76/11.5" bpf)	S-17A : WC=21% S-17B : WC=46%
				87.8			
	90	***CLAYSTONE***: extremely weak, gray to brown, laminated; slightly weathered; interbedded siltstone layers. (Bullion Creek Formation) [Hard, *Fat Clay (CH);* moist.]			S-18 (SPT)	N = 18,37,34 (71 bpf)	WC=19%
	91			91.0			

BOTTOM OF HOLE AT 91 FEET

Multiple Items Plotted *(see bottom legend on Page 1)*
0 50 100

APPENDIX B: LABORATORY TEST RESULTS

Appendix B

Laboratory Test Results

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Enclosure

Advanced Terra Testing Laboratory Data Report, July 29, 2024

APPENDIX B: LABORATORY TEST RESULTS

B.1 INTRODUCTION

Laboratory tests were completed on soil and rock samples retrieved from the borings in general accordance with the American Association of State Highway and Transportation Officials (AASHTO) and ASTM testing methods. The laboratory testing program was performed to classify the materials into similar geologic groups and provide data that can be used for design of the project. The geotechnical laboratory testing was performed at our laboratory in Denver, Colorado and by Advanced Terra Testing, Inc. (ATT) in Lakewood, Colorado. A summary of the laboratory test results is presented in Tables B-1 and B-2. The following sections describe the laboratory testing procedures.

B.2 GEOTECHNICAL INDEX TESTS

B.2.1 Water Content

Water content was determined on samples retrieved from the borings in general accordance with AASHTO T 265, Laboratory Determination of Moisture Content of Soils. Per the requirements of an NDDOT Linear Soil Survey and discussions with NDDOT, water content was performed on every SPT / MC sample collected from the borings, with tests conducted on 2.5-foot intervals in the upper 10 feet of borings SW-01 through SW-15. To perform this test, a sample was weighed before and after oven-drying, and the water content was calculated. Water contents are shown graphically on the boring logs presented in Appendix A and are also summarized in Table B-1.

B.2.2 Unit Weight

The unit weights or in-place densities of selected modified California (MC) samples were determined in the laboratory. The determination was performed in general accordance with ASTM D7263, Standard Test Methods for Laboratory Determination of Density and Unit Weight of Soil Specimens. To perform this test method, the dimensions of the sample were measured, the sample was weighed, and the moist unit weight was calculated. The results are summarized in Table B-1.

B.2.3 Grain Size Distribution and Hydrometer Analyses

The grain size distribution of selected samples was determined in general accordance with AASHTO T311, Standard Method of Test for Grain-Size Analysis of Granular Soil Materials and AASHTO T88, Standard method of Test for Particle Size Analysis of Soils for samples where a hydrometer analysis was completed. Results of these analyses are

presented as grain size distribution curves in Figure B-1 and summarized in Table B-1. Where applicable, the percent fines (silt- and clay-sized particles passing the No. 200 sieve) are summarized in Table B-1. Results completed by ATT are included in the enclosure. The percent fines (silt- and clay-sized particles passing the No. 200 sieve) are shown graphically on the boring logs in Appendix A and are also summarized in Table B-1.

B.2.4 Atterberg Limits

Soil plasticity was determined by performing Atterberg limits tests on selected samples. The tests were completed in general accordance with AASHTO T89, Standard Test Method for Determining the Liquid Limit of Soils and AASHTO T90, Standard Test Method for Determining the Plastic Limit and Plasticity Index of Soils. The Atterberg limits include liquid limit (LL), plastic limit (PL), and plasticity index (PI equals LL minus PL) and are generally used to assist in classification of soils, to indicate soil consistency (when compared to natural water content), and to provide correlation to soil properties. The results of the Atterberg limits tests are plotted on a plasticity chart on Figure B-2, shown graphically on the boring logs in Appendix A, and summarized in Table B-1. Tests completed by ATT are included in the enclosure.

B.3 GEOTECHNICAL ENGINEERING PROPERTY TESTS

B.3.1 One-Dimensional Swell/Collapse Tests

One-dimensional swell/collapse tests were performed in general accordance with Method B of ASTM D 4546, Standard Test Methods for One-Dimensional Swell or Collapse of Soils. Samples were obtained from a driven modified California sampler lined with thin-walled bass tubes. The samples were then loaded at field moisture conditions in a fixed-ring consolidometer that measures vertical changes in height for different loading conditions. During loading, the sample's pore pressures are allowed to drain from both the top and bottom of the sample. At a specified pressure, the sample is inundated with distilled water and then allowed to reach equilibrium. The vertical height change caused from the water inundation was then measured and expressed in percent strain. The swell/collapse test reports are provided in the individual Swell/Collapse Test Reports (Figure B-3 through B-5) and summarized in Table B-2. The unit weight or in-place density and the water content of the sample, which are determined as part of the test, are included in Table B-1.

B.3.2 One-Dimensional Consolidation Test

A one-dimensional consolidation test was completed by ATT on a relatively undisturbed sample of clayey soil collected using a Shelby tube from boring SW-05. Testing was completed in general accordance with Method B of ASTM D2435, Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading. The test report results are included in the enclosure. The coefficient of compression, coefficient of re-compression, pre-consolidation pressure, and initial void ratio are provided in Table B-2.

B.3.3 Unconsolidated-Undrained (UU) Triaxial Compression

A UU triaxial compression test was performed by ATT on a relatively undisturbed sample of clayey soil collected using a Shelby tube from boring SW-06. Testing was completed in general accordance with ASTM D2850, Standard Test Method for Unconsolidated-Undrained Triaxial Compression Tests on Cohesive Soils. The results completed by ATT are included in the enclosure. Peak stress, axial strain at peak stress, and confining pressure are summarized in Table B-2.

B.3.4 Corrosion

Corrosion testing of select samples were performed by ATT for pH, resistivity, sulfate content, and chloride content. Testing for pH was completed in general accordance with AASHTO T289, Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing. Resistivity testing was completed in accordance with AASHTO T288, Standard Method of Test for Determining Minimum Laboratory Soil Resistivity. Sulfate content testing was completed in general accordance with AASHTO T290B, Standard Method of Test for Determining Water-Soluble Sulfate Ion Content in Soil. Chloride content testing was completed in general accordance with AASHTO T291A, Standard Method of Test for Determining Water-Soluble Chloride Ion Content in Soil. Test results for sulfate and chloride content are given in units of percent by weight. The test results are summarized in Table B-2.

B.3.5 Moisture-Density Relationship (Compaction) Tests

The moisture-density relationship (compaction) was tested for bulk samples from borings SW-01, SW-02, SW-04, SW-05, SW-07, SW-09, SW-11, SW-12, SW-14, and SW-15 by ATT. All of the samples, except bulk sample from boring SW-11, were tested in general accordance with AASHTO T99 Standard Method of Test for Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) drop. The bulk sample from boring SW-11 was tested in general accordance with AASHTO T180,

APPENDIX B: LABORATORY TEST RESULTS

Standard Method of Test for Moisture-Density Relations of Soil Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop. Results of these tests are presented as a moisture-density curve reports in the enclosure.

Table B-1 - Summary of Laboratory Test Results by Boring

SAMPLE DATA								GRAIN SIZE ANALYSIS[2]			ATTERBERG LIMITS			COMPACTION	
Boring	Sample	Depth (feet)		USCS Symbol[1]	AASHTO SOIL CLASSIFICATION AND GROUP INDEX	Natural Moisture Content	Moist Unit Weight	Gravel	Sand	Fines	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Dry Density	Optimum Water Content
		Top	Bottom			(%)	(pcf)	(%)	(%)	(%)	(%)	(%)	(%)	(pcf)	(%)
SW-01	S-1	1.0	2.5			5.7									
	G-1	1.5	5.0	CL	A-6(15)			2	15	83	36	17	19	113.3	14.9
	S-2	2.5	4.0			22.4									
	S-3	4.0	5.5			23.6	126								
	S-4	7.0	8.5			24.8									
	S-5	9.0	10.5			22.2									
SW-02	S-1	1.0	2.5			19.4									
	G-1	1.5	5.0	CL	A-6(12)			2	14	84	34	19	15	113.1	15.2
	S-2	2.5	4.0			22.9									
	S-3	4.0	5.5			21.0									
	S-4	7.0	8.5			20.7									
	S-5	9.0	10.5			19.3									
SW-03	S-1	1.0	2.5			20.1									
	S-2	2.5	4.0	CH	A-7-6(41)	24.0	127	0	~0	100	56	19	37		
	S-3	4.0	5.5			16.3									
	S-4	7.0	8.5			15.0									
	S-5	9.0	10.5			14.6									
	S-6	14.0	15.5			14.2									
	S-7	19.0	20.5			16.6									
	S-8	24.0	25.5	CL	A-6(7)	17.7		23	17	60	33	17	16		
	S-9	29.0	30.5			16.2									
	S-10	34.0	35.0	CL	A-7-6(30)	16.3	125	0	2	98	47	19	28		
	S-11	39.0	40.5			28.2									
	S-12	44.0	45.4			20.1									

Table B-1 - Summary of Laboratory Test Results by Boring

SAMPLE DATA								GRAIN SIZE ANALYSIS[2]			ATTERBERG LIMITS			COMPACTION	
Boring	Sample	Depth (feet)		USCS Symbol[1]	AASHTO SOIL CLASSIFICATION AND GROUP INDEX	Natural Moisture Content	Moist Unit Weight	Gravel	Sand	Fines	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Dry Density	Optimum Water Content
		Top	Bottom			(%)	(pcf)	(%)	(%)	(%)	(%)	(%)	(%)	(pcf)	(%)
SW-04	G-1	1.0	5.0	CL	A-6(8)			4	24	72	30	15	15	115.1	14.5
	G-2	1.1	1.5			19.3									
	S-1	2.0	3.5			16.8									
	S-2	3.5	5.0			15.1									
	S-3	7.0	8.5			16.3									
	S-4	9.0	10.5	CL	A-6(6)	15.8		1	32	67	27	13	14		
	S-5	14.0	15.5			17.6									
	S-6	19.0	20.5			15.4									
	S-7	24.0	25.5			18.0									
	S-8	29.0	30.5			16.2									
	S-9	34.0	35.4			15.7									
	S-10	39.0	40.5			14.3									
	S-11	44.0	45.5			18.2									
SW-05	S-1	1.0	2.5			14.5									
	G-1	1.0	5.0	CL	A-6(10)			5	19	76	33	17	16	115.3	14.8
	S-2	2.5	4.0			19.9									
	S-3	4.0	5.5			18.7									
	S-4	7.0	9.0	CL	A-6(12)	22.1	122	~0	22	78	33	15	18		
	S-5	14.0	15.5			27.7									
	S-6	19.0	20.5			21.0									

Table B-1 - Summary of Laboratory Test Results by Boring

SAMPLE DATA								GRAIN SIZE ANALYSIS[2]			ATTERBERG LIMITS			COMPACTION	
Boring	Sample	Depth (feet)		USCS Symbol[1]	AASHTO SOIL CLASSIFICATION AND GROUP INDEX	Natural Moisture Content	Moist Unit Weight	Gravel	Sand	Fines	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Dry Density	Optimum Water Content
		Top	Bottom			(%)	(pcf)	(%)	(%)	(%)	(%)	(%)	(%)	(pcf)	(%)
SW-06	S-1	1.0	3.0			15.9									
	S-2	2.5	4.5			20.3									
	S-3	4.0	5.5			16.9	130								
	S-4	7.0	8.5			20.2									
	S-5	9.5	11.0			16.4									
	S-6	14.0	15.5			27.1									
	S-7	19.0	20.5			22.2									
	S-8	4.0	6.0	CL	A-6(20)	18.6	130	0	5	95	39	18	21		
SW-07	G-1	0.9	5.0	CL	A-6(11)			3	21	76	32	15	17	116.9	14.1
	S-1	1.0	3.0			12.4									
	S-2	2.5	4.5			9.5									
	S-3	4.5	6.0			13.8									
	S-4	7.0	8.5			16.7									
	S-5	9.0	10.5	CL	A-6(9)	16.2		0	16	84	27	14	13		
SW-08	S-1	1.5	3.0			14.9									
	S-2	3.0	4.5			13.8									
	S-3	4.5	6.0			11.3									
	S-4	7.0	8.5	SM	A-2-4(0)	8.8		16	57	27	NV	NP	NP		
	S-5	10.0	11.5			15.2									
	S-6	14.5	16.0			20.9									
	S-7	19.5	21.0			26.3									
	S-8	24.5	26.0			85.9									

Table B-1 - Summary of Laboratory Test Results by Boring

SAMPLE DATA								GRAIN SIZE ANALYSIS[2]			ATTERBERG LIMITS			COMPACTION	
Boring	Sample	Depth (feet)		USCS Symbol[1]	AASHTO SOIL CLASSIFICATION AND GROUP INDEX	Natural Moisture Content	Moist Unit Weight	Gravel	Sand	Fines	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Dry Density	Optimum Water Content
		Top	Bottom			(%)	(pcf)	(%)	(%)	(%)	(%)	(%)	(%)	(pcf)	(%)
SW-09	G-1	0.9	5.0	CL	A-6(4)			8	39	53	31	17	14	117.4	13.6
	S-1	1.5	3.0	SC	A-4(1)	11.4	135	13	41	46	25	16	9		
	S-2	3.0	4.5			20.0									
	S-3	5.0	6.5			24.4									
	S-4	7.0	8.5	CH	A-7-6(36)	22.3	127	0	~0	100	52	19	33		
	S-5	9.5	11.0			21.2									
	S-6	15.0	16.5			15.6									
	S-7	20.0	21.5			16.7									
	S-8	25.0	26.5			13.5									
	S-9	30.0	31.5			15.6									
	S-10	34.0	35.5			20.1									
SW-10	S-1	1.0	2.5			13.2									
	S-2	2.5	4.0			14.8									
	S-3	4.0	5.5			5.6									
	S-4	7.0	8.5			5.3		10	83	7					
	S-5	9.0	10.5			7.7									
	S-6	14.0	15.5			20.7									
	S-7	19.0	20.5	ML	A-4(0)	18.3		0	6	94	NV	NP	NP		
	S-8	24.0	25.5	CL	A-6(14)	20.2		0	1	99	32	17	15		
	S-9	29.0	30.5			18.9									
	S-10	34.0	35.5			16.4									
	S-11	39.0	40.5			19.9									
	S-12	44.0	45.5			19.7									

Table B-1 - Summary of Laboratory Test Results by Boring

SAMPLE DATA								GRAIN SIZE ANALYSIS[2]			ATTERBERG LIMITS			COMPACTION	
Boring	Sample	Depth (feet)		USCS Symbol[1]	AASHTO SOIL CLASSIFICATION AND GROUP INDEX	Natural Moisture Content	Moist Unit Weight	Gravel	Sand	Fines	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Dry Density	Optimum Water Content
		Top	Bottom			(%)	(pcf)	(%)	(%)	(%)	(%)	(%)	(%)	(pcf)	(%)
SW-11	G-1	0.9	2.5	SC	A-2-4(0)			28	57	15	27	19	8	139.8	8.7
	S-1	1.0	2.5			6.7									
	S-2	2.5	4.0			7.5									
	S-3	4.0	5.5			5.0									
	S-4	7.0	8.5			2.5									
	S-5	9.0	10.5			4.7									
	S-6	14.0	15.5			8.4									
	S-8	24.0	24.9			7.6									
	S-9	29.0	30.5			6.9									
	S-10	34.0	35.5			10.1									
	S-11	39.0	40.5	CL	A-7-6(24)	17.9		0	~0	100	42	20	22		
	S-12	44.0	45.5			22.4									
SW-12	G-1	0.9	5.0	CL	A-6(4)			2	41	57	28	17	11	118.3	12.9
	S-1	1.0	2.5			14.9	133								
	S-2	2.5	4.0			15.9									
	S-3	4.0	5.5			13.7									
	S-4	7.0	8.5			13.2									
	S-5	9.0	10.5	ML	A-4(0)	10.0		2	44	54	NV	NP	NP		
	S-6	14.0	15.5			17.8									
	S-7	19.0	20.5												
	S-8	24.0	25.5			6.7									
	S-9	29.0	30.5			17.5									
	S-10	34.0	35.5	ML	A-4(0)	16.3		0	21	79	NV	NP	NP		

Table B-1 - Summary of Laboratory Test Results by Boring

SAMPLE DATA								GRAIN SIZE ANALYSIS[2]			ATTERBERG LIMITS			COMPACTION	
Boring	Sample	Depth (feet)		USCS Symbol[1]	AASHTO SOIL CLASSIFICATION AND GROUP INDEX	Natural Moisture Content	Moist Unit Weight	Gravel	Sand	Fines	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Dry Density	Optimum Water Content
		Top	Bottom			(%)	(pcf)	(%)	(%)	(%)	(%)	(%)	(%)	(pcf)	(%)
SW-13	S-1	1.0	2.5			19.9									
	S-2	2.5	4.0			11.8									
	S-3	4.0	5.5			5.7		22	70	8					
	S-4	7.0	8.5			29.7									
	S-6	14.0	15.5	CL	A-6(17)	19.9	130	0	~0	100	37	21	16		
	S-7	19.0	20.5			20.5									
	S-8	24.0	25.5			22.2									
SW-14	G-1	1.4	5.0	CL	A-6(7)			8	32	60	32	16	16	110.5	15.4
	S-1	2.0	3.5			20.8									
	S-2	3.5	5.0			19.6									
	S-3	7.0	8.5			11.2									
	S-4	9.0	10.5	CH	A-7-6(46)	33.7	111	0	1	99	66	26	40		
SW-15	G-1	0.9	5.0	CL	A-6(8)			6	30	64	34	18	16	111.3	15.5
	S-1	1.0	2.5			20.1									
	S-2	2.5	4.0	CL	A-6(10)	20.6	137	1	19	80	34	20	14		
	S-3	4.0	5.5			16.7									
	S-4	7.0	8.5			21.6									
	S-5	9.0	10.5	CL	A-6(20)	20.3		~0	1	99	37	17	20		

Table B-1 - Summary of Laboratory Test Results by Boring

SAMPLE DATA							GRAIN SIZE ANALYSIS[2]			ATTERBERG LIMITS			COMPACTION	
Boring	Sample	Depth (feet)		USCS Symbol[1]	AASHTO SOIL CLASSIFICATION AND GROUP INDEX	Natural Moisture Content	Moist Unit Weight	Gravel	Sand	Fines	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Dry Density	Optimum Water Content
		Top	Bottom			(%)	(pcf)	(%)	(%)	(%)	(%)	(%)	(%)	(pcf)	(%)
SW-16	S-1	4.0	5.5			21.9									
	S-2	9.0	10.5			21.6									
	S-3	14.0	15.5	ML	A-4(0)	8.6		0	13	87	23	22	1		
	S-4	19.0	20.5	CL	A-6(18)	20.8		0	2	98	38	21	17		
	S-5A	24.0	24.5			8.4									
	S-5B	24.5	25.5	MH	A-7-5(7)	53.2		4	39	57	56	44	12		
	S-6	29.0	30.5			17					24	15	9		
	S-7	34.0	35.3	CL	A-4(7)	16.2	141	0	0	98					
	S-8	39.0	40.5			14.9									
	S-9	44.0	45.5	SM	A-4(0)	6.7		0	55	45	NV	NP	NP		
	S-10	49.0	50.5			18.4									
	S-11	54.0	55.3			17.1	136								
	S-12	59.0	60.5			16.4									
	S-13	64.0	65.5	CL	A-7-6(26)	16.2		0	5	95	42	15	27		
	S-14	69.0	70.3			17.9									
	S-15	74.0	75.5			17.3									

Table B-1 - Summary of Laboratory Test Results by Boring

SAMPLE DATA								GRAIN SIZE ANALYSIS[2]			ATTERBERG LIMITS			COMPACTION	
Boring	Sample	Depth (feet)		USCS Symbol[1]	AASHTO SOIL CLASSIFICATION AND GROUP INDEX	Natural Moisture Content	Moist Unit Weight	Gravel	Sand	Fines	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Dry Density	Optimum Water Content
		Top	Bottom			(%)	(pcf)	(%)	(%)	(%)	(%)	(%)	(%)	(pcf)	(%)
SW-17	S-1	4.5	6.0			12.3									
	S-2	9.5	11.0			19.3									
	S-3	14.5	16.0			19.6									
	S-4	19.5	21.0	ML	A-4(2)	9.9	110	0	4	96	26	23	3		
	S-5	24.5	26.0			14.6									
	S-6	29.5	31.0			12.2									
	S-7	34.5	36.0	ML	A-4(2)	10.5		0	1	99	25	22	3		
	S-8	39.5	41.0			17.5	133								
	S-9	44.5	46.0	CL-ML	A-4(5)	14.6		0	3	97	26	20	6		
	S-10	50.5	51.0	ML	A-4(0)	12.2		0	5	95	25	24	1		
	S-11	54.5	56.0	CL	A-6(10)	17.3		0	2	98	29	18	11		
	S-12	59.5	61.0			17.6	134								
	S-13	64.5	66.0	CL	A-7-6(19)	19.6		0	12	88	43	22	21		
	S-14	69.5	71.0			19									
	S-15	74.5	76.0	SM	A-4(0)	11.6		0	59	41	20	20	NP		
	S-16	79.5	80.8	CL	A-4(3)	14.3	120	0	35	65	26	17	9		
	S-17A	84.5	85.5			20.6									
	S-17B	85.5	86.0			45.9									
	S-18	89.5	91.0			18.8									

NOTES:

1 Refer to Appendix A, Log Key for definitions.

2 Gravel defined as particles larger than the No. 4 sieve size, Sand as particles between the No. 4 and No. 200 sieve sizes, and Fines as particles passing the No. 200 sieve.

NP = non plastic, NV = no value, pcf = pounds per cubic foot

Table B-2 - Summary of Enginering Property Test Results by Boring

SAMPLE DATA				SWELL / COLLAPSE			CORROSION				COMPACTION		UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION			ONE DIMENSIONAL CONSOLIDATION			
Boring	Sample	Depth (feet)		Swell (+) Collapse (-) Inundation Pressure		Swell Pressure	pH	Resistivity	Sulfates	Chlorides	Maximum Dry Density	Optimum Water Content	Confining Stress	Peak Deviator Stress	Axial Strain at Peak Stress	Coefficient of Compression	Coefficient of Re-Compression	Pre-Consolidation Pressure	Initial Void Ratio
		Top	Bottom	%	(psf)	(psf)	(%)	(ohm-cm)	(%)	(%)			(psf)	(psf)	(%)	(Cc)	(Cr)	(psf)	(e_0)
SW-01	G-1	1.5	5.0				7.5	1468	0.04	0.006	113.3	14.9							
SW-02	G-1	1.5	5.0								113.1	15.2							
SW-03	S-2	2.5	4.0	1.8	250	1200													
SW-04	G-1	1.0	5.0								115.1	14.5							
SW-05	G-1	1.0	5.0				7.8	1458	0.04	0.008	115.3	14.8							
SW-05	S-4	7.0	9.0													0.177	0.030	3350	0.66
SW-06	S-8	4.0	6.0										400	3337	15.9				
SW-07	G-1	0.9	5.0								116.9	14.1							
SW-09	G-1	0.9	5.0				6.7	1812	0.03	0.004	117.4	13.6							
	S-1	1.5	3.0	-0.1	250	N/A													
SW-11	G-1	0.9	2.5								139.8	8.7							
SW-12	G-1	0.9	5.0								118.3	12.9							
SW-14	G-1	1.4	5.0								110.5	15.4							
SW-15	G-1	0.9	5.0				7.7	2500	0.01	0.006	111.3	15.5							
	S-2	2.5	4.0	0.1	250	730													

NOTES:

psf = pounds per square foot

pcf = pounds per cubic foot

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FIG B-1
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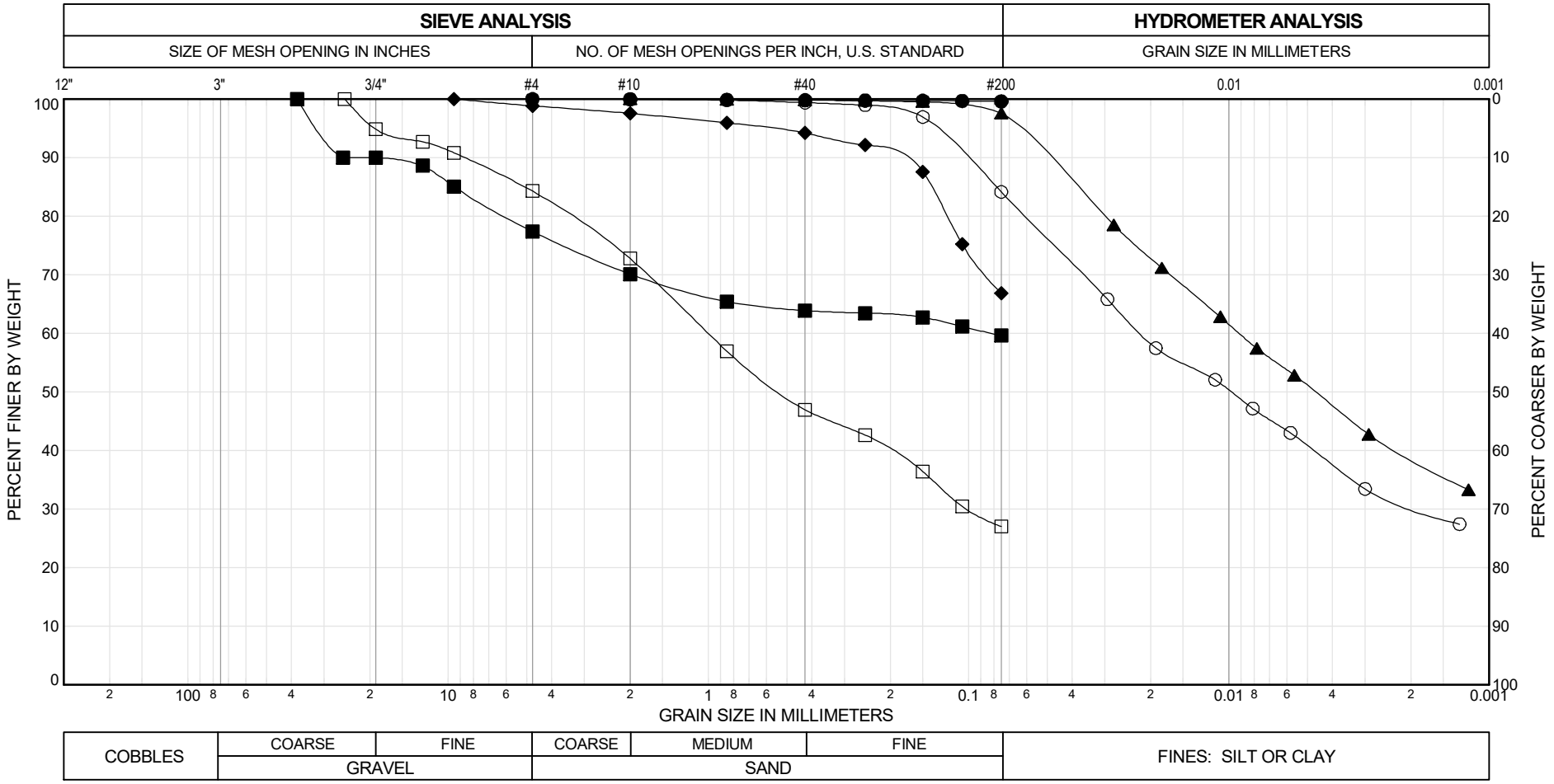

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
● SW-03, S-2	2.5	FAT CLAY	CH	0	~0	100	24.0	ATY ASW	T311	
■ SW-03, S-8	24.0	GRAVELLY LEAN CLAY with SAND	CL	23	18	60	17.7	ATY ASW	T311	
▲ SW-03, S-10	34.0	LEAN CLAY [CLAYSTONE]	CL	0	2	98	16.3	ATY ASW	T88 T88	
◆ SW-04, S-4	9.0	SANDY LEAN CLAY	CL	1	32	67	15.8	ATY ASW	T311	
○ SW-07, S-5	9.0	LEAN CLAY with SAND	CL	0	16	84	16.2	ATY ASW	T88 T88	
□ SW-08, S-4	7.0	SILTY SAND with GRAVEL	SM	16	57	27	8.8	ATY ASW	T311	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the grain size distribution test results.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

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FIG B-1
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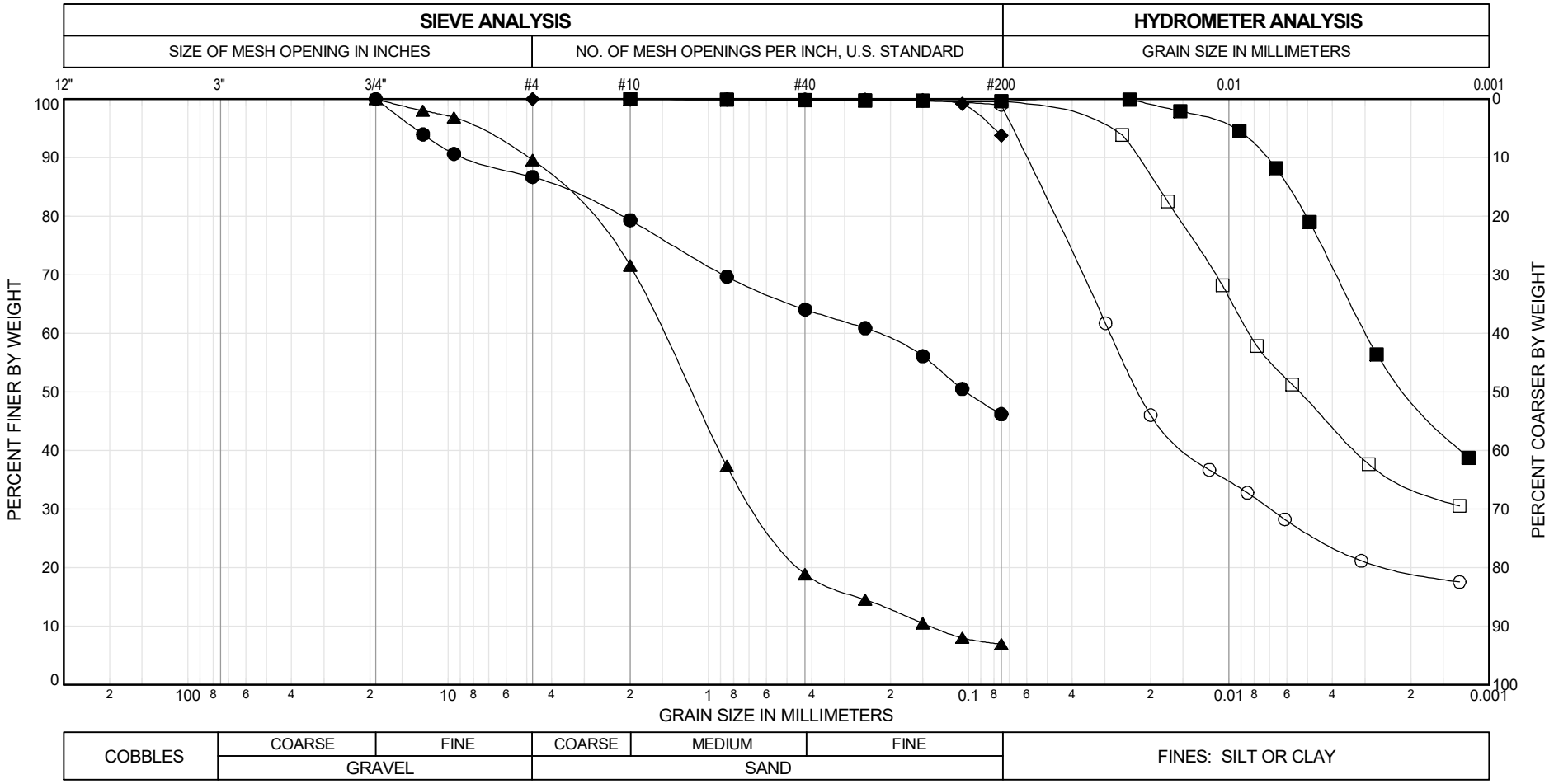

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	CF %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
● SW-09, S-1	1.5	CLAYEY SAND	SC	13	41	46		11.4	ATY ASW	T311	
■ SW-09, S-4	7.0	FAT CLAY [CLAYSTONE]	CH	0	~0	100	50	22.3	ATY ASW	T88 T88	
▲ SW-10, S-4	7.0	*Sieve analysis only - no Atterberg Limits: Group Name not estimated*		10	83	7		5.3	ATY ASW	T311	
◆ SW-10, S-7	19.0	SILT [SILTSTONE]	ML	0	6	94		18.3	ATY ASW	T311	
○ SW-10, S-8	24.0	LEAN CLAY [CLAYSTONE]	CL	0	1	99	19	20.2	ATY ASW	T88 T88	
□ SW-11, S-11	39.0	LEAN CLAY [CLAYSTONE]	CL	0	~0	100	34	17.9	ATY ASW	T88 T88	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the grain size distribution test results.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

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FIG B-1
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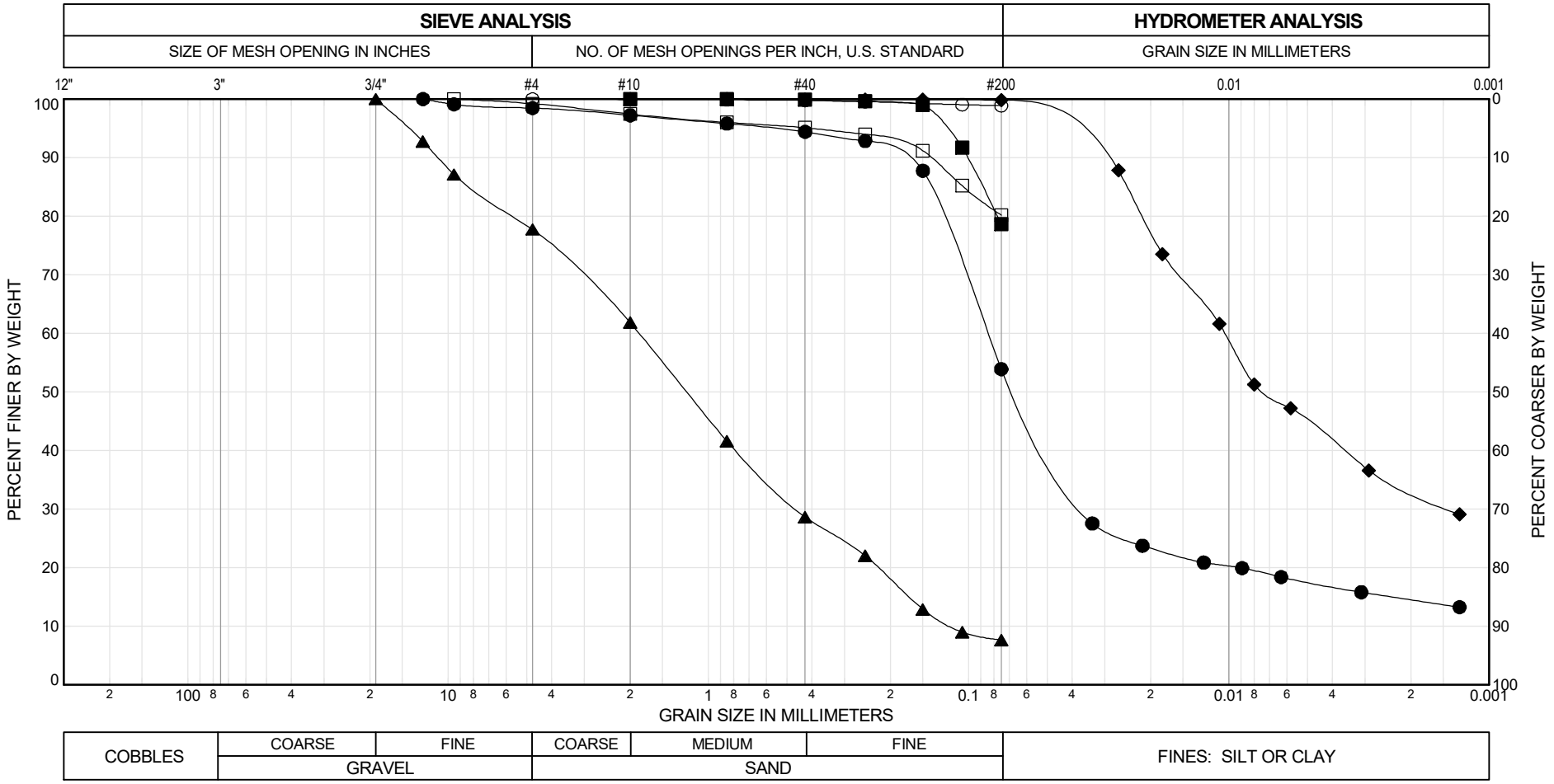

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
● SW-12, S-5	9.0	SANDY SILT	ML	2	45	54	10.0	ATY ASW	T88 T88	
■ SW-12, S-10	34.0	SILT with SAND [SILTSTONE]	ML	0	21	79	16.3	ATY ASW	T311	
▲ SW-13, S-3	4.0	*Sieve analysis only - no Atterberg Limits: Group Name not estimated*		22	70	8	5.7	ATY ASW	T311	
◆ SW-13, S-6	14.0	LEAN CLAY [CLAYSTONE]	CL	0	~0	100	19.9	ATY ASW	T88 T88	
○ SW-14, S-4	9.0	FAT CLAY [CLAYSTONE]	CH	0	1	99	33.7	ATY ASW	T311	
□ SW-15, S-2	2.5	LEAN CLAY with SAND	CL	1	19	80	20.6	ATY ASW	T311	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the grain size distribution test results.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

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FIG B-1
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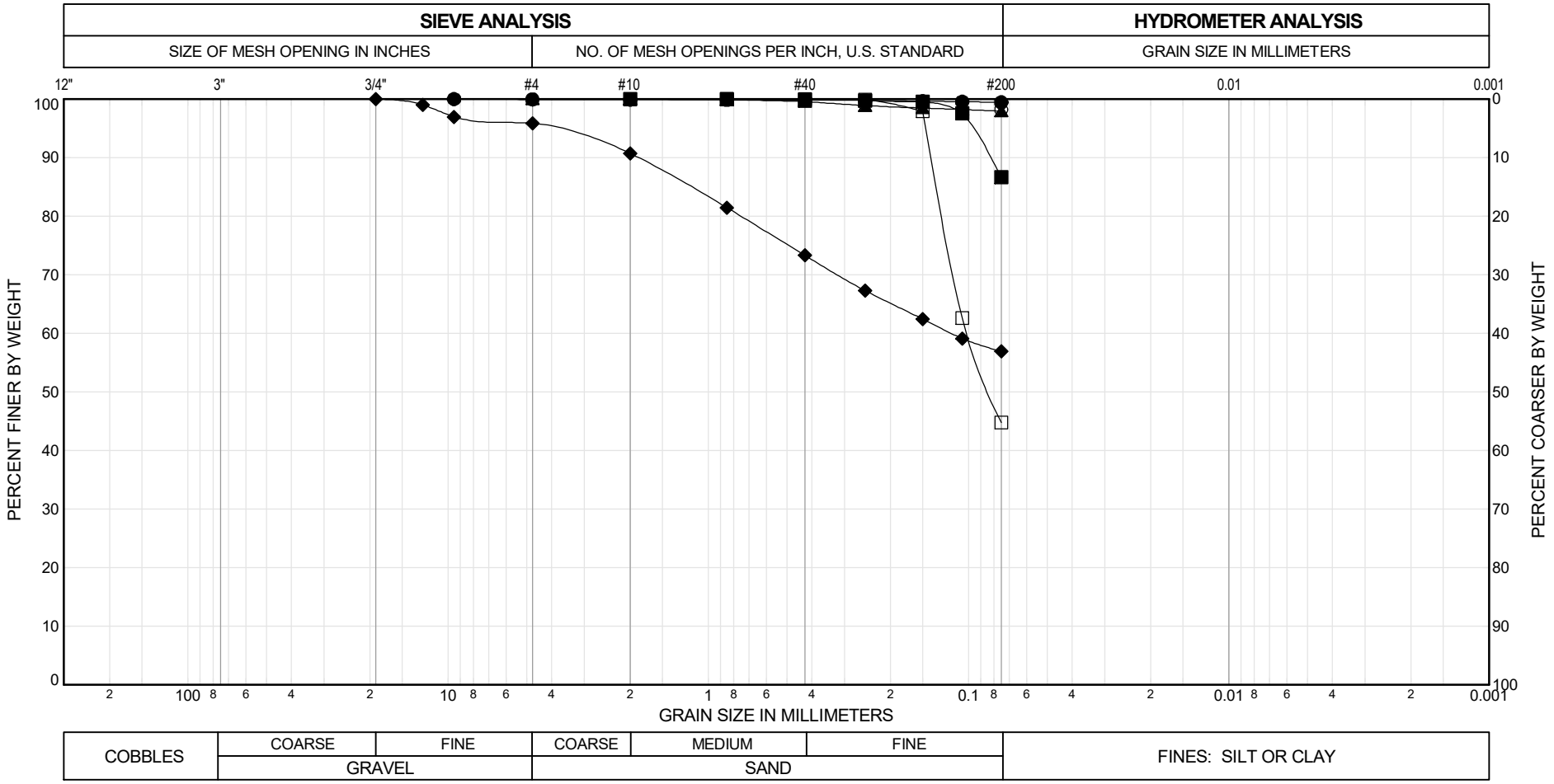

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
● SW-15, S-5	9.0	LEAN CLAY [CLAYSTONE]	CL	~0	1	99	20.3	ATY ASW	T311	
■ SW-16, S-3	14.0	SILT [SILTSTONE]	ML	0	13	87	8.6	JDT JYS	D6913	
▲ SW-16, S-4	19.0	LEAN CLAY [CLAYSTONE]	CL	0	2	98	20.8	JDT JYS	D6913	
◆ SW-16, S-5B	24.5	SANDY ELASTIC SILT [COAL]	MH	4	39	57	53.2	JDT JYS	D6913	
○ SW-16, S-7	34.0	LEAN CLAY [CLAYSTONE]	CL			98	16.2	JDT JYS	D1140	
□ SW-16, S-9	44.0	SILTY SAND [SANDSTONE]	SM	0	55	45	6.7	JDT JYS	D6913	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the grain size distribution test results.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

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FIG B-1
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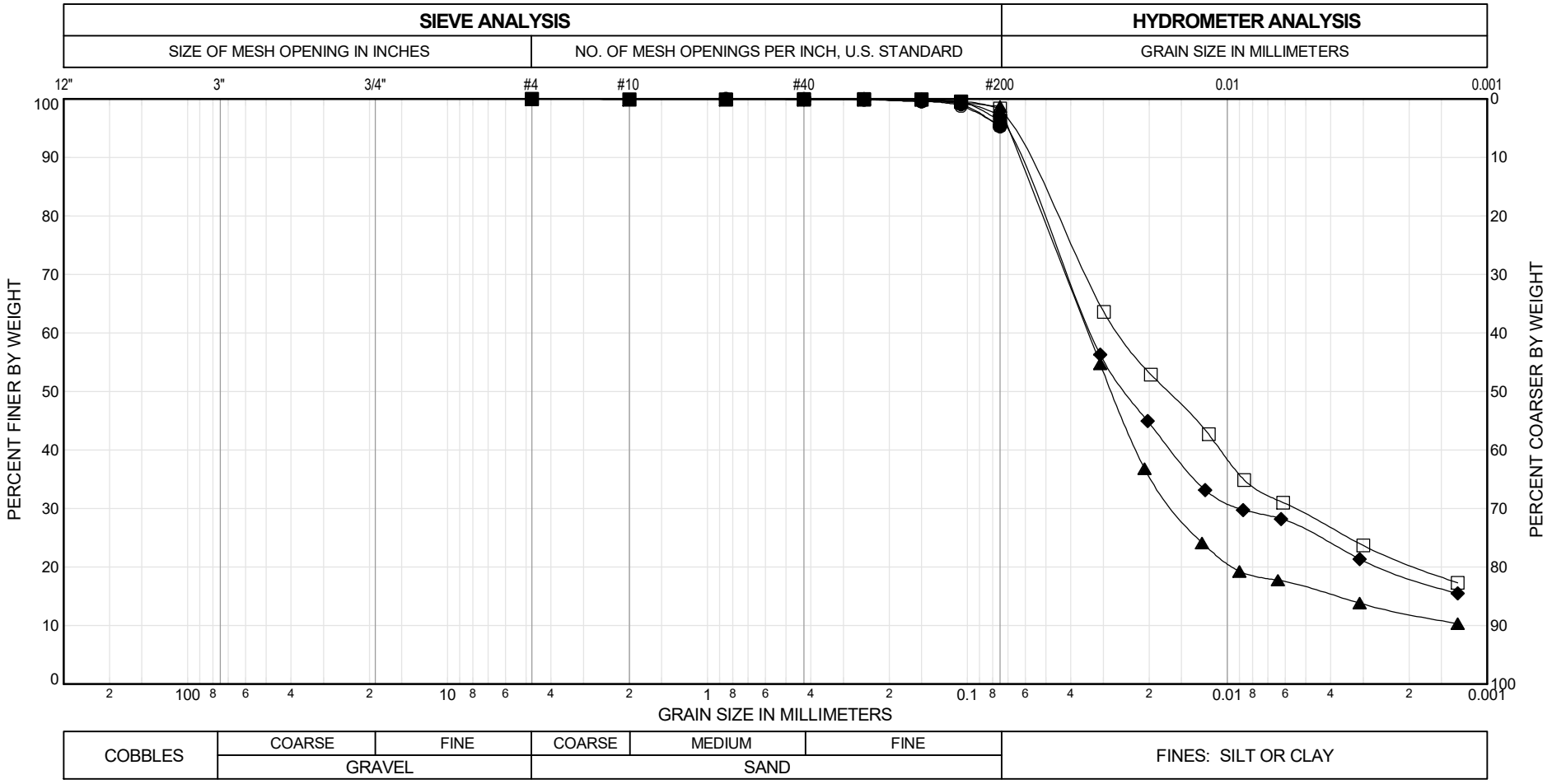

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	CF %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
● SW-16, S-13	64.0	LEAN CLAY [CLAYSTONE]	CL	0	5	95		16.2	JDT JYS	D6913	
■ SW-17, S-4	19.5	SILT [SILTSTONE]	ML	0	4	96		9.9	JDT JYS	T311	
▲ SW-17, S-7	34.5	SILT [SILTSTONE]	ML	0	1	99	12	10.5	JDT JYS	T88 T88	
◆ SW-17, S-9	44.5	SILTY CLAY [CLAYSTONE/SILTSTONE]	CL-ML	0	3	97	18	14.6	JDT JYS	T88 T88	
○ SW-17, S-10	49.5	SILT [SILTSTONE]	ML	0	5	95		12.2	JDT JYS	T311	
□ SW-17, S-11	54.5	LEAN CLAY [CLAYSTONE]	CL	0	2	98	21	17.3	JDT JYS	T88 T88	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the grain size distribution test results.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

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FIG B-1
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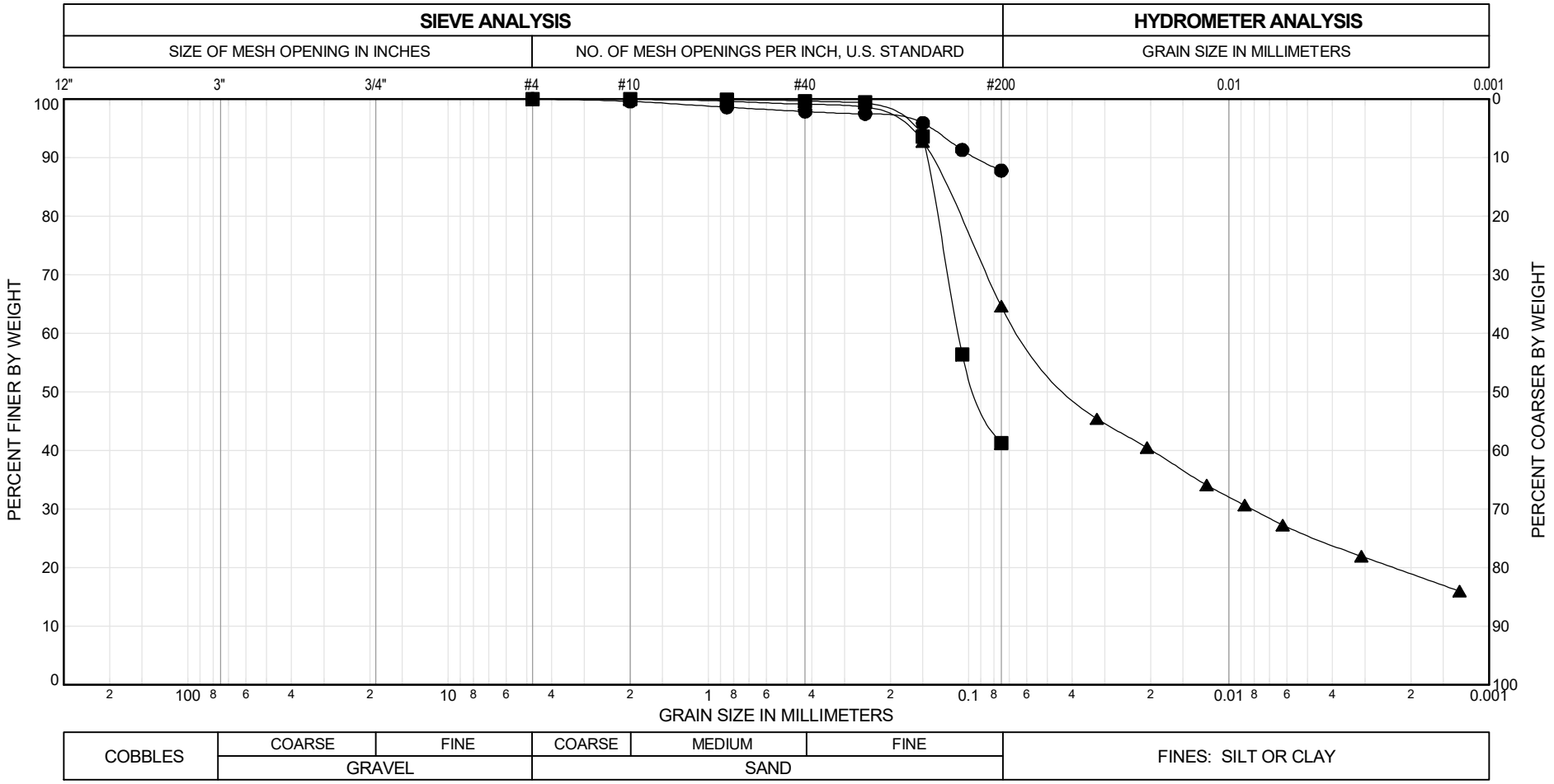

EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	CF %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
● SW-17, S-13	64.5	LEAN CLAY [CLAYSTONE]	CL	0	12	88		19.6	JDT JYS	T311	
■ SW-17, S-15	74.5	SILTY SAND [SANDSTONE]	SM	0	59	41		11.6	JDT JYS	T311	
▲ SW-17, S-16	79.5	SANDY LEAN CLAY [CLAYSTONE]	CL	0	35	65	19	14.3	JDT JYS	T88 T88	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the grain size distribution test results.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

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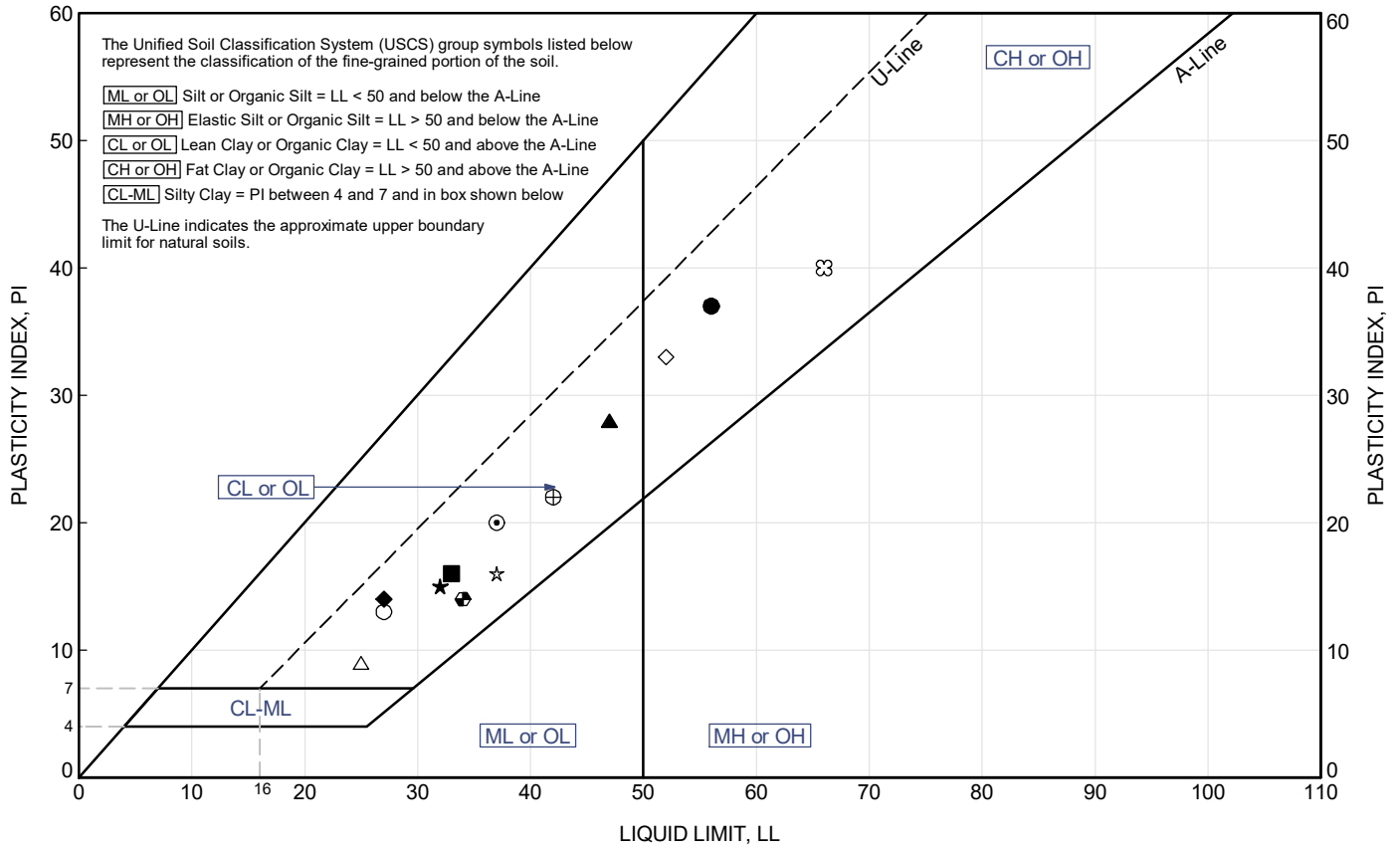
FIG B-2



EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	LL	PL	PI	FINES (%)	NAT MC %	TEST BY/RVW	TEST STD	TEST NOTE
● SW-03, S-2	2.5	FAT CLAY	CH	56	19	37	100	24.0	BXE ASW	T89,T90	
■ SW-03, S-8	24.0	GRAVELLY LEAN CLAY with SAND	CL	33	17	16	60	17.7	BXE ASW	T89,T90	
▲ SW-03, S-10	34.0	LEAN CLAY [CLAYSTONE]	CL	47	19	28	98	16.3	JDT ASW	T89,T90	
◆ SW-04, S-4	9.0	SANDY LEAN CLAY	CL	27	13	14	67	15.8	JDT ASW	T89,T90	
○ SW-07, S-5	9.0	LEAN CLAY with SAND	CL	27	14	13	84	16.2	JYS ASW	T89,T90	
SW-08, S-4	7.0	SILTY SAND with GRAVEL	SM	*NP*	NP	*NP*	27	8.8	BXE ASW	T89,T90	
△ SW-09, S-1	1.5	CLAYEY SAND	SC	25	16	9	46	11.4	BXE ASW	T89,T90	
◇ SW-09, S-4	7.0	FAT CLAY [CLAYSTONE]	CH	52	19	33	100	22.3	BXE ASW	T89,T90	
SW-10, S-7	19.0	SILT [SILTSTONE]	ML	*NP*	NP	*NP*	94	18.3	BXE ASW	T89,T90	
★ SW-10, S-8	24.0	LEAN CLAY [CLAYSTONE]	CL	32	17	15	99	20.2	BXE ASW	T89,T90	
⊕ SW-11, S-11	39.0	LEAN CLAY [CLAYSTONE]	CL	42	20	22	100	17.9	JDT ASW	T89,T90	
SW-12, S-5	9.0	SANDY SILT	ML	*NP*	NP	*NP*	54	10.0	BXE ASW	T89,T90	
SW-12, S-10	34.0	SILT with SAND [SILTSTONE]	ML	*NP*	NP	*NP*	79	16.3	BXE ASW	T89,T90	
☆ SW-13, S-6	14.0	LEAN CLAY [CLAYSTONE]	CL	37	21	16	100	19.9	JDT ASW	T89,T90	
⊠ SW-14, S-4	9.0	FAT CLAY [CLAYSTONE]	CH	66	26	40	99	33.7	JDT ASW	T89,T90	
◈ SW-15, S-2	2.5	LEAN CLAY with SAND	CL	34	20	14	80	20.6	JDT ASW	T89,T90	
⊙ SW-15, S-5	9.0	LEAN CLAY [CLAYSTONE]	CL	37	17	20	99	20.3	BXE ASW	T89,T90	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the Atterberg Limits test results.
ABBREVIATIONS: LL = liquid limit; NAT MC = natural moisture content; n/a = test attempted; NP = nonplastic; PI = plasticity index; PL = plastic limit; STD = standard; RVW = reviewed by; USCS = Unified Soil Classification System symbol

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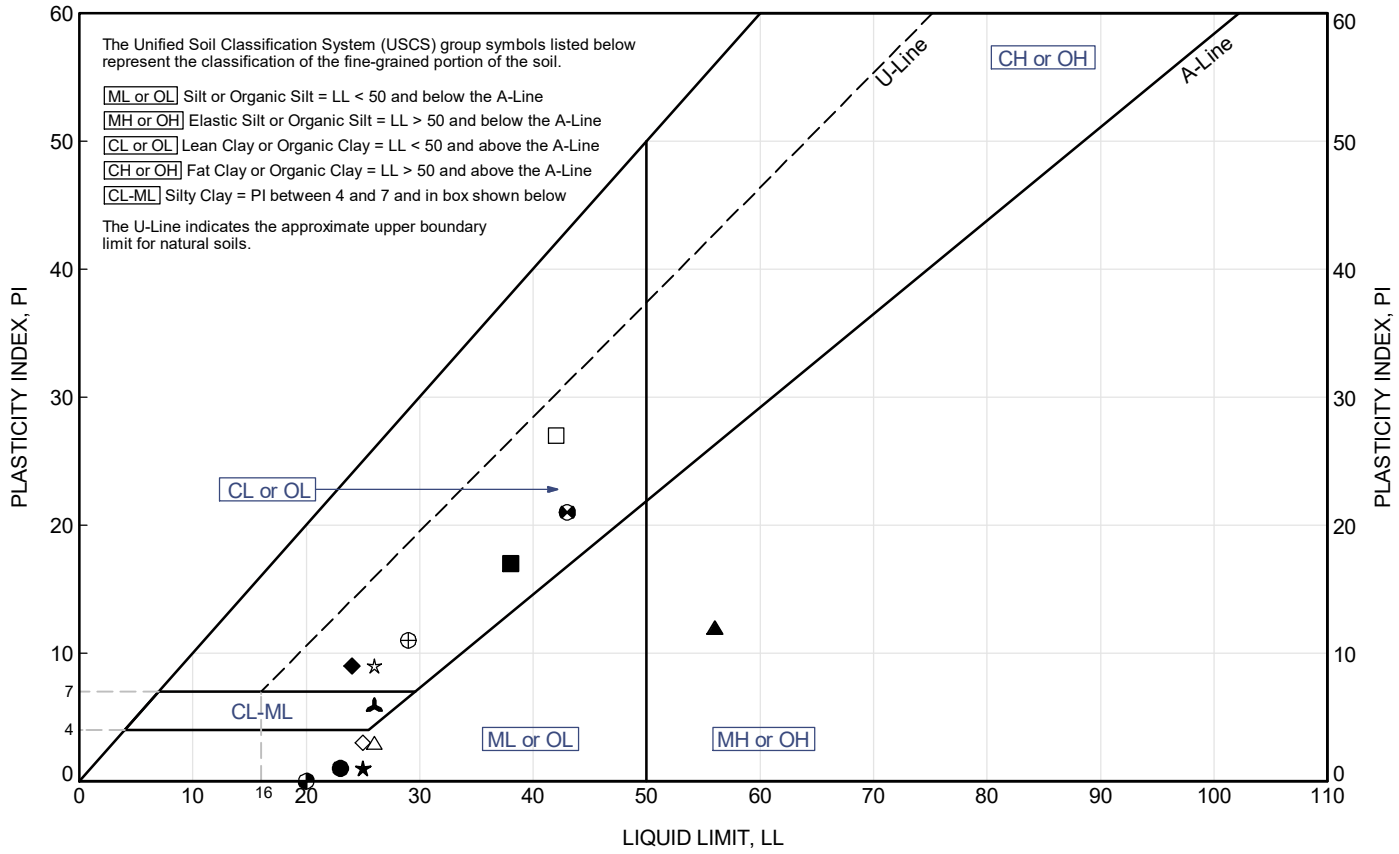
FIG B-2

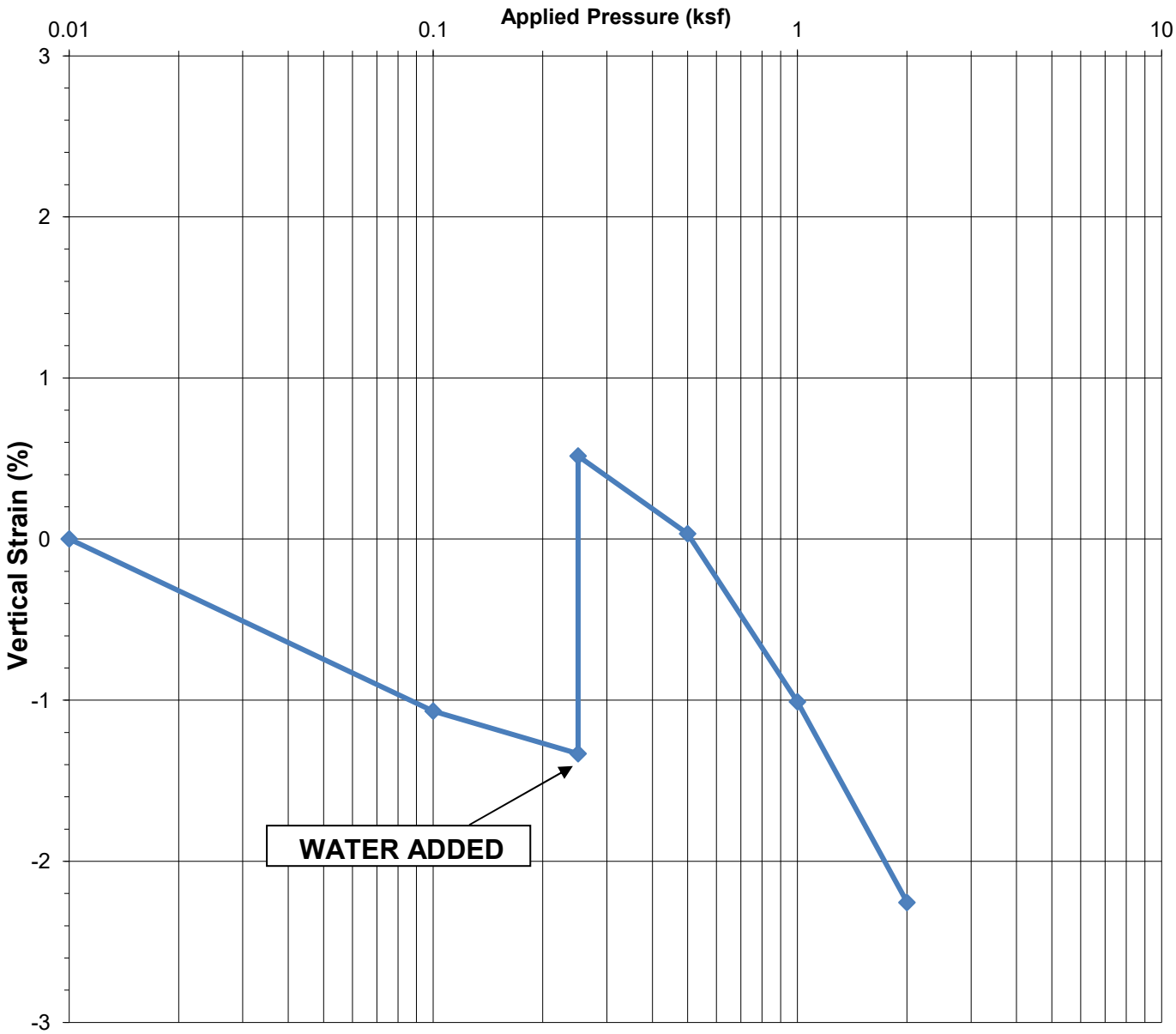


EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	LL	PL	PI	FINES (%)	NAT MC %	TEST BY/RVW	TEST STD	TEST NOTE
● SW-16, S-3	14.0	SILT [SILTSTONE]	ML	23	22	1	87	8.6	CXO ASW	T89,T90	
■ SW-16, S-4	19.0	LEAN CLAY [CLAYSTONE]	CL	38	21	17	98	20.8	CXO ASW	T89,T90	
▲ SW-16, S-5B	24.5	SANDY ELASTIC SILT [COAL]	MH	56	44	12	57	53.2	CXO JYS	T89,T90	
◆ SW-16, S-7	34.0	LEAN CLAY [CLAYSTONE]	CL	24	15	9	98	16.2	ATY JYS	T89,T90	
SW-16, S-9	44.0	SILTY SAND [SANDSTONE]	SM	*NP*	NP	*NP*	45	6.7	ATY JYS	T89,T90	
□ SW-16, S-13	64.0	LEAN CLAY [CLAYSTONE]	CL	42	15	27	95	16.2	ATY JYS	T89,T90	
△ SW-17, S-4	19.5	SILT [SILTSTONE]	ML	26	23	3	96	9.9	JYS JYS	T89,T90	
◇ SW-17, S-7	34.5	SILT [SILTSTONE]	ML	25	22	3	99	10.5	JYS JYS	T89,T90	
SW-17, S-9	44.5	SILTY CLAY [CLAYSTONE/SILTSTONE]	CL-ML	26	20	6	97	14.6	JYS JYS	T89,T90	
★ SW-17, S-10	49.5	SILT [SILTSTONE]	ML	25	24	1	95	12.2	ASW JYS	T89,T90	
⊕ SW-17, S-11	54.5	LEAN CLAY [CLAYSTONE]	CL	29	18	11	98	17.3	JYS JYS	T89,T90	
SW-17, S-13	64.5	LEAN CLAY [CLAYSTONE]	CL	43	22	21	88	19.6	JYS JYS	T89,T90	
SW-17, S-15	74.5	SILTY SAND [SANDSTONE]	SM	20	*NP*	NP	41	11.6	JYS JYS	T89,T90	
☆ SW-17, S-16	79.5	SANDY LEAN CLAY [CLAYSTONE]	CL	26	17	9	65	14.3	ASW JYS	T89,T90	

* Where indicated by *, the USCS Group Name was based on visual-manual examination procedures (ASTM D2488) and the Atterberg Limits test results.
ABBREVIATIONS: LL = liquid limit; NAT MC = natural moisture content; n/a = test attempted; NP = nonplastic; PI = plasticity index; PL = plastic limit; STD = standard; RVW = reviewed by; USCS = Unified Soil Classification System symbol

Chateau Road Reconstruction Medora, North Dakota	Boring: SW-03 Sample: S-2 Depth: 2.5 to 4.0 ft

SWELL/COLLAPSE TEST REPORT



Swell Pressure =	1,200	psf
Swell =	1.8	%
Inundation Pressure =	250	psf
Initial Moisture Content =	22.9	%
Final Moisture Content =	25.4	%
Moist Unit Weight =	127.1	pcf

Notes

1. The swell pressure is the applied pressure required to compress the sample to its height immediately prior to inundation.
2. Testing was done in general accordance with Methods B and C (reloading on intact specimen after undergoning swell deformation) of ASTM D 4546, Standard Test Methods for One-Dimensional Swell or Collapse of Soils.

Checked By: JYS 8/9/2024

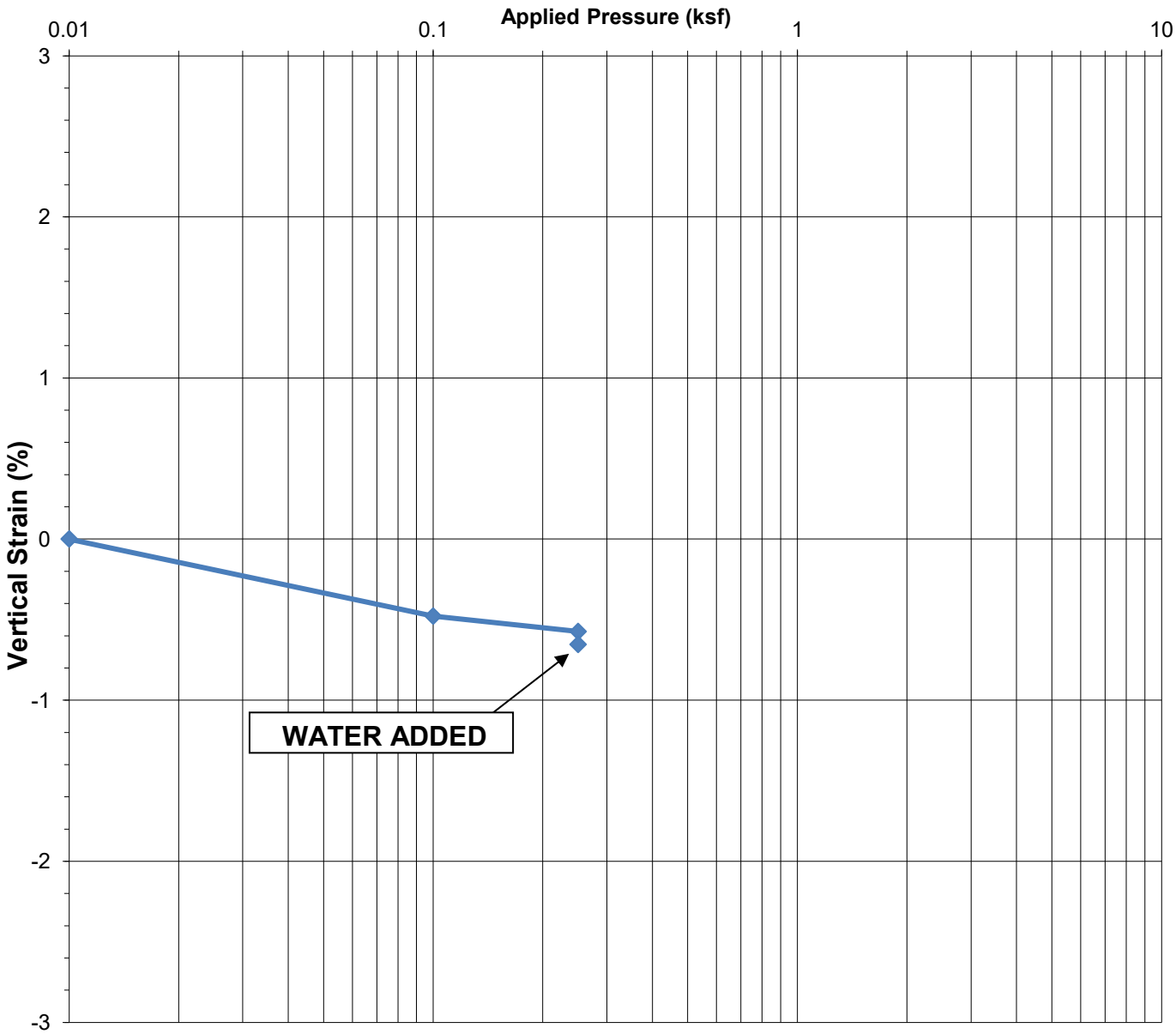
SW-03 S-2_Swell Test Master 2024 2025 w swell pressure.xlsx

113316-001

Standard Test Method for One-Dimensional Swell or Collapse of Soils

Chateau Road Reconstruction **Medora, North Dakota**	**Boring: SW-09** **Sample: S-1** **Depth: 1.5 to 3.0 ft**

SWELL/COLLAPSE TEST REPORT



Swell Pressure =	-	psf
Swell =	-0.1	%
Inundation Pressure =	250	psf
Initial Moisture Content =	11.8	%
Final Moisture Content =	15.5	%
Moist Unit Weight =	134.5	pcf

Notes

1. The swell pressure is the applied pressure required to compress the sample to its height immediately prior to inundation.
2. Testing was done in general accordance with Method B (an intact specimen obtained from a natural deposit) of ASTM D 4546, Standard Test Methods for One-Dimensional Swell or Collapse of Soils.

Checked By: ASW 8/9/24

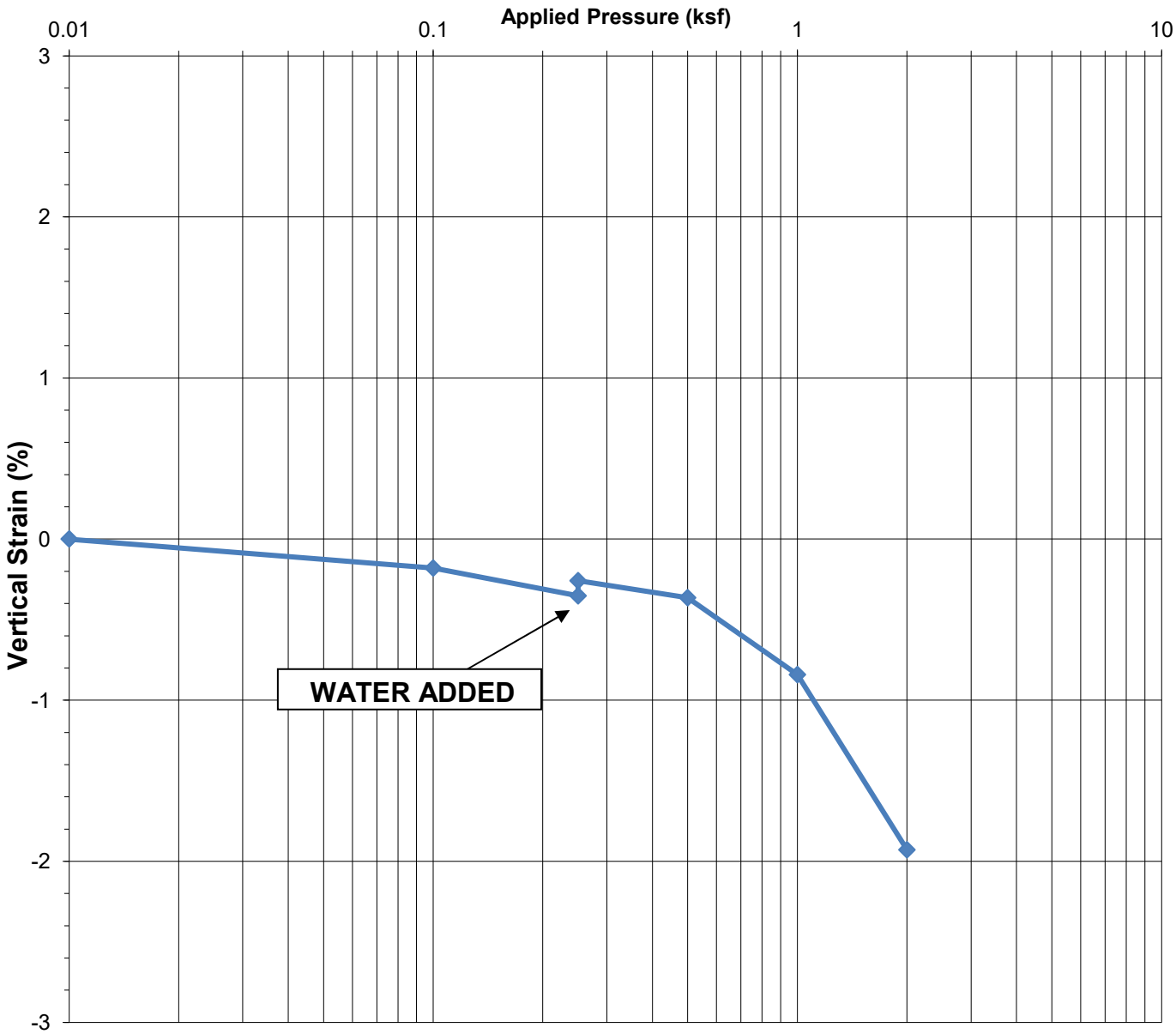
SW-09 S-1_Swell Test Master 2024 2025 w swell pressure.xlsx

113316-001

Standard Test Method for One-Dimensional Swell or Collapse of Soils

Chateau Road Reconstruction **Medora, North Dakota**	**Boring: SW-15** **Sample: S-2** **Depth: 2.5 to 4.0 ft**

SWELL/COLLAPSE TEST REPORT



Swell Pressure =	730	psf
Swell =	0.1	%
Inundation Pressure =	250	psf
Initial Moisture Content =	14.0	%
Final Moisture Content =	17.3	%
Moist Unit Weight =	136.6	pcf

Notes

1. The swell pressure is the applied pressure required to compress the sample to its height immediately prior to inundation.
2. Testing was done in general accordance with Methods B and C (reloading on intact specimen after undergoning swell deformation) of ASTM D 4546, Standard Test Methods for One-Dimensional Swell or Collapse of Soils.

Checked By: JYS 8/9/2024

SW-15 S-2_Swell Test Master 2024 2025 w swell pressure.xlsx

113316-001

ADVANCED TERRA TESTING
833 PARFET ST UNIT A
LAKEWOOD, CO
303-232-8308 www.terratesting.com

Monday, July 29, 2024

Project Number: 2481-335

Company: Shannon & Wilson

Address:

City:

State:

RE: Soil Testing
NDDOT Chateau Rd
113316-001

Dear Dan Markowski,

With this letter you will find a report on Soil samples assigned on 7/2/2024.

