# ADDENDUM NO. 2

## HUNNING ROAD SAFETY IMPROVEMENTS

## STP-5403 (696)

## COUNTY OF JEFFERSON, MISSOURI

**September 6, 2024**

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This addendum forms a part of the bidding and contract documents and modifies the original bidding documents. Acknowledge receipt of this addendum in the space provided on this bid form. **FAILURE TO DO SO MAY SUBJECT BIDDER TO DISQUALIFICATION.**

## PROJECT SPECIFICATIONS:

***STP-5403 (696)*** Geotechnical Report

Add the following PDF: **Hunning Road – Safety Improvement Geotechnical Report** to the Hunning Road Specification Book. The purpose is to include the Geotechnical Report to the Project Specifications.

***STP-5403 (696)*** Shared Lane Marking, White Standard Waterborne Pavement Marking Paint, Type P Beads

Change the following Bid Item: Shared Lane Marking, White Standard Waterborne Pavement Marking Paint, Type P Beads to **Shared Lane Markings, Durable Intersection Pavement Markings** on Pages 14 and 23 of the Project Specifications. The pay item number, unit item, and quantity will remain the same. The purpose is to meet MoDOT's 620.20.3.2 specification. Please note this change on Sheet 3A and 3D to the Project Plans.

STATE OF MISSOURI
KURT W. WENGERT
NUMBER PE-2004017266
PROFESSIONAL ENGINEER

9-6-2024

# Geotechnical Report

Hunning Road Improvements
Jefferson County, Missouri

**Prepared For:**
Oates Associates
720 Olive Street, Suite 700
St. Louis, Missouri, 63101
Attn: Mike Busch, PE

**Prepared By:**
Millennia Professional Services, Ltd.
6439 Plymouth Avenue, Suite W-129
St. Louis, Missouri
618-624-8610

Authored By:
Jacob A. Schaeffer, PE
jschaeffer@millennia.pro
Millennia Project Number MG21043
March 24, 2022

## Contents

# Geotechnical Report
# Hunning Road Improvements
# Jefferson County, Missouri

## 1.0 Project Description

### 1.1 Introduction

Millennia Professional Services (Millennia) is pleased to submit this geotechnical report to Oates Associates, performed for the design and construction of the Hunning Road Improvements project in Jefferson County, Missouri. The purpose of this study was to provide a geotechnical assessment, based on subsurface conditions encountered at the boring locations performed by Millennia. This report describes the exploration procedures used, presents the field and laboratory data, and includes an assessment of the subsurface conditions in the area. The work was performed in general accordance with the proposal for the project, dated December 9, 2020.

### 1.2 Project Description

The project consists of roadway improvements along Hunning Road in Jefferson County, Missouri in order to decrease the radius of two curves. The project is bounded by Cheryl Court to the northwest and Diehl Lane to the southeast. A box culvert will be replaced near the western limits of the project area, with dimensions of about 9 feet by 6 feet. Based on preliminary design plans provided by Oates, we understand fills ranging from about 2 to 8 feet are planned from approximately Station 30+00 to Station 33+00. Cuts ranging from approximately a few feet to about 14 feet are planned from about Station 33+00 to Station 36+00.

The general site area is presented in the Vicinity Map (Figure 1) in Appendix A. The approximate locations of the borings performed for this study are presented in the Boring Location Plan (Figure 2) in Appendix A.

### 1.3 Purpose and Scope

The purpose of the geotechnical study was to obtain information concerning subsurface conditions at the site, in order to form conclusions and make engineering recommendations for the following geotechnical considerations:

- A general geologic reconnaissance of the site to observe for geotechnical conditions that might affect the design, construction, and performance of the structures.
- Bearing capacity, settlement and lateral earth pressure assessments for the culvert and wing walls.
- Assessment of settlement induced by new fill placement.
- Recommendations for the culvert replacement near western portion of the project.
- The location and description of any potentially deleterious materials encountered at the boring locations that may interfere with construction progress or structure performance.
- The potential impact of groundwater on the design and construction of the structures.

- The potential impact of shallow bedrock on the design and construction of the structures.
- The suitability of the on-site materials for use as fill and backfill, including engineering criteria for the placement of those materials.
- Recommended observation, documentation and materials testing programs during construction of the structure.

# 2.0 Subsurface Exploration and Laboratory Testing

## 2.1 Exploration

On January 10, 2022, Millennia conducted a subsurface exploration at the site consisting of three borings. Two borings were drilled for the culvert replacement, designated as CB-1 and CB-2. One boring was drilled for the realignment curves for the new roadway, designated as RB-1. The realignment boring RB-1 was advanced to a depth of five feet in order to sample the underlying soils. The two culvert borings CB-1 and CB-2 were advanced to depths of approximately 13.3 feet and 20 feet, respectively. The borings were drilled with all-terrain mounted drill rigs using either hollow stem auger method. The approximate locations of the borings are indicated on the Boring Location Plans in Appendix A.

Two borings remain to be drilled as part of the overall scope in the areas of the proposed large cuts near Stations 33+00 to 36+00. However, Millennia understands that the City is in the process of negotiating access permissions for these areas at the time of this report.

## 2.2 Sampling

Samples were obtained at 2.5- and 5-foot intervals. Split-spoon samples were recovered using a 2-inch outside-diameter, split-barrel sampler, driven by a CME automatic hammer, in accordance with ASTM D 1586. Shelby tube samples were obtained using a 3-inch outside-diameter, thin-walled tube sampler, in accordance with ASTM D 1587. The split-spoon samples were placed in glass jars for later testing in the laboratory. Shelby tube samples were preserved by sealing the entire sample in the tube. The sampling sequence for each boring is summarized on the Boring Logs in Appendix B of this report.

## 2.3 Field Tests and Measurements

The following field tests and measurements were performed, unless otherwise noted, during the course of the subsurface exploration:

- The boring locations were marked in the field by Millennia, based on project information provided by Oates Associates.
- Standard penetration tests were performed and resistances recorded during the recovery of each split-barrel sample.
- Sample recovery measurements were made and recorded for each sampling attempt.
- A field classification by color and texture was made for each recovered sample.
- Observations for the presence of groundwater were made during drilling.

## 2.4 Laboratory Testing

The following laboratory tests were performed on selected samples recovered from the borings:

- Visual descriptions by color and texture of each sample (ASTM 2488).
- Natural moisture content of each cohesive sample (ASTM D 2216).
- Dry density of selected Shelby tube samples (ASTM D 7263).
- Unconfined compression strength of selected Shelby tube samples (ASTM D 2166).

## 2.5 Data

The results of the field tests and measurements were recorded on field logs and appropriate data sheets in the field. These data sheets and logs contain information concerning the drilling methods, samples attempted and recovered, indications of the presence of various subsurface materials, and the observation of groundwater. The field logs and data sheets also contain the engineer's interpretations of the conditions between samples, based on the performance of the equipment and cuttings brought to the surface by the drilling tools.

Data and observations from laboratory tests were recorded on laboratory data sheets during the course of the testing program. The results of the tests are summarized on the Boring Logs in Appendix B and on the Laboratory Test Results in Appendix C.

The boring logs are an interpretation of the subsurface conditions based on a combination of the field and laboratory data. The analyses and conclusions contained in this report are based on these field and laboratory test results, and on the interpretations of the subsurface conditions, as reported in the Boring Logs. Only data pertinent to the objectives of this report have been included on the logs, therefore, these records should not be used for other purposes.

The general subsurface conditions encountered and their pertinent engineering characteristics are described in the following paragraphs. Conditions represented by the borings should be considered applicable only at the boring locations on the dates shown; the reported conditions may be different at other locations and at other times.

# 3.0 Subsurface Conditions

## 3.1 Generalized Subsurface Profile

The generalized subsurface profile encountered at the site consists of lean clay and clayey gravel (CL and GC, according to the Unified Soil Classification System). The soils also contain a variable content of chert and limestone fragments at many of the locations. Some of the upper soils consist of existing fill related to the construction of the original culvert and roadway.

<u>Realignment Borings:</u>

An N-value of 8 blows per foot (bpf) was observed, indicating that consistency of the soil is medium stiff to stiff. Unconfined compression values estimated using a hand penetrometer device range from 1.5 to 2.5 tsf. Moisture contents vary from 21 to 22 percent. A Shelby tube sample obtained in the soil yielded an undrained shear strength value of 0.31 tsf, with a corresponding dry unit weight value of 99 pcf.

<u>Culvert Borings:</u>

Existing fill was encountered to a depth of approximately 4 feet at Boring CB-2. The existing fill consists of lean clay with a variable content of gravel and brick pieces. An N-value in the fill of 9 bpf was observed, with an unconfined compressive strength value of 1.25 tsf estimated from a hand penetrometer. A moisture content of 19 percent was recorded in the fill.

Cohesive soil was encountered at both of the borings drilled for the culvert to depths of approximately 8 to 17 feet below the existing ground surface. N-values observed in the cohesive soil range from 4 to 38 blows per foot (bpf), indicating that the overall consistency of the soil is generally soft to hard. The higher blow counts were observed in samples containing a higher content of rock fragments. Unconfined compression values estimated using a hand penetrometer device vary from 0.5 to 3.5 tsf. Moisture contents range from 15 to 26 percent.

Granular soil consisting of clayey gravel was encountered beneath the cohesive layer at both boring locations. N-values range from 8 bpf to 50 blows for 5 inches. The higher blow count is associated with the gravel with limestone fragments observed within a sample at boring CB-2. Moisture contents vary from 14 to 25 percent.

Weathered bedrock consisting of sandstone was encountered at Boring CB-2, at a depth of approximately 13.0 feet. An N-value of 50 blows for three inches of penetration was recorded. Auger refusal was encountered at a depth of approximately 13.3 feet at Boring CB-2.

## 3.2 Groundwater

Groundwater was observed during drilling or at the completion of drilling at Boring CB-1 at depth approximately 14.0 to 15.0 feet below the existing ground surface. Groundwater was not encountered at any of the other borings drilled for the project. Groundwater information at each boring location is reported on the Boring Logs in Appendix B. The presence or absence of groundwater at a particular location does not necessarily indicate that groundwater will be present or absent at that location at other times. Groundwater levels may vary significantly over time due to the effect of seasonal variations in precipitation, the level in the existing drainage feature, or other factors not evident at the time of exploration.

# 4.0 Geotechnical Recommendations

## 4.1 Pavement Design Considerations

Based on the general character of the soils encountered at the borings, as well as the results of the laboratory testing, a CBR value of 3 is considered appropriate for design of new asphalt pavements. A modulus-of-subgrade reaction value of 100 pounds per cubic inch can be used for the design of Portland cement concrete pavements. These values are based on the assumption that the subgrade is prepared in accordance with the recommendations provided in this geotechnical report.

Based on the soil conditions encountered at the borings, additional remediation of the underlying subgrade may be necessary along portions of the roadway alignment. Please refer to the subsequent sections in this report for additional guidance on the subgrade preparation.

Millennia recommends including a unit rate in the contract documents for removal and replacement of soft or disturbed subgrade areas if encountered during the proof roll process.

## 4.2 Culvert Considerations

Based on preliminary information provided by Oates, we understand the culvert will bear approximately 11 feet below the existing surface (Approximately Elevation 780). Foundation soils are anticipated to consist of soft to medium stiff clays with a variable content of sand and rock fragments.

The culvert structure and wing walls may be designed for a factored bearing pressure (pressure in excess of adjacent overburden pressure) of up to 2,000 pounds per square foot (psf) for structural dead load plus maximum live load, if constructed based on recommendations outlined above.

Based on the conditions encountered at the boring locations, the maximum anticipated settlement of the proposed box culvert should be no more than one inch, and the maximum differential settlement should be less than one half the total settlement. The majority of the settlement should take place during construction as the structural loads are applied to the foundations.