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 thirty 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 high quality laboratory testing for your project. 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,

Brandon Ferro

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Respectfully,

Brandon Ferro

ADVANCED TERRA TESTING

Laboratory Compaction Characteristics

AASHTO T99*

CLIENT	Shannon & Wilson	BORING NO.	SW-01
JOB NO.	2481-335	DEPTH	1.5-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/22/24	NOTE	*Deviated method - tested on minus 3/8" material
TECHNICIAN	JB		

Laboratory Compaction Characteristics

Hygroscopic Moisture

Mass of Wet Pan and Soil (g):	978.76
Mass of Dry Pan and Soil (g):	966.13
Mass of Pan (g):	256.37
Moisture (%):	1.8

Rock Correction ASTM D 4718

Method:	--
Course Fraction (%):	0.5
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

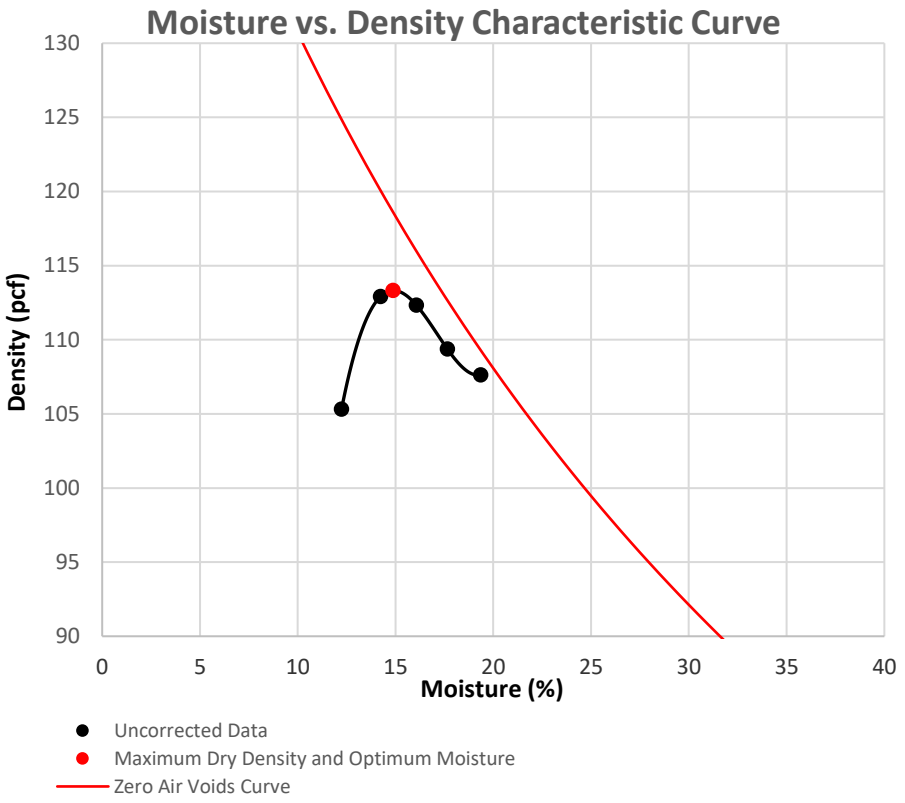
Optimum Dry Density and Moisture

Uncorrected

Dry Density (pcf):	**113.3**
Dry Density (kg/m³):	**1815**
Moisture (%):	**14.9**

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):	157.98	141.60	180.61	129.93	163.37
Mass of Dry Soil and Pan (g):	141.49	124.78	156.53	111.45	137.96
Mass of Pan (g);	6.79	6.63	6.70	6.78	6.73
Moisture (%):	12.2	14.2	16.1	17.7	19.4
Mass of Wet Soil and Mold (g):	6355.2	6518.1	6539.1	6513.4	6510.3
Mass of Mold (g):	4567.8	4567.8	4567.8	4567.8	4567.8
Wet Density (pcf):	118.2	129.0	130.4	128.7	128.5
Dry Density (pcf):	105.3	112.9	112.3	109.4	107.6
Wet Density (kg/m³):	1894	2066	2088	2061	2058
Dry Density (kg/m³):	1687	1809	1799	1752	1724

Data entry by: JB Date: 07/26/27
Checked by: BDF Date: 07/29/24
File name: 2481335__compaction AASHTO_T99_6.xlsm

ADVANCED TERRA TESTING

Laboratory Compaction Characteristics

AASHTO T99*

CLIENT	Shannon & Wilson	BORING NO.	SW-02
JOB NO.	2481-335	DEPTH	1.5-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/22/24	NOTE	*Deviated method - tested on minus 3/8" material
TECHNICIAN	JB		

Laboratory Compaction Characteristics

Hygroscopic Moisture

Mass of Wet Pan and Soil (g):	858.37
Mass of Dry Pan and Soil (g):	848.03
Mass of Pan (g):	256.61
Moisture (%):	1.7

Rock Correction ASTM D 4718

Method:	--
Course Fraction (%):	0.9
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

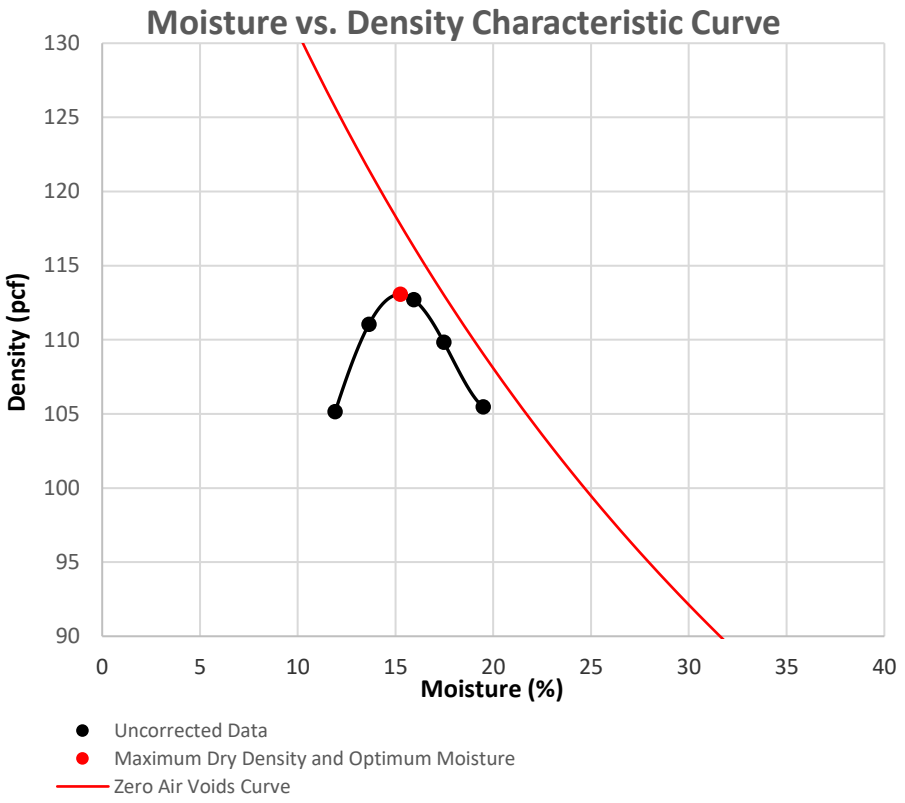
Optimum Dry Density and Moisture

Uncorrected

Dry Density (pcf):	**113.1**
Dry Density (kg/m³):	**1811**
Moisture (%):	**15.2**

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):	140.30	178.10	167.83	171.58	155.44
Mass of Dry Soil and Pan (g):	126.08	157.53	145.71	147.06	131.19
Mass of Pan (g);	6.72	6.72	6.91	6.71	6.70
Moisture (%):	11.9	13.6	15.9	17.5	19.5
Mass of Wet Soil and Mold (g):	6347.0	6475.6	6543.4	6518.5	6473.3
Mass of Mold (g):	4567.8	4567.8	4567.8	4567.8	4567.8
Wet Density (pcf):	117.7	126.2	130.7	129.0	126.0
Dry Density (pcf):	105.1	111.0	112.7	109.8	105.5
Wet Density (kg/m³):	1885	2021	2093	2067	2019
Dry Density (kg/m³):	1684	1779	1805	1759	1690

Data entry by: JB Date: 07/23/24

Checked by: BDF Date: 07/23/24

File name: 2481335__compaction AASHTO_T99_4.xlsm

ADVANCED TERRA TESTING

Laboratory Compaction Characteristics

AASHTO T99*

CLIENT	Shannon & Wilson	BORING NO.	SW-04
JOB NO.	2481-335	DEPTH	1.0-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/16/24	NOTE	*Deviated method - tested on minus 3/8" material
TECHNICIAN	JB		

Laboratory Compaction Characteristics

Hygroscopic Moisture

Mass of Wet Pan and Soil (g):	822.88
Mass of Dry Pan and Soil (g):	812.42
Mass of Pan (g):	253.76
Moisture (%):	1.9

Rock Correction ASTM D 4718

Method:	--
Course Fraction (%):	1.4
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

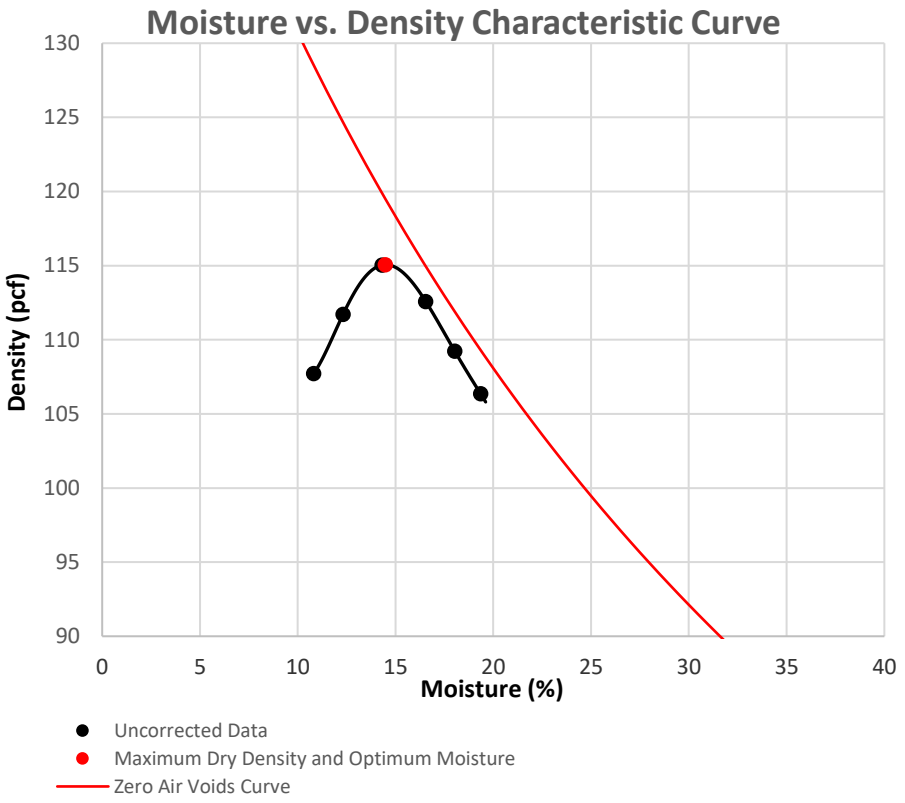
Optimum Dry Density and Moisture

Uncorrected

Dry Density (pcf):	**115.1**
Dry Density (kg/m³):	**1843**
Moisture (%):	**14.5**

Corrected

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



Sample Number:	1	2	3	4	5	6
Mass of Wet Pan and Soil (g):	138.68	157.51	144.00	134.59	143.27	122.23
Mass of Dry Soil and Pan (g):	124.20	138.61	124.50	115.04	121.12	110.96
Mass of Pan (g);	6.67	6.59	6.66	6.64	6.67	6.68
Moisture (%):	12.3	14.3	16.5	18.0	19.4	10.8
Mass of Wet Soil and Mold (g):	6465.0	6556.1	6551.6	6517.0	6487.0	6372.4
Mass of Mold (g):	4567.8	4567.8	4567.8	4567.8	4567.8	4567.8
Wet Density (pcf):	125.5	131.5	131.2	128.9	126.9	119.4
Dry Density (pcf):	111.7	115.0	112.6	109.2	106.4	107.7
Wet Density (kg/m³):	2010	2106	2102	2065	2033	1912
Dry Density (kg/m³):	1790	1843	1803	1750	1704	1725

Data entry by: JB Date: 07/22/24

Checked by: BDF Date: 07/22/24

File name: 2481335__compaction AASHTO_T99_3.xlsm

ADVANCED TERRA TESTING

Laboratory Compaction Characteristics

AASHTO T99*

CLIENT	Shannon & Wilson	BORING NO.	SW-05
JOB NO.	2481-335	DEPTH	1.0-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/16/24	NOTE	*Deviated method - tested on minus 3/8" material
TECHNICIAN	JB		

Laboratory Compaction Characteristics

Hygroscopic Moisture

Mass of Wet Pan and Soil (g):	1100.90
Mass of Dry Pan and Soil (g):	1072.50
Mass of Pan (g):	371.60
Moisture (%):	4.1

Rock Correction ASTM D 4718

Method:	--
Course Fraction (%):	2.7
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

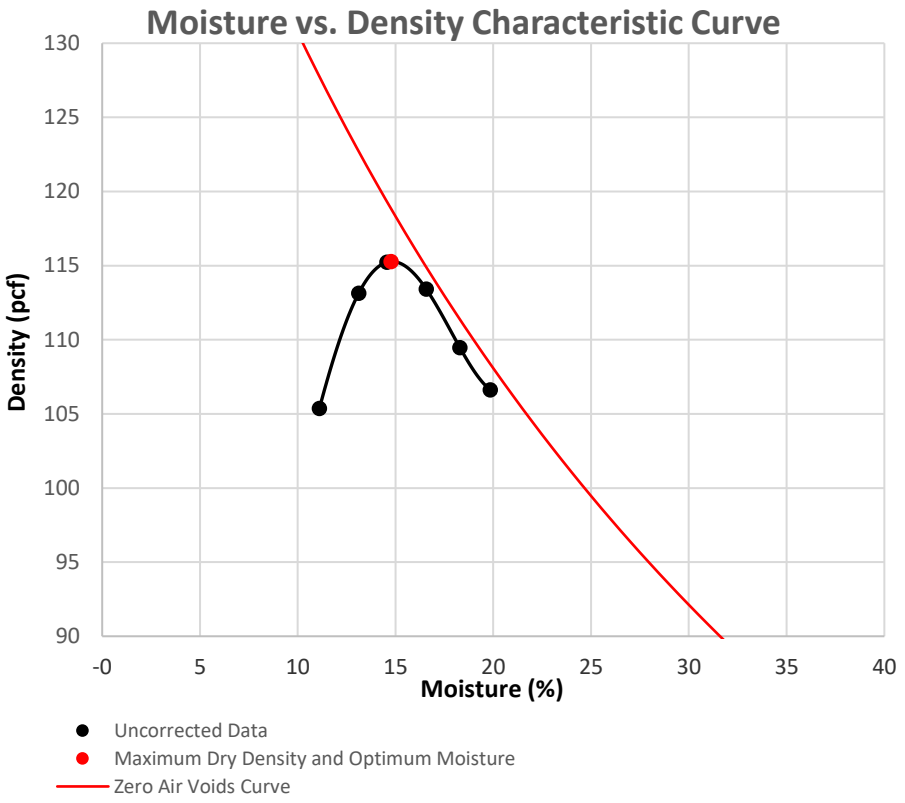
Optimum Dry Density and Moisture

Uncorrected

Dry Density (pcf):	**115.3**
Dry Density (kg/m³):	**1846**
Moisture (%):	**14.8**

Corrected

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



Sample Number:	1	2	3	4	5	6
Mass of Wet Pan and Soil (g):	142.93	162.77	172.84	131.89	158.07	136.93
Mass of Dry Soil and Pan (g):	127.14	142.92	149.21	112.52	133.01	123.90
Mass of Pan (g);	6.74	6.61	6.65	6.66	6.74	6.60
Moisture (%):	13.1	14.6	16.6	18.3	19.8	11.1
Mass of Wet Soil and Mold (g):	6502.9	6564.0	6567.0	6525.9	6500.2	6338.2
Mass of Mold (g):	4568.1	4568.1	4568.1	4568.1	4568.1	4568.1
Wet Density (pcf):	128.0	132.0	132.2	129.5	127.8	117.1
Dry Density (pcf):	113.1	115.2	113.4	109.5	106.6	105.4
Wet Density (kg/m³):	2050	2115	2118	2074	2047	1875
Dry Density (kg/m³):	1812	1846	1817	1753	1708	1688

Data entry by: JB Date: 07/22/24

Checked by: BDF Date: 07/22/24

File name: 2481335__compaction AASHTO_T99_2.xlsm

ADVANCED TERRA TESTING

Laboratory Compaction Characteristics

AASHTO T99*

CLIENT	Shannon & Wilson	BORING NO.	SW-07
JOB NO.	2481-335	DEPTH	1.5-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/16/24	NOTE	*Deviated method - tested on minus 3/8" material
TECHNICIAN	JB		

Laboratory Compaction Characteristics

Hygroscopic Moisture

Mass of Wet Pan and Soil (g):	589.60
Mass of Dry Pan and Soil (g):	576.39
Mass of Pan (g):	13.98
Moisture (%):	2.3

Rock Correction ASTM D 4718

Method:	--
Course Fraction (%):	2.3
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

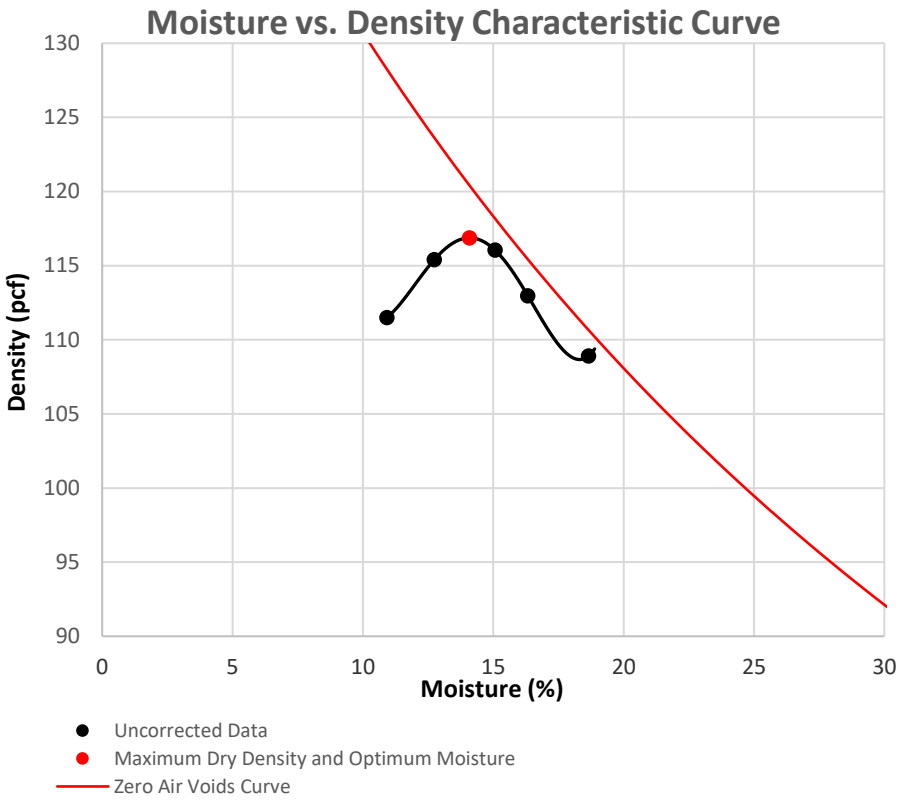
Optimum Dry Density and Moisture

Uncorrected

Dry Density (pcf):	**116.9**
Dry Density (kg/m³):	**1872**
Moisture (%):	**14.1**

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):	146.24	170.30	165.56	183.51	150.37
Mass of Dry Soil and Pan (g):	132.49	151.81	144.80	158.69	127.76
Mass of Pan (g);	6.60	6.63	7.00	6.64	6.56
Moisture (%):	10.9	12.7	15.1	16.3	18.7
Mass of Wet Soil and Mold (g):	6438.1	6535.0	6587.0	6555.0	6521.9
Mass of Mold (g):	4568.1	4568.1	4568.1	4568.1	4568.1
Wet Density (pcf):	123.7	130.1	133.5	131.4	129.2
Dry Density (pcf):	111.5	115.4	116.0	113.0	108.9
Wet Density (kg/m³):	1981	2084	2139	2105	2070
Dry Density (kg/m³):	1786	1848	1859	1810	1745

Data entry by: JB Date: 07/22/24

Checked by: BDF Date: 07/22/24

File name: 2481335__compaction AASHTO_T99_1.xlsm

ADVANCED TERRA TESTING

Laboratory Compaction Characteristics

AASHTO T99*

CLIENT	Shannon & Wilson	BORING NO.	SW-09
JOB NO.	2481-335	DEPTH	0.9-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/24/24	NOTE	*Deviated method - tested on minus 3/8" material
TECHNICIAN	JB		

Laboratory Compaction Characteristics

Hygroscopic Moisture

Mass of Wet Pan and Soil (g):	918.53
Mass of Dry Pan and Soil (g):	883.92
Mass of Pan (g):	255.83
Moisture (%):	5.5

Rock Correction ASTM D 4718

Method:	--
Course Fraction (%):	2.7
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

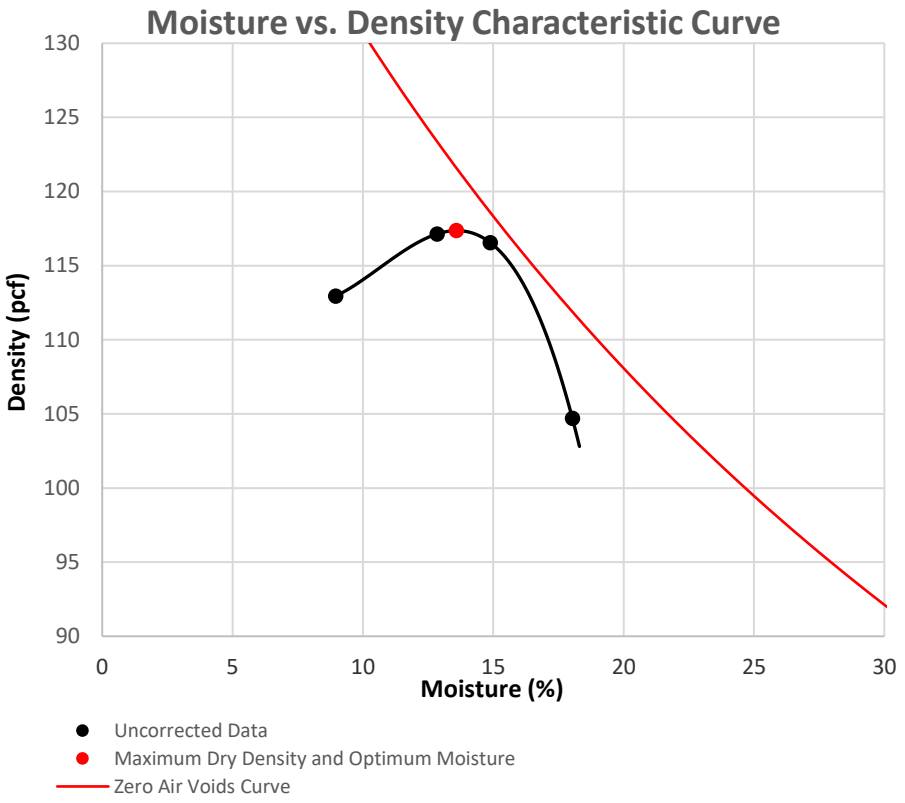
Optimum Dry Density and Moisture

Uncorrected

Dry Density (pcf):	**117.4**
Dry Density (kg/m³):	**1880**
Moisture (%):	**13.6**

Corrected

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



Sample Number:	1	2	3	4
Mass of Wet Pan and Soil (g):	272.93	176.70	189.33	165.08
Mass of Dry Soil and Pan (g):	242.63	154.67	161.41	152.06
Mass of Pan (g);	6.73	6.68	6.59	6.75
Moisture (%):	12.8	14.9	18.0	9.0
Mass of Wet Soil and Mold (g):	6566.3	6592.3	6436.3	6428.5
Mass of Mold (g):	4567.8	4567.8	4567.8	4567.8
Wet Density (pcf):	132.2	133.9	123.6	123.1
Dry Density (pcf):	117.1	116.5	104.7	112.9
Wet Density (kg/m³):	2117	2145	1980	1971
Dry Density (kg/m³):	1876	1867	1677	1809

Data entry by: JB Date: 07/31/24
Checked by: BDF Date: 08/06/24
File name: 2481335__compaction AASHTO_T99_8.xlsm

ADVANCED TERRA TESTING

Laboratory Compaction Characteristics

AASHTO T99*

CLIENT	Shannon & Wilson	BORING NO.	SW-11
JOB NO.	2481-335	DEPTH	0.9-2.5'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	08/02/24	NOTE	*Deviated method - tested on minus 3/8" material. Corrected value includes +3/8". Limited material provided - reused material throughout test
TECHNICIAN	JB		

Laboratory Compaction Characteristics

Hygroscopic Moisture

Mass of Wet Pan and Soil (g):	692.32
Mass of Dry Pan and Soil (g):	682.70
Mass of Pan (g):	186.83
Moisture (%):	1.9

Rock Correction ASTM D 4718

Method:	--
Course Fraction (%):	12.4
Rock Correction Applied:	YES
Mass of Dry Aggregate (g):	765.9
Mass of SSD Aggregate (g):	779.8
Mass of Aggregate in Water (g):	487.0
Rock Specific Gravity:	2.62
Zero Air Voids Specific Gravity:	2.9

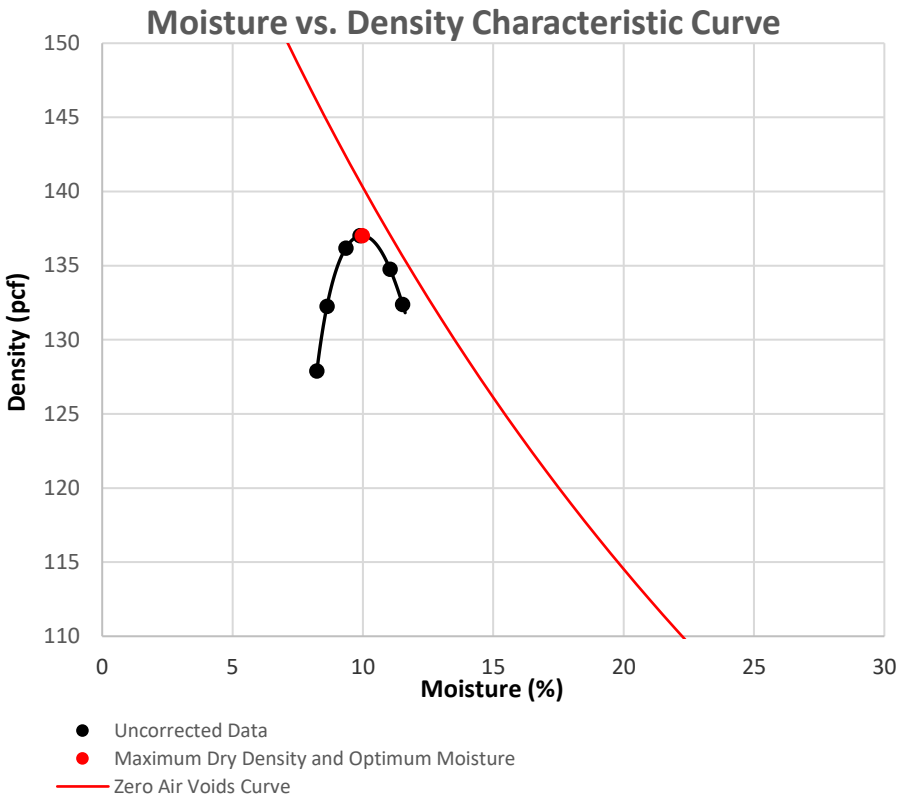
Optimum Dry Density and Moisture

Uncorrected

Dry Density (pcf):	**137.0**
Dry Density (kg/m³):	**2195**
Moisture (%):	**10.0**

Corrected

Dry Density (pcf):	**139.8**
Dry Density (kg/m³):	**2240**
Moisture (%):	**8.7**



Sample Number:	1	2	3	4	5	6
Mass of Wet Pan and Soil (g):	182.33	148.75	159.06	199.98	209.00	162.80
Mass of Dry Soil and Pan (g):	168.39	136.61	145.38	180.76	188.10	150.93
Mass of Pan (g);	6.67	6.70	7.00	6.69	6.72	6.76
Moisture (%):	8.6	9.3	9.9	11.0	11.5	8.2
Mass of Wet Soil and Mold (g):	6739.8	6819.3	6844.2	6830.3	6800.0	6660.5
Mass of Mold (g):	4567.8	4567.8	4567.8	4567.8	4567.8	4567.8
Wet Density (pcf):	143.7	148.9	150.6	149.6	147.6	138.4
Dry Density (pcf):	132.3	136.2	137.0	134.8	132.4	127.9
Wet Density (kg/m³):	2301	2385	2412	2397	2365	2217
Dry Density (kg/m³):	2119	2181	2195	2159	2121	2048

Data entry by: JB Date: 08/06/24

Checked by: BDF Date: 08/06/24

File name: 2481335__compaction AASHTO_T99_9.xlsm

ADVANCED TERRA TESTING

Laboratory Compaction Characteristics

AASHTO T99*

CLIENT	Shannon & Wilson	BORING NO.	SW-12
JOB NO.	2481-335	DEPTH	0.9-5'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/22/24	NOTE	*Deviated method - tested on minus 3/8" material
TECHNICIAN	JB		

Laboratory Compaction Characteristics

Hygroscopic Moisture

Mass of Wet Pan and Soil (g):	669.32
Mass of Dry Pan and Soil (g):	636.63
Mass of Pan (g):	13.81
Moisture (%):	5.2

Rock Correction ASTM D 4718

Method:	--
Course Fraction (%):	1.0
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

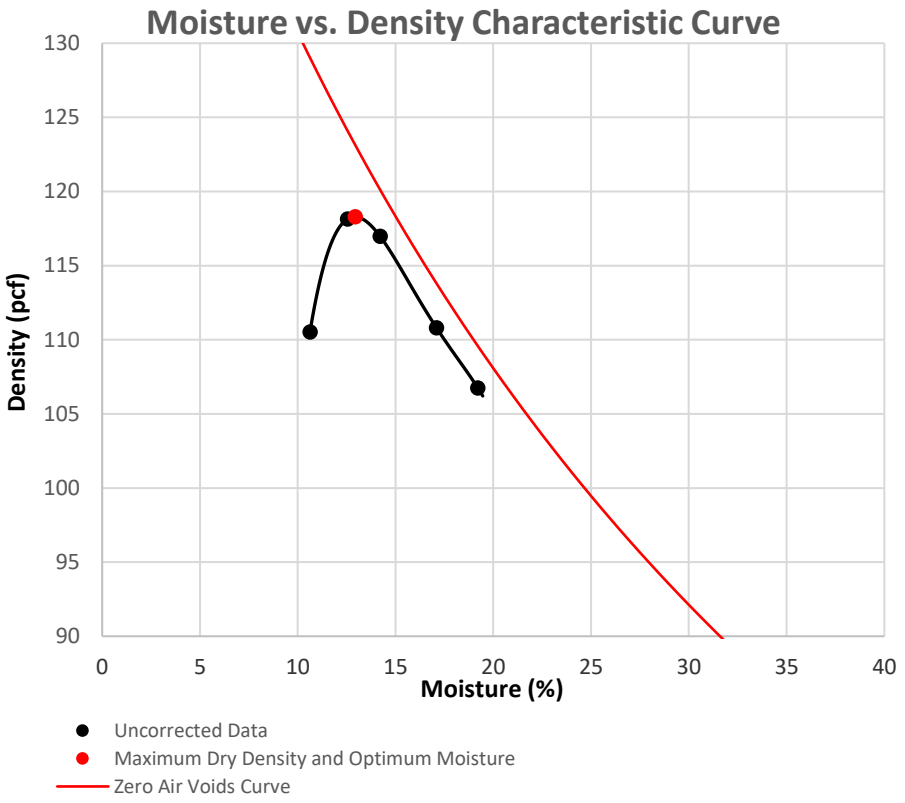
Optimum Dry Density and Moisture

Uncorrected

Dry Density (pcf):	**118.3**
Dry Density (kg/m³):	**1895**
Moisture (%):	**12.9**

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):	141.10	173.18	150.55	164.79	148.66
Mass of Dry Soil and Pan (g):	126.12	152.47	129.55	139.29	135.03
Mass of Pan (g);	6.71	6.76	6.70	6.52	6.75
Moisture (%):	12.5	14.2	17.1	19.2	10.6
Mass of Wet Soil and Mold (g):	6578.4	6587.9	6529.7	6492.0	6416.4
Mass of Mold (g):	4567.9	4567.9	4567.9	4567.9	4567.9
Wet Density (pcf):	133.0	133.6	129.8	127.3	122.3
Dry Density (pcf):	118.2	117.0	110.8	106.8	110.5
Wet Density (kg/m³):	2130	2140	2078	2038	1958
Dry Density (kg/m³):	1893	1874	1775	1710	1770

Data entry by: JB Date: 07/26/24
Checked by: BDF Date: 07/29/24
File name: 2481335__compaction AASHTO_T99_5.xlsm

ADVANCED TERRA TESTING

Laboratory Compaction Characteristics

AASHTO T99*

CLIENT	Shannon & Wilson	BORING NO.	SW-14
JOB NO.	2481-335	DEPTH	1.4-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/26/24	NOTE	*Deviated method - tested on minus 3/8" material
TECHNICIAN	JB		

Laboratory Compaction Characteristics

Hygroscopic Moisture

Mass of Wet Pan and Soil (g):	559.89
Mass of Dry Pan and Soil (g):	551.04
Mass of Pan (g):	13.88
Moisture (%):	1.6

Rock Correction ASTM D 4718

Method:	--
Course Fraction (%):	4.8
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

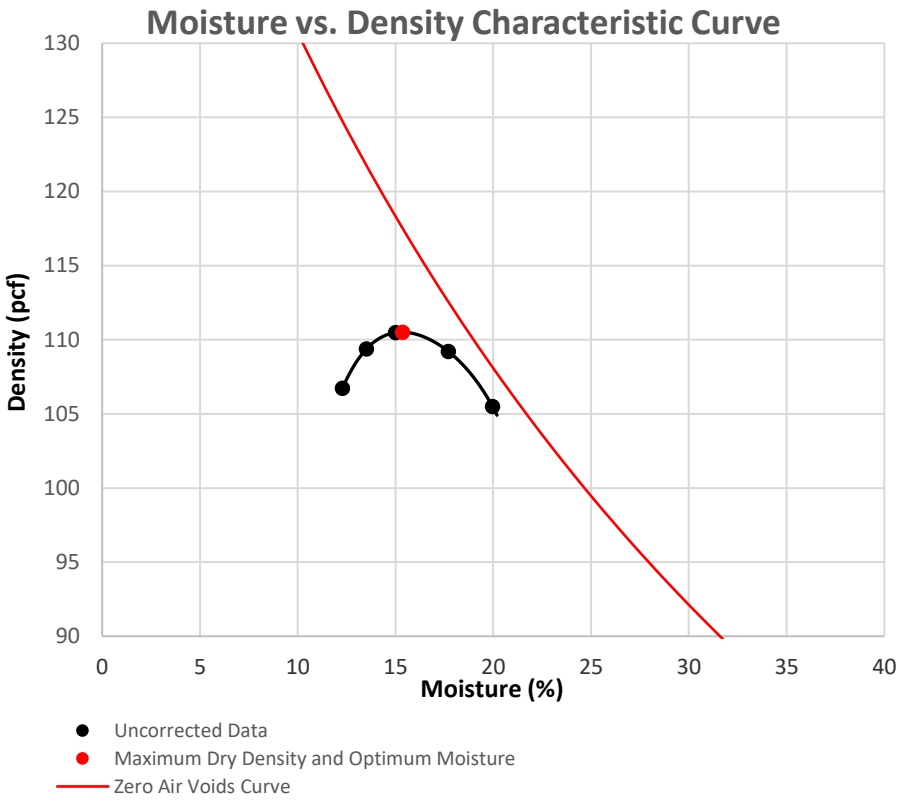
Optimum Dry Density and Moisture

Uncorrected

Dry Density (pcf):	**110.5**
Dry Density (kg/m³):	**1770**
Moisture (%):	**15.4**

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):	159.51	164.06	161.25	139.55	153.51
Mass of Dry Soil and Pan (g):	141.32	143.53	137.99	117.44	137.45
Mass of Pan (g);	6.67	6.68	6.63	6.68	6.71
Moisture (%):	13.5	15.0	17.7	20.0	12.3
Mass of Wet Soil and Mold (g):	6444.8	6488.8	6511.3	6481.2	6379.5
Mass of Mold (g):	4567.8	4567.8	4567.8	4567.8	4567.8
Wet Density (pcf):	124.1	127.1	128.5	126.6	119.8
Dry Density (pcf):	109.4	110.5	109.2	105.5	106.7
Wet Density (kg/m³):	1989	2035	2059	2027	1919
Dry Density (kg/m³):	1752	1770	1749	1690	1709

Data entry by: JB Date: 07/31/24
Checked by: BDF Date: 08/01/24
File name: 2481335__compaction AASHTO_T99_7.xlsm

ADVANCED TERRA TESTING

Laboratory Compaction Characteristics

AASHTO T99*

CLIENT	Shannon & Wilson	BORING NO.	SW-15
JOB NO.	2481-335	DEPTH	0.9-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/17/24	NOTE	*Deviated method - tested on minus 3/8" material
TECHNICIAN	JB		

Laboratory Compaction Characteristics

Hygroscopic Moisture

Mass of Wet Pan and Soil (g):	925.49
Mass of Dry Pan and Soil (g):	907.61
Mass of Pan (g):	262.17
Moisture (%):	2.8

Rock Correction ASTM D 4718

Method:	--
Course Fraction (%):	2.3
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

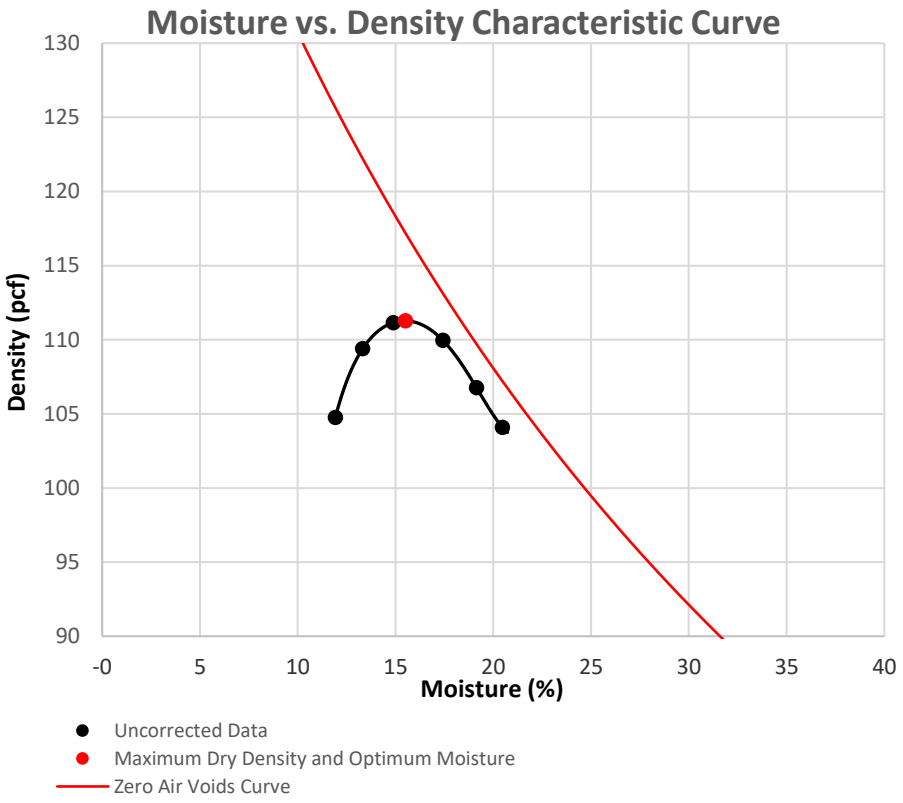
Optimum Dry Density and Moisture

Uncorrected

Dry Density (pcf):	**111.3**
Dry Density (kg/m³):	**1782**
Moisture (%):	**15.5**

Corrected

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



Sample Number:	1	2	3	4	5	6
Mass of Wet Pan and Soil (g):	151.53	175.62	159.81	175.59	172.56	177.52
Mass of Dry Soil and Pan (g):	134.50	153.73	137.09	148.46	144.35	159.33
Mass of Pan (g);	6.69	6.70	6.67	6.75	6.54	6.77
Moisture (%):	13.3	14.9	17.4	19.1	20.5	11.9
Mass of Wet Soil and Mold (g):	6442.4	6498.7	6520.1	6491.1	6464.0	6340.7
Mass of Mold (g):	4567.9	4567.9	4567.9	4567.9	4567.9	4567.9
Wet Density (pcf):	124.0	127.7	129.1	127.2	125.4	117.3
Dry Density (pcf):	109.4	111.2	110.0	106.8	104.1	104.8
Wet Density (kg/m³):	1986	2046	2068	2038	2009	1878
Dry Density (kg/m³):	1752	1780	1761	1710	1667	1678

Data entry by: JB Date: 07/22/24
Checked by: BDF Date: 07/22/24
File name: 2481335__compaction AASHTO_T99_0.xlsm

ADVANCED TERRA TESTING

Grain Size Analysis
AASHTO T311

CLIENT	Shannon & Wilson	BORING NO.	SW-01
JOB NO.	2481-335	DEPTH	1.5-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/12/24		
TECHNICIAN	WB		

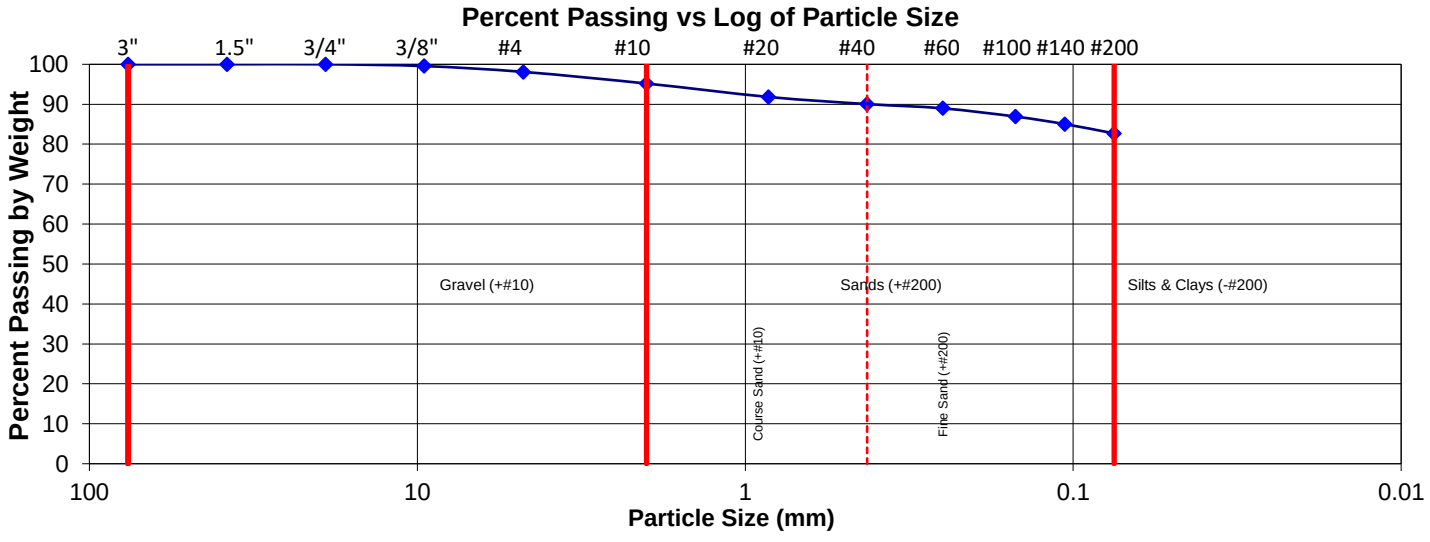
Hygroscopic Moisture of Fines

Mass Wet Pan and Soil (g):	978.76
Mass Dry Pan and Soil (g):	966.13
Mass of Pan (g):	256.37
Moisture (%):	**1.8**

Sample Data

Total Wet Mass of Sample (g):	15871.5
Total Dry Mass of Sample (g):	15595.2
Split Fraction:	3/8"
Mass of Sub-Sample Fraction (g):	722.39

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	0.0	0.0	0.0	1.00	**100.0**
3/8"	9.53	69.0	0.0	69.0	1.00	**99.6**
#4	4.75	10.4	0.0	10.4	1.00	**98.1**
#10	2.00	20.7	0.0	20.7	1.00	**95.2**
#20	0.850	24.0	0.0	24.0	1.00	**91.8**
#40	0.425	12.7	0.0	12.7	1.00	**90.0**
#60	0.250	7.6	0.0	7.6	1.00	**89.0**
#100	0.150	14.7	0.0	14.7	1.00	**86.9**
#140	0.106	13.5	0.0	13.5	1.00	**85.0**
#200	0.075	16.6	0.0	16.6	1.00	**82.7**



AASHTO Classification M 145

AASHTO Classification:	A-6	Gravel (%):	4.8
Group Index:	14.68	Course Sand (%):	5.1
Atterberg Classification:	CL	Fine Sand (%):	7.3
Plastic Limit:	17	Minus #200 (%):	82.7
Liquid Limit:	36		

Data entry by:	CK	Date:	07/15/24
Checked by:	WB	Date:	07/15/24
File name:	2481335__Grain Size Analysis AASHTO T311_5.xlsm		

ADVANCED TERRA TESTING

Grain Size Analysis
AASHTO T311

CLIENT	Shannon & Wilson	BORING NO.	SW-02
JOB NO.	2481-335	DEPTH	1.5-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/15/24		
TECHNICIAN	CK		

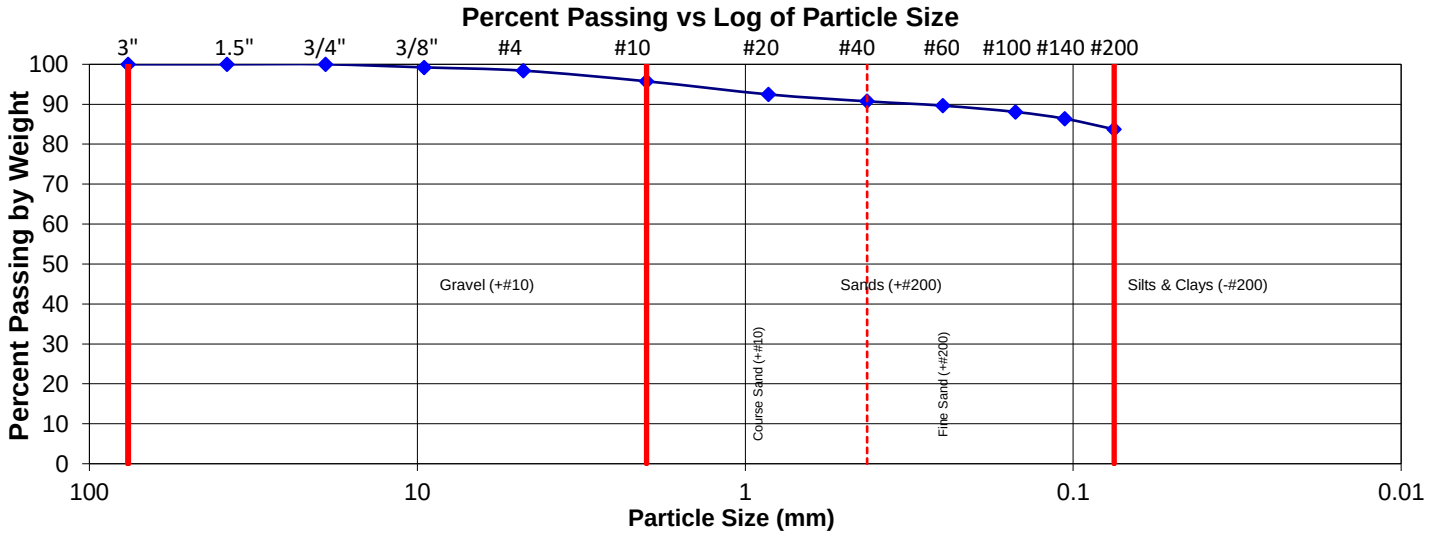
Hygroscopic Moisture of Fines

Mass Wet Pan and Soil (g):	858.37
Mass Dry Pan and Soil (g):	848.03
Mass of Pan (g):	256.61
Moisture (%):	**1.7**

Sample Data

Total Wet Mass of Sample (g):	17264.1
Total Dry Mass of Sample (g):	16969.7
Split Fraction:	3/8"
Mass of Sub-Sample Fraction (g):	601.76

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	0.0	0.0	0.0	1.00	**100.0**
3/8"	9.53	131.2	0.0	131.2	1.00	**99.2**
#4	4.75	4.9	0.0	4.9	0.99	**98.4**
#10	2.00	15.8	0.0	15.8	0.99	**95.8**
#20	0.850	19.6	0.0	19.6	0.99	**92.5**
#40	0.425	10.3	0.0	10.3	0.99	**90.7**
#60	0.250	6.4	0.0	6.4	0.99	**89.7**
#100	0.150	9.4	0.0	9.4	0.99	**88.1**
#140	0.106	10.2	0.0	10.2	0.99	**86.4**
#200	0.075	15.7	0.0	15.7	0.99	**83.7**



AASHTO Classification M 145

AASHTO Classification:	A-6	Gravel (%):	4.2
Group Index:	11.72	Course Sand (%):	5.0
Atterberg Classification:	CL	Fine Sand (%):	7.0
Plastic Limit:	19	Minus #200 (%):	83.7
Liquid Limit:	34		

Data entry by:	CK	Date:	07/16/24
Checked by:	MH	Date:	07/17/24
File name:	2481335__Grain Size Analysis AASHTO T311_7.xlsm		

ADVANCED TERRA TESTING

Grain Size Analysis
AASHTO T311

CLIENT	Shannon & Wilson	BORING NO.	SW-04
JOB NO.	2481-335	DEPTH	1.0-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/10/24		
TECHNICIAN	WB		

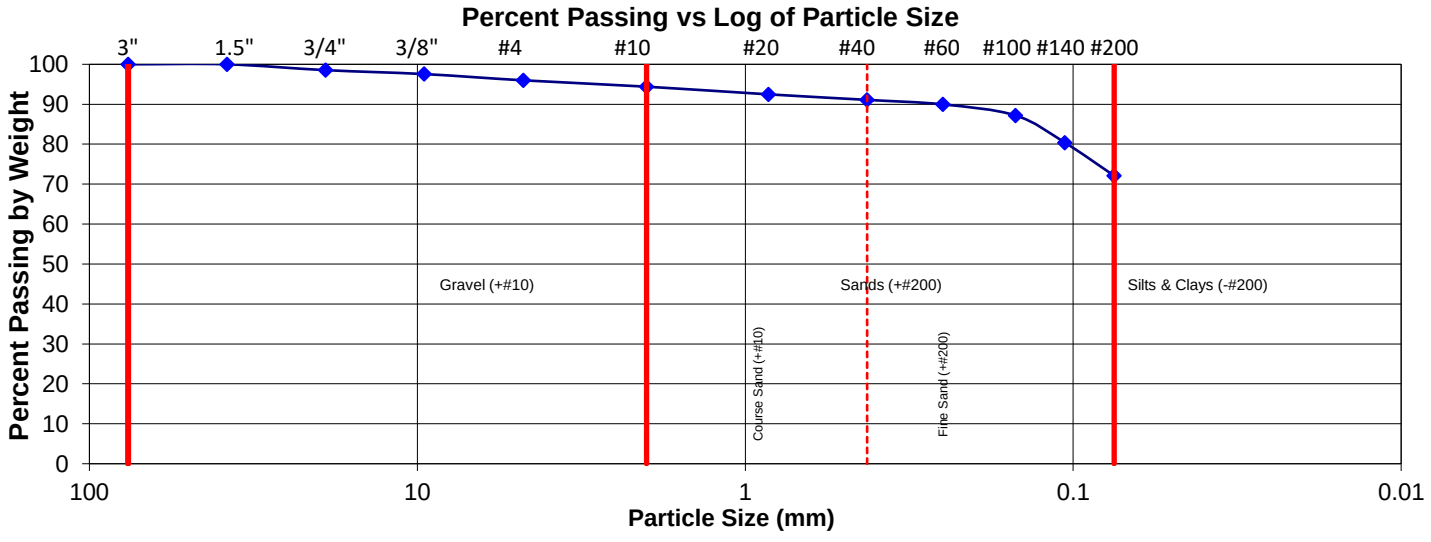
Hygroscopic Moisture of Fines

Mass Wet Pan and Soil (g):	398.42
Mass Dry Pan and Soil (g):	393.42
Mass of Pan (g):	181.20
Moisture (%):	**2.4**

Sample Data

Total Wet Mass of Sample (g):	1139.4
Total Dry Mass of Sample (g):	1114.2
Split Fraction:	#4
Mass of Sub-Sample Fraction (g):	217.22

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	0.0	0.0	1.00	**100.0**
3/4"	19.05	16.3	0.0	16.3	1.00	**98.5**
3/8"	9.53	11.0	0.0	11.0	1.00	**97.6**
#4	4.75	17.4	0.0	17.4	1.00	**96.0**
#10	2.00	3.5	0.0	3.5	0.96	**94.4**
#20	0.850	4.3	0.0	4.3	0.96	**92.5**
#40	0.425	3.1	0.0	3.1	0.96	**91.1**
#60	0.250	2.5	0.0	2.5	0.96	**90.0**
#100	0.150	6.1	0.0	6.1	0.96	**87.2**
#140	0.106	15.1	0.0	15.1	0.96	**80.4**
#200	0.075	18.3	0.0	18.3	0.96	**72.1**



AASHTO Classification M 145

AASHTO Classification:	A-6	Gravel (%):	5.6
Group Index:	8.42	Course Sand (%):	3.3
Atterberg Classification:	CL	Fine Sand (%):	19.0
Plastic Limit:	15	Minus #200 (%):	72.1
Liquid Limit:	30		

Data entry by:	WB	Date:	07/11/24
Checked by:	CK	Date:	07/17/24
File name:	2481335__Grain Size Analysis AASHTO T311_2.xlsm		

ADVANCED TERRA TESTING

Grain Size Analysis
AASHTO T311

CLIENT	Shannon & Wilson	BORING NO.	SW-05
JOB NO.	2481-335	DEPTH	1.0-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/09/24		
TECHNICIAN	WB		

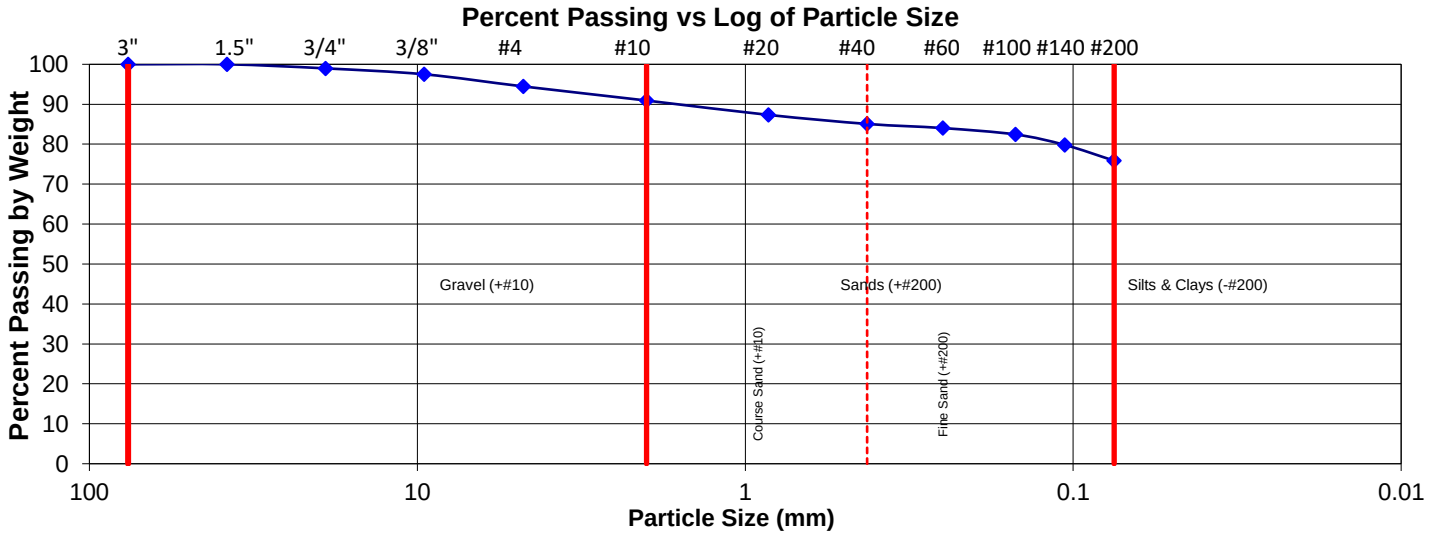
Hygroscopic Moisture of Fines

Mass Wet Pan and Soil (g):	1100.90
Mass Dry Pan and Soil (g):	1072.50
Mass of Pan (g):	371.60
Moisture (%):	**4.1**

Sample Data

Total Wet Mass of Sample (g):	17144.1
Total Dry Mass of Sample (g):	16492.6
Split Fraction:	3/8"
Mass of Sub-Sample Fraction (g):	729.30

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	0.0	0.0	1.00	**100.0**
3/4"	19.05	168.0	0.0	168.0	1.00	**99.0**
3/8"	9.53	245.1	0.0	245.1	1.00	**97.5**
#4	4.75	21.8	0.0	21.8	0.97	**94.5**
#10	2.00	25.4	0.0	25.4	0.97	**90.9**
#20	0.850	25.8	0.0	25.8	0.97	**87.3**
#40	0.425	16.3	0.0	16.3	0.97	**85.1**
#60	0.250	7.5	0.0	7.5	0.97	**84.0**
#100	0.150	11.5	0.0	11.5	0.97	**82.4**
#140	0.106	18.9	0.0	18.9	0.97	**79.8**
#200	0.075	28.3	0.0	28.3	0.97	**75.9**



AASHTO Classification M 145

AASHTO Classification:	A-6	Gravel (%):	9.1
Group Index:	10.39	Course Sand (%):	5.9
Atterberg Classification:	CL	Fine Sand (%):	9.2
Plastic Limit:	17	Minus #200 (%):	75.9
Liquid Limit:	33		

Data entry by:	WB	Date:	07/10/24
Checked by:	CK	Date:	07/17/24
File name:	2481335__Grain Size Analysis AASHTO T311_0.xlsm		

ADVANCED TERRA TESTING

Grain Size Analysis
AASHTO T311

CLIENT	Shannon & Wilson	BORING NO.	SW-05
JOB NO.	2481-335	DEPTH	7.0-9.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	S-4
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	08/13/24		
TECHNICIAN	CK		

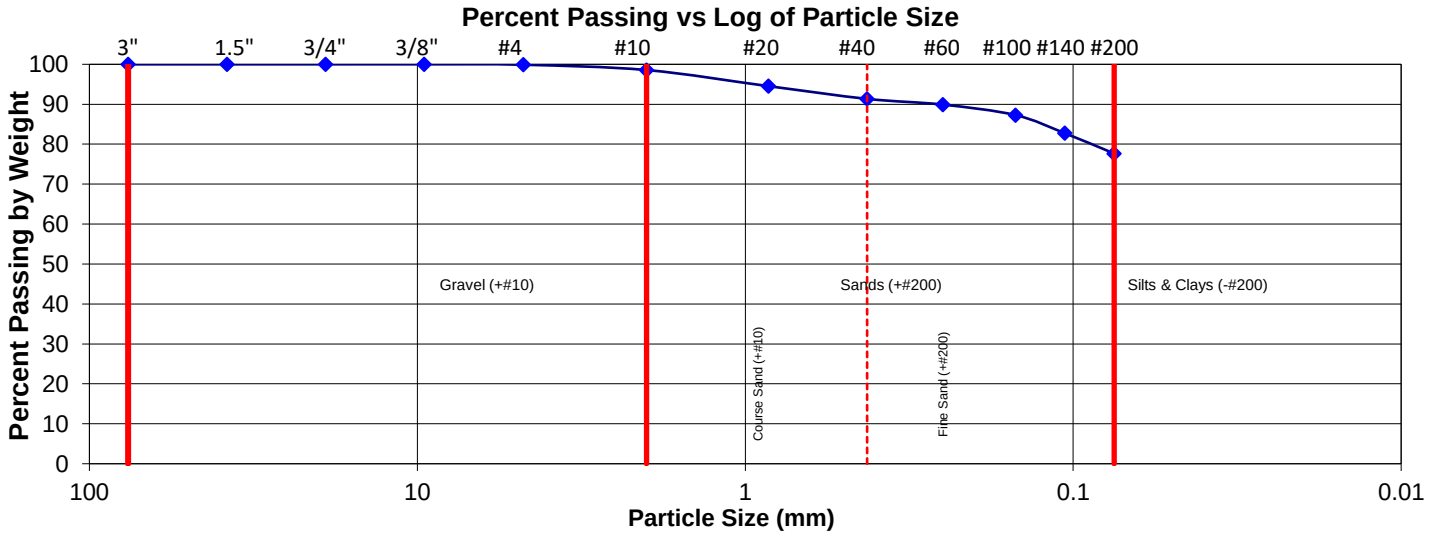
Hygroscopic Moisture of Fines

Mass Wet Pan and Soil (g):	386.61
Mass Dry Pan and Soil (g):	382.00
Mass of Pan (g):	172.44
Moisture (%):	**2.2**

Sample Data

Total Wet Mass of Sample (g):	637.4
Total Dry Mass of Sample (g):	623.7
Split Fraction:	#4
Mass of Sub-Sample Fraction (g):	214.17

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	--	--	--	--	**--**
3/8"	9.53	0.0	0.0	0.0	1.00	**100.0**
#4	4.75	0.7	0.0	0.7	1.00	**99.9**
#10	2.00	2.8	0.0	2.8	1.00	**98.6**
#20	0.850	8.5	0.0	8.5	1.00	**94.5**
#40	0.425	6.7	0.0	6.7	1.00	**91.3**
#60	0.250	3.0	0.0	3.0	1.00	**89.9**
#100	0.150	5.5	0.0	5.5	1.00	**87.3**
#140	0.106	9.5	0.0	9.5	1.00	**82.7**
#200	0.075	10.7	0.0	10.7	1.00	**77.7**



AASHTO Classification M 145

AASHTO Classification:	A-6	Gravel (%):	1.4
Group Index:	12.05	Course Sand (%):	7.2
Atterberg Classification:	CL	Fine Sand (%):	13.7
Plastic Limit:	15	Minus #200 (%):	77.7
Liquid Limit:	33		

Data entry by:	BDF	Date:	08/14/24
Checked by:	CK	Date:	08/14/24
File name:	2481335__Grain Size Analysis AASHTO T311_10.xlsm		

ADVANCED TERRA TESTING

Grain Size Analysis
AASHTO T311

CLIENT	Shannon & Wilson	BORING NO.	SW-06
JOB NO.	2481-335	DEPTH	4.0-6.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	S-8
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	08/12/24		
TECHNICIAN	CK		

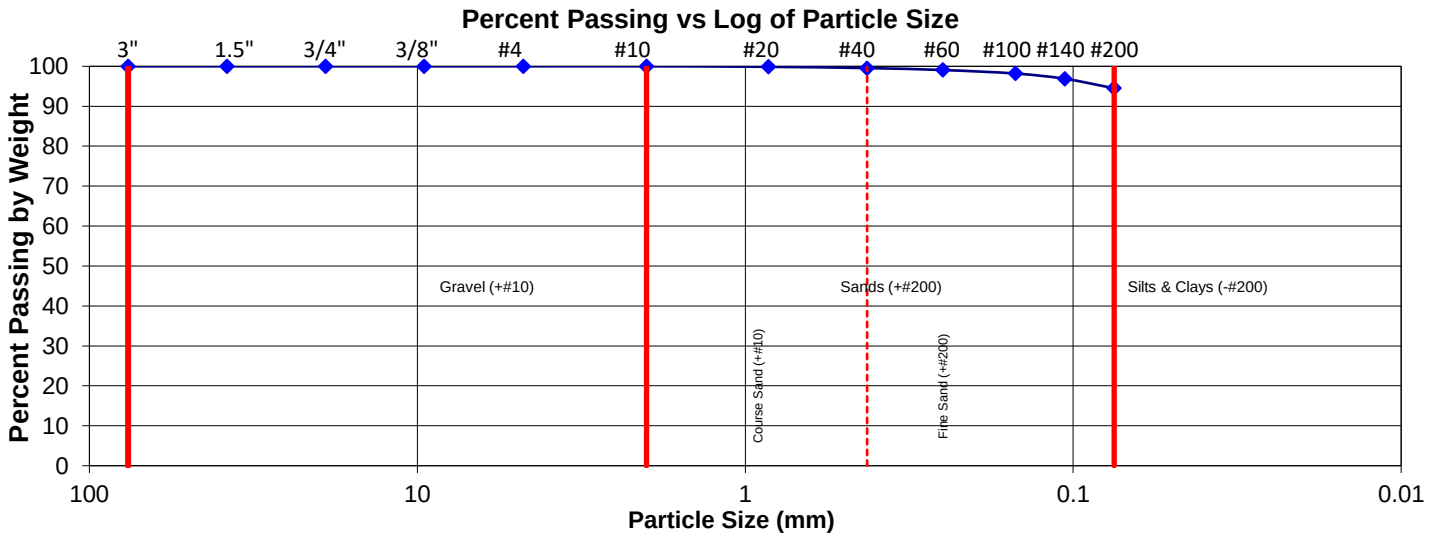
Hygroscopic Moisture of Fines

Mass Wet Pan and Soil (g):	365.36
Mass Dry Pan and Soil (g):	358.60
Mass of Pan (g):	124.07
Moisture (%):	**2.9**

Sample Data

Total Wet Mass of Sample (g):	456.1
Total Dry Mass of Sample (g):	443.3
Split Fraction:	#4
Mass of Sub-Sample Fraction (g):	241.29

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	--	--	--	--	**--**
3/8"	9.53	--	--	--	--	**--**
#4	4.75	--	--	--	--	**--**
#10	2.00	0.0	0.0	0.0	1.00	**100.0**
#20	0.850	0.3	0.0	0.3	1.00	**99.9**
#40	0.425	0.8	0.0	0.8	1.00	**99.5**
#60	0.250	1.1	0.0	1.1	1.00	**99.1**
#100	0.150	2.1	0.0	2.1	1.00	**98.2**
#140	0.106	3.1	0.0	3.1	1.00	**96.9**
#200	0.075	5.6	0.0	5.6	1.00	**94.5**



AASHTO Classification M 145

AASHTO Classification:	A-6	Gravel (%):	0.0
Group Index:	20.35	Course Sand (%):	0.5
Atterberg Classification:	CL	Fine Sand (%):	5.0
Plastic Limit:	18	Minus #200 (%):	94.5
Liquid Limit:	39		

Data entry by:	BDF	Date:	08/14/24
Checked by:	CK	Date:	08/14/24
File name:	2481335__Grain Size Analysis AASHTO T311_11.xlsm		

ADVANCED TERRA TESTING

Grain Size Analysis
AASHTO T311

CLIENT	Shannon & Wilson	BORING NO.	SW-07
JOB NO.	2481-335	DEPTH	1.5-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	7/10/24		
TECHNICIAN	WB		

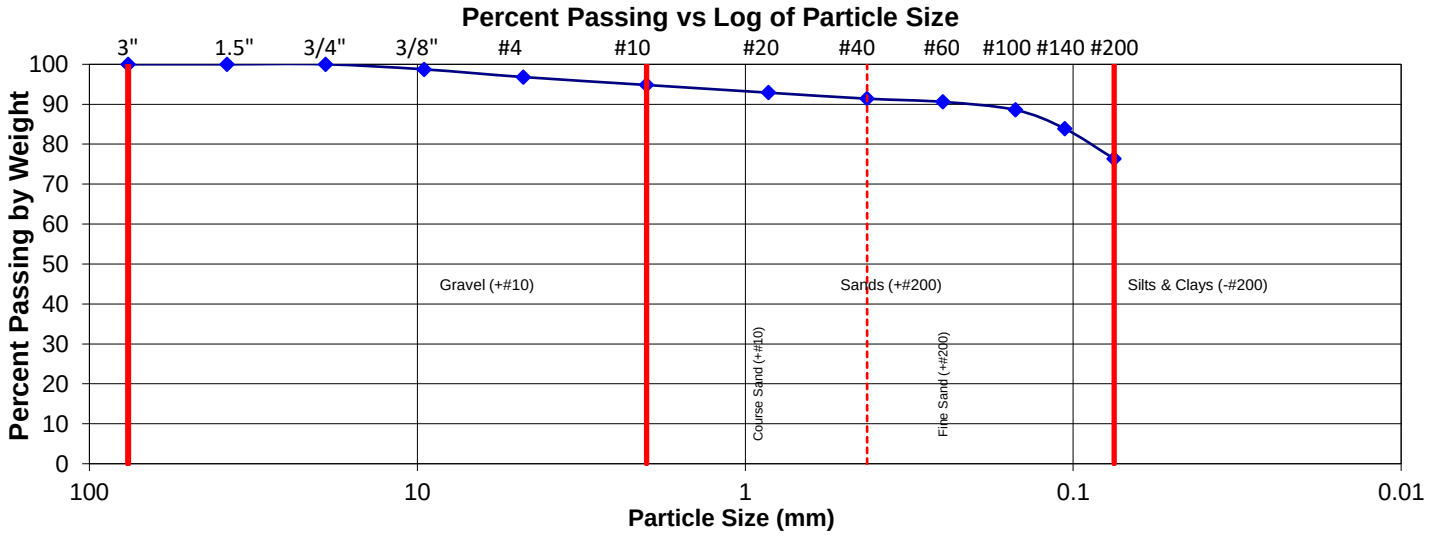
Hygroscopic Moisture of Fines

Mass Wet Pan and Soil (g):	354.86
Mass Dry Pan and Soil (g):	345.32
Mass of Pan (g):	139.26
Moisture (%):	**4.6**

Sample Data

Total Wet Mass of Sample (g):	1095.0
Total Dry Mass of Sample (g):	1048.0
Split Fraction:	#4
Mass of Sub-Sample Fraction (g):	215.60

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	0.0	0.0	0.0	1.00	**100.0**
3/8"	9.53	13.2	0.0	13.2	1.00	**98.7**
#4	4.75	20.2	0.0	20.2	1.00	**96.8**
#10	2.00	4.2	0.0	4.2	0.97	**94.8**
#20	0.850	4.1	0.0	4.1	0.97	**92.9**
#40	0.425	3.2	0.0	3.2	0.97	**91.4**
#60	0.250	1.7	0.0	1.7	0.97	**90.6**
#100	0.150	4.3	0.0	4.3	0.97	**88.6**
#140	0.106	10.0	0.0	10.0	0.97	**83.9**
#200	0.075	16.1	0.0	16.1	0.97	**76.3**



AASHTO Classification M 145

AASHTO Classification:	A-6	Gravel (%):	5.2
Group Index:	10.91	Course Sand (%):	3.4
Atterberg Classification:	CL	Fine Sand (%):	15.1
Plastic Limit:	15	Minus #200 (%):	76.3
Liquid Limit:	32		

Data entry by:	WB	Date:	07/11/24
Checked by:	CK	Date:	07/19/24
File name:	2481335__Grain Size Analysis AASHTO T311_3.xlsm		

ADVANCED TERRA TESTING

Grain Size Analysis
AASHTO T311

CLIENT	Shannon & Wilson	BORING NO.	SW-09
JOB NO.	2481-335	DEPTH	0.9-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/12/24		
TECHNICIAN	WB		

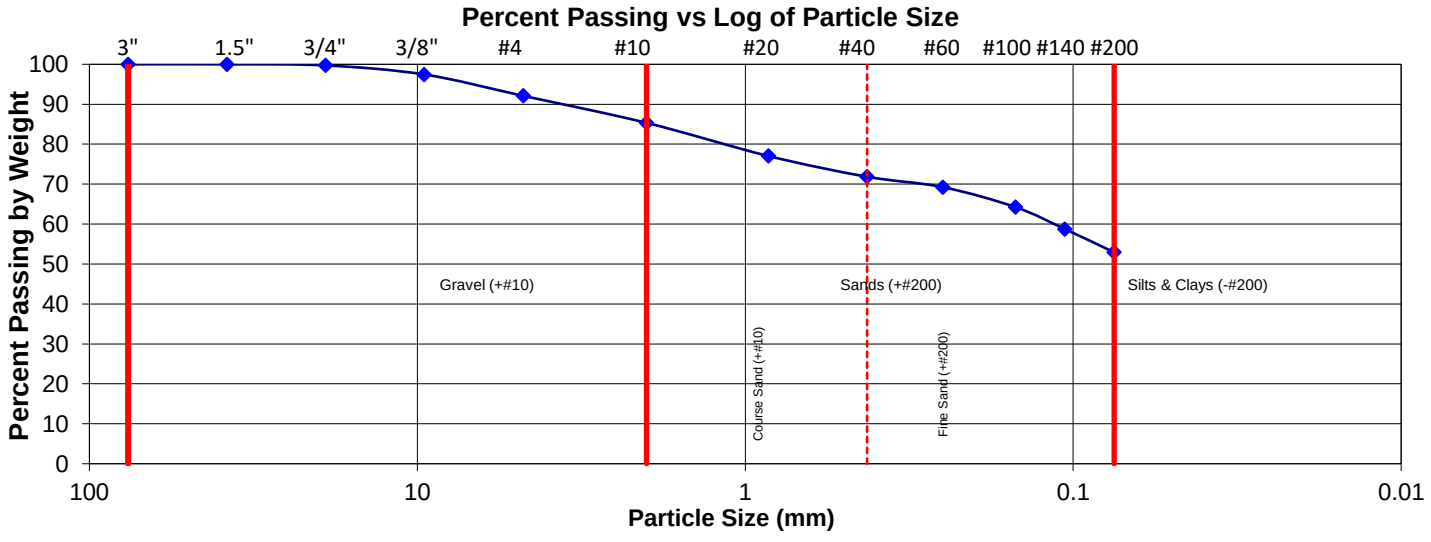
Hygroscopic Moisture of Fines

Mass Wet Pan and Soil (g):	918.53
Mass Dry Pan and Soil (g):	883.94
Mass of Pan (g):	255.83
Moisture (%):	**5.5**

Sample Data

Total Wet Mass of Sample (g):	19669.0
Total Dry Mass of Sample (g):	18667.2
Split Fraction:	3/8"
Mass of Sub-Sample Fraction (g):	662.70

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	0.0	0.0	1.00	**100.0**
3/4"	19.05	53.0	0.0	53.0	1.00	**99.7**
3/8"	9.53	422.2	0.0	422.2	1.00	**97.5**
#4	4.75	34.5	0.0	34.5	0.97	**92.1**
#10	2.00	43.6	0.0	43.6	0.97	**85.3**
#20	0.850	53.5	0.0	53.5	0.97	**77.0**
#40	0.425	33.5	0.0	33.5	0.97	**71.8**
#60	0.250	16.7	0.0	16.7	0.97	**69.3**
#100	0.150	32.3	0.0	32.3	0.97	**64.2**
#140	0.106	35.5	0.0	35.5	0.97	**58.7**
#200	0.075	37.5	0.0	37.5	0.97	**52.9**



AASHTO Classification M 145

AASHTO Classification:	A-6	Gravel (%):	14.7
Group Index:	4.30	Course Sand (%):	13.5
Atterberg Classification:	CL	Fine Sand (%):	18.9
Plastic Limit:	17	Minus #200 (%):	52.9
Liquid Limit:	31		

Data entry by:	CK	Date:	07/15/24
Checked by:	WB	Date:	07/15/24
File name:	2481335__Grain Size Analysis AASHTO T311_6.xlsm		

ADVANCED TERRA TESTING

Grain Size Analysis
AASHTO T311

CLIENT	Shannon & Wilson	BORING NO.	SW-11
JOB NO.	2481-335	DEPTH	0.9-2.5'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/19/24		
TECHNICIAN	WB		

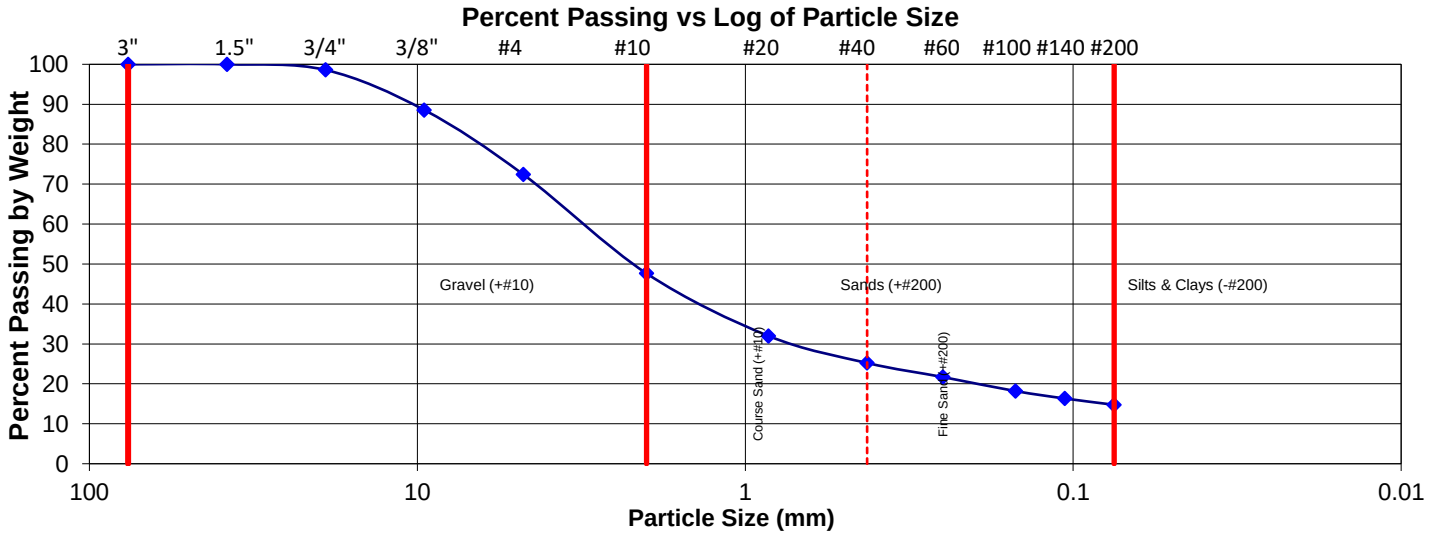
Hygroscopic Moisture of Fines

Mass Wet Pan and Soil (g):	692.32
Mass Dry Pan and Soil (g):	682.70
Mass of Pan (g):	186.83
Moisture (%):	**1.9**

Sample Data

Total Wet Mass of Sample (g):	6468.7
Total Dry Mass of Sample (g):	6359.4
Split Fraction:	3/8"
Mass of Sub-Sample Fraction (g):	505.49

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	0.0	0.0	1.00	**100.0**
3/4"	19.05	89.8	0.0	89.8	1.00	**98.6**
3/8"	9.53	637.3	0.0	637.3	1.00	**88.6**
#4	4.75	90.5	0.0	90.5	0.89	**72.4**
#10	2.00	138.7	0.0	138.7	0.89	**47.6**
#20	0.850	87.6	0.0	87.6	0.89	**32.0**
#40	0.425	37.9	0.0	37.9	0.89	**25.2**
#60	0.250	19.7	0.0	19.7	0.89	**21.7**
#100	0.150	19.7	0.0	19.7	0.89	**18.2**
#140	0.106	10.4	0.0	10.4	0.89	**16.3**
#200	0.075	8.8	0.0	8.8	0.89	**14.8**



AASHTO Classification M 145

AASHTO Classification:	A-2-4	Gravel (%):	52.4
Group Index:	-2.73	Course Sand (%):	22.4
Atterberg Classification:	CL	Fine Sand (%):	10.5
Plastic Limit:	19	Minus #200 (%):	14.8
Liquid Limit:	27		

Data entry by:	CK	Date:	07/22/24
Checked by:	MH	Date:	07/22/24
File name:	2481335__Grain Size Analysis AASHTO T311_9.xlsm		

ADVANCED TERRA TESTING

Grain Size Analysis
AASHTO T311

CLIENT	Shannon & Wilson	BORING NO.	SW-12
JOB NO.	2481-335	DEPTH	0.9-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/10/24		
TECHNICIAN	WB		

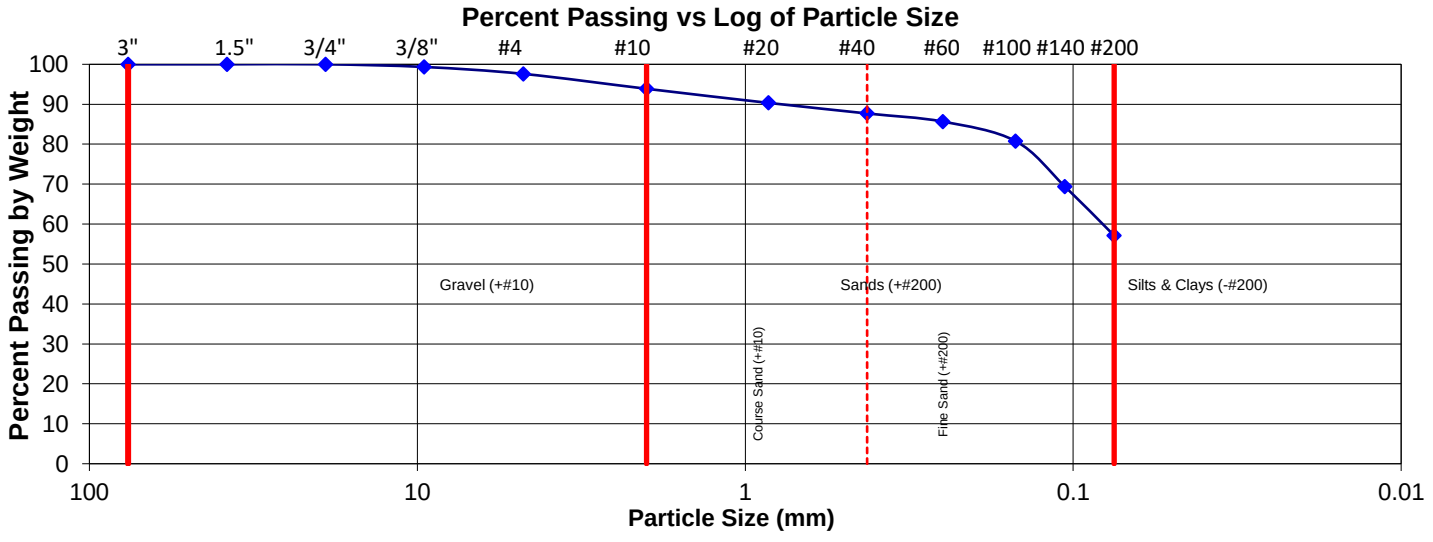
Hygroscopic Moisture of Fines

Mass Wet Pan and Soil (g):	331.23
Mass Dry Pan and Soil (g):	318.62
Mass of Pan (g):	123.60
Moisture (%):	**6.5**

Sample Data

Total Wet Mass of Sample (g):	1278.3
Total Dry Mass of Sample (g):	1202.4
Split Fraction:	#4
Mass of Sub-Sample Fraction (g):	207.63

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	0.0	0.0	0.0	1.00	**100.0**
3/8"	9.53	8.0	0.0	8.0	1.00	**99.3**
#4	4.75	20.8	0.0	20.8	1.00	**97.6**
#10	2.00	7.5	0.0	7.5	0.98	**93.9**
#20	0.850	7.1	0.0	7.1	0.98	**90.3**
#40	0.425	5.3	0.0	5.3	0.98	**87.7**
#60	0.250	4.1	0.0	4.1	0.98	**85.7**
#100	0.150	9.7	0.0	9.7	0.98	**80.8**
#140	0.106	22.8	0.0	22.8	0.98	**69.4**
#200	0.075	24.6	0.0	24.6	0.98	**57.1**



AASHTO Classification M 145

AASHTO Classification:	A-6	Gravel (%):	6.1
Group Index:	3.52	Course Sand (%):	6.2
Atterberg Classification:	CL	Fine Sand (%):	30.6
Plastic Limit:	17	Minus #200 (%):	57.1
Liquid Limit:	28		

Data entry by:	WB	Date:	07/11/24
Checked by:	MH	Date:	07/18/24
File name:	2481335__Grain Size Analysis AASHTO T311_1.xlsm		

ADVANCED TERRA TESTING

Grain Size Analysis
AASHTO T311

CLIENT	Shannon & Wilson	BORING NO.	SW-14
JOB NO.	2481-335	DEPTH	1.4-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/10/24		
TECHNICIAN	WB		

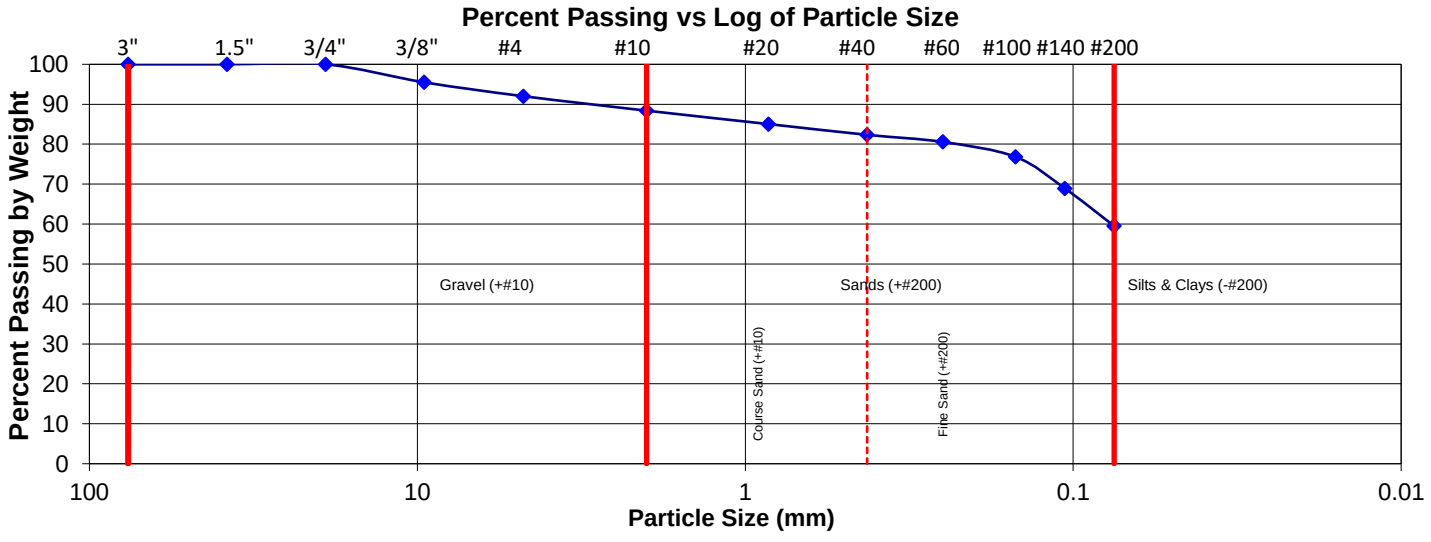
Hygroscopic Moisture of Fines

Mass Wet Pan and Soil (g):	330.09
Mass Dry Pan and Soil (g):	325.80
Mass of Pan (g):	123.50
Moisture (%):	**2.1**

Sample Data

Total Wet Mass of Sample (g):	1192.5
Total Dry Mass of Sample (g):	1169.7
Split Fraction:	#4
Mass of Sub-Sample Fraction (g):	206.59

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	0.0	0.0	0.0	1.00	**100.0**
3/8"	9.53	52.8	0.0	52.8	1.00	**95.5**
#4	4.75	40.6	0.0	40.6	1.00	**92.0**
#10	2.00	8.0	0.0	8.0	0.92	**88.4**
#20	0.850	7.4	0.0	7.4	0.92	**85.0**
#40	0.425	5.9	0.0	5.9	0.92	**82.3**
#60	0.250	3.9	0.0	3.9	0.92	**80.6**
#100	0.150	8.2	0.0	8.2	0.92	**76.8**
#140	0.106	17.4	0.0	17.4	0.92	**68.9**
#200	0.075	20.7	0.0	20.7	0.92	**59.5**



AASHTO Classification M 145

AASHTO Classification:	A-6	Gravel (%):	11.6
Group Index:	6.60	Course Sand (%):	6.1
Atterberg Classification:	CL	Fine Sand (%):	22.8
Plastic Limit:	16	Minus #200 (%):	59.5
Liquid Limit:	32		

Data entry by:	WB	Date:	07/11/24
Checked by:	CK	Date:	07/19/24
File name:	2481335__Grain Size Analysis AASHTO T311_4.xlsm		

ADVANCED TERRA TESTING

Grain Size Analysis
AASHTO T311

CLIENT	Shannon & Wilson	BORING NO.	SW-15
JOB NO.	2481-335	DEPTH	0.9-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/15/24		
TECHNICIAN	CK		

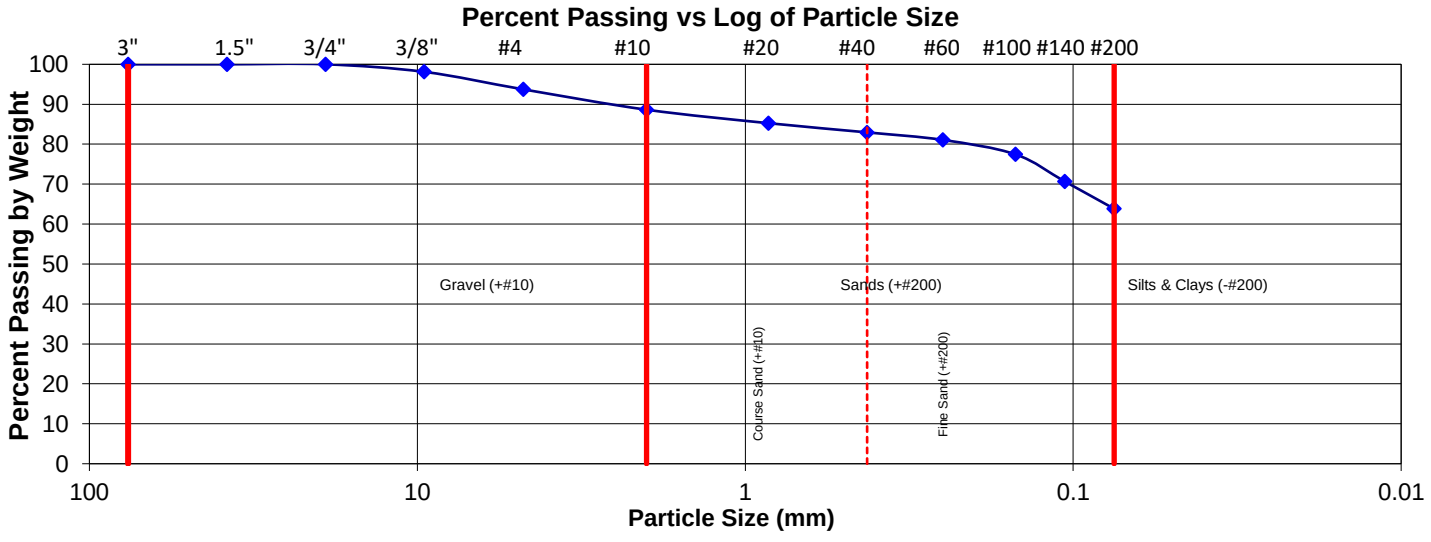
Hygroscopic Moisture of Fines

Mass Wet Pan and Soil (g):	925.49
Mass Dry Pan and Soil (g):	907.61
Mass of Pan (g):	262.17
Moisture (%):	**2.8**

Sample Data

Total Wet Mass of Sample (g):	14948.6
Total Dry Mass of Sample (g):	14553.0
Split Fraction:	3/8"
Mass of Sub-Sample Fraction (g):	663.32

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	0.0	0.0	0.0	1.00	**100.0**
3/8"	9.53	275.2	0.0	275.2	1.00	**98.1**
#4	4.75	28.8	0.0	28.8	0.98	**93.7**
#10	2.00	33.5	0.0	33.5	0.98	**88.6**
#20	0.850	22.2	0.0	22.2	0.98	**85.3**
#40	0.425	15.1	0.0	15.1	0.98	**83.0**
#60	0.250	12.4	0.0	12.4	0.98	**81.1**
#100	0.150	23.8	0.0	23.8	0.98	**77.5**
#140	0.106	44.8	0.0	44.8	0.98	**70.6**
#200	0.075	44.8	0.0	44.8	0.98	**63.8**



AASHTO Classification M 145

AASHTO Classification:	A-6	Gravel (%):	11.4
Group Index:	7.83	Course Sand (%):	5.7
Atterberg Classification:	CL	Fine Sand (%):	19.1
Plastic Limit:	18	Minus #200 (%):	63.8
Liquid Limit:	34		

Data entry by:	CK	Date:	07/16/24
Checked by:	MH	Date:	07/17/24
File name:	2481335__Grain Size Analysis AASHTO T311_8.xlsm		

ADVANCED TERRA TESTING

Atterberg Limits
AASHTO T89 T90

CLIENT	Shannon & Wilson	BORING NO.	SW-01
JOB NO.	2481-335	DEPTH	1.5-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	07/17/24	DESCRIPTION	--
TECHNICIAN	MH		

Plastic Limits

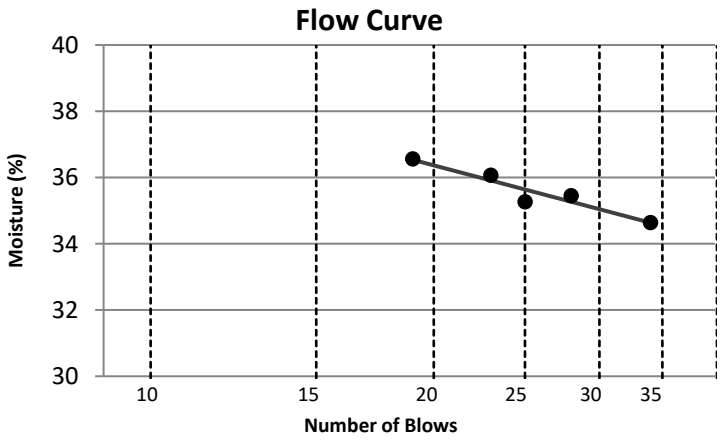
Mass of Wet Pan and Soil (g):	25.91	25.91	25.95
Mass of Dry Pan and Soil (g):	24.81	24.84	24.89
Mass of Pan (g):	18.59	18.63	18.66
Moisture (%)	**17.7**	**17.3**	**17.1**

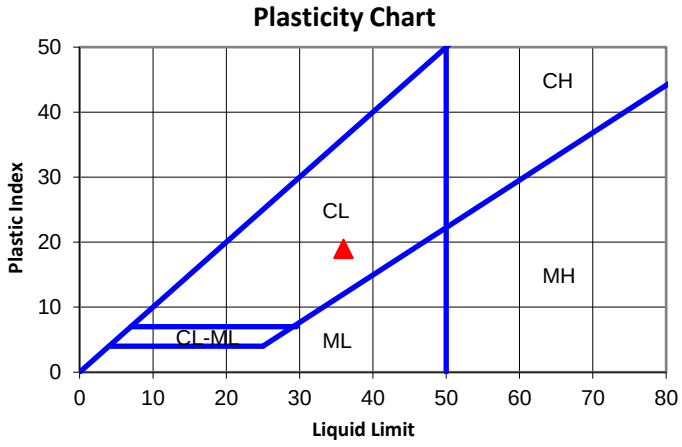
Liquid Limits

Number of Blows	19	23	28	25	34
Mass of Wet Pan and Soil (g):	23.95	23.89	23.53	24.24	25.05
Mass of Dry Pan and Soil (g):	22.31	22.49	22.03	22.78	23.39
Mass of Pan (g):	17.81	18.59	17.79	18.63	18.60
Moisture (%)	**36.6**	**36.1**	**35.4**	**35.3**	**34.6**

Plastic Index

Plastic Limit:	**17**	Atterberg Classification:	CL
Liquid Limit:	**36**	Method:	A
Plastic Index:	**19**		





NOTES

Data entry by:	MH	Date:	07/18/24
Checked by:	WB	Date:	07/19/24
File name:	2481335__Atterberg AASHTO_T89_T90_8.xlsm		

ADVANCED TERRA TESTING

Atterberg Limits
AASHTO T89 T90

CLIENT	Shannon & Wilson	BORING NO.	SW-02
JOB NO.	2481-335	DEPTH	1.5-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	07/16/24	DESCRIPTION	--
TECHNICIAN	WB		

Plastic Limits

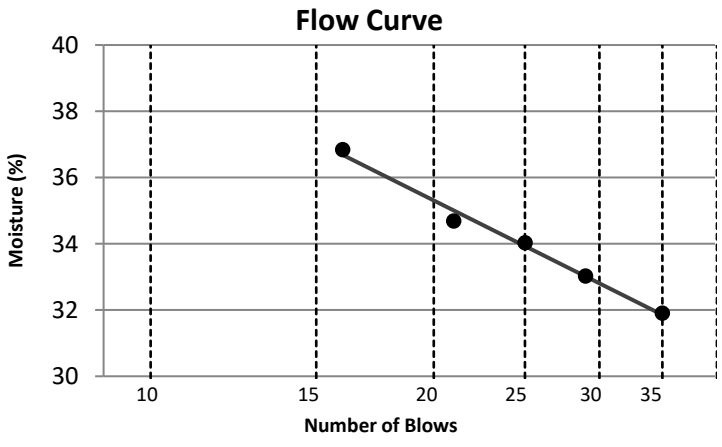
Mass of Wet Pan and Soil (g):	26.34	26.59	26.80
Mass of Dry Pan and Soil (g):	25.09	25.35	25.53
Mass of Pan (g):	18.37	18.63	18.64
Moisture (%)	**18.6**	**18.5**	**18.5**

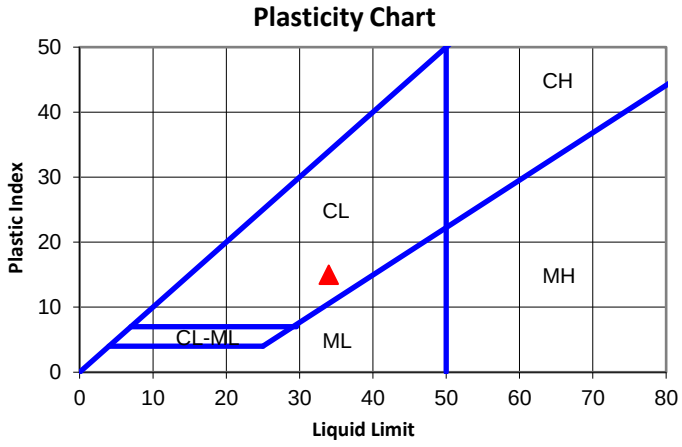
Liquid Limits

Number of Blows	16	21	25	29	35
Mass of Wet Pan and Soil (g):	30.19	28.45	28.12	28.46	25.41
Mass of Dry Pan and Soil (g):	26.97	25.70	25.73	25.95	23.76
Mass of Pan (g):	18.24	17.79	18.70	18.36	18.59
Moisture (%)	**36.8**	**34.7**	**34.0**	**33.0**	**31.9**

Plastic Index

Plastic Limit:	**19**	Atterberg Classification:	CL
Liquid Limit:	**34**	Method:	A
Plastic Index:	**15**		





NOTES

Data entry by:	WB	Date:	07/17/24
Checked by:	MH	Date:	07/17/24
File name:	2481335__Atterberg AASHTO T89_T90_3.xlsm		

ADVANCED TERRA TESTING

Atterberg Limits
AASHTO T89 T90

CLIENT	Shannon & Wilson	BORING NO.	SW-04
JOB NO.	2481-335	DEPTH	1.0-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	07/15/24	DESCRIPTION	--
TECHNICIAN	MH		

Plastic Limits

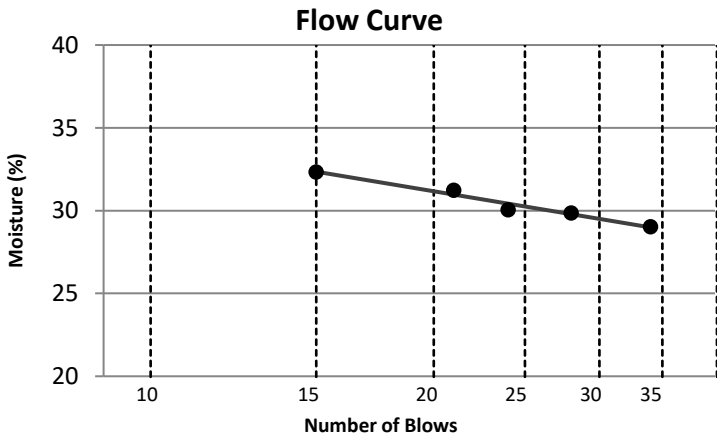
Mass of Wet Pan and Soil (g):	25.98	25.86
Mass of Dry Pan and Soil (g):	25.01	24.89
Mass of Pan (g):	18.71	18.61
Moisture (%)	**15.5**	**15.5**

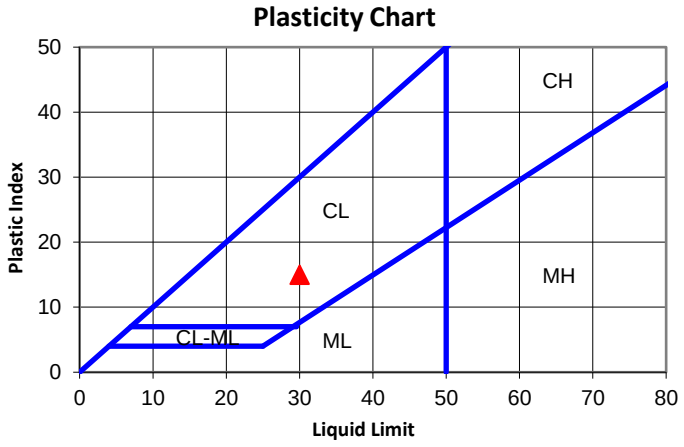
Liquid Limits

Number of Blows	15	21	24	28	34
Mass of Wet Pan and Soil (g):	25.49	24.83	25.67	24.57	24.97
Mass of Dry Pan and Soil (g):	23.81	23.31	24.04	23.00	23.56
Mass of Pan (g):	18.63	18.47	18.62	17.77	18.69
Moisture (%)	**32.3**	**31.2**	**30.1**	**29.9**	**29.0**

Plastic Index

Plastic Limit:	**15**	Atterberg Classification:	CL
Liquid Limit:	**30**	Method:	A
Plastic Index:	**15**		





NOTES

Data entry by:	MH	Date:	07/16/24
Checked by:	CK	Date:	07/17/24
File name:	2481335__Atterberg AASHTO_T89_T90_2.xlsm		

ADVANCED TERRA TESTING

Atterberg Limits
AASHTO T89 T90

CLIENT	Shannon & Wilson	BORING NO.	SW-05
JOB NO.	2481-335	DEPTH	1.0-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	07/08/24	DESCRIPTION	--
TECHNICIAN	WB		

Plastic Limits

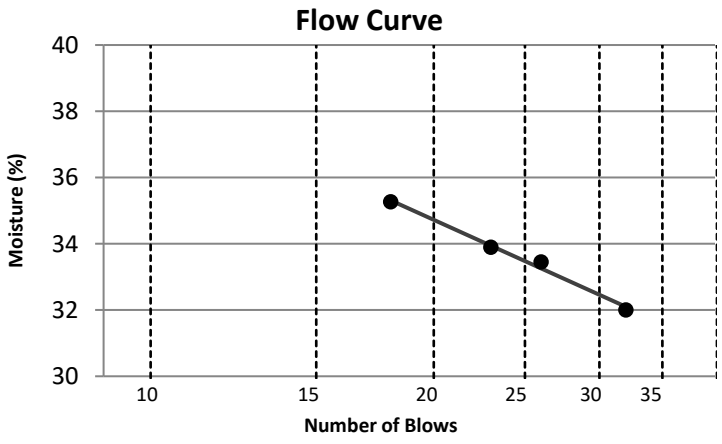
Mass of Wet Pan and Soil (g):	26.75	26.73
Mass of Dry Pan and Soil (g):	25.55	25.58
Mass of Pan (g):	18.63	18.83
Moisture (%)	**17.2**	**17.2**

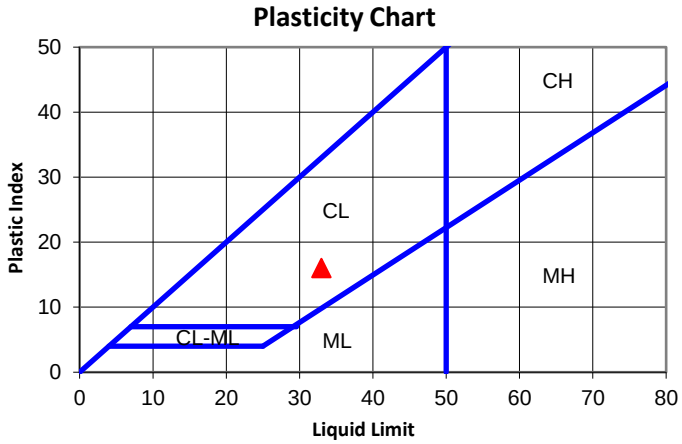
Liquid Limits

Number of Blows	18	23	26	32
Mass of Wet Pan and Soil (g):	30.07	28.79	28.45	27.06
Mass of Dry Pan and Soil (g):	27.10	26.20	25.75	25.01
Mass of Pan (g):	18.70	18.57	17.71	18.59
Moisture (%)	**35.3**	**33.9**	**33.4**	**32.0**

Plastic Index

Plastic Limit:	**17**	Atterberg Classification:	CL
Liquid Limit:	**33**	Method:	A
Plastic Index:	**16**		





NOTES

Data entry by:	WB	Date:	07/09/24
Checked by:	CK	Date:	07/17/24
File name:	2481335__Atterberg AASHTO_T89_T90_0.xlsm		

ADVANCED TERRA TESTING

Atterberg Limits
AASHTO T89 T90

CLIENT	Shannon & Wilson	BORING NO.	SW-05
JOB NO.	2481-335	DEPTH	7.0-9.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	S-4
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	08/13/24	DESCRIPTION	--
TECHNICIAN	MH		

Plastic Limits

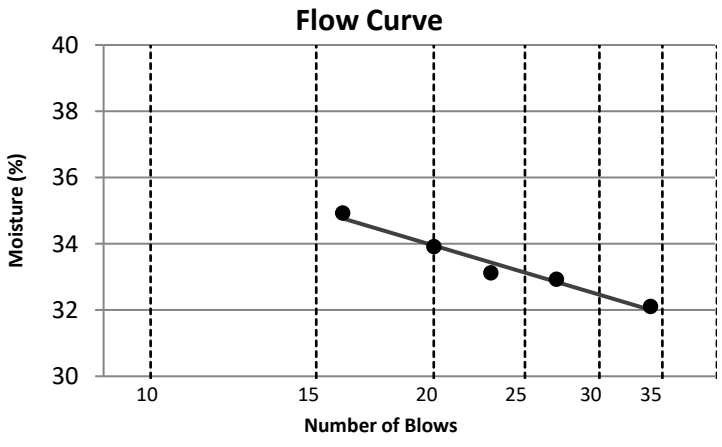
Mass of Wet Pan and Soil (g):	25.89	26.25	25.93
Mass of Dry Pan and Soil (g):	24.90	25.26	24.96
Mass of Pan (g):	18.28	18.62	18.32
Moisture (%)	**15.0**	**15.0**	**14.7**

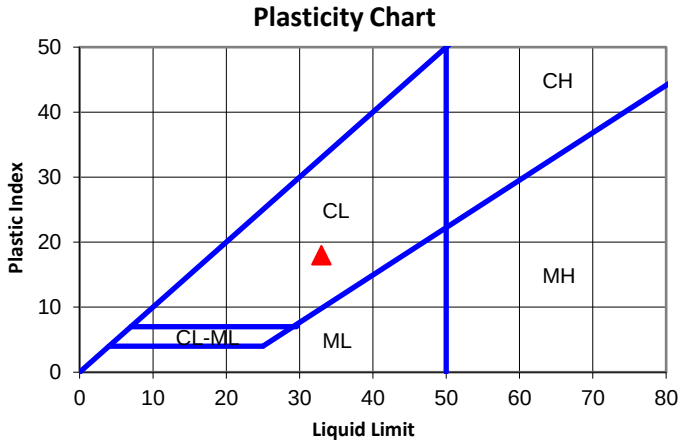
Liquid Limits

Number of Blows	16	20	23	27	34
Mass of Wet Pan and Soil (g):	25.38	25.07	25.44	25.69	25.04
Mass of Dry Pan and Soil (g):	23.64	23.19	23.74	23.87	23.45
Mass of Pan (g):	18.66	17.67	18.59	18.35	18.50
Moisture (%)	**34.9**	**33.9**	**33.1**	**32.9**	**32.1**

Plastic Index

Plastic Limit:	**15**	Atterberg Classification:	CL
Liquid Limit:	**33**	Method:	A
Plastic Index:	**18**		





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Data entry by:	BDF	Date:	08/14/24
Checked by:	CK	Date:	08/14/24
File name:	2481335__Atterberg AASHTO_T89_T90_10.xlsm		

ADVANCED TERRA TESTING

Atterberg Limits
AASHTO T89 T90

CLIENT	Shannon & Wilson	BORING NO.	SW-06
JOB NO.	2481-335	DEPTH	4.0-6.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	S-8
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	08/13/24	DESCRIPTION	--
TECHNICIAN	MH		

Plastic Limits

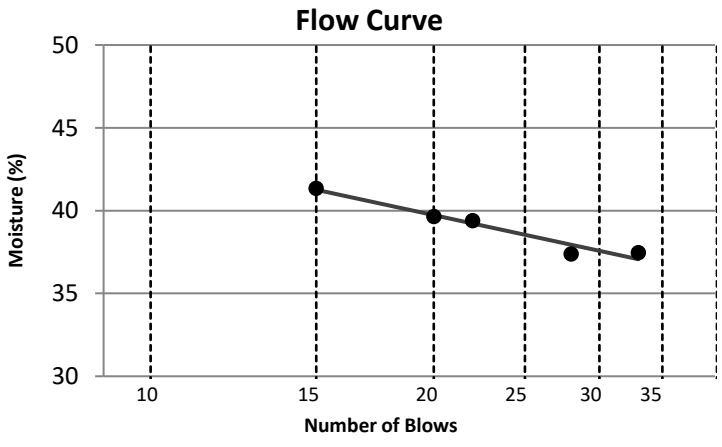
Mass of Wet Pan and Soil (g):	26.24	25.99	25.26
Mass of Dry Pan and Soil (g):	25.07	24.83	24.10
Mass of Pan (g):	18.63	18.39	17.66
Moisture (%)	**18.1**	**18.0**	**18.0**

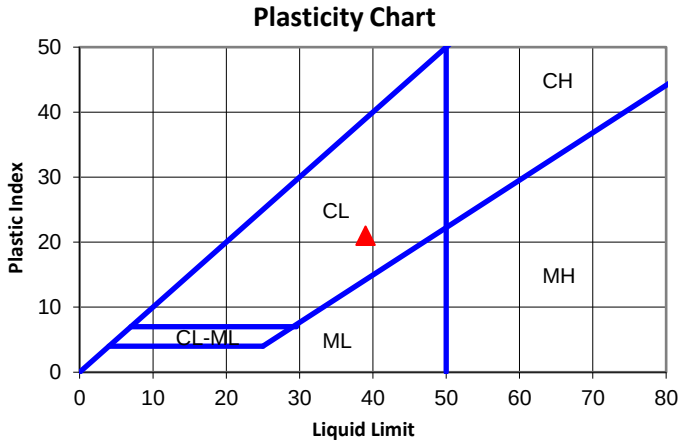
Liquid Limits

Number of Blows	15	20	22	33	28
Mass of Wet Pan and Soil (g):	25.04	25.59	24.92	25.08	25.11
Mass of Dry Pan and Soil (g):	23.12	23.63	23.10	23.38	23.34
Mass of Pan (g):	18.47	18.68	18.48	18.83	18.60
Moisture (%)	**41.3**	**39.6**	**39.4**	**37.5**	**37.4**

Plastic Index

Plastic Limit:	**18**	Atterberg Classification:	CL
Liquid Limit:	**39**	Method:	A
Plastic Index:	**21**		





NOTES

Data entry by:	BDF	Date:	08/14/24
Checked by:	CK	Date:	08/14/24
File name:	2481335__Atterberg AASHTO_T89_T90_11.xlsm		

ADVANCED TERRA TESTING

Atterberg Limits
AASHTO T89 T90

CLIENT	Shannon & Wilson	BORING NO.	SW-07
JOB NO.	2481-335	DEPTH	1.5-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	07/15/24	DESCRIPTION	--
TECHNICIAN	CK		

Plastic Limits

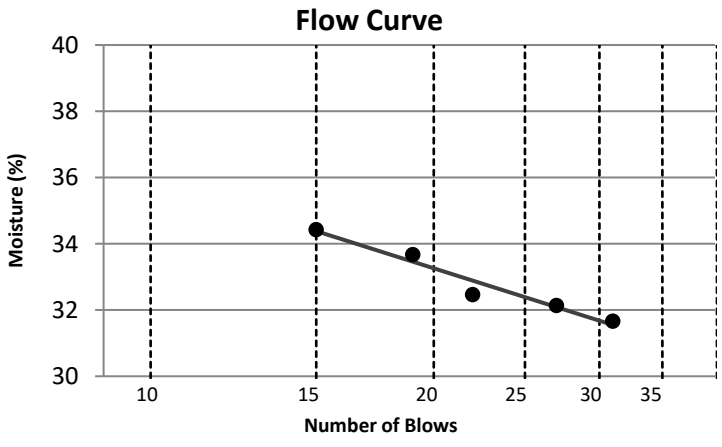
Mass of Wet Pan and Soil (g):	26.62	26.55	26.90
Mass of Dry Pan and Soil (g):	25.53	25.54	25.84
Mass of Pan (g):	18.34	18.72	18.66
Moisture (%)	**15.1**	**14.9**	**14.8**

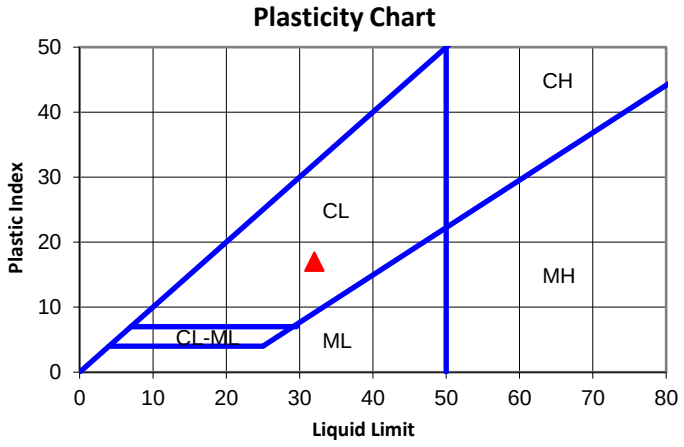
Liquid Limits

Number of Blows	15	19	22	27	31
Mass of Wet Pan and Soil (g):	31.71	29.88	30.64	32.27	30.80
Mass of Dry Pan and Soil (g):	28.37	27.04	27.71	28.97	27.85
Mass of Pan (g):	18.68	18.58	18.68	18.69	18.53
Moisture (%)	**34.4**	**33.7**	**32.5**	**32.1**	**31.7**

Plastic Index

Plastic Limit:	**15**	Atterberg Classification:	CL
Liquid Limit:	**32**	Method:	A
Plastic Index:	**17**		





NOTES

Data entry by:	CK	Date:	07/16/24
Checked by:	WB	Date:	07/17/24
File name:	2481335__Atterberg AASHTO_T89_T90_1.xlsm		

ADVANCED TERRA TESTING

Atterberg Limits
AASHTO T89 T90

CLIENT	Shannon & Wilson	BORING NO.	SW-09
JOB NO.	2481-335	DEPTH	0.9-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	07/16/24	DESCRIPTION	--
TECHNICIAN	MH		

Plastic Limits

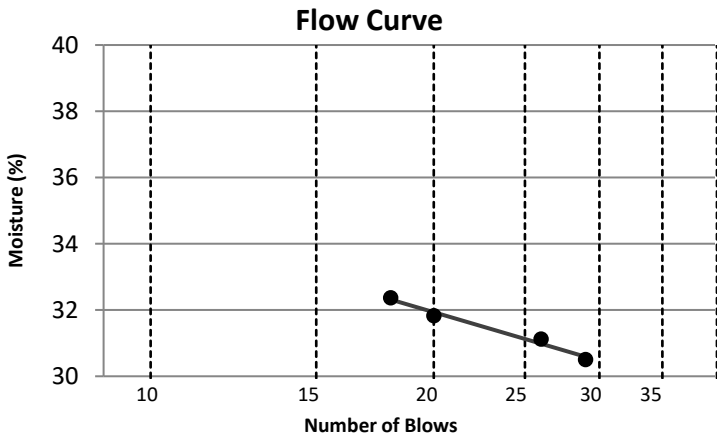
Mass of Wet Pan and Soil (g):	26.11	25.93
Mass of Dry Pan and Soil (g):	25.02	24.83
Mass of Pan (g):	18.63	18.44
Moisture (%)	**17.2**	**17.1**

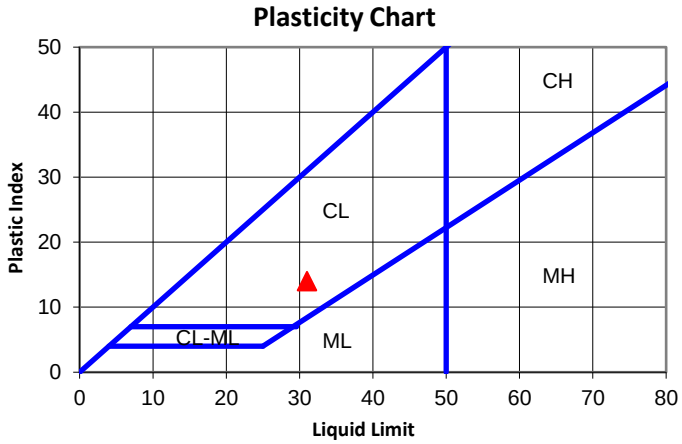
Liquid Limits

Number of Blows	18	20	26	29
Mass of Wet Pan and Soil (g):	24.33	23.19	23.83	24.07
Mass of Dry Pan and Soil (g):	22.96	21.87	22.54	22.77
Mass of Pan (g):	18.71	17.73	18.39	18.51
Moisture (%)	**32.4**	**31.8**	**31.1**	**30.5**

Plastic Index

Plastic Limit:	**17**	Atterberg Classification:	CL
Liquid Limit:	**31**	Method:	A
Plastic Index:	**14**		





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Data entry by: MH — Date: 07/17/24
Checked by: CK — Date: 07/18/24
File name: 2481335__Atterberg AASHTO_T89_T90_7.xlsm

ADVANCED TERRA TESTING

Atterberg Limits
AASHTO T89 T90

CLIENT	Shannon & Wilson	BORING NO.	SW-11
JOB NO.	2481-335	DEPTH	0.9-2.5'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	07/19/24	DESCRIPTION	--
TECHNICIAN	CK		

Plastic Limits

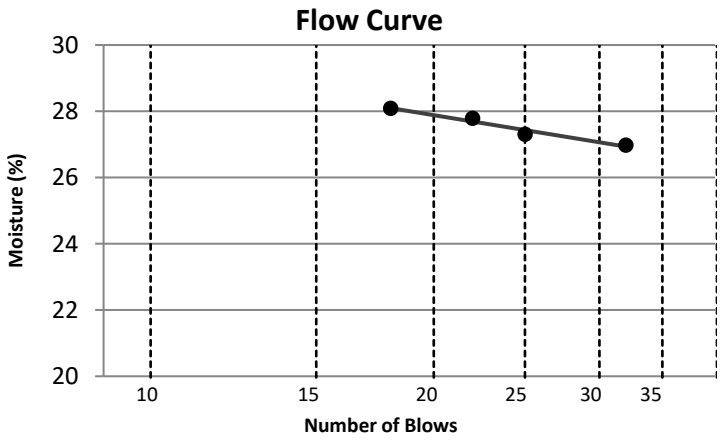
Mass of Wet Pan and Soil (g):	28.32	28.28
Mass of Dry Pan and Soil (g):	26.81	26.78
Mass of Pan (g):	18.67	18.69
Moisture (%)	**18.6**	**18.6**

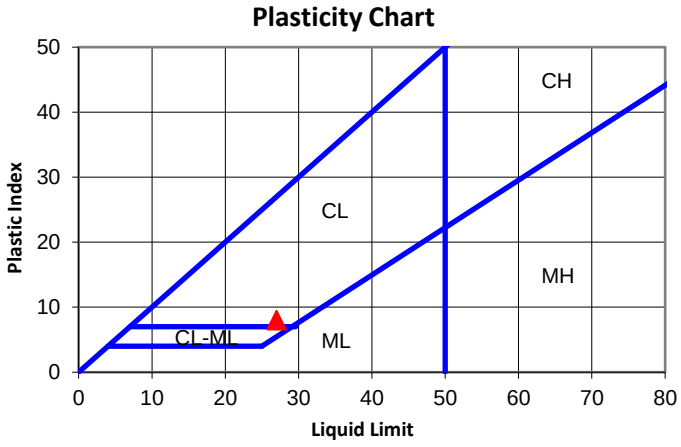
Liquid Limits

Number of Blows	18	22	25	32
Mass of Wet Pan and Soil (g):	27.11	26.59	25.45	27.70
Mass of Dry Pan and Soil (g):	25.27	24.83	23.98	25.80
Mass of Pan (g):	18.72	18.51	18.57	18.73
Moisture (%)	**28.1**	**27.8**	**27.3**	**27.0**

Plastic Index

Plastic Limit:	**19**	Atterberg Classification:	CL
Liquid Limit:	**27**	Method:	A
Plastic Index:	**8**		





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Data entry by:	CK	Date:	07/22/24
Checked by:	MH	Date:	07/22/24
File name:	2481335__Atterberg AASHTO_T89_T90_9.xlsm		

ADVANCED TERRA TESTING

Atterberg Limits
AASHTO T89 T90

CLIENT	Shannon & Wilson	BORING NO.	SW-12
JOB NO.	2481-335	DEPTH	0.9-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	07/16/24	DESCRIPTION	--
TECHNICIAN	MH		

Plastic Limits

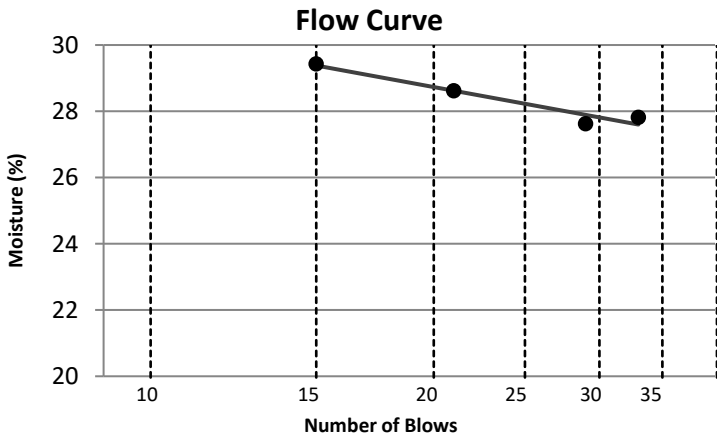
Mass of Wet Pan and Soil (g):	25.88	26.40
Mass of Dry Pan and Soil (g):	24.79	25.32
Mass of Pan (g):	18.28	18.81
Moisture (%)	**16.8**	**16.5**

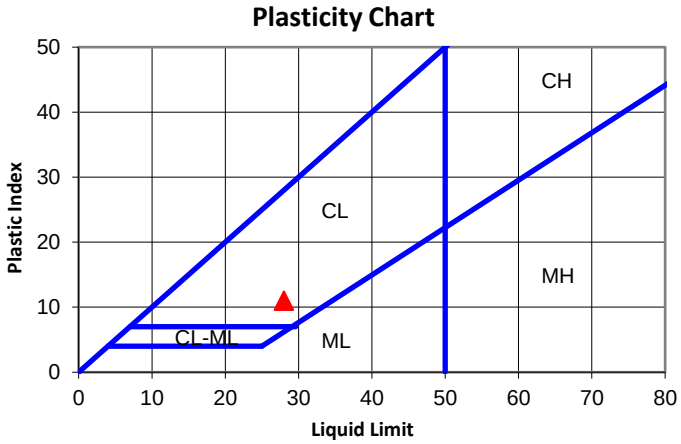
Liquid Limits

Number of Blows	15	21	33	29
Mass of Wet Pan and Soil (g):	23.94	24.39	23.30	24.61
Mass of Dry Pan and Soil (g):	22.70	23.11	22.07	23.33
Mass of Pan (g):	18.49	18.66	17.65	18.69
Moisture (%)	**29.4**	**28.6**	**27.8**	**27.6**

Plastic Index

Plastic Limit:	**17**	Atterberg Classification:	CL
Liquid Limit:	**28**	Method:	A
Plastic Index:	**11**		





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Data entry by:	MH	Date:	07/17/24
Checked by:	WB	Date:	07/19/24
File name:	2481335__Atterberg AASHTO_T89_T90_6.xlsm		

ADVANCED TERRA TESTING

Atterberg Limits
AASHTO T89 T90

CLIENT	Shannon & Wilson	BORING NO.	SW-14
JOB NO.	2481-335	DEPTH	1.4-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	07/16/24	DESCRIPTION	--
TECHNICIAN	MH		

Plastic Limits

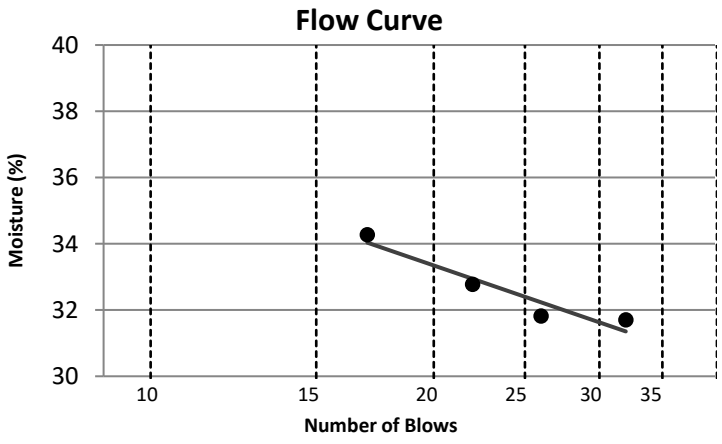
Mass of Wet Pan and Soil (g):	25.58	25.52
Mass of Dry Pan and Soil (g):	24.57	24.52
Mass of Pan (g):	18.31	18.30
Moisture (%)	**16.2**	**16.1**

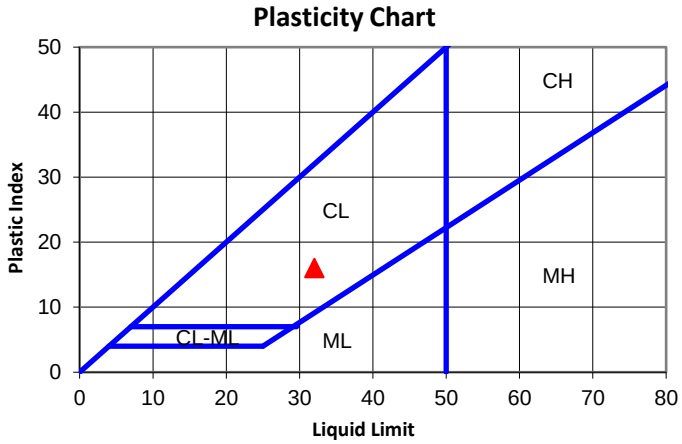
Liquid Limits

Number of Blows	17	22	26	32
Mass of Wet Pan and Soil (g):	23.40	24.02	24.62	24.35
Mass of Dry Pan and Soil (g):	21.95	22.72	23.19	23.00
Mass of Pan (g):	17.75	18.74	18.67	18.73
Moisture (%)	**34.3**	**32.8**	**31.8**	**31.7**

Plastic Index

Plastic Limit:	**16**	Atterberg Classification:	CL
Liquid Limit:	**32**	Method:	A
Plastic Index:	**16**		





NOTES

Data entry by:	MH	Date:	07/17/24
Checked by:	CK	Date:	07/19/24
File name:	2481335__Atterberg AASHTO_T89_T90_5.xlsm		

ADVANCED TERRA TESTING

Atterberg Limits
AASHTO T89 T90

CLIENT	Shannon & Wilson	BORING NO.	SW-15
JOB NO.	2481-335	DEPTH	0.9-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	07/16/24	DESCRIPTION	--
TECHNICIAN	WB		

Plastic Limits

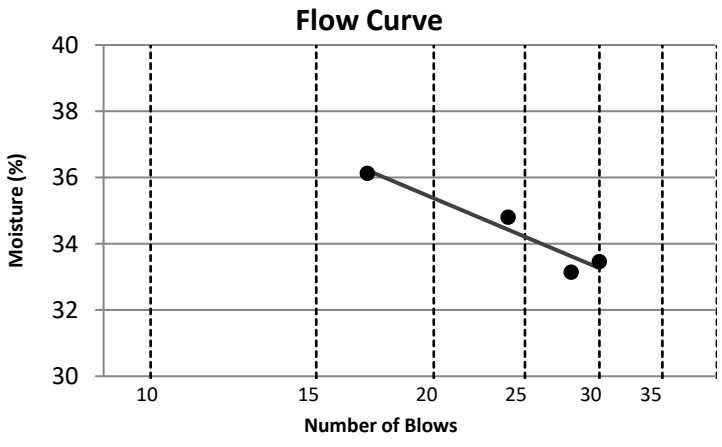
Mass of Wet Pan and Soil (g):	26.52	26.74
Mass of Dry Pan and Soil (g):	25.24	25.47
Mass of Pan (g):	18.29	18.43
Moisture (%)	**18.3**	**18.1**

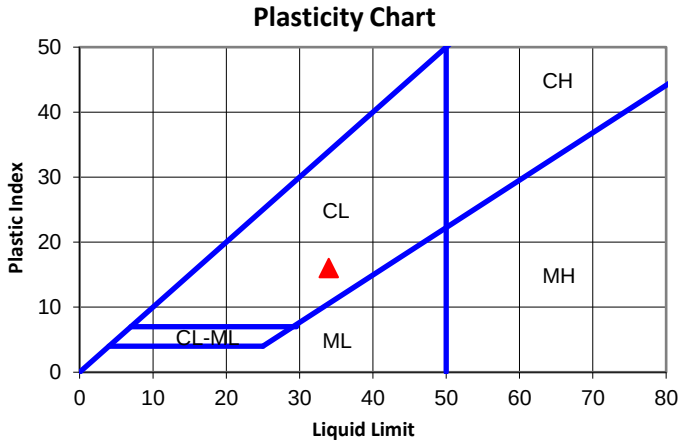
Liquid Limits

Number of Blows	17	24	30	28
Mass of Wet Pan and Soil (g):	27.70	30.68	30.60	24.90
Mass of Dry Pan and Soil (g):	25.31	27.61	27.60	23.26
Mass of Pan (g):	18.72	18.77	18.65	18.31
Moisture (%)	**36.1**	**34.8**	**33.5**	**33.1**

Plastic Index

Plastic Limit:	**18**	Atterberg Classification:	CL
Liquid Limit:	**34**	Method:	A
Plastic Index:	**16**		





NOTES

Data entry by:	WB	Date:	07/17/24
Checked by:	MH	Date:	07/17/24
File name:	2481335__Atterberg AASHTO_T89_T90_4.xlsm		

ADVANCED TERRA TESTING

Chemical Analysis

CLIENT	Shannon & Wilson	BORING NO.	SW-01
JOB NO.	2481-335	DEPTH	1.5-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/25/24		
TECHNICIAN	WB		

Sulfate Concentration - AASHTO T290B

Measured Sulfate Concentration (ppm):	14.14
Dilution:	25.00:1
Sulfate Concentration (ppm):	354

Chloride Concentration - AASHTO T291A

Dillution:	10.00:1
Cartridge Multiplier:	0.23
Titrator Reading:	26
Chloride Concentration (ppm):	58.5

Ph - AASHTO T289

pH:	7.5
Temperature (°C):	23.2

Resistivity - AASHTO T288

Minimum Measured Resistivity (Ω):	734
Temperature (°C):	22.4
Box Correction Factor (cm):	2.00
Minimum Resistivity (Ω·cm):	1468

Sulfide Concentration - ASTM D4658

Measured Sulfide Concentration (ppm):	--
Dilution:	--
Sulfide Concentration (ppm):	--

Oxidation-Reduction Potential - ASTM D1498

ORP (mV):	--
Temperature (°C):	--

Carbonate Content - ASTM D4373

Pressure (psi):	--
Sample Weight (g):	--
Percent Calcite Equivalent:	--

NOTES

Data entry by:	WB	Date: 07/25/24
Checked by:	BDF	Date: 07/29/24
File name:	2481335__Chemical Analysis_1.xlsm	

ADVANCED TERRA TESTING

Chemical Analysis

CLIENT	Shannon & Wilson	BORING NO.	SW-05
JOB NO.	2481-335	DEPTH	1.0-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	--
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/25/24		
TECHNICIAN	WB		

Sulfate Concentration - AASHTO T290B

Measured Sulfate Concentration (ppm):	39.66
Dilution:	10.00:1
Sulfate Concentration (ppm):	397

Chloride Concentration - AASHTO T291A

Dillution:	10.00:1
Cartridge Multiplier:	0.23
Titrator Reading:	36
Chloride Concentration (ppm):	81.2

Ph - AASHTO T289

pH:	7.8
Temperature (°C):	24.5

Resistivity - AASHTO T288

Minimum Measured Resistivity (Ω):	729
Temperature (°C):	22.5
Box Correction Factor (cm):	2.00
Minimum Resistivity (Ω·cm):	1458

Sulfide Concentration - ASTM D4658

Measured Sulfide Concentration (ppm):	--
Dilution:	--
Sulfide Concentration (ppm):	--

Oxidation-Reduction Potential - ASTM D1498

ORP (mV):	--
Temperature (°C):	--

Carbonate Content - ASTM D4373

Pressure (psi):	--
Sample Weight (g):	--
Percent Calcite Equivalent:	--

NOTES

Data entry by:	WB	Date: 07/25/24
Checked by:	BDF	Date: 07/29/24
File name:	2481335__Chemical Analysis_2.xlsm	

ADVANCED TERRA TESTING

Chemical Analysis

CLIENT	Shannon & Wilson	BORING NO.	SW-09
JOB NO.	2481-335	DEPTH	0.9-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	G-1
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/25/24		
TECHNICIAN	WB		

Sulfate Concentration - AASHTO T290B

Measured Sulfate Concentration (ppm):	29.49
Dilution:	10.00:1
Sulfate Concentration (ppm):	295

Chloride Concentration - AASHTO T291A

Dillution:	10.00:1
Cartridge Multiplier:	0.23
Titrator Reading:	19
Chloride Concentration (ppm):	42.8

Ph - AASHTO T289

pH:	6.7
Temperature (°C):	25.0

Resistivity - AASHTO T288

Minimum Measured Resistivity (Ω):	906
Temperature (°C):	22.9
Box Correction Factor (cm):	2.00
Minimum Resistivity (Ω·cm):	1812

Sulfide Concentration - ASTM D4658

Measured Sulfide Concentration (ppm):	--
Dilution:	--
Sulfide Concentration (ppm):	--

Oxidation-Reduction Potential - ASTM D1498

ORP (mV):	--
Temperature (°C):	--

Carbonate Content - ASTM D4373

Pressure (psi):	--
Sample Weight (g):	--
Percent Calcite Equivalent:	--

NOTES

Data entry by:	WB	Date: 07/25/24
Checked by:	BDF	Date: 07/29/24
File name:	2481335__Chemical Analysis_3.xlsm	

ADVANCED TERRA TESTING

Chemical Analysis

CLIENT	Shannon & Wilson	BORING NO.	SW-15
JOB NO.	2481-335	DEPTH	0.9-5.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	--
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/25/24		
TECHNICIAN	WB		

Sulfate Concentration - AASHTO T290B

Measured Sulfate Concentration (ppm):	25.55
Dilution:	5.00:1
Sulfate Concentration (ppm):	128

Chloride Concentration - AASHTO T291A

Dillution:	10.00:1
Cartridge Multiplier:	0.23
Titrator Reading:	25
Chloride Concentration (ppm):	56.3

Ph - AASHTO T289

pH:	7.7
Temperature (°C):	25.1

Resistivity - AASHTO T288

Minimum Measured Resistivity (Ω):	1250
Temperature (°C):	22.4
Box Correction Factor (cm):	2.00
Minimum Resistivity (Ω·cm):	2500

Sulfide Concentration - ASTM D4658

Measured Sulfide Concentration (ppm):	--
Dilution:	--
Sulfide Concentration (ppm):	--

Oxidation-Reduction Potential - ASTM D1498

ORP (mV):	--
Temperature (°C):	--

Carbonate Content - ASTM D4373

Pressure (psi):	--
Sample Weight (g):	--
Percent Calcite Equivalent:	--

NOTES

Data entry by:	WB	Date: 07/25/24
Checked by:	BDF	Date: 07/29/24
File name:	2481335__Chemical Analysis_4.xlsm	

ADVANCED TERRA TESTING

One-Dimensional Consolidation

ASTM D 2435

CLIENT	Shannon & Wilson	BORING NO.	SW-05
JOB NO.	2481-335	DEPTH	7-9'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	S-4
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	07/23/24	DESCRIPTION	--
TECHNICIAN	AC		

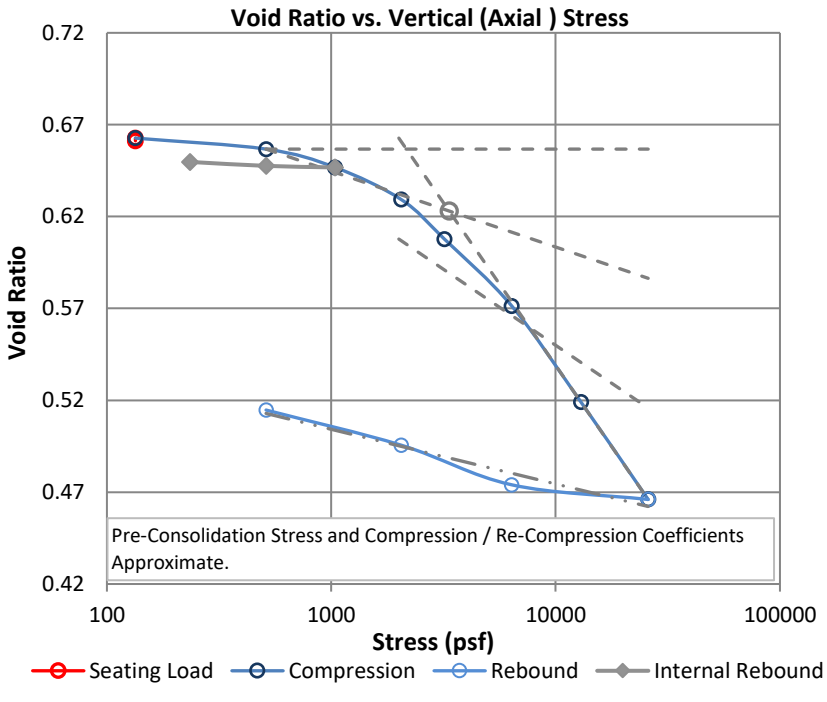
Sample Conditions

Before Test Mass of Wet Soil and Ring (g):	191.35	Initial Wet Density (pcf):	121.6
After Test Mass of Wet Soil and Ring (g):	188.93	Initial Dry Density (pcf):	99.6
Mass of Dry Soil, Ring, and Pan (g):	214.14	Initial Wet Density (kg/m³):	1948
Diameter (in):	2.41	Initial Dry Density (kg/m³):	1595
Initial Height (in):	1.00	Initial Moisture (%):	22.1
Mass of Ring (g):	45.75	Final Wet Density (pcf):	131.2
Mass of Pan (g):	49.13	Final Dry Density (pcf):	109.3
Assumed Specific Gravity:	2.65	Final Wet Density (kg/m³):	2102
Initial Saturation (%):	88.7	Final Dry Density (kg/m³):	1751
Final Saturation (%):	100.0	Final Moisture (%):	20.1

Consolidation Data

Coefficient of Compression:	0.177	Pre-Consolidation Stress (psf):	3350
Coefficient of Re-Compression:	0.030	Pre-Consolidation Stress (kPa):	161

Load (psf)	Void Ratio	Deformation (in)	Strain (%)
134	0.661	0.0000	0.00
Inundation	0.663	-0.0009	-0.09
512	0.657	0.0027	0.27
1040	0.647	0.0087	0.87
2048	0.629	0.0192	1.92
3195	0.608	0.0322	3.22
6377	0.571	0.0541	5.41
12975	0.519	0.0856	8.56
25854	0.466	0.1175	11.75
Rebound			
25854	0.466	0.1175	11.75
6377	0.474	0.1127	11.27
2048	0.496	0.0997	9.97
512	0.515	0.0882	8.82
Internal			
1040	0.647	0.0087	0.87
512	0.648	0.0082	0.82
235	0.650	0.0069	0.69



NOTES:

Data entry by:	AC	Date:	08/13/24
Checked by:	BDF	Date:	08/13/24
File name:	2481335__Consol ASTM D2435_0.xlsm		Page 1 of 3

ADVANCED TERRA TESTING

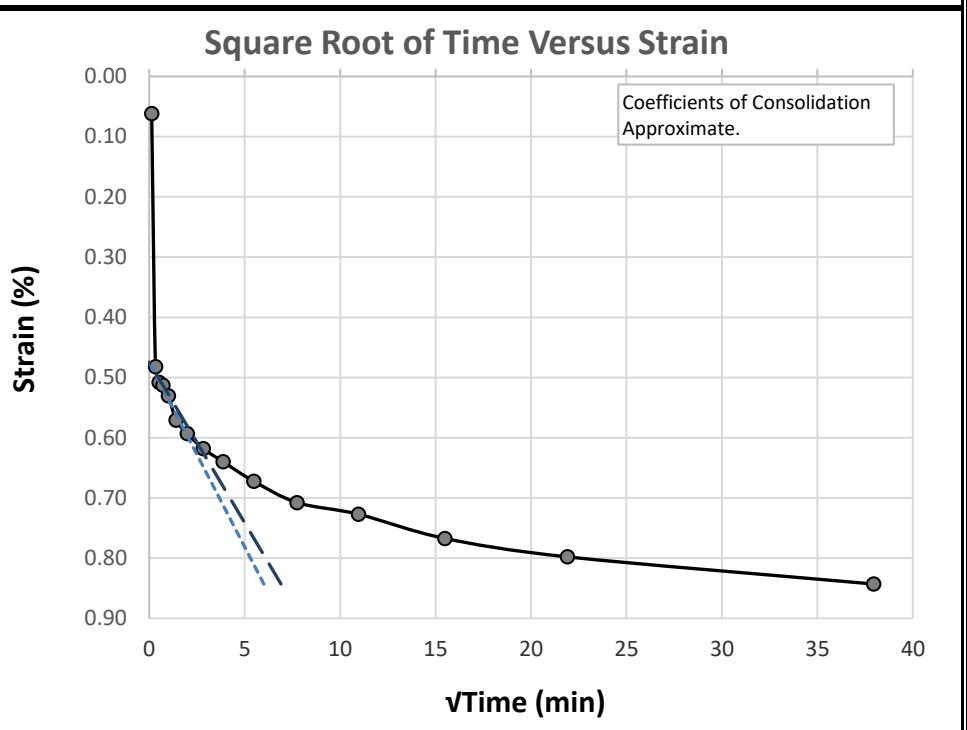
One-Dimensional Consolidation

ASTM D 2435

CLIENT	Shannon & Wilson	BORING NO.	SW-05
JOB NO.	2481-335	DEPTH	7-9'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	S-4
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	07/23/24	DESCRIPTION	--
TECHNICIAN	AC		

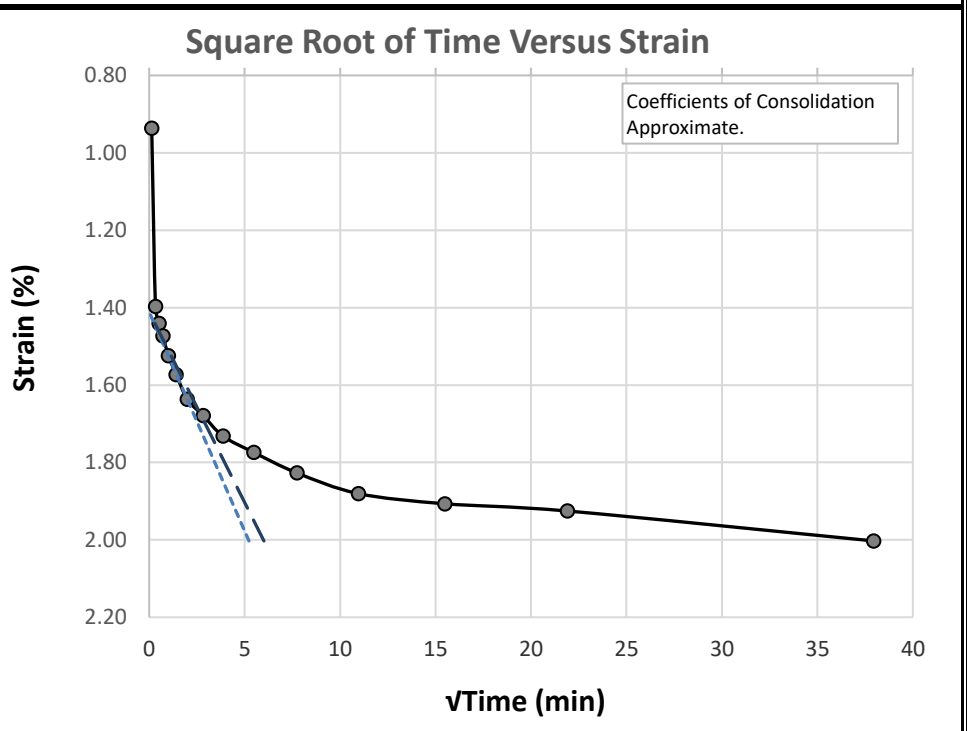
Coefficient of Consolidation (cm^2/s)	T90 (min)	Load (psf)
0.0035	6.351	1040

Elapsed Time (min)	Deformation (in)	Strain (%)
0	-0.0050	0.06
0.1	-0.0092	0.48
0.27	-0.0095	0.51
0.5	-0.0095	0.51
1	-0.0097	0.53
2	-0.0101	0.57
4	-0.0103	0.59
8	-0.0106	0.62
15	-0.0108	0.64
30	-0.0111	0.67
60	-0.0115	0.71
120	-0.0117	0.73
240	-0.0121	0.77
480	-0.0124	0.80
1440	-0.0128	0.84



Coefficient of Consolidation (cm^2/s)	T90 (min)	Load (psf)
0.0032	6.796	2048

Elapsed Time (min)	Deformation (in)	Strain (%)
0	-0.0138	0.94
0.1	-0.0184	1.40
0.27	-0.0188	1.44
0.5	-0.0191	1.47
1	-0.0196	1.52
2	-0.0201	1.57
4	-0.0208	1.64
8	-0.0212	1.68
15	-0.0217	1.73
30	-0.0221	1.77
60	-0.0227	1.83
120	-0.0232	1.88
240	-0.0235	1.91
480	-0.0237	1.93
1440	-0.0244	2.00



Data Files 2481-335_SW-05_7_S-4_1040PSF_07-24.txt, 2481-335_SW-05_7_S-4_2048PSF_07-26.txt

File name: 2481335__Consol ASTM D2435_0.xlsm

ADVANCED TERRA TESTING

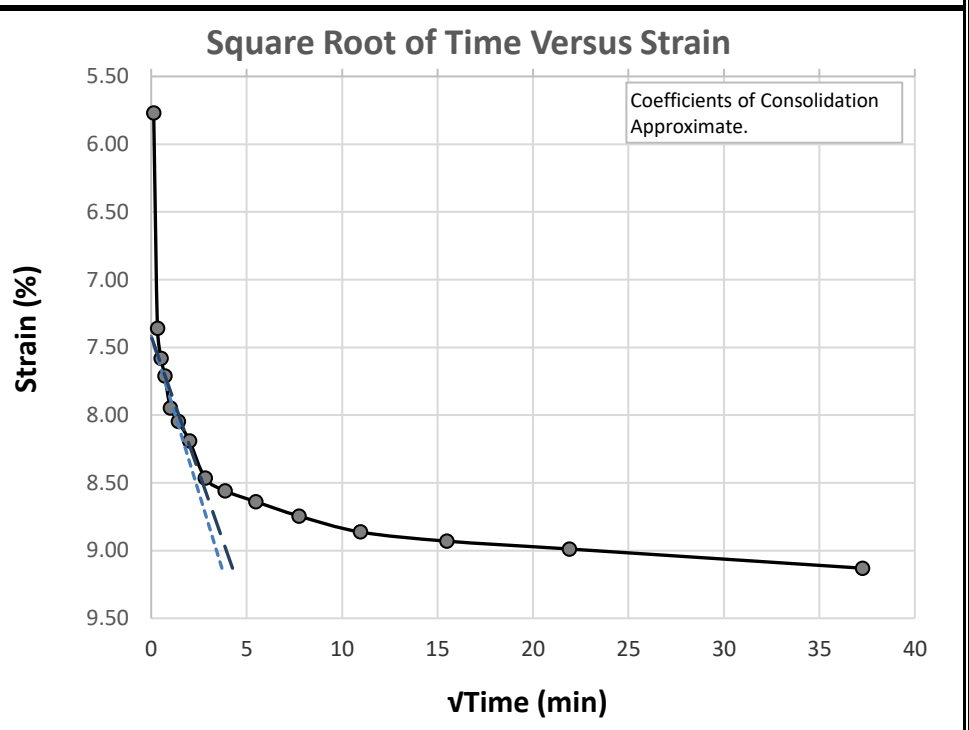
One-Dimensional Consolidation

ASTM D 2435

CLIENT	Shannon & Wilson	BORING NO.	SW-05
JOB NO.	2481-335	DEPTH	7-9'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	S-4
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	07/23/24	DESCRIPTION	--
TECHNICIAN	AC		

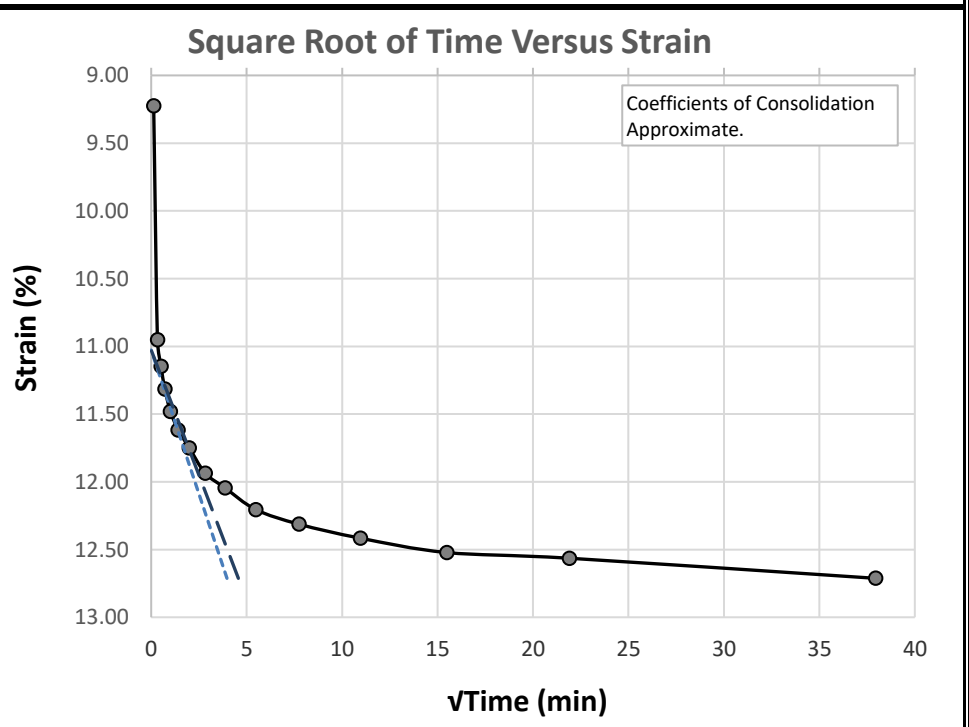
Coefficient of Consolidation (cm^2/s)	T90 (min)	Load (psf)
0.0060	3.230	12975

Elapsed Time (min)	Deformation (in)	Strain (%)
0	-0.0621	5.77
0.1	-0.0780	7.36
0.27	-0.0802	7.58
0.5	-0.0815	7.71
1	-0.0839	7.95
2	-0.0849	8.05
4	-0.0863	8.19
8	-0.0890	8.46
15	-0.0900	8.56
30	-0.0908	8.64
60	-0.0919	8.75
120	-0.0930	8.86
240	-0.0937	8.93
480	-0.0943	8.99
1389	-0.0957	9.13



Coefficient of Consolidation (cm^2/s)	T90 (min)	Load (psf)
0.0050	3.585	25854

Elapsed Time (min)	Deformation (in)	Strain (%)
0	-0.0967	9.23
0.1	-0.1139	10.95
0.27	-0.1159	11.15
0.5	-0.1176	11.32
1	-0.1192	11.48
2	-0.1206	11.62
4	-0.1219	11.75
8	-0.1238	11.94
15	-0.1249	12.05
30	-0.1264	12.20
60	-0.1275	12.31
120	-0.1286	12.42
240	-0.1296	12.52
480	-0.1300	12.56
1440	-0.1315	12.71



Data Files 2481-335_SW-05_7_S-4_12975PSF_07-31.txt, 2481-335_SW-05_7_S-4_25854PSF_08-01.txt

File name: 2481335__Consol ASTM D2435_0.xlsm

ADVANCED TERRA TESTING

Atterberg Limits
ASTM D 4318

CLIENT	Shannon & Wilson	BORING NO.	SW-05
JOB NO.	2481-335	DEPTH	7.0-9.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	S-4
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	08/13/24	DESCRIPTION	--
TECHNICIAN	MH		

Plastic Limits

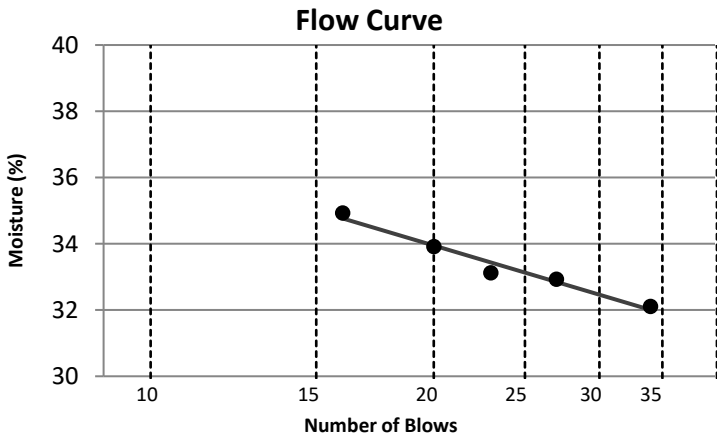
Mass of Wet Pan and Soil (g):	25.89	26.25	25.93
Mass of Dry Pan and Soil (g):	24.90	25.26	24.96
Mass of Pan (g):	18.28	18.62	18.32
Moisture (%)	**15.0**	**15.0**	**14.7**

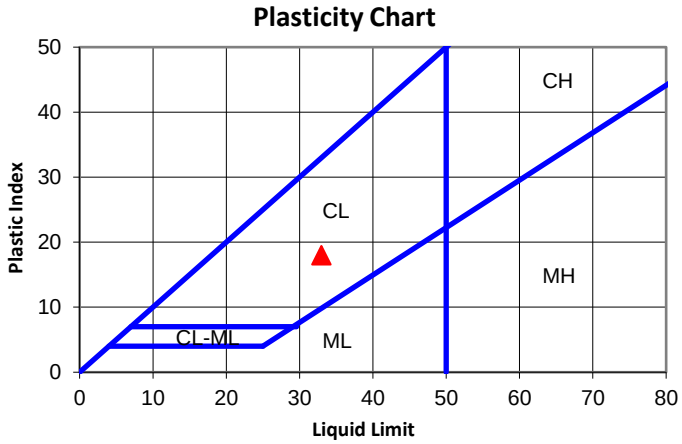
Liquid Limits

Number of Blows	16	20	23	27	34
Mass of Wet Pan and Soil (g):	25.38	25.07	25.44	25.69	25.04
Mass of Dry Pan and Soil (g):	23.64	23.19	23.74	23.87	23.45
Mass of Pan (g):	18.66	17.67	18.59	18.35	18.50
Moisture (%)	**34.9**	**33.9**	**33.1**	**32.9**	**32.1**

Plastic Index

Plastic Limit:	**15**	Atterberg Classification:	CL
Liquid Limit:	**33**	Method:	A
Plastic Index:	**18**		





NOTES

Data entry by:	BDF	Date:	08/14/24
Checked by:	CK	Date:	08/14/24
File name:	2481335__Atterberg ASTM D4318_10.xlsm		

ADVANCED TERRA TESTING

Grain Size Analysis
ASTM D 6913

CLIENT	Shannon & Wilson	BORING NO.	SW-05
JOB NO.	2481-335	DEPTH	7.0-9.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	S-4
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	08/13/24		
TECHNICIAN	CK		

Hygroscopic Moisture of Fines

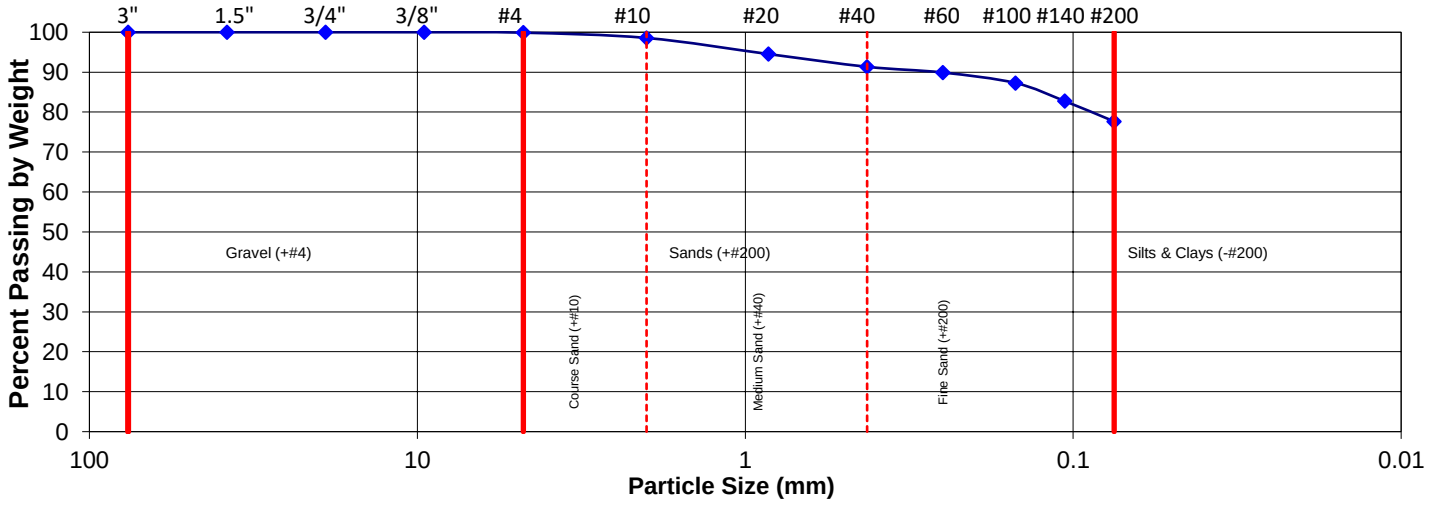
Mass Wet Pan and Soil (g):	386.61
Mass Dry Pan and Soil (g):	382.00
Mass of Pan (g):	172.44
Moisture (%):	**2.2**

Sample Data

Total Wet Mass of Sample (g):	637.4
Total Dry Mass of Sample (g):	623.7
Split Fraction:	#4
Mass of Sub-Sample Fraction (g):	214.17

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	--	--	--	--	**--**
3/8"	9.53	0.0	--	0.0	1.00	**100.0**
#4	4.75	0.7	--	0.7	1.00	**99.9**
#10	2.00	2.8	--	2.8	1.00	**98.6**
#20	0.850	8.5	--	8.5	1.00	**94.5**
#40	0.425	6.7	--	6.7	1.00	**91.3**
#60	0.250	3.0	--	3.0	1.00	**89.9**
#100	0.150	5.5	--	5.5	1.00	**87.3**
#140	0.106	9.5	--	9.5	1.00	**82.7**
#200	0.075	10.7	--	10.7	1.00	**77.7**

Percent Passing vs Log of Particle Size



USCS Classification ASTM D 2487

Atterberg Classification:	CL	Coefficient of Curvature - C_c:	--
Group Symbol:	CL	Coefficient of Uniformity - C_u:	--
USCS Classification:	Lean Clay With Sand		

Data entry by:	BDF	Date:	08/14/24
Checked by:	CK	Date:	08/14/24
File name:	2481335__Grain Size Analysis ASTM D6913_10.xlsm		

ADVANCED TERRA TESTING

Unconsolidated Undrained Triaxial Compression

ASTM D 2850

CLIENT	Shannon & Wilson	BORING NO.	SW-06
JOB NO.	2481-335	DEPTH	4-6'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	S-8
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/30/24		
TECHNICIAN	AC		

Test Parameters

Strain Rate (in/min):	0.062	Confining Stress (psf):	400
Strain Rate (cm/min):	0.157		

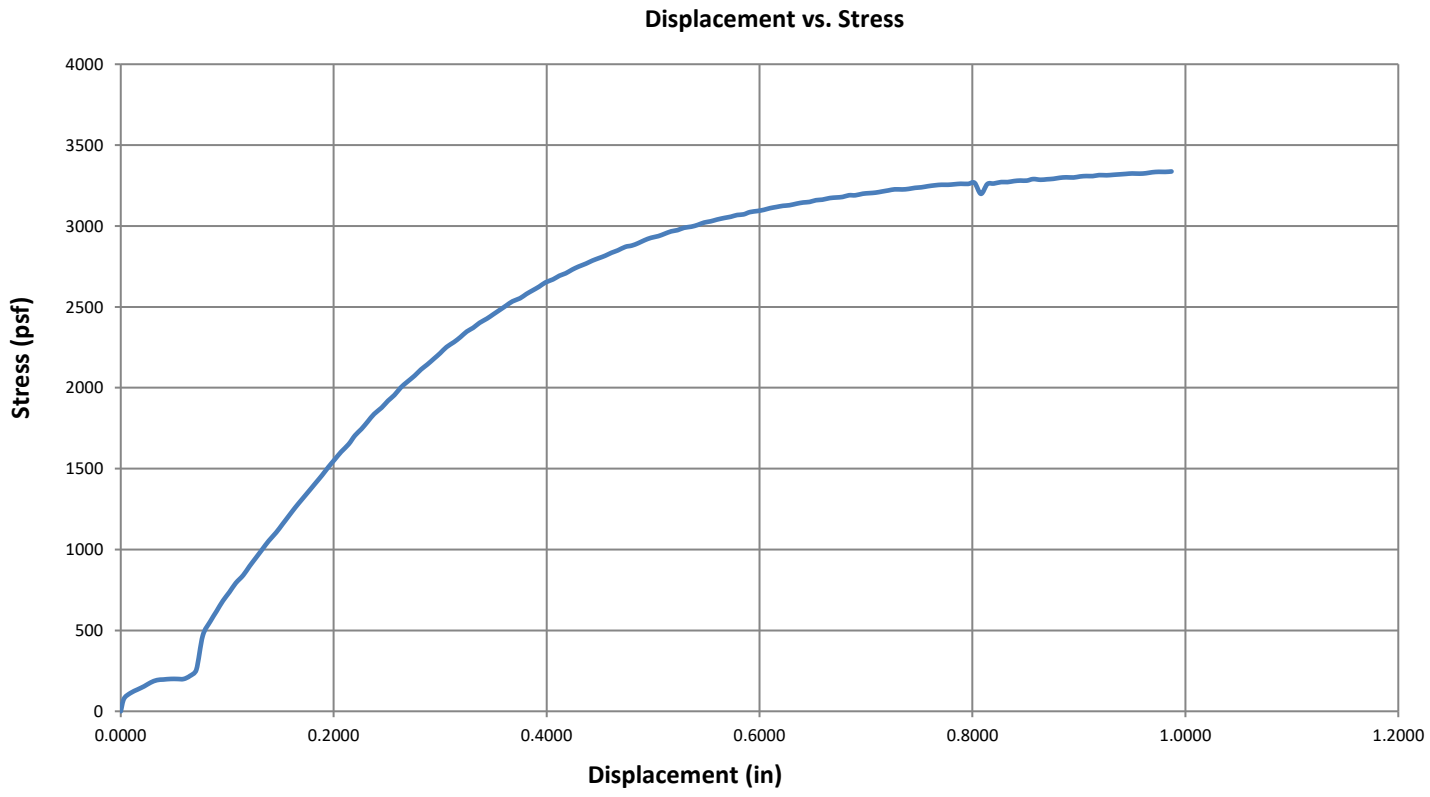
Raw Data Files: 2481-335-SW-06-4-6-S-8-UU-400PSF 7-30-2024 1.45.58 PM.txt

Moisture & Density Data

Mass of Wet Soil and Pan (g):	1614.24	Initial Wet Density (pcf):	129.9
Mass of Dry Soil and Pan (g):	1401.26	Initial Dry Density (pcf):	109.5
Mass of Pan (g):	256.66	Initial Wet Density (kg/m³):	2080
Mass of Wet Soil (g):	1357.58	Initial Dry Density (kg/m³):	1754
Initial Diameter (in):	2.862	Initial Moisture (%):	18.6
Initial Height (in):	6.191	Young's Modulus of the Membrane (psi):	72.6

Test Results

Peak Stress (psf):	3337	Axial Strain at Peak Stress (%):	15.9
Peak Stress (kPa):	160	Height to Diameter Ratio:	2.2:1



NOTES:

Data entry by:	AC	Date:	07/31/24
Checked by:	JL	Date:	08/01/24
File name:	2481335__TxUU ASTM D2850_0.xlsm		

Unconsolidated Undrained Triaxial Compression
ASTM D2850

CLIENT	Shannon & Wilson	BORING NO.	SW-06
JOB NO.	2481-335	DEPTH	4-6'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	S-8
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/30/24		
TECHNICIAN	AC		

Displacement (in)	Displacement (cm)	Strain (%)	Average Cross Sectional Area (in²)	Axial Load (lbs)	Membrane Correction (psf)	Deviator Stress (psf)	Deviator Stress (kPa)	Major Principal Stress - σ_1 (psf)	Major Principal Stress - σ_1 (kPa)
0.0000	0.000	0.00	6.433	0.0	0	0	0	400	19
0.0030	0.008	0.05	6.436	3.5	0	77	4	477	23
0.0090	0.023	0.15	6.443	5.0	1	112	5	512	25
0.0160	0.041	0.26	6.450	6.1	2	135	6	535	26
0.0220	0.056	0.36	6.456	6.9	3	155	7	555	27
0.0280	0.071	0.45	6.462	8.0	3	178	8	578	28
0.0340	0.086	0.55	6.469	8.7	4	193	9	593	28
0.0400	0.102	0.65	6.475	8.8	5	196	9	596	29
0.0470	0.119	0.76	6.482	9.0	5	200	10	600	29
0.0530	0.135	0.86	6.489	9.0	6	200	10	600	29
0.0590	0.150	0.95	6.495	9.0	7	200	10	600	29
0.0650	0.165	1.05	6.501	9.9	8	219	10	619	30
0.0710	0.180	1.15	6.508	11.6	8	257	12	657	31
0.0770	0.196	1.24	6.514	21.1	9	467	22	867	42
0.0840	0.213	1.36	6.522	25.1	10	554	27	954	46
0.0900	0.229	1.45	6.528	28.1	10	619	30	1019	49
0.0960	0.244	1.55	6.535	31.0	11	683	33	1083	52
0.1020	0.259	1.65	6.541	33.4	12	736	35	1136	54
0.1080	0.274	1.74	6.547	36.0	12	792	38	1192	57
0.1150	0.292	1.86	6.555	38.3	13	841	40	1241	59
0.1210	0.307	1.95	6.561	40.9	14	897	43	1297	62
0.1270	0.323	2.05	6.568	43.3	15	949	45	1349	65
0.1330	0.338	2.15	6.574	45.7	15	1001	48	1401	67
0.1390	0.353	2.25	6.581	48.1	16	1054	50	1454	70
0.1460	0.371	2.36	6.589	50.6	17	1105	53	1505	72
0.1520	0.386	2.46	6.595	53.0	18	1157	55	1557	75
0.1580	0.401	2.55	6.602	55.4	18	1209	58	1609	77
0.1640	0.417	2.65	6.608	57.8	19	1261	60	1661	80
0.1700	0.432	2.75	6.615	60.1	20	1308	63	1708	82
0.1770	0.450	2.86	6.623	62.7	20	1363	65	1763	84
0.1830	0.465	2.96	6.629	64.9	21	1411	68	1811	87
0.1890	0.480	3.05	6.636	67.2	22	1458	70	1858	89
0.1950	0.495	3.15	6.642	69.6	23	1509	72	1909	91
0.2010	0.511	3.25	6.649	71.9	23	1557	75	1957	94
0.2070	0.526	3.34	6.656	74.1	24	1604	77	2004	96
0.2140	0.544	3.46	6.664	76.4	25	1651	79	2051	98
0.2200	0.559	3.55	6.670	79.0	25	1705	82	2105	101
0.2260	0.574	3.65	6.677	80.9	26	1744	84	2144	103
0.2320	0.589	3.75	6.684	83.1	27	1791	86	2191	105
0.2380	0.605	3.84	6.690	85.4	27	1838	88	2238	107
0.2450	0.622	3.96	6.698	87.3	28	1877	90	2277	109
0.2510	0.638	4.05	6.705	89.4	29	1919	92	2319	111
0.2570	0.653	4.15	6.712	91.1	30	1955	94	2355	113

Unconsolidated Undrained Triaxial Compression
ASTM D2850

CLIENT	Shannon & Wilson	BORING NO.	SW-06
JOB NO.	2481-335	DEPTH	4-6'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	S-8
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/30/24		
TECHNICIAN	AC		

Displacement (in)	Displacement (cm)	Strain (%)	Average Cross Sectional Area (in²)	Axial Load (lbs)	Membrane Correction (psf)	Deviator Stress (psf)	Deviator Stress (kPa)	Major Principal Stress - σ_1 (psf)	Major Principal Stress - σ_1 (kPa)
0.2630	0.668	4.25	6.719	93.4	30	2001	96	2401	115
0.2690	0.683	4.35	6.725	95.1	31	2036	97	2436	117
0.2760	0.701	4.46	6.733	97.0	32	2074	99	2474	118
0.2820	0.716	4.55	6.740	98.9	33	2113	101	2513	120
0.2880	0.732	4.65	6.747	100.5	33	2144	103	2544	122
0.2940	0.747	4.75	6.754	102.2	34	2179	104	2579	123
0.3000	0.762	4.85	6.761	103.9	35	2213	106	2613	125
0.3060	0.777	4.94	6.768	105.8	35	2252	108	2652	127
0.3130	0.795	5.06	6.776	107.4	36	2282	109	2682	128
0.3190	0.810	5.15	6.783	108.9	37	2313	111	2713	130
0.3250	0.826	5.25	6.790	110.7	38	2347	112	2747	132
0.3310	0.841	5.35	6.797	111.9	38	2371	114	2771	133
0.3370	0.856	5.44	6.804	113.4	39	2401	115	2801	134
0.3440	0.874	5.56	6.812	114.8	40	2427	116	2827	135
0.3500	0.889	5.65	6.819	116.2	40	2454	118	2854	137
0.3560	0.904	5.75	6.826	117.6	41	2481	119	2881	138
0.3620	0.919	5.85	6.833	119.0	42	2508	120	2908	139
0.3680	0.935	5.94	6.840	120.4	42	2534	121	2934	140
0.3750	0.953	6.06	6.848	121.4	43	2553	122	2953	141
0.3810	0.968	6.15	6.855	122.8	44	2579	124	2979	143
0.3870	0.983	6.25	6.862	124.0	45	2602	125	3002	144
0.3930	0.998	6.35	6.869	125.2	45	2625	126	3025	145
0.3990	1.013	6.44	6.876	126.6	46	2651	127	3051	146
0.4060	1.031	6.56	6.885	127.6	47	2670	128	3070	147
0.4120	1.046	6.65	6.892	128.9	48	2692	129	3092	148
0.4180	1.062	6.75	6.899	129.7	48	2708	130	3108	149
0.4240	1.077	6.85	6.906	130.9	49	2730	131	3130	150
0.4300	1.092	6.95	6.913	132.0	50	2749	132	3149	151
0.4370	1.110	7.06	6.922	133.0	50	2767	132	3167	152
0.4430	1.125	7.16	6.929	134.1	51	2786	133	3186	153
0.4490	1.140	7.25	6.936	134.9	52	2801	134	3201	153
0.4550	1.156	7.35	6.944	135.8	53	2816	135	3216	154
0.4610	1.171	7.45	6.951	136.8	53	2835	136	3235	155
0.4670	1.186	7.54	6.958	137.7	54	2850	136	3250	156
0.4740	1.204	7.66	6.967	138.9	55	2871	137	3271	157
0.4800	1.219	7.75	6.974	139.4	55	2879	138	3279	157
0.4860	1.234	7.85	6.981	140.3	56	2894	139	3294	158
0.4920	1.250	7.95	6.989	141.3	57	2912	139	3312	159
0.4980	1.265	8.04	6.996	142.2	57	2927	140	3327	159
0.5050	1.283	8.16	7.005	142.9	58	2937	141	3337	160
0.5110	1.298	8.25	7.012	143.8	59	2952	141	3352	161
0.5170	1.313	8.35	7.019	144.6	60	2967	142	3367	161
0.5230	1.328	8.45	7.027	145.1	60	2974	142	3374	162