Millennia recommends that the culvert be underlain by a working pad consisting of a minimum of 6 inches of crushed limestone meeting the requirements of MoDOT Type 1 material. The working pad should extend at least 18 inches beyond the sides of the planned culvert.

Millennia recommends that any soft soils, if encountered at the base of the excavations, be over-excavated to approximately one to two feet below the bottom of the planned granular bedding elevation. The unsuitable soils should be replaced with compacted, well-graded crushed limestone such as MoDOT Type 5. An initial bridge lift of larger crushed stone may be needed. It is recommended that a non-woven geotechnical fabric be placed to separate the aggregate improvement and excavated base surface. The limits and quantities of removal and replacement may be modified by the field engineers for variable surface conditions encountered in the field. Any over excavation should be conducted in such a manner that limits or minimizes the potential for disturbance of the subgrade. To prevent unnecessary disturbance of the subgrade soils, trucks and other heavy construction vehicles should be restricted from traveling through the finished subgrade area. If disturbed areas develop, they should be reworked and compacted as necessary. These remedial actions will likely improve the bearing capacity of the planned culvert. For preliminary planning purposes, Millennia recommends that the northern half of the culvert be overexcavated approximately 2 feet, then replaced and compacted as recommended above.

The groundwater level may fluctuate due to seasonal variations and other considerations that may not have been evident at the time the measurements were made, which may require temporary water diversion and control. Groundwater seepage into the excavations should be anticipated and the contractor should be prepared to handle dewatering the excavations. We believe that dewatering measures consisting of stream diversion will be required.

### 4.3 Lateral Earth Pressures

Lateral earth pressure parameters are provided for the design of the culverts and wing walls. Structures that are restricted from movement at the top should be designed to resist at-rest earth pressures. Structures that are free to move and deflect at the top may be designed to resist active earth pressures. A horizontal deflection at the top of the structure of approximately 1% of the freestanding height is typically required to permit active pressure to develop. Earth pressures are a function of the excavation configuration and the backfill materials. The following design parameters are recommended for backfill materials:

**Lateral Earth Pressure Parameters**

**No factor of safety has been applied to the values below.** **pcf = pounds per cubic foot**

| Parameter | | Crushed Limestone | | Cohesive Soil | |
|---|---|---|---|---|---|
| | | Earth Pressure Coefficient | Equivalent Fluid Pressure | Earth Pressure Coefficient | Equivalent Fluid Pressure |
| Active | Drained | 0.27 | 35 pcf | 0.42 | 50 pcf |
| | Submerged | | 80 pcf | | 85 pcf |
| At-Rest | Drained | 0.42 | 55 pcf | 0.58 | 70 pcf |
| | Submerged | | 90 pcf | | 95 pcf |
| Passive | Drained | 3.71 | 480 pcf | 2.40 | 295 pcf |
| | Submerged | | 310 pcf | | 205 pcf |
| Soil Moist Unit Weight | | 130 pcf | | 120 pcf | |
| Angle of Internal Friction | | 35° | | 25° | |
| Assumed Surcharge Condition | | None | | None | |
| Slope Profile | | Horizontal | | Horizontal | |

Submerged values should be used for the calculation of lateral pressures for those portions of the walls that extend below the highest level of anticipated groundwater. The values for submerged fluid pressure for active and at-rest conditions include hydrostatic pressures.

Significant horizontal movement would be necessary to develop the full values of passive pressure; typically the passive values stated are reduced by up to one-half for design. The effects of vertical surcharge or seismic loads, or sloping ground behind vertical structures, are not included for the stated fluid pressures. Vertical loading may be accounted for by assuming that a lateral force equal to 0.5 times the vertical load will act at the midpoint of the structure. To limit unbalanced hydrostatic pressure behind the structures, a free-draining granular backfill material encased in a nonwoven geotextile should be placed behind the structures, in conjunction with weep holes or perforated pipes draining by gravity to daylight, to allow free drainage of the backfill. Resistance to sliding may be analyzed using a friction factor of 0.3 for mass concrete on soil. No factor of safety has been included in this friction factor.

### 4.4 Seismic Considerations

Although several areas exhibiting seismic activity are present in the central United States, the St. Louis area is most directly affected by the New Madrid and Wabash Valley seismic zones. Liquefaction is the reduction or loss of shear strength that occurs within a saturated soil mass when a cyclic load is applied, such as that induced by a seismic event. Based on the conditions encountered at the boring locations and the distance to known energy sources, the risk for liquefaction potential at the project site is considered to be negligible.

In accordance with the AASHTO 2009 Guide Specifications, a Seismic Site Class “D” is considered most appropriate for the conditions at the project site. Maximum considered spectral response accelerations at both short periods ($S_S$) and at a 1-second period ($S_1$) for use in design are readily available through the United States Geological Survey (USGS) “Geohazards” database, but will depend upon which version of the code that governs the design of this project.

### 4.5 General Earthwork Considerations

Widening of the new roadway will require additional fill placement along portions of the road sections and side slopes for the project. Based on preliminary plans provided by Oates, Millennia understands that fills of up to 8 feet are planned along the side slopes from approximately Station 30+00 to 33+00. Settlement due to the placement of the new fill as part of the earthwork process for the road widening are anticipated to results in as much as approximately 1 to 2 inches. The settlement will be significantly less in areas where the fills taper towards lesser overall fill thicknesses. Settlement along areas of the side slopes where thicker fill placement is required may result in the eventual need for additional minor fill placement to maintain design slope grades. A majority of the settlement should take place as the fill is placed during construction.

Also mentioned previously in this report, two borings remain as part of the overall scope in the areas of the proposed large cuts near Stations 33+00 to 36+00. The City is in the process of negotiating access permissions for these areas at the time of this report and an addendum addressing the cut considerations will be issued once the borings within the cut areas have been completed. Cuts ranging from approximately a few feet to about 14 feet are planned from about Station 33+00 to Station 36+00.

### 4.6 General Side Slope Considerations

Current designs along the southern section of the project indicate side slopes with inclinations ranging from 2H:1V to 4H:1V. Fill slopes with inclinations of 3H:1V are generally considered stable based on the soil conditions encountered at the boring locations for this project. Cut slopes with inclinations of 2H:1V generally appear to match existing slope inclinations. The existing slopes also appear to be stable and performing favorably. A global stability analysis will be performed for the 2H:1V cut slopes once the borings within the planned cut areas have been completed.

The clay soils found at the site can potentially be highly erosive, a mechanism of soil movement unrelated to global stability. Future erosion and shallow, superficial slumps are always a possibility, despite the results of advanced computer modeling for slope stability. Maintaining healthy vegetation, along with appropriate erosion control practices, will reduce the potential for these issues to become problematic.

Existing side slopes where new fill placement is planned should be benched prior to any new fill placement. Benching and any planned earthwork should be performed in general accordance with the MoDOT Standard Specifications for Highway Construction.

# 5.0 Construction Considerations

## 5.1 Excavations

Trenching, excavating, and bracing should be performed in accordance with Occupational Safety and Health Administration (OSHA) regulations, and other applicable regulatory agencies. In accordance with the OSHA excavation standards, the soil at the site is considered to be Type C, which requires a side slope for excavations no steeper than 1.5H:1.0V. However, worker safety and classification of the excavation soil is the responsibility of the contractor. According to OSHA requirements, any excavation extending to a depth of more than 20 feet must be designed by a registered professional engineer. Where the excavation lies within the zone of influence of existing pavements, buildings, utilities, or other structures, the integrity of those elements should be maintained by a properly designed earth retention system, underpinning, or other suitable means.

Portions of the excavations may be constructed within a few feet horizontally of existing utilities. Some of these utilities are likely backfilled with granular material. The granular backfill may contain free water and could be unstable when excavating beneath or adjacent to it. The undermining of these utilities and the adjacent area could occur due to running and caving of the granular backfill and surrounding soils. Temporary support of any utilities, if present, that cross over or lie adjacent to the excavations will likely be required.

Adequate benching along the slopes to allow for construction equipment and production should be utilized and follow OSHA standards. Heavy machinery, equipment, and tooling should not be stored on the construction benches for extended periods of time. The benches should be constructed with positive drainage in a way to eliminate ponding or standing water while in use. The benches should be backfilled and dressed as the construction advances to eliminate the potential for saturating the slopes.

## 5.2 Subgrade Preparation

After the removal of the existing pavement section materials, and where further excavation is not planned, the exposed subgrade should be proof-rolled, which is accomplished by passing over the subgrade with a loaded tandem axle dump truck and observing the subgrade for pockets of excessively soft, wet, disturbed, or otherwise unsuitable soils. Any unacceptable materials thus found should be excavated and either recompacted or replaced with new fill.

Generally, prior to placing fill, pavement materials, or structural elements in any area, the subgrade should be scarified to a depth of about six inches, the moisture content of the soil adjusted to near its optimum moisture content, and the subgrade recompacted in accordance with recommendations made in subsequent sections of this report. This recommended proof-rolling and recompaction of the subgrade may be waived by Millennia if it is determined based on field observations that it is unnecessary or could be detrimental to the existing subgrade condition.

### 5.3 Subgrade Protection

Construction areas should be properly drained in order to reduce or prevent surface runoff from collecting on the subgrade. Any ponded water on the exposed subgrade should be removed immediately. To prevent unnecessary disturbance of the subgrade soils, trucks and other heavy construction vehicles should be restricted from traveling through the finished subgrade area. If disturbed areas develop, they should be reworked and compacted as previously described.

Generally, prior to placing fill, pavement materials, or structural elements in any area, the subgrade should be scarified to a depth of about 6 inches, the moisture content of the soil adjusted to near its optimum moisture content, and the subgrade recompacted in accordance with recommendations made in subsequent sections of this report. This recommended proofrolling and recompaction of the subgrade may be waived by Millennia if it is determined based on field observations that it is unnecessary or could be detrimental to the existing subgrade condition.

### 5.4 Fill Material

The required site and structural fill and backfill may be constructed using the natural lean clay materials available from on-site excavations. Fill material from off-site borrow sources may also be used, but should be approved by Millennia prior to placement. In general, structural fill should consist of low plasticity lean clays or clayey silts with a liquid limit of less than 50 and a plasticity index of less than 25.

At the time of construction, the moisture content of the fill materials may be variable, and may not be within the range considered necessary for proper placement and compaction. Prior to compaction, some of the soil may require moisture content adjustment. During warm weather, moisture reduction can generally be accomplished by disking, or otherwise aerating, the soil. When air-drying is not feasible, a moisture-reducing chemical additive, such as “Code L” lime dust, could be incorporated into the cohesive soil. Lime dust is a caustic material that should be used with caution by a contractor experienced with its application. Millennia should be consulted to assess the effectiveness of any additive and to recommend the amount and methods for application.

If earthwork is performed during a period of dry weather, some of the fill may require the addition of moisture prior to compaction. This should be performed in a controlled manner using a tank truck with a spray bar, and the moistened soil should be thoroughly blended with a disk or pulverizer to produce a uniform moisture content. Repeated passages of the equipment may be required to achieve a reasonably uniform moisture content.

### 5.5 Fill Placement

Fill for general site grading should be placed in layers not exceeding eight inches in loose thickness and compacted to the required dry density. Backfill compacted by handheld equipment should be placed in layers not greater than six inches. The layer thickness may be increased if tests indicate that compaction could be achieved uniformly throughout the layer using a greater thickness. At the time of compaction, fill should generally be within three percent, wet or dry, of the optimum moisture content of the material as determined by the standard Proctor compaction test, ASTM D 698. Fill should be compacted to a dry density of not less than 95 percent of the standard Proctor maximum dry density of the material. In order to develop a usable Proctor curve, sand fill will need to include a component of finer sand or silt. Well graded sands, while typically suitable for use as fill, can be difficult to test for compliance with compacted density specifications. Granular material such as crushed limestone, placed for structure support should be compacted to at least 100% of the standard Proctor maximum dry density.