Unconsolidated Undrained Triaxial Compression
ASTM D2850

CLIENT	Shannon & Wilson	BORING NO.	SW-06
JOB NO.	2481-335	DEPTH	4-6'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	S-8
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/30/24		
TECHNICIAN	AC		

Displacement (in)	Displacement (cm)	Strain (%)	Average Cross Sectional Area (in²)	Axial Load (lbs)	Membrane Correction (psf)	Deviator Stress (psf)	Deviator Stress (kPa)	Major Principal Stress - σ_1 (psf)	Major Principal Stress - σ_1 (kPa)
0.5290	1.344	8.54	7.034	146.0	61	2989	143	3389	162
0.5360	1.361	8.66	7.043	146.5	62	2996	143	3396	163
0.5420	1.377	8.75	7.050	147.2	63	3007	144	3407	163
0.5480	1.392	8.85	7.058	148.1	63	3021	145	3421	164
0.5540	1.407	8.95	7.065	148.6	64	3029	145	3429	164
0.5600	1.422	9.05	7.073	149.3	65	3040	146	3440	165
0.5670	1.440	9.16	7.082	150.0	65	3050	146	3450	165
0.5730	1.455	9.26	7.089	150.5	66	3057	146	3457	166
0.5790	1.471	9.35	7.097	151.2	67	3068	147	3468	166
0.5850	1.486	9.45	7.105	151.5	68	3072	147	3472	166
0.5910	1.501	9.55	7.112	152.4	68	3086	148	3486	167
0.5980	1.519	9.66	7.121	152.9	69	3093	148	3493	167
0.6040	1.534	9.76	7.129	153.5	70	3100	148	3500	168
0.6100	1.549	9.85	7.136	154.1	70	3110	149	3510	168
0.6160	1.565	9.95	7.144	154.7	71	3118	149	3518	168
0.6220	1.580	10.05	7.152	155.2	72	3125	150	3525	169
0.6280	1.595	10.14	7.159	155.5	72	3128	150	3528	169
0.6350	1.613	10.26	7.168	156.2	73	3138	150	3538	169
0.6410	1.628	10.35	7.176	156.7	74	3145	151	3545	170
0.6470	1.643	10.45	7.184	157.1	75	3149	151	3549	170
0.6530	1.659	10.55	7.192	157.8	75	3159	151	3559	170
0.6590	1.674	10.64	7.200	158.1	76	3163	151	3563	171
0.6660	1.692	10.76	7.209	158.8	77	3173	152	3573	171
0.6720	1.707	10.85	7.217	159.2	78	3176	152	3576	171
0.6780	1.722	10.95	7.224	159.5	78	3180	152	3580	171
0.6840	1.737	11.05	7.232	160.2	79	3190	153	3590	172
0.6900	1.753	11.15	7.240	160.4	80	3190	153	3590	172
0.6970	1.770	11.26	7.249	161.1	80	3200	153	3600	172
0.7030	1.786	11.36	7.257	161.4	81	3203	153	3603	173
0.7090	1.801	11.45	7.265	161.8	82	3206	154	3606	173
0.7150	1.816	11.55	7.273	162.3	83	3213	154	3613	173
0.7210	1.831	11.65	7.281	162.8	83	3220	154	3620	173
0.7270	1.847	11.74	7.289	163.3	84	3227	154	3627	174
0.7340	1.864	11.86	7.299	163.5	85	3226	154	3626	174
0.7400	1.880	11.95	7.307	163.8	85	3229	155	3629	174
0.7460	1.895	12.05	7.315	164.4	86	3236	155	3636	174
0.7520	1.910	12.15	7.323	164.7	87	3239	155	3639	174
0.7580	1.925	12.24	7.331	165.2	87	3246	155	3646	175
0.7650	1.943	12.36	7.340	165.7	88	3252	156	3652	175
0.7710	1.958	12.45	7.348	166.1	89	3255	156	3655	175
0.7770	1.974	12.55	7.357	166.3	90	3255	156	3655	175
0.7830	1.989	12.65	7.365	166.6	90	3258	156	3658	175
0.7890	2.004	12.74	7.373	167.0	91	3261	156	3661	175

Unconsolidated Undrained Triaxial Compression
ASTM D2850

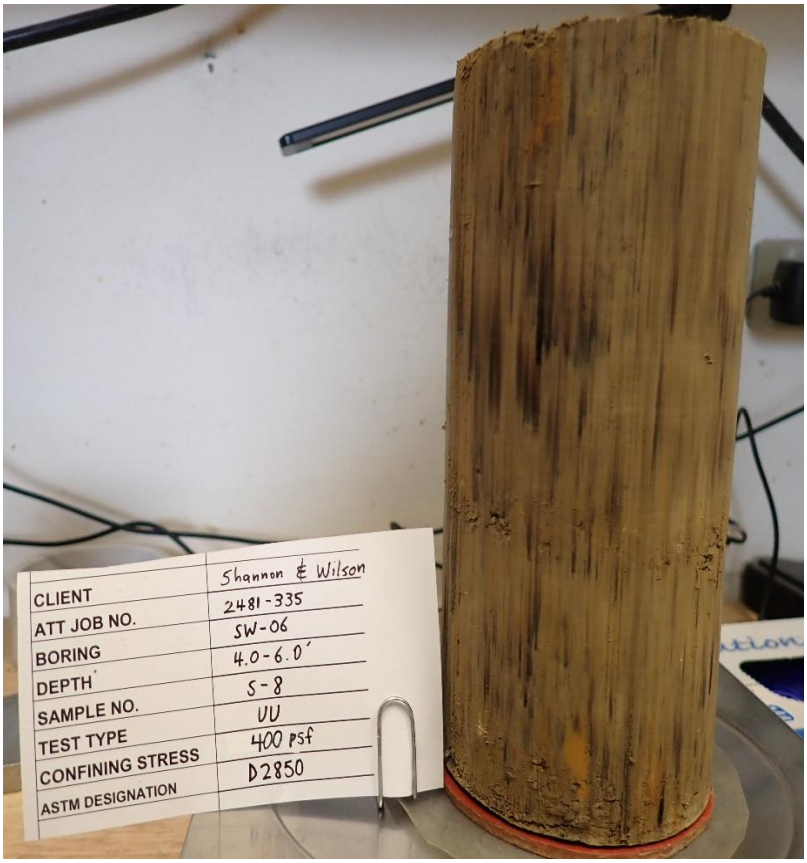
CLIENT	Shannon & Wilson	BORING NO.	SW-06
JOB NO.	2481-335	DEPTH	4-6'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	S-8
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	07/30/24		
TECHNICIAN	AC		

Displacement (in)	Displacement (cm)	Strain (%)	Average Cross Sectional Area (in²)	Axial Load (lbs)	Membrane Correction (psf)	Deviator Stress (psf)	Deviator Stress (kPa)	Major Principal Stress - σ_1 (psf)	Major Principal Stress - σ_1 (kPa)
0.7960	2.022	12.86	7.382	167.1	92	3260	156	3660	175
0.8020	2.037	12.95	7.391	167.7	93	3267	156	3667	176
0.8080	2.052	13.05	7.399	164.4	93	3199	153	3599	172
0.8140	2.068	13.15	7.407	167.7	94	3259	156	3659	175
0.8200	2.083	13.25	7.415	168.0	95	3262	156	3662	175
0.8270	2.101	13.36	7.425	168.7	95	3272	157	3672	176
0.8330	2.116	13.46	7.433	168.9	96	3271	157	3671	176
0.8390	2.131	13.55	7.442	169.4	97	3278	157	3678	176
0.8450	2.146	13.65	7.450	169.7	98	3281	157	3681	176
0.8510	2.162	13.75	7.458	169.9	98	3280	157	3680	176
0.8570	2.177	13.84	7.467	170.6	99	3290	158	3690	177
0.8640	2.195	13.96	7.477	170.6	100	3286	157	3686	176
0.8700	2.210	14.05	7.485	170.9	100	3289	157	3689	177
0.8760	2.225	14.15	7.494	171.3	101	3292	158	3692	177
0.8820	2.240	14.25	7.502	171.8	102	3298	158	3698	177
0.8880	2.256	14.34	7.510	172.2	102	3301	158	3701	177
0.8950	2.273	14.46	7.520	172.3	103	3300	158	3700	177
0.9010	2.289	14.55	7.529	172.9	104	3306	158	3706	177
0.9070	2.304	14.65	7.537	173.2	105	3309	158	3709	178
0.9130	2.319	14.75	7.546	173.4	105	3308	158	3708	178
0.9190	2.334	14.84	7.555	173.9	106	3315	159	3715	178
0.9260	2.352	14.96	7.565	174.1	107	3313	159	3713	178
0.9320	2.367	15.05	7.573	174.4	108	3316	159	3716	178
0.9380	2.383	15.15	7.582	174.8	108	3319	159	3719	178
0.9440	2.398	15.25	7.591	175.1	109	3322	159	3722	178
0.9500	2.413	15.34	7.599	175.4	110	3325	159	3725	178
0.9570	2.431	15.46	7.610	175.6	110	3323	159	3723	178
0.9630	2.446	15.55	7.618	176.0	111	3326	159	3726	178
0.9690	2.461	15.65	7.627	176.5	112	3332	160	3732	179
0.9750	2.477	15.75	7.636	176.8	113	3335	160	3735	179
0.9810	2.492	15.85	7.645	177.0	113	3334	160	3734	179
0.9870	2.507	15.94	7.653	177.4	114	3337	160	3737	179

ADVANCED TERRA TESTING

Unconsolidated Undrained Triaxial Compression
ASTM D2850
(Before Picture)

CLIENT	Shannon & Wilson	BORING NO.	SW-06
JOB NO.	2481-335	DEPTH	4-6'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	S-8
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	07/30/24	DESCRIPTION	--
TECHNICIAN	AC		



NOTES

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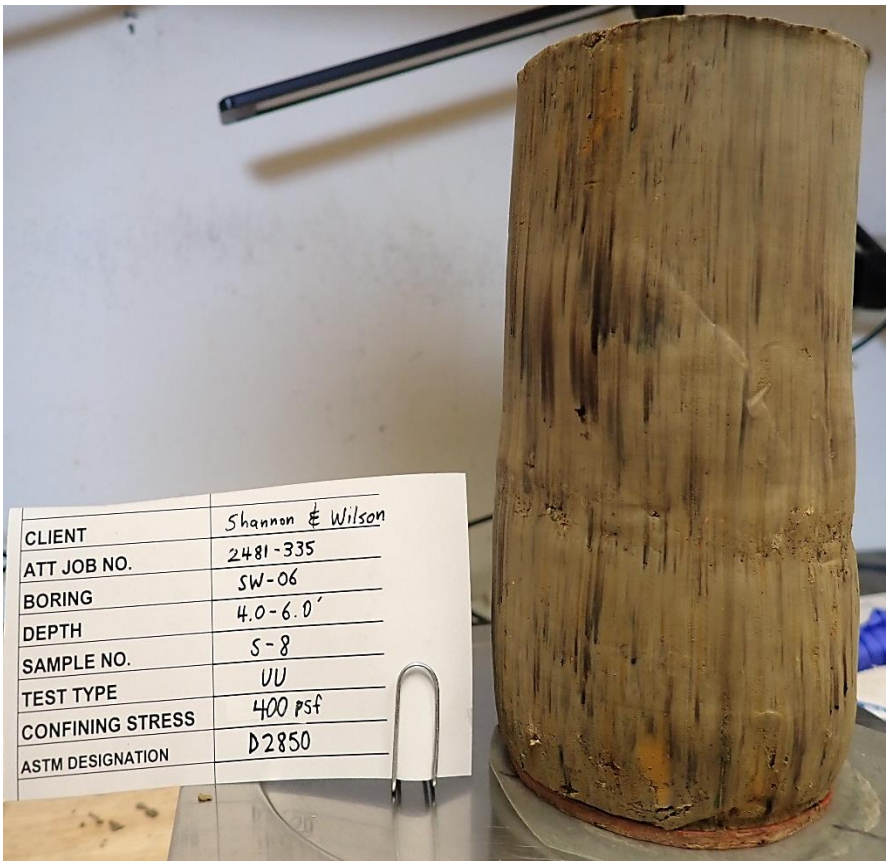
File name: 2481335__TxUU ASTM D2850_0.xlsm

ADVANCED TERRA TESTING

Unconsolidated Undrained Triaxial Compression
ASTM D2850
(After Picture)

CLIENT	Shannon & Wilson	BORING NO.	SW-06
JOB NO.	2481-335	DEPTH	4-6'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	S-8
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	07/30/24	DESCRIPTION	--
TECHNICIAN	AC		



NOTES

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ADVANCED TERRA TESTING

Atterberg Limits
ASTM D 4318

CLIENT	Shannon & Wilson	BORING NO.	SW-06
JOB NO.	2481-335	DEPTH	4.0-6.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	S-8
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	SAMPLED BY	--
DATE TESTED	08/13/24	DESCRIPTION	--
TECHNICIAN	MH		

Plastic Limits

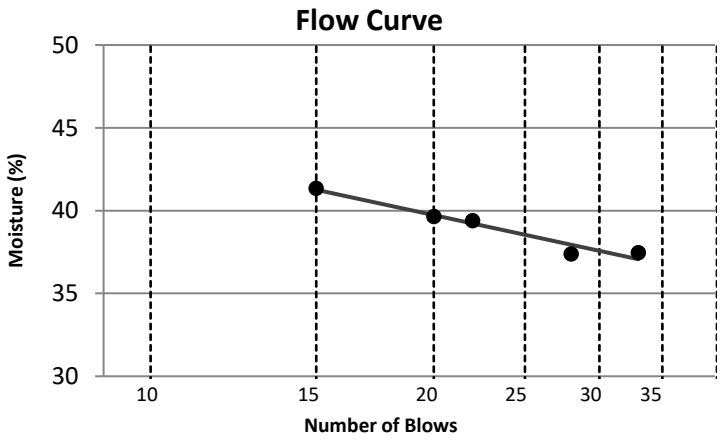
Mass of Wet Pan and Soil (g):	26.24	25.99	25.26
Mass of Dry Pan and Soil (g):	25.07	24.83	24.10
Mass of Pan (g):	18.63	18.39	17.66
Moisture (%)	**18.1**	**18.0**	**18.0**

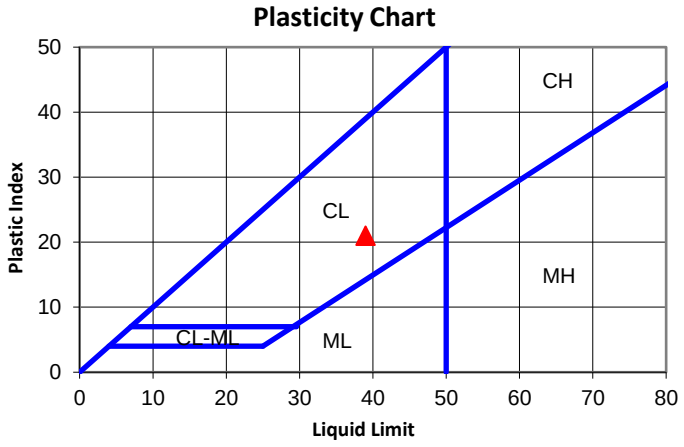
Liquid Limits

Number of Blows	15	20	22	33	28
Mass of Wet Pan and Soil (g):	25.04	25.59	24.92	25.08	25.11
Mass of Dry Pan and Soil (g):	23.12	23.63	23.10	23.38	23.34
Mass of Pan (g):	18.47	18.68	18.48	18.83	18.60
Moisture (%)	**41.3**	**39.6**	**39.4**	**37.5**	**37.4**

Plastic Index

Plastic Limit:	**18**	Atterberg Classification:	CL
Liquid Limit:	**39**	Method:	A
Plastic Index:	**21**		





NOTES

Data entry by:	BDF	Date:	08/14/24
Checked by:	CK	Date:	08/14/24
File name:	2481335__Atterberg ASTM D4318_11.xlsm		

ADVANCED TERRA TESTING

Grain Size Analysis
ASTM D 6913

CLIENT	Shannon & Wilson	BORING NO.	SW-06
JOB NO.	2481-335	DEPTH	4.0-6.0'
PROJECT	NDDOT Chateau Rd	SAMPLE NO.	S-8
PROJECT NO.	113316-001	DATE SAMPLED	--
LOCATION	Medora, ND	DESCRIPTION	--
DATE TESTED	08/12/24		
TECHNICIAN	CK		

Hygroscopic Moisture of Fines

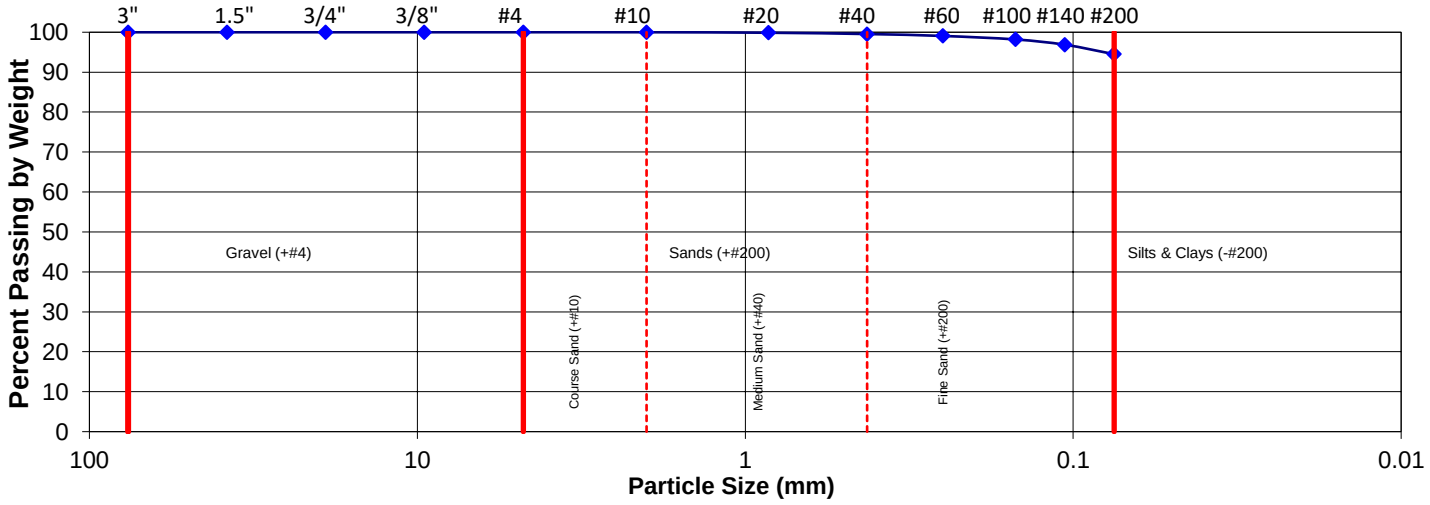
Mass Wet Pan and Soil (g): 365.36
Mass Dry Pan and Soil (g): 358.60
Mass of Pan (g): 124.07
Moisture (%): **2.9**

Sample Data

Total Wet Mass of Sample (g): 456.1
Total Dry Mass of Sample (g): 443.3
Split Fraction: #4
Mass of Sub-Sample Fraction (g): 241.29

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	--	--	--	--	**--**
3/8"	9.53	--	--	--	--	**--**
#4	4.75	--	--	--	--	**--**
#10	2.00	0.0	--	0.0	1.00	**100.0**
#20	0.850	0.3	--	0.3	1.00	**99.9**
#40	0.425	0.8	--	0.8	1.00	**99.5**
#60	0.250	1.1	--	1.1	1.00	**99.1**
#100	0.150	2.1	--	2.1	1.00	**98.2**
#140	0.106	3.1	--	3.1	1.00	**96.9**
#200	0.075	5.6	--	5.6	1.00	**94.5**

Percent Passing vs Log of Particle Size



USCS Classification ASTM D 2487

Atterberg Classification: CL
Group Symbol: CL
USCS Classification: Lean Clay

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

Data entry by: BDF — Date: 08/14/24
Checked by: CK — Date: 08/14/24
File name: 2481335__Grain Size Analysis ASTM D6913_11.xlsm

APPENDIX C: FIELD RECONNAISSANCE NOTES

Appendix C

Field Reconnaissance Notes

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Figure C-1 through C-10: Reconnaissance Photographs Features

APPENDIX C: FIELD RECONNAISSANCE NOTES

C.1 INTRODUCTION

A Shannon & Wilson geologist performed a geologic reconnaissance on June 11, 2024, to support the design, reconstruction, and realignment of Chateau Road from its intersection with Pacific Avenue to the Burning Hills Amphitheater (BHA) parking lot. The geologist also identified potential areas for subsurface explorations. At the request of KLJ, we completed a second reconnaissance on September 26, 2024, to evaluate a proposed extension of Chateau Road to the west through the northern edge of the BHA parking lot.

The geologist mapped notable geologic features, such as landslide scarps, landslide toes, landslide spills (areas where landslide debris has progressed downslope beyond the extents of the initial slip surface), areas of standing water and seepage, hydrophytic vegetation (plants that thrive in wet conditions), erosional rills and gullies, soil pipes and sinkholes, culvert locations, rock and soil exposures, and cut and fill slope characteristics. This information was used to develop a better understanding of the existing site conditions. The approximate extent of our initial reconnaissance was between Station 1000+00 to Station 1046+85 (station limits per the October 15, 2024, alignment and cross sections provided by KLJ). Our second reconnaissance focused on the area from the entrance to the BHA parking lot to approximately 1,000 feet west, at the northern edge of the upper plateau.

A summary of our field observations at each reconnaissance feature number (feature) is provided below. The location of each feature number is shown in Figure 2. Rock and soil descriptions below are based on field observation and may differ from information shown in the geotechnical report, boring logs, and laboratory test results.

C.2 FEATURE DESCRIPTIONS

C2.1 Feature 1

Located south of the existing road, Feature 1 extends from approximate Stations 1031+00 to 1036+00. The slopes are approximately 35 to 40 feet high with scarps ranging from 50 to 90 degrees. Pavement distress (longitudinal cracking) was observed in the location of boring SW-03 (see Figure 2, Sheet 1). The drainage channel to the south is V-shaped and is characterized by vegetated slopes on both sides, excluding the steep areas with scarps. Three sinkholes measuring up to 6 feet long and 6 feet wide were observed (see Figure 2, Sheet 1 and Figure C-1).

C2.2 Feature 2

Feature 2 is located north of the existing road near Feature 1 at the first major northerly bend of the road (approximate Stations 1031+00 to 1033+00). Several small set-down scarps are scattered along the slope above the existing road. The cut slope is approximately 40 to 50 degrees and 15 feet high. The slope is mostly vegetated with grass (see Figure C-2). Proposed cuts in this area are at 3H:1V (horizontal to vertical) and will remove the set-down features.

C2.3 Feature 3

Feature 3 is located south and west of the existing alignment at approximate Stations 1025+00 to 1028+00. The slopes are approximately 30 to 40 feet high with slope angles ranging from 40 to 55 degrees. The slopes are vegetated with trees and grass; however, several shallow set-down scarps were observed (see Figure C-3). Instability did not appear to be active at the time of the reconnaissance. Proposed cuts in this area are at 4H:1V and will remove material that may be unstable.

C2.4 Feature 4

Feature 4 is located northeast of Chateau Road between approximate Stations 1025+00 to 1027+00. The existing cut slope appears to be performing satisfactorily with a grassy slope and no observed instability at the time of the field reconnaissance. The cut is approximately 15 to 20 feet high with 20 to 30-degree slope angles (see Figure C-4).

C2.5 Feature 5

Feature 5 is located northwest of Chateau Road between approximate Stations 1021+00 and 1022+00, more than 250 feet away from the existing alignment (see Figure 2, Sheets 2 and 3). This drainage basin hosts a combination of new and old shallow slumps. The slumps appear to be caused by over-steepened slopes. At the time of the reconnaissance, none of the slumps appeared to be characterized by deep-seated movement (see Figure C-5). Proposed construction will not have an impact on this drainage basin or the features characterized by shallow instability located in the steeper sidewalls and head of the basin.

C2.6 Feature 6

Feature 6 is characterized by a 15-to-20-foot-high embankment east of Chateau Road between approximately Stations 1019+00 and 1022+00 (see Figure C-6, Sheet 1). The side slopes of the embankment are as steep as 1H:1V in places. We observed pavement distress consisting of longitudinal cracking and up to 2 inches of separation at the concrete joints

toward the downhill side of embankment (see Figure C-6). Proposed construction will flatten the side slopes of the embankment to 4H:1V, which should improve global stability.

C2.7 Feature 7

Feature 7 is a drainage basin northwest of the existing alignment of Chateau Road and in the location of a proposed cut between Stations 1017+00 and 1020+00. The north side of the drainage basin has bedrock exposures up to approximately 20 to 30 feet in height. The exposures are old landslide scarps with multiple set-downs; however, there was no evidence of recent movement (e.g., open tension cracks) during the time of the reconnaissance. Slope angles in this location range from 45 to 60 degrees. The southwest side of the valley is characterized by slopes approaching 60 degrees and is vegetated with grasses and trees. Several set-downs are obscured by trees (see Figure C-7). Proposed cuts in this area will flatten slopes to between 3H:1V and 4H:1V and are anticipated to remove material involved in shallow instability.

C2.8 Feature 8

Feature 8 is a view of a drainage channel north of Chateau Road between Stations 1035+50 and 1036+50. The drainage is disrupted by the lack of a culvert below the roadway in this location (see Figure C-8). The absence of a culvert may be contributing to slope instability and sinkholes south of the existing roadway.

C2.9 Feature 9

Feature 9 is in the BHA parking lot. Prior to our reconnaissance, the concrete had already been removed before we could observe the existing condition of the pavement. Adjacent areas of remaining concrete indicated distress consisting of longitudinal and transverse cracking; however, in some of those areas, it was not clear whether the distress was caused by construction (see Figure C-9, Sheet 1). Underneath the parking lot concrete pavement, we observed a brown, clayey subbase with no apparent base course (see Figure C-9, Sheet 2).

C2.10 Feature 10

Feature 10 is characterized by the roundabout area and the slopes directly to the north of it. We observed a gravel base layer from the western edge of the old parking lot throughout the roundabout; however, we are uncertain of the thickness of the gravel base layer (see Figure C-10, Sheet 1). At the time of the reconnaissance, the area to the north of the parking lot was blocked off by a silt fence and a second level of taller (approximately 4 feet tall) orange fencing. The slopes in the upper portion of the drainage channel north of the

proposed roundabout are relatively shallow. We did not observe any evidence of slope instability impacting the proposed roundabout or the area where Chateau Road will be extended through the northern portion of the BHA parking lot (see Figure C-10, Sheet 2).

View southwest showing scarps (blue) south of Chateau Road. Photograph taken June 11, 2024.

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

RECONNAISSANCE PHOTOGRAPHS
FEATURE 1

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FIG. C-1
Sheet 1 of 2

FIG. C-1
Sheet 1 of 2

View northeast showing scarps (blue) and sinkholes (green) south of Chateau Road. Photograph taken June 11, 2024.

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5-999(036), PCN 24246
Medora, North Dakota

RECONNAISSANCE PHOTOGRAPHS
FEATURE 1

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FIG. C-1
Sheet 2 of 2

FIG. C-1
Sheet 2 of 2

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5-999(036), PCN 24246
Medora, North Dakota

RECONNAISSANCE PHOTOGRAPHS
FEATURE 2

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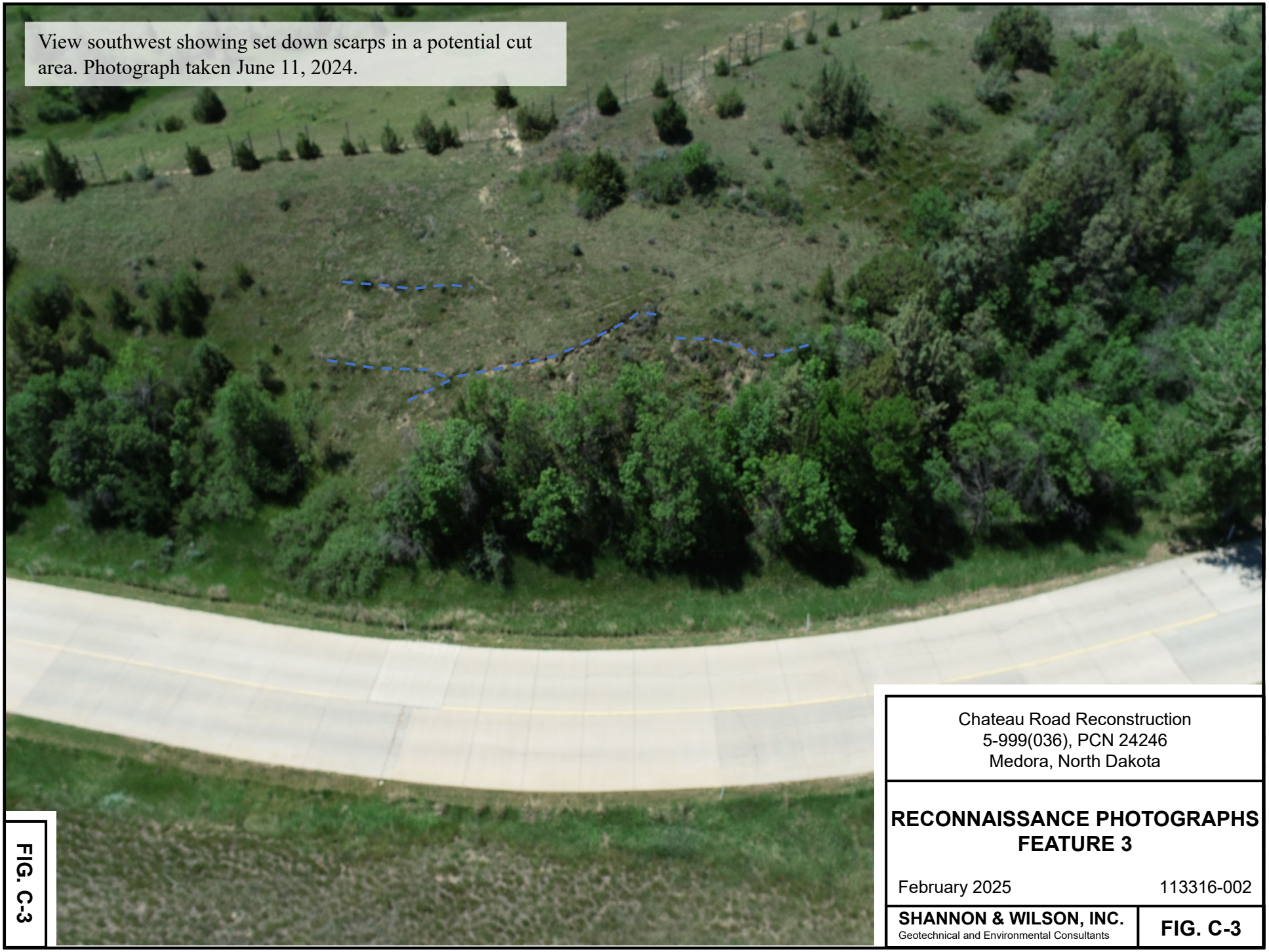
FIG. C-2

FIG. C-2



View southwest showing set down scarps in a potential cut area. Photograph taken June 11, 2024.

FIG. C-3

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FEATURE 3

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FIG. C-3

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RECONNAISSANCE PHOTOGRAPHS
FEATURE 4

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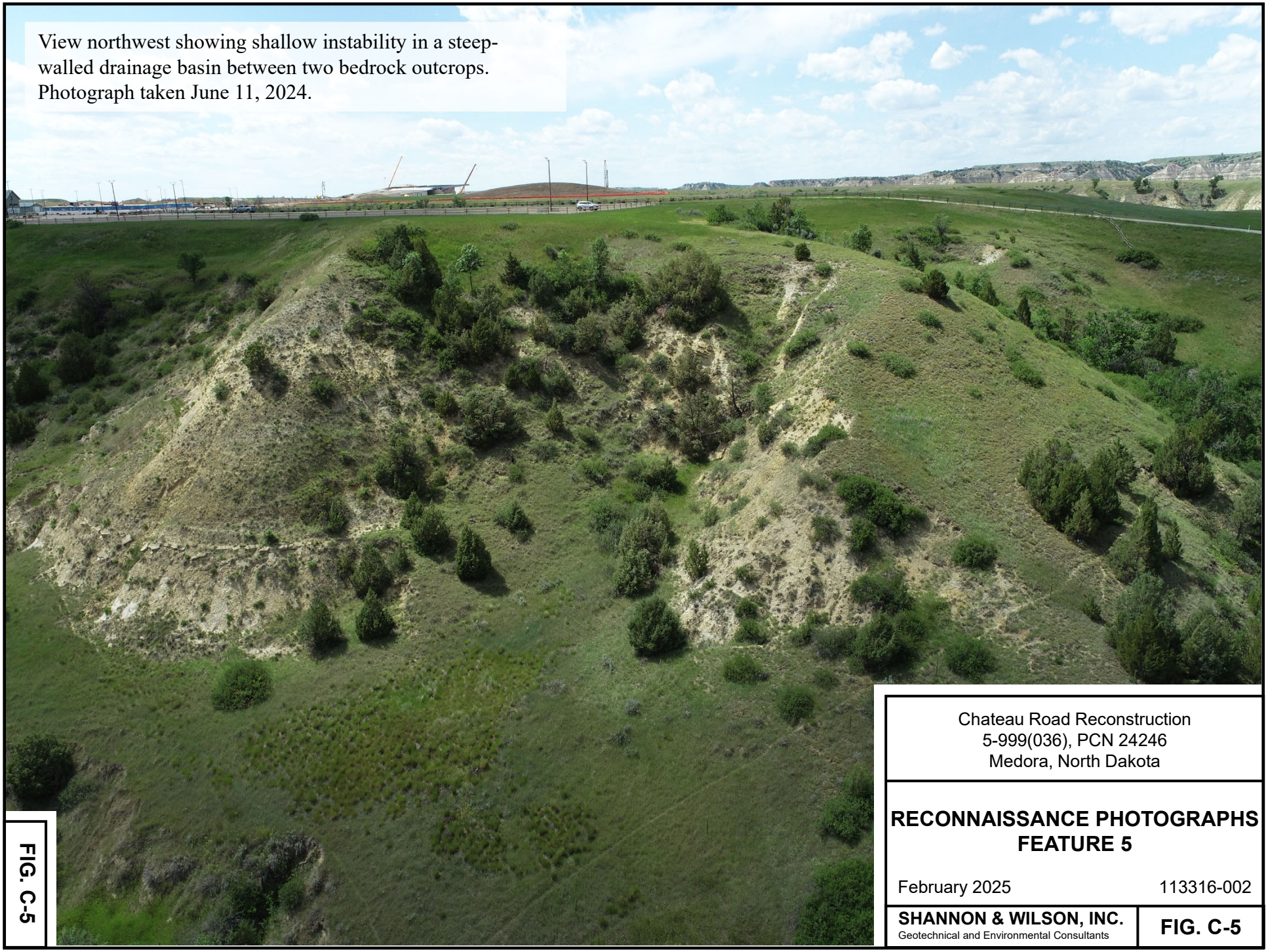
FIG. C-4

FIG. C-4



View northwest showing shallow instability in a steep-walled drainage basin between two bedrock outcrops. Photograph taken June 11, 2024.

FIG. C-5

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RECONNAISSANCE PHOTOGRAPHS
FEATURE 5

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FIG. C-5

View east showing embankment slope where pavement shows distress. See C-6, Sheet 2. Photograph taken June 11, 2024.

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Medora, North Dakota

RECONNAISSANCE PHOTOGRAPHS
FEATURE 6

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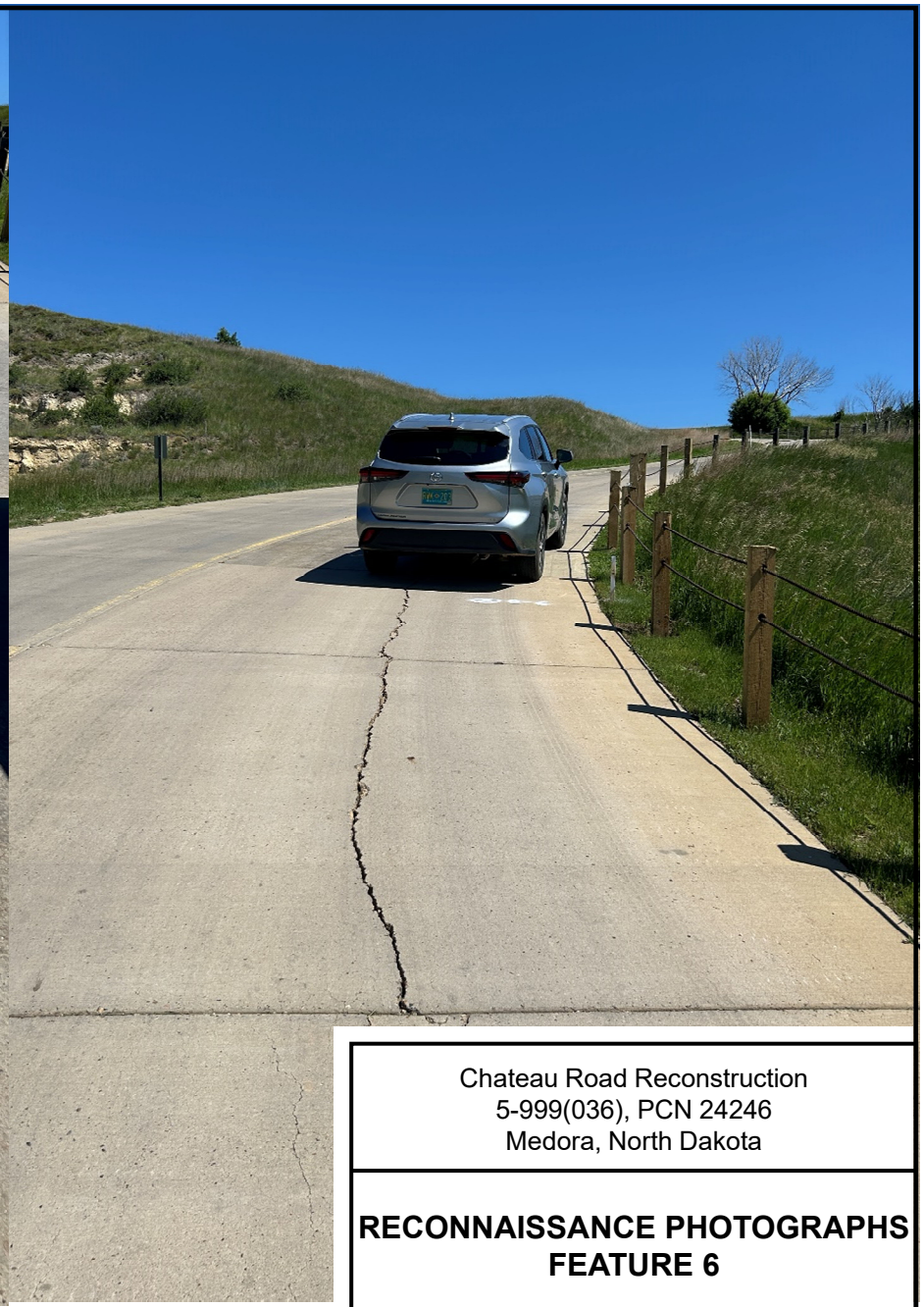
FIG. C-6
Sheet 1 of 2

FIG. C-6
Sheet 1 of 2

View northeast showing pavement distress at site Feature 6.
Photograph taken June 11, 2024.



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RECONNAISSANCE PHOTOGRAPHS
FEATURE 6

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FIG. C-6
Sheet 2 of 2

FIG. C-6
Sheet 2 of 2

View northwest showing shallow landslide scarps (blue) throughout the drainage basin. Photograph taken June 11, 2024.

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FEATURE 7

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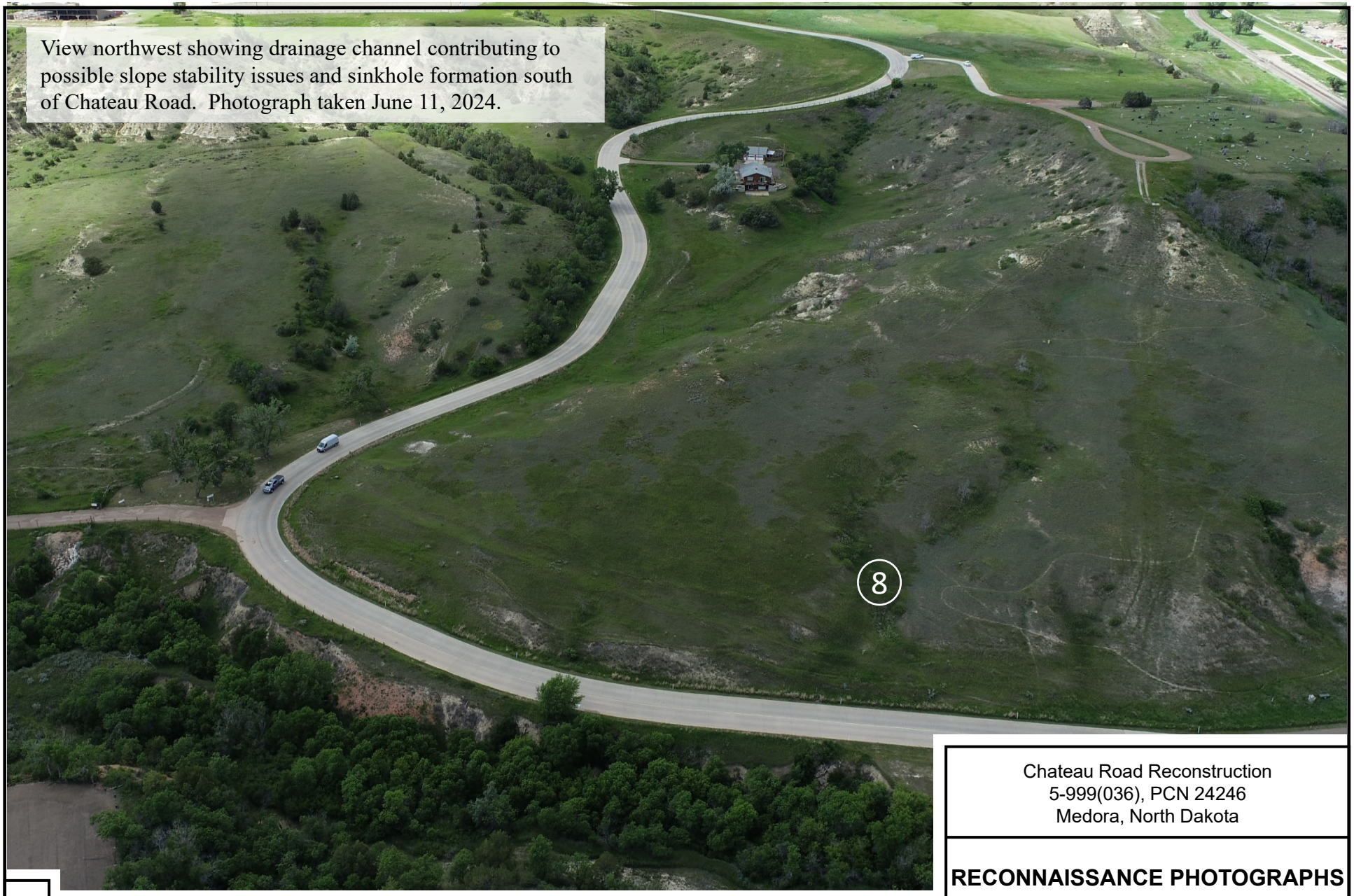
FIG. C-7

FIG. C-7



View northwest showing drainage channel contributing to possible slope stability issues and sinkhole formation south of Chateau Road. Photograph taken June 11, 2024.

FIG. C-8

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RECONNAISSANCE PHOTOGRAPHS
FEATURE 8

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FIG. C-8

View west showing cracking of remaining concrete pavement at the northern portion of BHA parking lot. Photograph taken September 26, 2024.

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RECONNAISSANCE PHOTOGRAPHS
FEATURE 9

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FIG. C-9
Sheet 1 of 2

FIG. C-9
Sheet 1 of 2

View east showing the soils beneath the previous parking lot concrete pavement section. Photograph taken September 26, 2024.

FIG. C-9
Sheet 2 of 2

Chateau Road Reconstruction
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RECONNAISSANCE PHOTOGRAPHS
FEATURE 9

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FIG. C-9
Sheet 2 of 2

View west showing aggregate base course at the roundabout.
Photograph taken September 26, 2024.

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RECONNAISSANCE PHOTOGRAPHS
FEATURE 10

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FIG. C-10
Sheet 1 of 2

FIG. C-10
Sheet 1 of 2

View northwest showing the relatively shallow slopes adjacent to the roundabout. The location of the roundabout in this photograph is to the left. Photograph taken September 26, 2024.

Chateau Road Reconstruction
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RECONNAISSANCE PHOTOGRAPHS
FEATURE 10

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FIG. C-10
Sheet 2 of 2

FIG. C-10
Sheet 2 of 2

APPENDIX D: SETTLEMENT ANALYSES

Appendix D

Settlement Analyses

Enclosures

Schmertmann Settlement Analysis Worksheet: Sta. 1009+50, SW-11 Conditions (1 sheet)

Schmertmann Settlement Analysis Worksheet: Sta. 1009+50, SW-12 Conditions (1 sheet)

Schmertmann Settlement Analysis Worksheet: Sta. 1016+75, SW-10 Conditions (1 sheet)

Schmertmann Settlement Analysis Worksheet: Sta. 1020+00, SW-08 Conditions (1 sheet)

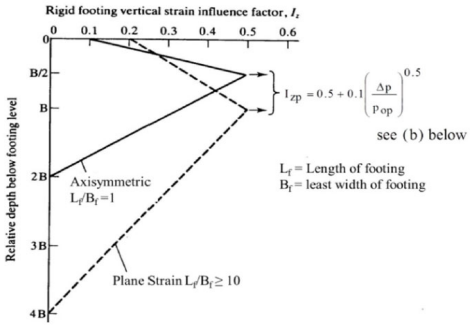
Settle3 Analysis Information Chateau Road Reconstruction: Sta 1024+50 (34 sheets)

Schmertmann Settlement Analysis Worksheet

Reference: AASHTO LRFD Bridge Design Specifications, 9ed. 2020, Section 10.6.2.4.2c - Schmertmann Method
Analysis Location: Sta. 1009+50 - SW-11 conditions

Job Number: 113316
Analysis By: NXG

Embankment Width, B_f =	100.0	feet
Embankment Length, L_f =	400.0	feet
Depth of Embankment, D_f =	0.0	feet
Elapsed Time, t =	0.1	years
Embankment Load, p =	1,250	psf
Unit Weight Above G.S., γ_f =	120	pcf
In-Situ Effective Stress at Peak Strain, p_{op} =	8,004	psf
In-situ Effective Stress at Base of Foundation, p_o =	0	psf
L_f/B_f =	4.00	
Applied Stress, $\Delta p = p - p_o$ =	1,250	psf



1 ≤ Lf/Bf ≤ 10, Assume Max. Depth of Inflence = Df + 2.7 Bf based on Linear Interpolation

Max. Depth of Influence = 266.7 feet = $D_f + (Z/B_f)\ B_f$ where Z/B_f varies 2.0 to 4.0

1 ≤ Lf/Bf ≤ 10, Assume Depth to Peak Strain = Df + 0.7 Bf based on Linear Interpolation

Depth to In-Situ Effective Stress at Peak Strain = 66.7 feet = $D_f + K\ B_f$ where K varies 0.5 to 1.0

X = 1.42 X = 1.25 for L_f/B_f = 1; 1.75 for $L_f/B_f \geq 10$; Linear Inerpolation Between

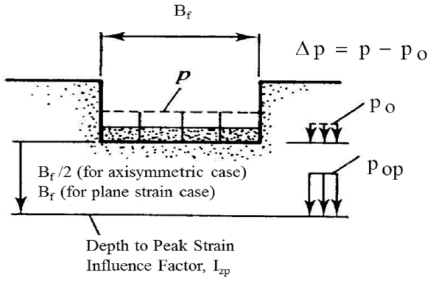
1 ≤ Lf/Bf ≤ 10, Assume Influence Below Foundation = 0.13 based on Linear Interpolation

I_z below Foundation = 0.13

$I_{zp} = 0.5 + 0.1\ [\ (\Delta p / p_{op}\ ]^{0.5}$ = 0.54

Soil Properties

Top of Layer Depth (feet)	Soil Description	E (ksf)
0.0	Medium Dense, Silty/Clayey Sand	400
12.0	Dense, Sand	750
17.0	Sandstone (Dense to very dense, Silty Sand)	1150

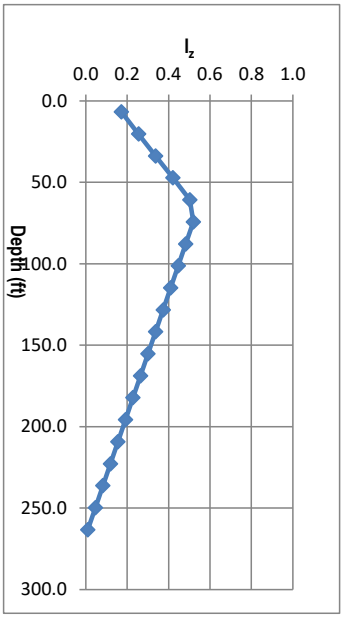


$\Delta J_i = H_c\ I_z\ /\ (X\ E)$

Z / B_f	Layer: Top of Layer (feet)	Layer: Bottom of Layer (feet)	Layer: Midpoint (feet)	Layer: Thickness, H_c (feet)	E (ksf)	I_z	ΔJ_i (x 1,000) (ft./ksf)
0.0	0.0	13.5	6.8	13.5	400	0.171	4.084
0.1	13.5	27.0	20.3	13.5	1150	0.254	2.107
0.3	27.0	40.5	33.8	13.5	1150	0.337	2.794
0.4	40.5	54.0	47.3	13.5	1150	0.420	3.481
0.5	54.0	67.5	60.8	13.5	1150	0.503	4.168
0.7	67.5	81.0	74.3	13.5	1150	0.519	4.302
0.8	81.0	94.5	87.8	13.5	1150	0.483	4.000
0.9	94.5	108.0	101.3	13.5	1150	0.446	3.698
1.1	108.0	121.5	114.8	13.5	1150	0.410	3.397
1.2	121.5	135.0	128.3	13.5	1150	0.373	3.095
1.4	135.0	148.5	141.8	13.5	1150	0.337	2.793
1.5	148.5	162.0	155.3	13.5	1150	0.301	2.491
1.6	162.0	175.5	168.8	13.5	1150	0.264	2.190
1.8	175.5	189.0	182.3	13.5	1150	0.228	1.888
1.9	189.0	202.5	195.8	13.5	1150	0.191	1.586
2.0	202.5	216.0	209.3	13.5	1150	0.155	1.284
2.2	216.0	229.5	222.8	13.5	1150	0.119	0.982
2.3	229.5	243.0	236.3	13.5	1150	0.082	0.681
2.4	243.0	256.5	249.8	13.5	1150	0.046	0.379
2.6	256.5	270.0	263.3	13.5	1150	0.009	0.077
2.7	270.0	-	-	-	-	-	-

Z = Depth below Foundation

$\Sigma\ \Delta J_i$ (x 1,000) = 49.478



$C_1 = 1 - 0.5\ [p_o / \Delta p\ ]$ =	1.00	≥ 0.5
$C_2 = 1 + 0.2 \log_{10}\ [\ t / 0.1\ (yrs)\ ]$ =	1.00	

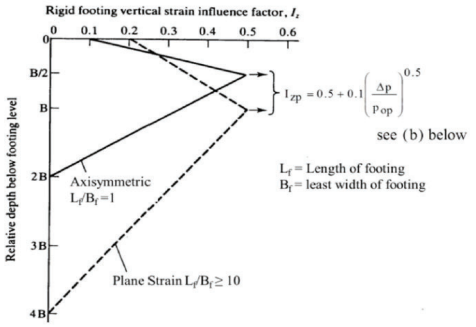
10.6.2.4.2c-1: $S_i = C_1\ C_2\ \Delta p\ \Sigma\ \Delta J_i$ = **0.74** **inches**

Schmertmann Settlement Analysis Worksheet

Reference: AASHTO LRFD Bridge Design Specifications, 9ed. 2020, Section 10.6.2.4.2c - Schmertmann Method
Analysis Location: Sta. 1009+50 - SW-12 conditions

Job Number: 113316
Analysis By: NXG

Embankment Width, B_f =	100.0	feet
Embankment Length, L_f =	400.0	feet
Depth of Embankment, D_f =	0.0	feet
Elapsed Time, t =	0.1	years
Embankment Load, p =	1,250	psf
Unit Weight Above G.S., γ_f =	120	pcf
In-Situ Effective Stress at Peak Strain, p_{op} =	8,004	psf
In-situ Effective Stress at Base of Foundation, p_o =	0	psf
L_f/B_f =	4.00	
Applied Stress, $\Delta p = p - p_o$ =	1,250	psf



1 ≤ Lf/Bf ≤ 10, Assume Max. Depth of Inflence = Df + 2.7 Bf based on Linear Interpolation

Max. Depth of Influence = 266.7 feet = $D_f + (Z/B_f)\ B_f$ where Z/B_f varies 2.0 to 4.0

1 ≤ Lf/Bf ≤ 10, Assume Depth to Peak Strain = Df + 0.7 Bf based on Linear Interpolation

Depth to In-Situ Effective Stress at Peak Strain = 66.7 feet = $D_f + K\ B_f$ where K varies 0.5 to 1.0

X = 1.42 X = 1.25 for L_f/B_f = 1; 1.75 for $L_f/B_f \geq 10$; Linear Inerpolation Between

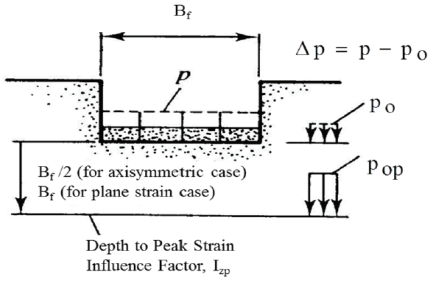
1 ≤ Lf/Bf ≤ 10, Assume Influence Below Foundation = 0.13 based on Linear Interpolation

I_z below Foundation = 0.13

$I_{zp} = 0.5 + 0.1\ [\ (\Delta p / p_{op}\ ]^{0.5}$ = 0.54

Soil Properties

Top of Layer Depth (feet)	Soil Description	E (ksf)
0.0	Fill (Medium stiff, Clay and Loose, Sandy Silt)	250
18.0	Medium Dense, Gravel and Sand	575
27.0	Claystone (Very stiff, Lean Clay)	850

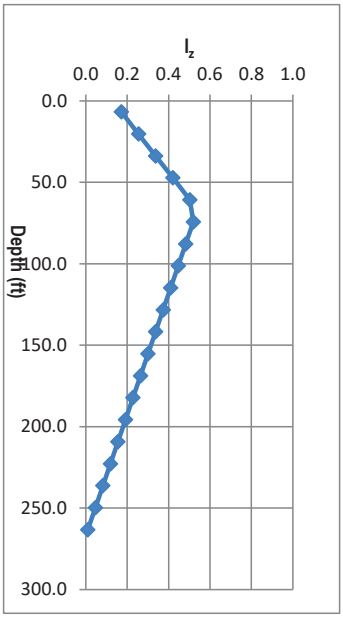


$\Delta J_i = H_c\ I_z\ /\ (X\ E)$

Z / B_f	Layer: Top of Layer (feet)	Layer: Bottom of Layer (feet)	Layer: Midpoint (feet)	Layer: Thickness, H_c (feet)	E (ksf)	I_z	ΔJ_i (x 1,000) (ft./ksf)
0.0	0.0	13.5	6.8	13.5	250	0.171	6.535
0.1	13.5	27.0	20.3	13.5	575	0.254	4.215
0.3	27.0	40.5	33.8	13.5	850	0.337	3.781
0.4	40.5	54.0	47.3	13.5	850	0.420	4.710
0.5	54.0	67.5	60.8	13.5	850	0.503	5.639
0.7	67.5	81.0	74.3	13.5	850	0.519	5.820
0.8	81.0	94.5	87.8	13.5	850	0.483	5.412
0.9	94.5	108.0	101.3	13.5	850	0.446	5.004
1.1	108.0	121.5	114.8	13.5	850	0.410	4.595
1.2	121.5	135.0	128.3	13.5	850	0.373	4.187
1.4	135.0	148.5	141.8	13.5	850	0.337	3.779
1.5	148.5	162.0	155.3	13.5	850	0.301	3.371
1.6	162.0	175.5	168.8	13.5	850	0.264	2.962
1.8	175.5	189.0	182.3	13.5	850	0.228	2.554
1.9	189.0	202.5	195.8	13.5	850	0.191	2.146
2.0	202.5	216.0	209.3	13.5	850	0.155	1.737
2.2	216.0	229.5	222.8	13.5	850	0.119	1.329
2.3	229.5	243.0	236.3	13.5	850	0.082	0.921
2.4	243.0	256.5	249.8	13.5	850	0.046	0.513
2.6	256.5	270.0	263.3	13.5	850	0.009	0.104
2.7	270.0	-	-	-	-	-	-

Z = Depth below Foundation

$\Sigma\ \Delta J_i$ (x 1,000) = 69.314



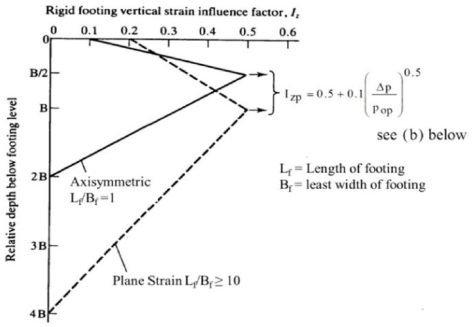
$C_1 = 1 - 0.5\ [p_o / \Delta p\ ]$ =	1.00	≥ 0.5
$C_2 = 1 + 0.2 \log_{10}\ [\ t / 0.1\ (yrs)\ ]$ =	1.00	

10.6.2.4.2c-1: $S_i = C_1\ C_2\ \Delta p\ \Sigma\ \Delta J_i$ = **1.04** **inches**

Schmertmann Settlement Analysis Worksheet

Reference: AASHTO LRFD Bridge Design Specifications, 9ed. 2020, Section 10.6.2.4.2c - Schmertmann Method
Job Number: 113316
Analysis Location: Sta. 1016+75 - SW-10 conditions
Analysis By: NXG

Embankment Width, B_f =	80.0	feet
Embankment Length, L_f =	100.0	feet
Depth of Embankment, D_f =	0.0	feet
Elapsed Time, t =	0.1	years
Embankment Load, p =	2,500	psf
Unit Weight Above G.S., γ_f =	120	pcf
In-Situ Effective Stress at Peak Strain, p_{op} =	4,932	psf
In-situ Effective Stress at Base of Foundation, p_o =	0	psf
L_f/B_f =	1.25	
Applied Stress, $\Delta p = p - p_o$ =	2,500	psf



1 ≤ Lf/Bf ≤ 10, Assume Max. Depth of Inflence = Df + 2.1 Bf based on Linear Interpolation

Max. Depth of Influence = 164.4 feet = $D_f + (Z/B_f)\ B_f$ where Z/B_f varies 2.0 to 4.0

1 ≤ Lf/Bf ≤ 10, Assume Depth to Peak Strain = Df + 0.5 Bf based on Linear Interpolation

Depth to In-Situ Effective Stress at Peak Strain = 41.1 feet = $D_f + K\ B_f$ where K varies 0.5 to 1.0

X = 1.26 X = 1.25 for L_f/B_f = 1; 1.75 for $L_f/B_f \geq 10$; Linear Inerpolation Between

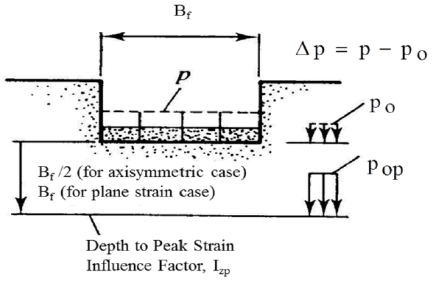
1 ≤ Lf/Bf ≤ 10, Assume Influence Below Foundation = 0.10 based on Linear Interpolation

I_z below Foundation = 0.10

$I_{zp} = 0.5 + 0.1\ [\ (\Delta p / p_{op}\ ]^{0.5}$ = 0.57

Soil Properties

Top of Layer Depth (feet)	Soil Description	E (ksf)
0.0	Medium stiff CL Colluvium over Loose Sand Alluvium	250
12.0	Claystone (Very stiff, Lean Clay)	850

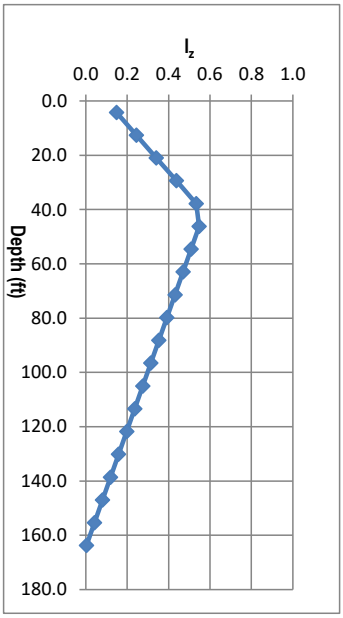


$\Delta J_i = H_c\ I_z\ /\ (X\ E)$

Z / B_f	Layer: Top of Layer (feet)	Layer: Bottom of Layer (feet)	Layer: Layer Midpoint (feet)	Layer: Thickness, H_c (feet)	E (ksf)	I_z	ΔJ_i (x 1,000) (ft./ksf)
0.0	0.0	8.4	4.2	8.4	250	0.148	3.939
0.1	8.4	16.8	12.6	8.4	850	0.244	1.911
0.2	16.8	25.2	21.0	8.4	850	0.341	2.664
0.3	25.2	33.6	29.4	8.4	850	0.437	3.417
0.4	33.6	42.0	37.8	8.4	850	0.533	4.170
0.5	42.0	50.4	46.2	8.4	850	0.548	4.281
0.6	50.4	58.8	54.6	8.4	850	0.509	3.977
0.7	58.8	67.2	63.0	8.4	850	0.470	3.673
0.8	67.2	75.6	71.4	8.4	850	0.431	3.369
0.9	75.6	84.0	79.8	8.4	850	0.392	3.064
1.1	84.0	92.4	88.2	8.4	850	0.353	2.760
1.2	92.4	100.8	96.6	8.4	850	0.314	2.456
1.3	100.8	109.2	105.0	8.4	850	0.275	2.152
1.4	109.2	117.6	113.4	8.4	850	0.236	1.847
1.5	117.6	126.0	121.8	8.4	850	0.197	1.543
1.6	126.0	134.4	130.2	8.4	850	0.158	1.239
1.7	134.4	142.8	138.6	8.4	850	0.120	0.935
1.8	142.8	151.2	147.0	8.4	850	0.081	0.630
1.9	151.2	159.6	155.4	8.4	850	0.042	0.326
2.0	159.6	168.0	163.8	8.4	850	0.003	0.022
2.1	168.0	-	-	-	-	-	-

Z = Depth below Foundation

$\Sigma\ \Delta J_i$ (x 1,000) = 48.376



$C_1 = 1 - 0.5\ [p_o / \Delta p\ ]$ =	1.00	≥ 0.5
$C_2 = 1 + 0.2\ \log_{10}\ [\ t / 0.1\ (yrs)\ ]$ =	1.00	

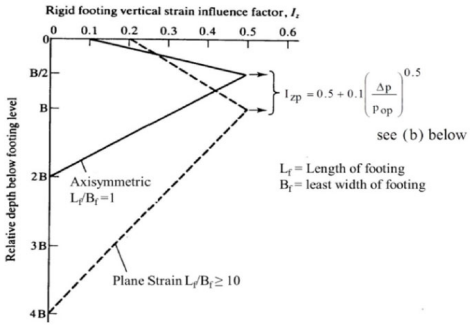
10.6.2.4.2c-1: $S_i = C_1\ C_2\ \Delta p\ \Sigma\ \Delta J_i$ = **1.45** **inches**

Schmertmann Settlement Analysis Worksheet

Reference: AASHTO LRFD Bridge Design Specifications, 9ed. 2020, Section 10.6.2.4.2c - Schmertmann Method
Analysis Location: Sta. 1020+00 - SW-08 conditions

Job Number: 113316
Analysis By: NXG

Embankment Width, B_f =	60.0	feet
Embankment Length, L_f =	125.0	feet
Depth of Embankment, D_f =	0.0	feet
Elapsed Time, t =	0.1	years
Embankment Load, p =	1,750	psf
Unit Weight Above G.S., γ_f =	120	pcf
In-Situ Effective Stress at Peak Strain, p_{op} =	4,032	psf
In-situ Effective Stress at Base of Foundation, p_o =	0	psf
L_f/B_f =	2.08	
Applied Stress, $\Delta p = p - p_o$ =	1,750	psf



1 ≤ Lf/Bf ≤ 10, Assume Max. Depth of Inflence = Df + 2.2 Bf based on Linear Interpolation

Max. Depth of Influence = 134.4 feet = $D_f + (Z/B_f)\ B_f$ where Z/B_f varies 2.0 to 4.0

1 ≤ Lf/Bf ≤ 10, Assume Depth to Peak Strain = Df + 0.6 Bf based on Linear Interpolation

Depth to In-Situ Effective Stress at Peak Strain = 33.6 feet = $D_f + K\ B_f$ where K varies 0.5 to 1.0

X = 1.31 X = 1.25 for $L_f/B_f = 1$; 1.75 for $L_f/B_f \geq 10$; Linear Inerpolation Between

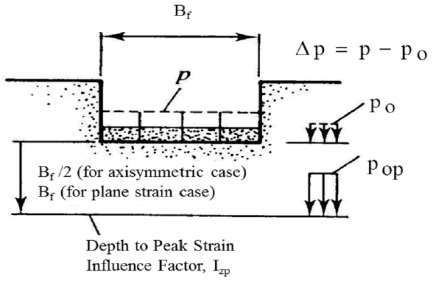
1 ≤ Lf/Bf ≤ 10, Assume Influence Below Foundation = 0.11 based on Linear Interpolation

I_z below Foundation = 0.11

$I_{zp} = 0.5 + 0.1\ [\ (\Delta p / p_{op}\ ]^{0.5}$ = 0.57

Soil Properties

Top of Layer Depth (feet)	Soil Description	E (ksf)
0.0	Medium stiff CL Colluvium over Loose Sand Alluvium	250
13.0	Claystone (Very stiff, Lean Clay)	850

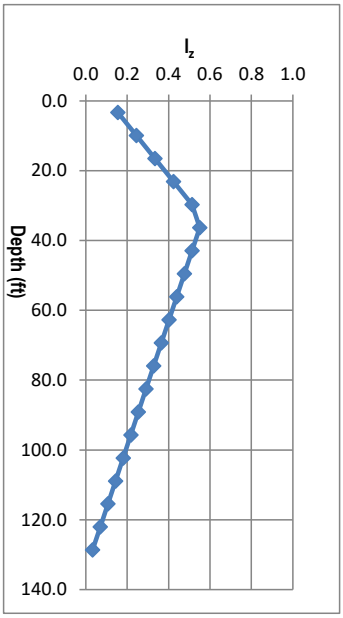


$\Delta J_i = H_c\ I_z\ /\ (X\ E)$

Z / B_f	Layer: Top of Layer (feet)	Layer: Bottom of Layer (feet)	Layer: Layer Midpoint (feet)	Layer: Thickness, H_c (feet)	E (ksf)	I_z	ΔJ_i (x 1,000) (ft./ksf)
0.0	0.0	6.6	3.3	6.6	250	0.155	3.119
0.1	6.6	13.2	9.9	6.6	250	0.244	4.924
0.2	13.2	19.8	16.5	6.6	850	0.334	1.979
0.3	19.8	26.4	23.1	6.6	850	0.423	2.510
0.4	26.4	33.0	29.7	6.6	850	0.513	3.040
0.6	33.0	39.6	36.3	6.6	850	0.551	3.264
0.7	39.6	46.2	42.9	6.6	850	0.514	3.045
0.8	46.2	52.8	49.5	6.6	850	0.477	2.825
0.9	52.8	59.4	56.1	6.6	850	0.440	2.605
1.0	59.4	66.0	62.7	6.6	850	0.403	2.386
1.1	66.0	72.6	69.3	6.6	850	0.365	2.166
1.2	72.6	79.2	75.9	6.6	850	0.328	1.947
1.3	79.2	85.8	82.5	6.6	850	0.291	1.727
1.4	85.8	92.4	89.1	6.6	850	0.254	1.507
1.5	92.4	99.0	95.7	6.6	850	0.217	1.288
1.7	99.0	105.6	102.3	6.6	850	0.180	1.068
1.8	105.6	112.2	108.9	6.6	850	0.143	0.849
1.9	112.2	118.8	115.5	6.6	850	0.106	0.629
2.0	118.8	125.4	122.1	6.6	850	0.069	0.409
2.1	125.4	132.0	128.7	6.6	850	0.032	0.190
2.2	132.0	-	-	-	-	-	-

Z = Depth below Foundation

$\Sigma\ \Delta J_i$ (x 1,000) = 41.477



$C_1 = 1 - 0.5\ [p_o / \Delta p\ ]$ =	1.00	≥ 0.5
$C_2 = 1 + 0.2\ \log_{10}\ [\ t / 0.1\ (yrs)\ ]$ =	1.00	

10.6.2.4.2c-1: $S_i = C_1\ C_2\ \Delta p\ \Sigma\ \Delta J_i$ =	**0.87**	**inches**

Settle3 Analysis Information

Chateau Road Reconstruction

Project Settings

Document Name	Sta 1024+50 Settlement (one clay)
Project Title	Chateau Road Reconstruction
Analysis	Embankment Settlement
Author	NXG
Company	Shannon and Wilson, Inc.
Date Created	9/10/2024, 2:38:47 PM
Stress Computation Method	Boussinesq
Minimum settlement ratio for subgrade modulus	0.9
Use average properties to calculate layered stresses	
Improve consolidation accuracy	
Ignore negative effective stresses in settlement calculations	

Stage Settings

Stage #	Name
1	Temporary Embankment
2	Final Embankment

Results

Time taken to compute: 0.0918514 seconds

Stage: Temporary Embankment

Data Type	Minimum	Maximum
Total Settlement [in]	0	5.18504
Total Consolidation Settlement [in]	0	5.18504
Virgin Consolidation Settlement [in]	0	3.69189
Recompression Consolidation Settlement [in]	0	1.49315
Immediate Settlement [in]	0	0
Loading Stress ZZ [ksf]	-3.34795e-08	2.24
Loading Stress XX [ksf]	-0.957088	2.51129
Loading Stress YY [ksf]	-0.564275	1.45515
Effective Stress ZZ [ksf]	-3.34795e-08	3.99643
Effective Stress XX [ksf]	-0.150308	4.37421
Effective Stress YY [ksf]	0.0958012	3.33015
Total Stress ZZ [ksf]	-3.34795e-08	3.99643
Total Stress XX [ksf]	-0.150308	4.37421
Total Stress YY [ksf]	0.0958012	3.33015
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	-2.79737e-07	0.3155
Pore Water Pressure [ksf]	0	0
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.003	5.997
Over-consolidation Ratio	1	3.20011
Void Ratio	0.13627	0.66
Hydroconsolidation Settlement [in]	0	0
Undrained Shear Strength	0	0.134794

Stage: Final Embankment

Data Type	Minimum	Maximum
Total Settlement [in]	0	5.20037
Total Consolidation Settlement [in]	0	5.20037
Virgin Consolidation Settlement [in]	0	3.69932
Recompression Consolidation Settlement [in]	0	1.50105
Immediate Settlement [in]	0	0
Loading Stress ZZ [ksf]	2.06818e-11	2.24096
Loading Stress XX [ksf]	-0.841125	2.43784
Loading Stress YY [ksf]	-0.357097	1.43937
Effective Stress ZZ [ksf]	2.06818e-11	4.07676
Effective Stress XX [ksf]	-0.166826	4.31284
Effective Stress YY [ksf]	0.161681	3.31437
Total Stress ZZ [ksf]	2.06818e-11	4.07676
Total Stress XX [ksf]	-0.166826	4.31284
Total Stress YY [ksf]	0.161681	3.31437
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	0.000655632	0.31552
Pore Water Pressure [ksf]	0	0
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.003	5.997
Over-consolidation Ratio	1	2.94355
Void Ratio	0.136237	0.658912
Hydroconsolidation Settlement [in]	0	0
Undrained Shear Strength	0	0.135541

Embankments

1. Embankment: "Final Embankment"

Label	Final Embankment
Center Line	(-105, 0) to (-105, 450)
Near End Angle	90 degrees
Far End Angle	90 degrees
Number of Zones	1
Number of Sections	1

Zone	Name	Unit Weight (kips/ft3)
1	New Zone	0.14

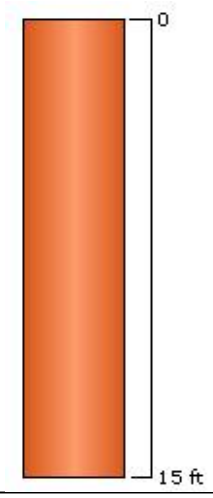
2. Embankment: "Temporary Embankment"

Label	Temporary Embankment
Center Line	(-55, 0) to (-55, 450)
Near End Angle	90 degrees
Far End Angle	90 degrees
Number of Zones	1
Number of Sections	1

Zone	Name	Unit Weight (kips/ft3)
1	New Zone	0.14

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	Soft Clay	15	0



Soil Properties

Property	Soft Clay
Color	
Unit Weight [kips/ft3]	0.125
Saturated Unit Weight [kips/ft3]	0.125
K0	1
Primary Consolidation	Enabled
Material Type	Non-Linear
Cc	0.177
Cr	0.03
e0	0.66
OCR	3.2
Secondary Consolidation	Standard
Ca	0.03
Car	0.03
Undrained Su A [kips/ft2]	0
Undrained Su S	0.2
Undrained Su m	0.8
Piezo Line ID	0

Groundwater

Groundwater method	Piezometric Lines
Water Unit Weight	0.0624 kips/ft3

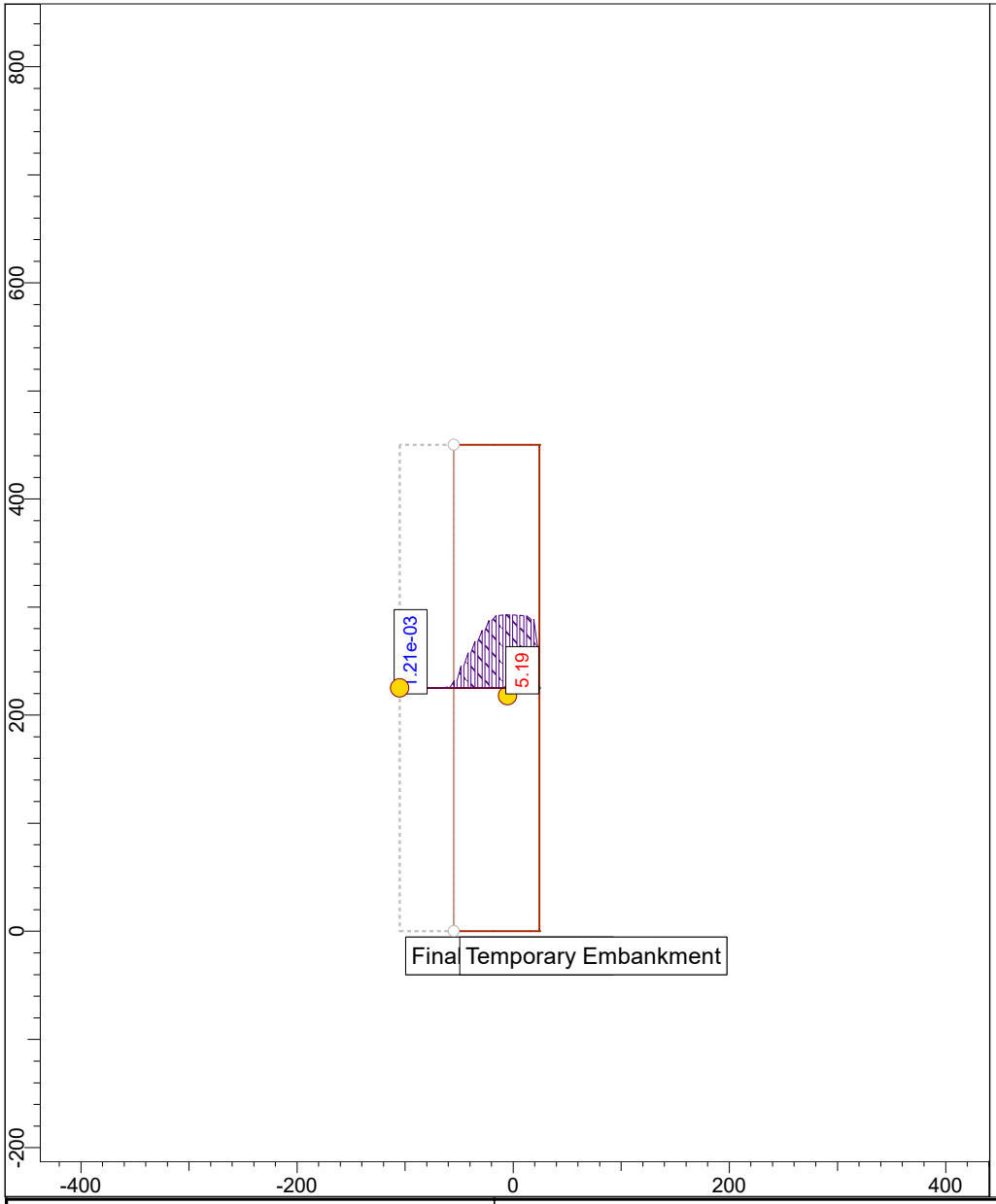
Query Points

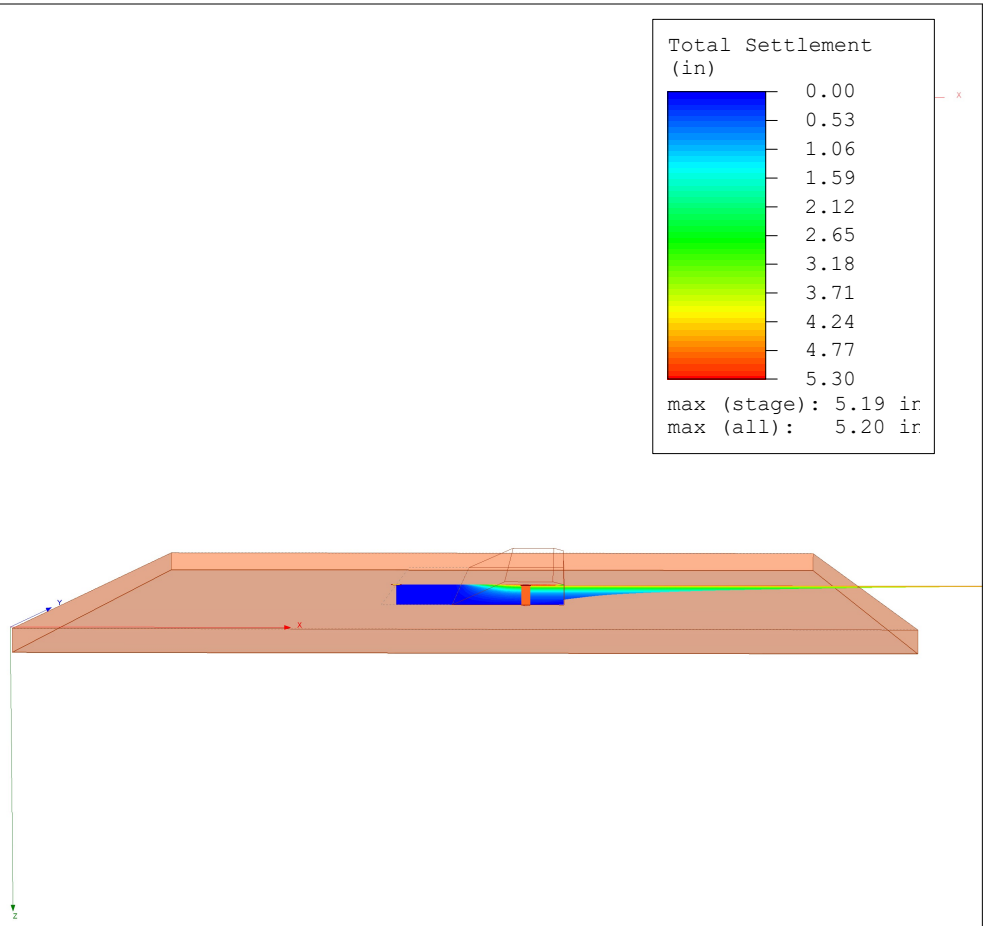
Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Query Point 1	-5.158, 217.988	Auto: 31
2	Query Point 2	-55, 218.833	Auto: 31

Query Lines

Line #	Query Line Name	Start Location	End Location	Horizontal Divisions	Vertical Divisions
1	Query Line 1	-105, 225	24, 225	20	Auto: 31