Backfill placed next to walls or foundations should be compacted with hand-operated compaction equipment and not large self-propelled or machine-operated equipment. The operation of large pieces of equipment adjacent to these structures can result in overcompaction and higher lateral pressures than those recommended herein for design. Compaction should be reduced within approximately one foot of any structures. Structures should be observed periodically during backfilling for signs of movement. If movement is detected, it may be necessary to change backfilling procedures.

### 5.6 Groundwater Considerations

The potential for groundwater seepage will depend in-part upon the magnitude of cuts and fills required to develop the site, which will be governed by the eventual grading plan. Groundwater seepage is not expected to be significant during general site grading activities for the roadway portion of the project. Should groundwater seepage be encountered during excavation, it is expected that it can be handled by an excavation drainage system consisting of drainage ditches, sumps, and pumps. In the absence of significant rainfall, saturated zones should drain over a period of days. If more significant groundwater flow is encountered, Millennia should be contacted to assess the situation.

Groundwater control options for the culvert are discussed in Section 4.2 of this report.

### 5.7 Soft Subgrade

Soft subgrade conditions were not encountered in the surficial soils of the borings along the roadway alignment. However, if during the course of construction, soft or disturbed soils are encountered, the recommendations in the following paragraph should be followed. Soft soils that are encountered at the pavement subgrade level may be difficult to recompact to the required density in a conventional manner. These soils may require removal and replacement with crushed limestone. No more than 1 to 2 feet of overexcavation is expected to be necessary. Crushed limestone with a gradation similar to Type 5 Aggregate as specified by MoDOT would be acceptable replacement fill. The crushed limestone should be placed in 8-inch lifts and mechanically compacted to 100% of the standard Proctor maximum density of the material (ASTM D 698). At the time of compaction, the crushed limestone should be within 3% of the optimum moisture content of the material as determined by the standard Proctor compaction test. Alternatively, a soft subgrade could be stabilized by using a lime additive. Typically, “Code L” or quicklime in the amount of 3 to 5% of the dry weight of the soil should be effective for the lean clay soils. The lime should be thoroughly mixed into the top 12 inches of the subgrade, allowed to hydrate, then the soil recompacted to 95% of the standard Proctor maximum density. Caution should be used when applying lime, and local authorities should be contacted for permission to use lime, for it is a fine-grained and somewhat caustic material that is easily windborne. Millennia should be consulted if extensive areas of soft subgrade soils are encountered that prove difficult to compact.

## 6.0 Construction Phase Services

It is recommended that Millennia review the plans and specifications for the project prior to bid solicitation in order to determine the relationship of the geotechnical information presented in this report with the final design of the substation rebuild. This additional service is recommended in order to reduce construction phase problems that might otherwise arise in the field and result in construction delays or change orders.

Documenting observations and performing materials testing during construction of foundations, retaining walls, pavements, and other structures that are supported by earth materials, is an integral aspect of the geotechnical engineering process. The geotechnical engineering profession is based on the "Observational Method," through which design assumptions and recommendations, based on limited drilling and sampling data, can be verified or modified in response to actual conditions observed as the materials are exposed by construction equipment.

Selecting the same firm that provided the geotechnical engineering services to also perform observation and materials testing services during construction results in decreased risk to the owner and entire design team. The geotechnical firm is most familiar with the site and can recognize unanticipated conditions that might otherwise adversely affect construction progress or structure performance. Millennia has a staff of experienced field technicians and a geotechnical and materials testing laboratory equipped to support a wide variety of construction projects. After the project plans and specifications have been prepared, Millennia requests the opportunity to submit a proposal to perform the specified construction observation and materials testing services.

For this project, it is recommended that Millennia be retained by Oates Associates or the owner during construction to perform the following observations and field tests, where applicable:

- Observation and documentation of asphalt placement, along with compaction testing for conformance with the project specifications.
- Observation of earthwork operations for the new road construction, including proof roll, and compaction of soil and base rock.
- Quality assurance testing of fresh concrete delivered to the site, and compressive strength testing of concrete cylinders cast on site for conformance with the project specifications, if applicable
- Observation and documentation of topsoil stripping and the removal of any deleterious materials encountered.
- Observation and documentation of fill and backfill placement, along with compaction testing for conformance with the project specifications.

These quality assurance services should help to verify design assumptions, and to maintain construction procedures in accordance with the contract plans, specifications, and good construction and engineering practices.

## 7.0 Closing

This report has been prepared for the exclusive use of Oates Associates for use in the design and construction for the proposed new roadway improvements along Hunning Road in Jefferson County, Missouri. This report has been prepared in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made to the professional advice and recommendations included herein. This report is not for use by parties other than those named or for purposes other than those stated herein. It may not contain sufficient information for the use of other parties or for other purposes.

If there is a substantial lapse of time between the submission of this report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, this report should be reviewed by Millennia to determine the applicability of the analyses and recommendations considering the changed conditions and time lapse. The report should also be reviewed by Millennia if changes occur in structure location, size, and type, or in the planned loads, elevations, grading plans, and project concepts.

These analyses and recommendations are based on data obtained from site reconnaissance, the borings performed for this study and other pertinent information presented herein. This report does not reflect any variations between, beyond, or below the borings. Should such variations become evident, it may be necessary to re-evaluate the recommendations of this report after performing on-site observation during the construction period and noting the characteristics of any such variation.

We appreciate this opportunity to be of service to you and would be pleased to discuss any aspect of this report with you at your convenience.

Sincerely,

**Millennia Professional Services, Ltd.**

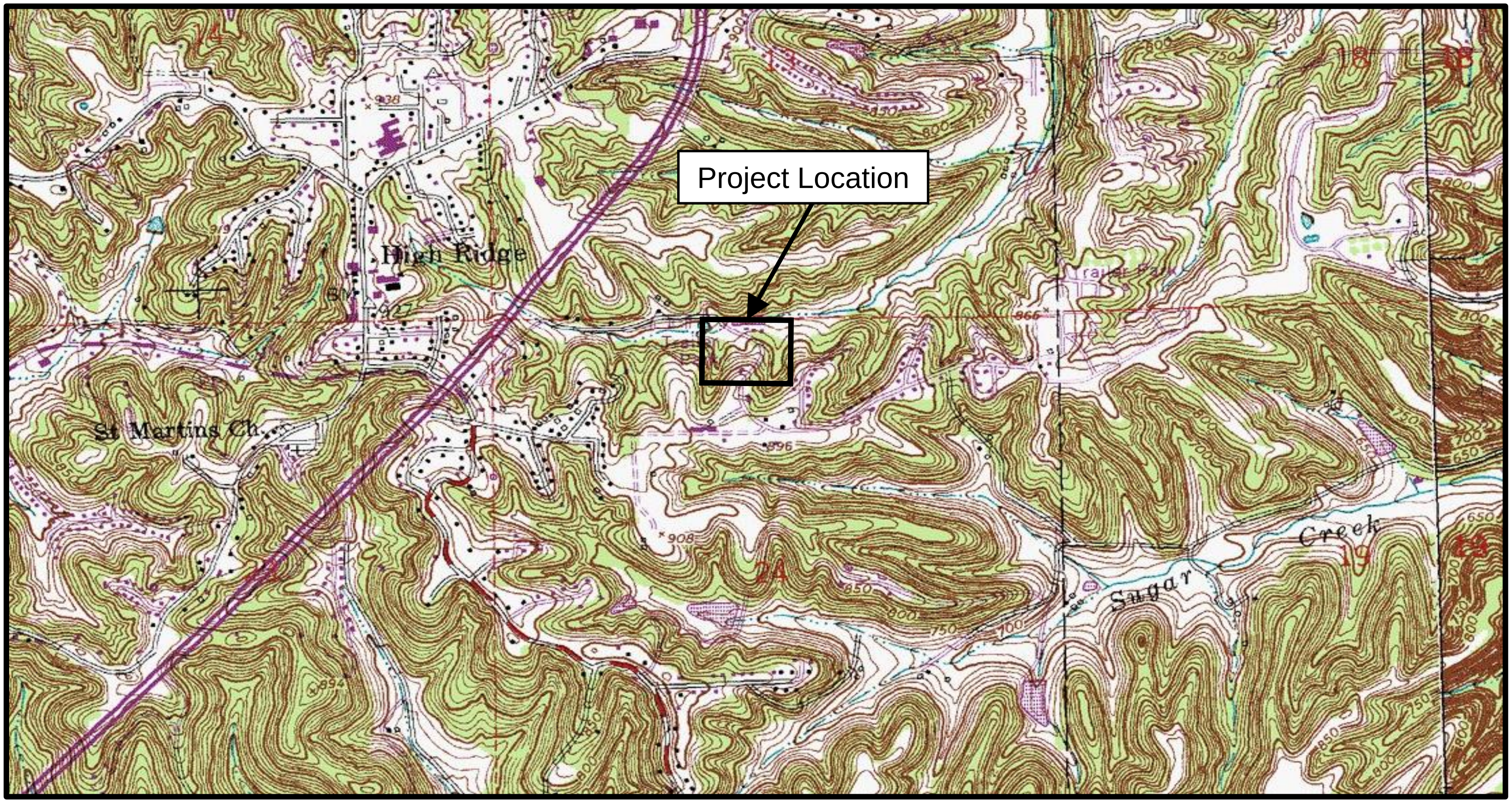
Jacob A. Schaeffer, P.E.
Project Manager

STATE OF MISSOURI
JACOB A. SCHAEFFER
3-24-22
NUMBER
PE-2015017050
PROFESSIONAL ENGINEER

# Appendix A

## Vicinity Map – Figure 1
## Boring Location Plan -  Figure 2

**Millennia Professional Services**
6439 Plymouth Ave W-129, St. Louis, MO
Phone: (618) 624-8610
Fax: (618) 624-8611
Project No.: MG21043




## FIGURE 1: VICINITY MAP

Hunning Road - Safety Improvement
High Ridge, Missouri

N

Image obtained from TopoQuest

*Not to scale

| | | | |
|---|---|---|---|
| Drawn by: | M. Jenkins | Checked by: | J. Schaeffer |
| Project No.: | MG21043 | Date: | 8/12/2021 |