One Clay Model



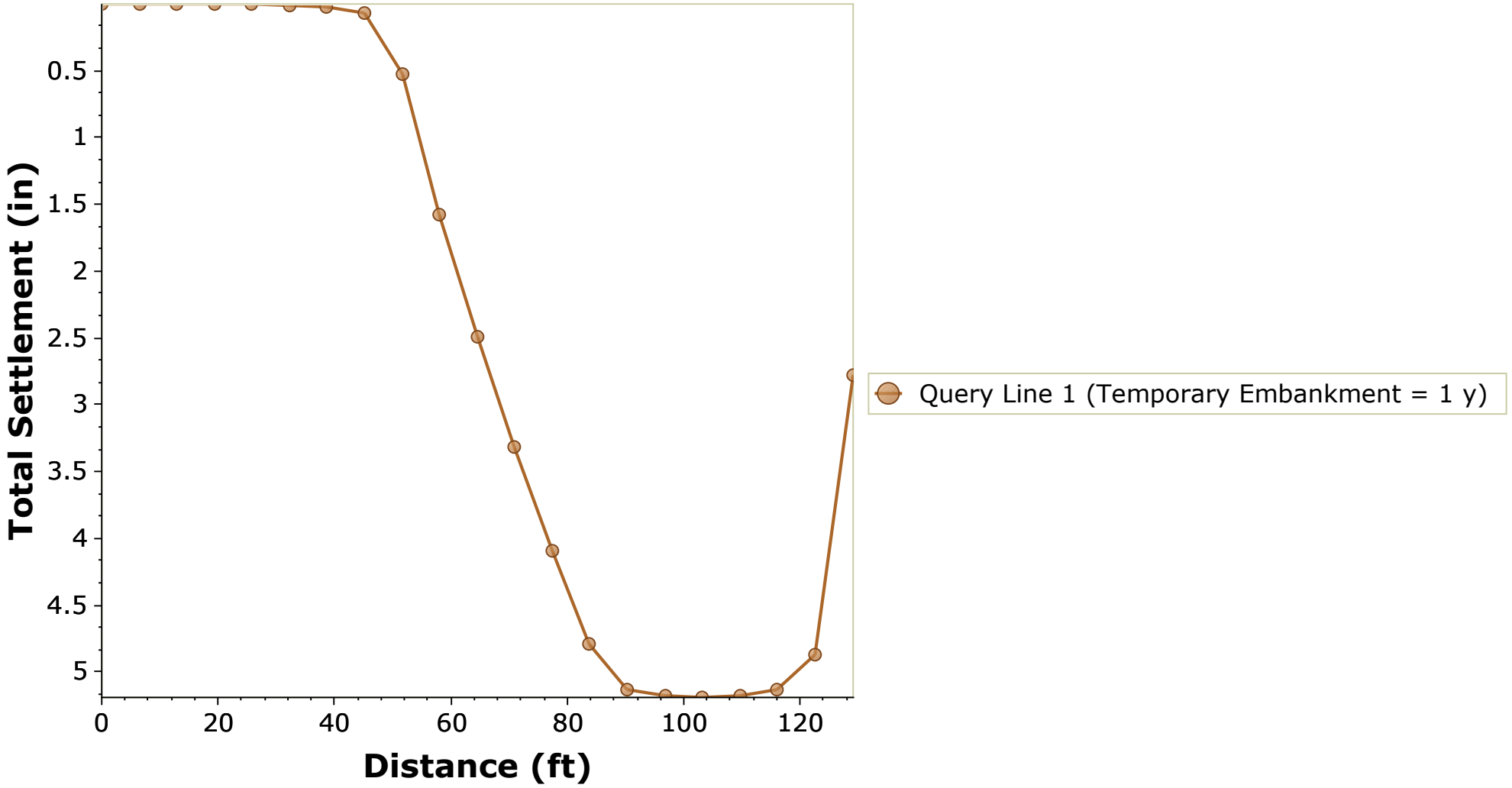


rocscience	*Project*	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	*Company* Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	*File Name* Sta 1024+50 Settlement (one clay).s3z

SETTLE3 5.012

One Clay Model

Distance vs. Total Settlement



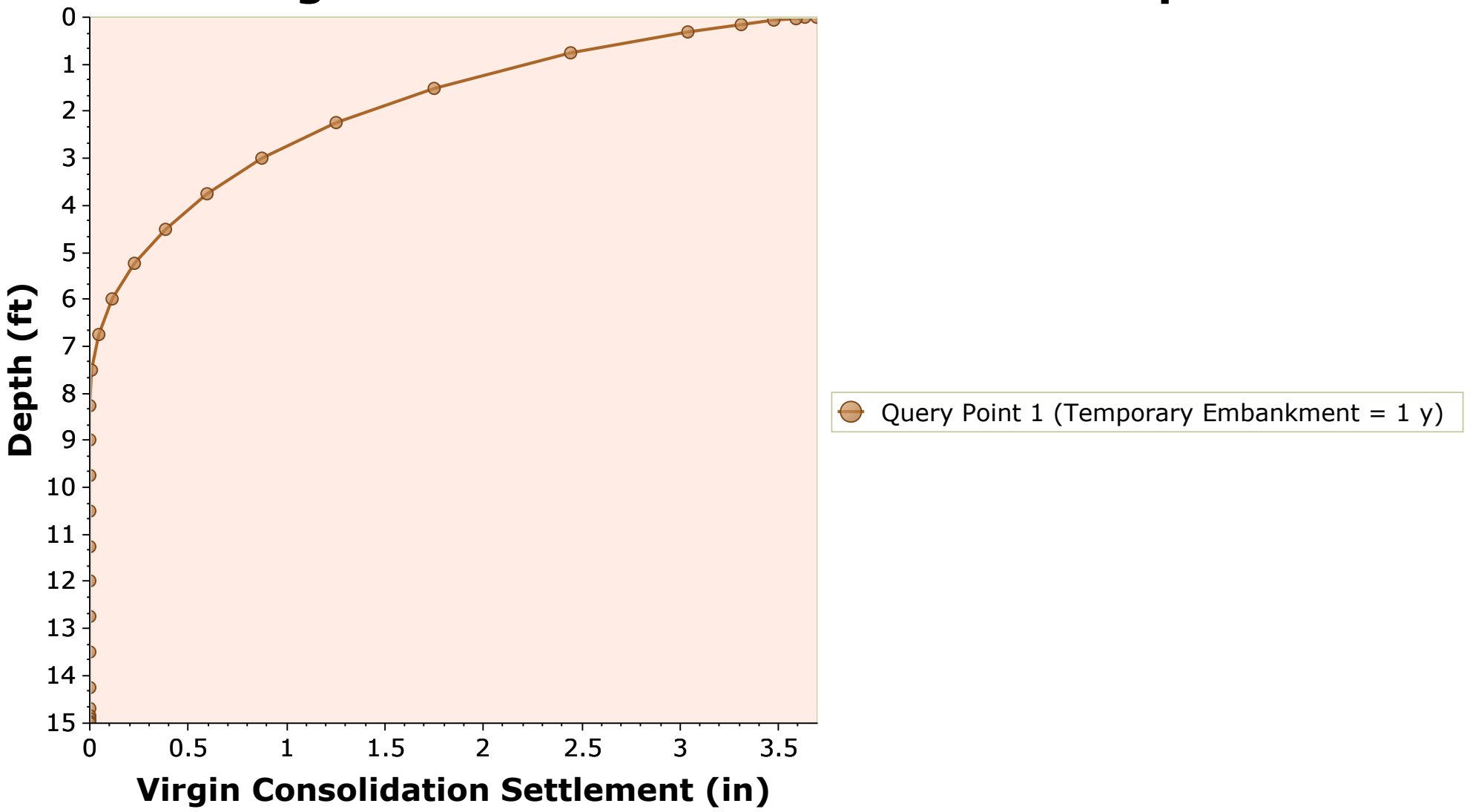
Reference Stage: None
Total Settlement at Depth = 0 ft

rocscience	Project	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	Company: Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	File Name: Sta 1024+50 Settlement (one clay).s3z

SETTLE3 5.012

One Clay Model

Virgin Consolidation Settlement vs. Depth



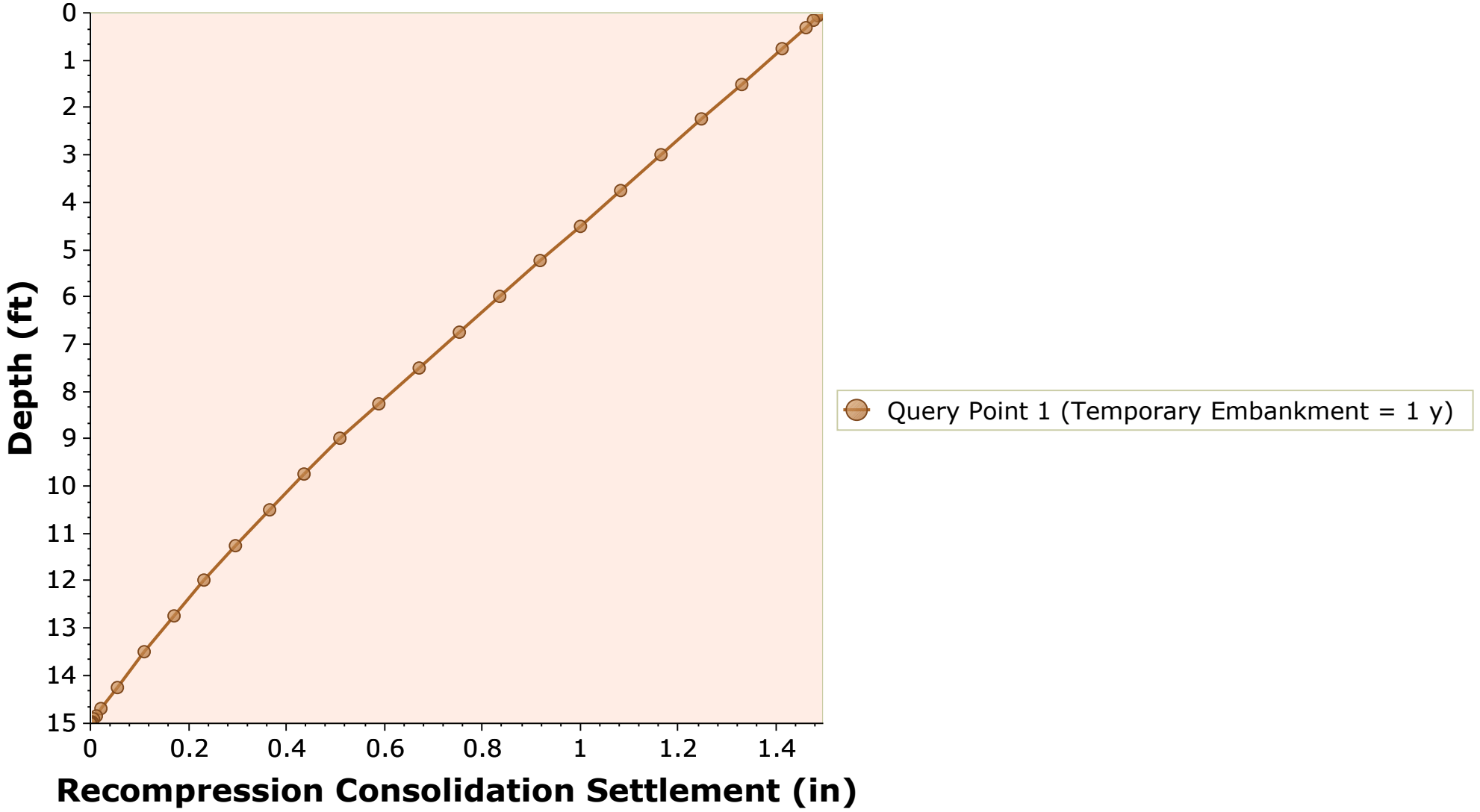
Reference Stage: None

rocscience	*Project*	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	*Company* Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	*File Name* Sta 1024+50 Settlement (one clay).s3z

SETTLE3 5.012

One Clay Model

Recompression Consolidation Settlement vs. Depth

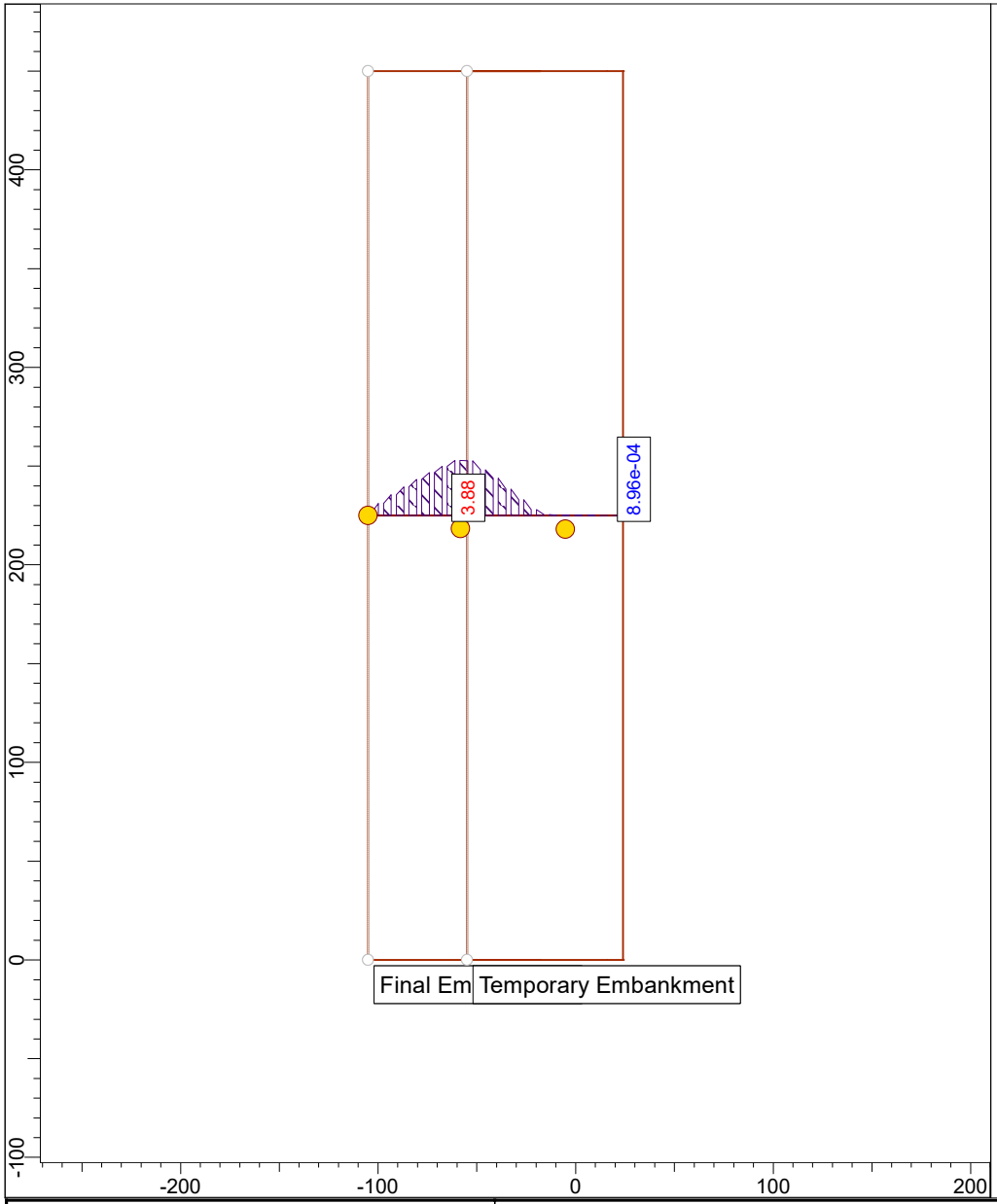


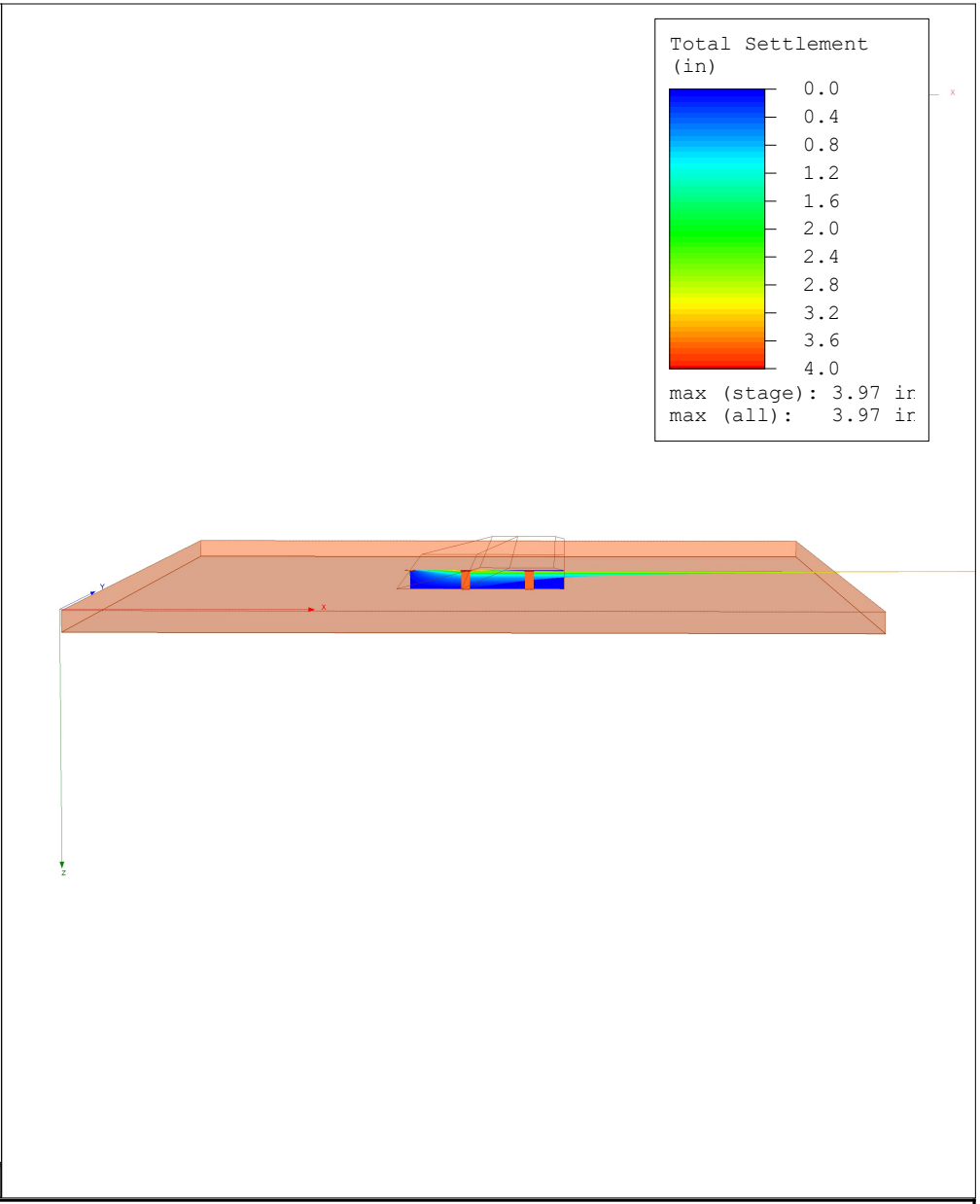
Reference Stage: None

rocscience	*Project*	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	*Company* Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	*File Name* Sta 1024+50 Settlement (one clay).s3z

SETTLE3 5.012

One Clay Model



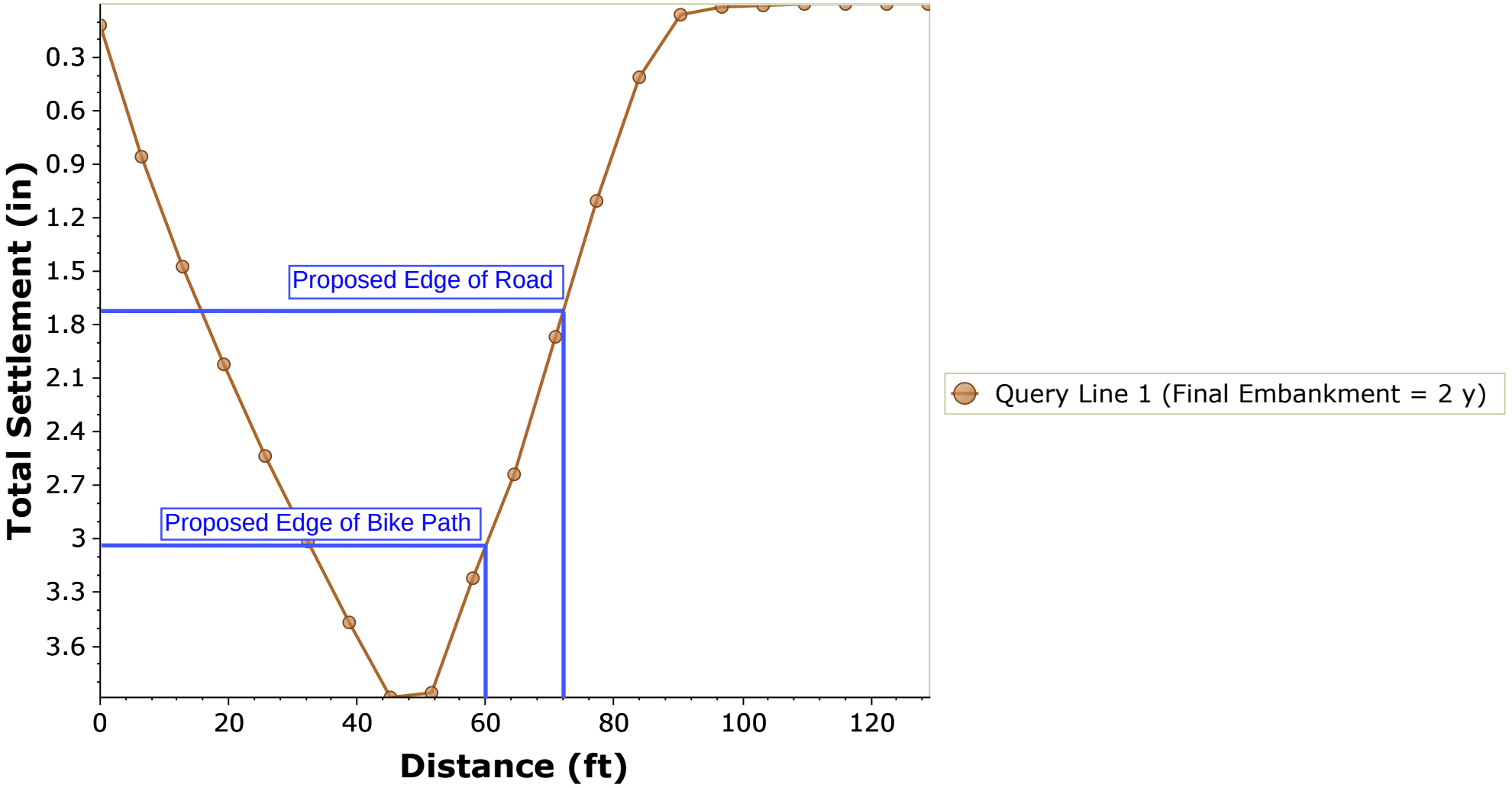


rocscience	*Project*	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	*Company* Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	*File Name* Sta 1024+50 Settlement (one clay).s3z

SETTLE3 5.012

One Clay Model

Distance vs. Total Settlement



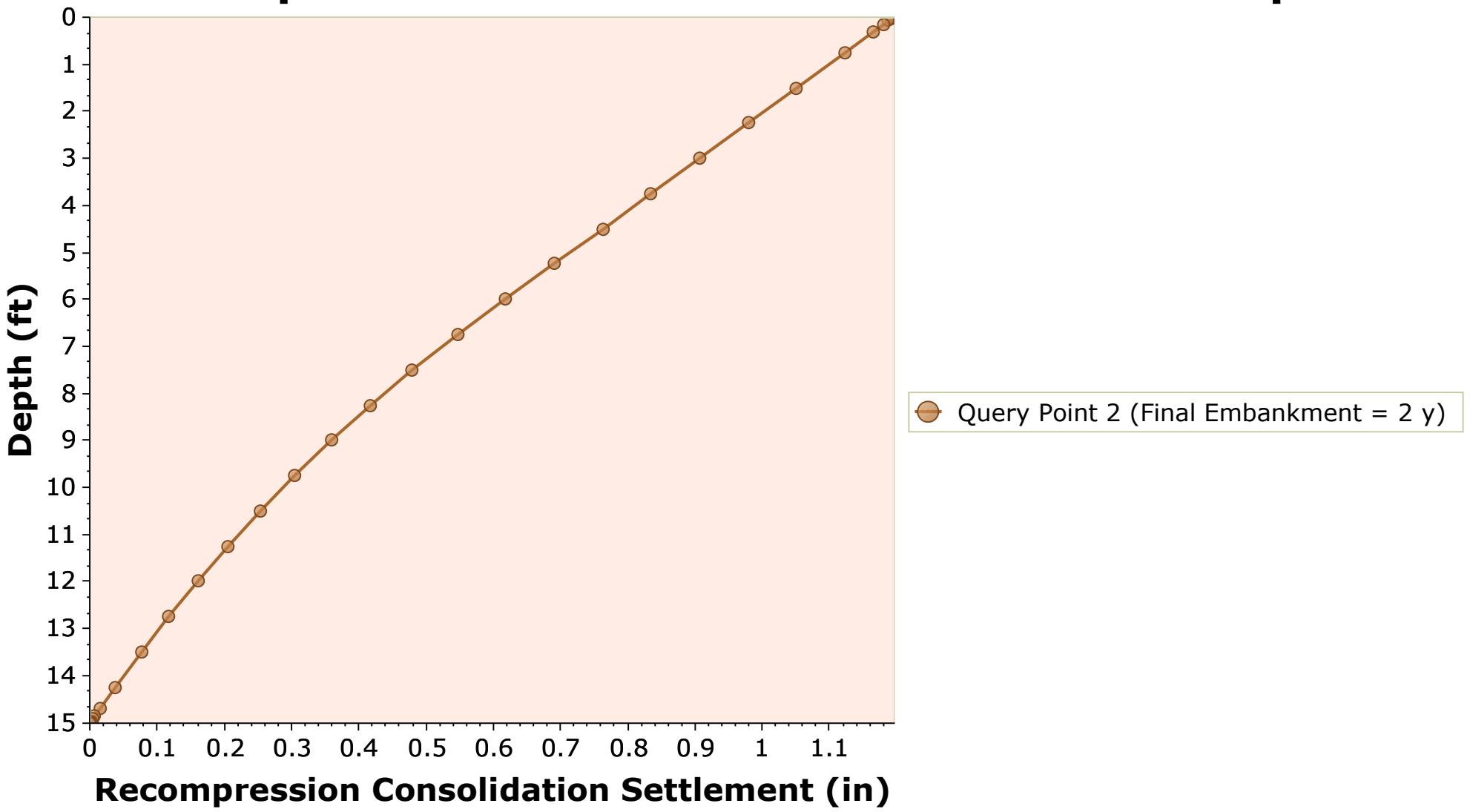
Reference Stage: Temporary Embankment = 1 y
Total Settlement at Depth = 0 ft

rocscience	*Project*	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	*Company* Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	*File Name* Sta 1024+50 Settlement (one clay).s3z

SETTLE3 5.012

One Clay Model

Recompression Consolidation Settlement vs. Depth



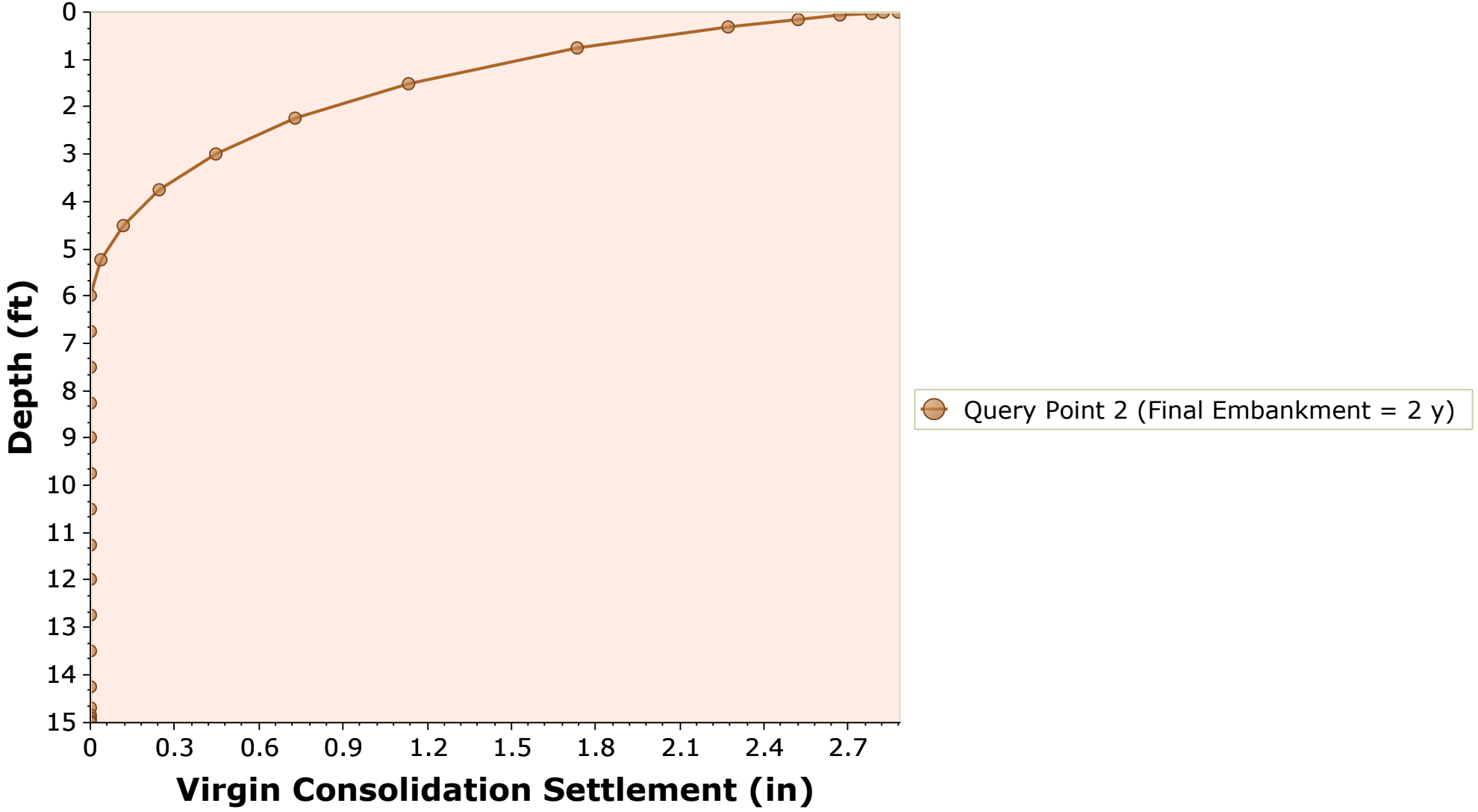
Reference Stage: Temporary Embankment = 1 y

rocscience	Project	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	Company: Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	File Name: Sta 1024+50 Settlement (one clay).s3z

SETTLE3 5.012

One Clay Model

Virgin Consolidation Settlement vs. Depth



Reference Stage: Temporary Embankment = 1 y

rocscience	*Project*	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	*Company* Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	*File Name* Sta 1024+50 Settlement (one clay).s3z

SETTLE3 5.012

Settle3 Analysis Information

Chateau Road Reconstruction

Project Settings

Document Name	Sta 1024+50 Settlement (Two clays)
Project Title	Chateau Road Reconstruction
Analysis	Embankment Settlement
Author	NXG
Company	Shannon and Wilson, Inc.
Date Created	9/10/2024, 2:38:47 PM
Stress Computation Method	Boussinesq
Minimum settlement ratio for subgrade modulus	0.9
Use average properties to calculate layered stresses	
Improve consolidation accuracy	
Ignore negative effective stresses in settlement calculations	

Stage Settings

Stage #	Name
1	Temporary Embankment
2	Final Embankment

Results

Time taken to compute: 0.146165 seconds

Stage: Temporary Embankment

Data Type	Minimum	Maximum
Total Settlement [in]	0	6.20802
Total Consolidation Settlement [in]	0	6.20802
Virgin Consolidation Settlement [in]	0	4.00482
Recompression Consolidation Settlement [in]	0	2.2032
Immediate Settlement [in]	0	0
Loading Stress ZZ [ksf]	-3.34795e-08	2.24
Loading Stress XX [ksf]	-0.957088	2.51142
Loading Stress YY [ksf]	-0.491514	1.45515
Effective Stress ZZ [ksf]	-3.34795e-08	3.06043
Effective Stress XX [ksf]	-0.235606	3.43821
Effective Stress YY [ksf]	0.0958012	2.39415
Total Stress ZZ [ksf]	-3.34795e-08	3.99643
Total Stress XX [ksf]	-0.107657	4.37421
Total Stress YY [ksf]	0.0958012	3.33015
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	-8.39191e-07	0.3188
Pore Water Pressure [ksf]	0	0.936
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.003443	3.43525
Over-consolidation Ratio	1	11.0012
Void Ratio	0.130791	0.660001
Hydroconsolidation Settlement [in]	0	0
Undrained Shear Strength	0	0.185486

Stage: Final Embankment

Data Type	Minimum	Maximum
Total Settlement [in]	0	6.27429
Total Consolidation Settlement [in]	0	6.27429
Virgin Consolidation Settlement [in]	0	4.07092
Recompression Consolidation Settlement [in]	0	2.20337
Immediate Settlement [in]	0	0
Loading Stress ZZ [ksf]	2.06818e-11	2.24096
Loading Stress XX [ksf]	-0.841125	2.43784
Loading Stress YY [ksf]	-0.357097	1.43937
Effective Stress ZZ [ksf]	2.06818e-11	3.14076
Effective Stress XX [ksf]	-0.227069	3.37684
Effective Stress YY [ksf]	0.148075	2.37837
Total Stress ZZ [ksf]	2.06818e-11	4.07676
Total Stress XX [ksf]	-0.166955	4.31284
Total Stress YY [ksf]	0.161703	3.31437
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	0.00125882	0.31882
Pore Water Pressure [ksf]	0	0.936
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.003443	3.43525
Over-consolidation Ratio	1	9.34171
Void Ratio	0.130759	0.65791
Hydroconsolidation Settlement [in]	0	0
Undrained Shear Strength	0	0.18555

Embankments

1. Embankment: "Final Embankment"

Label	Final Embankment
Center Line	(-105, 0) to (-105, 450)
Near End Angle	90 degrees
Far End Angle	90 degrees
Number of Zones	1
Number of Sections	1

Zone	Name	Unit Weight (kips/ft3)
1	New Zone	0.14

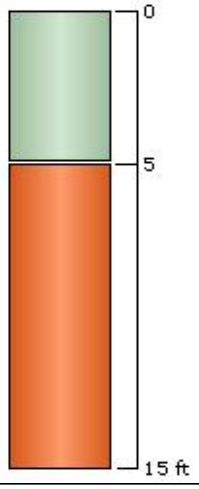
2. Embankment: "Temporary Embankment"

Label	Temporary Embankment
Center Line	(-55, 0) to (-55, 450)
Near End Angle	90 degrees
Far End Angle	90 degrees
Number of Zones	1
Number of Sections	1

Zone	Name	Unit Weight (kips/ft3)
1	New Zone	0.14

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	Soft Clay (Upper 5ft)	5	0
2	Soft Clay	10	5



Soil Properties

Property	Soft Clay	Soft Clay (Upper 5ft)
Color		
Unit Weight [kips/ft3]	0.125	0.125
Saturated Unit Weight [kips/ft3]	0.125	0.125
K0	1	1
Primary Consolidation	Enabled	Enabled
Material Type	Non-Linear	Non-Linear
Cc	0.177	0.177
Cr	0.03	0.03
e0	0.66	0.66
OCR	3.2	11
Secondary Consolidation	Standard	Standard
Ca	0.009	0.009
Car	0.002	0.002
Undrained Su A [kips/ft2]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8
Piezo Line ID	1	1

Groundwater

Groundwater method	Piezometric Lines
Water Unit Weight	0.0624 kips/ft3

Piezometric Line Entities

ID	Depth (ft)
1	0 ft

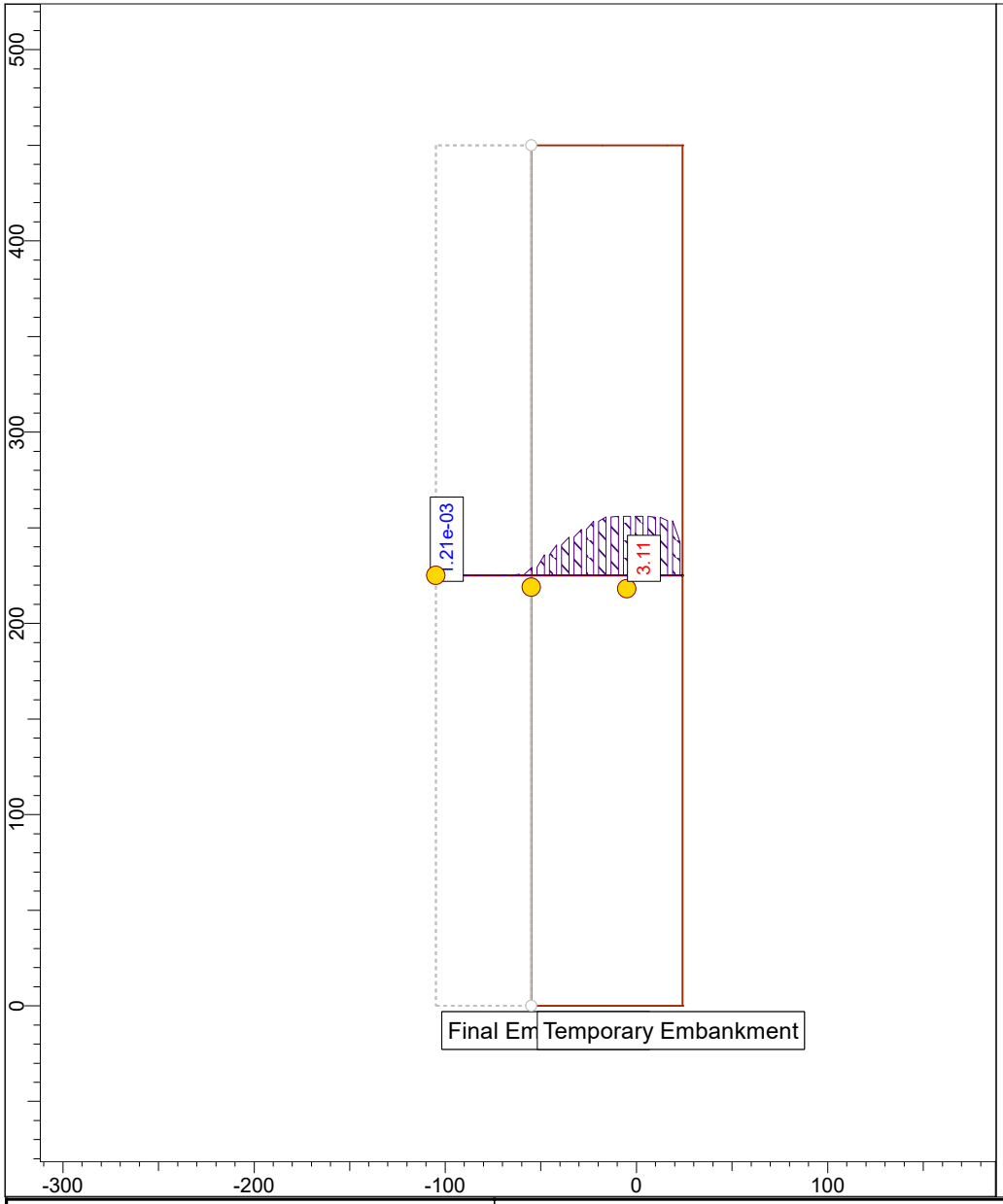
Query Points

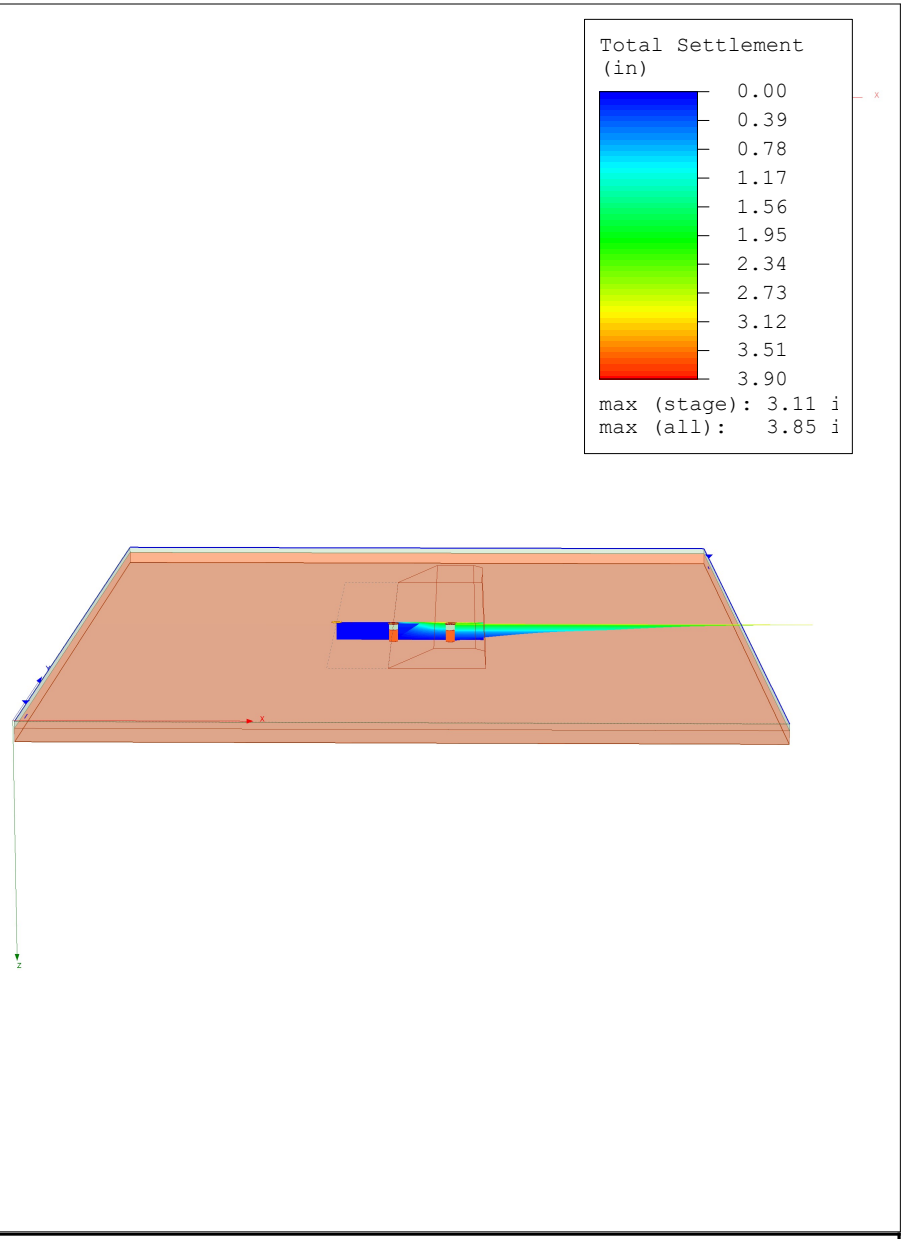
Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Query Point 1	-5.158, 217.988	Auto: 49
2	Query Point 2	-46.829, 217.54	Auto: 49

Query Lines

Line #	Query Line Name	Start Location	End Location	Horizontal Divisions	Vertical Divisions
1	Query Line 1	-105, 225	24, 225	20	Auto: 49

Two Clay Model



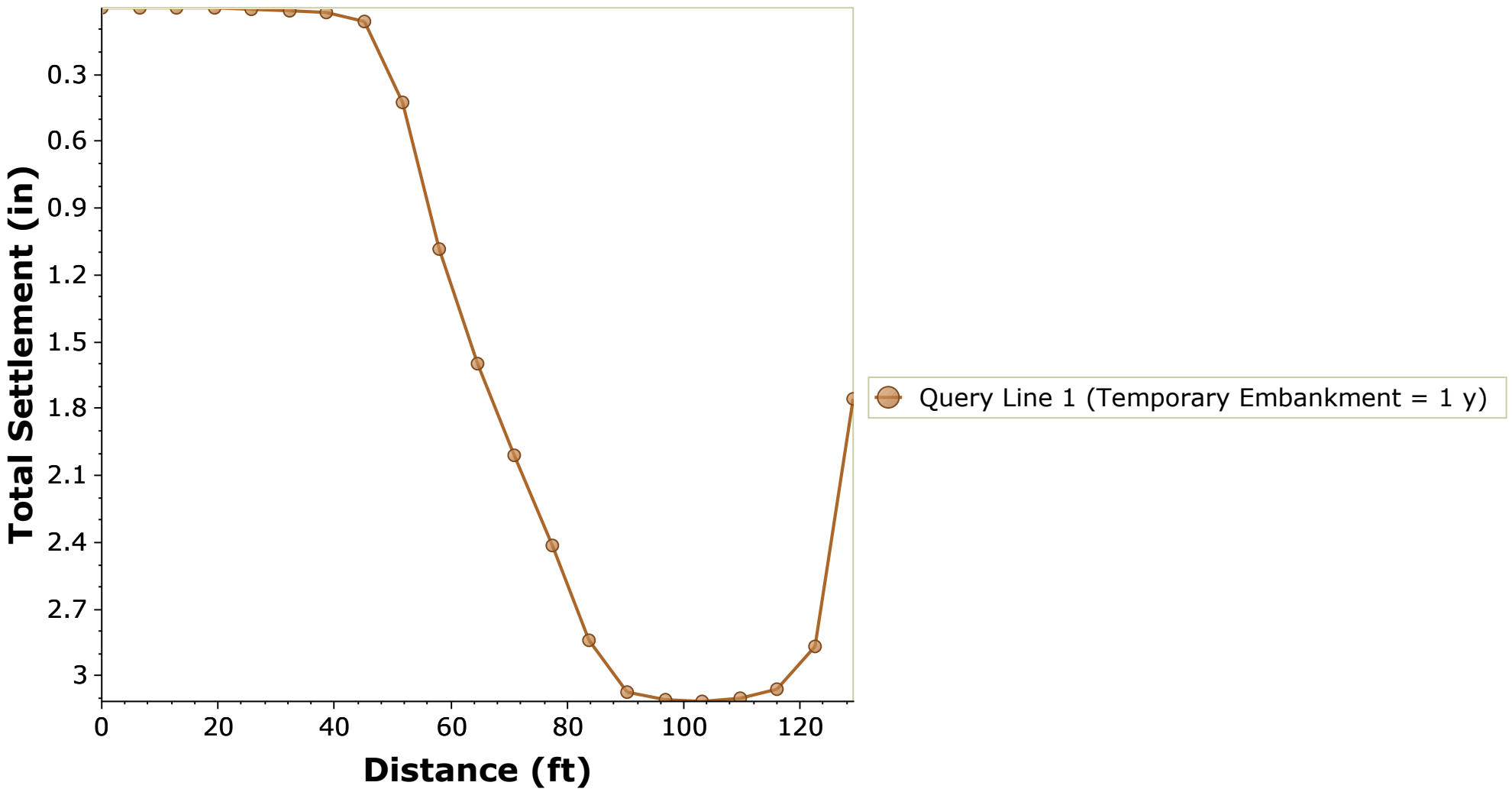


rocscience	*Project*	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	*Company* Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	*File Name* Sta 1024+50 Settlement (Two clays) - Copy.s3z

SETTLE3 5.012

Two Clay Model

Distance vs. Total Settlement



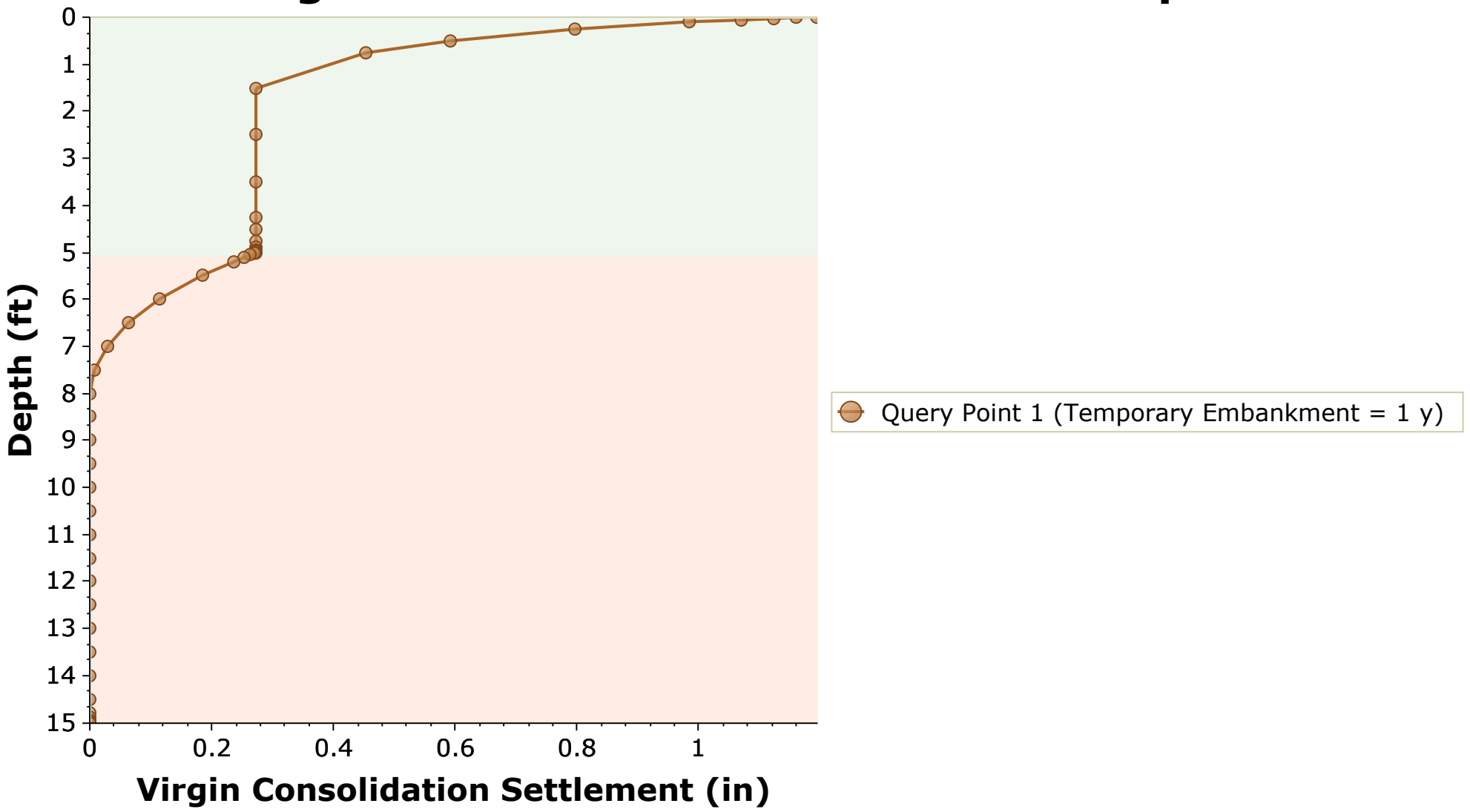
Reference Stage: None
Total Settlement at Depth = 0 ft

rocscience	*Project*	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	*Company* Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	*File Name* Sta 1024+50 Settlement (Two clays) - Copy.s3z

SETTLE3 5.012

Two Clay Model

Virgin Consolidation Settlement vs. Depth



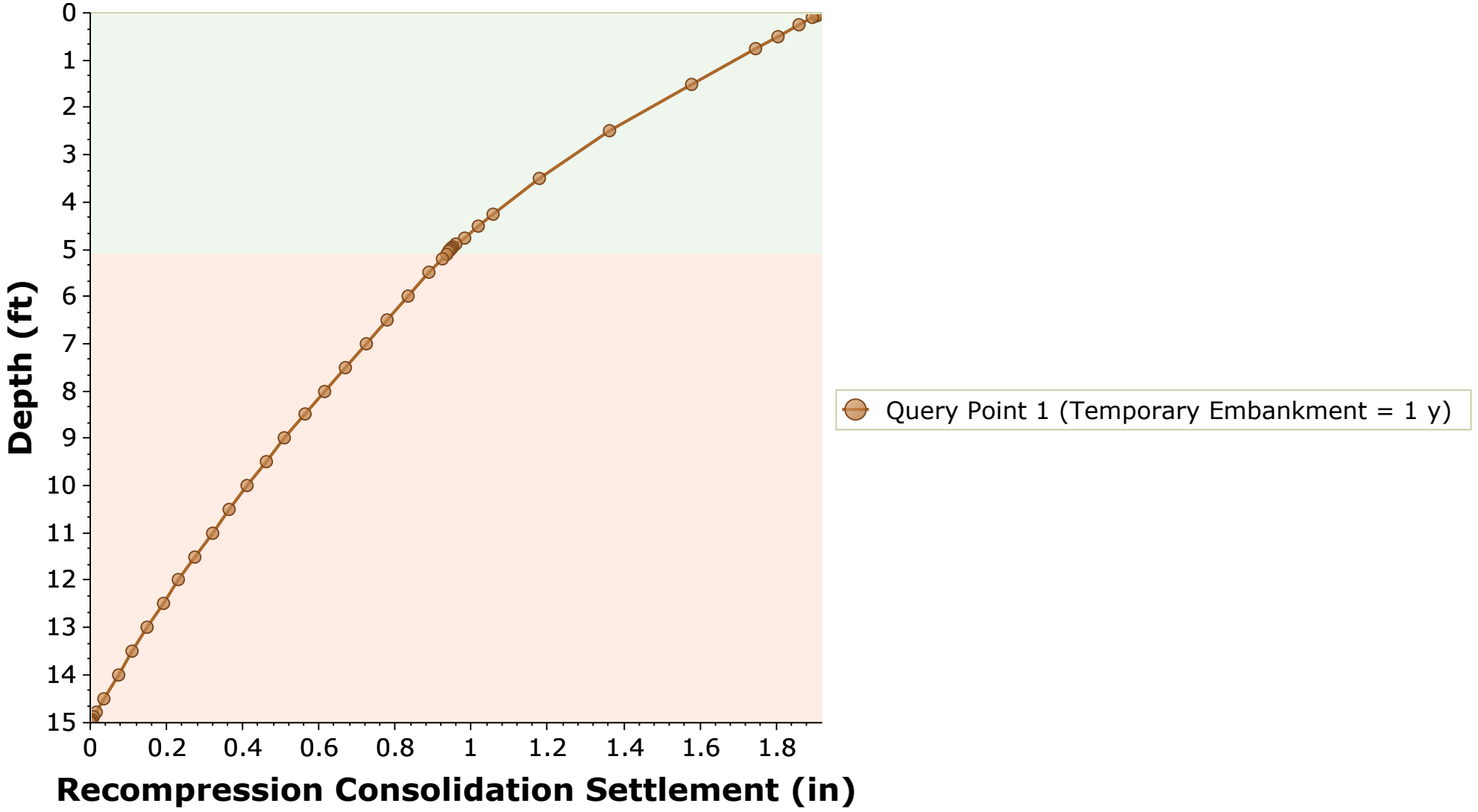
Reference Stage: None

rocscience	Project	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	Company: Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	File Name: Sta 1024+50 Settlement (Two clays) - Copy.s3z

SETTLE3 5.012

Two Clay Model

Recompression Consolidation Settlement vs. Depth

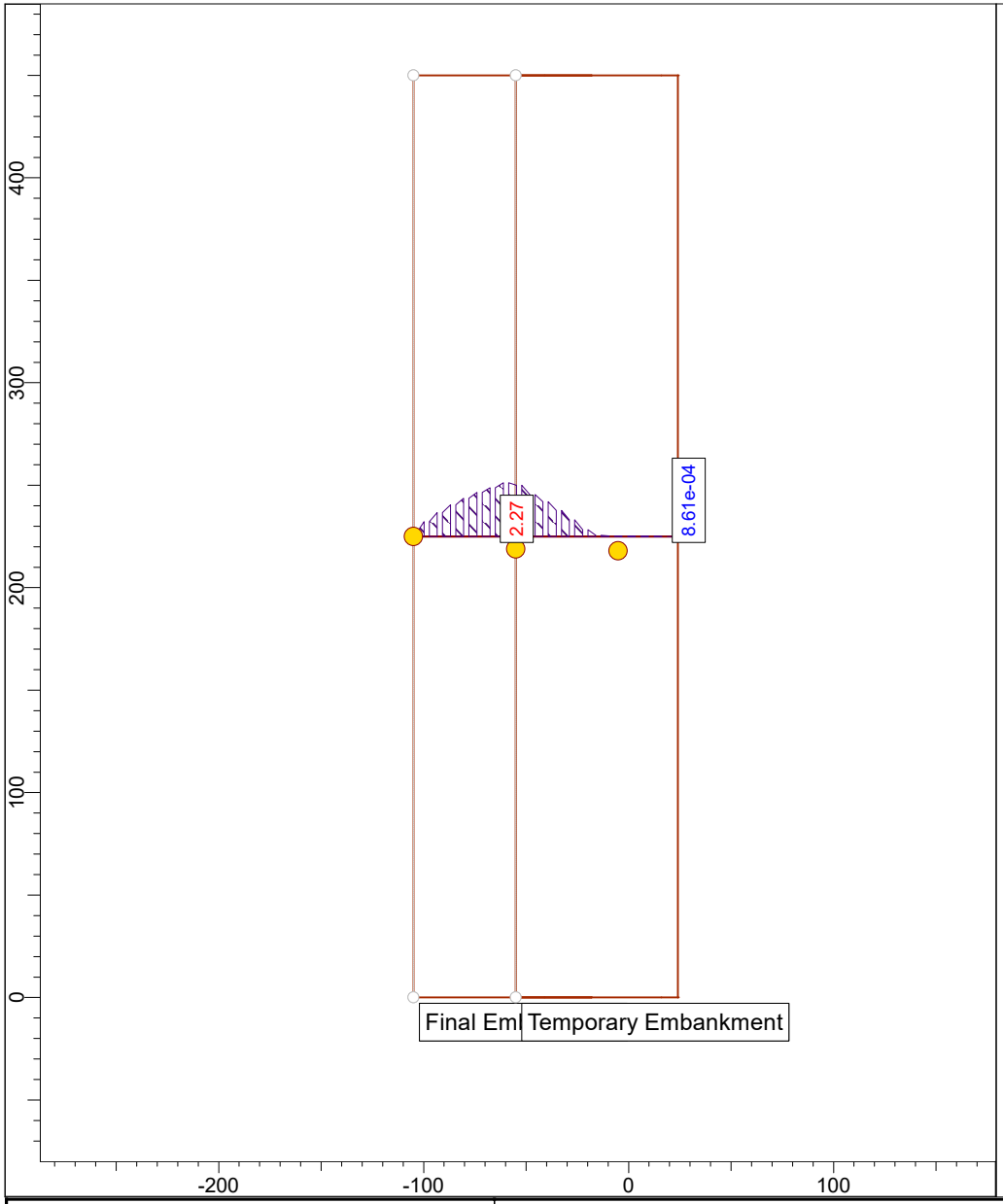


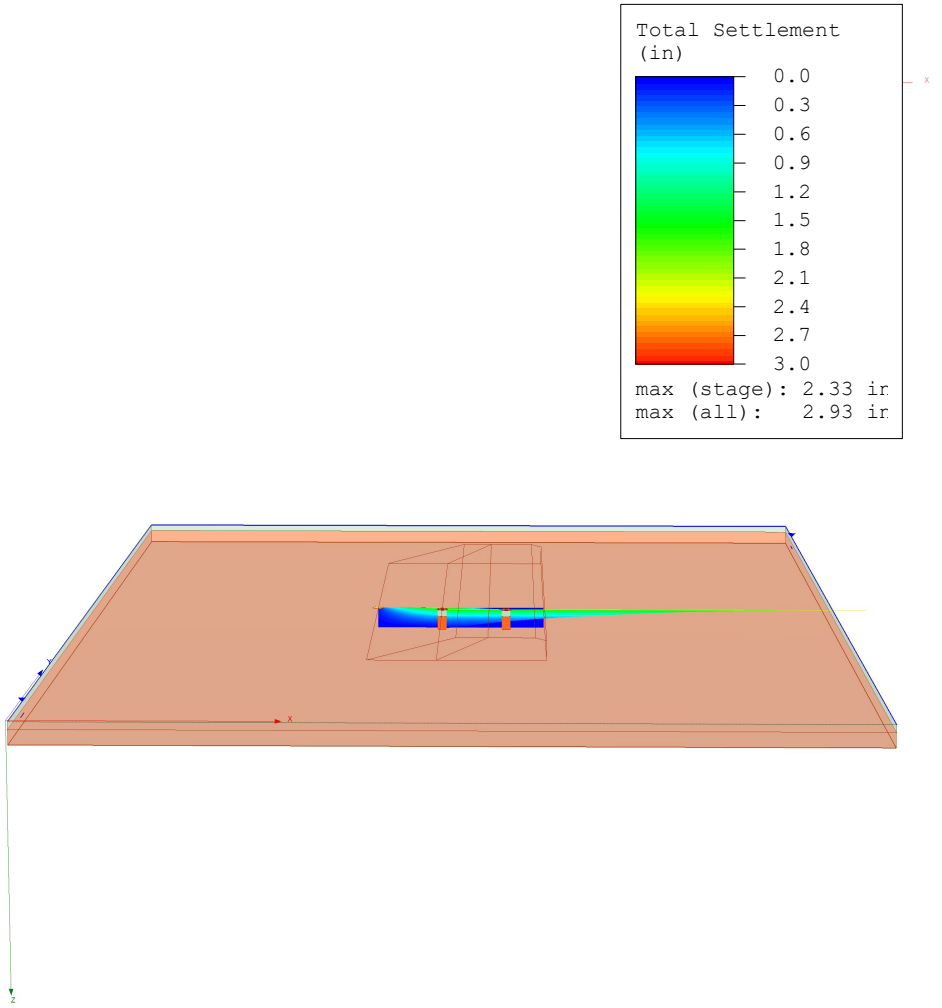
Reference Stage: None

rocscience	Project	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	Company: Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	File Name: Sta 1024+50 Settlement (Two clays) - Copy.s3z

SETTLE3 5.012

Two Clay Model



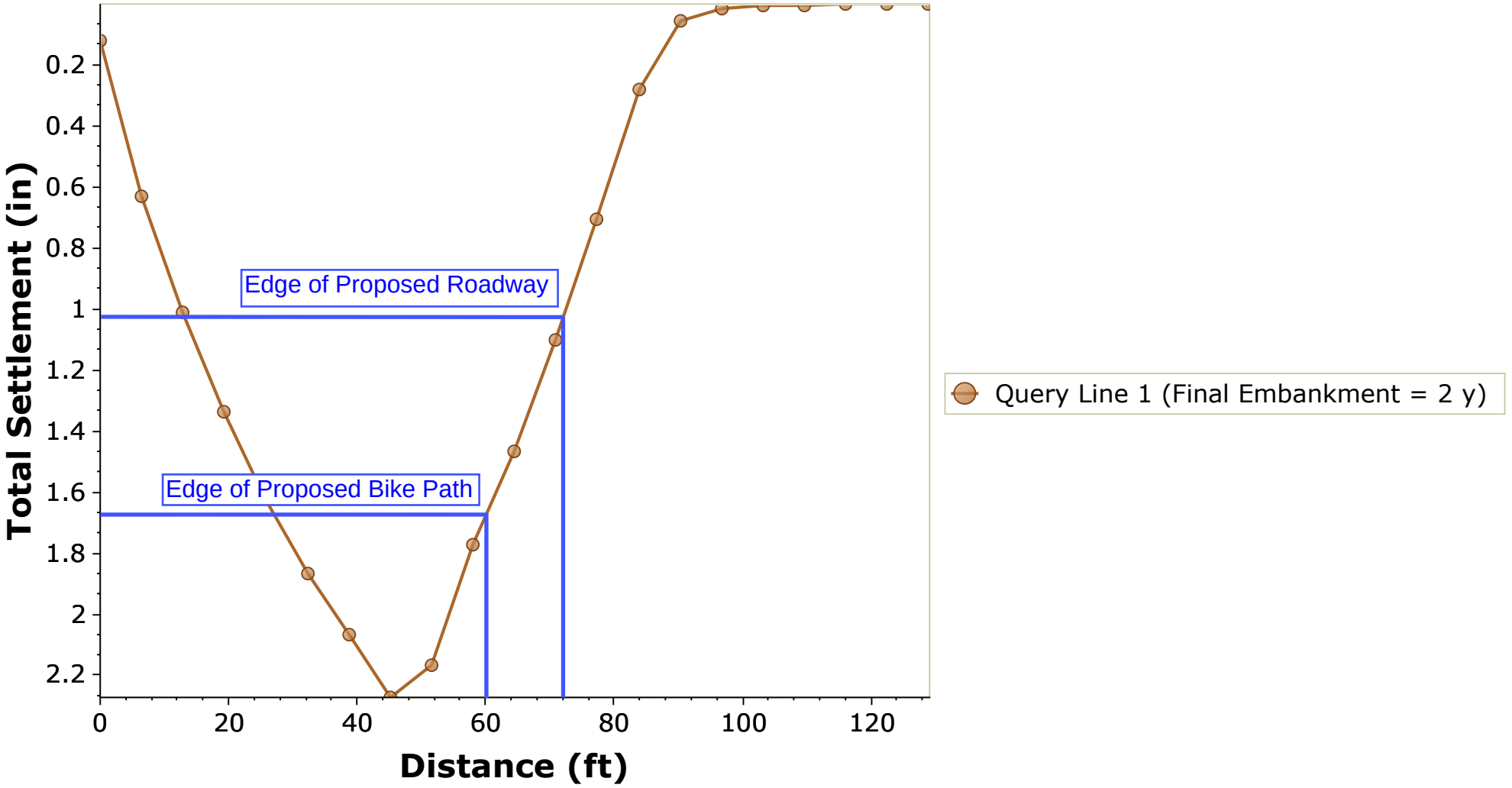


rocscience	*Project*	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	*Company* Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	*File Name* Sta 1024+50 Settlement (Two clays) - Copy.s3z

SETTLE3 5.012

Two Clay Model

Distance vs. Total Settlement



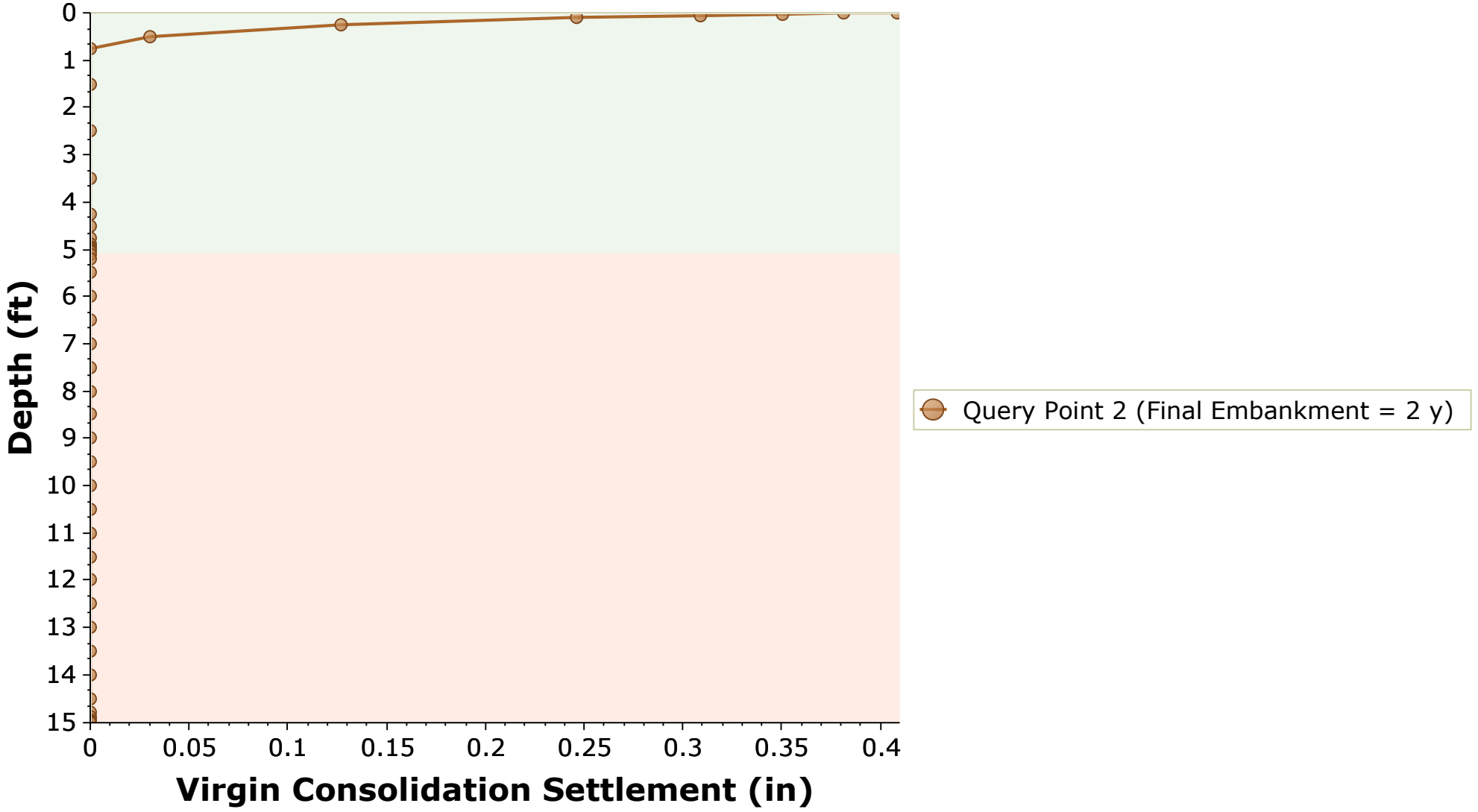
Reference Stage: Temporary Embankment = 1 y
Total Settlement at Depth = 0 ft

rocscience	*Project*	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	*Company* Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	*File Name* Sta 1024+50 Settlement (Two clays) - Copy.s3z

SETTLE3 5.012

Two Clay Model

Virgin Consolidation Settlement vs. Depth



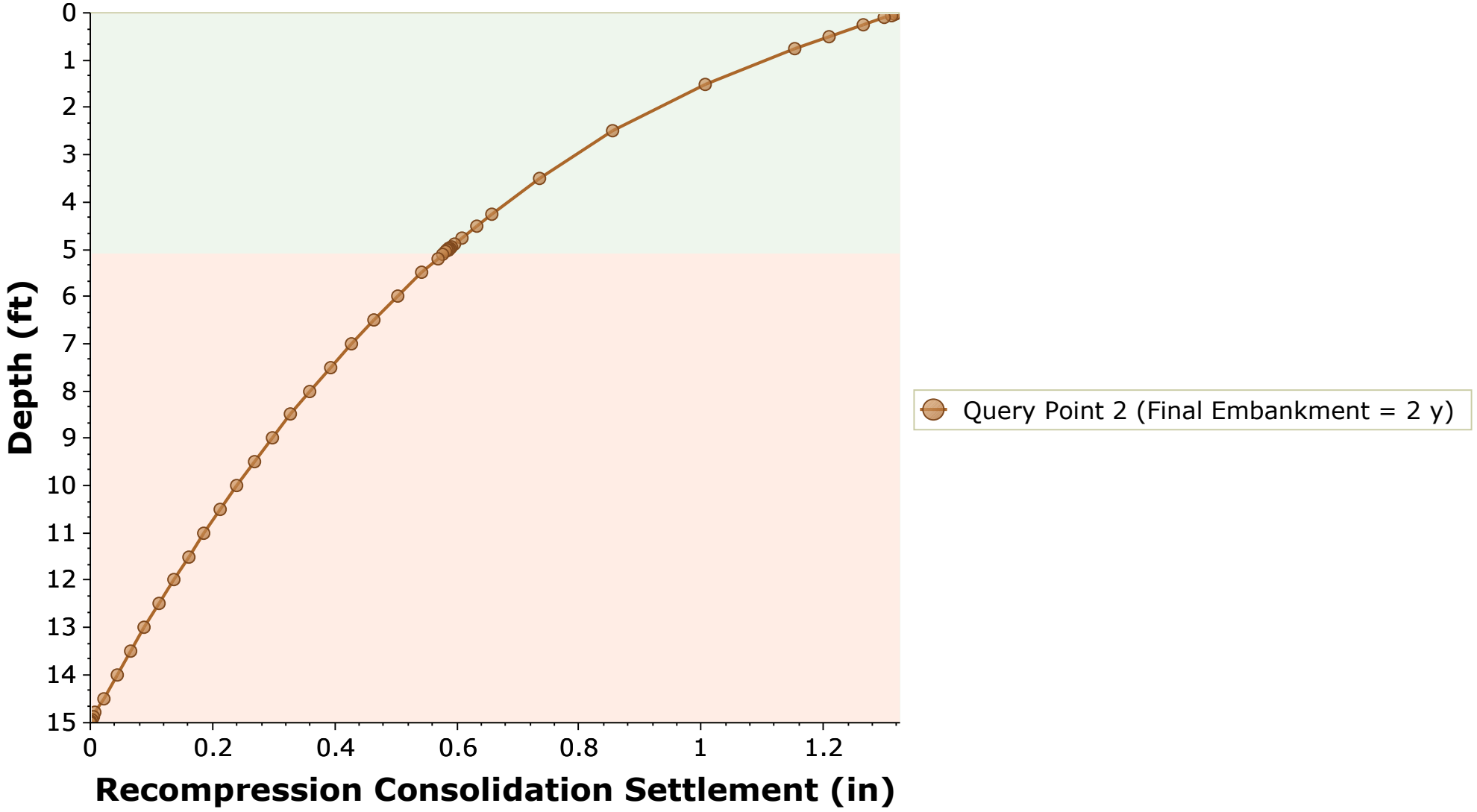
Reference Stage: Temporary Embankment = 1 y

rocscience	*Project*	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	*Company* Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	*File Name* Sta 1024+50 Settlement (Two clays) - Copy.s3z

SETTLE3 5.012

Two Clay Model

Recompression Consolidation Settlement vs. Depth

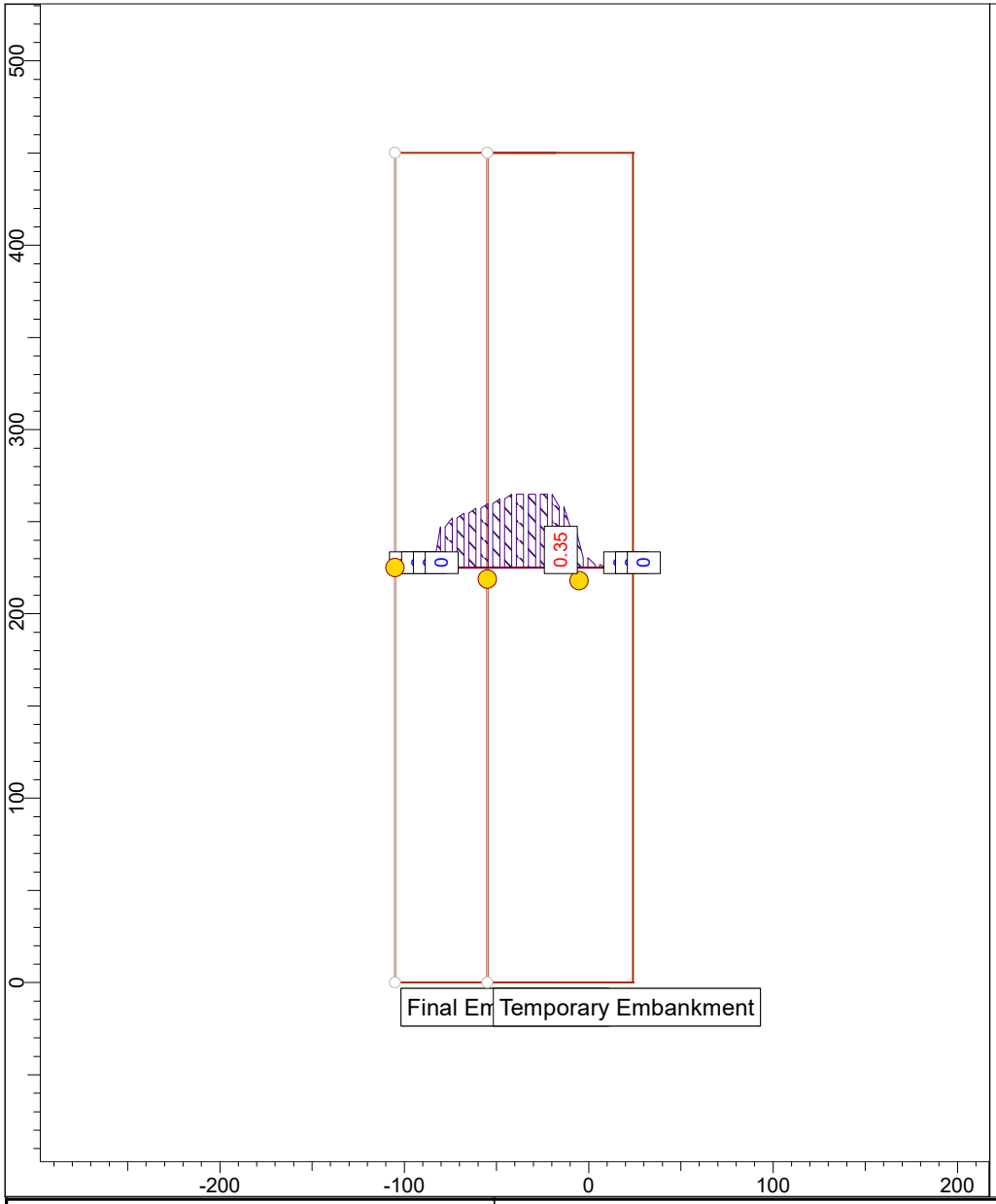


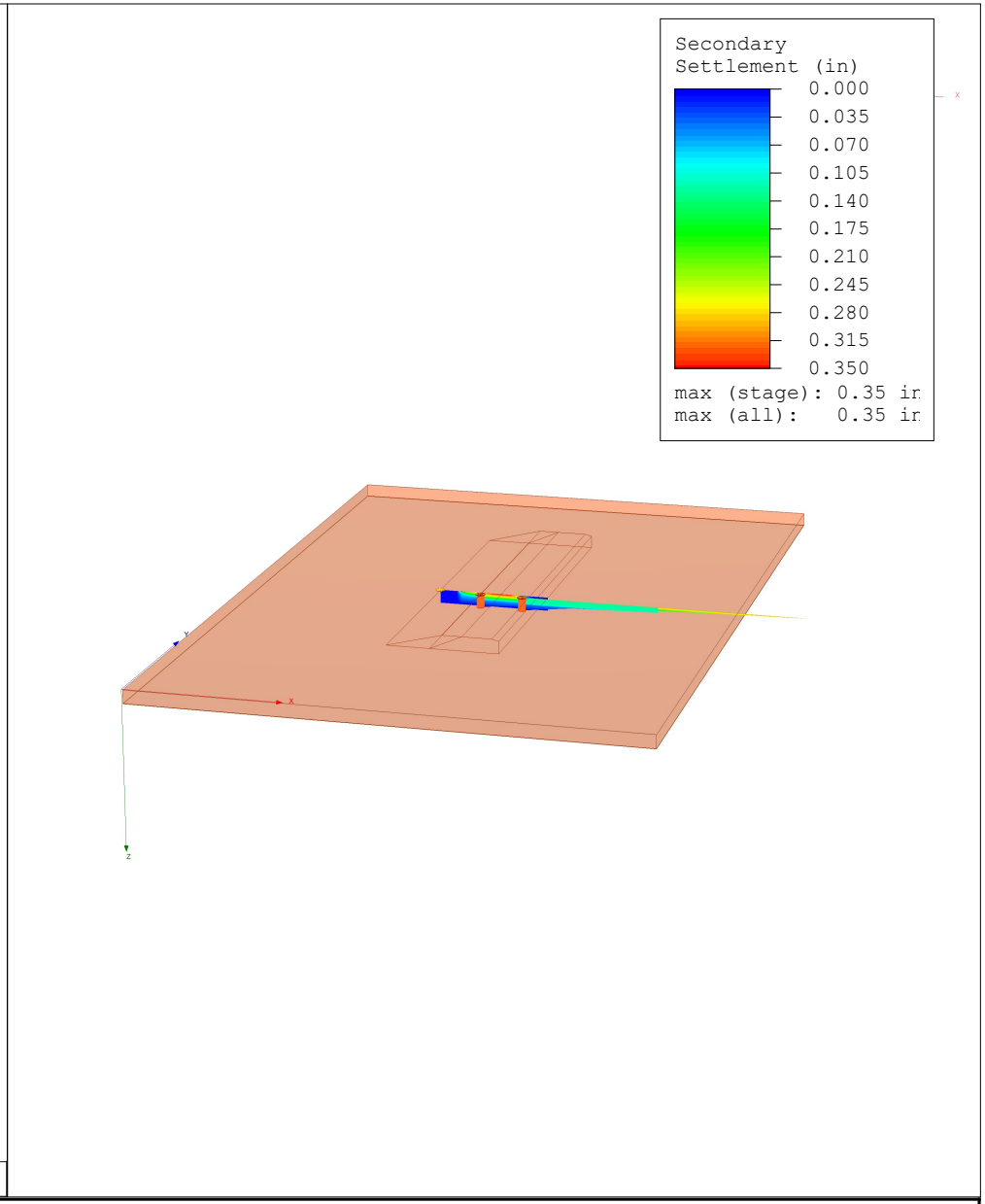
Reference Stage: Temporary Embankment = 1 y

rocscience	*Project*	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	*Company* Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	*File Name* Sta 1024+50 Settlement (Two clays) - Copy.s3z