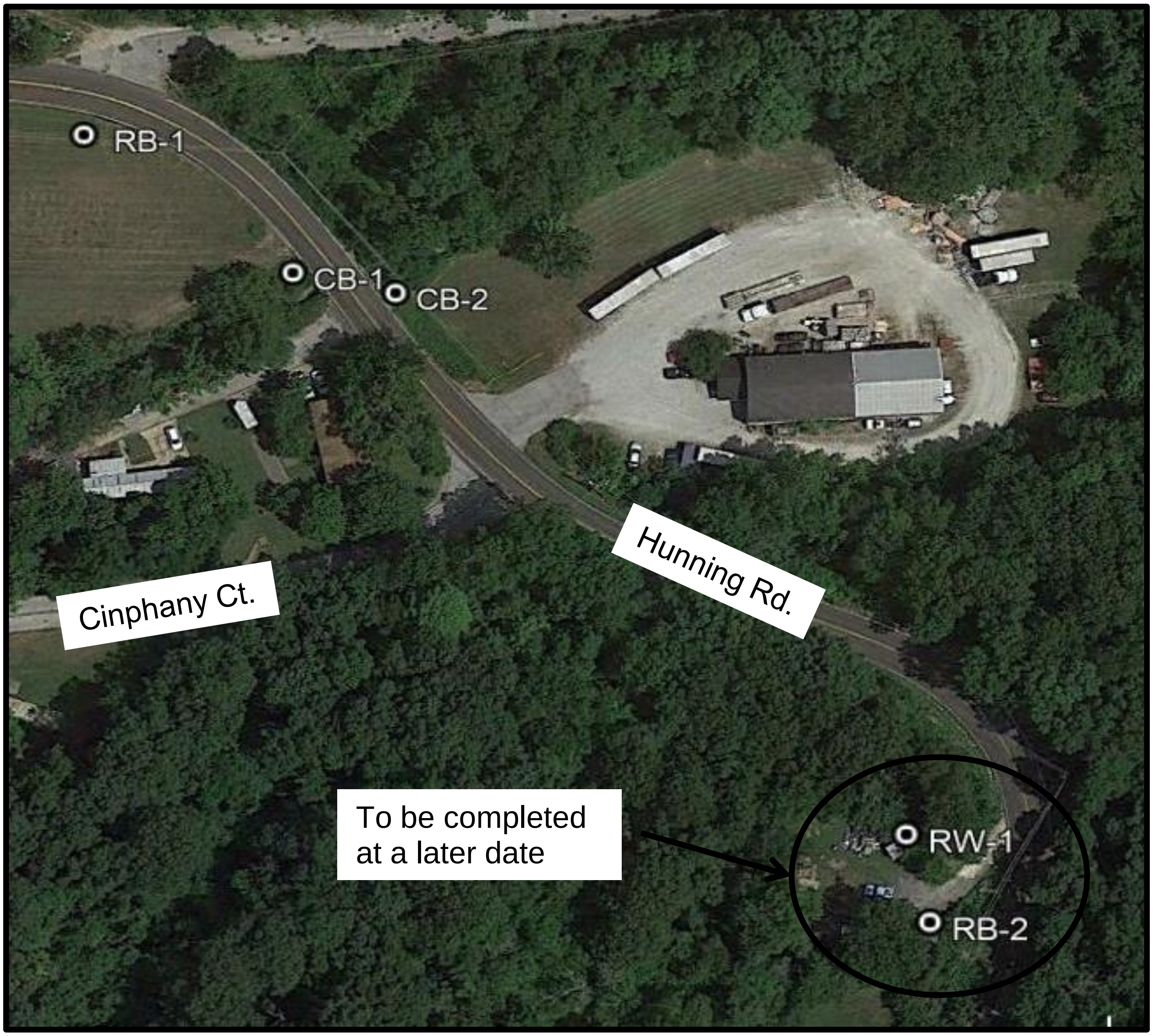
# Millennia Professional Services

6439 Plymouth Ave W-129, St. Louis, MO

Phone: (618) 624-8610

Fax: (618) 624-8611


Project No.: MG21043




## FIGURE 2: BORING LOCATION PLAN

Hunning Road - Safety Improvement
High Ridge, Missouri

N

Approximate Boring Location: ◉

Image obtained from Google Earth

*Not to scale

| | | | |
|---|---|---|---|
| Drawn by: | M. Jenkins | Checked by: | J. Schaeffer |
| Project No.: | MG21043 | Date: | 3/22/2022 |

6439 Plymouth Avenue, Suite W-129, St. Louis, Missouri 63133 618-624-8610

## Appendix B

## Boring Logs

# BORING NUMBER CB-1



Millennia Professional Services

**CLIENT** High Ridge, MO
**PROJECT NAME** Hunning Road Improvements
**PROJECT NUMBER** MG21043
**PROJECT LOCATION** High Ridge, MO
**DATE STARTED** 1/10/22 **COMPLETED** 1/10/22
**GROUND ELEVATION** **HOLE SIZE** inches
**DRILLING CONTRACTOR** Jacobi Geotechnical
**GROUND WATER LEVELS:**
**DRILLING METHOD** Hollow Stem Auger
▽ **AT TIME OF DRILLING** 14.00 ft
**LOGGED BY** P. Adhikari **CHECKED BY** J. Schaeffer
▼ **AT END OF DRILLING** 15.00 ft
**NOTES**
**AFTER DRILLING** ---

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil (3.0 in.) | | | | | | | | | | |
| | | Brown, lean CLAY (CL), trace chert | | | | | | | | | | |
| | | | SS 1 | 50 | 3-4-2 (6) | 2.0 | | 16 | | | | |
| 5 | | | SS 2 | 61 | 1-3-5 (8) | 0.5 | | 21 | | | | |
| | | - with chert below 6.0 ft. | SS 3 | 67 | 10-14-14 (28) | 3.5 | | 19 | | | | |
| 10 | | - with sand and chert below 8.5 ft. | SS 4 | 61 | 14-19-19 (38) | 1.5 | | 15 | | | | |
| | ▽ | - trace sand below 13.5 ft. | SS 5 | 100 | 1-2-2 (4) | 0.5 | | 25 | | | | |
| 15 | ▼ | | | | | | | | | | | |
| | | | SS 6 | 44 | 4-6-2 (8) | 1.25 | | 25 | | | | |
| | | Brown, clayey GRAVEL (GC), with sand | | | | | | | | | | |
| 20 | | | SS 7 | 17 | 6-7-6 (13) | | | | | | | |

Bottom of borehole at 20.0 feet.

GEOTECH BH COLUMNS - GINT STD US LAB.GDT - 3/24/22 11:00 - G:\PROJECT FILES\2021\MG21043 HUNNING ROAD - SAFETY IMPROVEMENT\FIELD DATA\HUNNING ROAD - SAFETY GINT.GPJ

Millennia Professional Services

# BORING NUMBER CB-2



**CLIENT** High Ridge, MO

**PROJECT NAME** Hunning Road Improvements

**PROJECT NUMBER** MG21043

**PROJECT LOCATION** High Ridge, MO

**DATE STARTED** 1/10/22 **COMPLETED** 1/10/22

**GROUND ELEVATION** **HOLE SIZE** inches

**DRILLING CONTRACTOR** Jacobi Geotechnical

**GROUND WATER LEVELS:**

**DRILLING METHOD** Hollow Stem Auger

**AT TIME OF DRILLING** ---

**LOGGED BY** P. Adhikari **CHECKED BY** J. Schaeffer

**AT END OF DRILLING** ---

**NOTES**

**AFTER DRILLING** ---

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | FILL: Brown, lean CLAY (CL), with gravel, trace brick fines | | | | | | | | | | |
| | | | SS 1 | 44 | 3-5-4 (9) | 1.25 | | 19 | | | | |
| | | Brown lean CLAY (CL), trace chert | | | | | | | | | | |
| | | | SS 2 | 28 | 2-4-3 (7) | 2.0 | | 23 | | | | |
| 5 | | | | | | | | | | | | |
| | | - soft, trace gravel below 6.0 ft. | SS 3 | 11 | 0-3-2 (5) | 0.5 | | 26 | | | | |
| | | Brown, clayey GRAVEL (GC), with sand | | | | | | | | | | |
| | | | SS 4 | 41 | 10-13-50/5" | | | 14 | | | | |
| 10 | | | | | | | | | | | | |
| | | Brown, SANDSTONE | SS 5 | 100 | 50/3" | 4.5 | | 9 | | | | |

Refusal at 13.3 feet.
Bottom of borehole at 13.3 feet.

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Millennia Professional Services

**CLIENT** High Ridge, MO
**PROJECT NAME** Hunning Road Improvements
**PROJECT NUMBER** MG21043
**PROJECT LOCATION** High Ridge, MO
**DATE STARTED** 1/10/22 **COMPLETED** 1/10/22
**GROUND ELEVATION** **HOLE SIZE** inches
**DRILLING CONTRACTOR** Jacobi Geotechnical
**GROUND WATER LEVELS:**
**DRILLING METHOD** Hollow Stem Auger
**AT TIME OF DRILLING** --- Dry
**LOGGED BY** P. Adhikari **CHECKED BY** J. Schaeffer
**AT END OF DRILLING** --- Dry
**NOTES**
**AFTER DRILLING** ---

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | Brown, lean CLAY (CL), trace gravel and chert | | | | | | | | | | |
| | | | SS 1 | 39 | 3-4-4 (8) | 1.5 | | 21 | | | | |
| | | - with gravel below 3.0 ft.<br>- undrained shear strength = 0.31 tsf at 3.0 ft. | ST 2 | 71 | | 2.5 | 99 | 22 | | | | |
| 5 | | | | | | | | | | | | |

Bottom of borehole at 5.0 feet.

## GENERAL NOTES

The number of borings is based on topographic and geologic factors: the magnitude of loading; the size, shape, and value of the structure; consequences of failure; and other factors. The type and sequence of sampling is selected to reduce the possibility of undiscovered anomalies and increase drilling efficiency. Attempts are made to detect and/or identify occurrences during drilling and sampling such as encountering water, boulders, gas, zones of lost circulation, relative ease or resistance of drilling progress, unusual sample recovery, variation in driving resistance, unusual odors, etc. However, lack of mention of such variations does not preclude their presence.

Although attempts are made to obtain stabilized groundwater levels, the levels shown on the Boring Logs may not have stabilized, particularly in more permeable cohesive soils. Consequently, the indicated groundwater levels may not represent present or future levels. Groundwater levels may vary significantly over time due to effects of precipitation, infiltration, or other factors not evident at the times indicated.

Unless otherwise noted, soil classifications indicated on the Boring Logs are based on visual observations and are not the result of classification tests. Although visual classifications are performed by experienced technicians or engineers, classifications so made may not be conclusive.

Generally, variations in texture less than one foot in thickness will be described as seams while thicker strata will be logged as individual strata. However, minor anomalies and changes of questionable lateral extent may appear only in the verbal description. The lines indicating changes in strata on the Boring Logs are approximate boundaries only as the actual material change may be between samples or may be a gradual transition.

Samples chosen for laboratory testing are selected in such a manner so as to determine selected physical characteristics of each material encountered. However, as samples are recovered only intermittently and only representative samples are tested, the results of such tests may not conclusively represent the characteristics of all subsurface materials present.

# Appendix C

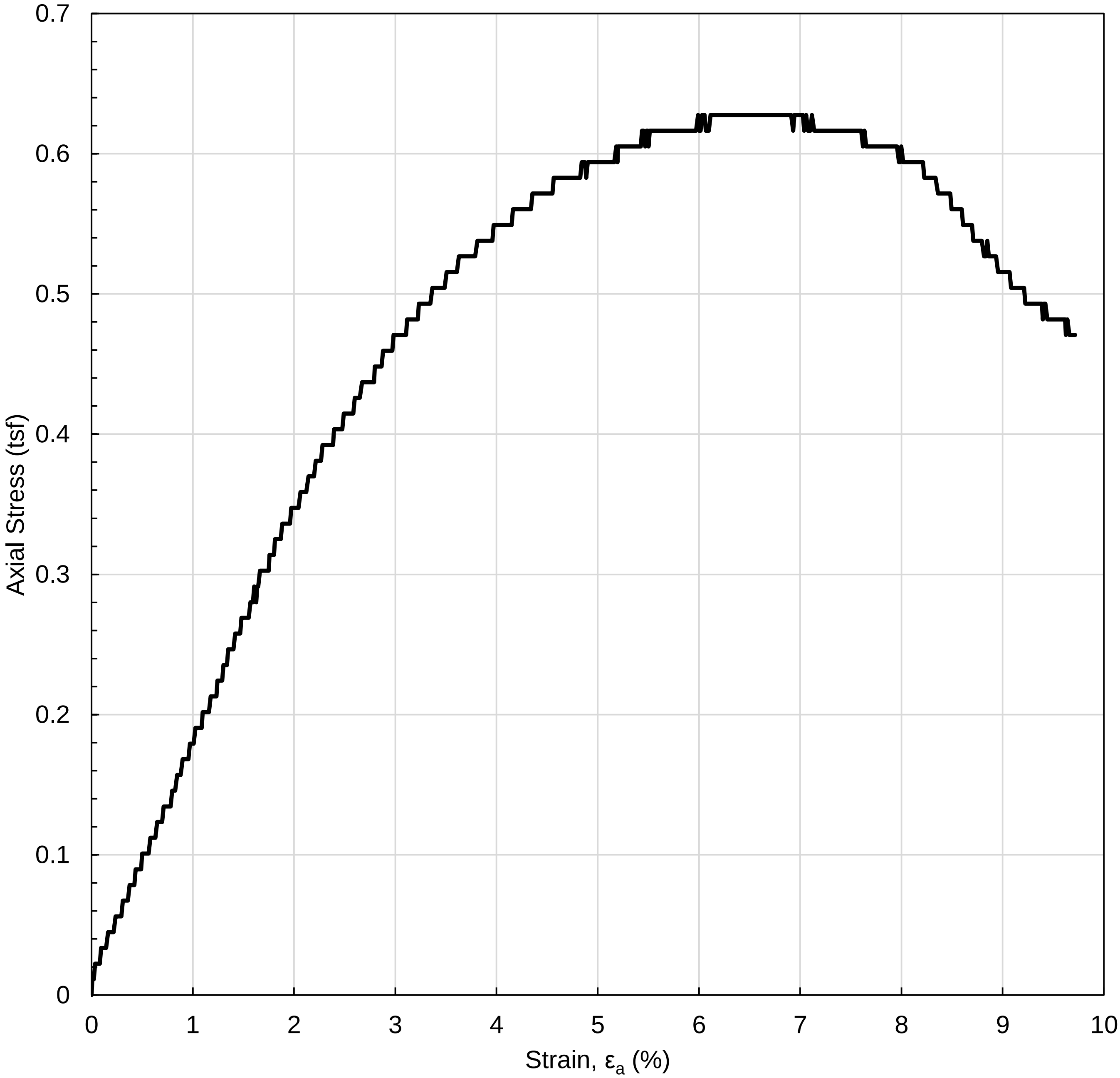
## Laboratory Test Results

## Unconfined Compression Test - ASTM D2166

| | | | |
|---|---|---|---|
| Project Name: | Hunning Road Safety Improvements | Boring: | RB-1 |
| Project No.: | MG21043 | Sample ID: | ST-2 |
| | | Sample Depth: | 3.0 |

### Lab Test Results

| | |
|---|---|
| Dry Unit Weight: | 99.1 pcf |
| Moisture Content: | 22.2% |
| Undrained Shear Strength: | 0.31 tsf |




Fairview Heights Office: 11 Executive Drive, Suite 12, Fairview Heights, Illinois 62208
Phone: 618-624-8610, Fax: 618-624-8611

Millennia Professional Services, Ltd

6439 Plymouth Avenue, Suite W-129, St. Louis, Missouri 63133 618-624-8610

# Geotechnical Report

Hunning Road Improvements
Jefferson County, Missouri

**Prepared For:**
Oates Associates
720 Olive Street, Suite 700
St. Louis, Missouri, 63101
Attn: Mike Busch, PE

**Prepared By:**
Millennia Professional Services, Ltd.
6439 Plymouth Avenue, Suite W-129
St. Louis, Missouri
618-624-8610


Authored By:
Jacob A. Schaeffer, PE
jschaeffer@millennia.pro

Millennia Project Number MG21043
March 24, 2022

## Contents

# Geotechnical Report
# Hunning Road Improvements
# Jefferson County, Missouri

## 1.0 Project Description

### 1.1 Introduction

Millennia Professional Services (Millennia) is pleased to submit this geotechnical report to Oates Associates, performed for the design and construction of the Hunning Road Improvements project in Jefferson County, Missouri. The purpose of this study was to provide a geotechnical assessment, based on subsurface conditions encountered at the boring locations performed by Millennia. This report describes the exploration procedures used, presents the field and laboratory data, and includes an assessment of the subsurface conditions in the area. The work was performed in general accordance with the proposal for the project, dated December 9, 2020.

### 1.2 Project Description

The project consists of roadway improvements along Hunning Road in Jefferson County, Missouri in order to decrease the radius of two curves. The project is bounded by Cheryl Court to the northwest and Diehl Lane to the southeast. A box culvert will be replaced near the western limits of the project area, with dimensions of about 9 feet by 6 feet. Based on preliminary design plans provided by Oates, we understand fills ranging from about 2 to 8 feet are planned from approximately Station 30+00 to Station 33+00. Cuts ranging from approximately a few feet to about 14 feet are planned from about Station 33+00 to Station 36+00.

The general site area is presented in the Vicinity Map (Figure 1) in Appendix A. The approximate locations of the borings performed for this study are presented in the Boring Location Plan (Figure 2) in Appendix A.

### 1.3 Purpose and Scope

The purpose of the geotechnical study was to obtain information concerning subsurface conditions at the site, in order to form conclusions and make engineering recommendations for the following geotechnical considerations:

- A general geologic reconnaissance of the site to observe for geotechnical conditions that might affect the design, construction, and performance of the structures.
- Bearing capacity, settlement and lateral earth pressure assessments for the culvert and wing walls.
- Assessment of settlement induced by new fill placement.
- Recommendations for the culvert replacement near western portion of the project.
- The location and description of any potentially deleterious materials encountered at the boring locations that may interfere with construction progress or structure performance.
- The potential impact of groundwater on the design and construction of the structures.

- The potential impact of shallow bedrock on the design and construction of the structures.
- The suitability of the on-site materials for use as fill and backfill, including engineering criteria for the placement of those materials.
- Recommended observation, documentation and materials testing programs during construction of the structure.

# 2.0 Subsurface Exploration and Laboratory Testing

## 2.1 Exploration

On January 10, 2022, Millennia conducted a subsurface exploration at the site consisting of three borings. Two borings were drilled for the culvert replacement, designated as CB-1 and CB-2. One boring was drilled for the realignment curves for the new roadway, designated as RB-1. The realignment boring RB-1 was advanced to a depth of five feet in order to sample the underlying soils. The two culvert borings CB-1 and CB-2 were advanced to depths of approximately 13.3 feet and 20 feet, respectively. The borings were drilled with all-terrain mounted drill rigs using either hollow stem auger method. The approximate locations of the borings are indicated on the Boring Location Plans in Appendix A.

Two borings remain to be drilled as part of the overall scope in the areas of the proposed large cuts near Stations 33+00 to 36+00. However, Millennia understands that the City is in the process of negotiating access permissions for these areas at the time of this report.

## 2.2 Sampling

Samples were obtained at 2.5- and 5-foot intervals. Split-spoon samples were recovered using a 2-inch outside-diameter, split-barrel sampler, driven by a CME automatic hammer, in accordance with ASTM D 1586. Shelby tube samples were obtained using a 3-inch outside-diameter, thin-walled tube sampler, in accordance with ASTM D 1587. The split-spoon samples were placed in glass jars for later testing in the laboratory. Shelby tube samples were preserved by sealing the entire sample in the tube. The sampling sequence for each boring is summarized on the Boring Logs in Appendix B of this report.

## 2.3 Field Tests and Measurements

The following field tests and measurements were performed, unless otherwise noted, during the course of the subsurface exploration:

- The boring locations were marked in the field by Millennia, based on project information provided by Oates Associates.
- Standard penetration tests were performed and resistances recorded during the recovery of each split-barrel sample.
- Sample recovery measurements were made and recorded for each sampling attempt.
- A field classification by color and texture was made for each recovered sample.
- Observations for the presence of groundwater were made during drilling.

## 2.4 Laboratory Testing

The following laboratory tests were performed on selected samples recovered from the borings:

- Visual descriptions by color and texture of each sample (ASTM 2488).
- Natural moisture content of each cohesive sample (ASTM D 2216).
- Dry density of selected Shelby tube samples (ASTM D 7263).
- Unconfined compression strength of selected Shelby tube samples (ASTM D 2166).

## 2.5 Data

The results of the field tests and measurements were recorded on field logs and appropriate data sheets in the field. These data sheets and logs contain information concerning the drilling methods, samples attempted and recovered, indications of the presence of various subsurface materials, and the observation of groundwater. The field logs and data sheets also contain the engineer's interpretations of the conditions between samples, based on the performance of the equipment and cuttings brought to the surface by the drilling tools.

Data and observations from laboratory tests were recorded on laboratory data sheets during the course of the testing program. The results of the tests are summarized on the Boring Logs in Appendix B and on the Laboratory Test Results in Appendix C.

The boring logs are an interpretation of the subsurface conditions based on a combination of the field and laboratory data. The analyses and conclusions contained in this report are based on these field and laboratory test results, and on the interpretations of the subsurface conditions, as reported in the Boring Logs. Only data pertinent to the objectives of this report have been included on the logs, therefore, these records should not be used for other purposes.

The general subsurface conditions encountered and their pertinent engineering characteristics are described in the following paragraphs. Conditions represented by the borings should be considered applicable only at the boring locations on the dates shown; the reported conditions may be different at other locations and at other times.

# 3.0 Subsurface Conditions

## 3.1 Generalized Subsurface Profile

The generalized subsurface profile encountered at the site consists of lean clay and clayey gravel (CL and GC, according to the Unified Soil Classification System). The soils also contain a variable content of chert and limestone fragments at many of the locations. Some of the upper soils consist of existing fill related to the construction of the original culvert and roadway.

<u>Realignment Borings:</u>

An N-value of 8 blows per foot (bpf) was observed, indicating that consistency of the soil is medium stiff to stiff. Unconfined compression values estimated using a hand penetrometer device range from 1.5 to 2.5 tsf. Moisture contents vary from 21 to 22 percent. A Shelby tube sample obtained in the soil yielded an undrained shear strength value of 0.31 tsf, with a corresponding dry unit weight value of 99 pcf.

<u>Culvert Borings:</u>

Existing fill was encountered to a depth of approximately 4 feet at Boring CB-2. The existing fill consists of lean clay with a variable content of gravel and brick pieces. An N-value in the fill of 9 bpf was observed, with an unconfined compressive strength value of 1.25 tsf estimated from a hand penetrometer. A moisture content of 19 percent was recorded in the fill.

Cohesive soil was encountered at both of the borings drilled for the culvert to depths of approximately 8 to 17 feet below the existing ground surface. N-values observed in the cohesive soil range from 4 to 38 blows per foot (bpf), indicating that the overall consistency of the soil is generally soft to hard. The higher blow counts were observed in samples containing a higher content of rock fragments. Unconfined compression values estimated using a hand penetrometer device vary from 0.5 to 3.5 tsf. Moisture contents range from 15 to 26 percent.

Granular soil consisting of clayey gravel was encountered beneath the cohesive layer at both boring locations. N-values range from 8 bpf to 50 blows for 5 inches. The higher blow count is associated with the gravel with limestone fragments observed within a sample at boring CB-2. Moisture contents vary from 14 to 25 percent.

Weathered bedrock consisting of sandstone was encountered at Boring CB-2, at a depth of approximately 13.0 feet. An N-value of 50 blows for three inches of penetration was recorded. Auger refusal was encountered at a depth of approximately 13.3 feet at Boring CB-2.

## 3.2 Groundwater

Groundwater was observed during drilling or at the completion of drilling at Boring CB-1 at depth approximately 14.0 to 15.0 feet below the existing ground surface. Groundwater was not encountered at any of the other borings drilled for the project. Groundwater information at each boring location is reported on the Boring Logs in Appendix B. The presence or absence of groundwater at a particular location does not necessarily indicate that groundwater will be present or absent at that location at other times. Groundwater levels may vary significantly over time due to the effect of seasonal variations in precipitation, the level in the existing drainage feature, or other factors not evident at the time of exploration.