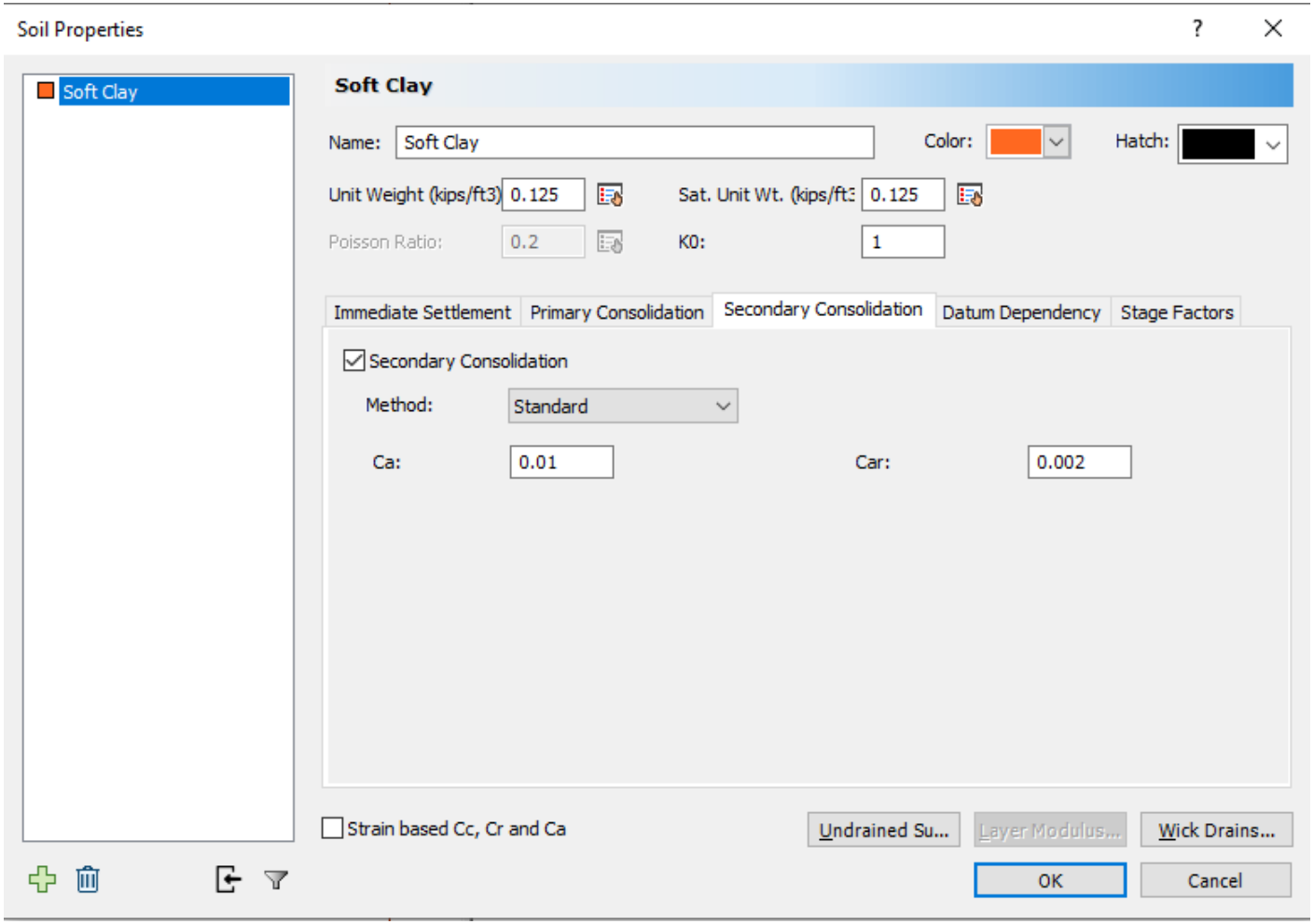
SETTLE3 5.012

One Clay - Secondary Settlement



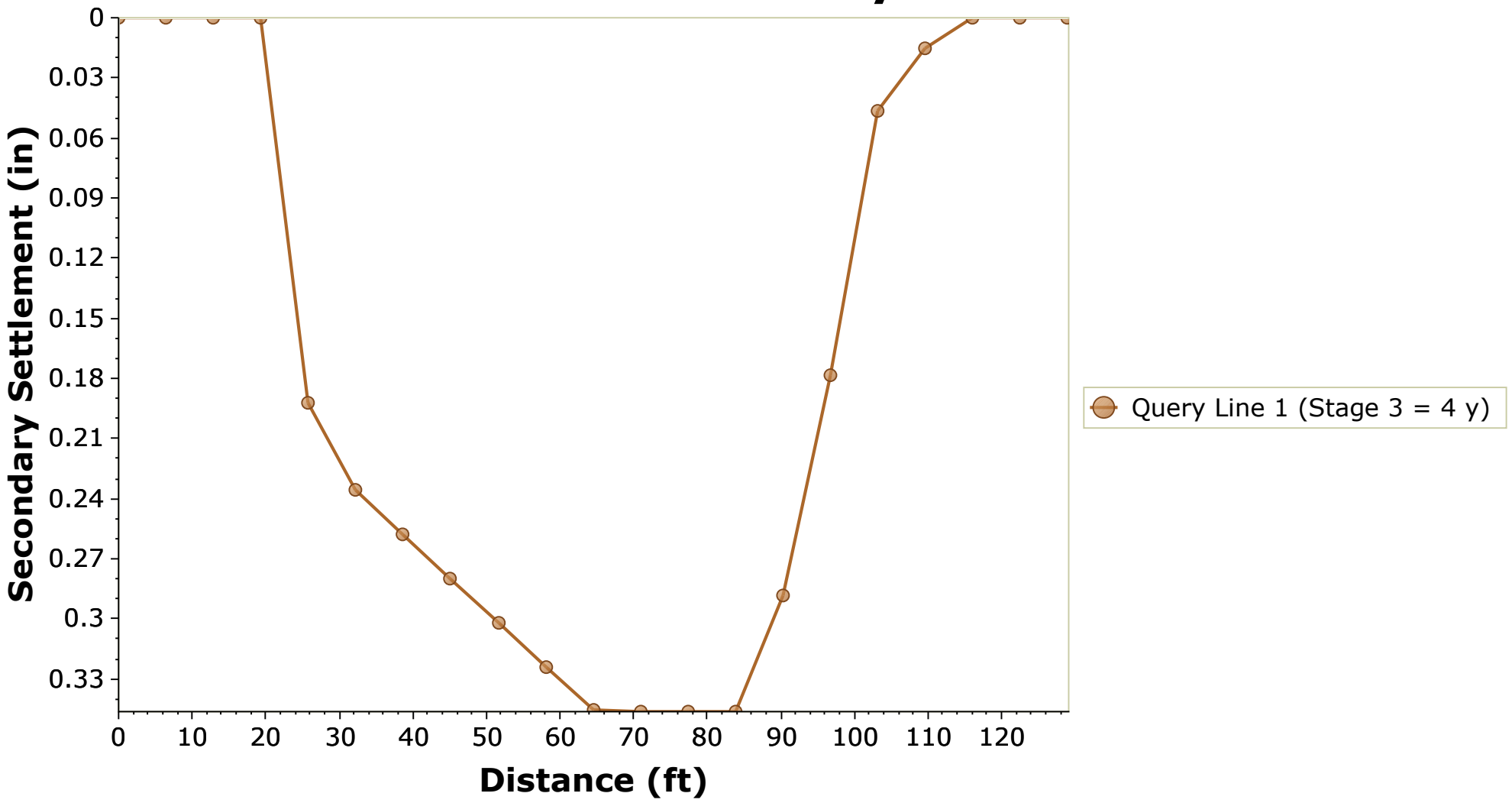


rocscience SETTLE3 5.012	*Project*	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	*Company* Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	*File Name* Sta 1024+50 Settlement (one clay).s3z


Soil Properties
Soft Clay
Soft Clay
Name: Soft Clay
Color:
Hatch:
Unit Weight (kips/ft3) 0.125
Sat. Unit Wt. (kips/ft3 0.125
Poisson Ratio: 0.2
K0: 1
Immediate Settlement
Primary Consolidation
Secondary Consolidation
Datum Dependency
Stage Factors
Secondary Consolidation
Method: Standard
Ca: 0.01
Car: 0.002
Strain based Cc, Cr and Ca
Undrained Su...
Layer Modulus...
Wick Drains...
OK
Cancel

One Clay - Secondary Settlement

Distance vs. Secondary Settlement



Reference Stage: None

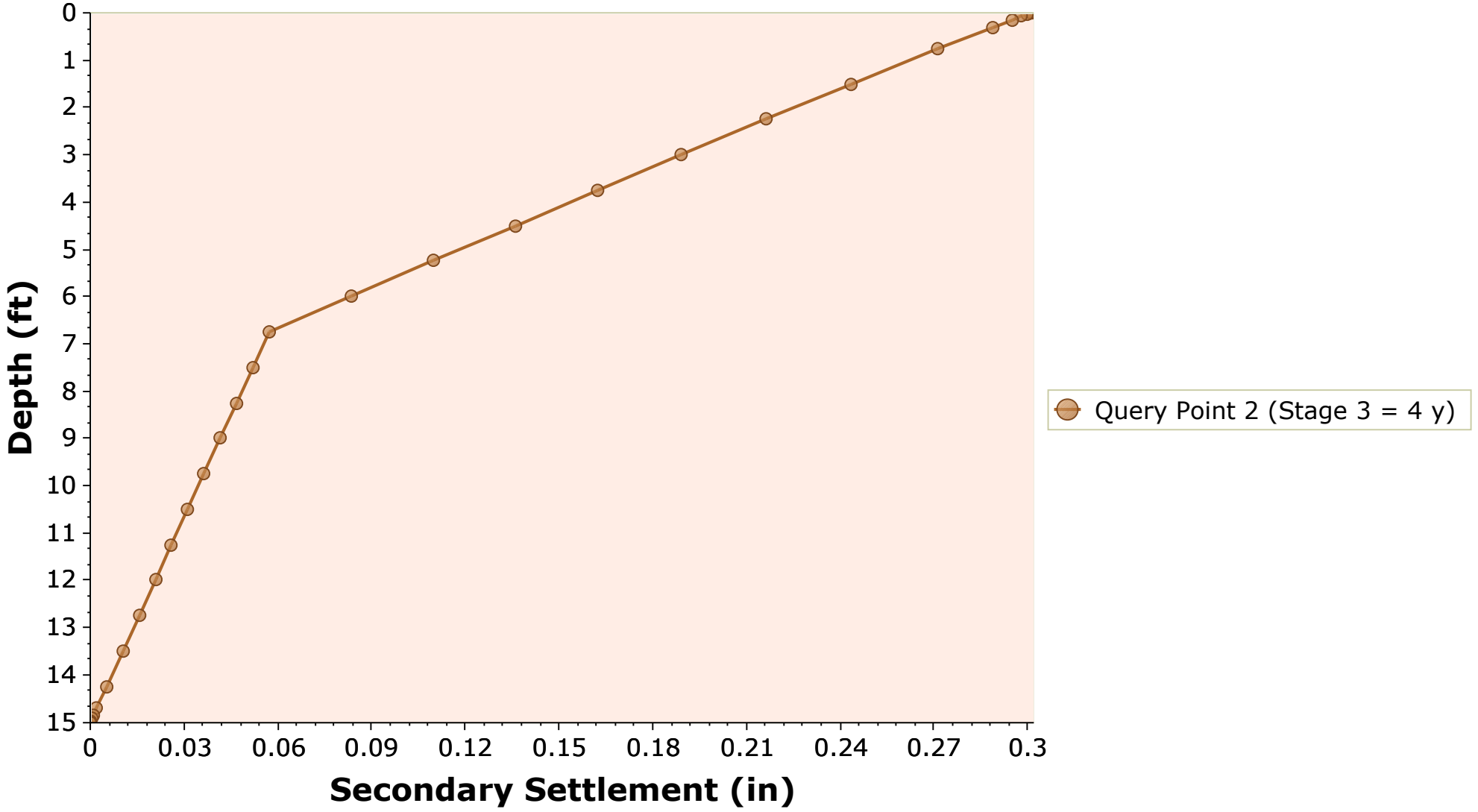
Secondary Settlement at Depth = 0 ft

rocscience	*Project*	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	*Company* Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	*File Name* Sta 1024+50 Settlement (one clay).s3z

SETTLE3 5.012

One Clay - Secondary Settlement

Secondary Settlement vs. Depth

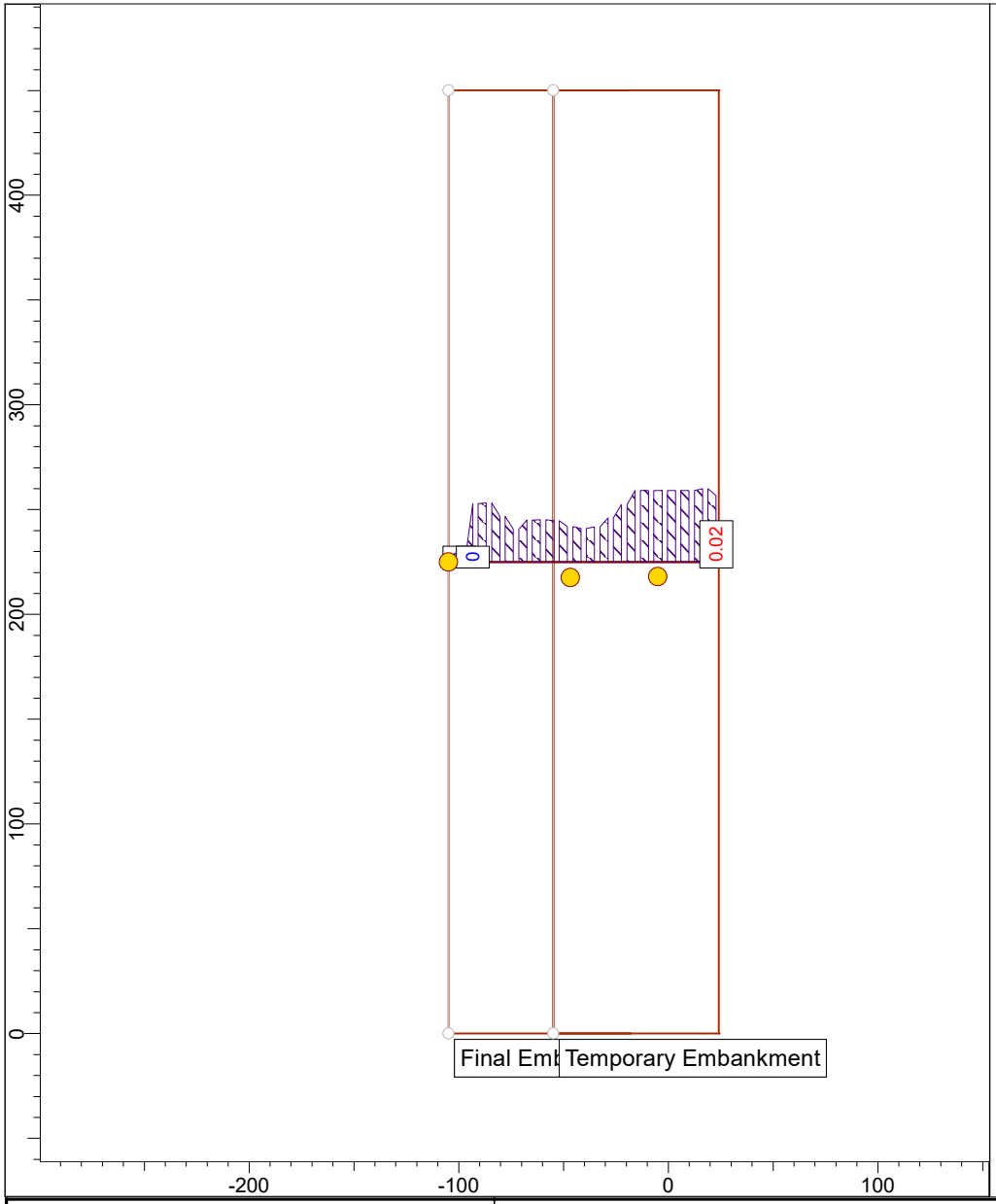


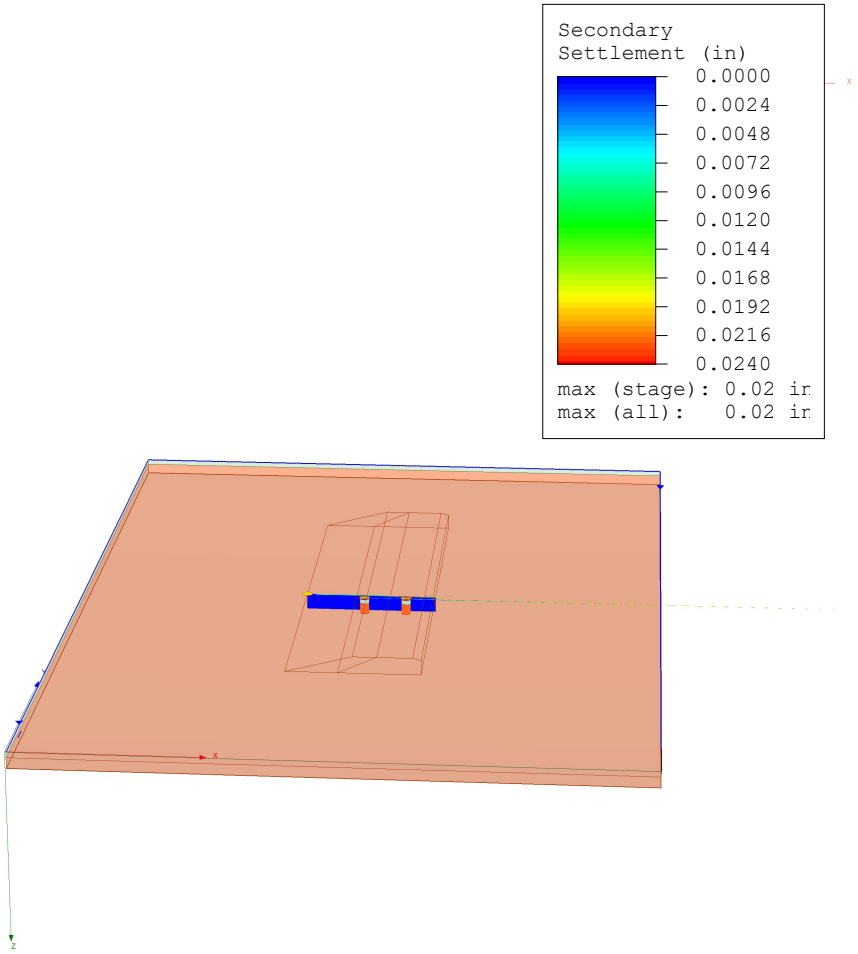
Reference Stage: None

rocscience	*Project*	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	*Company* Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	*File Name* Sta 1024+50 Settlement (one clay).s3z

SETTLE3 5.012

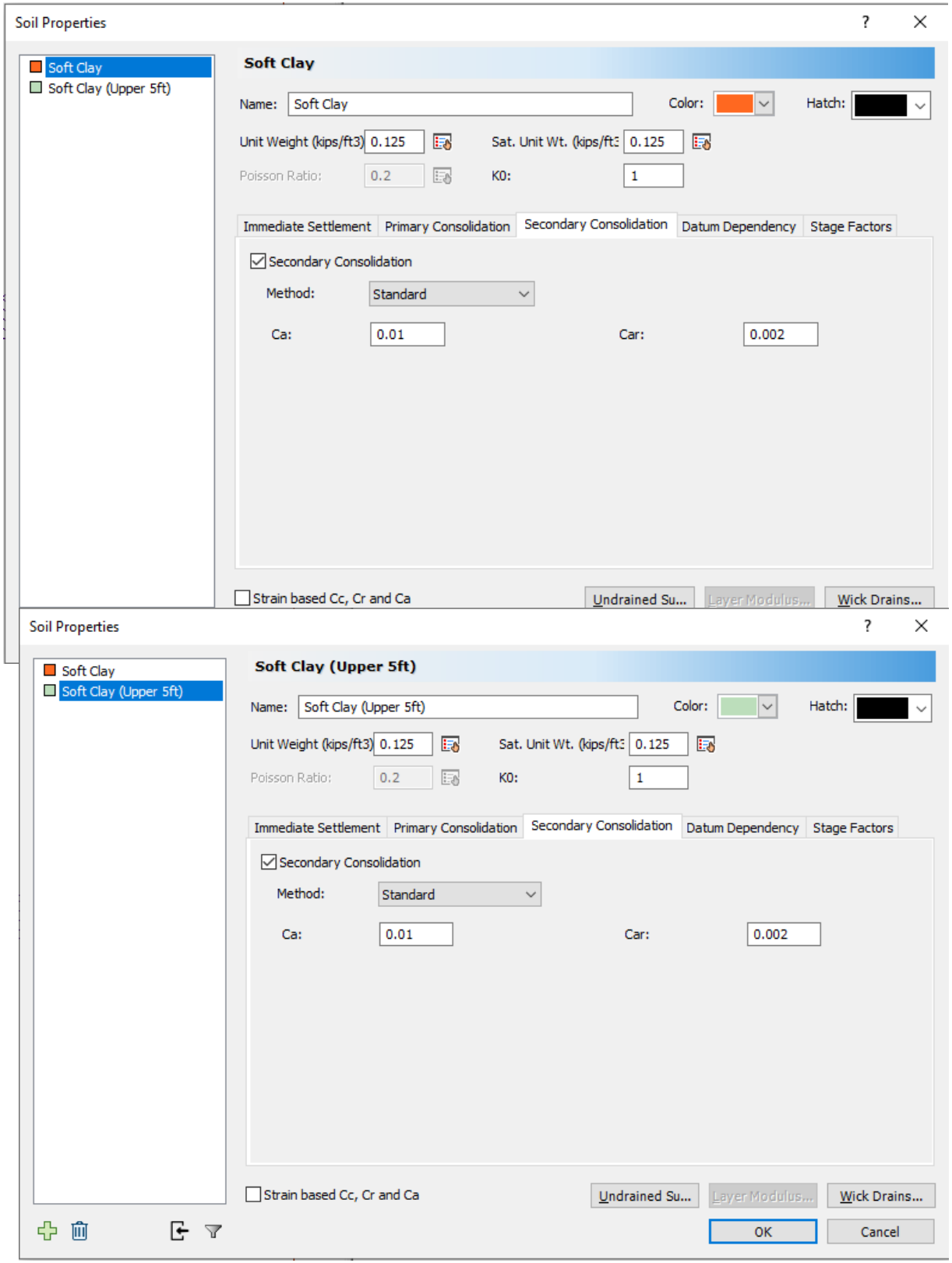
Two Clay - Secondary Settlement





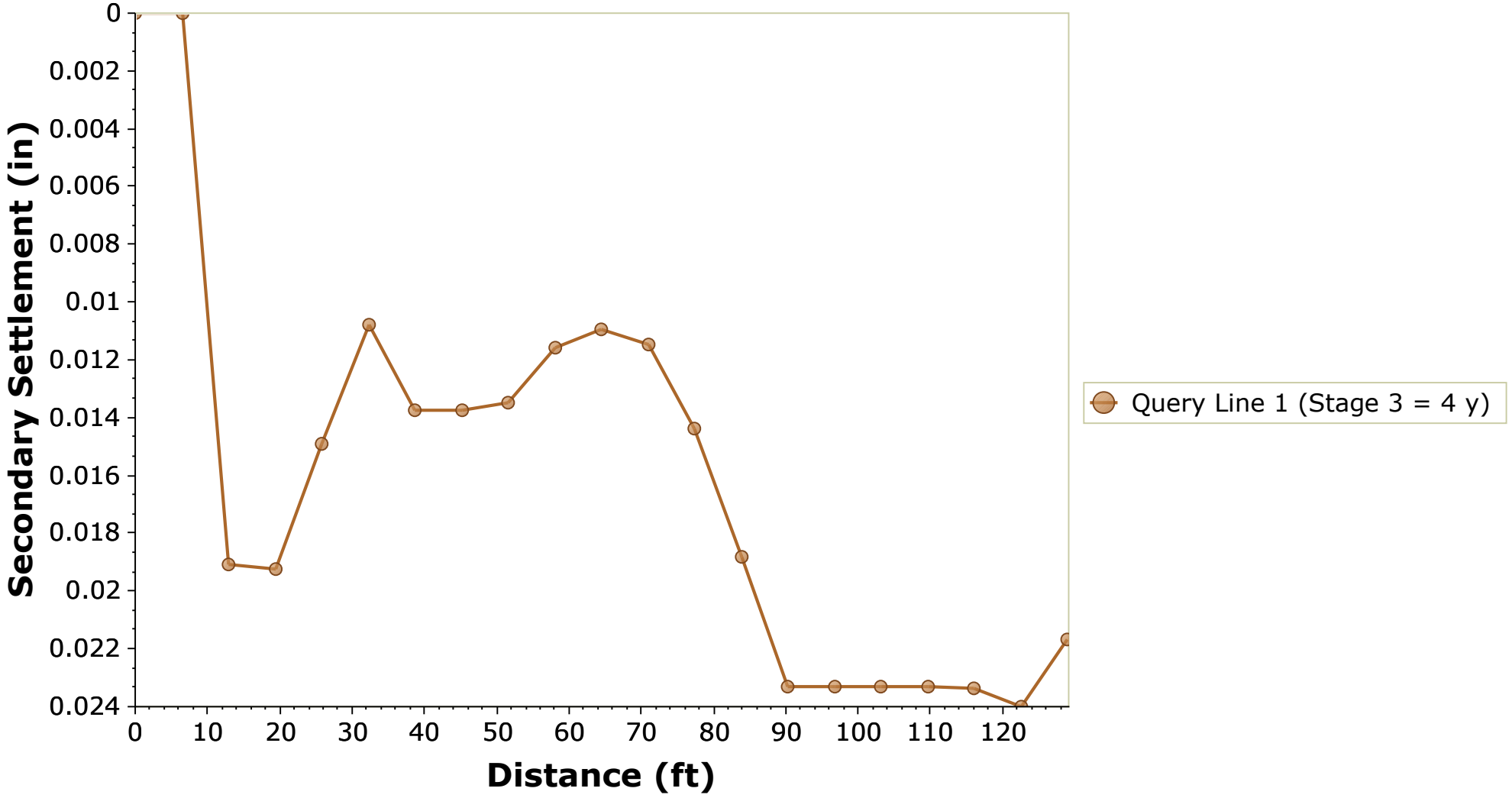
rocscience	*Project*	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	*Company* Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	*File Name* Sta 1024+50 Settlement (Two clays).s3z

SETTLE3 5.012


Soil Properties
Soft Clay
Soft Clay (Upper 5ft)
Soft Clay
Name: Soft Clay
Color:
Hatch:
Unit Weight (kips/ft3) 0.125
Sat. Unit Wt. (kips/ft3 0.125
Poisson Ratio: 0.2
K0: 1
Immediate Settlement
Primary Consolidation
Secondary Consolidation
Datum Dependency
Stage Factors
Secondary Consolidation
Method: Standard
Ca: 0.01
Car: 0.002
Strain based Cc, Cr and Ca
Undrained Su...
Layer Modulus...
Wick Drains...
Soil Properties
Soft Clay
Soft Clay (Upper 5ft)
Soft Clay (Upper 5ft)
Name: Soft Clay (Upper 5ft)
Color:
Hatch:
Unit Weight (kips/ft3) 0.125
Sat. Unit Wt. (kips/ft3 0.125
Poisson Ratio: 0.2
K0: 1
Immediate Settlement
Primary Consolidation
Secondary Consolidation
Datum Dependency
Stage Factors
Secondary Consolidation
Method: Standard
Ca: 0.01
Car: 0.002
Strain based Cc, Cr and Ca
Undrained Su...
Layer Modulus...
Wick Drains...
OK
Cancel

Two Clay - Secondary Settlement

Distance vs. Secondary Settlement



Reference Stage: None

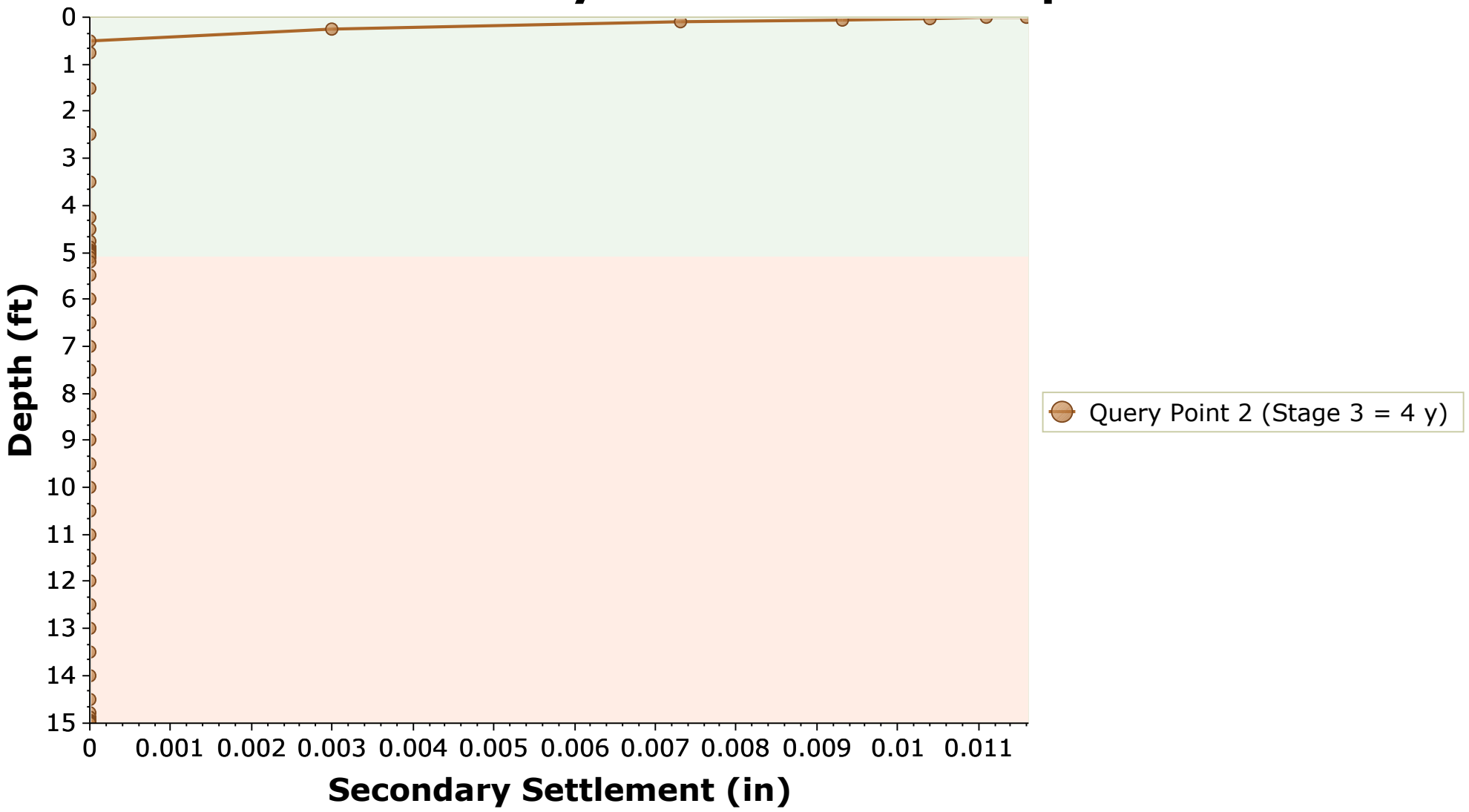
Secondary Settlement at Depth = 0 ft

rocscience	*Project*	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	*Company* Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	*File Name* Sta 1024+50 Settlement (Two clays).s3z

SETTLE3 5.012

Two Clay - Secondary Settlement

Secondary Settlement vs. Depth



Reference Stage: None

rocscience	*Project*	Chateau Road Reconstruction	
	Analysis Description	Embankment Settlement	
	Drawn By	NXG	*Company* Shannon and Wilson, Inc.
	Date	9/10/2024, 2:38:47 PM	*File Name* Sta 1024+50 Settlement (Two clays).s3z

SETTLE3 5.012

APPENDIX E: GLOBAL STABILITY ANALYSES

Appendix E

Global Stability Analyses

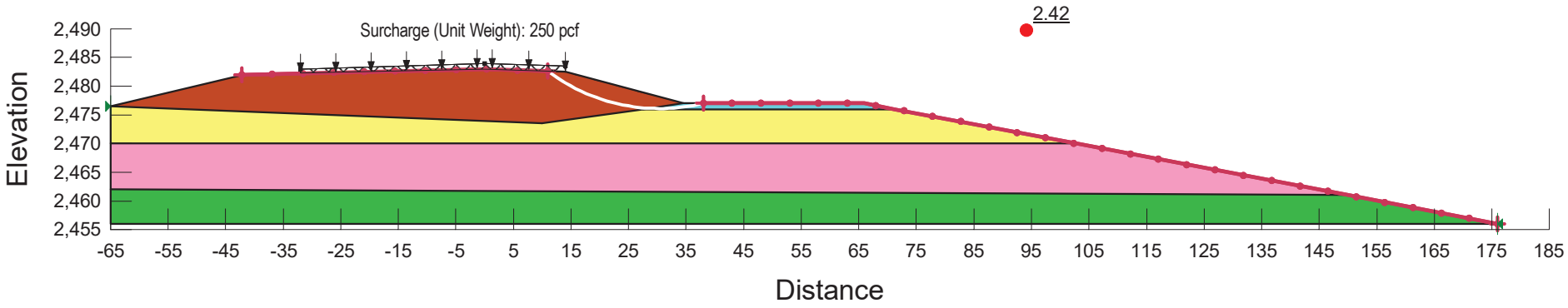
Figures

Figure E-1: Sta. 1009+00 Final Embankment Drained Conditions
Figure E-2: Sta. 1009+00 Final Embankment Undrained Conditions
Figure E-3: Sta. 1011+75 Final Embankment Drained Conditions
Figure E-4: Sta. 1011+75 Final Embankment Undrained Conditions
Figure E-5: Sta. 1017+00 Final Embankment Drained Conditions
Figure E-6: Sta. 1017+00 Final Embankment Undrained Conditions
Figure E-7: Sta. 1018+50 Temp. Embankment Drained Conditions
Figure E-8: Sta. 1018+50 Temp. Embankment Undrained Conditions
Figure E-9: Sta. 1018+50 Final Embankment Drained Conditions
Figure E-10: Sta. 1018+50 Final Embankment Undrained Conditions
Figure E-11: Sta. 1019+75 Temp. Lower Embankment Drained Conditions
Figure E-12: Sta. 1019+75 Temp. Lower Embankment Undrained Conditions
Figure E-13: Sta. 1019+75 Final Lower Embankment Drained Conditions
Figure E-14: Sta. 1019+75 Final Lower Embankment Undrained Conditions
Figure E-15: Sta. 1019+75 Temp. Upper Embankment Drained Conditions
Figure E-16: Sta. 1020+25 Temp. Embankment Drained Conditions
Figure E-17: Sta. 1020+25 Temp. Embankment Undrained Conditions
Figure E-18: Sta. 1020+25 Final Embankment Drained Conditions
Figure E-19: Sta. 1020+25 Final Embankment Undrained Conditions
Figure E-20: Sta. 1021+25 Final Embankment Drained Conditions
Figure E-21: Sta. 1021+25 Final Embankment Undrained Conditions
Figure E-22: Sta. 1023+25 Temp. Embankment Drained Conditions
Figure E-23: Sta. 1023+25 Temp. Embankment Undrained Conditions
Figure E-24: Sta. 1023+25 Final Embankment Drained Conditions
Figure E-25: Sta. 1023+25 Final Embankment Undrained Conditions
Figure E-26: Sta. 1024+25 Temp. Embankment Drained Conditions
Figure E-27: Sta. 1024+25 Temp. Embankment Undrained Conditions
Figure E-28: Sta. 1024+25 Final Embankment Drained Conditions
Figure E-29: Sta. 1024+25 Final Embankment Undrained Conditions
Figure E-30: Sta. 1026+00 Temp. Embankment Pre-Cut Drained Conditions
Figure E-31: Sta. 1026+00 Temp. Embankment Pre-Cut Undrained Conditions

APPENDIX E: GLOBAL STABILITY ANALYSES

Figure E-32: Sta. 1026+00 Final Embankment Pre-Cut Drained Conditions
Figure E-33: Sta. 1026+00 Final Embankment Pre-Cut Undrained Conditions
Figure E-34: Sta. 1026+00 Temp. Embankment Post-Cut Drained Conditions
Figure E-35: Sta. 1026+00 Temp. Embankment Post-Cut Undrained Conditions
Figure E-36: Sta. 1026+00 Final Embankment Post-Cut Drained Conditions
Figure E-37: Sta. 1026+00 Final Embankment Post-Cut Undrained Conditions
Figure E-38: Sta. 1007+00 Proposed Cut (4H:1V) Drained Conditions
Figure E-39: Sta. 1012+50 Proposed Cut (4H:1V) Drained Conditions
Figure E-40: Sta. 1016+00 Proposed Cut (4H:1V) Drained Conditions
Figure E-41: Sta. 1018+50 Proposed Cut (4H:1V) Drained Conditions
Figure E-42: Sta. 1020+25 Proposed Cut (3H:1V) Drained Conditions
Figure E-43: Sta. 1020+75 Proposed Cut (3H:1V) Drained Conditions
Figure E-44: Sta. 1024+25 Proposed Cut (3H:1V) Drained Conditions
Figure E-45: Sta. 1038+00 Proposed Cut (2.5H:1V) Drained Conditions
Figure E-46: Sta. 1039+75 Proposed Cut (2.5H:1V) Drained Conditions
Figure E-47: Sta. 1032+50 Existing Slope Drained Conditions
Figure E-48: Sta. 1032+50 Edge of Grading Limits Drained Conditions
Figure E-49: Sta. 1032+50 Edge of Pavement Drained Conditions
Figure E-50: Sta. 1032+75 Existing Slope Drained Conditions
Figure E-51: Sta. 1032+75 Edge of Grading Limits Drained Conditions
Figure E-52: Sta. 1032+75 Edge of Pavement Drained Conditions
Figure E-53: Sta. 1033+75 Existing Slope Drained Conditions
Figure E-54: Sta. 1033+75 Edge of Grading Limits Drained Conditions
Figure E-55: Sta. 1033+75 Edge of Pavement Drained Conditions
Figure E-56: Sta. 1034+75 Existing Slope Drained Conditions
Figure E-57: Sta. 1034+75 Edge of Grading Limits Drained Conditions
Figure E-58: Sta. 1034+75 Edge of Pavement Drained Conditions
Figure E-59: Sta. 1035+50 Existing Slope Drained Conditions
Figure E-60: Sta. 1035+50 Edge of Grading Limits Drained Conditions
Figure E-61: Sta. 1035+50 Edge of Pavement Drained Conditions
Figure E-62: Sta. 1036+00 Existing Slope Drained Conditions
Figure E-63: Sta. 1036+00 Edge of Grading Limits Drained Conditions
Figure E-64: Sta. 1036+00 Edge of Pavement Drained Conditions

Chateau Road Reconstruction
113316-002
File Name: Sta. 1008+00 to 1012+25.gsz
Geometry: Name: Critical Section SW-12 Conditions (Sta.1009+00)
Name: Drained (Sta. 1009+00)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Clayey Embankment Fill (Drained)	Shear/Normal Fn.	125			LL = 38, CF = 30%
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF = 50%
	Lean Clay (Drained)	Shear/Normal Fn.	130			LL = 32, CF =28%
	Sand and Gravel	Mohr-Coulomb	130	0	32	
	Sandy Silt	Mohr-Coulomb	125	0	28	

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1009+00
FINAL EMBANKMENT
DRAINED CONDITIONS

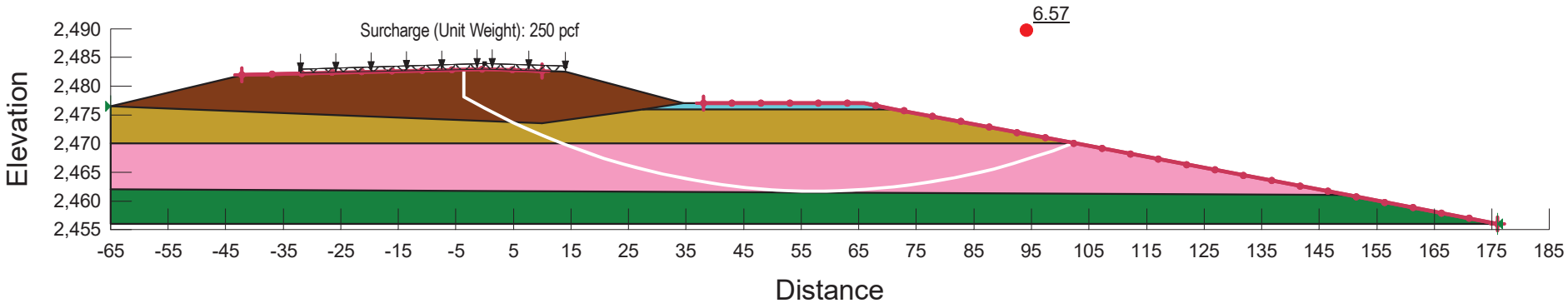
February 2025 113316-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. E-1

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1008+00 to 1012+25\Sta. 1008+00 to 1012+25.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1008+00 to 1012+25.gsz
Geometry: Name: Critical Section SW-12 Conditions (Sta.1009+00)
Name: Undrained (Sta. 1009+00)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Embankment Fill (Undrained)	Mohr-Coulomb	125	1,500	0
	Claystone (Undrained)	Mohr-Coulomb	135	3,000	0
	Lean Clay (Undrained)	Mohr-Coulomb	130	750	0
	Sand and Gravel	Mohr-Coulomb	130	0	32
	Sandy Silt	Mohr-Coulomb	125	0	28

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1009+00
FINAL EMBANKMENT
UNDRAINED CONDITIONS

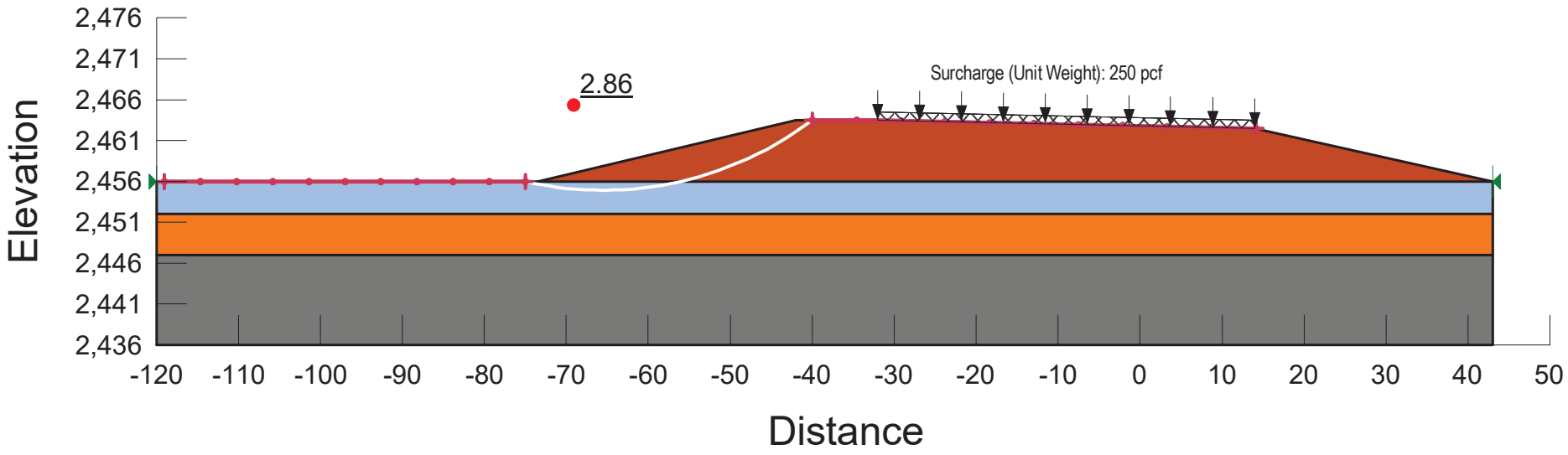
February 2025 113316-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. E-2

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1008+00 to 1012+25\Sta. 1008+00 to 1012+25.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1008+00 to 1012+25.gsz
Geometry: Name: Critical Section SW-11 Conditions (Sta. 1011+75)
Name: Drained (Sta. 1011+75)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Clayey Embankment Fill (Drained)	Shear/Normal Fn.	125			LL = 38, CF = 30%
	Dense Sand	Mohr-Coulomb	130	0	35	
	Sandstone	Mohr-Coulomb	140	0	38	
	Silty/Clayey Sand	Mohr-Coulomb	125	0	30	

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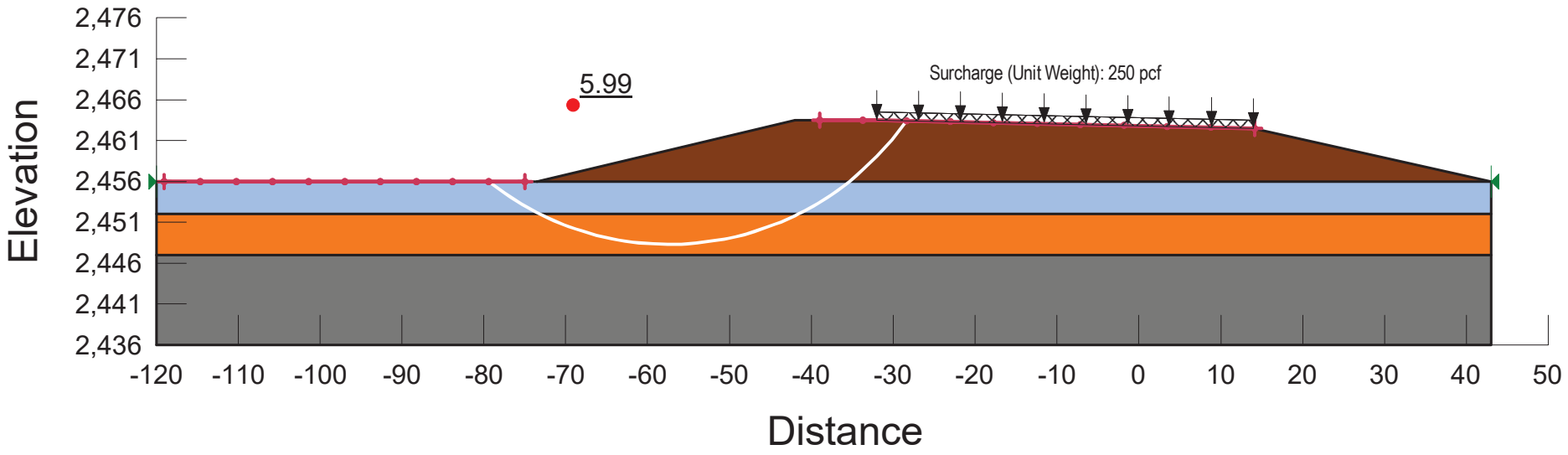
FIG. E-3

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1008+00 to 1012+25\Sta. 1008+00 to 1012+25.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1008+00 to 1012+25.gsz
Geometry: Name: Critical Section SW-11 Conditions (Sta. 1011+75)
Name: Undrained (Sta. 1011+75)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Embankment Fill (Undrained)	Mohr-Coulomb	125	1,500	0
	Dense Sand	Mohr-Coulomb	130	0	35
	Sandstone	Mohr-Coulomb	140	0	38
	Silty/Clayey Sand	Mohr-Coulomb	125	0	30

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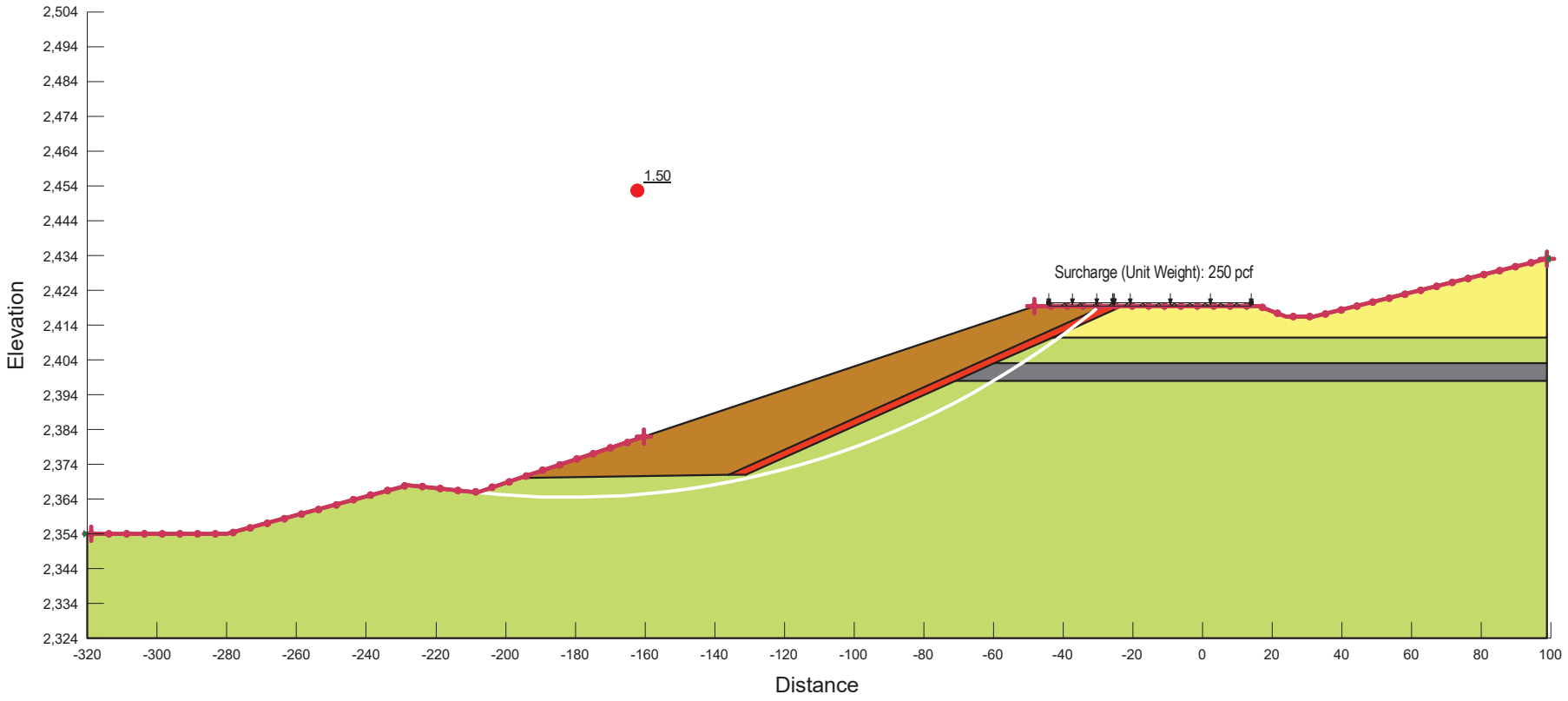
FIG. E-4

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1008+00 to 1012+25\Sta. 1008+00 to 1012+25.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1016+50 to 1017+50.gsz
Geometry Name: Critical Section (Sta. 1017+00)
Name: Drained



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Clayey Embankment Fill (Drained)	Shear/Normal Fn.	125			LL = 38, CF = 30%
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF = 50%
	Colluvium	Shear/Normal Fn.	120			LL = 32, CF = 28%, Residual
	Lean Clay (Drained)	Shear/Normal Fn.	130			LL = 32, CF = 28%, Fully Softened
	Siltstone	Mohr-Coulomb	140	0	34	

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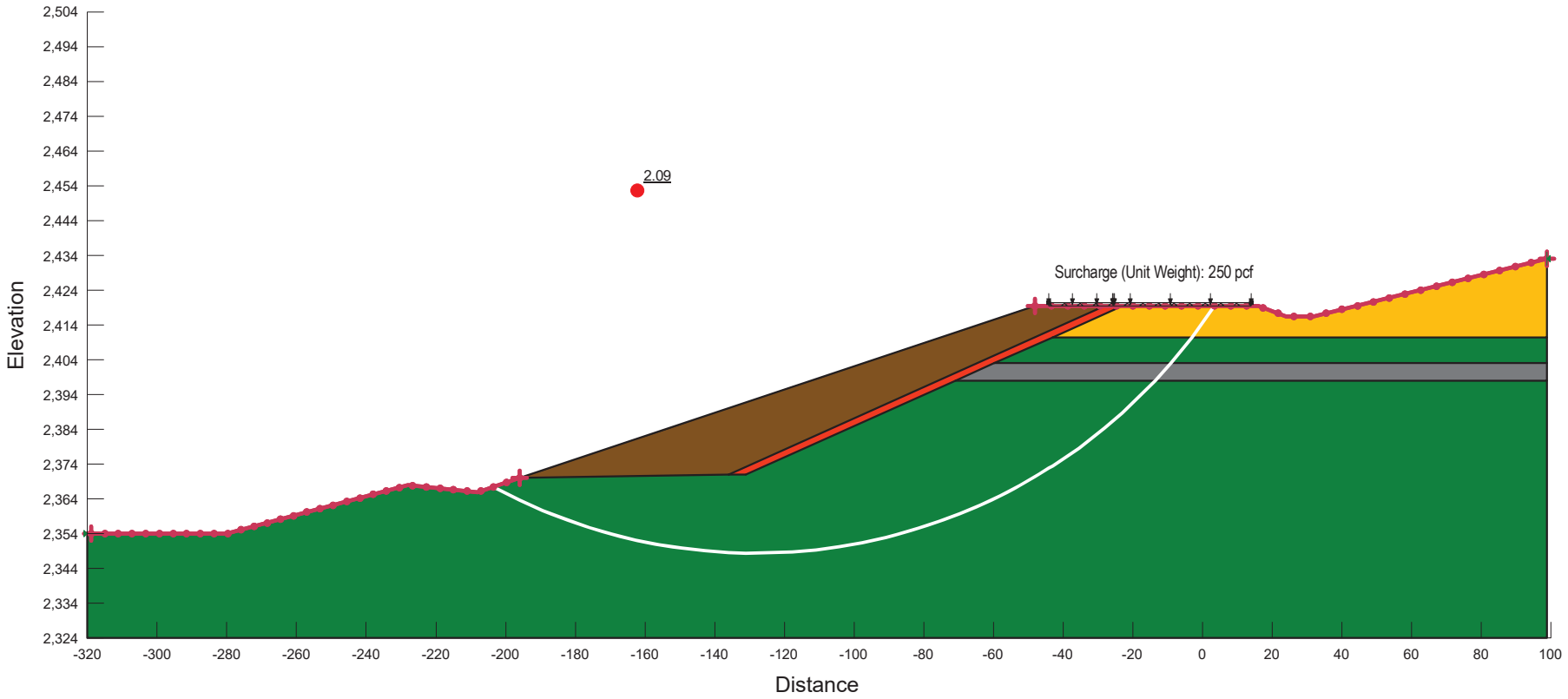
FIG. E-5

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1016+50 to 1017+50\Sta. 1016+50 to 1017+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1016+50 to 1017+50.gsz
Geometry Name: Critical Section (Sta. 1017+00)
Name: Undrained



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Cohesion Fn	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Embankment Fill (Undrained)	Mohr-Coulomb	125			1,500	0
	Claystone (Undrained)	Spatial Mohr-Coulomb	135		Cohesion vs. Depth		0
	Colluvium	Shear/Normal Fn.	120	LL = 32, CF = 28%, Residual			
	Lean Clay (Undrained)	Mohr-Coulomb	130			750	0
	Siltstone	Mohr-Coulomb	140			0	34

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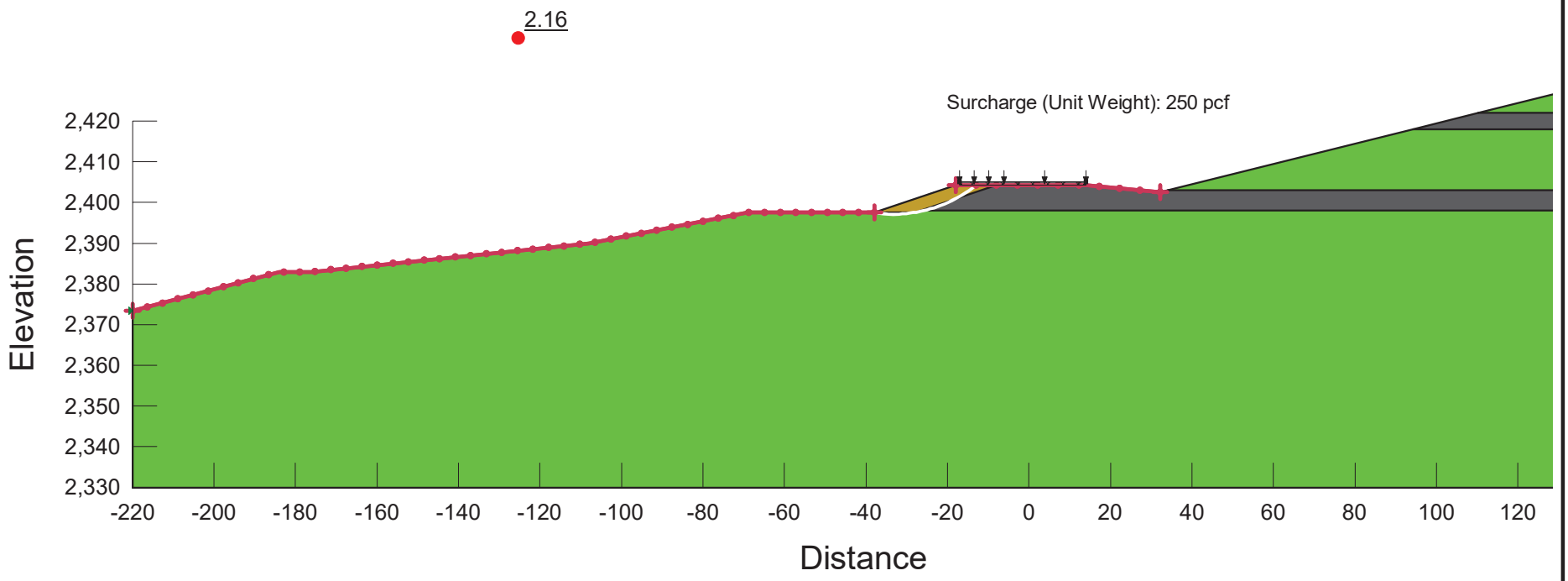
FIG. E-6

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1016+50 to 1017+50\Sta. 1016+50 to 1017+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1017+50 to 1018+50 - embankments.gsz
Geometry: Critical Section Sta 1018+50 (Temp)
Name: Temp Condtion Embankment (Drained)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Clayey Embankment Fill (Drained)	Shear/Normal Fn.	125			LL = 38, CF = 30%
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF = 50%
	Siltstone	Mohr-Coulomb	140	0	34	

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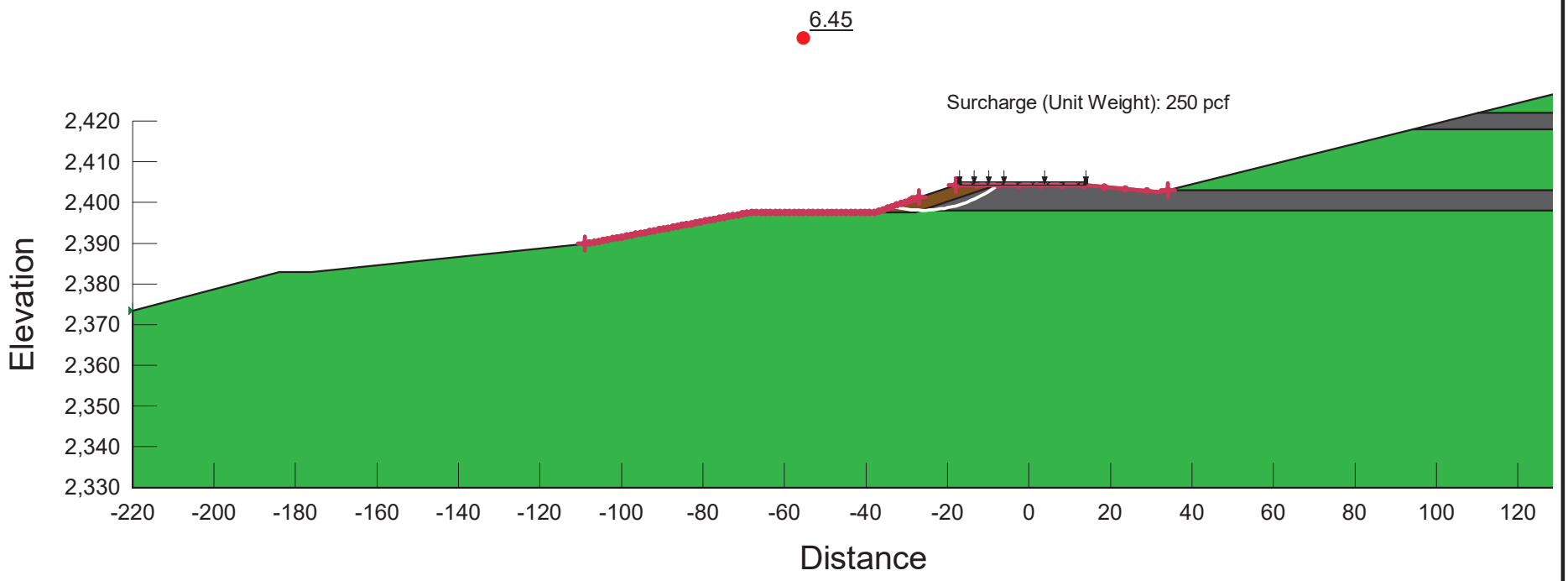
FIG. E-7

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1017+50 to 1018+50\Sta. 1017+50 to 1018+50 - embankments.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1017+50 to 1018+50 - embankments.gsz
Geometry: Critical Section Sta 1018+50 (Temp)
Name: Temp Condtion Embankment (Undrained)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Cohesion Fn	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Embankment Fill (Undrained)	Mohr-Coulomb	125		1,500	0
	Claystone (Undrained)	Spatial Mohr-Coulomb	135	Cohesion vs Depth		0
	Siltstone	Mohr-Coulomb	140		0	34

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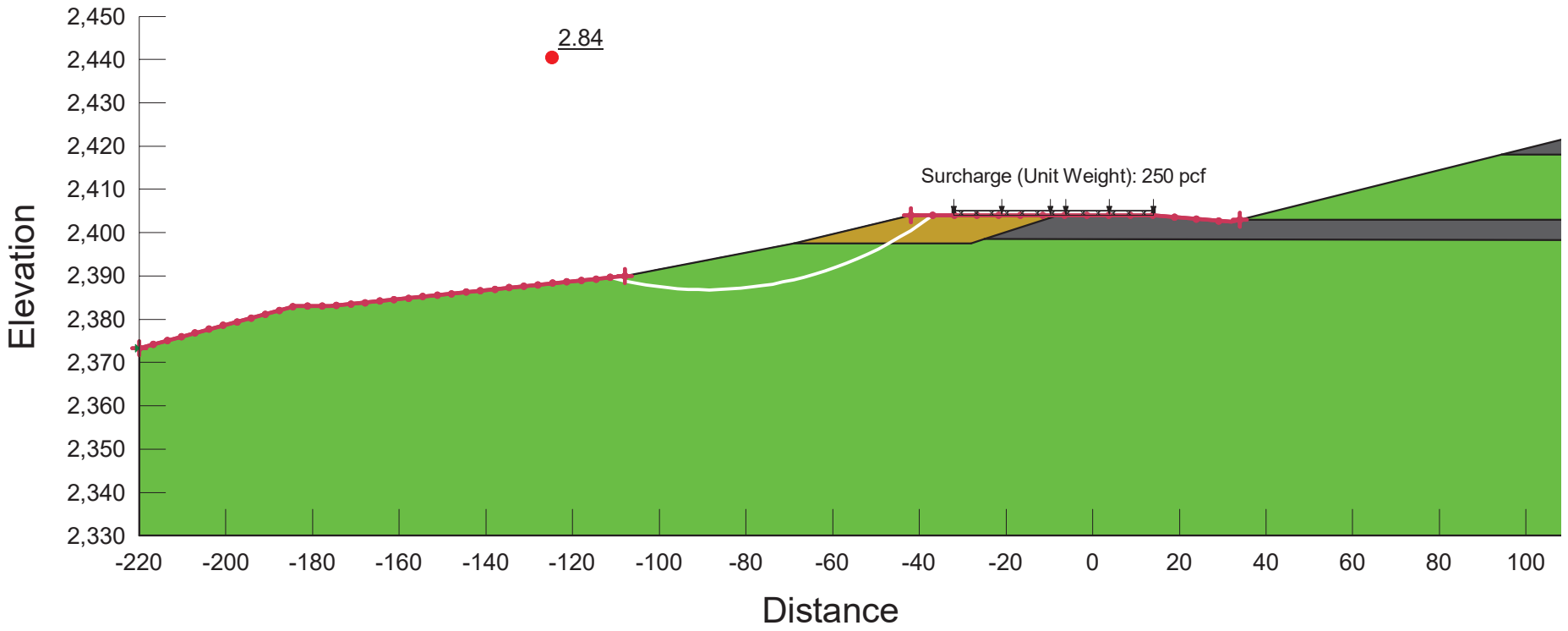
FIG. E-8

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1017+50 to 1018+50\Sta. 1017+50 to 1018+50 - embankments.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1017+50 to 1018+50 - embankments.gsz
Geometry: Critical Section Sta 1018+50 (Final)
Name: Proposed Embankment (Drained)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Clayey Embankment Fill (Drained)	Shear/Normal Fn.	125			LL = 38, CF = 30%
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF = 50%
	Siltstone	Mohr-Coulomb	140	0	34	

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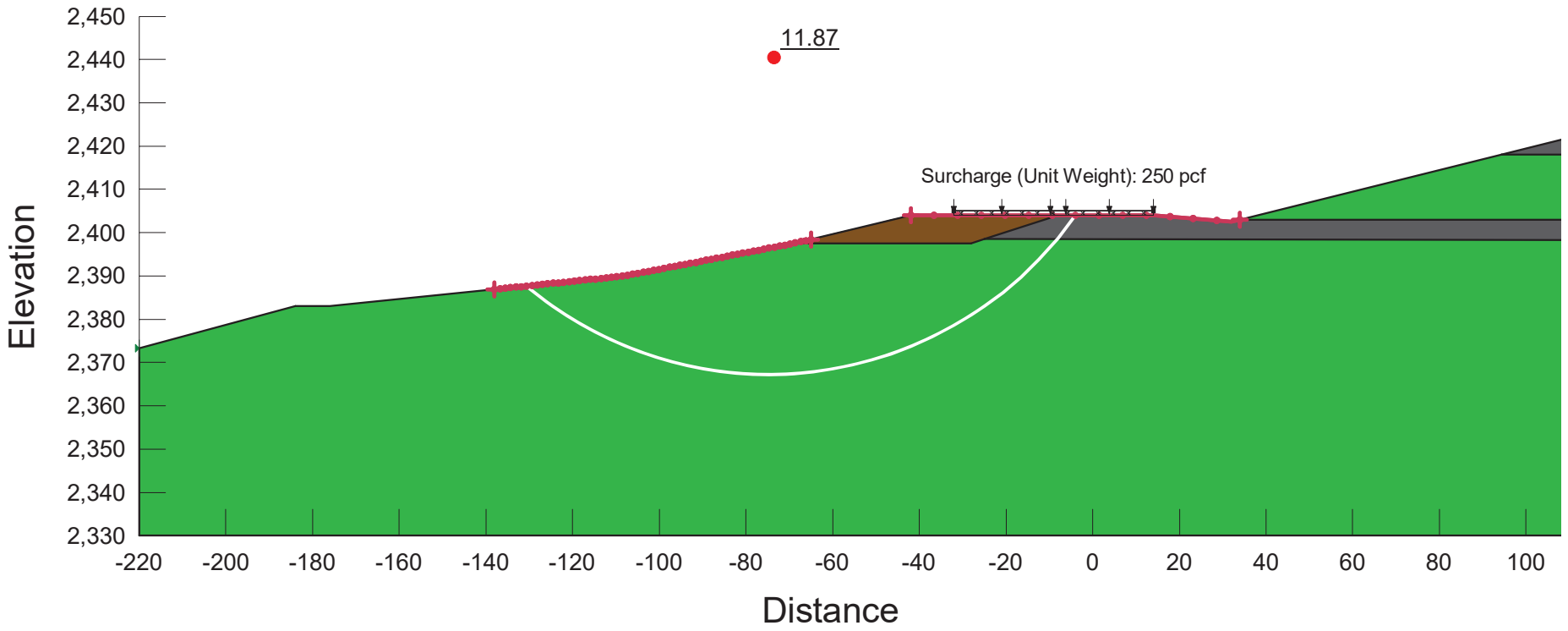
FIG. E-9

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1017+50 to 1018+50\Sta. 1017+50 to 1018+50 - embankments.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1017+50 to 1018+50 - embankments.gsz
Geometry: Critical Section Sta 1018+50 (Final)
Name: Proposed Embankment (Undrained)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Cohesion Fn	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Embankment Fill (Undrained)	Mohr-Coulomb	125		1,500	0
	Claystone (Undrained)	Spatial Mohr-Coulomb	135	Cohesion vs Depth		0
	Siltstone	Mohr-Coulomb	140		0	34

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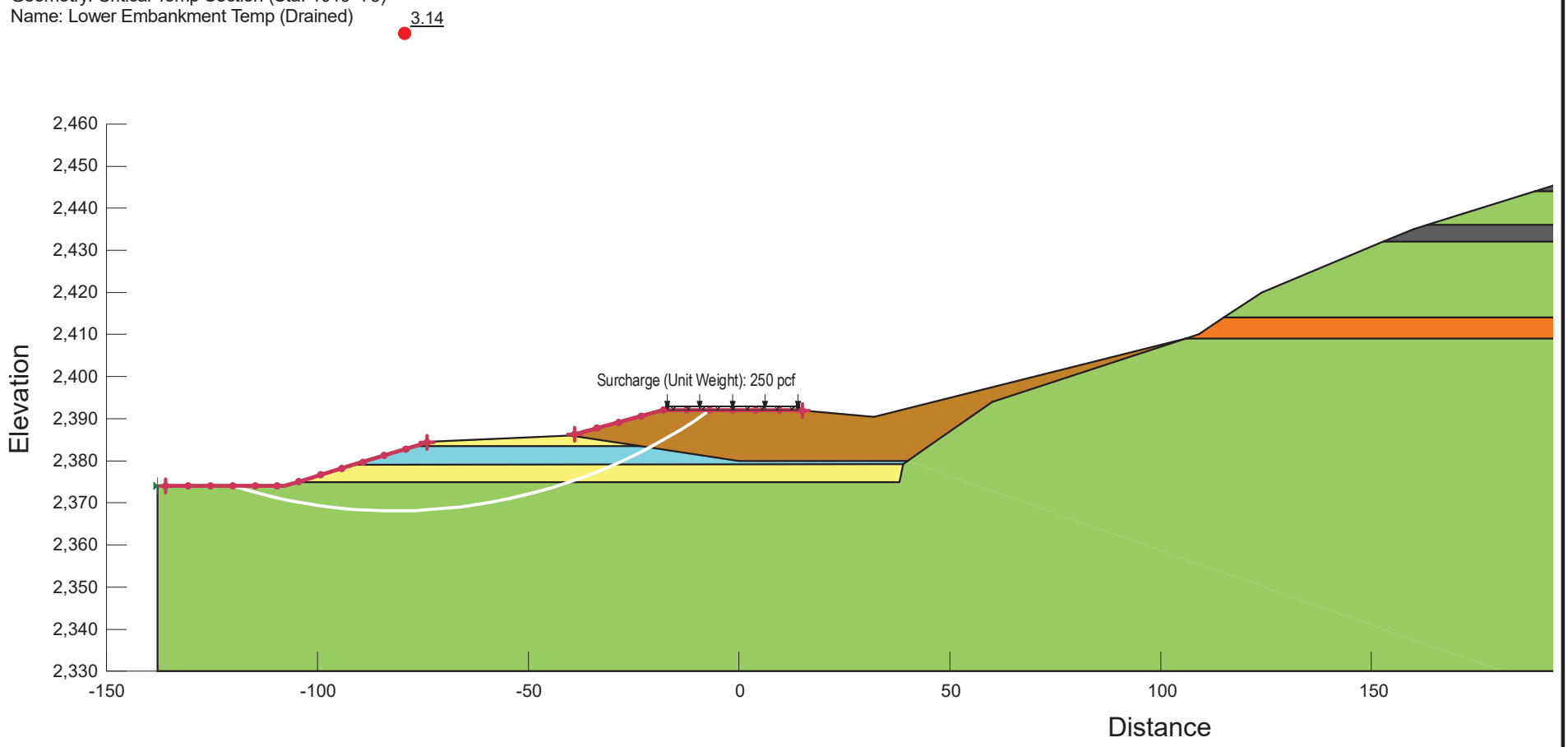
FIG. E-10

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1017+50 to 1018+50\Sta. 1017+50 to 1018+50 - embankments.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1019+00 to 1020+00 v2.gsz
Geometry: Critical Temp Section (Sta. 1019+75)
Name: Lower Embankment Temp (Drained)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Clayey Embankment Fill (Drained)	Shear/Normal Fn.	125			LL = 38, CF = 30%
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF = 50%
	Lean Clay (Drained)	Shear/Normal Fn.	120			LL = 32, CF = 28%
	Sandstone	Mohr-Coulomb	140	0	38	
	Siltstone	Mohr-Coulomb	140	0	34	
	Silty Sand	Mohr-Coulomb	125	0	28	

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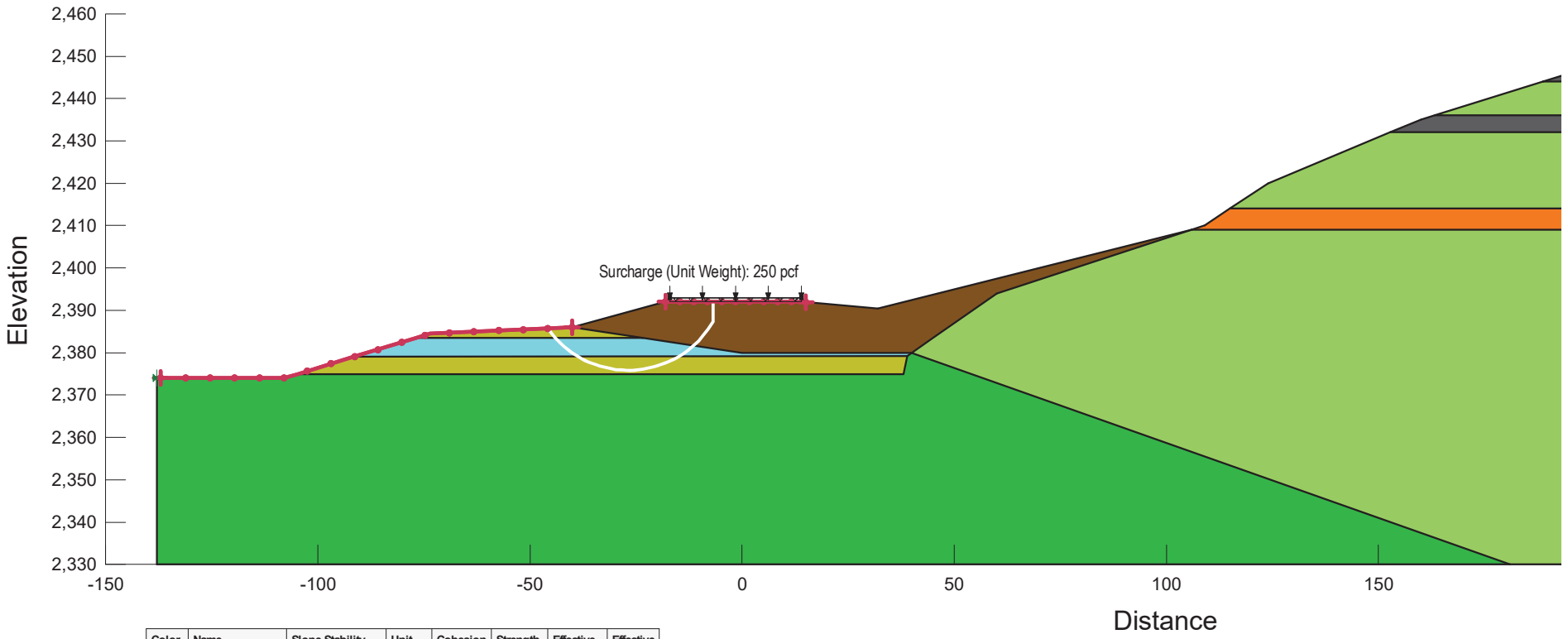
FIG. E-11

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1019+00 to 1020+00\Sta. 1019+00 to 1020+00 v2.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1019+00 to 1020+00 v2.gsz
Geometry: Critical Temp Section (Sta. 1019+75)
Name: Lower Embankment Temp (Undrained) 5.05



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Cohesion Fn	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Embankment Fill (Undrained)	Mohr-Coulomb	125			1,500	0
	Claystone (Drained)	Shear/Normal Fn.	135		LL = 66, CF = 50%		
	Claystone (Undrained)	Spatial Mohr-Coulomb	135	Cohesion vs Depth			0
	Lean Clay (Undrained)	Mohr-Coulomb	120			750	0
	Sandstone	Mohr-Coulomb	140			0	38
	Siltstone	Mohr-Coulomb	140			0	34
	Silty Sand	Mohr-Coulomb	125			0	28

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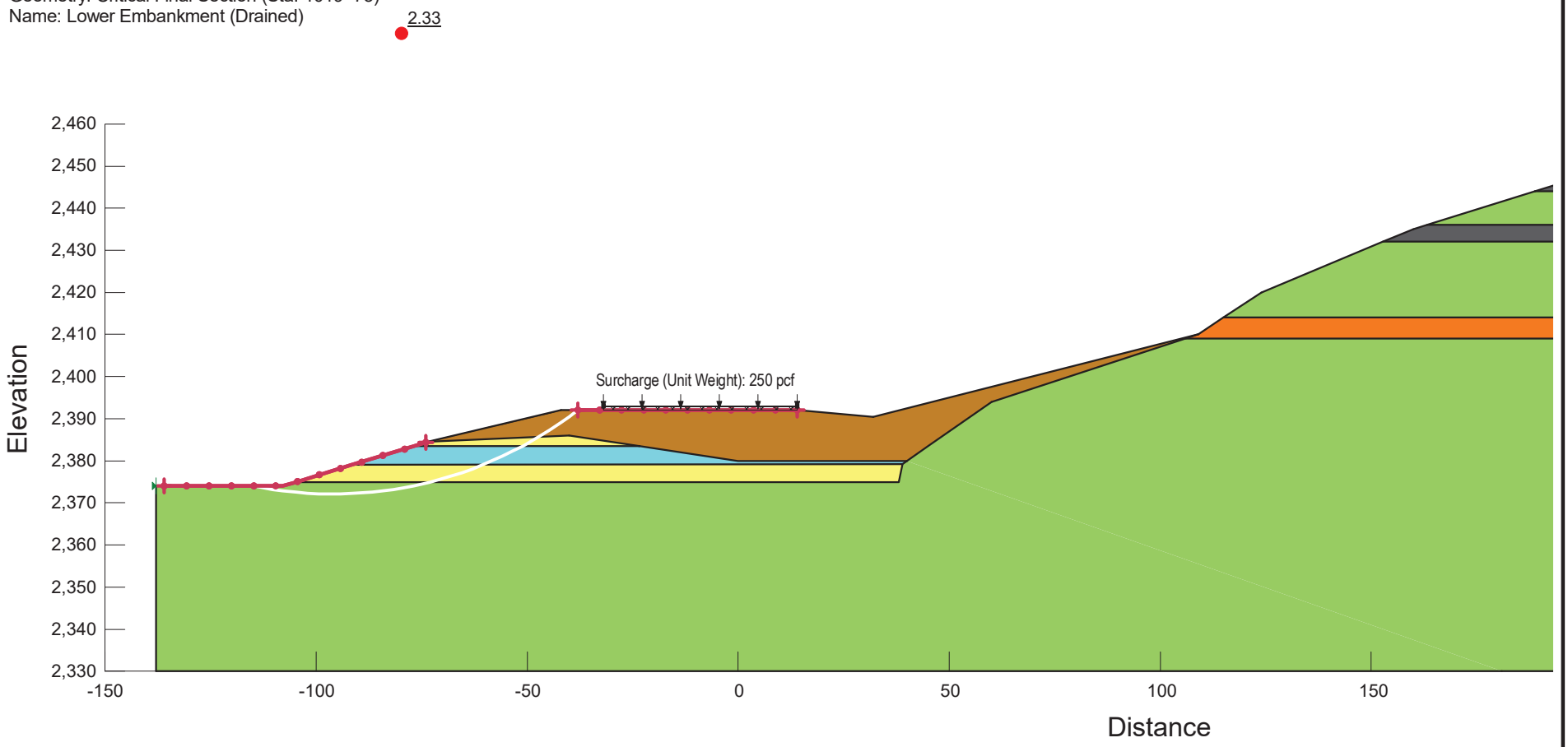
FIG. E-12

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1019+00 to 1020+00\Sta. 1019+00 to 1020+00 v2.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1019+00 to 1020+00 v2.gsz
Geometry: Critical Final Section (Sta. 1019+75)
Name: Lower Embankment (Drained)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Clayey Embankment Fill (Drained)	Shear/Normal Fn.	125			LL = 38, CF = 30%
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF = 50%
	Lean Clay (Drained)	Shear/Normal Fn.	120			LL = 32, CF = 28%
	Sandstone	Mohr-Coulomb	140	0	38	
	Siltstone	Mohr-Coulomb	140	0	34	
	Silty Sand	Mohr-Coulomb	125	0	28	

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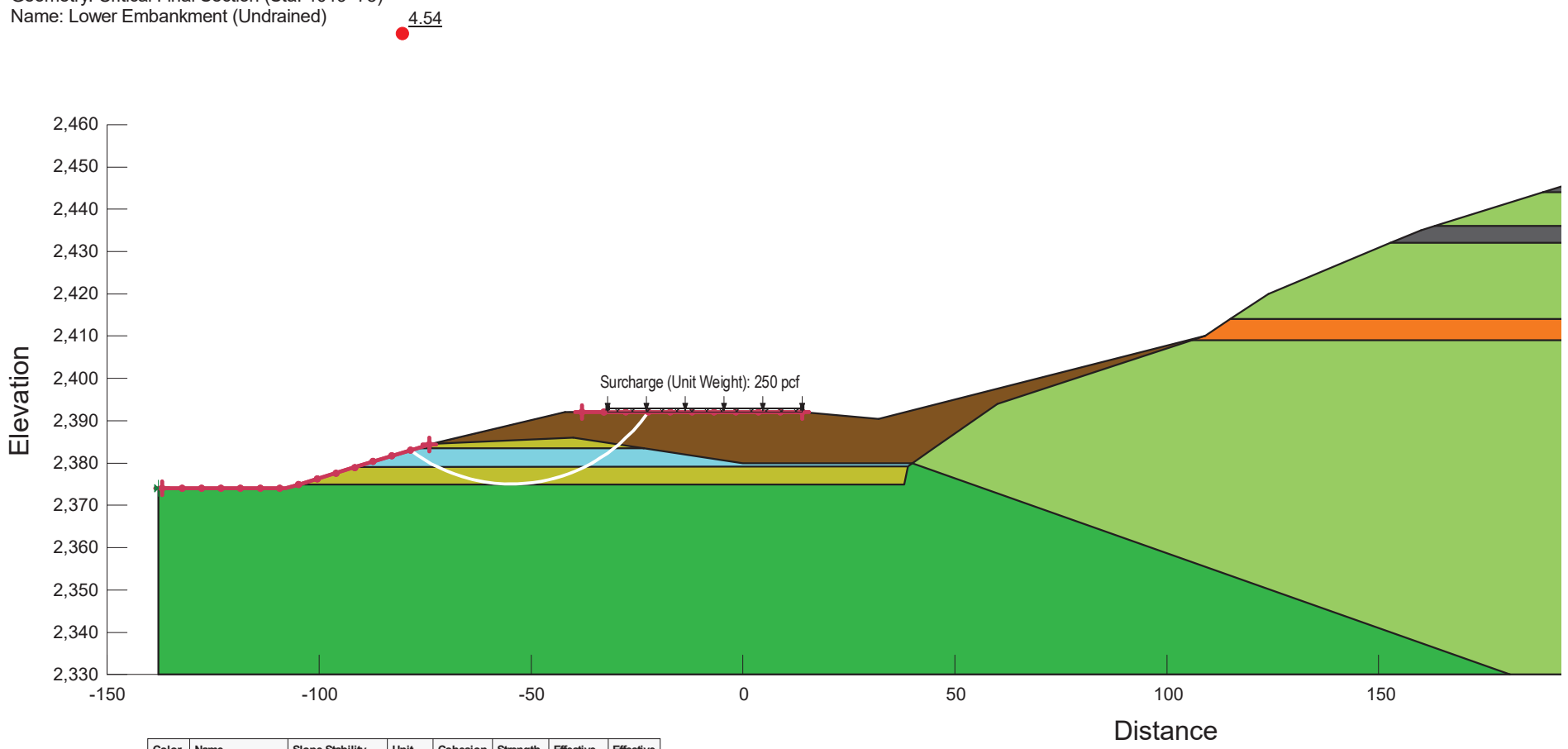
FIG. E-13

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1019+00 to 1020+00\Sta. 1019+00 to 1020+00 v2.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1019+00 to 1020+00 v2.gsz
Geometry: Critical Final Section (Sta. 1019+75)
Name: Lower Embankment (Undrained)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Cohesion Fn	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Embankment Fill (Undrained)	Mohr-Coulomb	125			1,500	0
	Claystone (Drained)	Shear/Normal Fn.	135		LL = 66, CF = 50%		
	Claystone (Undrained)	Spatial Mohr-Coulomb	135	Cohesion vs Depth			0
	Lean Clay (Undrained)	Mohr-Coulomb	120			750	0
	Sandstone	Mohr-Coulomb	140			0	38
	Siltstone	Mohr-Coulomb	140			0	34
	Silty Sand	Mohr-Coulomb	125			0	28