# 4.0 Geotechnical Recommendations

## 4.1 Pavement Design Considerations

Based on the general character of the soils encountered at the borings, as well as the results of the laboratory testing, a CBR value of 3 is considered appropriate for design of new asphalt pavements. A modulus-of-subgrade reaction value of 100 pounds per cubic inch can be used for the design of Portland cement concrete pavements. These values are based on the assumption that the subgrade is prepared in accordance with the recommendations provided in this geotechnical report.

Based on the soil conditions encountered at the borings, additional remediation of the underlying subgrade may be necessary along portions of the roadway alignment. Please refer to the subsequent sections in this report for additional guidance on the subgrade preparation.

Millennia recommends including a unit rate in the contract documents for removal and replacement of soft or disturbed subgrade areas if encountered during the proof roll process.

## 4.2 Culvert Considerations

Based on preliminary information provided by Oates, we understand the culvert will bear approximately 11 feet below the existing surface (Approximately Elevation 780). Foundation soils are anticipated to consist of soft to medium stiff clays with a variable content of sand and rock fragments.

The culvert structure and wing walls may be designed for a factored bearing pressure (pressure in excess of adjacent overburden pressure) of up to 2,000 pounds per square foot (psf) for structural dead load plus maximum live load, if constructed based on recommendations outlined above.

Based on the conditions encountered at the boring locations, the maximum anticipated settlement of the proposed box culvert should be no more than one inch, and the maximum differential settlement should be less than one half the total settlement. The majority of the settlement should take place during construction as the structural loads are applied to the foundations.

Millennia recommends that the culvert be underlain by a working pad consisting of a minimum of 6 inches of crushed limestone meeting the requirements of MoDOT Type 1 material. The working pad should extend at least 18 inches beyond the sides of the planned culvert.

Millennia recommends that any soft soils, if encountered at the base of the excavations, be over-excavated to approximately one to two feet below the bottom of the planned granular bedding elevation. The unsuitable soils should be replaced with compacted, well-graded crushed limestone such as MoDOT Type 5. An initial bridge lift of larger crushed stone may be needed. It is recommended that a non-woven geotechnical fabric be placed to separate the aggregate improvement and excavated base surface. The limits and quantities of removal and replacement may be modified by the field engineers for variable surface conditions encountered in the field. Any over excavation should be conducted in such a manner that limits or minimizes the potential for disturbance of the subgrade. To prevent unnecessary disturbance of the subgrade soils, trucks and other heavy construction vehicles should be restricted from traveling through the finished subgrade area. If disturbed areas develop, they should be reworked and compacted as necessary. These remedial actions will likely improve the bearing capacity of the planned culvert. For preliminary planning purposes, Millennia recommends that the northern half of the culvert be overexcavated approximately 2 feet, then replaced and compacted as recommended above.

The groundwater level may fluctuate due to seasonal variations and other considerations that may not have been evident at the time the measurements were made, which may require temporary water diversion and control. Groundwater seepage into the excavations should be anticipated and the contractor should be prepared to handle dewatering the excavations. We believe that dewatering measures consisting of stream diversion will be required.

### 4.3 Lateral Earth Pressures

Lateral earth pressure parameters are provided for the design of the culverts and wing walls. Structures that are restricted from movement at the top should be designed to resist at-rest earth pressures. Structures that are free to move and deflect at the top may be designed to resist active earth pressures. A horizontal deflection at the top of the structure of approximately 1% of the freestanding height is typically required to permit active pressure to develop. Earth pressures are a function of the excavation configuration and the backfill materials. The following design parameters are recommended for backfill materials:

**Lateral Earth Pressure Parameters**

**No factor of safety has been applied to the values below.** **pcf = pounds per cubic foot**

| **Parameter** | | **Crushed Limestone** | | **Cohesive Soil** | |
|---|---|---|---|---|---|
| | | **Earth Pressure Coefficient** | **Equivalent Fluid Pressure** | **Earth Pressure Coefficient** | **Equivalent Fluid Pressure** |
| Active | Drained | 0.27 | 35 pcf | 0.42 | 50 pcf |
| | Submerged | | 80 pcf | | 85 pcf |
| At-Rest | Drained | 0.42 | 55 pcf | 0.58 | 70 pcf |
| | Submerged | | 90 pcf | | 95 pcf |
| Passive | Drained | 3.71 | 480 pcf | 2.40 | 295 pcf |
| | Submerged | | 310 pcf | | 205 pcf |
| Soil Moist Unit Weight | | 130 pcf | | 120 pcf | |
| Angle of Internal Friction | | $35^{o}$ | | $25^{o}$ | |
| Assumed Surcharge Condition | | None | | None | |
| Slope Profile | | Horizontal | | Horizontal | |

Submerged values should be used for the calculation of lateral pressures for those portions of the walls that extend below the highest level of anticipated groundwater. The values for submerged fluid pressure for active and at-rest conditions include hydrostatic pressures.

Significant horizontal movement would be necessary to develop the full values of passive pressure; typically the passive values stated are reduced by up to one-half for design. The effects of vertical surcharge or seismic loads, or sloping ground behind vertical structures, are not included for the stated fluid pressures. Vertical loading may be accounted for by assuming that a lateral force equal to 0.5 times the vertical load will act at the midpoint of the structure. To limit unbalanced hydrostatic pressure behind the structures, a free-draining granular backfill material encased in a nonwoven geotextile should be placed behind the structures, in conjunction with weep holes or perforated pipes draining by gravity to daylight, to allow free drainage of the backfill. Resistance to sliding may be analyzed using a friction factor of 0.3 for mass concrete on soil. No factor of safety has been included in this friction factor.

### 4.4 Seismic Considerations

Although several areas exhibiting seismic activity are present in the central United States, the St. Louis area is most directly affected by the New Madrid and Wabash Valley seismic zones. Liquefaction is the reduction or loss of shear strength that occurs within a saturated soil mass when a cyclic load is applied, such as that induced by a seismic event. Based on the conditions encountered at the boring locations and the distance to known energy sources, the risk for liquefaction potential at the project site is considered to be negligible.

In accordance with the AASHTO 2009 Guide Specifications, a Seismic Site Class “D” is considered most appropriate for the conditions at the project site. Maximum considered spectral response accelerations at both short periods ($S_S$) and at a 1-second period ($S_1$) for use in design are readily available through the United States Geological Survey (USGS) “Geohazards” database, but will depend upon which version of the code that governs the design of this project.

### 4.5 General Earthwork Considerations

Widening of the new roadway will require additional fill placement along portions of the road sections and side slopes for the project. Based on preliminary plans provided by Oates, Millennia understands that fills of up to 8 feet are planned along the side slopes from approximately Station 30+00 to 33+00. Settlement due to the placement of the new fill as part of the earthwork process for the road widening are anticipated to results in as much as approximately 1 to 2 inches. The settlement will be significantly less in areas where the fills taper towards lesser overall fill thicknesses. Settlement along areas of the side slopes where thicker fill placement is required may result in the eventual need for additional minor fill placement to maintain design slope grades. A majority of the settlement should take place as the fill is placed during construction.

Also mentioned previously in this report, two borings remain as part of the overall scope in the areas of the proposed large cuts near Stations 33+00 to 36+00. The City is in the process of negotiating access permissions for these areas at the time of this report and an addendum addressing the cut considerations will be issued once the borings within the cut areas have been completed. Cuts ranging from approximately a few feet to about 14 feet are planned from about Station 33+00 to Station 36+00.

### 4.6 General Side Slope Considerations

Current designs along the southern section of the project indicate side slopes with inclinations ranging from 2H:1V to 4H:1V. Fill slopes with inclinations of 3H:1V are generally considered stable based on the soil conditions encountered at the boring locations for this project. Cut slopes with inclinations of 2H:1V generally appear to match existing slope inclinations. The existing slopes also appear to be stable and performing favorably. A global stability analysis will be performed for the 2H:1V cut slopes once the borings within the planned cut areas have been completed.

The clay soils found at the site can potentially be highly erosive, a mechanism of soil movement unrelated to global stability. Future erosion and shallow, superficial slumps are always a possibility, despite the results of advanced computer modeling for slope stability. Maintaining healthy vegetation, along with appropriate erosion control practices, will reduce the potential for these issues to become problematic.

Existing side slopes where new fill placement is planned should be benched prior to any new fill placement. Benching and any planned earthwork should be performed in general accordance with the MoDOT Standard Specifications for Highway Construction.

# 5.0 Construction Considerations

## 5.1 Excavations

Trenching, excavating, and bracing should be performed in accordance with Occupational Safety and Health Administration (OSHA) regulations, and other applicable regulatory agencies. In accordance with the OSHA excavation standards, the soil at the site is considered to be Type C, which requires a side slope for excavations no steeper than 1.5H:1.0V. However, worker safety and classification of the excavation soil is the responsibility of the contractor. According to OSHA requirements, any excavation extending to a depth of more than 20 feet must be designed by a registered professional engineer. Where the excavation lies within the zone of influence of existing pavements, buildings, utilities, or other structures, the integrity of those elements should be maintained by a properly designed earth retention system, underpinning, or other suitable means.

Portions of the excavations may be constructed within a few feet horizontally of existing utilities. Some of these utilities are likely backfilled with granular material. The granular backfill may contain free water and could be unstable when excavating beneath or adjacent to it. The undermining of these utilities and the adjacent area could occur due to running and caving of the granular backfill and surrounding soils. Temporary support of any utilities, if present, that cross over or lie adjacent to the excavations will likely be required.

Adequate benching along the slopes to allow for construction equipment and production should be utilized and follow OSHA standards. Heavy machinery, equipment, and tooling should not be stored on the construction benches for extended periods of time. The benches should be constructed with positive drainage in a way to eliminate ponding or standing water while in use. The benches should be backfilled and dressed as the construction advances to eliminate the potential for saturating the slopes.

## 5.2 Subgrade Preparation

After the removal of the existing pavement section materials, and where further excavation is not planned, the exposed subgrade should be proof-rolled, which is accomplished by passing over the subgrade with a loaded tandem axle dump truck and observing the subgrade for pockets of excessively soft, wet, disturbed, or otherwise unsuitable soils. Any unacceptable materials thus found should be excavated and either recompacted or replaced with new fill.

Generally, prior to placing fill, pavement materials, or structural elements in any area, the subgrade should be scarified to a depth of about six inches, the moisture content of the soil adjusted to near its optimum moisture content, and the subgrade recompacted in accordance with recommendations made in subsequent sections of this report. This recommended proof-rolling and recompaction of the subgrade may be waived by Millennia if it is determined based on field observations that it is unnecessary or could be detrimental to the existing subgrade condition.

## 5.3 Subgrade Protection

Construction areas should be properly drained in order to reduce or prevent surface runoff from collecting on the subgrade. Any ponded water on the exposed subgrade should be removed immediately. To prevent unnecessary disturbance of the subgrade soils, trucks and other heavy construction vehicles should be restricted from traveling through the finished subgrade area. If disturbed areas develop, they should be reworked and compacted as previously described.

Generally, prior to placing fill, pavement materials, or structural elements in any area, the subgrade should be scarified to a depth of about 6 inches, the moisture content of the soil adjusted to near its optimum moisture content, and the subgrade recompacted in accordance with recommendations made in subsequent sections of this report. This recommended proofrolling and recompaction of the subgrade may be waived by Millennia if it is determined based on field observations that it is unnecessary or could be detrimental to the existing subgrade condition.

## 5.4 Fill Material

The required site and structural fill and backfill may be constructed using the natural lean clay materials available from on-site excavations. Fill material from off-site borrow sources may also be used, but should be approved by Millennia prior to placement. In general, structural fill should consist of low plasticity lean clays or clayey silts with a liquid limit of less than 50 and a plasticity index of less than 25.

At the time of construction, the moisture content of the fill materials may be variable, and may not be within the range considered necessary for proper placement and compaction. Prior to compaction, some of the soil may require moisture content adjustment. During warm weather, moisture reduction can generally be accomplished by disking, or otherwise aerating, the soil. When air-drying is not feasible, a moisture-reducing chemical additive, such as “Code L” lime dust, could be incorporated into the cohesive soil. Lime dust is a caustic material that should be used with caution by a contractor experienced with its application. Millennia should be consulted to assess the effectiveness of any additive and to recommend the amount and methods for application.

If earthwork is performed during a period of dry weather, some of the fill may require the addition of moisture prior to compaction. This should be performed in a controlled manner using a tank truck with a spray bar, and the moistened soil should be thoroughly blended with a disk or pulverizer to produce a uniform moisture content. Repeated passages of the equipment may be required to achieve a reasonably uniform moisture content.

## 5.5 Fill Placement

Fill for general site grading should be placed in layers not exceeding eight inches in loose thickness and compacted to the required dry density. Backfill compacted by handheld equipment should be placed in layers not greater than six inches. The layer thickness may be increased if tests indicate that compaction could be achieved uniformly throughout the layer using a greater thickness. At the time of compaction, fill should generally be within three percent, wet or dry, of the optimum moisture content of the material as determined by the standard Proctor compaction test, ASTM D 698. Fill should be compacted to a dry density of not less than 95 percent of the standard Proctor maximum dry density of the material. In order to develop a usable Proctor curve, sand fill will need to include a component of finer sand or silt. Well graded sands, while typically suitable for use as fill, can be difficult to test for compliance with compacted density specifications. Granular material such as crushed limestone, placed for structure support should be compacted to at least 100% of the standard Proctor maximum dry density.

Backfill placed next to walls or foundations should be compacted with hand-operated compaction equipment and not large self-propelled or machine-operated equipment. The operation of large pieces of equipment adjacent to these structures can result in overcompaction and higher lateral pressures than those recommended herein for design. Compaction should be reduced within approximately one foot of any structures. Structures should be observed periodically during backfilling for signs of movement. If movement is detected, it may be necessary to change backfilling procedures.

### 5.6 Groundwater Considerations

The potential for groundwater seepage will depend in-part upon the magnitude of cuts and fills required to develop the site, which will be governed by the eventual grading plan. Groundwater seepage is not expected to be significant during general site grading activities for the roadway portion of the project. Should groundwater seepage be encountered during excavation, it is expected that it can be handled by an excavation drainage system consisting of drainage ditches, sumps, and pumps. In the absence of significant rainfall, saturated zones should drain over a period of days. If more significant groundwater flow is encountered, Millennia should be contacted to assess the situation.

Groundwater control options for the culvert are discussed in Section 4.2 of this report.

### 5.7 Soft Subgrade

Soft subgrade conditions were not encountered in the surficial soils of the borings along the roadway alignment. However, if during the course of construction, soft or disturbed soils are encountered, the recommendations in the following paragraph should be followed. Soft soils that are encountered at the pavement subgrade level may be difficult to recompact to the required density in a conventional manner. These soils may require removal and replacement with crushed limestone. No more than 1 to 2 feet of overexcavation is expected to be necessary. Crushed limestone with a gradation similar to Type 5 Aggregate as specified by MoDOT would be acceptable replacement fill. The crushed limestone should be placed in 8-inch lifts and mechanically compacted to 100% of the standard Proctor maximum density of the material (ASTM D 698). At the time of compaction, the crushed limestone should be within 3% of the optimum moisture content of the material as determined by the standard Proctor compaction test. Alternatively, a soft subgrade could be stabilized by using a lime additive. Typically, “Code L” or quicklime in the amount of 3 to 5% of the dry weight of the soil should be effective for the lean clay soils. The lime should be thoroughly mixed into the top 12 inches of the subgrade, allowed to hydrate, then the soil recompacted to 95% of the standard Proctor maximum density. Caution should be used when applying lime, and local authorities should be contacted for permission to use lime, for it is a fine-grained and somewhat caustic material that is easily windborne. Millennia should be consulted if extensive areas of soft subgrade soils are encountered that prove difficult to compact.

## 6.0 Construction Phase Services

It is recommended that Millennia review the plans and specifications for the project prior to bid solicitation in order to determine the relationship of the geotechnical information presented in this report with the final design of the substation rebuild. This additional service is recommended in order to reduce construction phase problems that might otherwise arise in the field and result in construction delays or change orders.

Documenting observations and performing materials testing during construction of foundations, retaining walls, pavements, and other structures that are supported by earth materials, is an integral aspect of the geotechnical engineering process. The geotechnical engineering profession is based on the "Observational Method," through which design assumptions and recommendations, based on limited drilling and sampling data, can be verified or modified in response to actual conditions observed as the materials are exposed by construction equipment.

Selecting the same firm that provided the geotechnical engineering services to also perform observation and materials testing services during construction results in decreased risk to the owner and entire design team. The geotechnical firm is most familiar with the site and can recognize unanticipated conditions that might otherwise adversely affect construction progress or structure performance. Millennia has a staff of experienced field technicians and a geotechnical and materials testing laboratory equipped to support a wide variety of construction projects. After the project plans and specifications have been prepared, Millennia requests the opportunity to submit a proposal to perform the specified construction observation and materials testing services.

For this project, it is recommended that Millennia be retained by Oates Associates or the owner during construction to perform the following observations and field tests, where applicable:

- Observation and documentation of asphalt placement, along with compaction testing for conformance with the project specifications.
- Observation of earthwork operations for the new road construction, including proof roll, and compaction of soil and base rock.
- Quality assurance testing of fresh concrete delivered to the site, and compressive strength testing of concrete cylinders cast on site for conformance with the project specifications, if applicable
- Observation and documentation of topsoil stripping and the removal of any deleterious materials encountered.
- Observation and documentation of fill and backfill placement, along with compaction testing for conformance with the project specifications.

These quality assurance services should help to verify design assumptions, and to maintain construction procedures in accordance with the contract plans, specifications, and good construction and engineering practices.

## 7.0 Closing

This report has been prepared for the exclusive use of Oates Associates for use in the design and construction for the proposed new roadway improvements along Hunning Road in Jefferson County, Missouri. This report has been prepared in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made to the professional advice and recommendations included herein. This report is not for use by parties other than those named or for purposes other than those stated herein. It may not contain sufficient information for the use of other parties or for other purposes.

If there is a substantial lapse of time between the submission of this report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, this report should be reviewed by Millennia to determine the applicability of the analyses and recommendations considering the changed conditions and time lapse. The report should also be reviewed by Millennia if changes occur in structure location, size, and type, or in the planned loads, elevations, grading plans, and project concepts.

These analyses and recommendations are based on data obtained from site reconnaissance, the borings performed for this study and other pertinent information presented herein. This report does not reflect any variations between, beyond, or below the borings. Should such variations become evident, it may be necessary to re-evaluate the recommendations of this report after performing on-site observation during the construction period and noting the characteristics of any such variation.

We appreciate this opportunity to be of service to you and would be pleased to discuss any aspect of this report with you at your convenience.

Sincerely,

**Millennia Professional Services, Ltd.**

Jacob A. Schaeffer, P.E.
Project Manager

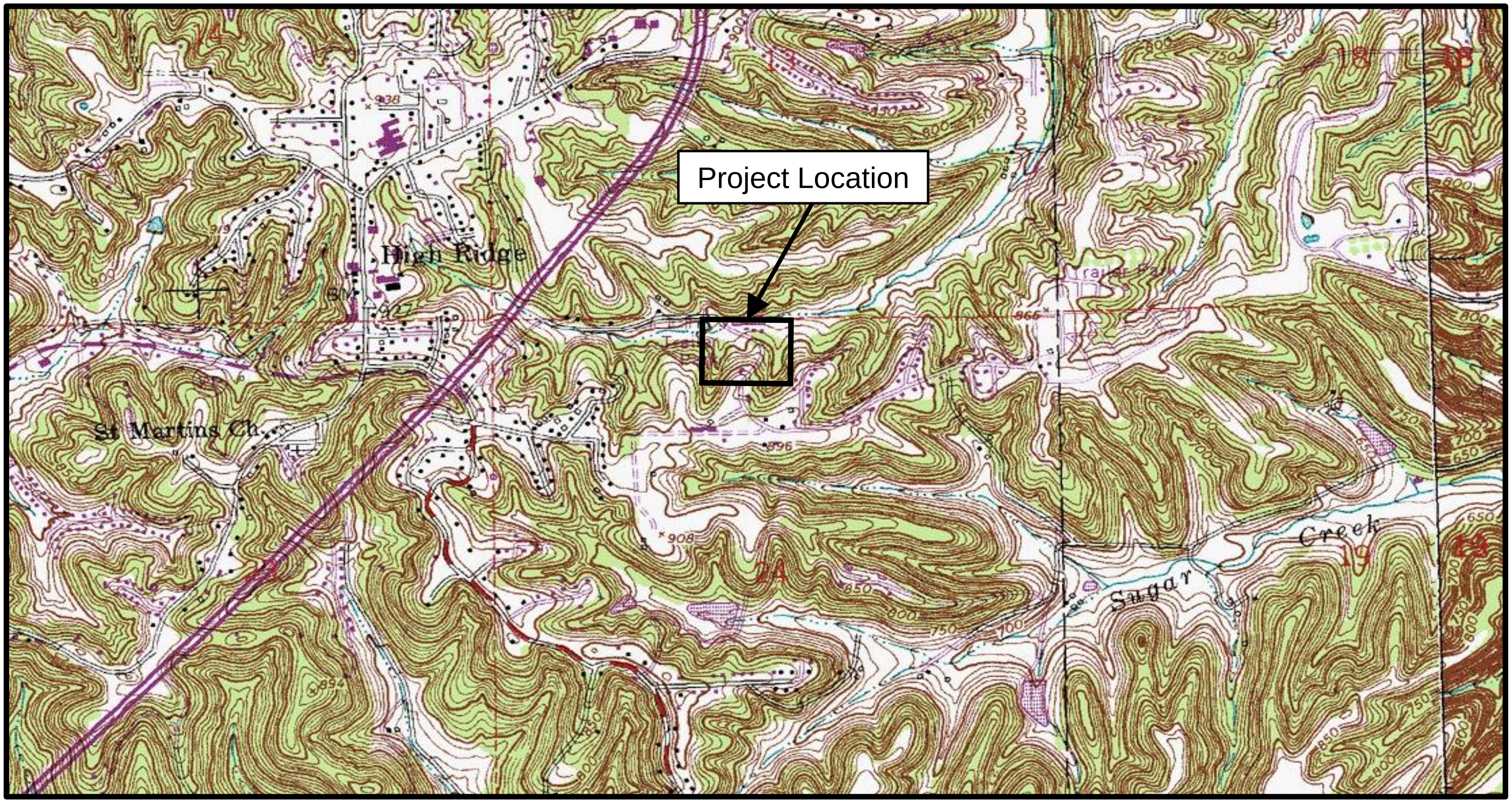
STATE OF MISSOURI
JACOB A.
SCHAEFFER
3-24-22
NUMBER
PE-2015017050
PROFESSIONAL ENGINEER

# Appendix A

## Vicinity Map – Figure 1
## Boring Location Plan - Figure 2

# Millennia Professional Services

6439 Plymouth Ave W-129, St. Louis, MO
Phone: (618) 624-8610
Fax: (618) 624-8611
Project No.: MG21043




N

Image obtained from TopoQuest

*Not to scale

**FIGURE 1: VICINITY MAP**

Hunning Road - Safety Improvement
High Ridge, Missouri

| | | | |
|---|---|---|---|
| Drawn by: | M. Jenkins | Checked by: | J. Schaeffer |
| Project No.: | MG21043 | Date: | 8/12/2021 |

Millennia Professional Services
6439 Plymouth Ave W-129, St. Louis, MO
Phone: (618) 624-8610
Fax: (618) 624-8611
Project No.: MG21043

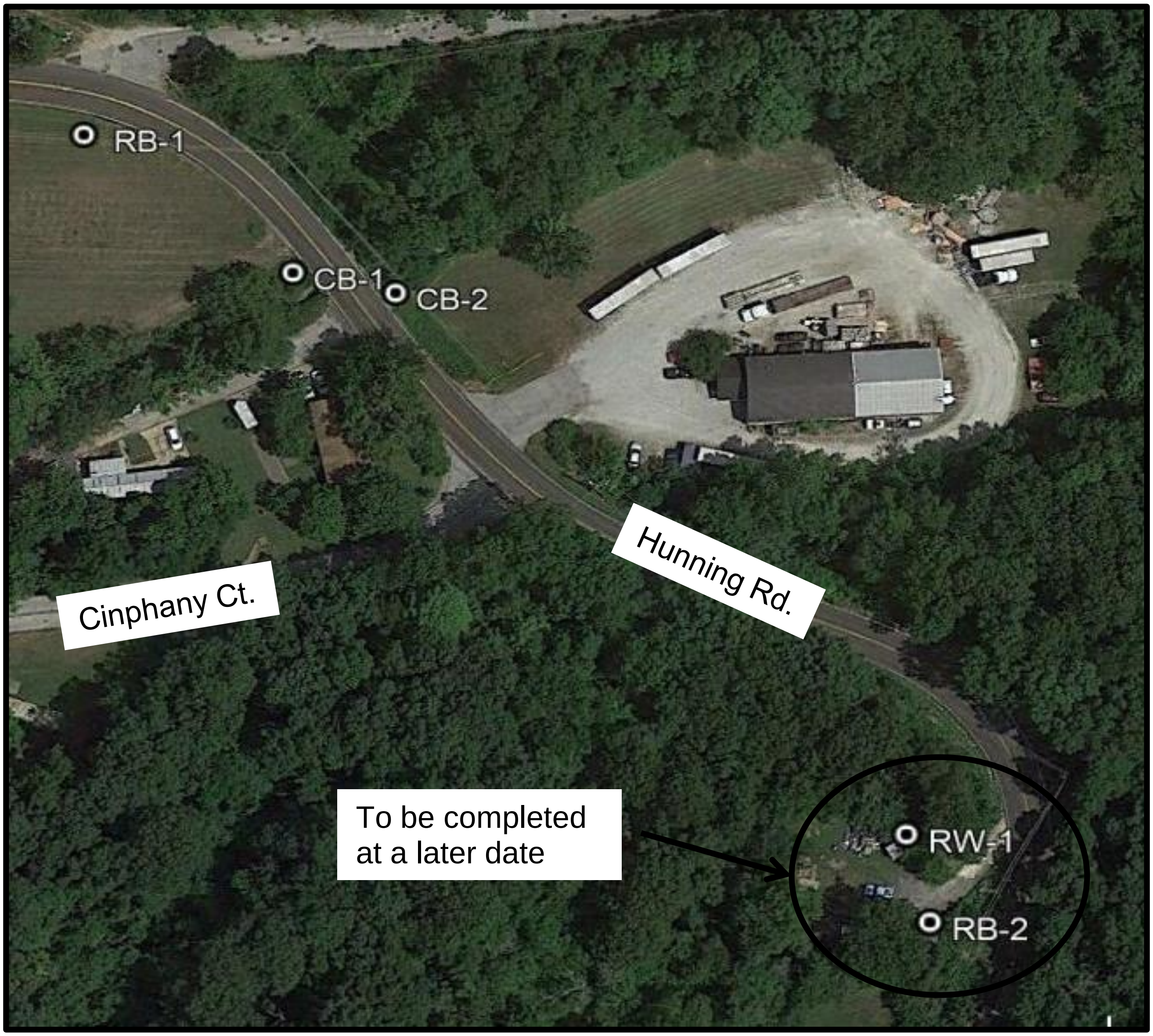



**FIGURE 2: BORING LOCATION PLAN**

Hunning Road - Safety Improvement
High Ridge, Missouri

N

| | | | | |
|---|---|---|---|---|
| Approximate Boring Location: ◉ | Drawn by: | M. Jenkins | Checked by: | J. Schaeffer |
| Image obtained from Google Earth<br>*Not to scale | Project No.: | MG21043 | Date: | 3/22/2022 |

# Appendix B

## Boring Logs

# BORING NUMBER CB-1



Millennia Professional Services

**CLIENT** High Ridge, MO
**PROJECT NAME** Hunning Road Improvements
**PROJECT NUMBER** MG21043
**PROJECT LOCATION** High Ridge, MO
**DATE STARTED** 1/10/22 **COMPLETED** 1/10/22
**GROUND ELEVATION** **HOLE SIZE** inches
**DRILLING CONTRACTOR** Jacobi Geotechnical
**GROUND WATER LEVELS:**
**DRILLING METHOD** Hollow Stem Auger
▽ **AT TIME OF DRILLING** 14.00 ft
**LOGGED BY** P. Adhikari **CHECKED BY** J. Schaeffer
▼ **AT END OF DRILLING** 15.00 ft
**NOTES**
**AFTER DRILLING** ---

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil (3.0 in.) | | | | | | | | | | |
| | | Brown, lean CLAY (CL), trace chert | | | | | | | | | | |
| | | | SS 1 | 50 | 3-4-2 (6) | 2.0 | | 16 | | | | |
| 5 | | | SS 2 | 61 | 1-3-5 (8) | 0.5 | | 21 | | | | |
| | | - with chert below 6.0 ft. | SS 3 | 67 | 10-14-14 (28) | 3.5 | | 19 | | | | |
| 10 | | - with sand and chert below 8.5 ft. | SS 4 | 61 | 14-19-19 (38) | 1.5 | | 15 | | | | |
| 15 | ▽ ▼ | - trace sand below 13.5 ft. | SS 5 | 100 | 1-2-2 (4) | 0.5 | | 25 | | | | |
| | | | SS 6 | 44 | 4-6-2 (8) | 1.25 | | 25 | | | | |
| | | Brown, clayey GRAVEL (GC), with sand | | | | | | | | | | |
| 20 | | | SS 7 | 17 | 6-7-6 (13) | | | | | | | |

Bottom of borehole at 20.0 feet.

# BORING NUMBER CB-2



Millennia Professional Services

**CLIENT** High Ridge, MO
**PROJECT NAME** Hunning Road Improvements
**PROJECT NUMBER** MG21043
**PROJECT LOCATION** High Ridge, MO
**DATE STARTED** 1/10/22 **COMPLETED** 1/10/22
**GROUND ELEVATION** **HOLE SIZE** inches
**DRILLING CONTRACTOR** Jacobi Geotechnical
**GROUND WATER LEVELS:**
**DRILLING METHOD** Hollow Stem Auger
**AT TIME OF DRILLING** ---
**LOGGED BY** P. Adhikari **CHECKED BY** J. Schaeffer
**AT END OF DRILLING** ---
**NOTES**
**AFTER DRILLING** ---

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | FILL: Brown, lean CLAY (CL), with gravel, trace brick fines | | | | | | | | | | |
| | | | SS 1 | 44 | 3-5-4 (9) | 1.25 | | 19 | | | | |
| | | Brown lean CLAY (CL), trace chert | | | | | | | | | | |
| | | | SS 2 | 28 | 2-4-3 (7) | 2.0 | | 23 | | | | |
| 5 | | | | | | | | | | | | |
| | | - soft, trace gravel below 6.0 ft. | SS 3 | 11 | 0-3-2 (5) | 0.5 | | 26 | | | | |
| | | Brown, clayey GRAVEL (GC), with sand | | | | | | | | | | |
| | | | SS 4 | 41 | 10-13-50/5" | | | 14 | | | | |
| 10 | | | | | | | | | | | | |
| | | Brown, SANDSTONE | SS 5 | 100 | 50/3" | 4.5 | | 9 | | | | |

Refusal at 13.3 feet.
Bottom of borehole at 13.3 feet.

# BORING NUMBER RB-1



Millennia Professional Services

**CLIENT** High Ridge, MO
**PROJECT NAME** Hunning Road Improvements
**PROJECT NUMBER** MG21043
**PROJECT LOCATION** High Ridge, MO
**DATE STARTED** 1/10/22 **COMPLETED** 1/10/22
**GROUND ELEVATION** **HOLE SIZE** inches
**DRILLING CONTRACTOR** Jacobi Geotechnical
**GROUND WATER LEVELS:**
**DRILLING METHOD** Hollow Stem Auger
**AT TIME OF DRILLING** --- Dry
**LOGGED BY** P. Adhikari **CHECKED BY** J. Schaeffer
**AT END OF DRILLING** --- Dry
**NOTES**
**AFTER DRILLING** ---

| DEPTH (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN. (tsf) | DRY UNIT WT. (pcf) | MOISTURE CONTENT (%) | ATTERBERG LIMITS: LIQUID LIMIT | ATTERBERG LIMITS: PLASTIC LIMIT | ATTERBERG LIMITS: PLASTICITY INDEX | FINES CONTENT (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | Brown, lean CLAY (CL), trace gravel and chert | | | | | | | | | | |
| | | | SS 1 | 39 | 3-4-4 (8) | 1.5 | | 21 | | | | |
| | | - with gravel below 3.0 ft.<br>- undrained shear strength = 0.31 tsf at 3.0 ft. | ST 2 | 71 | | 2.5 | 99 | 22 | | | | |
| 5 | | | | | | | | | | | | |

Bottom of borehole at 5.0 feet.

# GENERAL NOTES

The number of borings is based on topographic and geologic factors: the magnitude of loading; the size, shape, and value of the structure; consequences of failure; and other factors. The type and sequence of sampling is selected to reduce the possibility of undiscovered anomalies and increase drilling efficiency. Attempts are made to detect and/or identify occurrences during drilling and sampling such as encountering water, boulders, gas, zones of lost circulation, relative ease or resistance of drilling progress, unusual sample recovery, variation in driving resistance, unusual odors, etc. However, lack of mention of such variations does not preclude their presence.

Although attempts are made to obtain stabilized groundwater levels, the levels shown on the Boring Logs may not have stabilized, particularly in more permeable cohesive soils. Consequently, the indicated groundwater levels may not represent present or future levels. Groundwater levels may vary significantly over time due to effects of precipitation, infiltration, or other factors not evident at the times indicated.

Unless otherwise noted, soil classifications indicated on the Boring Logs are based on visual observations and are not the result of classification tests. Although visual classifications are performed by experienced technicians or engineers, classifications so made may not be conclusive.

Generally, variations in texture less than one foot in thickness will be described as seams while thicker strata will be logged as individual strata. However, minor anomalies and changes of questionable lateral extent may appear only in the verbal description. The lines indicating changes in strata on the Boring Logs are approximate boundaries only as the actual material change may be between samples or may be a gradual transition.

Samples chosen for laboratory testing are selected in such a manner so as to determine selected physical characteristics of each material encountered. However, as samples are recovered only intermittently and only representative samples are tested, the results of such tests may not conclusively represent the characteristics of all subsurface materials present.

# Appendix C

## Laboratory Test Results

## Unconfined Compression Test - ASTM D2166

| | | | |
|---|---|---|---|
| Project Name: | Hunning Road Safety Improvements | Boring: | RB-1 |
| Project No.: | MG21043 | Sample ID: | ST-2 |
| | | Sample Depth: | 3.0 |

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### Lab Test Results

| | |
|---|---|
| Dry Unit Weight: | 99.1 pcf |
| Moisture Content: | 22.2% |
| Undrained Shear Strength: | 0.31 tsf |