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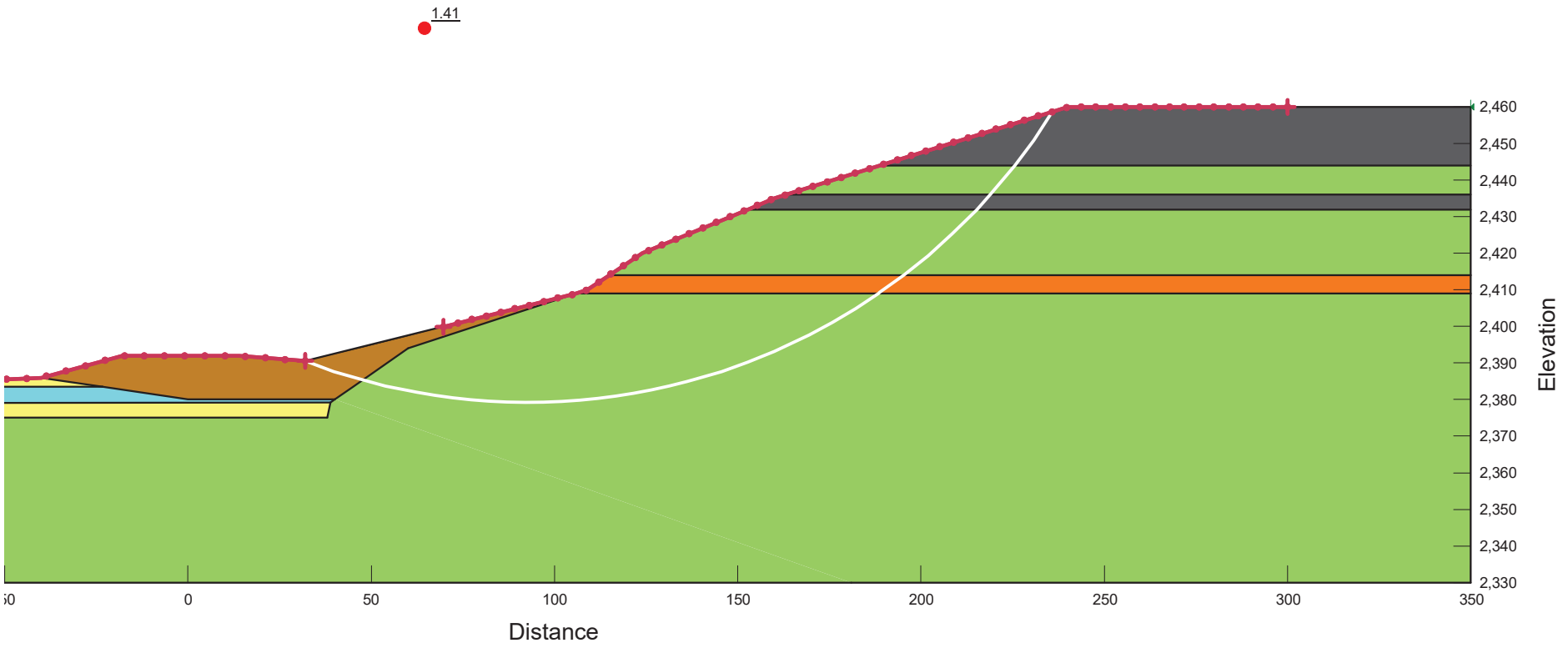
FIG. E-14

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1019+00 to 1020+00\Sta. 1019+00 to 1020+00 v2.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1019+00 to 1020+00 v2.gsz
Geometry: Critical Temp Section (Sta. 1019+75)
Name: Uppper Embankment Temp (Drained)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Clayey Embankment Fill (Drained)	Shear/Normal Fn.	125			LL = 38, CF = 30%
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF = 50%
	Lean Clay (Drained)	Shear/Normal Fn.	120			LL = 32, CF = 28%
	Sandstone	Mohr-Coulomb	140	0	38	
	Siltstone	Mohr-Coulomb	140	0	34	
	Silty Sand	Mohr-Coulomb	125	0	28	

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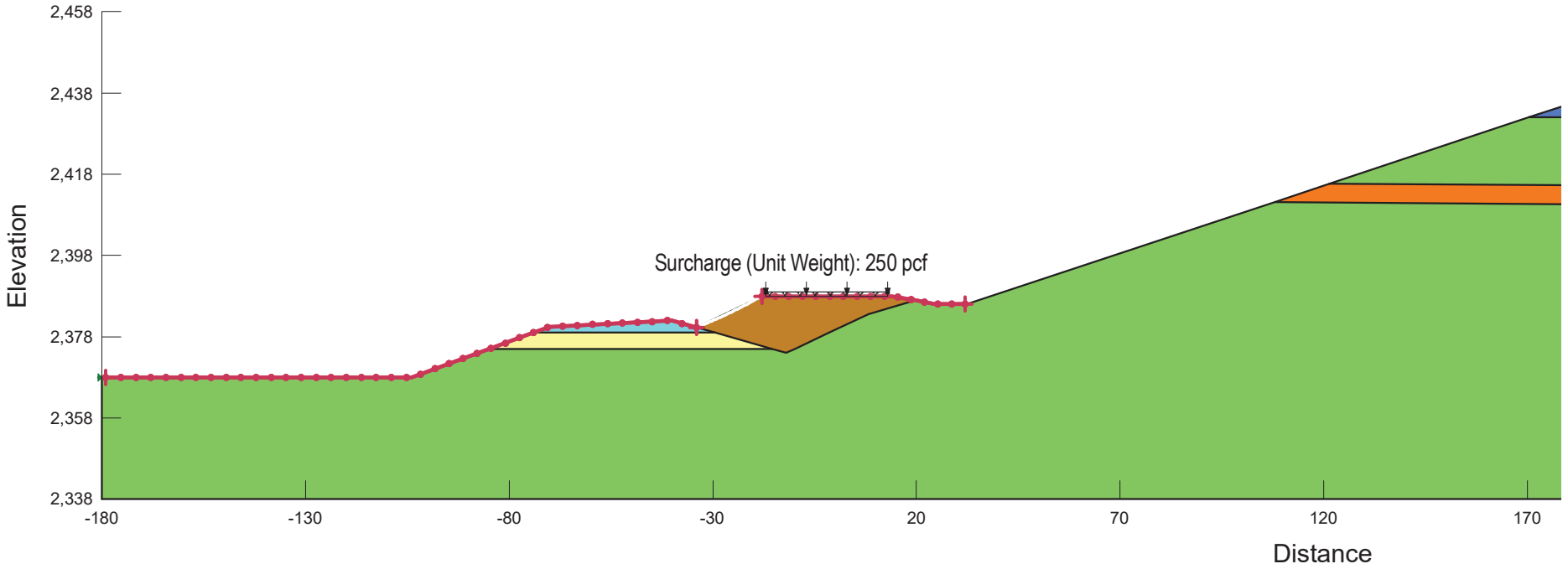
FIG. E-15

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1019+00 to 1020+00\Sta. 1019+00 to 1020+00 v2.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1020+25 to 1020+50.gsz
Geometry: Critical Temp Section (Sta. 1020+25)
Name: Drained (Embankment) (2)

1.41



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Clayey Embankment Fill (Drained)	Shear/Normal Fn.	125			LL = 38, CF = 30%
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF = 50%
	Lean Clay (Drained)	Shear/Normal Fn.	120			LL = 32, CF = 28%
	Sandstone	Mohr-Coulomb	140	0	38	
	Siltstone	Mohr-Coulomb	140	0	34	
	Silty Sand	Mohr-Coulomb	125	0	28	

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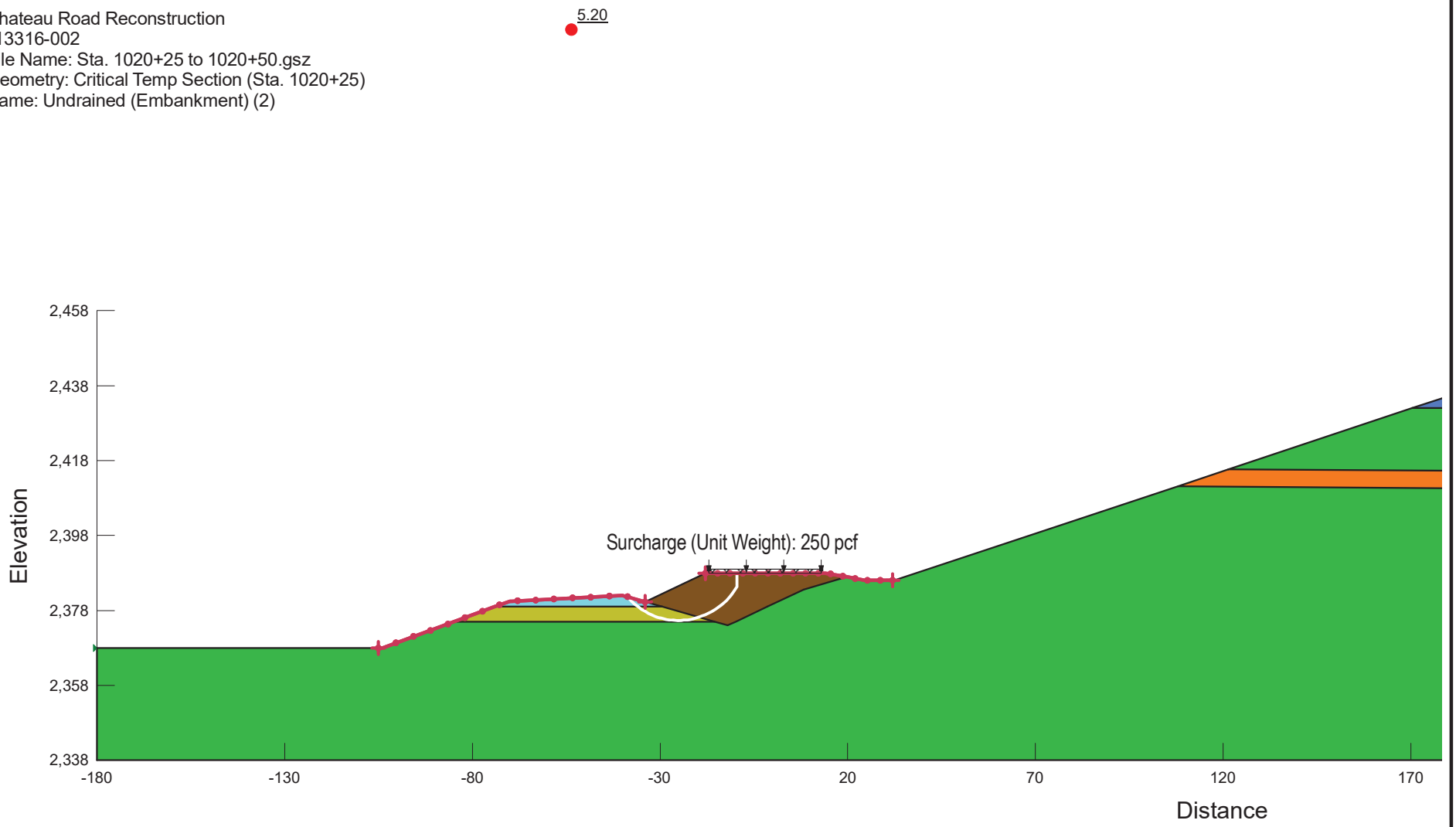
FIG. E-16

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1020+25 to 1020+50\Sta. 1020+25 to 1020+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1020+25 to 1020+50.gsz
Geometry: Critical Temp Section (Sta. 1020+25)
Name: Undrained (Embankment) (2)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Cohesion Fn	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Embankment Fill (Undrained)	Mohr-Coulomb	125		1,500	0
	Claystone (Undrained)	Spatial Mohr-Coulomb	135	Cohesion vs Depth		0
	Lean Clay (Undrained)	Mohr-Coulomb	120		750	0
	Sandstone	Mohr-Coulomb	140		0	38
	Siltstone	Mohr-Coulomb	140		0	34
	Silty Sand	Mohr-Coulomb	125		0	28

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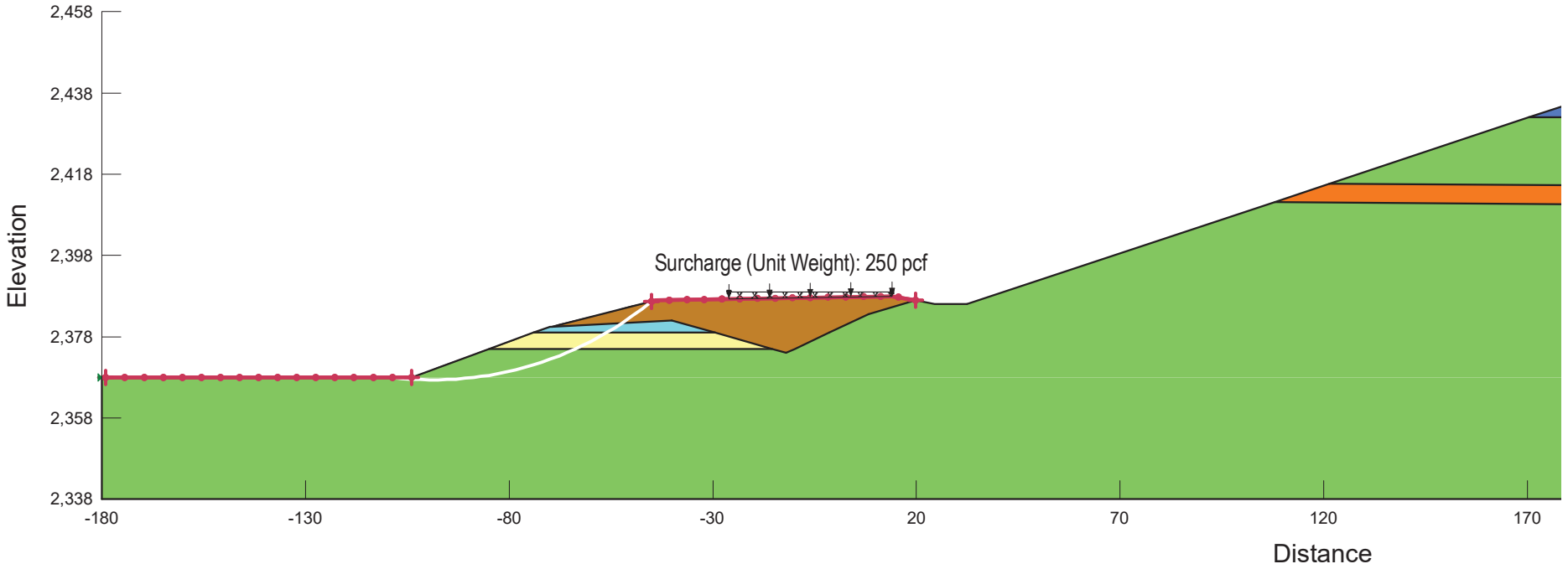
FIG. E-17

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1020+25 to 1020+50\Sta. 1020+25 to 1020+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1020+25 to 1020+50.gsz
Geometry: Critical Final Section (Sta. 1020+25)
Name: Drained (Embankment)

1.90



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Clayey Embankment Fill (Drained)	Shear/Normal Fn.	125			LL = 38, CF = 30%
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF = 50%
	Lean Clay (Drained)	Shear/Normal Fn.	120			LL = 32, CF = 28%
	Sandstone	Mohr-Coulomb	140	0	38	
	Siltstone	Mohr-Coulomb	140	0	34	
	Silty Sand	Mohr-Coulomb	125	0	28	

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STA. 1020+25
FINAL EMBANKMENT
DRAINED CONDITIONS

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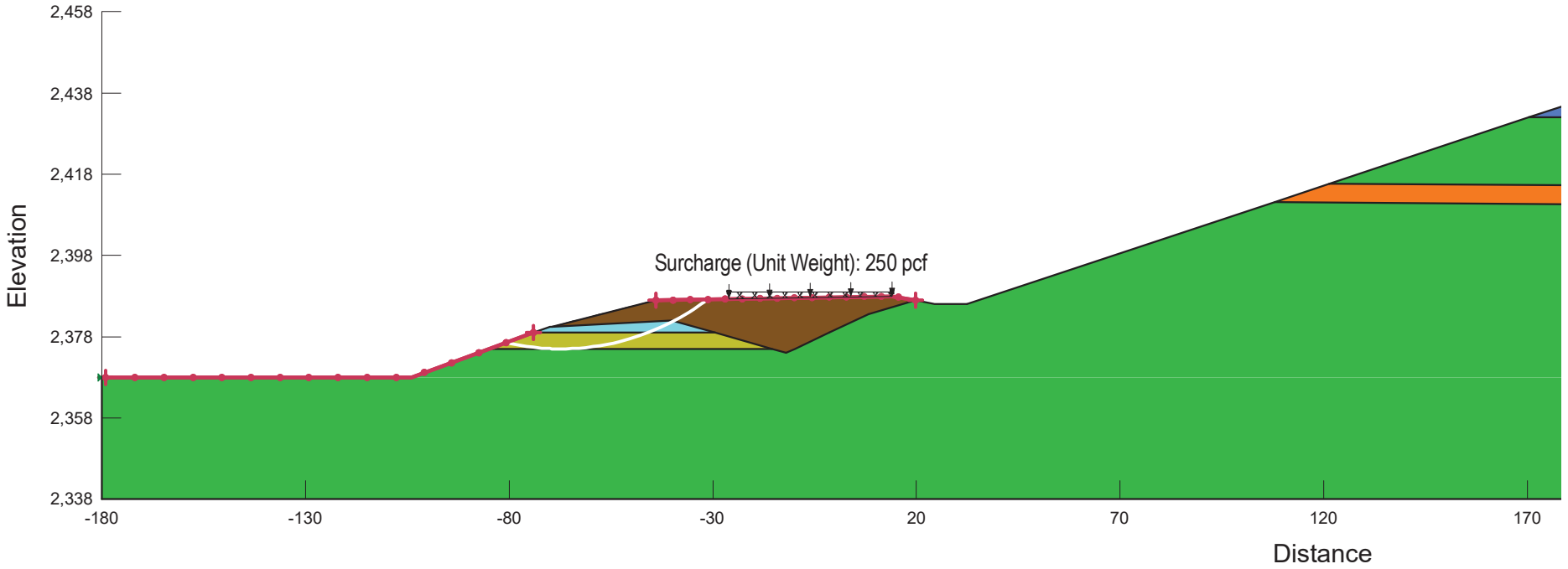
FIG. E-18

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1020+25 to 1020+50\Sta. 1020+25 to 1020+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1020+25 to 1020+50.gsz
Geometry: Critical Final Section (Sta. 1020+25)
Name: Undrained (Embankment)

6.49



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Cohesion Fn	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Embankment Fill (Undrained)	Mohr-Coulomb	125		1,500	0
	Claystone (Undrained)	Spatial Mohr-Coulomb	135	Cohesion vs Depth		0
	Lean Clay (Undrained)	Mohr-Coulomb	120		750	0
	Sandstone	Mohr-Coulomb	140		0	38
	Siltstone	Mohr-Coulomb	140		0	34
	Silty Sand	Mohr-Coulomb	125		0	28

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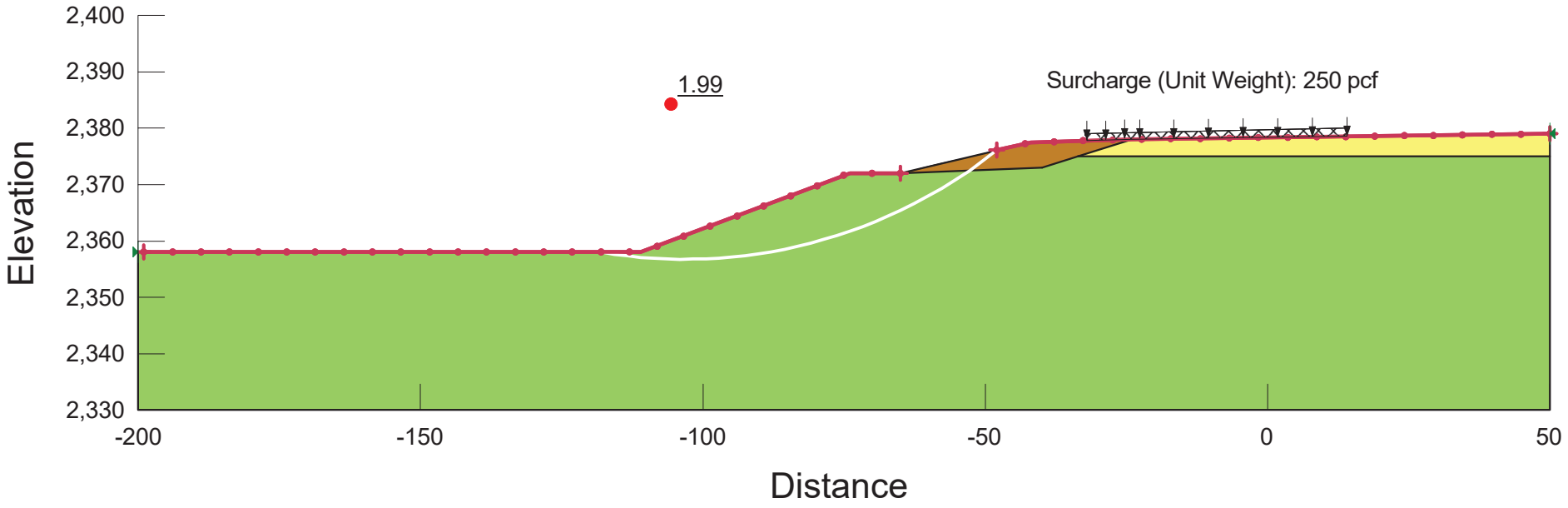
FIG. E-19

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1020+25 to 1020+50\Sta. 1020+25 to 1020+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1020+75 to 1021+25.gsz
Geometry: Critical Embankment Section (Sta. 1021+25)
Name: Embankment (Drained)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function
	Clayey Embankment Fill (Drained)	Shear/Normal Fn.	125	LL = 38, CF = 30%
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%
	Lean Clay (Drained)	Shear/Normal Fn.	120	LL = 32, CF =28%

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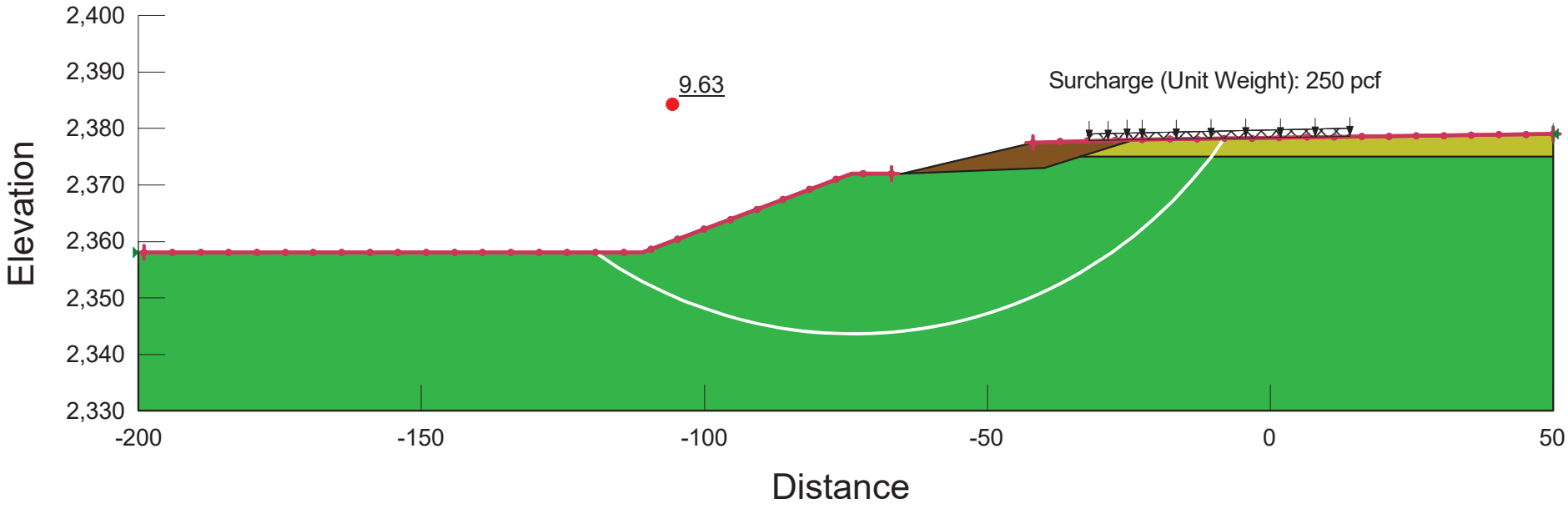
FIG. E-20

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1020+75 to 1021+25\Sta. 1020+75 to 1021+25.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1020+75 to 1021+25.gsz
Geometry: Critical Embankment Section (Sta. 1021+25)
Name: Embankment (Undrained)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Cohesion Fn	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Embankment Fill (Undrained)	Mohr-Coulomb	125		1,500	0
	Claystone (Undrained)	Spatial Mohr-Coulomb	135	Cohesion vs. Depth		0
	Lean Clay (Undrained)	Mohr-Coulomb	120		750	0

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FINAL EMBANKMENT
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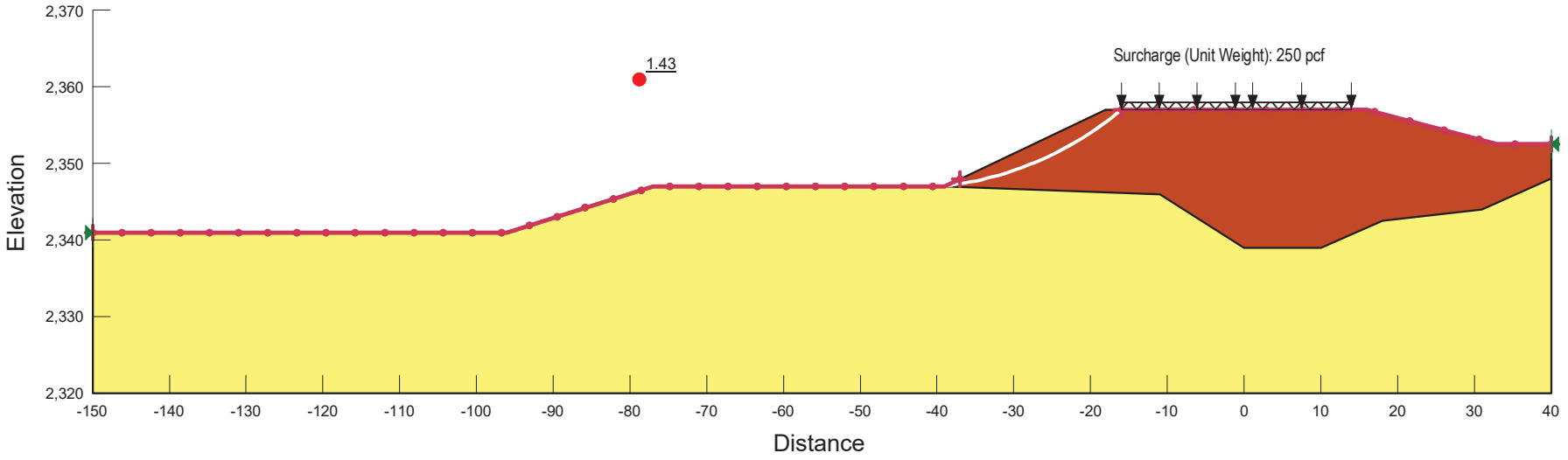
FIG. E-21

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1020+75 to 1021+25\Sta. 1020+75 to 1021+25.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1023+00 to 1024+00.gsz
Geometry: Critical Temporary Embankment (Sta. 1023+25)
Name: Drained (Temp)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)
	Granular Embankment Fill	Mohr-Coulomb	140		0	32
	Lean Clay (Drained)	Shear/Normal Fn.	120	LL = 32, CF = 28%		

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STA. 1023+25
TEMP EMBANKMENT
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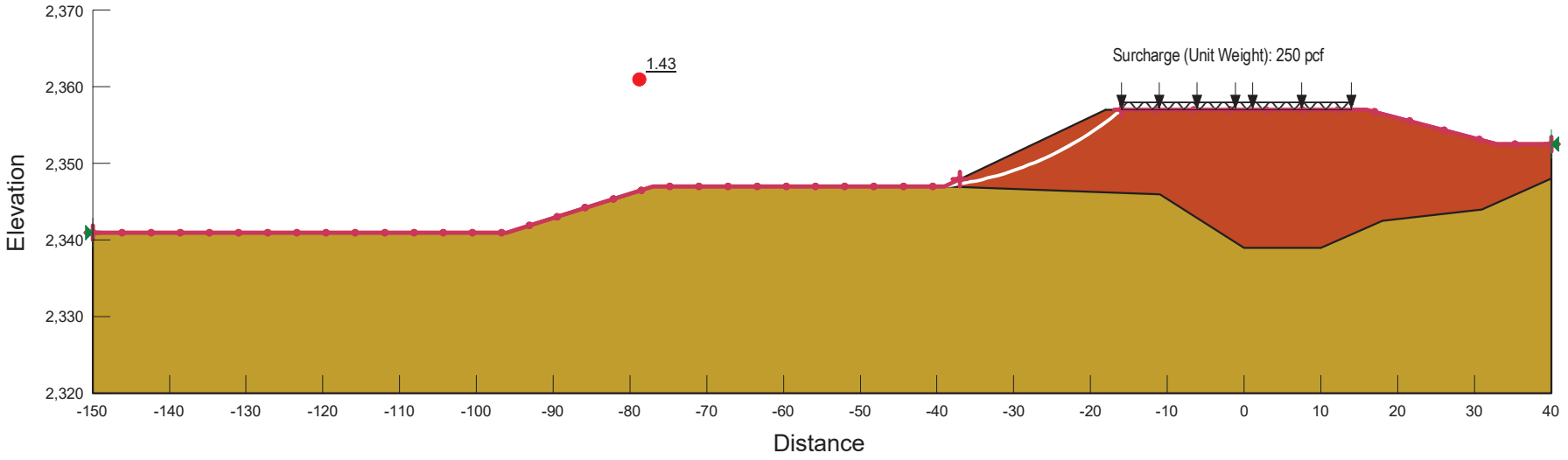
FIG. E-22

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1023+00 to 1024+00\Sta. 1023+00 to 1024+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1023+00 to 1024+00.gsz
Geometry: Critical Temporary Embankment (Sta. 1023+25)
Name: Undrained (Temp)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Granular Embankment Fill	Mohr-Coulomb	140	0	32
	Lean Clay (Undrained)	Mohr-Coulomb	120	750	0

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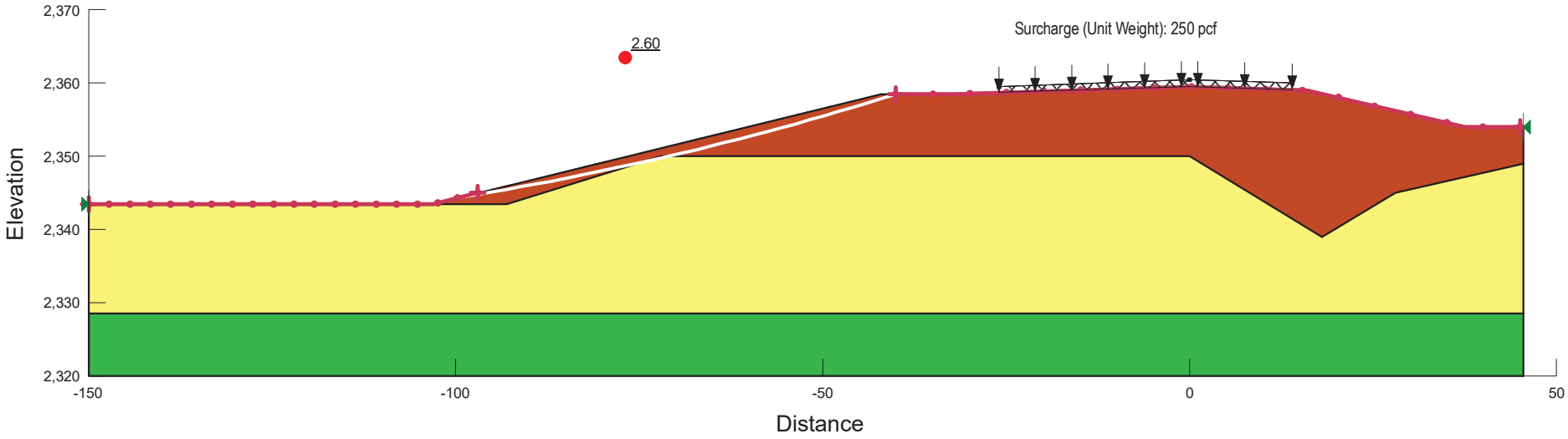
FIG. E-23

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1023+00 to 1024+00\Sta. 1023+00 to 1024+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1023+00 to 1024+00.gsz
Geometry: Critical Final Embankment (Sta. 1023+25)
Name: Drained



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF = 50%
	Granular Embankment Fill	Mohr-Coulomb	140	0	32	
	Lean Clay (Drained)	Shear/Normal Fn.	120			LL = 32, CF = 28%

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STA. 1023+25
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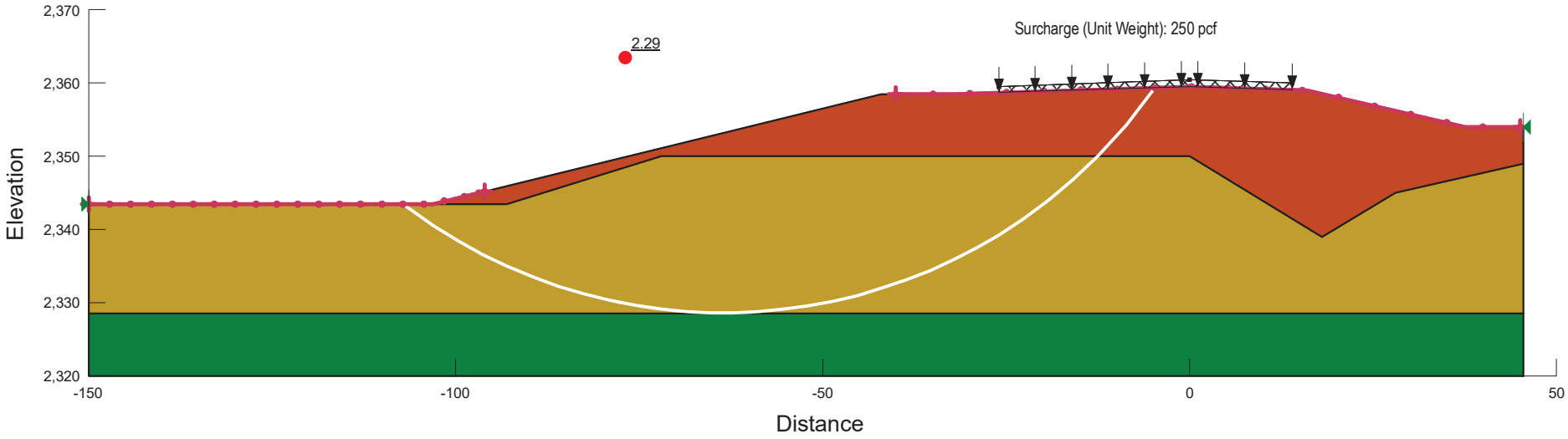
FIG. E-24

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1023+00 to 1024+00\Sta. 1023+00 to 1024+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1023+00 to 1024+00.gsz
Geometry: Critical Final Embankment (Sta. 1023+25)
Name: Undrained



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Claystone (Undrained)	Mohr-Coulomb	135	3,000	0
	Granular Embankment Fill	Mohr-Coulomb	140	0	32
	Lean Clay (Undrained)	Mohr-Coulomb	120	750	0

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STA. 1023+25
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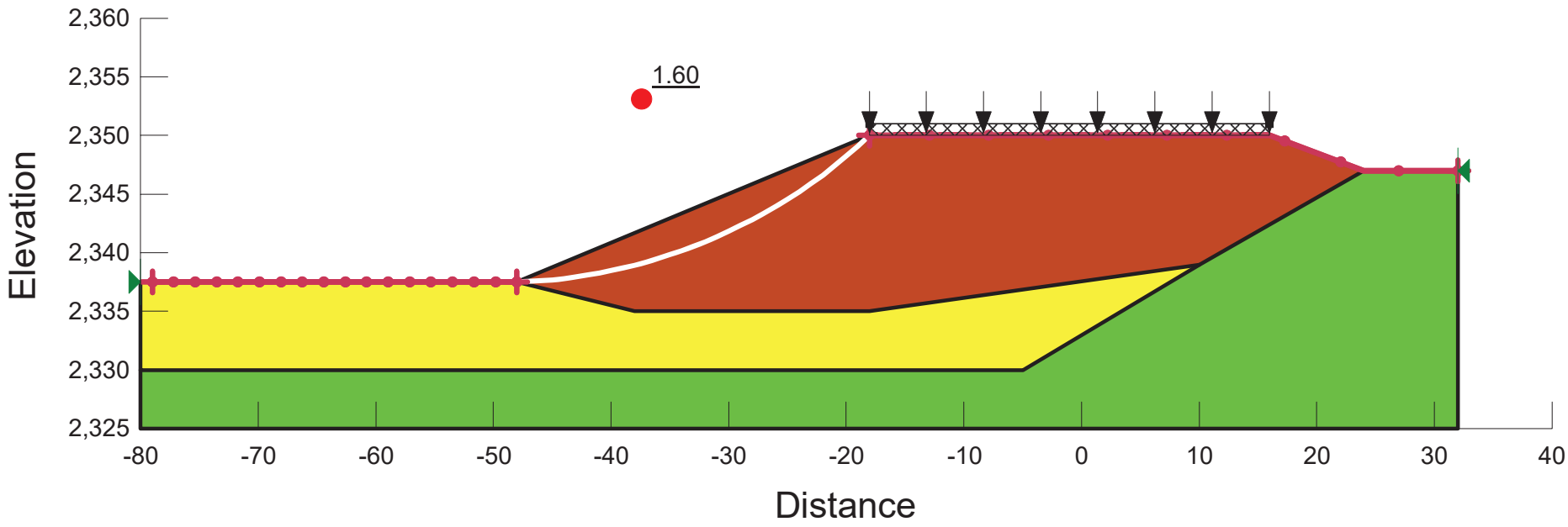
FIG. E-25

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1023+00 to 1024+00\Sta. 1023+00 to 1024+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1024+25 to 1028+50.gsz
Geometry: Name: Critical Temp Embankment (Sta. 1024+25)
Name: Drained (2)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF =50%
	Granular Embankment Fill	Mohr-Coulomb	140	0	32	
	Lean Clay (Drained)	Shear/Normal Fn.	120			LL=39, CF = 28%

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STA. 1024+25
TEMP. EMBANKMENT
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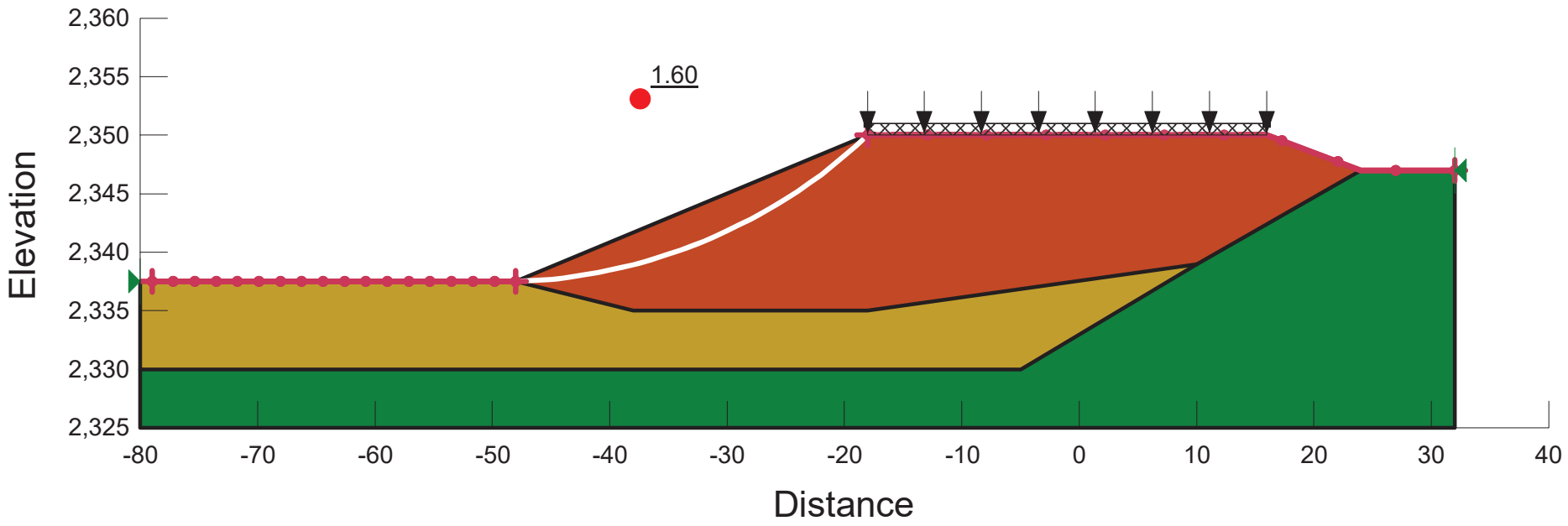
FIG. E-26

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1024+25 to 1028+50\Sta. 1024+25 to 1028+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1024+25 to 1028+50.gsz
Geometry: Name: Critical Temp Embankment (Sta. 1024+25)
Name: Undrained (2)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Claystone (Undrained)	Mohr-Coulomb	135	3,000	0
	Granular Embankment Fill	Mohr-Coulomb	140	0	32
	Lean Clay (Undrained)	Mohr-Coulomb	120	750	0

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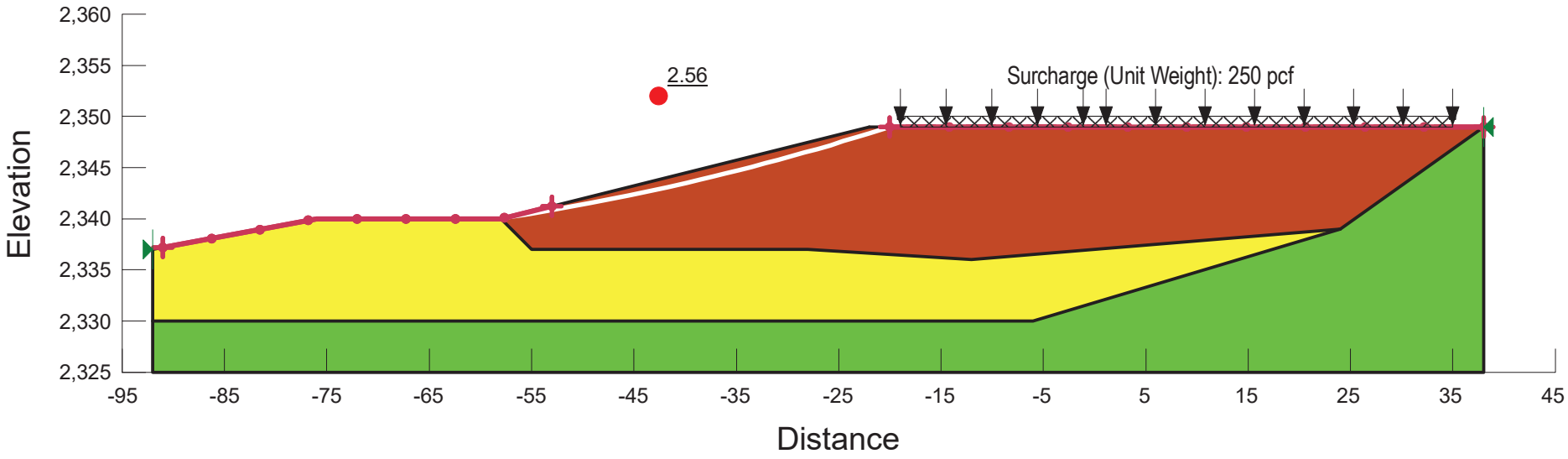
FIG. E-27

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1024+25 to 1028+50\Sta. 1024+25 to 1028+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1024+25 to 1028+50.gsz
Geometry: Name: Critical Final Embankment (Sta. 1024+25)
Name: Drained



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF =50%
	Granular Embankment Fill	Mohr-Coulomb	140	0	32	
	Lean Clay (Drained)	Shear/Normal Fn.	120			LL=39, CF = 28%

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STA. 1024+25
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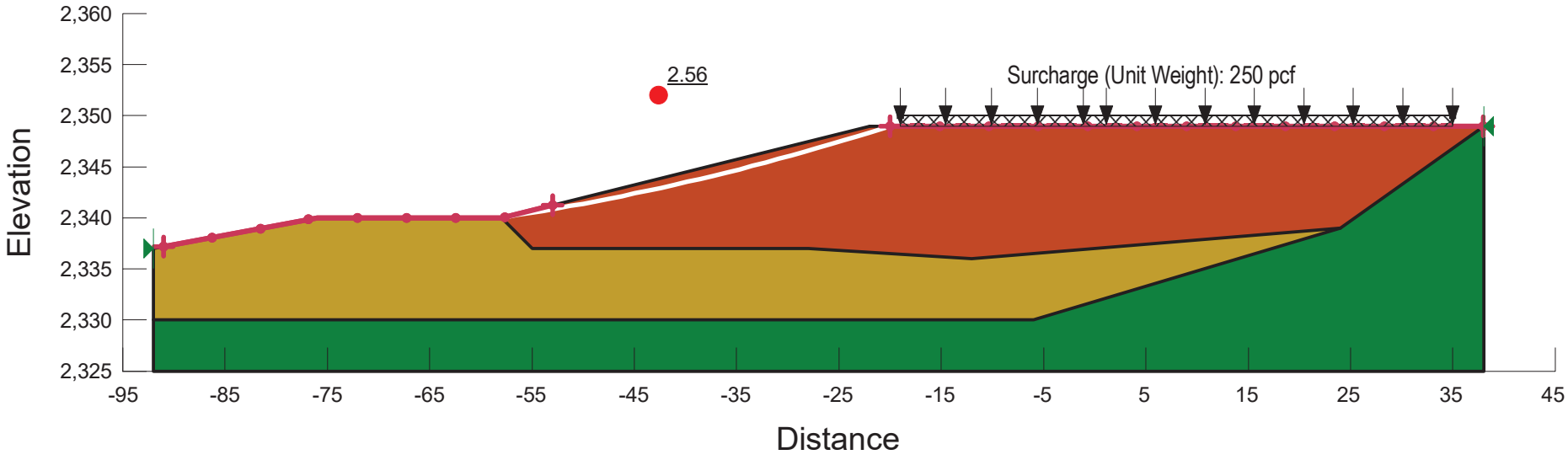
FIG. E-28

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1024+25 to 1028+50\Sta. 1024+25 to 1028+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1024+25 to 1028+50.gsz
Geometry: Name: Critical Final Embankment (Sta. 1024+25)
Name: Undrained



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Claystone (Undrained)	Mohr-Coulomb	135	3,000	0
	Granular Embankment Fill	Mohr-Coulomb	140	0	32
	Lean Clay (Undrained)	Mohr-Coulomb	120	750	0

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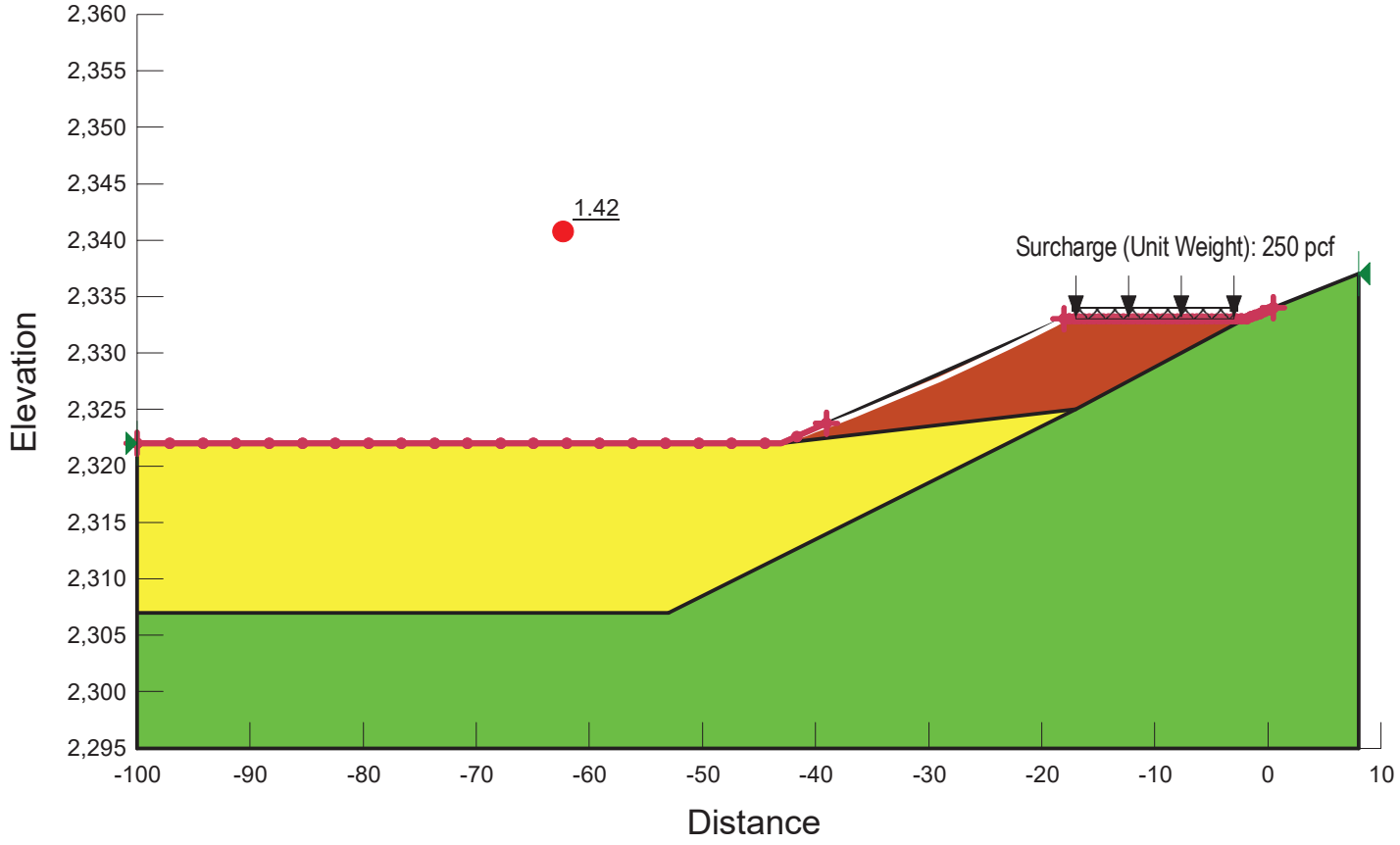
FIG. E-29

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1024+25 to 1028+50\Sta. 1024+25 to 1028+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1024+25 to 1028+50.gsz
Geometry: Name: Critical Temp Embankment Pre-Cut (Sta. 1026+00)
Name: Drained (Temp)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF =50%
	Granular Embankment Fill	Mohr-Coulomb	140	0	32	
	Lean Clay (Drained)	Shear/Normal Fn.	120			LL=39, CF = 28%

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STA. 1026+00
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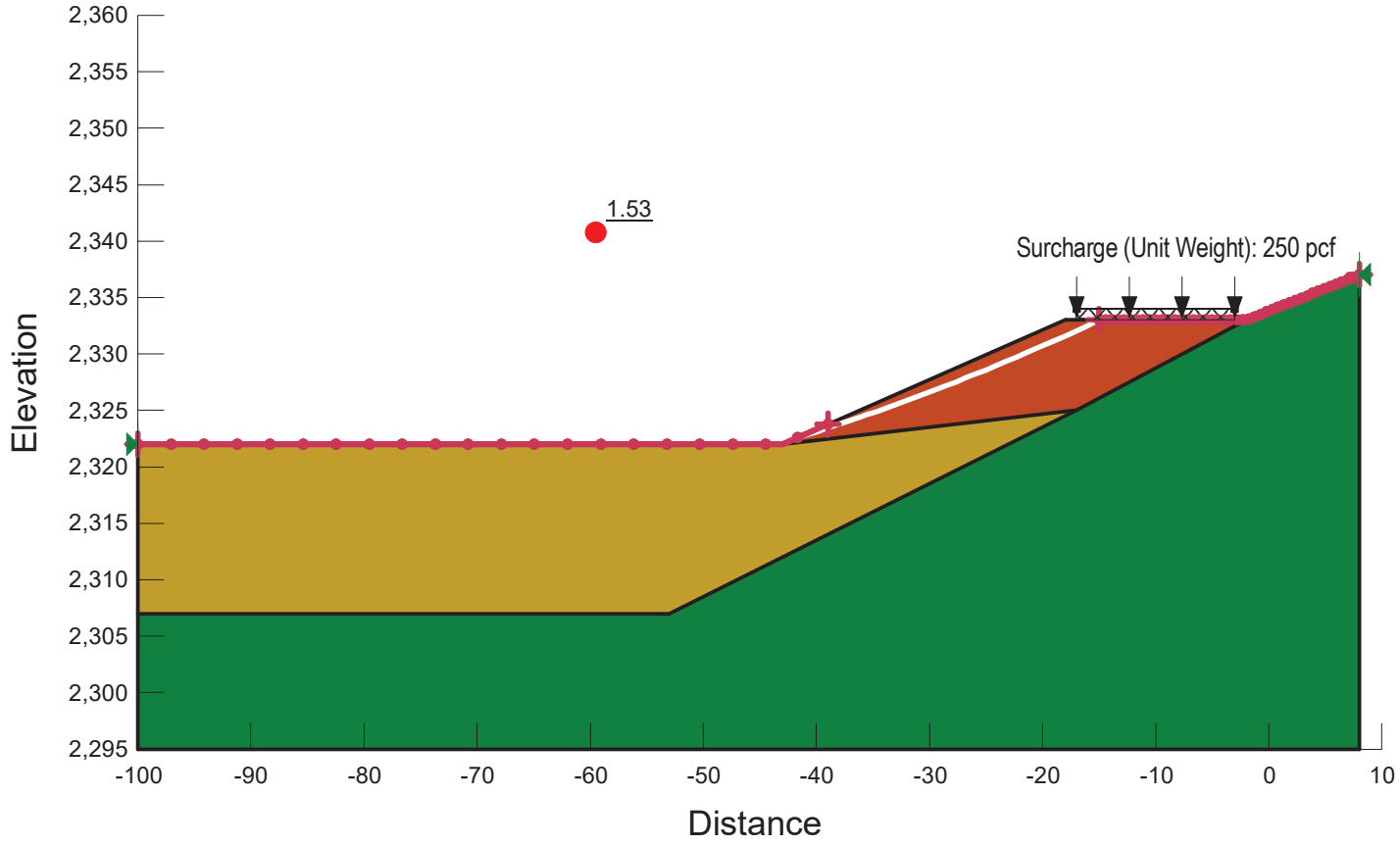
FIG. E-30

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1024+25 to 1028+50\Sta. 1024+25 to 1028+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1024+25 to 1028+50.gsz
Geometry: Name: Critical Temp Embankment Pre-Cut (Sta. 1026+00)
Name: Undrained (Temp)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Claystone (Undrained)	Mohr-Coulomb	135	3,000	0
	Granular Embankment Fill	Mohr-Coulomb	140	0	32
	Lean Clay (Undrained)	Mohr-Coulomb	120	750	0

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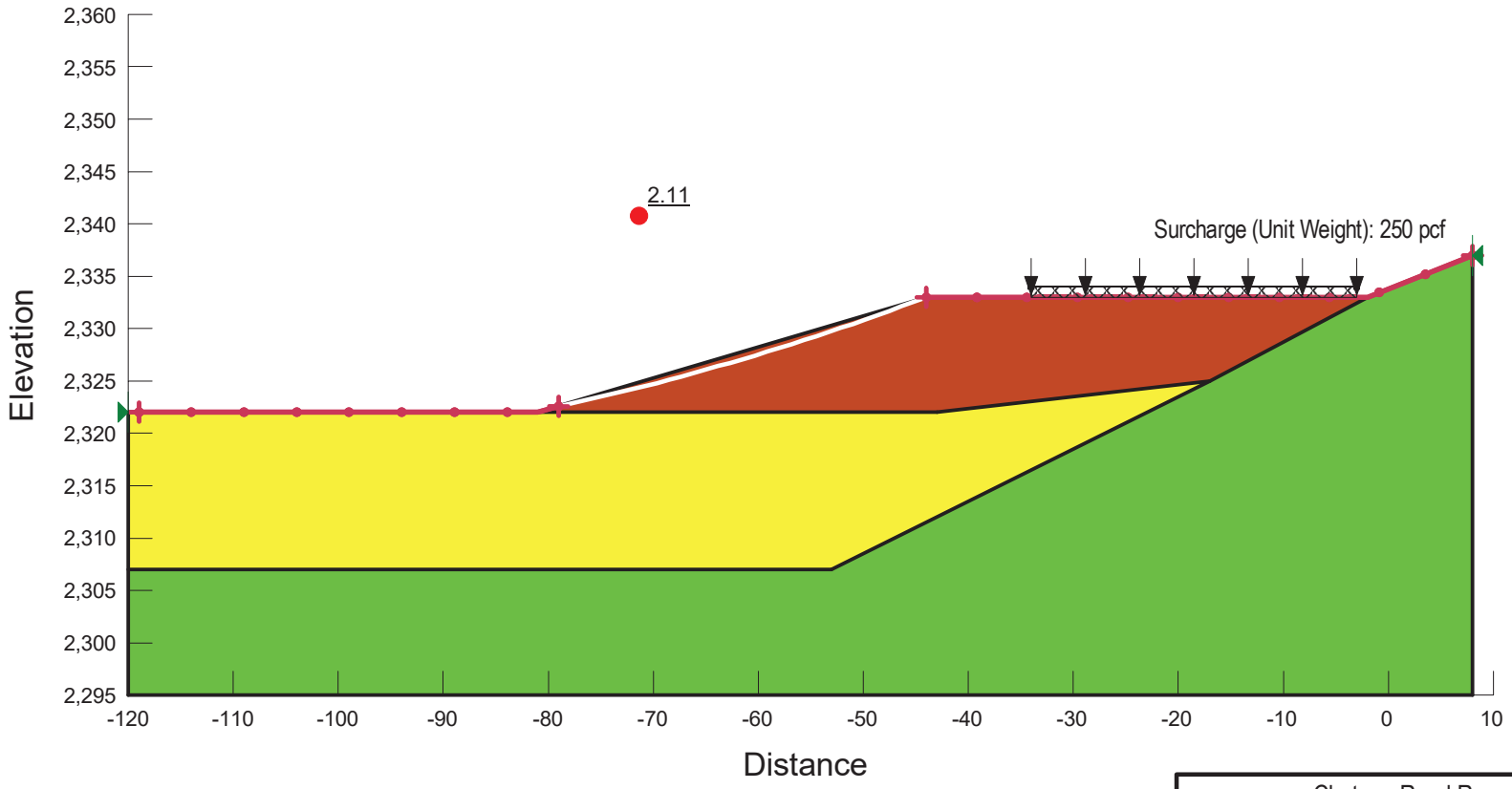
FIG. E-31

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1024+25 to 1028+50\Sta. 1024+25 to 1028+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1024+25 to 1028+50.gsz
Geometry: Name: Critical Final Embankment Pre-Cut (Sta. 1026+00)
Name: Drained (3)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF =50%
	Granular Embankment Fill	Mohr-Coulomb	140	0	32	
	Lean Clay (Drained)	Shear/Normal Fn.	120			LL=39, CF = 28%

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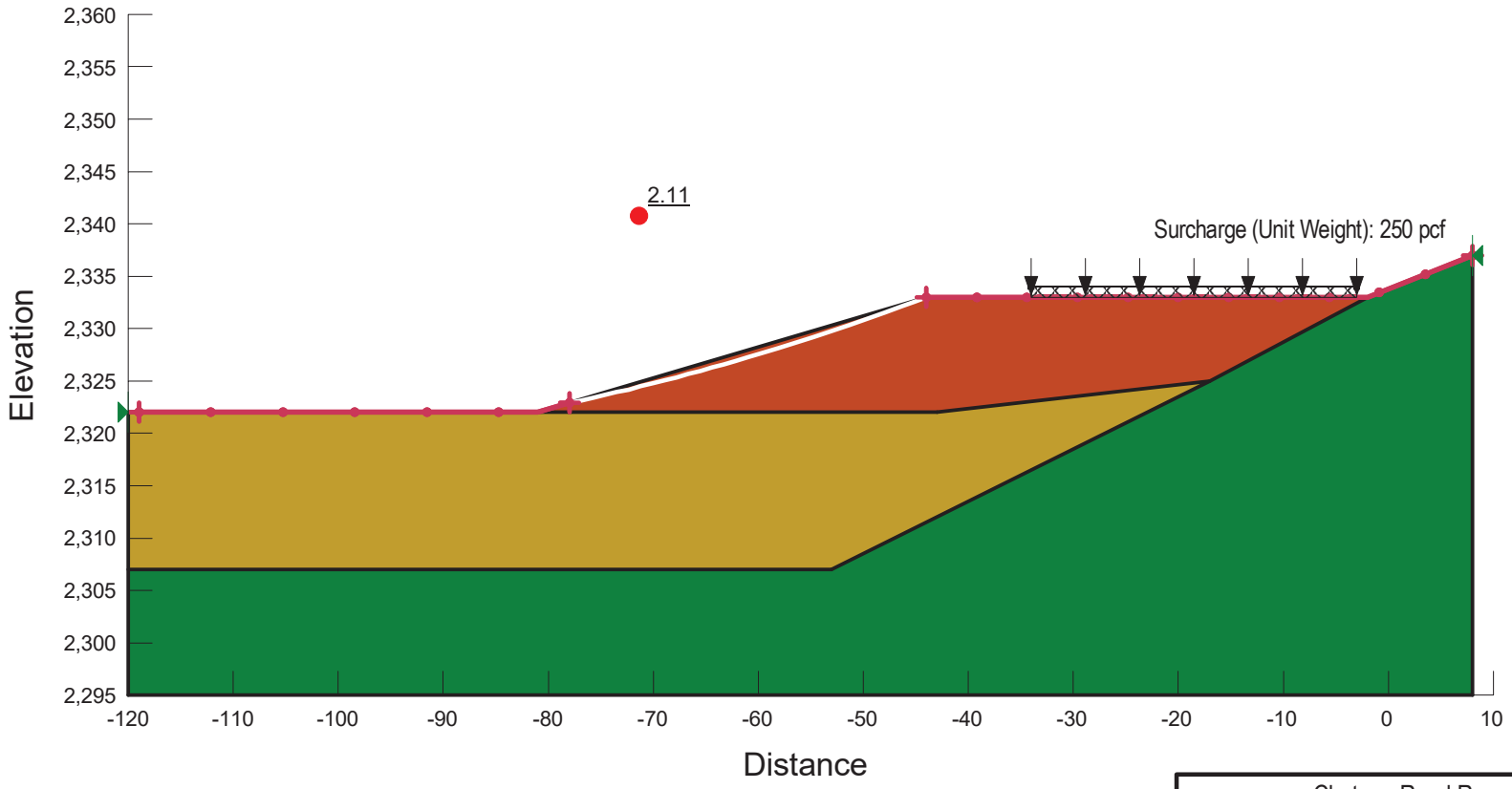
FIG. E-32

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1024+25 to 1028+50\Sta. 1024+25 to 1028+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1024+25 to 1028+50.gsz
Geometry: Name: Critical Final Embankment Pre-Cut (Sta. 1026+00)
Name: Undrained (3)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Claystone (Undrained)	Mohr-Coulomb	135	3,000	0
	Granular Embankment Fill	Mohr-Coulomb	140	0	32
	Lean Clay (Undrained)	Mohr-Coulomb	120	750	0

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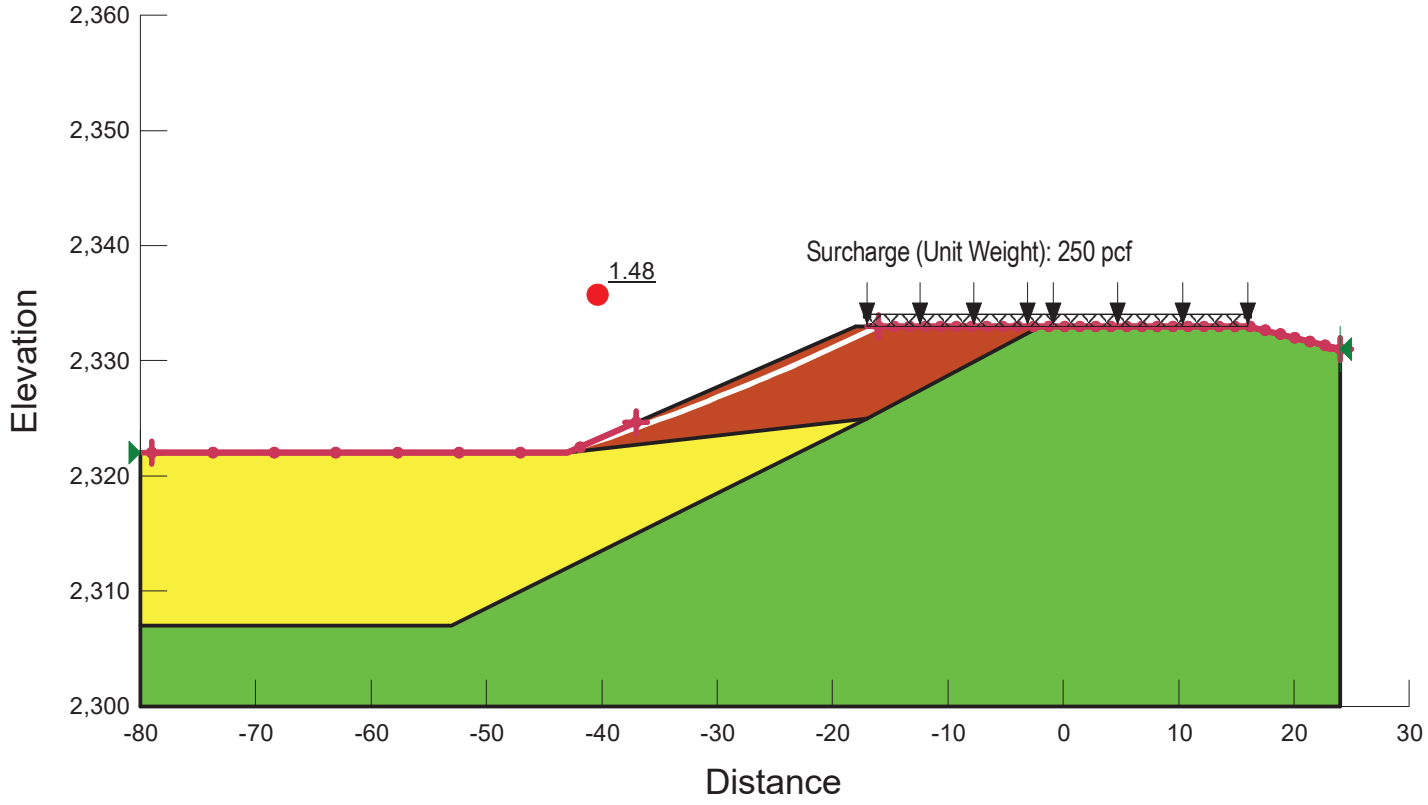
FIG. E-33

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1024+25 to 1028+50\Sta. 1024+25 to 1028+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1024+25 to 1028+50.gsz
Geometry: Name: Critical Temp Embankment Post-Cut (Sta. 1026+00)
Name: Drained (Temp) (2)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF =50%
	Granular Embankment Fill	Mohr-Coulomb	140	0	32	
	Lean Clay (Drained)	Shear/Normal Fn.	120			LL=39, CF = 28%

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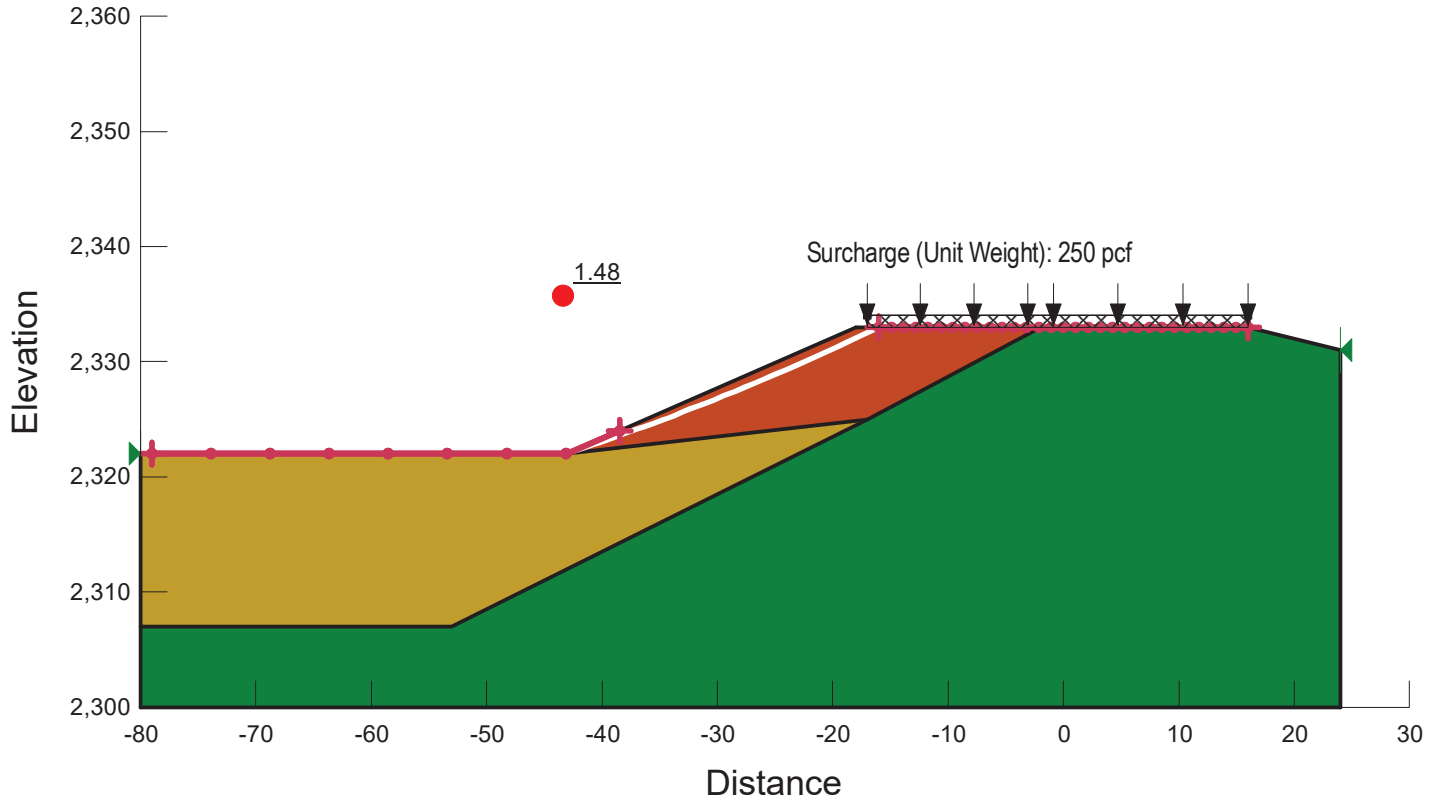
FIG. E-34

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1024+25 to 1028+50\Sta. 1024+25 to 1028+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1024+25 to 1028+50.gsz
Geometry: Name: Critical Temp Embankment Post-Cut (Sta. 1026+00)
Name: Undrained (Temp) (2)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Claystone (Undrained)	Mohr-Coulomb	135	3,000	0
	Granular Embankment Fill	Mohr-Coulomb	140	0	32
	Lean Clay (Undrained)	Mohr-Coulomb	120	750	0

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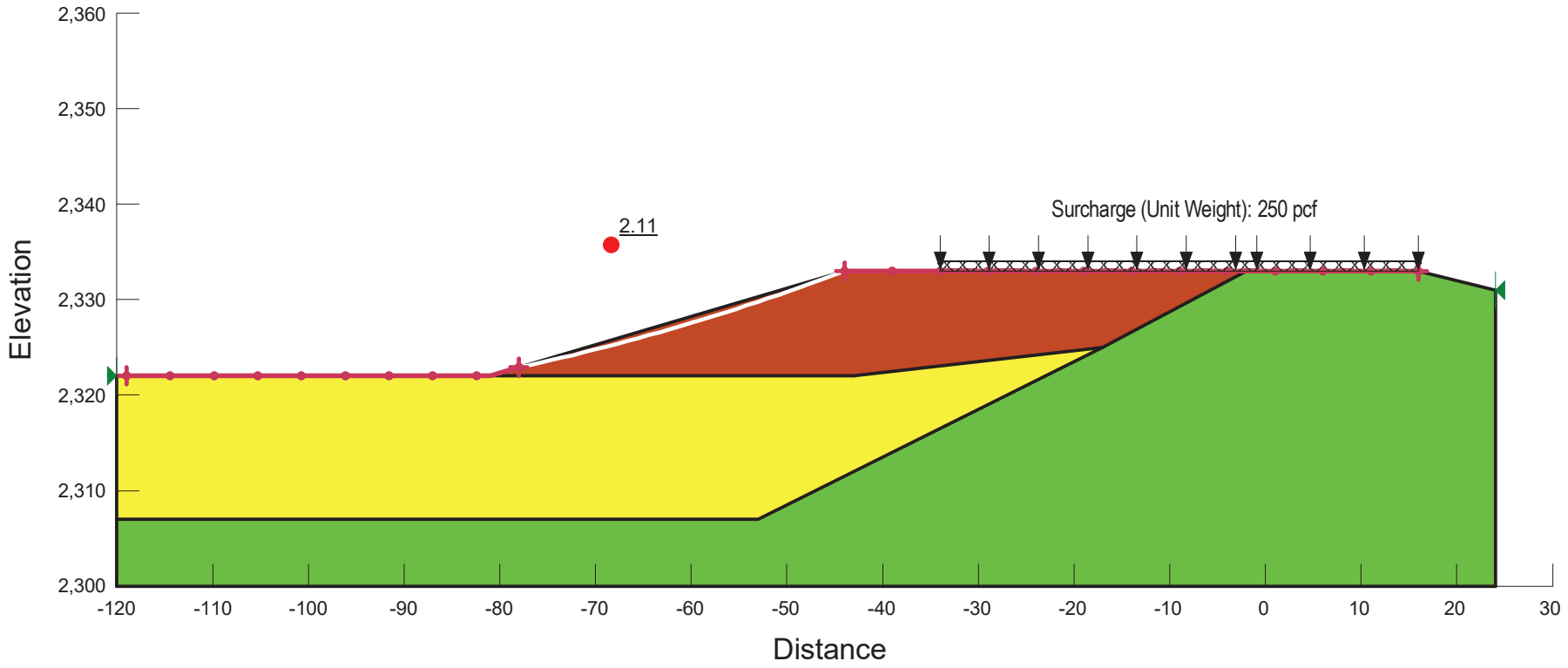
FIG. E-35

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1024+25 to 1028+50\Sta. 1024+25 to 1028+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1024+25 to 1028+50.gsz
Geometry: Name: Critical Final Embankment Post-Cut (Sta. 1026+00)
Name: Drained (4)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF =50%
	Granular Embankment Fill	Mohr-Coulomb	140	0	32	
	Lean Clay (Drained)	Shear/Normal Fn.	120			LL=39, CF = 28%

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1026+00
FINAL EMBANKMENT POST-CUT
DRAINED CONDITIONS

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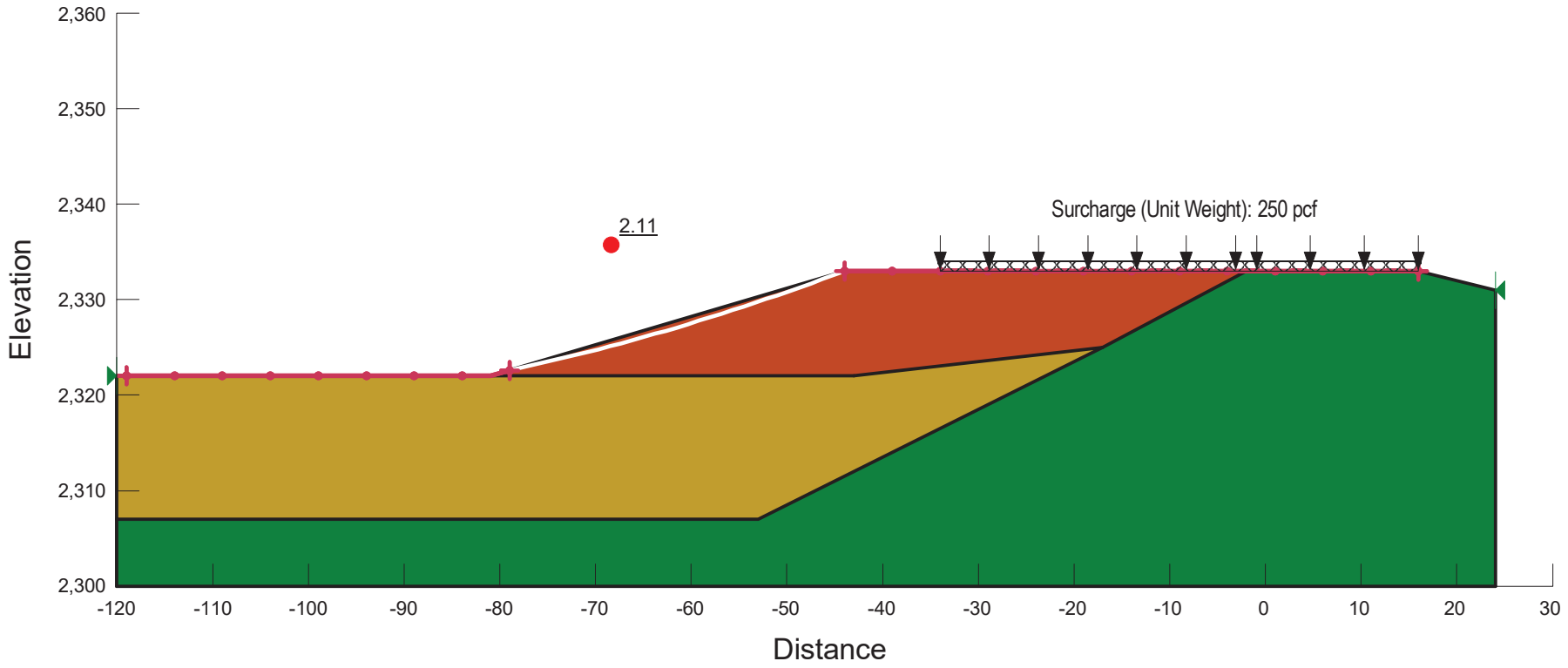
FIG. E-36

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1024+25 to 1028+50\Sta. 1024+25 to 1028+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1024+25 to 1028+50.gsz
Geometry: Name: Critical Final Embankment Post-Cut (Sta. 1026+00)
Name: Undrained (4)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Claystone (Undrained)	Mohr-Coulomb	135	3,000	0
	Granular Embankment Fill	Mohr-Coulomb	140	0	32
	Lean Clay (Undrained)	Mohr-Coulomb	120	750	0

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1026+00
FINAL EMBANKMENT POST-CUT
UNDRAINED CONDITIONS

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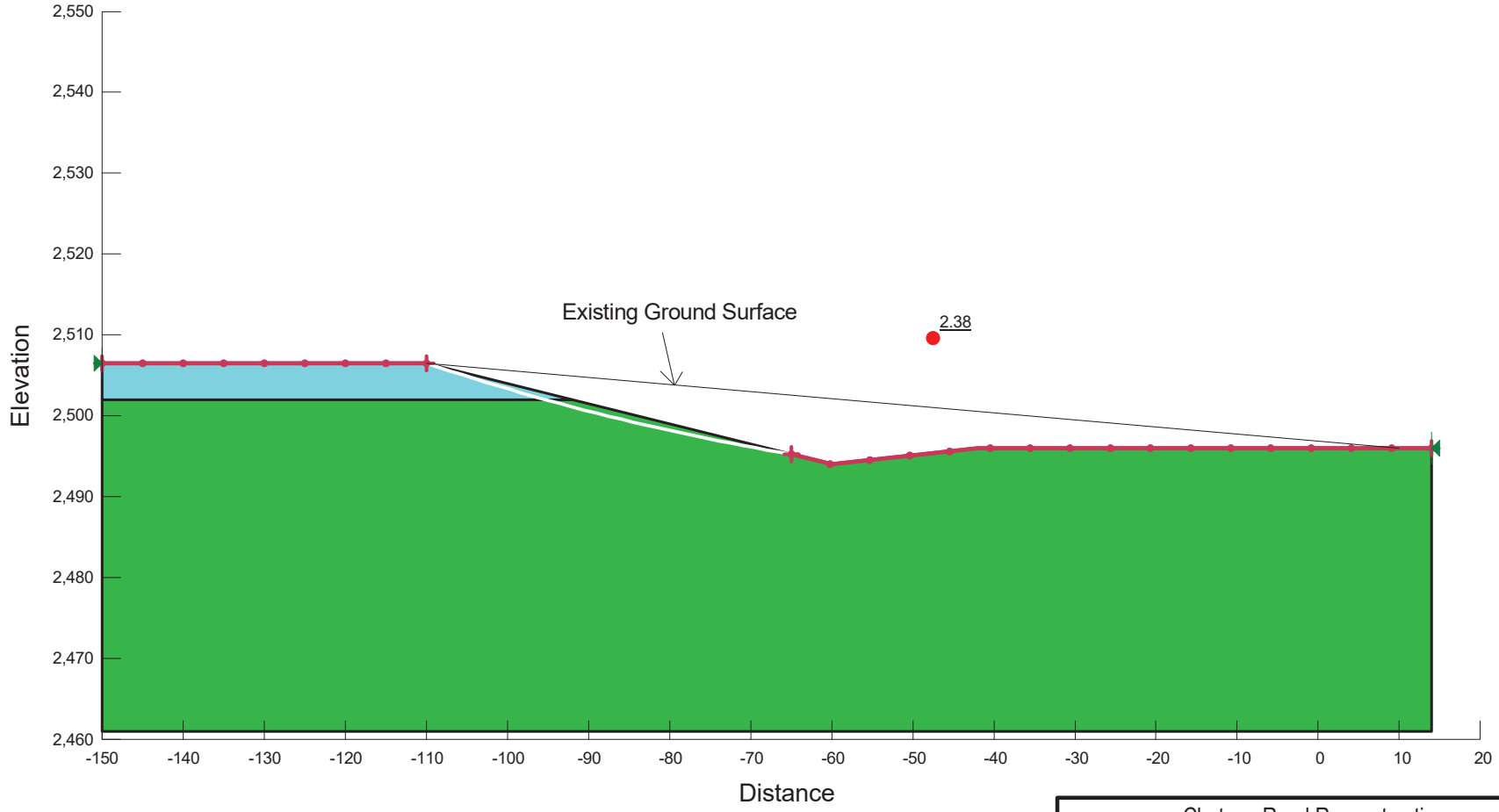
FIG. E-37

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1024+25 to 1028+50\Sta. 1024+25 to 1028+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1005+50 to 1007+25 v2.gsz
Geometry: Name: Critical Section (Sta. 1007+00)
Name: Drained Conditions



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF =50%
	Silty Sand	Mohr-Coulomb	125	0	28	

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1007+00
PROPOSED CUT (4H:1V)
DRAINED CONDITIONS

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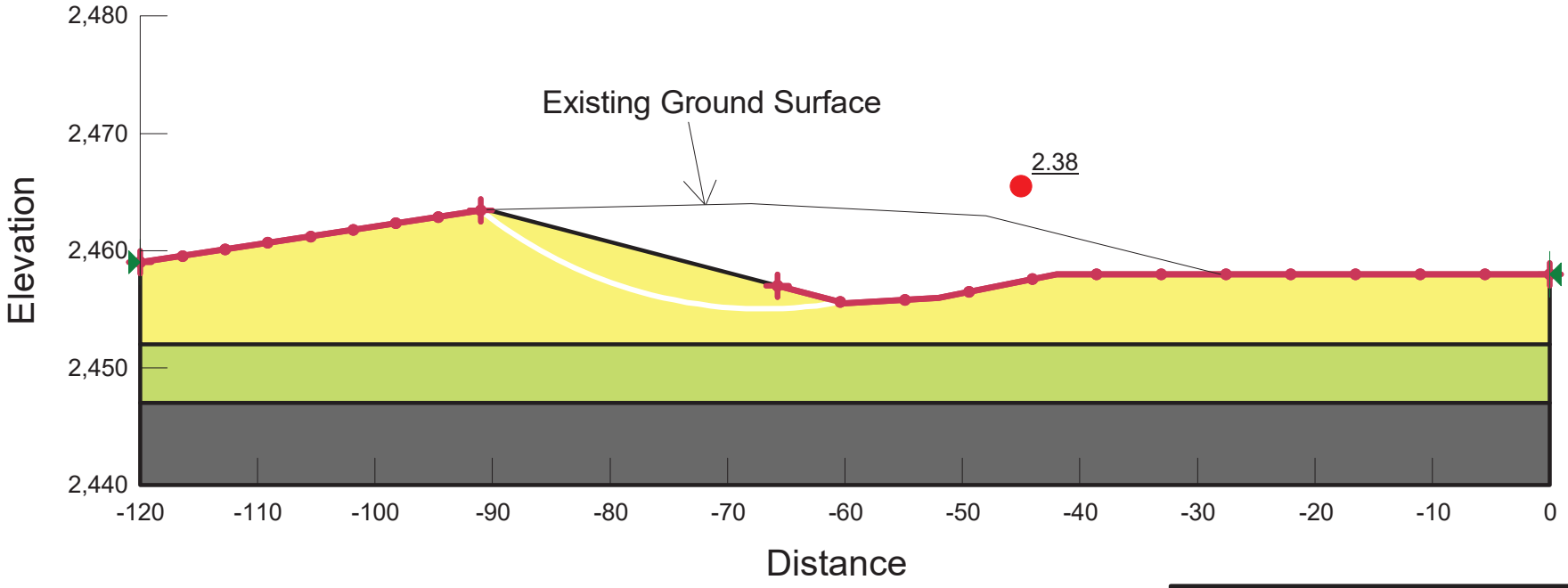
FIG. E-38

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1005+50 to 1007+25\Sta. 1005+50 to 1007+25 v2.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1012+50 to 1012+75.gsz
Geometry Name: Critical Section (Sta. 1012+50)
Name: Drained Conditions



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Sandstone	Mohr-Coulomb	140	0	38
	Silty/Clayey Sand	Mohr-Coulomb	125	0	30
	Well Graded Sand	Mohr-Coulomb	130	0	35

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1012+50
PROPOSED CUT (4H:1V)
DRAINED CONDITIONS

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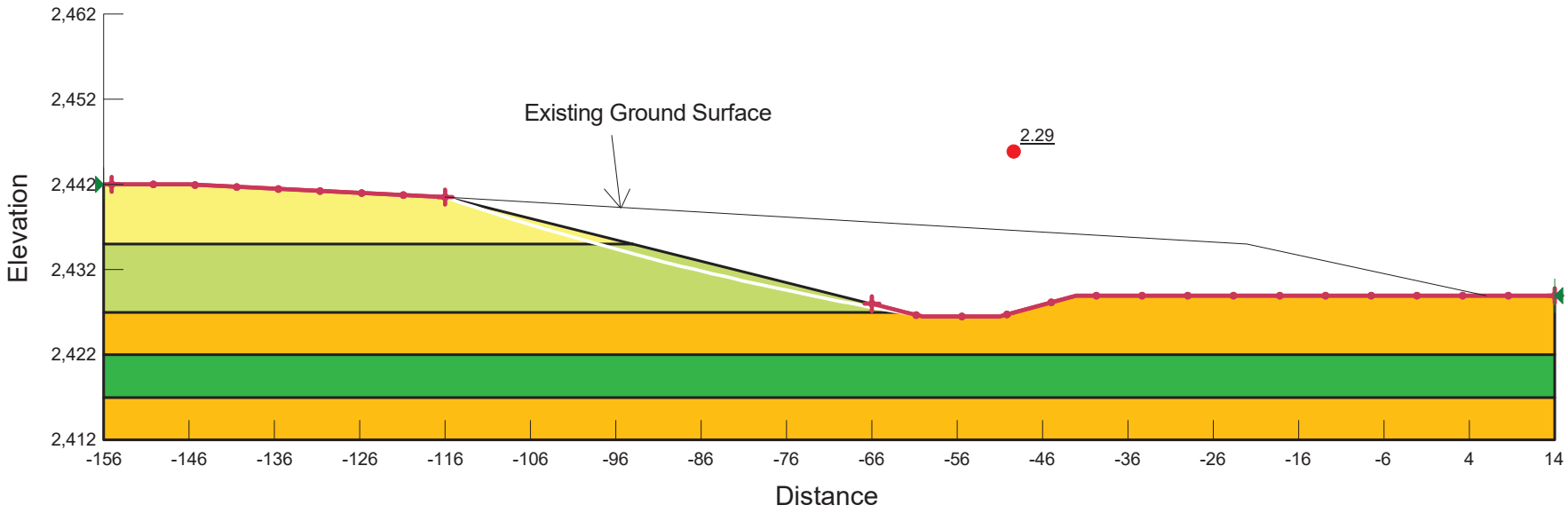
FIG. E-39

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1012+50 to 1012+75\Sta. 1012+50 to 1012+75.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1015+00 to 1016+00.gsz
Geometry Name: Critical Section (Sta. 1016+00)
Name: Drained Conditions



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF = 50%
	Lean Clay	Shear/Normal Fn.	130			LL = 32, CF = 28%
	Siltstone	Mohr-Coulomb	140	0	34	
	Silty Sand	Mohr-Coulomb	125	0	28	

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1016+00
PROPOSED CUT (4H:1V)
DRAINED CONDITIONS

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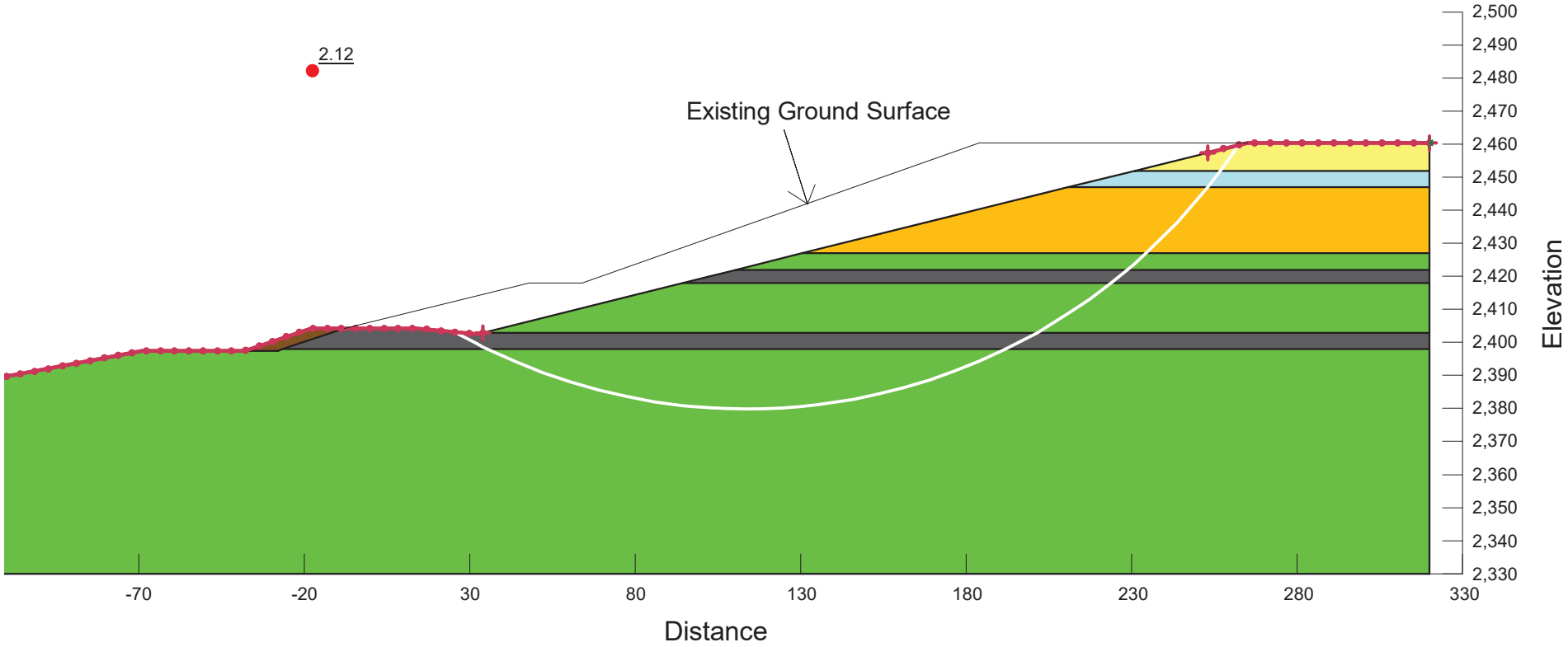
FIG. E-40

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1015+00 to 1016+00\Sta. 1015+00 to 1016+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1017+50 to 1018+50 v2.gsz
Geometry: Critical Section Sta 1018+50 (Temp)
Name: Temp Condtion Cut (Drained)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Embankment Fill (Undrained)	Mohr-Coulomb	125		1,500	0
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%		
	Dense Silty Sand	Mohr-Coulomb	130		0	35
	Sandstone	Mohr-Coulomb	140		0	38
	Siltstone	Mohr-Coulomb	140		0	34
	Silty/Clayey Sand	Mohr-Coulomb	125		0	30

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1018+50
PROPOSED CUT (4H:1V)
DRAINED CONDITIONS

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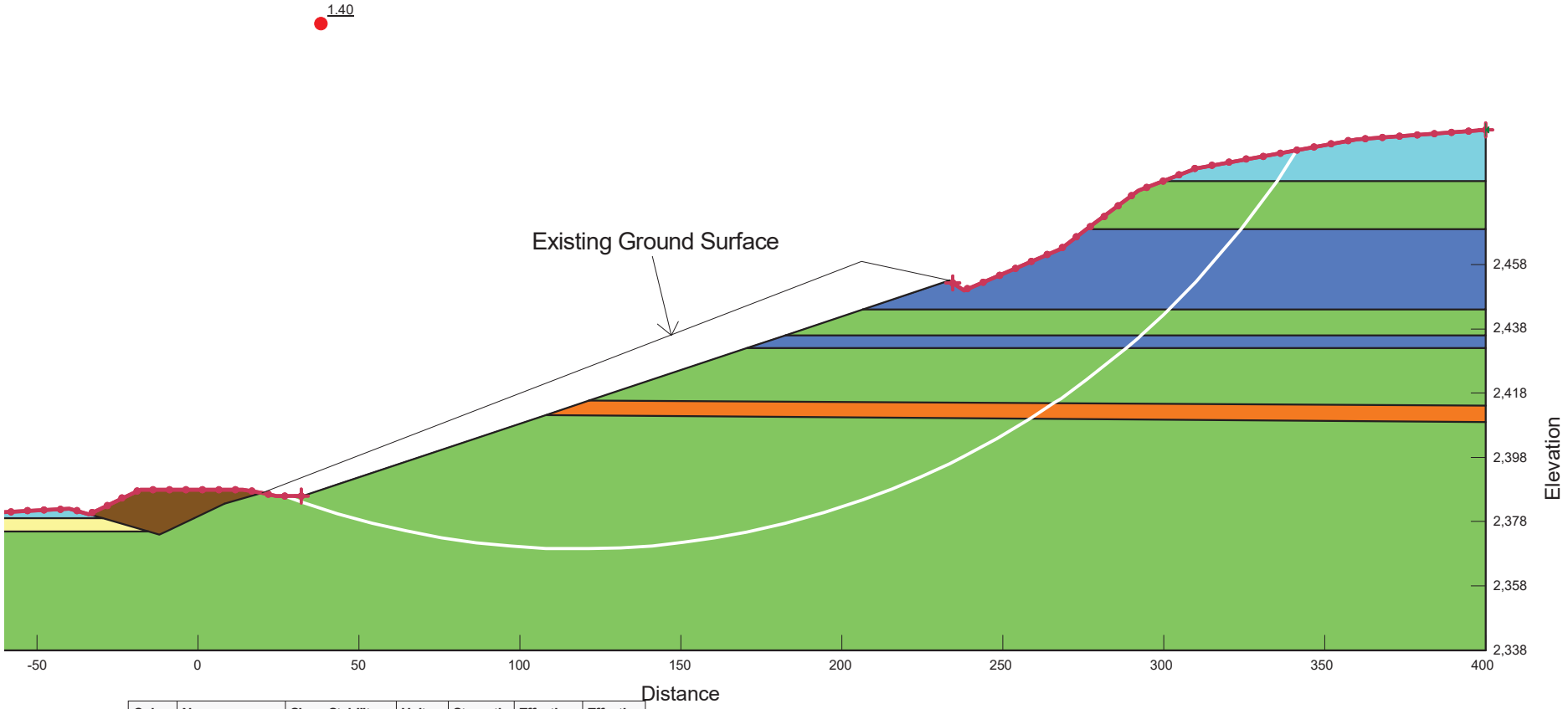
FIG. E-41

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1017+50 to 1018+50\Sta. 1017+50 to 1018+50 v2.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1020+25 to 1020+50 v2.gsz
Geometry: Critical Temp Section (Sta. 1020+25)
Name: Drained (Cut) (2)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Embankment Fill (Undrained)	Mohr-Coulomb	125		1,500	0
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%		
	Lean Clay (Drained)	Shear/Normal Fn.	120	LL = 32, CF = 28%		
	Sandstone	Mohr-Coulomb	140		0	38
	Siltstone	Mohr-Coulomb	140		0	34
	Silty Sand	Mohr-Coulomb	125		0	28

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1020+25
PROPOSED CUT (3H:1V)
DRAINED CONDITIONS

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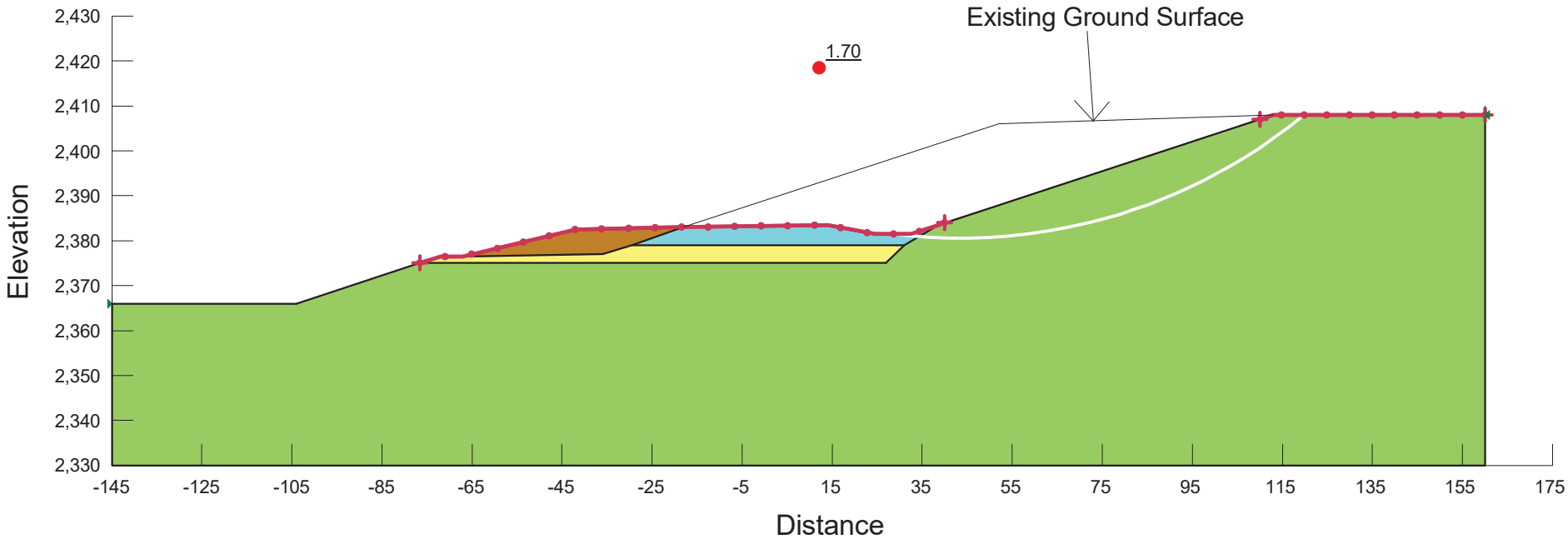
FIG. E-42

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1020+25 to 1020+50\Sta. 1020+25 to 1020+50 v2.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1020+75 to 1021+25.gsz
Geometry: Critcal Cut Section (Sta. 1020+75)
Name: Cut (Drained)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Clayey Embankment Fill (Drained)	Shear/Normal Fn.	125			LL = 38, CF = 30%
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF = 50%
	Lean Clay (Drained)	Shear/Normal Fn.	120			LL = 32, CF =28%
	Silty Sand	Mohr-Coulomb	125	0	28	

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1020+75
PROPOSED CUT (3H:1V)
DRAINED CONDITIONS

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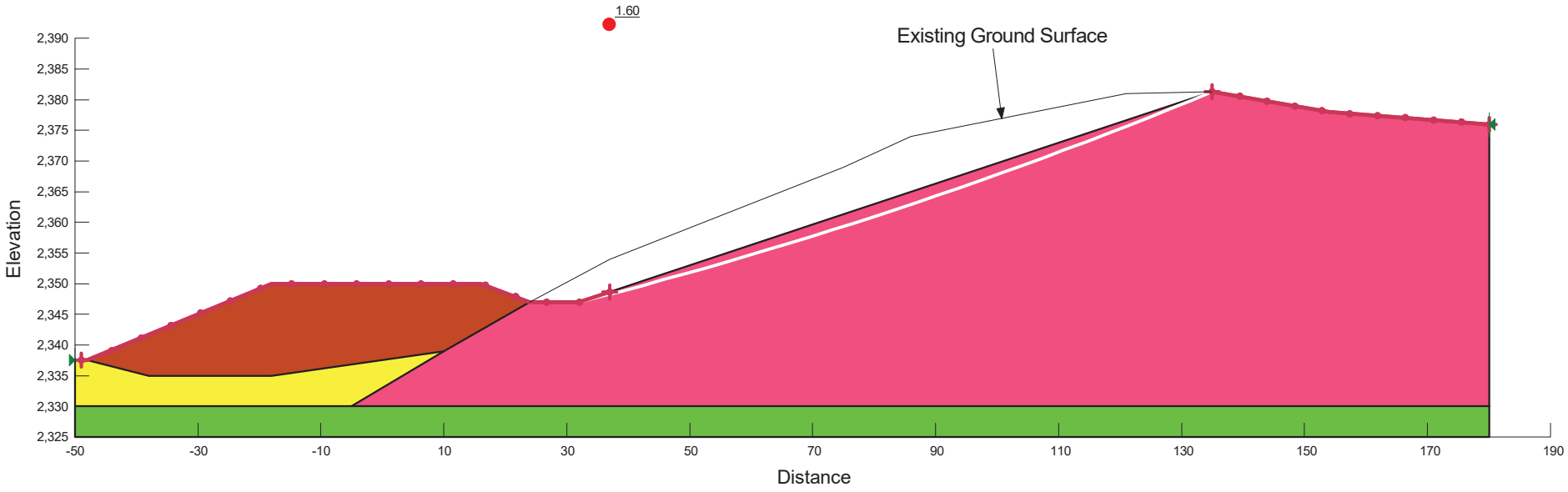
FIG. E-43

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1020+75 to 1021+25\Sta. 1020+75 to 1021+25.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1024+25 to 1028+50.gsz
Geometry: Name: Critical Cut (Sta. 1024+25)
Name: Drained (1)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 66, CF =50%
	Granular Embankment Fill	Mohr-Coulomb	140	0	32	
	In-Situ Material	Mohr-Coulomb	125	0	28	
	Lean Clay (Drained)	Shear/Normal Fn.	120			LL=39, CF = 28%

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1024+25
PROPOSED CUT (3H:1V)
DRAINED CONDITIONS

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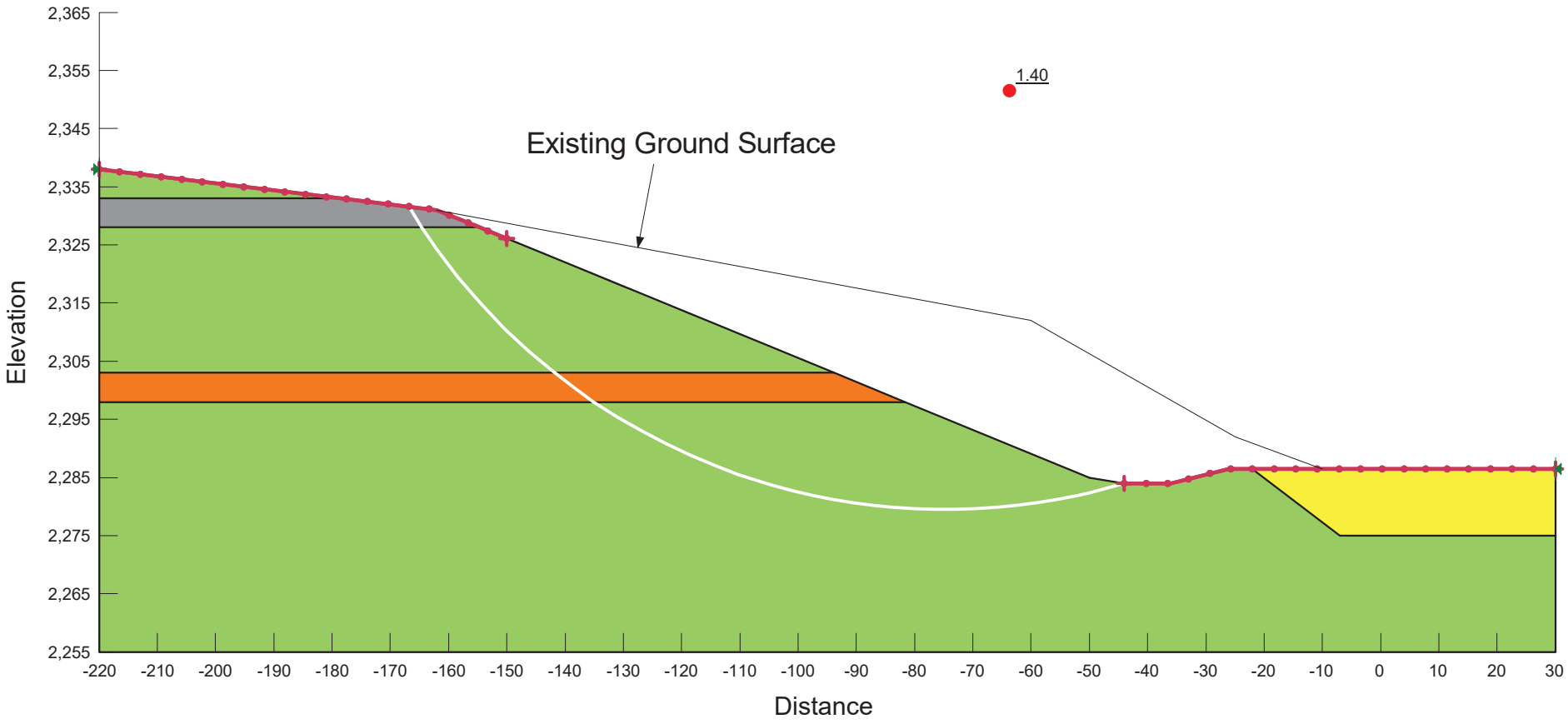
FIG. E-44

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1024+25 to 1028+50\Sta. 1024+25 to 1028+50.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1038+00 v2.gsz
Geometry: Critical Section Sta. 1038+00 (2.5H:1V)
Name: Drained (3)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 56, CF = 50%
	Lean Clay (Drained)	Shear/Normal Fn.	120			LL = 34, CF = 28%
	Sandstone	Mohr-Coulomb	140	0	38	
	Siltstone	Mohr-Coulomb	140	0	34	

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1038+00
PROPOSED CUT (2.5H:1V)
DRAINED CONDITIONS

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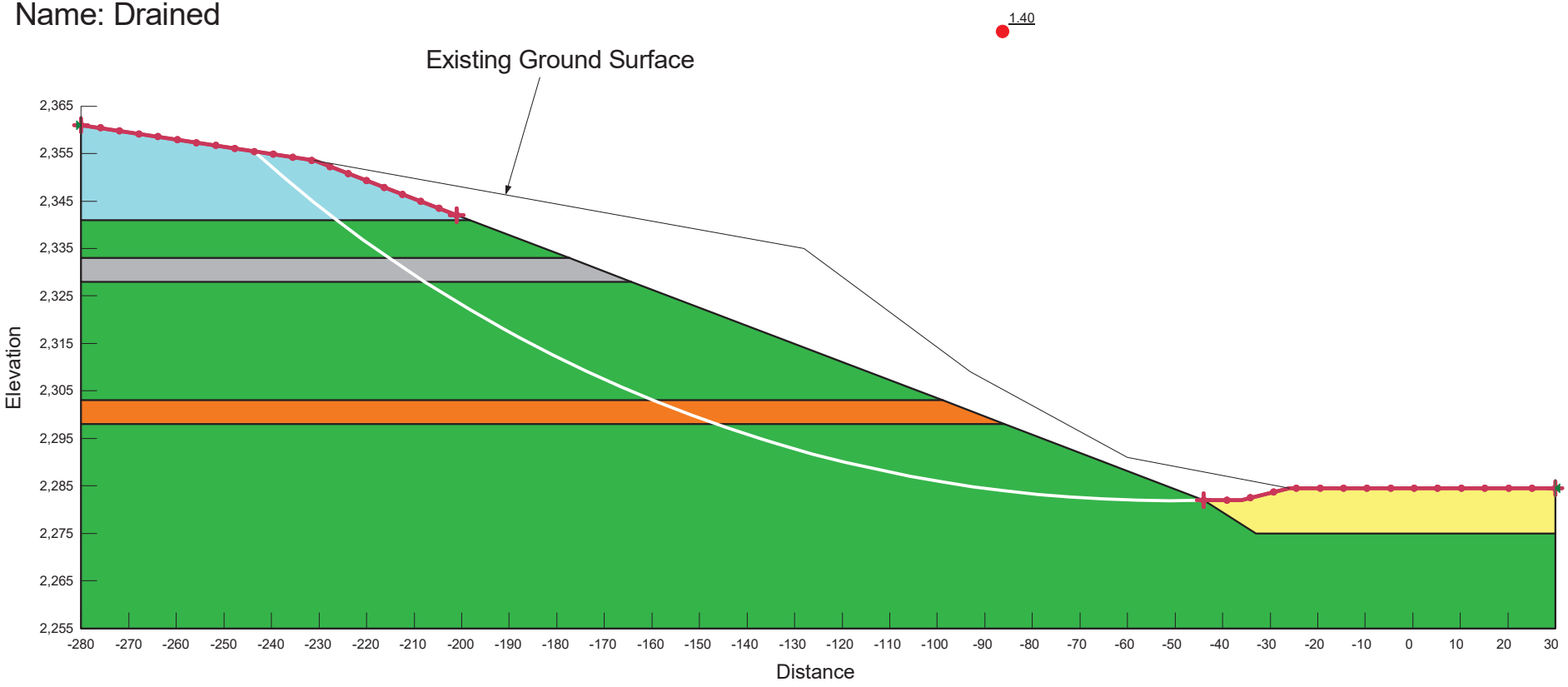
FIG. E-45

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1030+75 to 1039+75\Sta. 1038+00 v2.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1030+75 to 1039+75.gsz
Geometry: Critical Section Sta. 1039+75
Name: Drained



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Strength Function
	Claystone (Drained)	Shear/Normal Fn.	135			LL = 56, CF = 50%
	Lean Clay (Drained)	Shear/Normal Fn.	120			LL = 34, CF = 28%
	Sandstone	Mohr-Coulomb	140	0	38	
	Silt with Sand	Mohr-Coulomb	125	0	28	
	Siltstone	Mohr-Coulomb	140	0	34	

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1039+75
PROPOSED CUT (2.5H:1V)
DRAINED CONDITIONS

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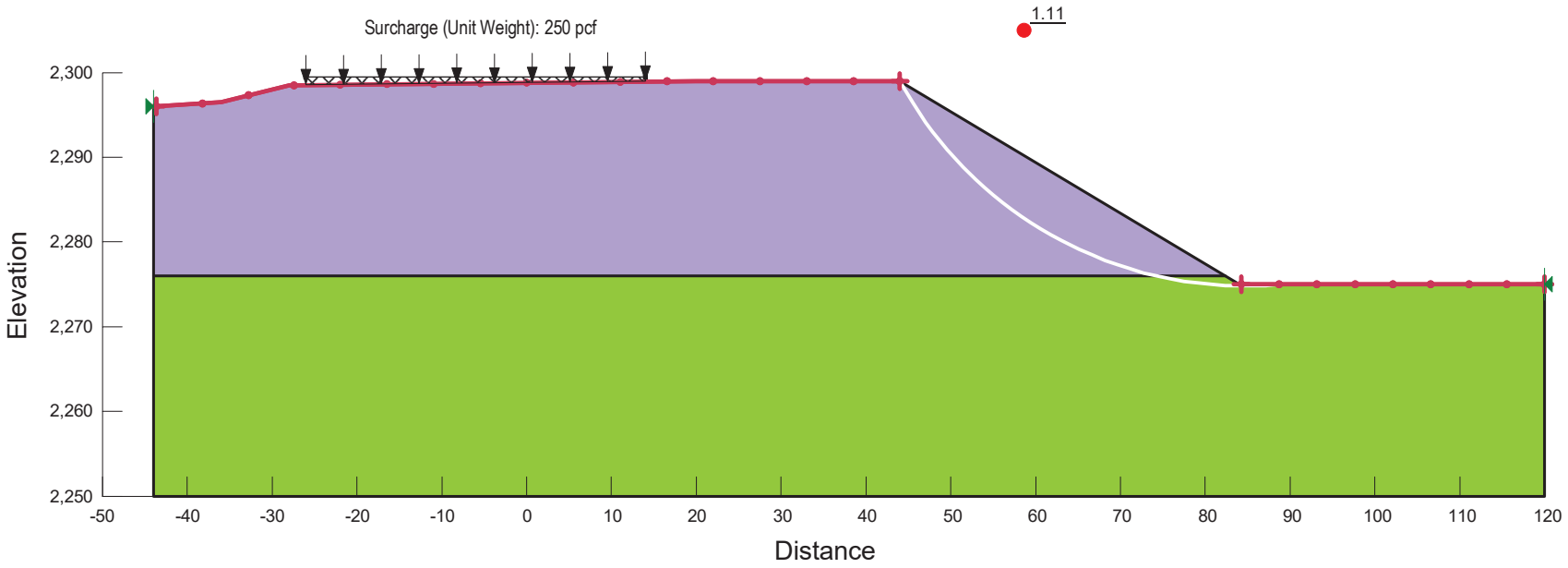
FIG. E-46

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1030+75 to 1039+75\Sta. 1030+75 to 1039+75.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1032+00 to 1036+00.gsz
Geometry: Sta 1032+50
Name: Drained (Slope FS) 1



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%
	Fat Clay (Drained)	Shear/Normal Fn.	130	LL = 56, CF = 50%

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1032+50
EXISTING SLOPE
DRAINED CONDITIONS

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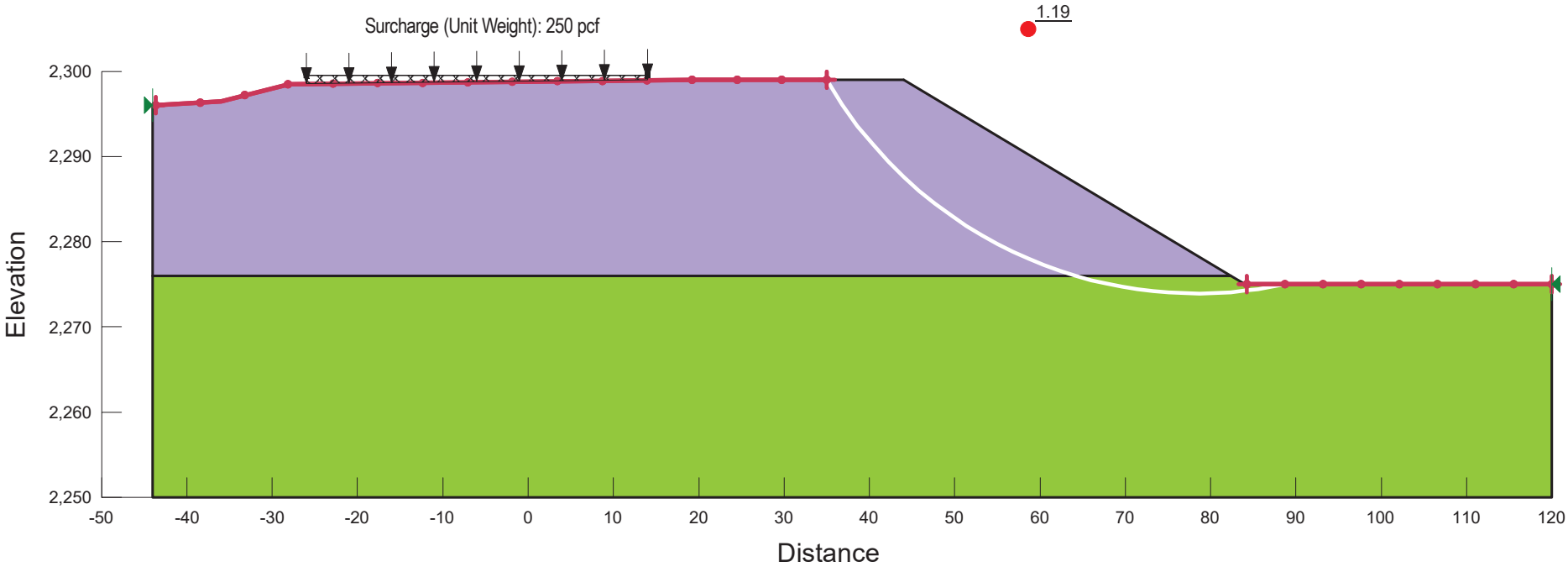
FIG. E-47

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1032+00 to 1036+00\Sta. 1032+00 to 1036+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1032+00 to 1036+00.gsz
Geometry: Sta 1032+50
Name: Drained (FS at edge of work) 1



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%
	Fat Clay (Drained)	Shear/Normal Fn.	130	LL = 56, CF = 50%

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1032+50
EDGE OF GRADING LIMITS
DRAINED CONDITIONS

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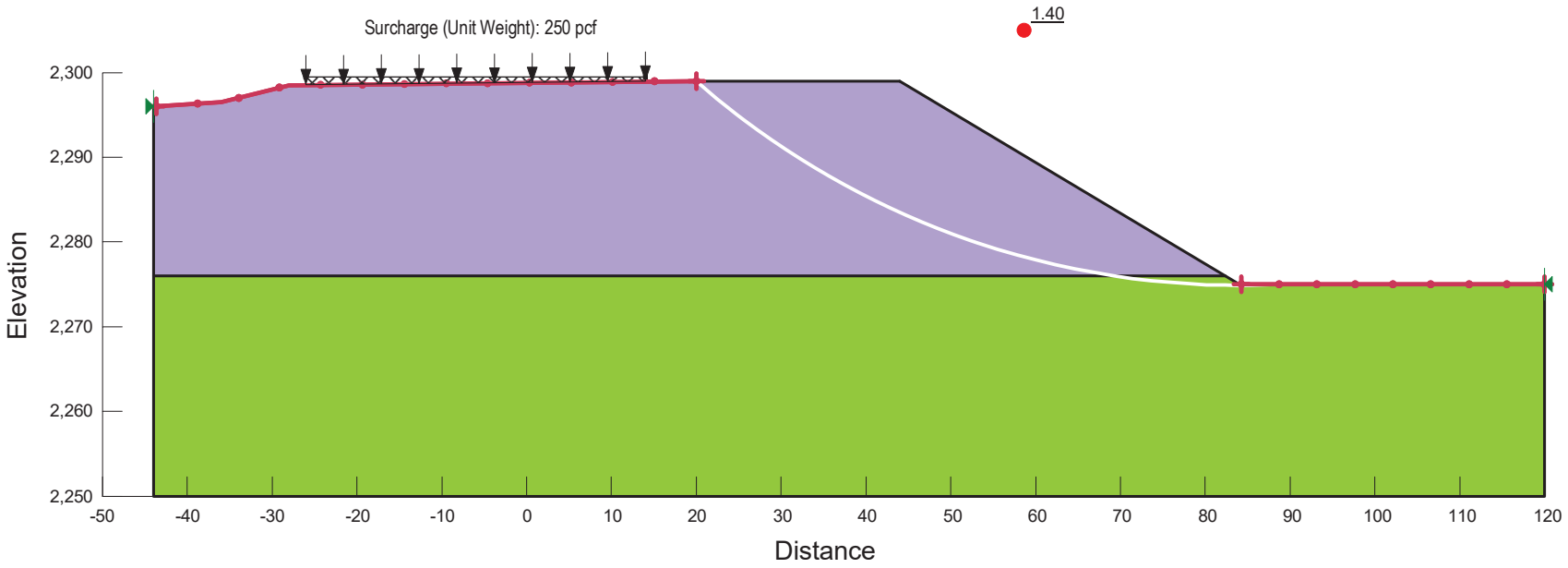
FIG. E-48

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1032+00 to 1036+00\Sta. 1032+00 to 1036+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1032+00 to 1036+00.gsz
Geometry: Sta 1032+50
Name: Drained (FS at edge of road) 1



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%
	Fat Clay (Drained)	Shear/Normal Fn.	130	LL = 56, CF = 50%

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1032+50
EDGE OF PAVEMENT
DRAINED CONDITIONS

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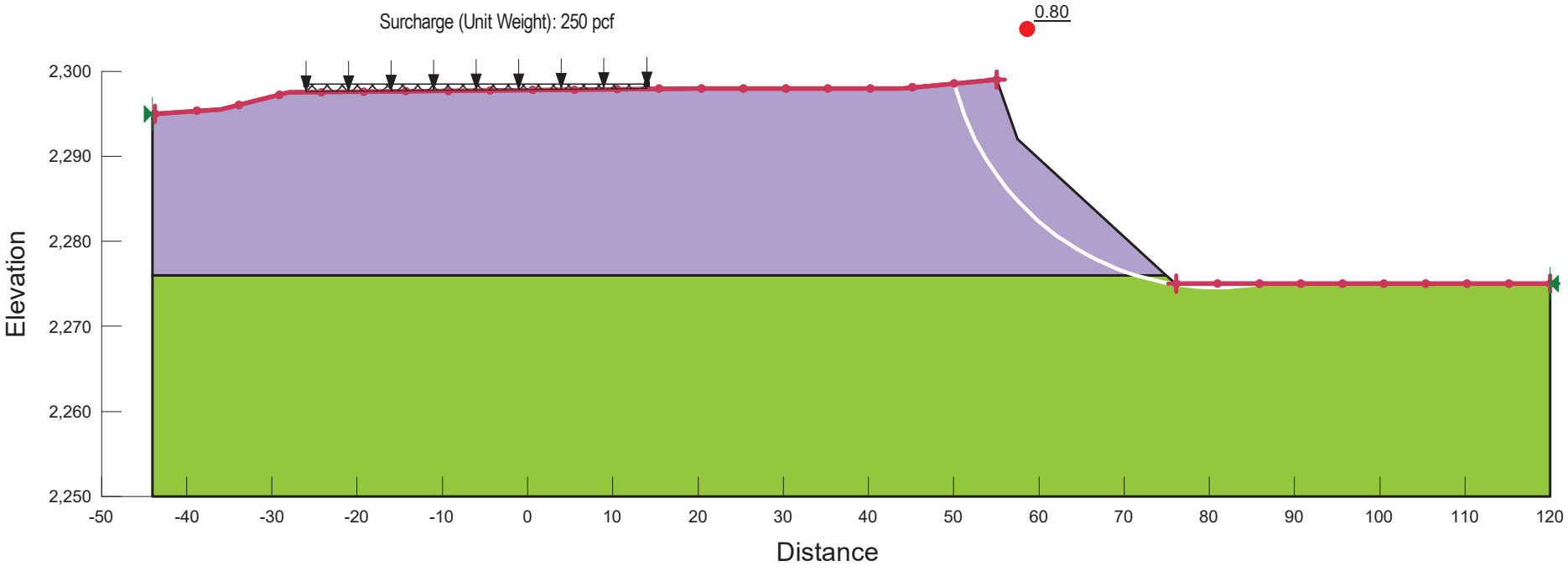
FIG. E-49

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1032+00 to 1036+00\Sta. 1032+00 to 1036+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1032+00 to 1036+00.gsz
Geometry: Sta. 1032+75
Name: Drained (Slope FS) 2



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%
	Fat Clay (Drained)	Shear/Normal Fn.	130	LL = 56, CF = 50%

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1032+75
EXISTING SLOPE
DRAINED CONDITIONS

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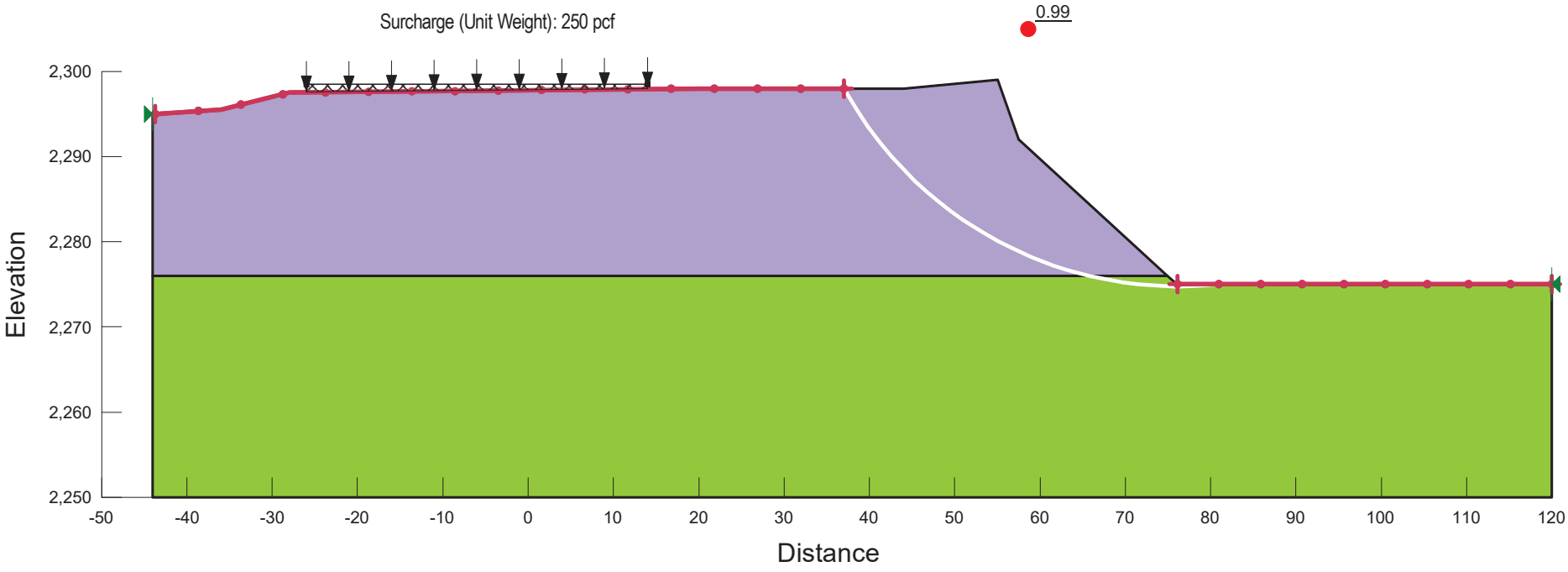
FIG. E-50

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1032+00 to 1036+00\Sta. 1032+00 to 1036+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1032+00 to 1036+00.gsz
Geometry: Sta. 1032+75
Name: Drained (FS at edge of work) 2



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%
	Fat Clay (Drained)	Shear/Normal Fn.	130	LL = 56, CF = 50%

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1032+75
EDGE OF GRADING LIMITS
DRAINED CONDITIONS

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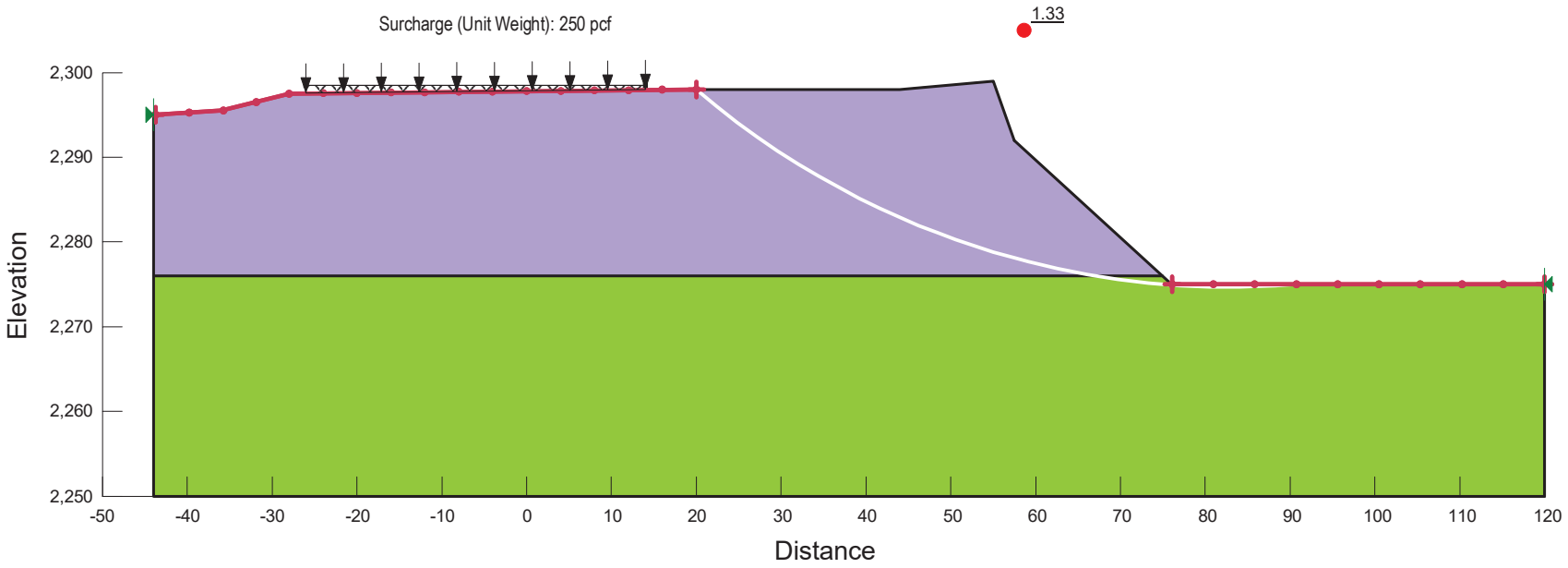
FIG. E-51

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1032+00 to 1036+00\Sta. 1032+00 to 1036+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1032+00 to 1036+00.gsz
Geometry: Sta. 1032+75
Name: Drained (FS at edge of road) 2



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%
	Fat Clay (Drained)	Shear/Normal Fn.	130	LL = 56, CF = 50%

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1032+75
EDGE OF PAVEMENT
DRAINED CONDITIONS

February 2025 113316-002

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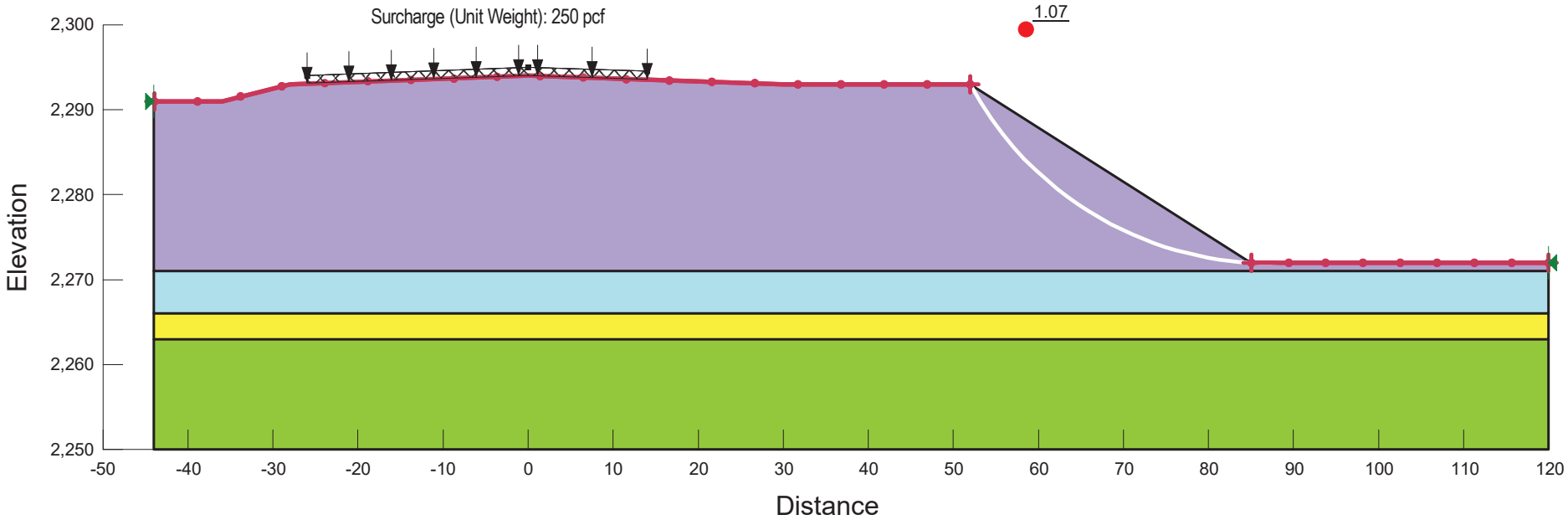
FIG. E-52

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1032+00 to 1036+00\Sta. 1032+00 to 1036+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1032+00 to 1036+00.gsz
Geometry: Sta. 1033+75
Name: Drained (Slope FS) 3



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Sand	Mohr-Coulomb	125		0	28
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%		
	Fat Clay (Drained)	Shear/Normal Fn.	130	LL = 56, CF = 50%		
	Lean Clay (SW-03) (Drained)	Shear/Normal Fn.	130	LL = 33, CF = 28%		

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1033+75
EXISTING SLOPE
DRAINED CONDITIONS

February 2025 113316-002

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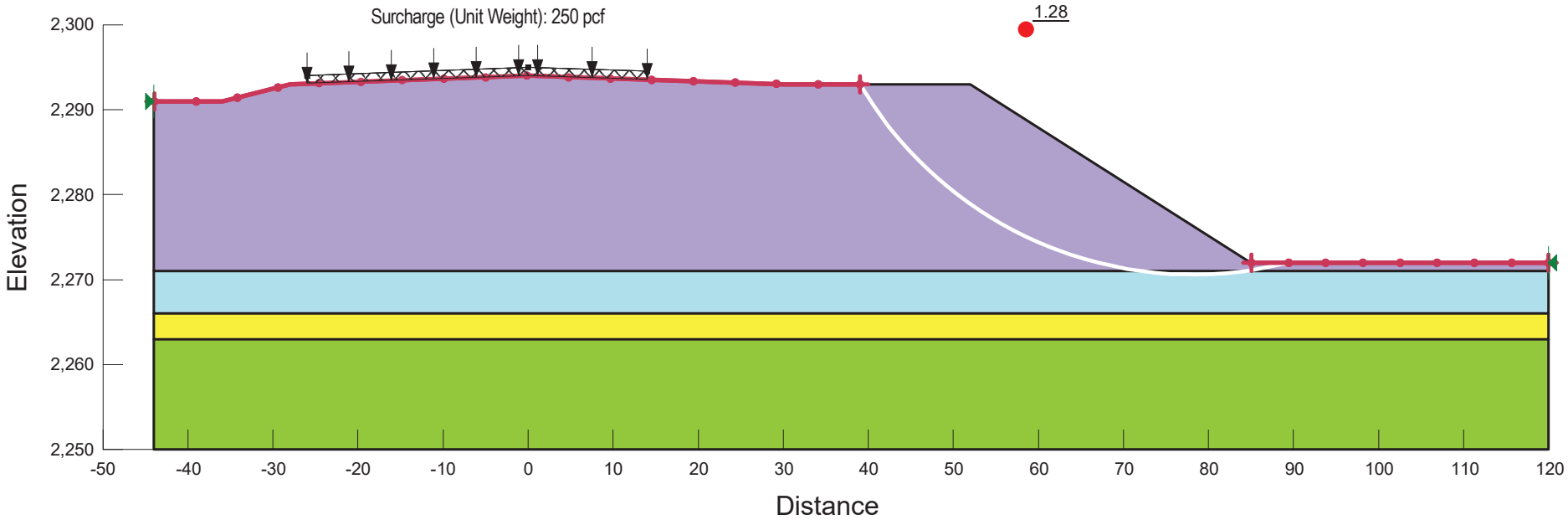
FIG. E-53

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1032+00 to 1036+00\Sta. 1032+00 to 1036+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1032+00 to 1036+00.gsz
Geometry: Sta. 1033+75
Name: Drained (FS at edge of work) 3



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Sand	Mohr-Coulomb	125		0	28
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%		
	Fat Clay (Drained)	Shear/Normal Fn.	130	LL = 56, CF = 50%		
	Lean Clay (SW-03) (Drained)	Shear/Normal Fn.	130	LL = 33, CF = 28%		

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1033+75
EDGE OF GRADING LIMITS
DRAINED CONDITIONS

February 2025 113316-002

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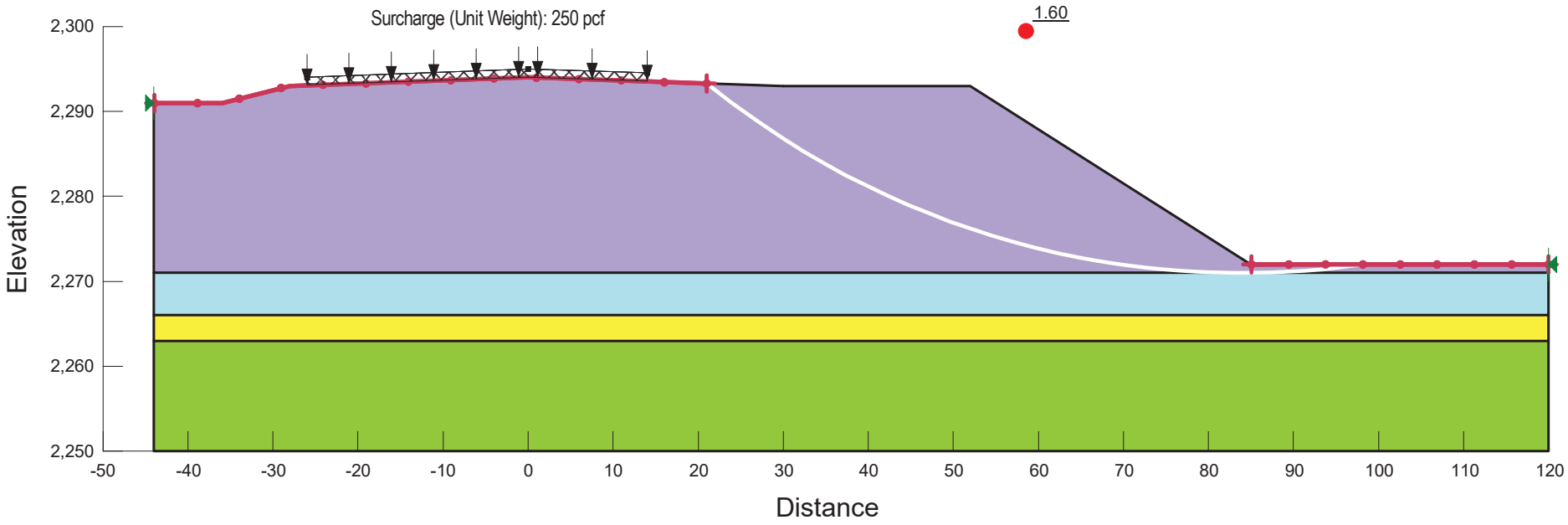
Geotechnical and Environmental Consultants

FIG. E-54

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1032+00 to 1036+00\Sta. 1032+00 to 1036+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1032+00 to 1036+00.gsz
Geometry: Sta. 1033+75
Name: Drained (FS at edge of road) 3



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Sand	Mohr-Coulomb	125		0	28
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%		
	Fat Clay (Drained)	Shear/Normal Fn.	130	LL = 56, CF = 50%		
	Lean Clay (SW-03) (Drained)	Shear/Normal Fn.	130	LL = 33, CF = 28%		

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1033+75
EDGE OF PAVEMENT
DRAINED CONDITIONS

February 2025 113316-002

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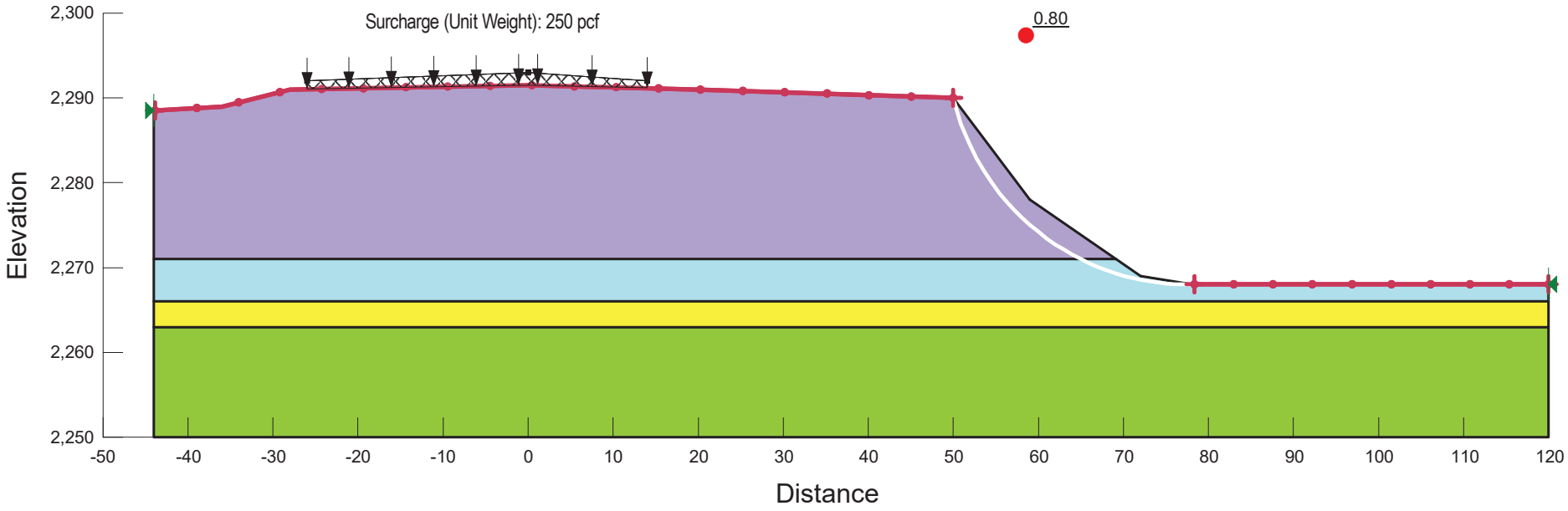
Geotechnical and Environmental Consultants

FIG. E-55

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1032+00 to 1036+00\Sta. 1032+00 to 1036+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1032+00 to 1036+00.gsz
Geometry: Sta. 1034+75
Name: Drained (Slope FS)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Sand	Mohr-Coulomb	125		0	28
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%		
	Fat Clay (Drained)	Shear/Normal Fn.	130	LL = 56, CF = 50%		
	Lean Clay (SW-03) (Drained)	Shear/Normal Fn.	130	LL = 33, CF = 28%		

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1034+75
EXISTING SLOPE
DRAINED CONDITIONS

February 2025 113316-002

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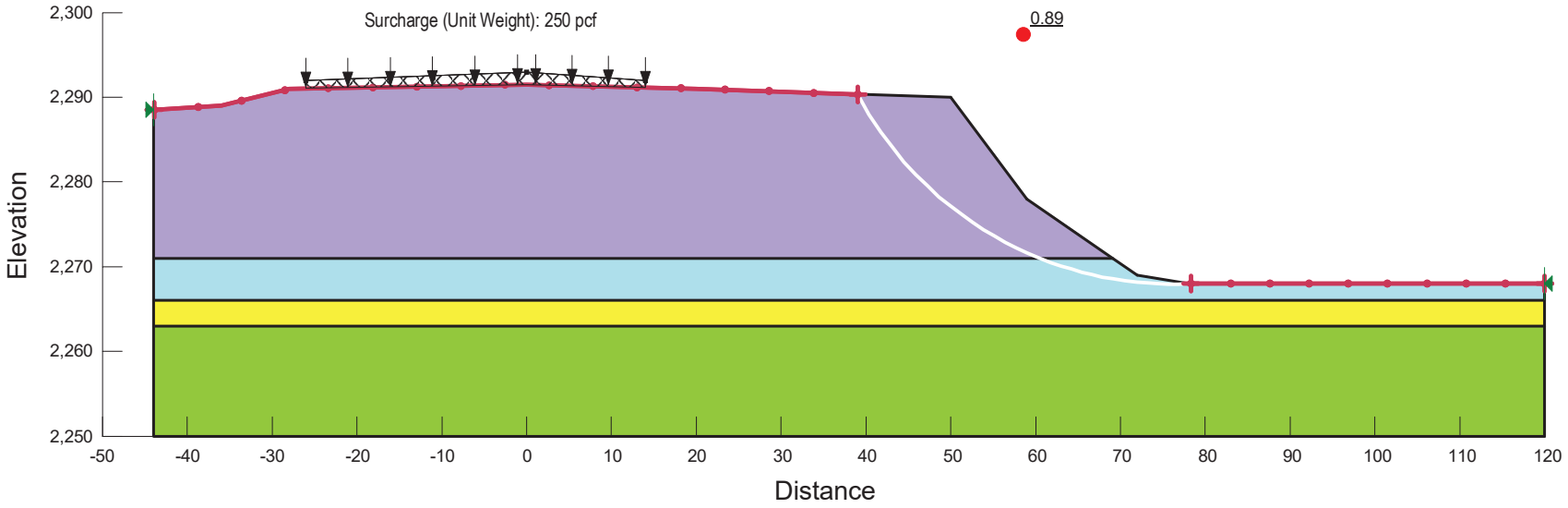
Geotechnical and Environmental Consultants

FIG. E-56

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1032+00 to 1036+00\Sta. 1032+00 to 1036+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1032+00 to 1036+00.gsz
Geometry: Sta. 1034+75
Name: Drained (FS at edge of work)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Sand	Mohr-Coulomb	125		0	28
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%		
	Fat Clay (Drained)	Shear/Normal Fn.	130	LL = 56, CF = 50%		
	Lean Clay (SW-03) (Drained)	Shear/Normal Fn.	130	LL = 33, CF = 28%		

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1034+75
EDGE OF GRADING LIMITS
DRAINED CONDITIONS

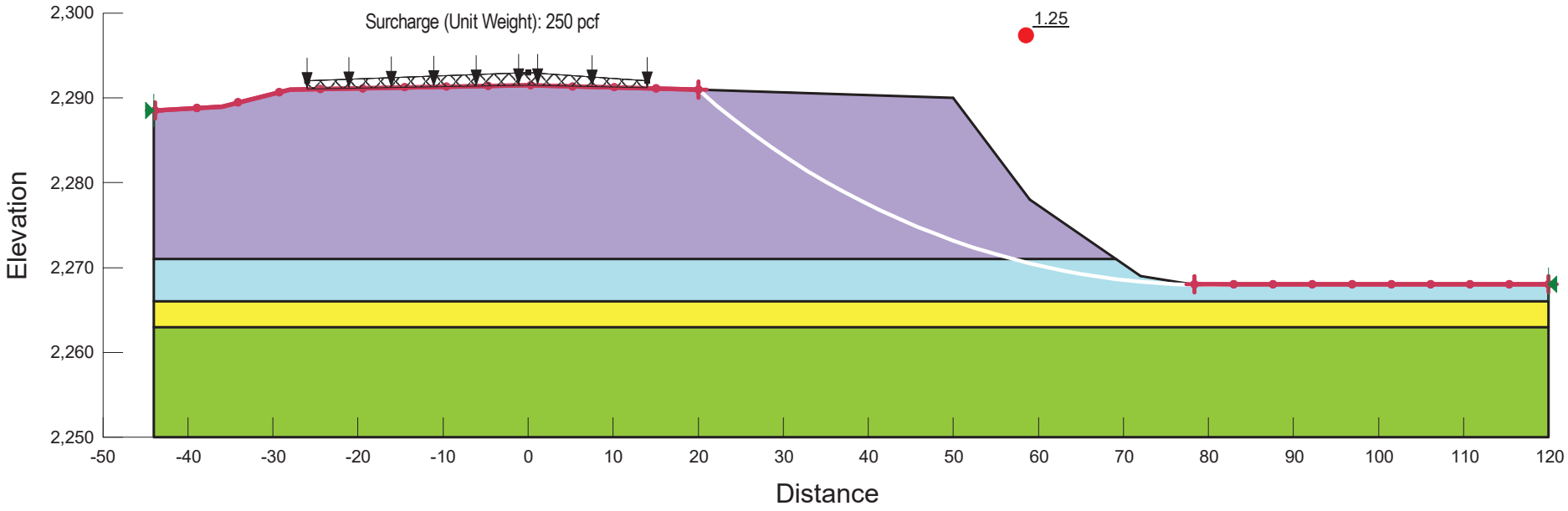
February 2025 113316-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. E-57

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1032+00 to 1036+00\Sta. 1032+00 to 1036+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1032+00 to 1036+00.gsz
Geometry: Sta. 1034+75
Name: Drained (FS at edge of road)



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Sand	Mohr-Coulomb	125		0	28
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%		
	Fat Clay (Drained)	Shear/Normal Fn.	130	LL = 56, CF = 50%		
	Lean Clay (SW-03) (Drained)	Shear/Normal Fn.	130	LL = 33, CF = 28%		

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1034+75
EDGE OF PAVEMENT
DRAINED CONDITIONS

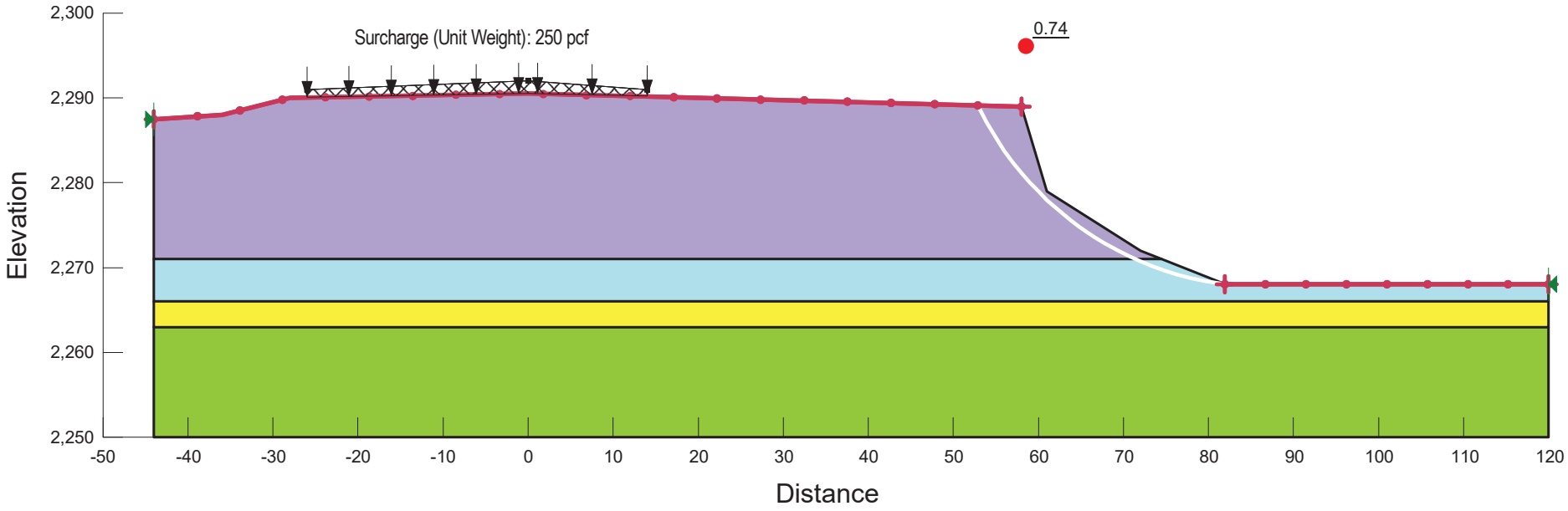
February 2025 113316-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. E-58

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1032+00 to 1036+00\Sta. 1032+00 to 1036+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1032+00 to 1036+00.gsz
Geometry: Sta. 1035+50
Name: Drained (Slope FS) 4



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Sand	Mohr-Coulomb	125		0	28
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%		
	Fat Clay (Drained)	Shear/Normal Fn.	130	LL = 56, CF = 50%		
	Lean Clay (SW-03) (Drained)	Shear/Normal Fn.	130	LL = 33, CF = 28%		

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1035+50
EXISTING SLOPE
DRAINED CONDITIONS

February 2025 113316-002

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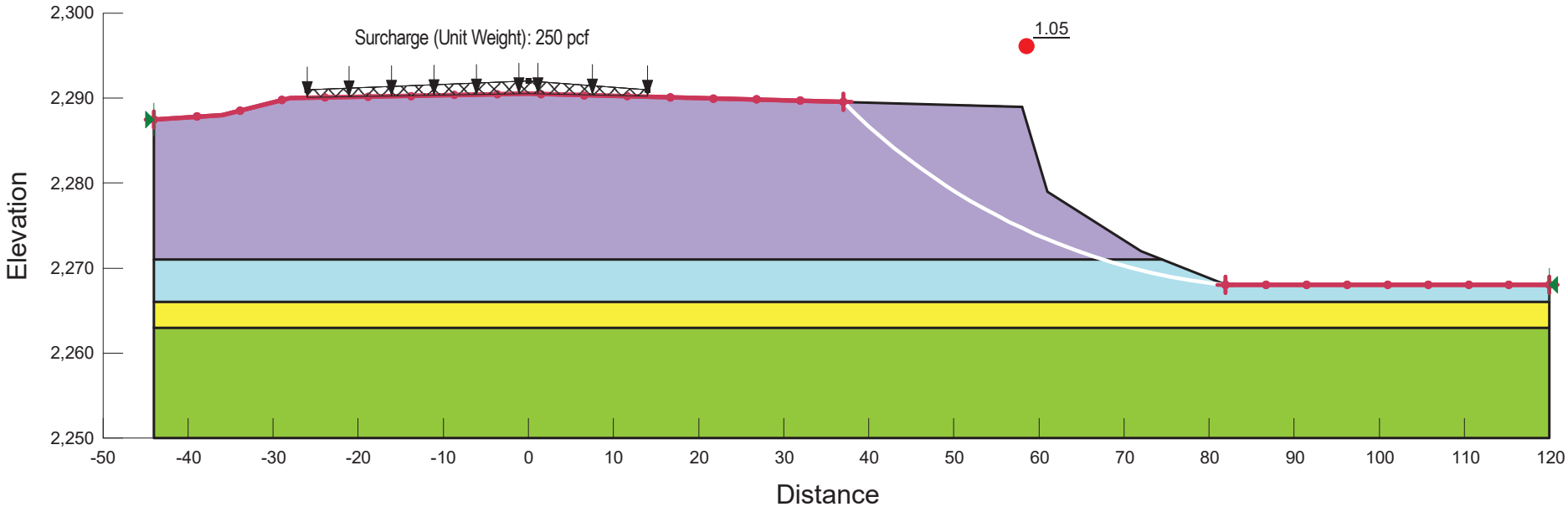
FIG. E-59

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1032+00 to 1036+00\Sta. 1032+00 to 1036+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1032+00 to 1036+00.gsz
Geometry: Sta. 1035+50
Name: Drained (FS at edge of work) 4



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Sand	Mohr-Coulomb	125		0	28
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%		
	Fat Clay (Drained)	Shear/Normal Fn.	130	LL = 56, CF = 50%		
	Lean Clay (SW-03) (Drained)	Shear/Normal Fn.	130	LL = 33, CF = 28%		

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1035+50
EDGE OF GRADING LIMITS
DRAINED CONDITIONS

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Geotechnical and Environmental Consultants

FIG. E-60

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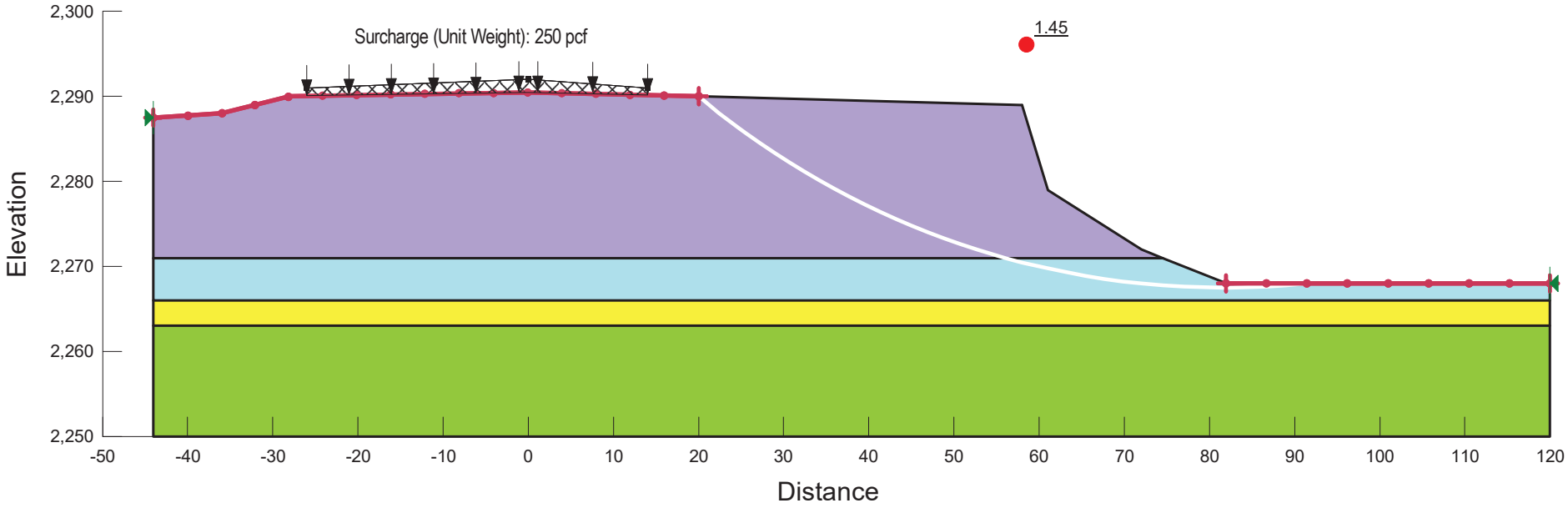
Chateau Road Reconstruction
113316-002
File Name: Sta. 1032+00 to 1036+00.gsz
Geometry: Sta. 1035+50
Name: Drained (FS at edge of road) 4



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Sand	Mohr-Coulomb	125		0	28
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%		
	Fat Clay (Drained)	Shear/Normal Fn.	130	LL = 56, CF = 50%		
	Lean Clay (SW-03) (Drained)	Shear/Normal Fn.	130	LL = 33, CF = 28%		

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1035+50
EDGE OF PAVEMENT
DRAINED CONDITIONS

February 2025 113316-002

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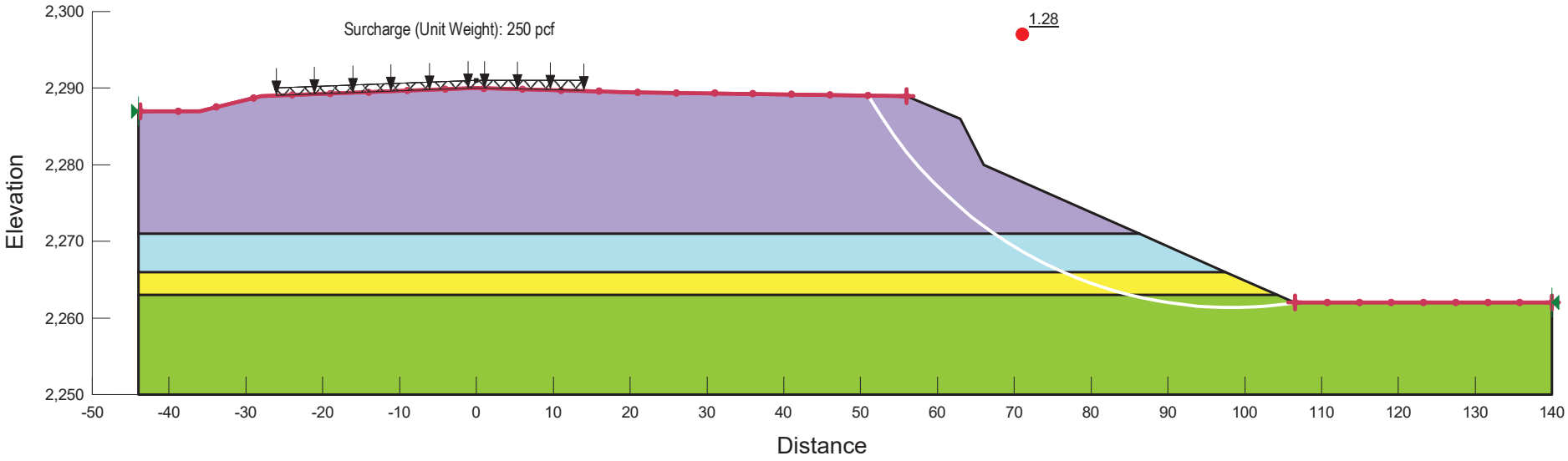
FIG. E-61

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1032+00 to 1036+00\Sta. 1032+00 to 1036+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1032+00 to 1036+00.gsz
Geometry: Sta. 1036+00
Name: Drained (Slope FS) 5



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Sand	Mohr-Coulomb	125		0	28
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%		
	Fat Clay (Drained)	Shear/Normal Fn.	130	LL = 56, CF = 50%		
	Lean Clay (SW-03) (Drained)	Shear/Normal Fn.	130	LL = 33, CF = 28%		

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1036+00
EXISTING SLOPE
DRAINED CONDITIONS

February 2025 113316-002

SHANNON & WILSON, INC.
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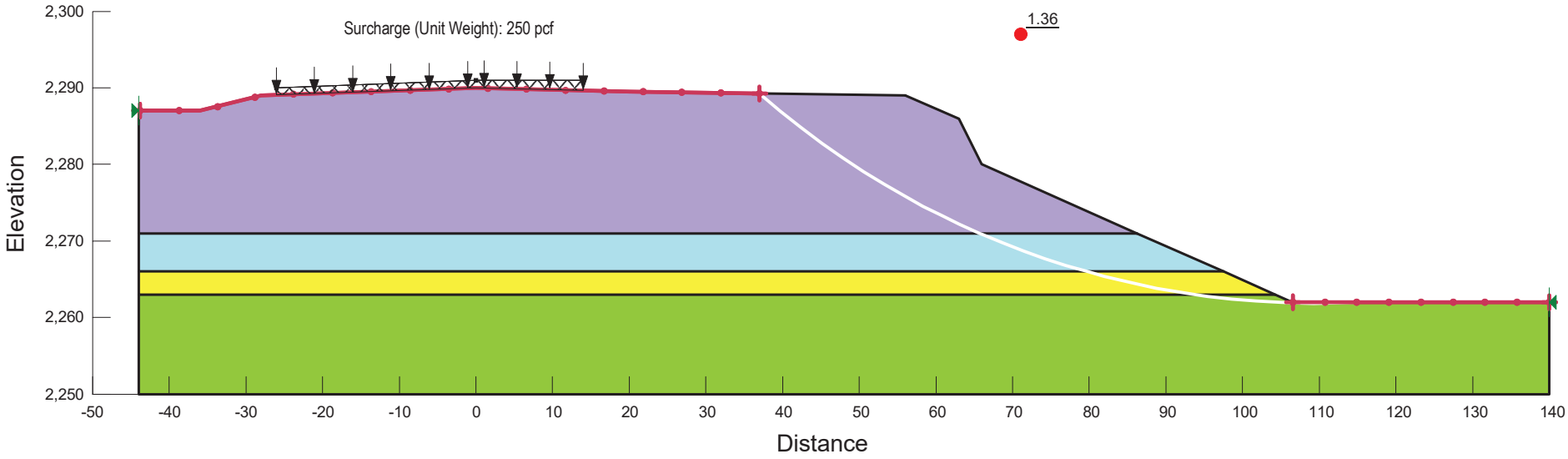
FIG. E-62

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1032+00 to 1036+00\Sta. 1032+00 to 1036+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1032+00 to 1036+00.gsz
Geometry: Sta. 1036+00
Name: Drained (FS at edge of work) 5



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Sand	Mohr-Coulomb	130		0	28
	Claystone (Drained)	Shear/Normal Fn.	125	LL = 66, CF = 50%		
	Fat Clay (Drained)	Shear/Normal Fn.	130	LL = 56, CF = 50%		
	Lean Clay (SW-03) (Drained)	Shear/Normal Fn.	125	LL = 33, CF = 28%		

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1036+00
EDGE OF GRADING LIMITS
DRAINED CONDITIONS

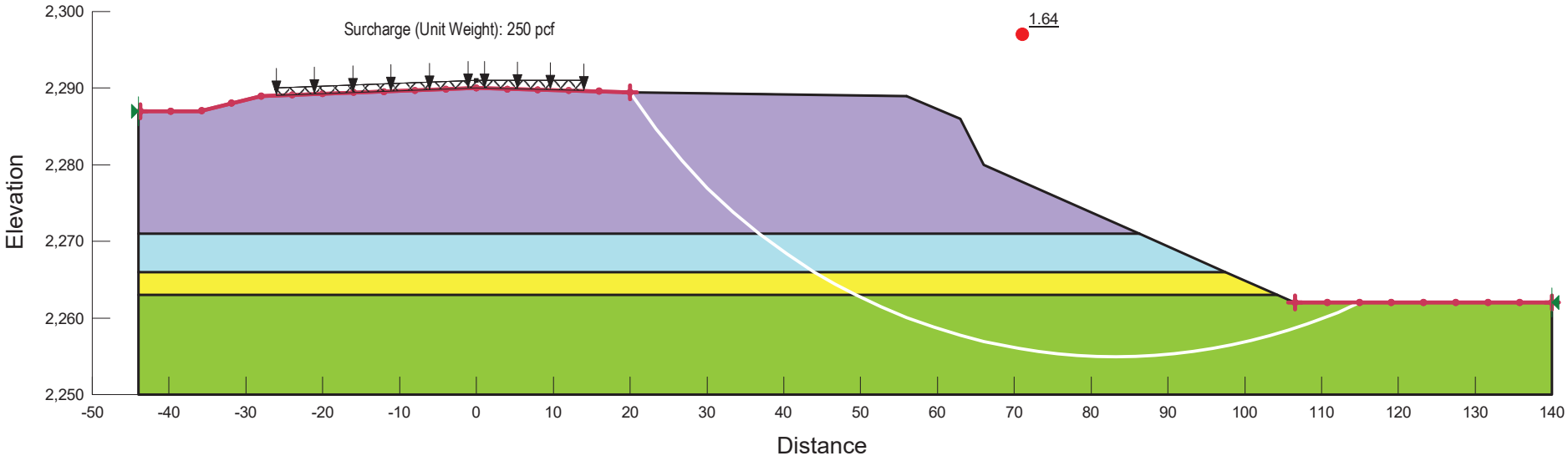
February 2025 113316-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. E-63

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1032+00 to 1036+00\Sta. 1032+00 to 1036+00.gsz

Chateau Road Reconstruction
113316-002
File Name: Sta. 1032+00 to 1036+00.gsz
Geometry: Sta. 1036+00
Name: Drained (FS at edge of road) 5



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Strength Function	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Sand	Mohr-Coulomb	125		0	28
	Claystone (Drained)	Shear/Normal Fn.	135	LL = 66, CF = 50%		
	Fat Clay (Drained)	Shear/Normal Fn.	130	LL = 56, CF = 50%		
	Lean Clay (SW-03) (Drained)	Shear/Normal Fn.	130	LL = 33, CF = 28%		

Chateau Road Reconstruction
5-999(036), PCN 24246
Medora, North Dakota

STA. 1036+00
EDGE OF PAVEMENT
DRAINED CONDITIONS

February 2025 113316-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. E-64

P:\DEN\113000s\113316 NDDOT Medora Chateau Rd\001 Geotechnical Se\Analysis\Global Stability 9-19\Sta. 1032+00 to 1036+00\Sta. 1032+00 to 1036+00.gsz

IMPORTANT INFORMATION

Important Information

About Your Geotechnical Report

IMPORTANT INFORMATION

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors that were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent

IMPORTANT INFORMATION

such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary, because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports, and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland.