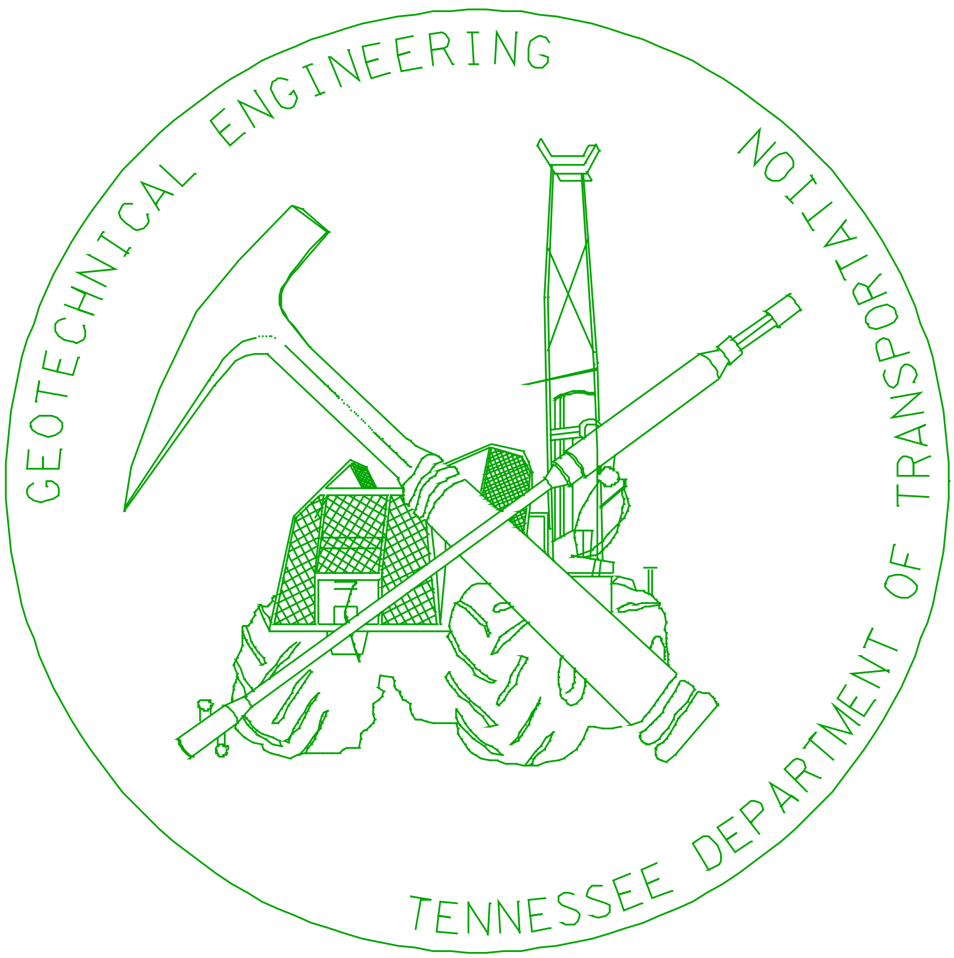
Section 1:

Geotechnical Report Manual



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TDOT Geotechnical Manual

Section 1: Geotechnical Consultant Manual

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Abstract			
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Introduction

Guidelines for geotechnical work should always be taken as a starting place for reports and investigations. They are not meant to be rigid rules, which apply a straight-jacket to the engineer or geologist responsible for a given project. Common sense and general geotechnical practice should always be used. The road to hell may be paved with good intentions, but the road to geotechnical disaster can be paved with too rigid an application of manuals and standards without the concurrent application of judgment and consideration of site conditions.

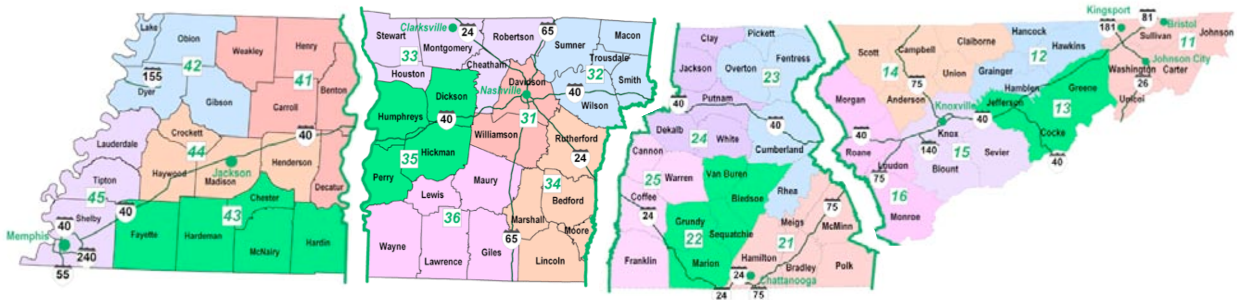
The intent of this document is to set out the information required to achieve the ends needed for TDOT projects. Included here are example drawings sheets, example reports and lists of required information for an investigation. This does not mean that there is no room for new techniques, better investigation methods or that the only information to be gathered at a site is set forth in this document. Each site and each project have their own unique problems and challenges. The intent of this document is to provide guidance for TDOT needs; not to attempt to codify all potential circumstances that the geotechnical engineer or engineering geologist may encounter.

A note on nomenclature

Throughout this document, divisions and sections within TDOT will be referred to using part of their name as a proper noun. For example, Structures, for the Structures Division or Geotechnical for the Geotechnical Engineering Section. Consultants may be hired by TDOT to perform these functions, and these general headings extend to the TDOT designated representatives.

Common Name	TDOT Department
Structures	Structures Division
Design	Design Division
ROW	Right of Way
Geotechnical	Geotechnical Engineering Section: Division of Materials and Tests
Environmental	Environmental Division
Maintenance	Maintenance Division
Construction	Construction Division

TDOT Regions and Geotechnical Offices



Region 4 **Region 3** **Region 2** **Region 1**

There are two geotechnical offices located within the state of Tennessee in the Department of Transportation: one in Nashville and one in Knoxville. All TDOT geotechnical work goes through one of these two offices. Region 1 work is the responsibility of the Knoxville Geotechnical Office. Work in Regions 2-4 are the responsibility of the Nashville Geotechnical Office with a few Region 2 projects shared with the Knoxville Geotechnical Office. The Geotechnical Engineering Section is part of the Division of Materials and Tests, located in Nashville which is part of the Engineering Bureau under TDOT's Chief Engineer.

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Geotechnical File Numbers and Project Numbers

All projects have a GES File Number that has been established for the project. This file number is to be used on all reports, documents, drawings and correspondence as it is the primary means for tracking projects within the Geotechnical Engineering Section. TDOT Project numbers are often shown on plans provided by Design and include the PE (Preliminary Engineering Number). This number should also be used on all reports, documents and correspondence. Another number which has come into common use at TDOT is the Pin number. This is a number that is permanently assigned to a project.

GES File Number Structure

GES File Number	County	Sequence	Fiscal Year
2600106	26	001	06

TDOT Project Number Structure

TDOT Project Number	County	Section Number	Job			Funds	
			Type Work	State System	Job Sequence Number	Federal	State
26011-1205-04	26	011	1	2	05	0	4

County - All counties in Tennessee are numbered in Alphabetical Order 1-95. Anderson County is 01 and Wilson County is 95. Development district projects use 96, region wide projects use 98 and Statewide projects use 99.

Sequence - Used with the GES File Number. A sequence number of 001 indicates the first project to be assigned a file number in a given fiscal year. Likewise a sequence number of 152 would be the 152nd project to be assigned a file number in a given year.

Fiscal Year - Fiscal year project was requested.

Section Number - This is assigned by Planning. It is a number given to a section of a highway that has similar geometrics or operating characteristics. It is used to subdivide a roadway into convenient or logical units.

Job - This is the job number assigned to a project, it has 3 components: 1. Type Work, 2. State System, 3. Job Sequence Number.

Type Work - This code indicates what type of work is being performed under the project number. Geotechnical studies for new projects almost always come under Code 1.

Code	Description
0	PE (Preliminary Engineering) for Planning and Environmental Studies
1	PE for Survey and Road Design
2	Right of Way Acquisition
3	Construction and Reconstruction
4	Routine Maintenance
5	PE for Structure Design
7	Planning and Research Projects
8	Resurfacing Projects
9	Outdoor Advertising, Mass Transit, Waterways and Rail

State System - This number indicates what kind of roadway the project is located upon.

Code	Description
1	Interstate
2	State Highway System (State Routes)
3	Rural System
4	Local County Roads
5	Local City Streets
6	No System
7	New Urban System

Job Sequence Number - Indicates the order a in which a project number was assigned along a section of roadway. A job sequence number of 001 indicates the first project issued along that section. Likewise a job sequence number of 011 indicates the 11th project issued along that section.

Funds - indicates the funding source for the project. It has two components: 1. Federal and 2. State.

Federal Funds - This code indicates the Federal appropriation authorized for the project.

Code	Description
0	No federal funds
1	Federal Aid - Primary
2	Federal Aid - Secondary
3	Federal Aid - Grade Crossing, Overhead Separations, Tunnels, Underpasses etc.
4	Federal Aid - Interstate
5	Federal Aid - Urban
6	Federal Aid - Appalachia
7	Federal Aid - HPR
8	Federal Aid - Forest Highways
9	Federal Aid - Other

State Funds - This number indicates TDOT’s accounting fund used for the project.

Code	Description
3	Rural and Secondary Roads Fund
4	State Highway Fund
9	Aeronautics

Chapter 1: West Tennessee Bridges

West Tennessee Bridges are those bridges in which rock is generally greater than 100 feet in depth. These are primarily located west of the Tennessee River and in TDOT Region 4. However, these provisions can be used for any bridge where friction piles are the preferred foundation alternative. For all other bridges, please see Chapter 2: General Bridge Projects.

Goals of investigation

The primary goals of a bridge project in West Tennessee is to gather subsurface data for the design of bridge piles, to check the slope stability of the embankment, to provide information for scour analysis, and to provide information for pavement design. Typically this involves drilling of at least 2 deep holes and liquefaction analysis. The end product of the investigation is a geotechnical report that addresses these issues as well as a bridge foundation data sheet that is prepared for the Structures Division.

This bridge foundation data sheet, along with the geotechnical report will be used to design the appropriate foundations. The data sheet will be included as a plans sheet. The Structures Division will use the geotechnical report to complete their design and will include other appropriate plans sheets for the foundations. If there are stability considerations that require alteration to the site or involve some geotechnical work, cross sections shall be supplied to detail the work needed. All appropriate recommendations, such as slope ratios and other geotechnical elements needed to address slope stability at the embankments shall be included on these cross sections as the geotechnical report will not be directly incorporated into the plans. Please see "Bridge and Approach Projects" also included in this manual for further detail

Drilling Requirements

For each bridge, at least 2 holes shall be drilled to sufficient depth for piles to support a bridge. These must be drilled sufficiently deep so that there is at least 10 feet of soil below any layers that are predicted to liquefy. AASHTO guidelines do not require liquefaction analysis for 1 span bridges, however even for these small bridges, unless very dense sand is hit, we typically drill from 75-90 feet in depth. Larger, more critical bridges will require more drilling. SPT or CPT shall be performed sufficient to describe the site for the purposes of:

1. Liquefaction Analysis,
2. Pile design,
3. Corrosion checks, and
4. Scour calculations.

Samples shall be taken at least every 5 feet. More holes may be appropriate at the site for a large bridge, for an interstate bridge or where there is significant variation in the subsurface conditions. Shelby tubes sufficient for checking embankment stability at the bridge may also be needed. Other drilling techniques that provide the necessary information may also be acceptable. For project where CPT testing is performed, at least one hole should be SPT, in order to gather samples for laboratory testing. All layers of soil shall be identified and appropriate parameters recorded during exploration.

Critical interstate bridges may require some complex analyses, please see current AASHTO guidelines for guidance. The required analyses may require additional exploration and more complex techniques.

Laboratory Analysis

If a bridge project has not had a “bridge and approach” report performed at the site before bridge foundation exploration, then all of the testing and laboratory analysis required for those projects shall be performed.

All SPT samples shall have Gradation, Hydrometer, Atterberg limits, pH and Resistivity tests performed. Each sample shall be classified by both AASHTO and USCS systems. Other testing may be performed as needed to provide sufficient information for the prediction of liquefaction and corrosion.

Engineering Analysis

One of the main geotechnical issues in West Tennessee is the New Madrid Seismic Zone. Acceleration maps are available from a variety of sources including the USGS as well as some studies performed by Memphis State University. Liquefaction analysis must be performed on all coarse-grained materials and we typically perform these for every appropriate SPT sample taken. AASHTO requires that this analysis be performed within a seismic risk area for all bridges larger than 1 span. All layers that have the potential for liquefaction must be clearly noted on the foundation data sheet supplied with the geotechnical report.

Critical and interstate bridges may require some complex analyses, please see current AASHTO guidelines for guidance. These analyses may include, site specific seismic analysis, CPT testing, soil-structure interaction considerations among others.

Geotechnical Report and Drawings

The geotechnical report for a West Tennessee bridge project should detail the investigations and the recommendations for the site. Recommendations for design parameters such as fs and qb shall be supplied for concrete friction piles, pipe piles and steel H piles. All cross sections provided with the report shall have explanatory material included in the report. For example, if a cross section is provided that is typical for station 30+00 to 34+50, there should be a section in the report that specifically references this drawing and provides a description of the repair and any needed geotechnical notes. All typed boring logs shall be included with the report as well as any laboratory results. This report will primarily be used by the GES and as a reference for the exploration performed at the site.

Report Format

Executive Summary or Cover Letter – this section gives a brief summary of the report.

Introduction – brief summary of the project and location. Any special constraints such as very limited right of way are noted here.

Geology, Soils and Site Conditions – All geology, soils and site conditions that may affect the project.

Surface and Subsurface Exploration – Exploration Performed

Recommendations – Provide recommendations for construction purposes such as types of foundations recommended, any site improvements and identification of soil layers that are representative for scour analysis.

Special Notes and Specifications – Any special notes to be included in the plans, these should also be on the cross sections, if provided. This section may be omitted if no special notes or specifications are required.

Appendix – Documents, boring logs and supporting information.

- Foundation Data Sheet
- Boring Logs
- Laboratory Testing
- Engineering Analyses and supporting Documents

The GES does require that all project documents be provided in both electronic and paper form.

Foundation Data Sheet Elements

The geotechnical sheets for a West Tennessee bridge project shall include a plan view layout of the drill holes, drill holes plotted by depth and any cross sections required to illustrate geotechnical design elements. The initial bridge sketch is provided either by the Structures Division or their designated representative. Drill holes and geotechnical information shall be plotted on these sheets. Cross sections, if any, shall also be included. Information other than foundation recommendations and layers representative for scour included in the report, but not on these sheets, may not make it into the construction plans. If this occurs, these geotechnical recommendations would then likely be ignored. It is critical that recommendations be illustrated with geotechnical plans sheets. The following elements must be included:

General Layout of Site – Plan view showing drilling and sampling locations. Usually placed on the bridge sketch supplied by Structures.

Graphical Boring Logs – showing all drill logs, these must show elevations and material types with elevations included. Fs and qb factors shall be shown as well as N values and all layers identified as subject to liquefaction shall be shown.

Example Reports and Geotechnical Sheets

The following pages show an example report and bridge sheet for a West Tennessee Bridge Project. Please see *Section 1: Appendix A - Examples* for these documents.

- West Tennessee Bridge Report
- West Tennessee Bridge Sketch

Supporting Documentation

Static Pile Capacity Charts

Please see *Section 1: Appendix B - Supporting Documents* for the "Static Pile Capacity" charts as developed and used at TDOT. Please note that one sheet shows only the unit pile and one specifies a particular concrete friction pile. If these charts are used for design, please use the unit chart for fs and qb. The other chart was designed as a field aid to check bearing during exploration. Please note that this chart is to be used at the geotechnical engineer / engineering geologists risk. These charts when used as a field aid will *not* guarantee that adequate exploration has been performed, as these charts do not account for liquefaction. These values may not be accurate where proper SPT procedures are not used. They were developed for a CME drill rigs with use of automatic hammers. Other equipment may give different results. Please note that the maximum values of fs and qb are achieved with N=30. For blow counts above this value, do not extrapolate further values, but use the values for N=30. For steel or pipe piles the fs values given on the chart are reduced by 1/3.

Chapter 2: General Bridge Projects

General bridge projects are all those which do not use friction piles for support. These projects will generally be all of those in Regions 1-3 and some in Region 4. When rock is greater than 100 feet, friction piles should be considered and the provisions for West Tennessee Bridge Projects shall be followed.

Goals of Investigation

The goal for non-west Tennessee bridge projects is to provide recommendations for appropriate bridge foundations and to evaluate embankment stability. If significant alterations are being made to the surrounding ground, a bridge and approach project should also be completed. These projects may have highly variable bedrock and be subject to karst related problems. Sufficient drilling must be completed in order to design appropriate foundation; this information is then sent on to TDOT Structures or their designated representatives. The primary end products for this type of investigation is a bridge foundation data sheet and a bridge foundation report used to describe appropriate foundation alternatives. A preferred alternative shall be laid out, but other foundation alternatives may be given in the report. Unlike retaining wall foundations, however, not every alternative will be shown on the drawings. Alternatives shall be discussed in the geotechnical report, and the foundation type actually used will be selected by Structures, with the occasional consultation by Geotechnical.

Drilling Requirements

The drilling performed at the site can be highly variable according to the depth of solid rock and the variability of the site. We generally recommend at least one to three holes per substructure, but this number may be increased when there is significant site variability. Appropriate explorations may include, but are not limited to, wireline drilling, SPT samples, auguring and hollow-stem auguring. Foundation types that are typically selected are shallow spread footings on rock, steel H piles and drilled shafts. Other alternatives such as micropiles and more innovative methods may also be recommended where appropriate, particularly if these methods are more suitable to site conditions than more "traditional" methods. Please note that at this time the Structures Division does not accept spread footings on soil for bridge foundations it is judged that the settlement risk is too high to allow such a foundation.

It is also important to pay particular attention to the bridge layout sketch as provided by Structures. Many bridge projects may involve a retaining wall used to limit the approach fill, and may not be given out as separate projects. If there is a retaining wall shown on a sketch, it is the responsibility of the Geotech to complete appropriate drilling, reporting and drawings for this structure in addition to the bridge exploration. Please see *Chapter 4: Retaining Wall Projects* included in this manual. Samples of soil shall be taken as appropriate in order to design the selected foundations and to evaluate embankment stability. Rock samples are also generally taken for laboratory testing. Please note that if advanced methods such as p-y analyses are used for lateral capacity of soils for deep foundations, additional drilling and sampling may be required. RQD and recovery shall be recorded for all rock samples and photographs shall be taken of all rock core.

Some rules of thumb employed at TDOT for sufficient drilling are as follows. As always, judgement, AASHTO guidelines and generally accepted geotechnical practice should also be used:

1. Shallow foundations in rock - at least 10 feet of good bedrock
2. Driven piles in rock - at least 5 feet of good bedrock
3. Drilled shafts in rock - at least 15-20 feet of good bedrock.

Please note that with drilled shafts the appropriate depth of rock to be drilled will vary depending upon whether or not the shaft will be end bearing or will be carried in side friction. General policy at TDOT at this time is that drilled shafts are designed either as friction or as end bearing. Variances in this shall be discussed with Structures. Also, please note that AASHTO guidelines specify a depth below the base of the shaft of 1.5* shaft diameter in flat lying rock and 2*shaft diameter in tilted rock. While this may be a conservative requirement, it remains in the current standards. This can be of great significance during exploration as this can increase the amount of rock that should be cored for the project in order to fulfill this design requirement.

Karst issues and problems should also receive special consideration. Bridge foundations in highly cavernous rock can present very difficult issues both in exploration and in constructability. Constructability concerns should be addressed by the geotechnical engineer / engineering geologist. Drilled shafts may require casing in rock due to cavities in the rock. Shallow foundations, which may appear appropriate when looking at the ground surface may turn out to be impractical due to only a small amount of competent rock in a layer. Also, due to the highly variable nature of many karst rocks, additional drill holes, or additional depth may be necessary in order to adequately design the bridge foundations. Similar problems may occur when a bridge site is located in an area where there has been faulting. Such areas can be very challenging.

Laboratory Analysis

Laboratory analysis may include, but not be limited to unconfined compressive tests for rock as well as gradation, classification, atterberg limits and hydrometer analysis for soils. Additionally, triaxial or other tests may be appropriate for checking embankment stability.

Engineering Analysis

Bearing capacity analysis is the primary calculation that must be performed for this type of project. Others may include stability analysis, p-y analysis and others as needed. Side friction calculations may need to be made for drilled shafts and other deep foundations. There are many methods for calculating the appropriate factors in soils and rock. However, TDOT does require that the methods used be a generally accepted and have some documentation. If a new or unfamiliar method is applied, checks with other methods or documentation for the method may be requested.

Geotechnical Report and Drawings

The geotechnical report for a bridge foundation report shall include details of the investigation, boring logs, engineering analysis and recommendations for foundation types and parameters necessary for design of the selected foundation types. These reports are generated to aid Structures in design and to document work and reasoning for Geotechnical.

New or innovative foundations may require more lengthly explanations as to why these are most appropriate for the site. A preferred alternative shall be selected, though other appropriate foundation types may be detailed in the report. This type of report is used both by the Geotechnical section and the Structures Division. The Structures division will select and design the foundations based on the information contained in the geotechnical report. All appropriate parameters for foundation design shall be included in the report. These may include items such as the following:

- Elevation of foundation bearing layer
- Elevation of first encounter of rock
- Type(s) of foundations recommended
- Bearing Capacity of rock: ultimate and allowable along with appropriate factor of safety
- Appropriate depth of rock socket
- Lateral capacity of soil or rock
- Side Friction factors

Geotechnical Report Format

Executive Summary or Cover Letter – this section gives a brief summary of the report.

Introduction – brief summary of the project and location. Any special constraints such as very limited right of way are noted here.

Geology, Soils and Site Conditions – All geology, soils and site conditions that may affect the project.

Surface and Subsurface Exploration – Exploration Performed

Recommendations – Provide recommendations for foundation design. This includes foundation type and all parameters needed for design.

Appendix – Documents and supporting data

- Foundation Data Sheet
- Boring Logs - these must include location data on the typed logs.
- Laboratory Testing
- Engineering Analyses
- Other documents

Foundation Data Sheet Elements

Unlike many other types of geotechnical drawings, the foundation data sheets for bridges do not require that all recommendations be reflected on the plans. These may be made in the geotechnical report; the Structures Division or their representative will provide other drawings for bridge foundations as required. If any alterations need to be made to the site due to embankment stability issues, cross sections detailing these requirements may be necessary.

General Layout of Site – plan view showing drilling and sampling locations. Usually placed on the bridge sketch supplied by Structures.

Graphical Boring Logs – showing all drill logs, these must show elevations and material types with elevations included.

Elevation Chart - showing the existing ground elevation at the time of exploration and first rock encounter elevation for all borings.

Example Reports and Bridge Foundation Data Sheets

Please see *Section 1: Appendix A - Examples* for these documents.

- General Bridge Report
- General Bridge Sketch

Chapter 3: Bridge and Approaches

A bridge and approach project consists of the geotechnical investigation for the roadway and slopes leading up to and away from a bridge locations. Despite the name, it does not include the investigation for the bridge structure which was covered under Chapter 1 and 2. A consultant may be given both the Bridge and the Bridge and Approaches to complete. These should be written up as separate reports, though they may be submitted in one binder. The Bridge and Approaches are primarily used by Design, bridge structure investigations are primarily used by Structures.

Goals of Investigation

The end result of a bridge and approach investigation project is to supply Geotechnical Sheets that describe any pertinent geotechnical issues and to provide CBR values for pavement design. These projects are often small and are in support of a bridge replacement or improvement. These differ from bridge projects where there is a large line improvement or change in that they are much more limited in affected area. These projects range from the very simple, which require little or no drilling to large cuts and fills which may require extensive geotechnical recommendations.

A bridge and approach investigation should be structured to provide appropriate geotechnical sheets (both plan view and cross sections) to lay out geotechnical design elements. This may include not only appropriate slope ratios for soil cuts and fills, but large rock cuts, accommodation for weak soils or swampland areas, sinkholes, landslides and other special geotechnical issues.

The primary end products are the geotechnical sheets, which will be included in the plans. The report will be used by the GES and will also be a reference available at request. It provides supplementary data and explanatory materials, some of which will not be included in the contract plans and documents. These are of great importance when evaluating geotechnical designs, dealing with construction related issues and understanding the reasons behind recommendations given. Remember that the report will be used by the GES, but the geotechnical sheets become part of the contract plans.

Drilling Requirements

At least one CBR sample sufficient for pavement design shall be taken at each bridge and approach project. Other drilling and site investigation shall be at the judgment of the engineering geologist or geotechnical engineer. This in turn depends upon the scale of the project and the amount of drilling needed to provide appropriate cross sections and geotechnical plans sheets. For a minor project where there are very small cuts and fills and no stability issues expected, this may mean a site visit and a CBR sample (or samples). For a project with large cuts and fills or major geotechnical issues, this may mean an extensive investigation.

Laboratory Analysis

The California Bearing Ratio test (CBR) is a requirement for TDOT projects as TDOT Pavement Design uses the results from this test. As typical for the CBR tests, proctors, gradation, plasticity and classification shall be reported along with the CBR results. Additionally, a small sample shall be taken of the CBR sample sufficient to obtain in-situ moisture for the soil. Other samples may be taken at the site as well, depending upon the scale and nature of the cuts and fills for the project. All soil samples shall have gradation, hydrometer, plasticity tests and shall be classified by both USCS and AASHTO soil classification systems. Samples taken in order to perform slope stability and settlement calculations may be required and include, but are not limited to triaxial tests, unconfined compression tests and direct shear tests.

Engineering Analysis

Types of analysis that have been needed for past TDOT Bridge and Approach projects include slope stability and settlement. Other analyses may be needed for complex and non-routine projects.

Geotechnical Reports and Drawings

The geotechnical report for a bridge and approach project should detail the investigations and the recommendations for the site. All cross sections provided with the report shall have explanatory material included in the report. For example, if a cross section is provided that is typical for station 30+00 to 34+50, there should be a section in the report that specifically references this drawing and provides a description of the repair and any needed geotechnical notes. A “Soil and Subgrade” report shall be included in the appendix and any CBR sample taken shall be included on this sheet. All typed boring logs shall be included with the report as well as any laboratory results. This report will primarily be used by the GES and as a reference for the exploration performed at the site.

Geotechnical Report Elements

Executive Summary or Cover Letter – This section gives a brief summary of the report.

Introduction – Brief summary of the project and location. Any special constraints such as very limited right of way are noted here.

Geology, Soils and Site Conditions – Any geology, soils and site conditions that may affect the project.

Surface and Subsurface Exploration – Exploration Performed

Recommendations – Provide recommendations for construction purposes such as allowable slopes, undercutting and replacement or other pertinent recommendations. The CBR values recommended for pavement design shall be included here.

Special Notes and Specifications – Any special notes to be included in the plans, these should also be on the retaining wall sheet(s). This section may be omitted if no special notes or specifications are required.

Appendix – Documents and other supporting data

- Geotechnical Sheets
- Soil and Subgrade report
- Boring Logs
- Laboratory Testing
- Engineering Analyses

Geotechnical Sheet Elements

The geotechnical sheets for a bridge and approach project shall include a plan view layout of the drill holes, drill holes plotted in relationship to centerline grade and any cross sections required to illustrate geotechnical design elements.

The initial layout sheets come from the preliminary design plans. Geotechnical data is added after exploration. These are the sheets that will be included in the plans. Information other than recommended CBR values for pavement design included in the report, but not on these sheets, may not make it into the construction plans. If this occurs, these geotechnical recommendations would then likely be ignored. It is critical that recommendations be illustrated with geotechnical plans sheets.

General Layout of Site – plan view showing drilling and sampling locations. This may also show limits of geotechnical design elements, such as plan view limits of undercutting.

Centerline grade sheets with graphical logs of drilling – showing all drill logs, these must show elevations and material types in relationship to the grade at centerline for the project. These may also show interpretations.

Cross Sections for the Project – Cross sections that describe the recommendations should be included with the geotechnical sheets. For very small and simple projects, only one cross section may be needed. Cross sections shall be provided to illustrate geotechnical design elements that are recommended for the project or to illustrate materials to be encountered. Recommended slope ratios shall be shown.

Geotechnical Notes – these would be added as needed. They could be included directly on the cross sections or on the general layout. These notes can also be included on a separate plans sheet. Please remember that these will be plans documents, so only appropriate material should be included.

Example Reports and Geotechnical Sheets

Please see *Section 1: Appendix A - Examples* for these documents.

- Bridge and Approaches Report
- Bridge and Approaches - Example Drawings

Supporting Documentation

Soil and Subgrade Report

A copy of the soil and subgrade report that shall be included with the report can be found in *Section 1: Appedix B - Supporting Documentation*

Chapter 4: Retaining Walls

Retaining wall projects for TDOT consist of geotechnical investigations of soil, rock and slope conditions for wall foundations and for excavations needed to construct the wall. Types of retaining walls that are acceptable for a site will need to be evaluated and all appropriate design parameters detailed.

Goals of Investigation

The end result of a Retaining Wall investigation is to provide enough data so that a structural engineer may complete retaining wall design for a given site and to aid construction contractors in bidding the project. In the past TDOT Structures would design a concrete cantilever wall for each site and any different wall types were submitted as value engineering projects. Now, when retaining walls are included as part of a project, these are designed by the contractor's consultant. The final geotechnical product is a retaining wall sheet for each wall that will be included in the roadway plans. These retaining wall sheets will be the reference that the structural engineer will use to design an appropriate retaining wall for the site.

An investigation shall be structured so that the geotechnical engineer or engineering geologist provides a list of all of the appropriate retaining wall types and all of the appropriate foundation types for these walls. Approved wall types and systems are included in the TDOT Retaining Wall Manual. This manual includes restrictions, specifications and descriptions of these walls and should be used as reference. All relevant parameters for the retaining wall design shall be included on the retaining wall sheet as well as any special conditions, foundation alternative descriptions and additional notes needed to provide data to the structural engineer and the construction engineer who will later oversee building of the wall.

The primary end product of a retaining wall investigation is the retaining wall sheet, which will be included in the plans. The report will be used by the GES and will also be a reference available at request. It provides supplementary data and explanatory materials, some of which will not be included in the contract plans and documents. These are of great importance when evaluating retaining wall designs, dealing with construction related issues and understanding the reasons behind retaining wall and foundation alternatives given. Remember that the report will be used by the GES, but the retaining wall sheet becomes part of the contract plans.

One very important point when selecting retaining walls for a site: **particular attention must be paid to the right-of-way available for construction**. If there is insufficient right-of-way for a particular wall type, either it should not be used, or the need for additional right-of-way must be clearly noted. A retaining wall that cannot be reasonably built at a site should not be included as a recommended option.

Drilling Requirements

Typically, TDOT borings are advanced to 1.5 times the wall height below the proposed bottom of footing if in soil. This is a nice rule of thumb will generally result in getting data that is within 2 times the foundation width. When initial drilling indicates questionable soil conditions (i.e. soft soil), extend borings to rock or to dense granular material (West Tennessee) as needed. Split spoon samples shall be taken where needed. Representative Shelby tube samples shall be taken of each soil type expected beneath the foundation. If rock is encountered less than 10 feet below proposed bottom of footing, the rock below the footing support elevation should be cored to obtain 7 to 10 feet of relatively sound continuous rock sufficient to support all retaining wall types feasible for the site.

Generally, TDOT exploration starts with drill holes approximately every 50 to 100 feet depending on consistency of soil and rock conditions expected. This may be expanded or reduced depending upon the consistency of conditions and the judgment of the geotechnical engineer or engineering geologist. If rock is encountered, space borings to determine an accurate rock line, this is often approximately 50 feet unless very erratic rock depths or poor quality rock is encountered.

Laboratory Analysis

The purpose of laboratory testing is to both determine the soil design parameters used for wall design and estimate amount of settlement a wall may undergo. The suggested testing described below is usually sufficient for small to medium size walls (less than 20 feet high) while more detailed and sophisticated tests may be required for higher walls.

First, all split spoon and Shelby tube samples should be tested for moisture content, gradation and classification, including Atterberg limits. Additionally, the Shelby tube samples shall be tested so that the engineering geologist or geotechnical engineer may choose appropriate strength parameters (c and φ) for the soils that will support the wall and be located behind the wall. Triaxial tests are preferred when possible. Consolidation tests should be performed on soil samples below proposed footing depth.

The number of tube samples and tests will depend on the size of wall, the variability of the type soils and the judgment of the engineering geologist or geotechnical engineer.

Engineering Analysis

It is not the purpose of this document to present all the engineering analysis involved with retaining wall design. Entire textbooks are available for review. The NAVFAC DM-7.1 and 7.2 are good sources of retaining wall design. AASHTO codes are also used at TDOT. However, analyses need to be made to provide the structural engineer with adequate information for wall design. The following information is needed:

Appropriate φ and Unit Weight if In-situ Soils and Backfill: Highly plastic clay material should not be used as backfill.

Sliding Coefficients: NAVFAC 7.2-63 Table 1 for friction and adhesion factors for soil at bearing level is a good reference for these factors.

Provide an allowable bearing pressure: Based on a suitable bearing capacity analysis. Show the Factor of Safety (FS) used for each wall type. Generally, the GES uses AASHTO requirements; FS=3.0 for concrete cantilever walls and FS=2.5 for MSE walls.

Factors of safety to be used in design: TDOT follows AASHTO guidance and required a FS=2.0 against overturning and FS=1.5 against sliding.

Allowable construction slopes: For example 1:1

Lateral Capacity of Rock: For any walls using piles or shafts socketed into rock, the lateral capacity of the rock shall be provided.

Foundation Improvements: Detail any foundation improvements needed to support the wall types shown.

Settlement: Estimate both total and differential settlement from consolidation tests of soil below footing level using net increase in pressure. That is, subtract removed overburden (if any) from increase in pressure due to wall to obtain net increase in pressure.

Global Stability: Check overall stability from a slope stability standpoint.

Seismic Considerations: Check liquefaction of soil and seismic stability if needed.

Unusual Problems: Determine if any possible unusual problems need analysis such as lateral squeeze.

Geotechnical Reports and Drawings

All the information included on the retaining wall sheet shall be included in the report along with appendices that detail the analyses performed for the project. All typed boring logs shall be included with the report. The initial layout sheet is provided by the Design Manager and geotechnical data is added after exploration.

Geotechnical Report Elements

Executive Summary or Cover Letter – this section gives a brief summary of the report.

Introduction – brief summary of purpose of the wall, general size, general type (cut or fill) and location. Any special constraints such as very limited right of way are noted here.

Geology, Soils and Site Conditions – Geology, soils and site conditions that may affect the project.

Surface and Subsurface Exploration – Exploration Performed

Recommendations – For retaining wall projects, the text of the retaining wall sheet is included in this section, along with any pertinent discussion of the recommendations. Detail acceptable wall types and provide parameters for design including any needed foundation improvements. Provide recommendations for construction purposes such as allowable temporary cut slopes, special drainage, undercutting or other pertinent recommendations

Special Notes and Specifications – Any special notes to be included in the plans, these should also be on the retaining wall sheet(s).

Appendix – Documents and supporting information
Retaining Wall Sheet(s) and any applicable cross sections
Boring Logs
Laboratory Testing
Engineering Analyses

Retaining Wall Sheet Elements

General Layout of Retaining Wall – showing the wall in relationship to its surroundings

Cross Sections – At least one cross section showing wall

All borings for the project – these must show elevations and material types. This is a graphical log that should match up with written boring logs.

Acceptable Wall Types – The geotechnical engineer / engineering geologist shall specify all wall types acceptable at the location.

Wall and Foundation Parameter data – any parameters needed from the geotechnical engineer / engineering geologist so that the structural engineer may design the wall.

Factors of Safety to be used – this includes factors of safety against sliding, overturning and bearing capacity.

Allowable construction slopes – please specify allowable temporary construction slopes. If 1:1 or shallower slopes are not acceptable due to right of way constraints, this needs to be stated on the sheet. If sheet piling is required, please specify.

Allowable bearing – allowable bearing of soil or rock in a given interval for a given foundation type.

Any explanatory foundation notes – please add any explanatory material needed such as depths of excavation and replacement or other pertinent data.

Other notes – any notes needed for design or construction not specified above.

Example Reports and Geotechnical Sheets

Please see *Section 1: Appendix A - Examples* for these documents.

Chapter 5: Intersections and Small Lines

These differ from full scale line projects only in the geographic extent of the project. Small lines are those projects in support of a roadway alignment that are generally less than 2.5 miles in length. However, these projects can involve extensive investigations if they incorporate structures and/or large cuts and fills. These projects may be given out separately from the structures used on the project. Guidance for the investigations of structure are included as separate chapters in this manual.

Goals of Investigation

The end result of an intersection or small line investigation project is to supply Geotechnical Sheets that describe any pertinent geotechnical issues, provide CBR values for pavement design and to provide proctor samples from cut areas on the site that may supply fill to the site. These projects are often small and may involve only very slight cuts and fills. Interchange projects frequently occur in urbanized areas where very little drilling can be performed due to utilities, site access issues and existing structures. These differ from large line improvement or change in that they are much more limited in affected area. These projects range from the very simple, which require little or no drilling to large cuts and fills which may require extensive geotechnical recommendations.

These investigations should be structured to provide appropriate geotechnical sheets (both plan view and cross sections) to lay out geotechnical design elements. This may include not only appropriate slope ratios for soil cuts and fills, but large rock cuts, accommodation for weak soils or swampland areas, sinkholes, landslides and other special geotechnical issues.

The primary end products are the geotechnical sheets, which will be included in the plans. The report will be used by the GES and will also be a reference available at request. It provides supplementary data and explanatory materials, some of which will not be included in the contract plans and documents. These are of great importance when evaluating geotechnical designs, dealing with construction related issues and understanding the reasons behind recommendations given. Remember that the report will be used by the GES, but the geotechnical sheets become part of the contract plans.

Drilling Requirements

At least one CBR sample sufficient for pavement design shall be taken at each site. For small lines, it is appropriate to take several CBR samples from the site, depending upon the soils present and the extent of the project. Proctor samples from on-site soils that may be used as fill shall also be taken. If no areas of soil cut are present, these are not necessary. Other drilling and site investigation shall be at the judgment of the engineering geologist or geotechnical engineer. This in turn depends upon the scale of the project and the amount of drilling needed to provide appropriate cross sections and geotechnical plans sheets. For a minor project where there are very small cuts and fills and no stability issues expected, this may mean a site visit and a CBR sample (or samples). For a project with large cuts and fills or major geotechnical issues, this may mean an extensive investigation. Soil and rock expected to be encountered on the site shall be noted. Particularly if potentially acid producing rock or other challenging earth material is found.

Laboratory Analysis

The California Bearing Ratio test (CBR) is a requirement for TDOT projects as TDOT Pavement Design uses the results from this test. As typical for the CBR tests, proctors, gradation, plasticity and classification shall be reported along with the CBR results. All soil sampled at the site shall have moisture, gradation, plasticity and classification tests completed. Where settlement is a concern, samples shall have a 1-D consolidation test performed. Where slope stability issues are expected, appropriate tests that provide slope stability parameters for use in slope stability analysis shall be performed. These include triaxial tests, direct shear or unconfined compression tests.

Engineering Analysis

Types of analysis that have been needed for past interchange and small line projects include slope stability and settlement calculations. Other analyses may be needed for complex and non-routine projects. If settlement at a site is expected to present a problem, particularly if it the settlement will take longer than construction to complete then alternatives to cope with the settlement shall be detailed in the report and in geotechnical sheets provided in the plans. Wait times for settlement and geotechnical designs such as wick/sand drains shall be included.

Typical slopes used for TDOT projects are 3:1 slope ratios for soil and 1.5:1 for rock fill slopes. Rock cuts may vary from vertical to 0.25:1 to other slope ratios as appropriate. If the rock is of sufficiently poor quality it may be wise to set slope ratios in a more typical soil configuration. These slopes can be altered at the discretion of the geotechnical engineer / engineering geologist if the analysis supports different slope configurations. Rock slope stability including rockfall considerations shall also be checked at the site where appropriate. Guidance for typical rockfall design can be found in Chapter ____ of this manual. However, please note that these provisions are not meant to replace analysis and judgement. It is the responsibility of the geotech to check that designed slopes for a project are stable.

Geotechnical Reports and Drawings

The geotechnical report for interchange and small line projects shall detail the investigations and the recommendations for the site. All cross sections provided with the report shall have explanatory material included in the report. For example, if a cross section is provided that is typical for station 30+00 to 34+50, there should be a section in the report that specifically references this drawing and provides a description of the repair and any needed geotechnical notes. A “Soil and Subgrade” report shall be included in the appendix and any CBR sample taken shall be included on this sheet. All typed boring logs shall be included with the report as well as any laboratory results. This report will primarily be used by the GES and as a reference for the exploration performed at the site.

The geotechnical sheets for an interchange and small line project shall include a plan view layout of the drill holes, drill holes plotted in relationship to centerline grade and any cross sections required to illustrate geotechnical design elements.

The initial layout sheets come from the preliminary design plans. Geotechnical data is added after exploration. These are the sheets that will be included in the plans. Information other than recommended CBR values for pavement design included in the report, but not on these sheets, may not make it into the construction plans. If this occurs, these geotechnical recommendations would then likely be ignored. It is critical that recommendations be illustrated with geotechnical plans sheets.

Geotechnical Report Elements:

Executive Summary or Cover Letter – This section gives a brief summary of the report.

Introduction – Brief summary of the project and location. Any special constraints such as very limited right of way are noted here.

Geology, Soils and Site Conditions – Geology, soils and site conditions that may affect the project.

Surface and Subsurface Exploration – Exploration Performed

Recommendations – Provide recommendations for construction purposes such as allowable slopes, undercutting and replacement or other pertinent recommendations. The CBR values recommended for pavement design shall be included here.

Special Notes and Specifications – Any special notes to be included in the plans, these should also be on the geotechnical sheet(s).

Appendix – Documents and supporting information
- Geotechnical Sheets
- Soil and Subgrade report
- Soils Description Sheet
- Boring Logs
- Laboratory Testing
- Engineering Analyses

Geotechnical Sheet Elements

General Layout of Site – plan view showing drilling and sampling locations. This may also show limits of geotechnical design elements, such as plan view limits of undercutting.

Centerline grade sheets – showing all drill logs, these must show elevations and material types in relationship to the grade at centerline for the project.

Cross Sections for the Project – Cross sections that describe the recommendations should be included with the geotechnical sheets. For very small and simple projects, only a few cross sections may be needed. Cross sections shall be provided to illustrate geotechnical design elements that are recommended for the project.

Soil Description Sheet/Table - For all soils that have been sampled on the project, the laboratory analysis along with descriptions of the soil shall be included on the plans. This includes proctor test results, atterberg limits as well as in-situ moisture and soil classification by both AASHTO and the Unified Soil Classification System. This can be presented as a chart at the beginning of the plans sheets or the soils present on a particular sheet can be shown as a table on that sheet. Please

Geotechnical Notes – These would be added as needed. They could be included directly on the cross sections or on the general layout. These notes can also be included on a separate plans sheet. Please remember that these will be plans documents, so only appropriate material should be included.

Supporting Documentation

Soil and Subgrade Report - A copy of the soil and subgrade report that shall be included with the report can be found in Section 1: Appedix B - Supporting Documentation.
Soils Description Sheet

Soil Description Sheet - An example soil description sheet can be found in Section 1: Appendix B - Supporting Documentation. All soils samples on a project shall be summarized in this chart and it shall be included both in the report and on the geotechnical sheets.

Chapter 6: Lines

Roadway alignment projects may vary from completely new alignments, to widening of existing alignments. Drilling requirements may be far more extensive for brand new alignment, but there can also be significant drilling and sampling needed for widening projects, particularly where there are large cuts and fills. These projects may be given out separately from the structures used on the project. Guidance for the investigations of structure are included as separate chapters in this manual.

Goals of Investigation

The end result of a line investigation project is to supply Geotechnical Sheets that describe any pertinent geotechnical issues, provide CBR values for pavement design and to provide proctor samples from cut areas on the site that may supply fill to the site. Some cuts and fills at the site may be quite large and require speciality recommendations such as reinforced soil slopes, undercutting, rock pads, specific rock cut geometries, settlement mitigation or other geotechnical mitigations and designs. Lines may be located both in urban and rural environments and utilities may present significant site access issues. These projects range from the very simple, which require only routine drilling to large cuts and fills which may require extensive geotechnical recommendations.

These investigations should be structured to provide appropriate geotechnical sheets (both plan view and cross sections) to lay out geotechnical design elements. This may include not only appropriate slope ratios for soil cuts and fills, but large rock cuts, accommodation for weak soils or swampland areas, sinkholes, landslides and other special geotechnical issues.

The primary end products are the geotechnical sheets, which will be included in the plans. The report will be used by the GES and will also be a reference available at request. It provides supplementary data and explanatory materials, some of which will not be included in the contract plans and documents. These are of great importance when evaluating geotechnical designs, dealing with construction related issues and understanding the reasons behind recommendations given. Remember that the report will be used by the GES, but the geotechnical sheets become part of the contract plans.

Drilling Requirements

CBR samples shall be taken where there is a significant change in the soil that will be or may be used underneath pavement. Multiple CBR's are often taken for line projects, depending upon the length. CBR samples shall not be taken from fill areas unless the fills are expected to be extremely small. These samples are used solely for pavement design and are not relevant for other geotechnical recommendations. Proctor samples from on-site soils that may be used as fill shall also be taken. If no areas of soil cut are present, these are not necessary. In the case where CBR and proctors are inappropriate, small bag samples sufficient for classification and moisture content can also be taken. Other drilling and site investigation shall be at the judgment of the engineering geologist or geotechnical engineer. This in turn depends upon the scale of the project and the amount of drilling needed to provide appropriate cross sections and geotechnical plans sheets. For a minor project where there are very small cuts and fills and no stability issues expected, this may mean limited drilling, Proctor and CBR samples. For a project with large cuts and fills or major geotechnical issues, this may mean an extensive investigation. Soil and rock expected to be encountered on the site shall be noted. Particularly if potentially acid producing rock or other challenging earth material is found.

Laboratory Analysis

The California Bearing Ratio test (CBR) is a requirement for TDOT projects as TDOT Pavement Design uses the results from this test. As typical for the CBR tests, proctors, gradation, plasticity and classification shall be reported along with the CBR results. All soil sampled at the site shall have moisture, gradation, plasticity and classification tests completed. Where settlement is a concern, samples shall have a 1-D consolidation test performed. Where slope stability issues are expected, appropriate tests that provide slope stability parameters for use in slope stability analysis shall be performed. These include triaxial tests, direct shear or unconfined compression tests.

Engineering Analysis

Types of analysis that have been needed for line projects include slope stability and settlement calculations. Other analyses may be needed for complex and non-routine projects. If settlement at a site is expected to present a problem, particularly if it the settlement will take longer than construction to complete then alternatives to cope with the settlement shall be detailed in the report and in geotechnical sheets provided in the plans. Wait times for settlement and geotechnical designs such as wick/sand drains shall be included. Stability of proposed rock cuts may also need to be analyzed in order to prevent rockfall and rock slope stability issues.

Typical slopes used for TDOT projects are 3:1 slope ratios for soil and 1.5:1 for rock fill slopes. Rock cuts may vary from vertical to 0.25:1 to other slope ratios as appropriate. If the rock is of sufficiently poor quality it may be wise to set slope ratios in a more typical soil configuration. These slopes can be altered at the discretion of the geotechnical engineer / engineering geologist if the analysis supports different slope configurations. Rock slope stability including rockfall considerations shall also be checked at the site where appropriate. This may involve the use of rock bolts, welded wire mesh draping, rockfall catchment fences, shotcrete and other mitigation methods. Guidance for typical rockfall design can be found in Chapter ____ of this manual. However, please note that these provisions are not meant to replace analysis and judgement. It is the responsibility of the Geotech to check that designed slopes for a project are stable.

Geotechnical Reports and Drawings

The geotechnical report for line projects shall detail the investigations and the recommendations for the site. All cross sections provided with the report shall have explanatory material included in the report. For example, if a cross section is provided that is typical for station 30+00 to 34+50, there should be a section in the report that specifically references this drawing and provides a description of the repair and any needed geotechnical notes. A “Soil and Subgrade” report shall be included in the appendix and any CBR samples taken shall be included on this sheet. All typed boring logs shall be included with the report as well as any laboratory results. This report will primarily be used by the GES and as a reference for the exploration performed at the site.

The geotechnical sheets for a line project shall include a plan view layout of the drill holes, drill holes plotted in relationship to centerline grade and any cross sections required to illustrate geotechnical design elements. Included on these plan view layout sheets are some summary soils testing and identification data. Please see Section 1: Appendix A for examples of typical geotechnical sheets.

The initial layout sheets come from the preliminary design plans. Geotechnical data is added after exploration. These are the sheets that will be included in the plans. Information other than recommended CBR values for pavement design included in the report, but not on these sheets, may not make it into the construction plans. If this occurs, these geotechnical recommendations would then likely be ignored. It is critical that recommendations be illustrated with geotechnical plans sheets.

Geotechnical Report Elements:

Executive Summary or Cover Letter – This section gives a brief summary of the report.

Introduction – Brief summary of the project and location. Any special constraints such as very limited right of way are noted here.

Geology, Soils and Site Conditions – Geology, soils and site conditions that may affect the project.

Surface and Subsurface Exploration – Exploration Performed

Recommendations – Provide recommendations for construction purposes such as allowable slopes, undercutting and replacement or other pertinent recommendations. The CBR values recommended for pavement design shall be included here.

Special Notes and Specifications – Any special notes to be included in the plans, these should also be on the geotechnical sheet(s).

Appendix – Documents and supporting information
- Geotechnical Sheets
- Soil and Subgrade report
- Soils Description Sheet

Boring Logs
Laboratory Testing
Engineering Analyses

Geotechnical Sheet Elements

General Layout of Site – plan view showing drilling and sampling locations. This may also show limits of geotechnical design elements, such as plan view limits of undercutting. Selected soils data are also shown on these sheets.

Centerline grade sheets – showing all drill logs, these must show elevations and material types in relationship to the grade at centerline for the project.

Cross Sections for the Project – Cross sections that describe the recommendations should be included with the geotechnical sheets. For very small and simple projects, only a few cross sections may be needed. Cross sections shall be provided to illustrate geotechnical design elements that are recommended for the project.

Soil Description Sheet/Table - For all soils that have been sampled on the project, the laboratory analysis along with descriptions of the soil shall be included on the plans. This includes proctor test results, atterberg limits as well as in-situ moisture and soil classification by both AASHTO and the Unified Soil Classification System. This can be presented as a chart at the beginning of the plans sheets or the soils present on a particular sheet can be shown as a table on that sheet. Please see Section 1: Appendix A for a typical sheet.

Geotechnical Notes – These would be added as needed. They could be included directly on the cross sections or on the general layout. These notes can also be included on a separate plans sheet. Please remember that these will be plans documents, so only appropriate material should be included.

Supporting Documentation

Soil and Subgrade Report - A copy of the soil and subgrade report that shall be included with the report can be found in Section 1: Appendix B - Supporting Documentation.
Soils Description Sheet

Soil Description Sheet - An example soil description sheet can be found in Section 1: Appendix B - Supporting Documentation. All soils samples on a project shall be summarized in this chart and it shall be included both in the report and on the geotechnical sheets.

Chapter 7: Landslides and Rockfall

Landslide (including rockslides) and rockfall projects can be the most challenging of TDOT Geotechnical projects, but can vary significantly in size and scope. These projects may be as simple as small scale typical soil failures to very large scale projects which require extensive investigation and analysis. Typically, these projects will be given out to consultants only on an emergency basis, that is just after a slide has occurred at a site where rapid repair is a high priority. Potential landslides and rockfall may need to be analyzed on other projects such as lines or interchanges in order to ensure that an existing slide does not worsen or cause a failure in the roadway. A variety of methods are available to mitigate or repair landslides and rockfall sites and TDOT will need a recommendations for alternative that may include both short term recommendations and longer term mitigation and repair.

Goals of Investigation

The end result of a landslide and rockfall investigation for TDOT is to provide comprehensive recommendations and alternatives for the repair or mitigation of the landslide or rockfall. Many projects may be so large in scope that repair of these site may not be feasible. In these cases, recommendations for mitigation of the problem will be needed. Multiple reports may be required for these investigations with early reports detailing possible alternatives with a discussion of relative risk and costs. Later, after consultation with TDOT, plans and cross sections along with a final report may be needed.

All details on construction of the mitigation or repair will need to be shown in the geotechnical sheets. The report will be used by the GES and will also be a reference available at request. It provides supplementary data and explanatory materials, some of which will not be included in the contract plans and documents. These are of great importance when evaluating geotechnical designs, dealing with construction related issues and understanding the reasons behind recommendations given. Remember that the report will be used by the GES, but the geotechnical sheets become part of the contract plans.

Drilling Requirements

Unlike typical geotechnical work, there are no specific rules of thumb for drilling landslide and rockfall projects. Sufficient drilling to analyze the problem and design appropriate repair and mitigation strategies should be used. It is the responsibility of the geotech to ensure that sufficient work has been completed in order to properly analyze the problem. There are numerous publications available that detail investigations of landslides. Split spoon sampling, test pits, shelby tubes, auguring, washboring and coring are all drilling methods which may be used on a project depending upon the type and nature of the failure at the site. It is critical to identify the limits of the failure surface when completing and investigation. It will not help if a smaller slide is mitigated only to see the road and mitigation fail from a larger slide.

Laboratory Analysis

Appropriate tests that provide slope stability parameters for use in slope stability analysis shall be performed. These include triaxial tests, direct shear or unconfined compression tests. Other speciality tests may be used as needed.

Engineering Analysis

Slope stability calculations sufficient to predict and mitigate or repair the site shall be performed. TDOT presently uses GSTABL 7 with STEDWin, although other software may be used to analyze the problem. Back calculation of the failure may be particularly useful for these projects and may provide more realistic data than laboratory sampling under some circumstances. Rock slope failures are more problematic, and it is critical that the failure surfaces be adequately identified and analyzed by recognized methods. Plane shear and wedge failures will need to be analyzed with appropriate analysis methods. Again, there are numerous geotechnical publications which detail these analyses as well as the potential pitfalls and necessary parameters.

Geotechnical Reports and Drawings

The geotechnical report for line projects shall detail the investigations and the recommendations for the site. All cross sections provided with the report shall have explanatory material included in the report. For example, if a cross section is provided that is typical for station 30+00 to 34+50, there should be a section in the report that specifically references this drawing and provides a description of the repair and any needed geotechnical notes. A plan view layout sheet showing the locations of the drilling and sampling sites along with limits of existing failure and any other important features. Cross sections showing all of the geotechnical design elements shall be included with the final report. A geotechnical notes sheet will also typically be needed for these projects. Additionally, any sheets needed to explain design elements such as rock bolts, soil nails, horizontal drainage etc shall also be included. Please see Section 1: Appendix A for examples of typical geotechnical sheets. Information included in the report, but not on these sheets, may not make it into the construction plans. If this occurs, these geotechnical recommendations would then likely be ignored. It is critical that recommendations be illustrated with geotechnical plans sheets.

Geotechnical Report Elements:

Executive Summary or Cover Letter – This section gives a brief summary of the report.

Introduction – Brief summary of the project and location. Any special constraints such as very limited right of way are noted here.

Geology, Soils and Site Conditions – Geology, soils and site conditions that may affect the project.

Surface and Subsurface Exploration – Exploration Performed

Recommendations – Provide recommendations for construction purposes such as allowable slopes, undercutting and replacement or other pertinent recommendations.

Special Notes and Specifications – Any special notes to be included in the plans, these should also be on the geotechnical sheet(s).

Appendix – Documents and supporting information
Geotechnical Sheets
Boring Logs
Laboratory Testing
Engineering Analyses

Geotechnical Sheet Elements

General Layout of Site – plan view showing drilling and sampling locations along with general limits of the slope failure and other pertinent features including the limits to the new repair.

Centerline grade sheets – showing all drill logs, these must show elevations and material types in relationship to the grade at centerline for the project.

Cross Sections for the Project – Cross sections that describe the recommendations should be included with the geotechnical sheets. For very small and simple projects, only a few cross sections may be needed. Cross sections shall be provided to illustrate geotechnical design elements that are recommended for the project. Graphical boring logs, as appropriate may also be included on these cross sections.

Geotechnical Notes – These would be added as needed. They could be included directly on the cross sections or on the general layout. These notes can also be included on a separate plans sheet. Please remember that these will be plans documents, so only appropriate material should be included.

Chapter 8: Sinkholes and Subsidence

Sinkholes and subsidence issues will generally be part of other projects, rather than given out to consultants as separate projects. They may occur on many different project types,but all require additional investigation and recommendations. Many areas of Tennessee are prone to sinkhole and karst related problems due to the underlying geology. Sinkholes and subsidence areas may already be present on a site, or may occur during or after construction. Non-landslide subsidence problems may be due to settlement of soils or as id frequently the case in West Tennessee due to erodible soils and water problems.

Goals of Investigation

The end result of a sinkhole or subsidence investigation for TDOT is to provide comprehensive recommendations and alternatives for the repair or mitigation. This includes delineating the affected areas and to the extent possible examining the causes of the sinkhole or subsidence problem. It is particularly important to examine potential causes of failure when there is a "sudden" sinkhole collapse as a repair not designed to address the root case, may not fix the problem. Multiple reports may be required for these investigations with early reports detailing possible alternatives with a discussion of relative risk and costs. Later, after consultation with TDOT, plans and cross sections along with a final report may be needed.

All details on construction of the mitigation or repair will need to be shown in the geotechnical sheets. The report will be used by the GES and will also be a reference available at request. It provides supplementary data and explanatory materials, some of which will not be included in the contract plans and documents. These are of great importance when evaluating geotechnical designs, dealing with construction related issues and understanding the reasons behind recommendations given. Remember that the report will be used by the GES, but the geotechnical sheets become part of the contract plans.

Drilling Requirements

Unlike typical geotechnical work, there are no specific rules of thumb for drilling sinkhole and subsidence projects. Sufficient drilling to analyze the problem and design appropriate repair and mitigation strategies should be used. It is the responsibility of the geotech to ensure that sufficient work has been completed in order to properly analyze the problem. TDOT will generally drill around sinkholes and in some subsidence areas in order to better define the nature and type of problem presented by the problem site. There are numerous publications available that detail investigations of sinkholes. Split spoon sampling, test pits, shelby tubes, auguring, washboring and coring are all drilling methods which may be used on a project depending upon the type and nature of the failure at the site. It is critical to identify the limits of the failure when completing and investigation. A sinkhole repair along a linear feature may require a larger repair than first appears from surface expression. Sinkholes have been known in the past to fail right beside an existing repair.

Laboratory Analysis

In the case of sinkholes, TDOT typically will perform soil classification, atterberg limits and sieve analysis. However, other subsidence problems may require additional tests such as the 1D Consolidation test or tests that better define the erodibility of the on site soils.

Engineering Analysis

There are few reliable mathematical methods for analyzing sinkhole related problems and none used in the practical application of sinkhole repair at TDOT. Here, as with many areas of geotechnical work, experience and judgement have to be the guide. Subsidence issues, depending on the cause can be modeled using the 1D Consolidation Test for sites which a problem due to the consolidation and settlement of soils. Erodibility calculations are also available, but may or may not provide additional guidance when repairing sites where water is plucking soils.

Geotechnical Reports and Drawings

The geotechnical report for line projects shall detail the investigations and the recommendations for the site. All cross sections provided with the report shall have explanatory material included in the report. For example, if a cross section is provided that is typical for station 30+00 to 34+50, there should be a section in the report that specifically references this drawing and provides a description of the repair and any needed geotechnical notes. A plan view layout sheet showing the locations of the drilling and sampling sites along with limits of existing failure and any other important features. Cross sections showing all of the geotechnical design elements shall be included with the final report. A geotechnical notes sheet will also typically be needed for these projects. Additionally, any sheets needed to explain design elements such as rock pads, geotextile fabric, compaction grouting points or any other elements. TDOT has a standard drawing for sinkhole repair alternatives which may be used as guidance. However, as with other TDOT drawings, these must be used with caution and judgement. It is up to the Geotech to make sure that the repair is appropriate for the site. It is insufficient simply to site the standard drawing and provide no additional thought or judgement to the matter. Please see Section 1: Appendix A for examples of typical geotechnical sheets. Also, please see Section 1: Appendix B - Supporting Documentation: Sinkhole Sheet.

Information included in the report, but not on the geotechnical sheets, may not make it into the construction plans. If this occurs, these geotechnical recommendations would then likely be ignored. It is critical that recommendations be illustrated with geotechnical plans sheets. A separate report is not needed where the sinkhole or subsidence issue is part of a larger report. It may be included as part of other reports, though separate sheets detailing the specific repairs and mitigation techniques will be needed. A separate report will only be needed if the project assigned is specifically a sinkhole or subsidence project. This would occur, for example, if a Geotechnical firm were called to come out in response to a sinkhole problem on a construction site where the report had already been previously completed.

Geotechnical Report Elements:

Executive Summary or Cover Letter – This section gives a brief summary of the report.

Introduction – Brief summary of the project and location. Any special constraints such as very limited right of way are noted here.

Geology, Soils and Site Conditions – Geology, soils and site conditions that may affect the project.

Surface and Subsurface Exploration – Exploration Performed

Recommendations – Provide recommendations for construction purposes such depth of excavation, compaction grouting parameters, geotechnical elements and limits of repairs.

Special Notes and Specifications – Any special notes to be included in the plans, these should also be on the geotechnical sheet(s).

Appendix – Documents and supporting information
Geotechnical Sheets
Boring Logs
Laboratory Testing
Engineering Analyses

Geotechnical Sheet Elements

General Layout of Site – plan view showing drilling and sampling locations along with general limits of the failure and other pertinent features including the limits to the new repair.

Cross Sections for the Project – Cross sections that describe the recommendations should be included with the geotechnical sheets. For very small and simple projects, only a few cross sections may be needed. Cross sections shall be provided to illustrate geotechnical design elements that are recommended for the project. Graphical boring logs, as appropriate may be included on these cross sections.

Geotechnical Notes – These would be added as needed. They could be included directly on the cross sections or on the general layout. These notes can also be included on a separate plans sheet. Please remember that these will be plans documents, so only appropriate material should be included.

Chapter 9: Preliminary Investigations

A preliminary geotechnical investigation is provided to the Planning Section within the TDOT Environmental Bureau in order to provide information in support of environmental documents and to provide a preliminary assessment as to the feasibility of a project or its alternates. These investigations differ from other TDOT projects in that drilling and sampling may not be required, or of they are required are performed on a much more limited basis than with a full scale investigation. Cross sections of the project are often not available and the project may be shown on a set of “Functional Drawings” that is a set drawings where the line is shown with a backdrop of an aerial photo of the site.

Goals of Investigation

Preliminary investigations are provided as a first look at the feasibility of a project and to identify potential geotechnical and environmental related issues that may come up on the project. For a line project there may be only one alignment to be studied, there may be multiple alignments or only a corridor may have been defined. Where there are multiple alignments, a preferred alignment, from a geotechnical standpoint shall be identified. Geological hazards and other geotechnical issues that may cause problems with construction, have a significant cost of mitigation or pose environmental issues and threats shall be identified for all alternates. Specific attention should be paid to the presence of sinkholes, landslides, rockfall, subsidence areas, soft or unstable ground, wetland locations, springs, seeps and potentially acid producing rock. Any of these threats which are identified at the site shall be clearly noted in the report.

Unlike many other TDOT projects, the end product of a preliminary investigation is a report which may be supported with maps, drawings or cross sections. This report will not be part of contract plans, neither will any of the supporting documentation. Preliminary investigations are used by TDOT in order to support feasibility studies, picking an alignment, assessing alternate alignments, as technical support for environmental documents and for assessing preliminary costs of a project. These projects may be very simple and require a ingle site visit and a reasonable desk study or they may be complex and require drilling, sampling and complex analyses.

Drilling Requirements

For simple projects, drilling and sampling may not be required. For more complex projects, it will depend upon the specific project and the goals for the investigation at the time of investigation. This will need to be assessed on a case by case basis depending upon the complexity of the project and TDOT needs.

Laboratory Analysis

For simple projects, laboratory analysis may not be required. For more complex projects, it will depend upon the specific project and the goals for the investigation at the time of investigation. This will need to be assessed on a case by case basis depending upon the complexity of the project and TDOT needs.

Engineering Analysis

For simple projects, engineering analysis may not be required. For more complex projects, it will depend upon the specific project and the goals for the investigation at the time of investigation. This will need to be assessed on a case by case basis depending upon the complexity of the project and TDOT needs. These may include any or all of the techniques described in other chapters of this manual.

Geotechnical Reports and Drawings

The geotechnical report for a preliminary investigation project should detail the investigations and the recommendations for the site. Geohazards at the site and any features which are expected to cause geotechnical problems shall be clearly identified. Maps, drawings and photographs may be attached as needed in order to clarify or bring out key points and issues. This report will be used by the GES, as a reference for the exploration performed at the site and as support for Planning and environmental documents.

Geotechnical Report Elements

Executive Summary or Cover Letter – This section gives a brief summary of the report.

Introduction – Brief summary of the project and location. Any special constraints such as very limited right of way are noted here.

Geology, Soils and Site Conditions – Any geology, soils and site conditions that may affect the project.

Surface and Subsurface Exploration – Exploration Performed. Please include site visits and surface exploration. Subsurface investigation, if performed shall be detailed here as well.

Recommendations – Provide recommendations for choosing and alignment and documentation of problems notes at the site along with potential mitigation methods. These may be very detailed or very general depending upon the complexity of the project.

Appendix – Documents and other supporting data

- Geotechnical Sheets and drawings
- Maps
- Boring Logs - if applicable
- Laboratory Testing - if applicable
- Engineering Analyses - if applicable

Geotechnical Sheet Elements

If geotechnical sheets are to be used for a preliminary report, please see other chapters in the manual for general guidance as to the appropriate information to include on the sheet for the type of project. For example, a preliminary investigation of a line which included exploration and will include geotechnical sheets shall attempt to incorporate all the information for a line project.

Example Reports and Geotechnical Sheets

Please see *Section 1: Appendix A - Examples* for this documents.

- Preliminary Investigation Report

Chapter 10: Pyrite and Potential APR

Potentially acid producing rock may be found on any project type, however, as these projects present special environmental and permitting projects, some additional information is required. TDOT has a standard operating procedure for Acid Producing Rock. This shall be used as a reference for both appropriate testing and suggested methods of mitigation.

A rock or soil formation may produce acid when excavated and exposed to air, water and *Thiobacillius* bacteria. Sulfide minerals, most commonly pyrite, produce this acid as a byproduct of the breakdown of the sulfur. This can cause environmental issues and impacts and may require special handling and procedures.

Goals of Investigation

Projects which include potentially acid producing rock need to have formations that may produce acid identified and tested. Intervals of excavated rock that may produce acid need to be assessed and recommendations as to handling and final placement of the rock shall be established. At this time TDOT uses seeral standard methods for dealing with these materials. For rock judged not to present a potential for acid production, nothing more need be done. For rock with a low potential for producing acid blending with lime is used and for rock with a moderate to high potential for producing acid, encapsulation of the material is used. Please see TDOT SOP for Acid Producing Rock for further detail.

Drilling Requirements

Sufficient drilling to identify, sample and test problem and potentially problematic formations shall be completed. Additional guidance is available in the TDOT SOP.

Laboratory and Engineering Analysis

For most projects, an Acid Based accounting of the samples will be required. This includes an assessment of the past pH, Acid Potential (AP), Neutralization Potential (NP), AP-NP (the calcium carbonate deficiency) as well as tests of total sulfur and pyritic sulfur. Other testing procedures are available such as the humidity cell and leach tests. All laboratory tests should be assessed for reasonableness and whether or not the samples are representative of the material out in the field. Multiple parameters may be needed in order to assess whether or not a soil or rock can produce acid in the field. Additionally, site assessments of the same material placed in the field may also need to be completed or addressed.

Geotechnical Reports and Drawings

Geotechnical Report

Generally, there is not a separate report provided for sites which contain potentially acid producing rock. Please see other chapters in this manual for the appropriate report format for the specific project type on which these materials have been identified.

Geotechnical Sheet Elements

If encapsulation or other special handing procedures are required these shall be shown on additional geotechnical sheets. Please make sure sufficient notes are provided in order to construct any proposed mitigation or repair.

Chapter 11: Noise Walls

Chapter 12: High Mast Lighting Projects

Chapter 13: Value Engineering Projects

Occasionally, a geotechnical firm will be called upon by a construction company to assist with a Value Engineering Project for TDOT. These projects, initiated by the contractor are intended to be a method where a construction company can introduce new and innovative techniques to TDOT that also save money over the original recommendations for the site. The cost savings of the new methods are split between the contractor and the state. These proposals must be submitted for approval to Construction as well as other areas within TDOT. VE proposals that contain geotechnical elements must be submitted for approval to the Geotechnical Engineering Section as well. Technical justification and additional information may be required.

Role of the Geotechnical Engineer/Engineering Geologist

Value Engineering (VE) proposals that involve geotechnical elements or design must involve a geotechnical engineer or engineering geologist who has a professional license with the State of Tennessee. A VE proposal will typically be submitted by a contractor to the department. Typical documentation that will be included in one of these proposals are details on the requested change and money that will be saved by implementing the proposal. What is often missing from VE projects that contain geotechnical elements are geotechnical reports, calculations and guidance.

When a VE project involves geotechnical elements, a geotechnical engineer or engineering geologist must submit engineering calculations, details of investigations (if any) and a geotechnical report summarizing recommendations. The geotechnical engineer is taking responsibility for the geotechnical elements of the plan and should not consider their role as merely supporting with no professional responsibility. It is recommended that a Geotechnical Consultant / Designer who has been requested by a contractor to provide geotechnical information / design as a part of a VE contact the Geotechnical Engineering Section to discuss, clarify and confirm what geotechnical information /design is expected and required.

For example for a project where a new type of retaining wall is added. The area may require a foundation investigation, if one has not already been completed, or may require additional geotechnical investigation in order to make appropriate and prudent engineering calculations. A report, details of the investigation and engineering calculations shall be submitted with the VE proposal exactly as if TDOT had asked the geotechnical engineer to supply such needed information for design. It is not sufficient for a project that contains significant geotechnical elements to provide only drilling with no recommendations or to only discuss the potential "cost savings" of the project. All VE projects need to have supporting documentation that indicate professional staff have designed and evaluated the proposed plan. Contractors who submit VE proposals that contain significant geotechnical elements are encouraged to retain responsible and professional engineering services from a geotechnical firm or geotechnical engineer / engineering geologist.

Chapter 14: Consultant Scope of Work

Part of the responsibility of a Geotechnical firm hired directly by TDOT or through another consultant is to provide a detailed scope of work for approval before any exploration begins. This may include a cover letter which provides a summary of the work to be completed at the site as well as other supporting documentation. Firms in the past have provided charts of proposed boring locations as well as plans sheets which show proposed boring locations. These may be required in the case of a complex project and may be particularly helpful of projects where there has been a design change that necessitates additional drilling and exploration.

Required Paperwork and Submittals

For all geotechnical work completed by consultant either directly for TDOT or through another consultant, a “Manhour Requirements and Cost Estimate” form must be filled out for the project and submitted to the TDOT Geotechnical Engineering Section. This cost estimate details the scope of work and pricing for each item in this scope of work. It must be approved by TDOT Geotechnical prior to any work other than preparation of scope to begin. Please note that scope preparation is considered part of the cost of doing business and is not a reimbursable expense.

The “Manhour Requirements and Cost Estimate” form details all expected items needed for completing the project, the estimated quantities of such items, the basis of payment and the cost per basis of payment as well as the total amount for each item. It is divided up into several sections.

Manhour Requirements and Cost Estimate form

Cost Cover Sheet - This sheet contains basic reference information including the project location data, Geotechnical Consultant Name, Date Prepared, Project Number, Geotechnical Office Number and Contact information for the preparer.

1.00 Drilling Costs - All drilling items are shown on this sheet and are to be listed on a per unit basis. For instance, Rock coring is charged on a per-foot basis. Specialty items not listed such as CPT drilling may be added to this sheet with the agreement of TDOT Geotechnical. The total estimated cost of drilling items is shown at the bottom of the page.

2.00 Lab Testing Costs - All laboratory testing items are shown on this sheet and are to be listed on a per unit basis. For instance, the Atterberg Limit test is charged on a per sample basis. Please note that tests which require multiple points, such as the C-U triaxial test are still charged on a per total test, not per point basis. So a test which may take 3 samples to complete, would still be charged as only 1 single test, because several points are required in order to provide a complete single test result. Specialty items not listed such as may be added to this sheet with the agreement of TDOT Geotechnical. The total estimated cost of laboratory testing items is shown at the bottom of the page.

3.00 Manpower Costs - All expected manpower hours estimated for the project are to be detailed on this sheet. It breaks down cost by tasks and by category of staff. These are charged on a per man hour basis. The hourly rate is determined on sheet 3.01 Manpower Breakdown. If CAD services are to be provided by others, such as the Design Consultant, the CAD technicians estimated hours may be shown either on the Geotechnical Consultants cost estimate **or** on the Design Consultants cost estimate, not both.

3.01 Manpower Breakdown - This is a particularly critical sheet in the cost estimate, failure to complete this sheet correctly can result in audits by the state or in dismissal of a consultant from a contract.

Direct Pay Rate - This is the actual rate paid to a member(s) of the Geotechnical Consultants staff. Evidence that this is the case may be required by TDOT.

Maximum Overhead Rate - This rate is determined by audit and can vary from Consultant to Consultant. However, if the consultant has an overhead rate higher than 1.45, the maximum allowable rate that may be used is 1.45.

Profit Multiplier - TDOT currently allows a profit multiplier of 2.35.

Profit Rate - For projects that are completed through a Design Consultant, the profit rate is the same as that established for the Design Consultant. This is typically no more than 0.12.

Hourly Rate - This is determined by the following formula:
= Direct Pay Rate + Direct Pay Rate * Profit Multiplier + Direct Pay Rate * Profit Multiplier * Profit Rate

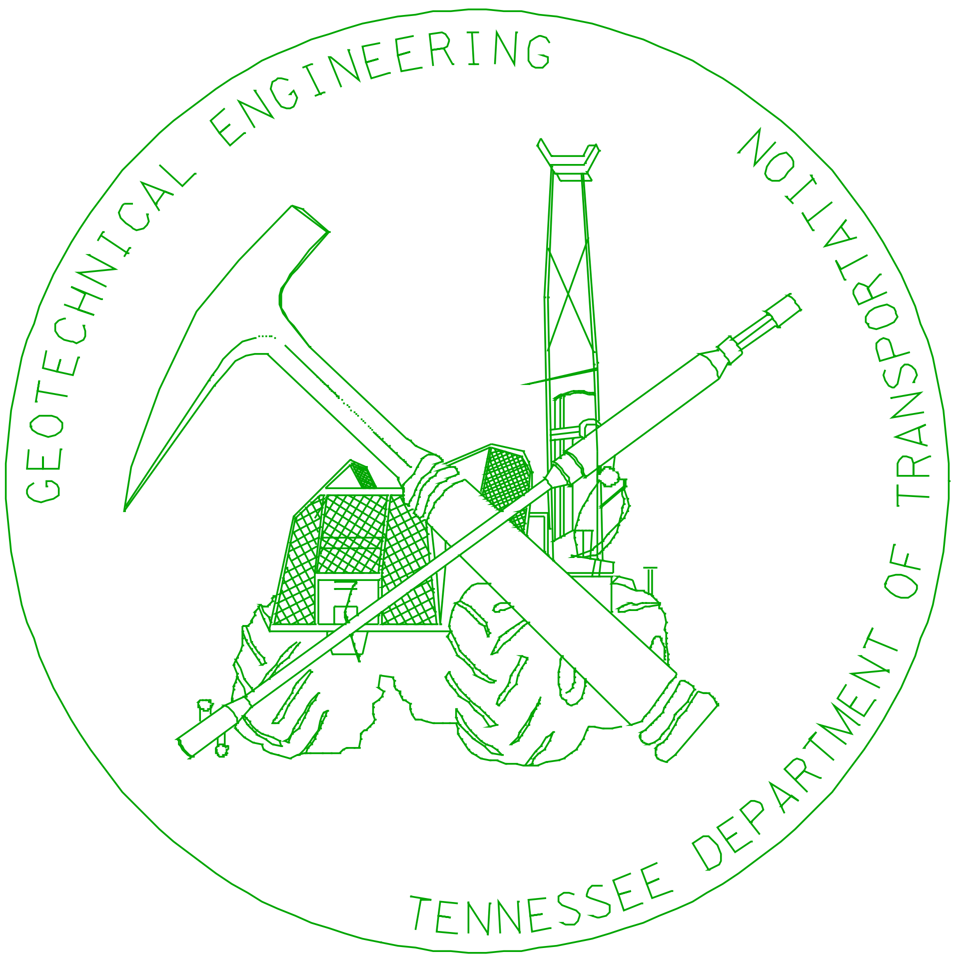
4.00 Other Costs - This sheet details other costs involved with the project that do not neatly fit onto one of the other sheets such as Per-Diem, Lodging and Mileage. Equipment rental and plans reproduction may also be included on this sheet. However, the only equipment rental which may be allowed will be speciality equipment. The consultant may not charge for standard geotechnical exploration or supporting equipment, neither may laboratory testing equipment rental be charged. Charges will only be allowed with prior authorization from TDOT Geotechnical and this will only be granted in unusual cases. Further explanation and justification for these charges may be requested. Also, plans printing may not be charged by the Geotechnical Consultant if that function is to be handled by the Design Consultant, unless the Design Consultant is not charging TDOT for the printing. Items listed under other expenses may only be pre-approved and as is the case for equipment rental will only be granted in unusual cases. Appropriate item numbers will be assigned by TDOT as needed. As with other sheets the total estimate of other expenses must be shown at the bottom of the sheet.

Costs-Summary - This final sheet summarizes the costs of Drilling Services, Laboratory Services, Manpower Requirements and Other Expenses in order to show a final “Total Not-to-Exceed” cost for the project.

For any project, the total that may be charged to the state for the Geotechnical work shall be no more than the “Total Not-to-Exceed” costs shown on an approved “Manhour and Requirements Cost Estimate Form.” Individual items used may vary somewhat from the estimate provided depending upon the needs of the project, but in no case will additional funds be provided unless the consultant receives an approval for a supplement to the original scope of work. A supplement request must be provided in the same format as that for the original scope of work, but may require additional meetings and justification before approval. If a specific Cost Estimate has not been approved, then no money will be paid for any work completed after the previously agreed upon costs have already been used and/or billed. Additional scope for additional work may not be approved by TDOT. For projects where work is completed directly for the Geotechnical Engineering Section, only Geotechnical approval needs to be received before work can begin. However, for projects completed through a design consultant, approval through both Geotechnical and Design will be required. If there is any significant change to a scope of work between the time it is submitted to Geotechnical and the time is submitted through Design, that change must be approved by Geotechnical before it is submitted to Design.

Section 1: Appendix A

Example Reports and Drawings



6601 Centennial Boulevard
Nashville, TN 37243-0360
(615) 350.4132

BRIDGE FOUNDATION REPORT
State Rout 436 over South Fork Obion River
Station 68+00.00, LM 3.89
Carroll County
State Project No. 09035-1217-94
PIN#: 101692.00

Executive Summary

State Route 436 over South Fork Obion River is a two-span bridge replacement of an existing bridge and realignment of bridge center line. The gradation, plasticity, pH, and natural moisture results are all found in the contractor's Boring Records. The bridge shall be supported by concrete friction piles. Seismic analysis calculations were performed and liquefiable samples are noted on foundation data sheet.

BRIDGE FOUNDATION REPORT

State Rout 436 over South Fork Obion River
Station 68+00.00, LM 3.89
Carroll County
State Project No. 09035-1217-94
PIN#: 101692.00

Introduction

This report concludes the geotechnical investigation for the State Route 436 over the South Fork Obion River in Carroll County. This project is a two-span bridge replacement of an existing bridge, and a shift of bridge centerline 33' to the west.

Geology, Soils, and Site Conditions

The site is located within the Gulf Costal Plain province of Tennessee and the Obion River flood plain. Soil at the site is characterized by a poorly drained gray, friable, silty loam. Soil is underlain primarily by sand with interbedding of clays and silts. Rock is not present at the site. Due to the poorly draining soils the site remains flooded through most of the winter and spring.

Surface and Subsurface Exploration

Two borings were conducted at this location. Both holes were offset to the east due to flooding at site. Split spoon sampling was conducted at five foot intervals for classification and laboratory analysis. Laboratory analysis and drilling logs are attached to this report.

Recommendations and Discussion

This bridge shall be supported by concrete friction piles. The skin friction (f_s) and end bearing (q_b) values are shown on the Foundation Data Sheet.

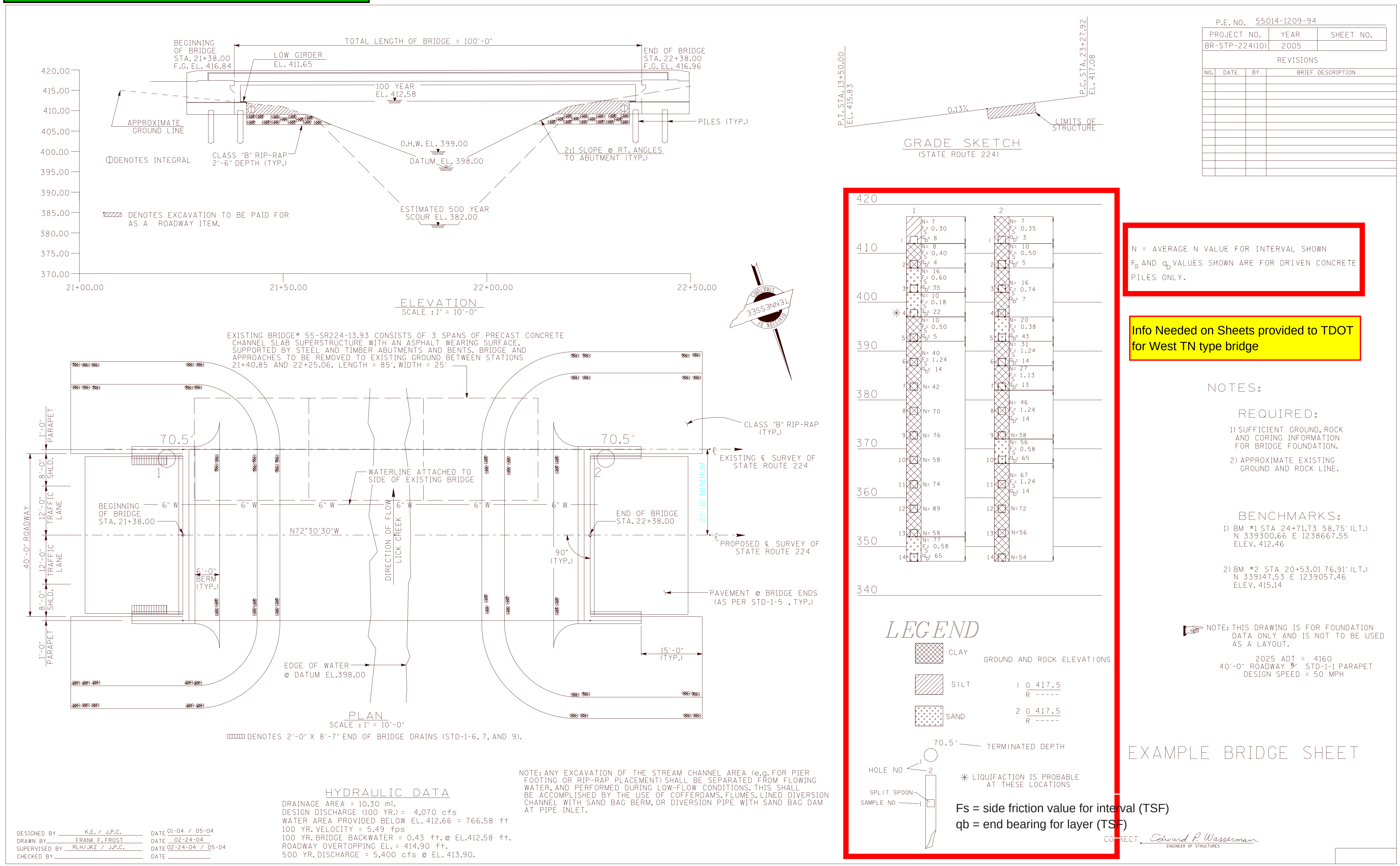
Values for pH tests are located on the boring logs. Samples from Boring 1, disregarding samples 1 and 2, shall be taken as a representative for scour. Seismic analysis indicates that liquefaction will occur at locations indicated on the Foundation Data Sheet. No skin friction should be accumulated for the liquefiable layers, and the pile tip should rest at least 5 feet below these liquefiable samples. If steel pipe piles or steel H piles are used, reduce the skin friction values (F_s) by one-third.

If there are questions concerning this report, please contact the Geotechnical Engineering Section.

Scott Crombie
Geologist 2

M. Leonard Oliver, P.E.
Civil Engineering Manager 2

West Tennessee Bridge Sketch



FOUNDATION REPORT
Fancher Mill Road over
Taylor Creek
State Project No. 93039-1405-94
Pin No. 010964.00
White County

Executive Summary

Summarized in this report are the results of a subsurface investigation for the project stated above located in White County. The proposed project consists of relocating the existing bridge 340ft. to the northwest and straightening the roadway in order to eliminate the existing curve in the southwest approach. It is recommended that this proposed bridge structure be supported on spread footings seated on sound shaley limestone. Enclosed are the Boring Records, Foundation Data Sheet, and recommendations for foundation design.

Purpose of Investigation

Summarized in this report are the results of a subsurface investigation for the project stated above located in Wayne County. The proposed project consists of relocating the existing bridge 340ft. to the northwest and straightening the roadway in order to eliminate the existing curve in the southwest approach. Enclosed are the Boring Records, Foundation Data Sheet, and recommendations for foundation design.

Geology of Area

White County lies on the edge of the Eastern Highland Rim physiographic province. The underlying material in the Cassville Quadrangle is made up of Mississippian aged shaley limestone from the Warsaw Formation. This shaley limestone is calcareous, argillaceous, medium- to dark-gray, fine- to medium-grained, and thin-bedded to laminated with shale partings.

Soil/Rock Conditions

Six boreholes were washed or cored at the investigated site to find refusal elevations and to examine the details and particulars of the rock. The extracted rock was gray, thin-bedded shaley limestone that was slightly weathered with crystallized vugs, calcite veins, and stylolites. Some of the interbedded shale and shale partings were washed out while drilling. Solid rock was visible at the bottom of the creek bed.

Abutment 1

The refusal elevation for the first abutment was found at 860.0ft. and 861.0ft. Spread footings or point bearing steel “H” piles with pile tip protection are recommended for this abutment. The ultimate bearing capacity of the limestone is 100TSF, using a factor of safety of 3.0. This gives an allowable bearing capacity of 33TSF.

Pier 1

Refusal elevation for this pier is 838.0ft. A solid rock bottom was visible beneath the shallow water in the creek bed. Spread footings seated on sound limestone are recommended to support this pier. The ultimate bearing capacity of the limestone is 100TSF, using a factor of safety of 3.0. This gives an allowable bearing capacity of 33TSF.

Pier 2

Refusal elevation for pier 2 is 838.4ft. Spread footings placed on rock are recommended to support this pier. The ultimate bearing capacity of the limestone is 100TSF, using a factor of safety of 3.0. This gives an allowable bearing capacity of 33TSF.

Abutment 2

The refusal elevations for the second abutment were found at 857.8ft and 859.4ft. Spread footings or point bearing steel “H” piles with pile tip protection are recommended for this abutment. The ultimate bearing capacity of the limestone is 100TSF, using a factor of safety of 3.0. This gives an allowable bearing capacity of 33TSF.

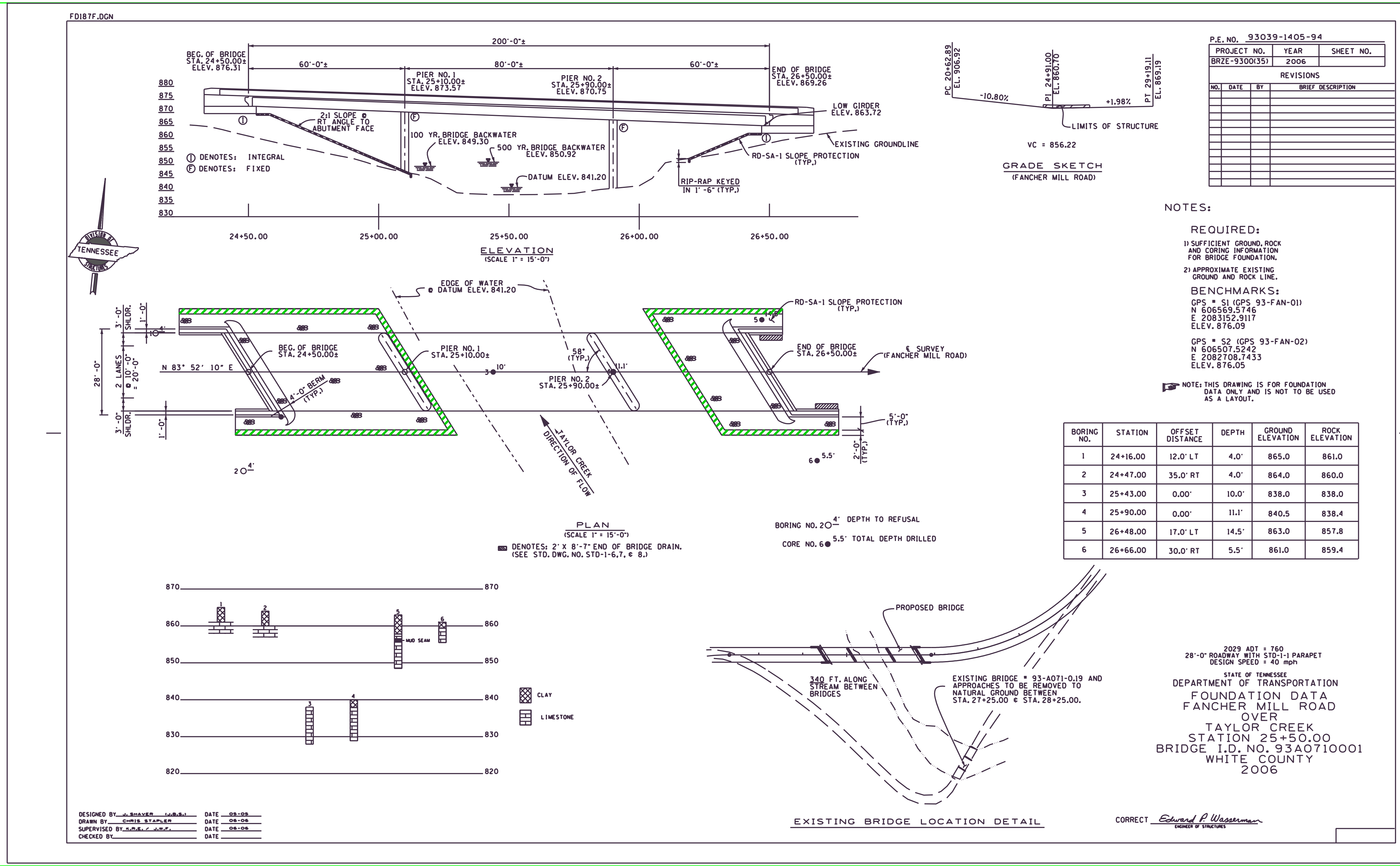
If there are questions concerning this report, please contact the Geotechnical Engineering Section.

Chilyere Anglin Smith
Geologist 3

M. Leonard Oliver, P.E.
Civil Engineering Manager 2

MLO:CAS:CJW
01-24-07

General Bridge Sketch



NOTES:

REQUIRED:

1) SUFFICIENT GROUND, ROCK AND CORING INFORMATION FOR BRIDGE FOUNDATION.

2) APPROXIMATE EXISTING GROUND AND ROCK LINE.

BENCHMARKS:

GPS # S1 (GPS 93-FAN-01)
N 606569.5746
E 2083152.9117
ELEV. 876.09

GPS # S2 (GPS 93-FAN-02)
N 606507.5242
E 2082708.7433
ELEV. 876.05

NOTE: THIS DRAWING IS FOR FOUNDATION DATA ONLY AND IS NOT TO BE USED AS A LAYOUT.

BORING NO.	STATION	OFFSET DISTANCE	DEPTH	GROUND ELEVATION	ROCK ELEVATION
1	24+16.00	12.0' LT	4.0'	865.0	861.0
2	24+47.00	35.0' RT	4.0'	864.0	860.0
3	25+43.00	0.00'	10.0'	838.0	838.0
4	25+90.00	0.00'	11.1'	840.5	838.4
5	26+48.00	17.0' LT	14.5'	863.0	857.8
6	26+66.00	30.0' RT	5.5'	861.0	859.4

2029 ADT = 760
28'-0" ROADWAY WITH STD-1-1 PARAPET
DESIGN SPEED = 40 mph

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
FOUNDATION DATA
FANCHER MILL ROAD
OVER
TAYLOR CREEK
STATION 25+50.00
BRIDGE I.D. NO. 93A0710001
WHITE COUNTY
2006

CORRECT Edward P. Wasserman
ENGINEER OF STRUCTURES

GEOTECHNICAL REPORT
Bridge and Approaches along
Jim Bob Scruggs Road Over Sugar Creek, L.M. 2.55
Project No.27945-1487-94
Pin No. 103885.00
Gibson County

Executive Summary

This report presents geotechnical recommendations for the Jim Bob Scruggs Road bridge and approaches over Sugar Creek. The existing 1-span bridge will be replaced with a 2 barrel reinforced concrete box bridge. A sample was taken along the approach location on Jim Bob Scruggs Road. The sample taken is a silt with gravel with an AASHTO classification of type A-4. Slope and CBR recommendations are included within the report.

GEOTECHNICAL REPORT
Bridge and Approaches along
Jim Bob Scruggs Road Over Sugar Creek, L.M. 2.55
Project No.27945-1487-94
Pin No. 103885.00
Gibson County

Introduction

This report presents geotechnical recommendations for a site investigation conducted to study the geologic setting and conditions for the above project. Improvements will be made by reconstructing the bridge of Jim Bob Scruggs Road at Station 57+22.00. The existing 1-span bridge will be replaced with a 2 barrel reinforced concrete box bridge.

Geology, Soils and Site Conditions

The proposed bridge replacement is located north of Jackson in Gibson County, which is in the Gulf Coastal Plain. The geologic material in the area is comprised of Tertiary coastal plain sediments and recent alluvium. The soil investigated was soft, moist, brown clay. The investigated area was a rural residential area. The outlying surface area is relatively flat and vegetated by trees, grasslands and cultivated fields. Minimum erosion was visible on the steep embankment slopes due to the vegetation.

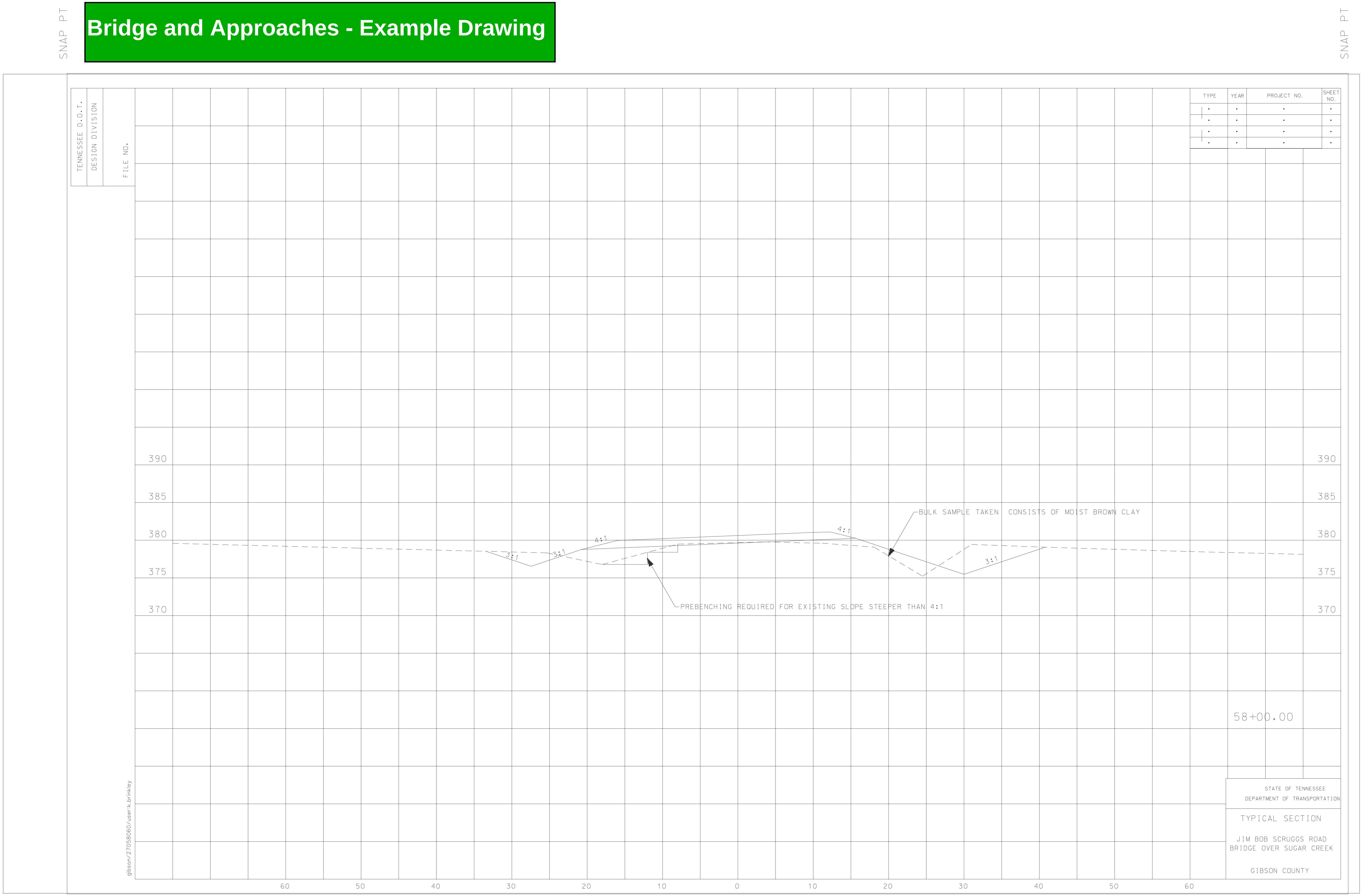
Surface and Subsurface Exploration

A bulk bag sample was taken at Station 58+00 on Jim Bob Scruggs Road. Through laboratory testing the sample is silt with some gravel with an AASHTO classification of type A-4.

Pavement Design Recommendations

A slope ratio of 3:1 or flatter is an adequate design for the proposed project. The recommended CBR value for pavement design is 4.0.

Bridge and Approaches - Example Drawing



RETAINING WALL REPORT
Central Pike
Wall No. 1, and Wall No. 2
Project No. 19958-1780-54, PIN No. 101200.00
Davidson County

<u>Executive Summary</u>

This report summarizes the results of the subsurface investigation accomplished for the referenced project with respect to recommendations for foundation design. The structure is designed to prevent encroachment to the adjacent commercial business (Tract 7). Based on the drilling, it is recommended that the structure is supported on in-place limestone. The acceptable wall types for this cut wall are cast-in-place concrete gravity wall, concrete cantilever, (reverse L-type included) Mechanically Stabilized Earth (MSE) walls with either Segmental Precast or Modular Block Facing, and a soldier pile/lagging cantilever wall. The boring data suggests that the wall may encounter bedrock above the bottom of the proposed wall and rock excavation will likely be required for construction. All wall types are acceptable if a temporary construction easement can be obtained, however, given the reason for the wall at this location, a soldier pile and lagging wall is the most effective for this location in that it requires little excavation behind the walls. A reversed L shape wall also limits needed construction easement.

Introduction

As part of a project designed for transportation improvements to increase the level of service for Central Pike including the intersection with State Route 24 (Lebanon Pike), this structure was requested by the Nashville Metro Department of Public Works to save a parking lot on Tract 7. According to the cross sections provided to the Geotechnical Engineering Section, the roadway grade along this site will be lowered to achieve the necessary minimum clearance between the roadway and an overhead railroad that is up station. Therefore, the increased lane widths and overall carrying capacity resulted in limited right-of-way constraints with the parking lot and the need to utilize a retaining structure. When completed, the cut wall will measure approximately 145 feet in length, up to 11 feet in height and located 48.5 feet right of the proposed centerline.

Two exploratory borings were accomplished near the footprint for the proposed retaining wall to define the general subsurface conditions at the site. A detailed description of the individual borings is shown on the Conceptual Drawing and Boring Records attached to the end of this report.

Geology, Soils and Site Conditions

The project area is located within a physiographic region of Tennessee known as the Central basin. The regional topography consists of gently rolling hills to bluffs or steepened slopes overlooking Stones River and Clover Bottom. In the immediate area much of the original surface cover has been reworked to accommodate the variety of land uses, including residential, warehousing and industrial and commercial.

Available geologic mapping (USGS Geologic Map of the Nashville East Quadrangle, 1966) indicates the site is underlain by the Bigby-Cannon Limestone Formation, representing the Ordovician Geologic period. The Bigby-Cannon formation typically consists of a medium dark to light gray, medium-grained, thin- to medium-bedded limestone. The residuum formed by the in-place weathering of the parent limestone consists of brown to reddish-brown silty clay. The soil/rock interface can be highly irregular due to soil-filled slots extending deep into the rock mass and rock pinnacles protruding into the soil overburden layer.

Surface and Subsurface Exploration

As discussed previously, the subsurface conditions in the vicinity of the proposed wall were explored with two borings. This was due to the underground and overhead utilities, as well as, lack of a working area in the parking lot. Where possible, the consistency of the soils was estimated based on the amount of effort required to advance the casing.

Boring 1 encountered 5.5 feet of wet to slightly moist, dark to reddish brown silty clay with trace amounts of gravel overlying slightly to moderately weathered limestone. Boring 2 consisted of nearly 7 feet of dark to light brown silty clay with varying amounts of gravel and 5 feet of boulder clay overlying unweathered limestone at a depth of 12 feet. It is not known if the latter deeper overburden depth is due to the nearby hills that have been cut and the low areas filled to make road frontages more accessible or if this is a vertical solution zone in the underlying bedrock.

The above subsurface description is of a generalized nature to highlight the major subsurface stratification features and material characteristics. The boring logs included in the report should be reviewed for specific information at individual boring locations. The stratifications shown on the boring logs represent the conditions only at the actual boring locations. Variations may occur and should be expected between boring locations.

Recommendations and Discussion

Geotechnical recommendations provided in this report and on the Retaining Wall Conceptual Drawing are based on information provided to the Geotechnical Engineering Section at the time of the request to conduct the geotechnical investigation. The Roadway and/or Structural Designer should review the report and drawings and determine if pertinent information regarding the retaining wall construction – such as available right-of-way, traffic sequencing or utility placement – remains valid. If any design information that may affect wall design or construction is altered after the time of the geotechnical report, this information should be provided to the Geotechnical Engineering Section for review.

Excavation for the wall and/or its footing shall not be accomplished until the contractor has labor and material resources available to begin and continue wall construction immediately after excavation. All walls must follow the design guidelines established in the TDOT Earth Retaining Structures Manual. All temporary construction slopes shall be placed at a maximum of a 1:1 slope in soil and shall not be left open without shoring for any longer than absolutely necessary. The contractor building the wall shall ensure that these temporary back slopes are not and do not become unstable. If slope is unstable, becomes unstable, is cut steeper than a 1:1 slope or is unacceptable for another reason, then temporary shoring shall be used. Any unusual soil conditions other than those assumed should be reported to the Geotechnical Engineering Section. Specific geotechnical parameters are described in the following recommendations.

Acceptable Wall Types

- Cast-in-Place Concrete Gravity Wall
- Cast-in-Place Concrete Cantilever Wall (including Reverse L)
- Mechanically Stabilized Earth (MSE) Wall – Segmental Precast
- Mechanically Stabilized Earth (MSE) Wall – Modular Block
- Soldier Pile

The boring data suggests that the retaining wall will be placed on in-place limestone at elevations ranging from approximately 441 feet at the beginning of the wall, Station 19+89 to an elevation of 432 feet at Station 21+35 or the end of the wall. This will involve some excavation of soil and limestone bedrock near the base of the proposed wall. For soldier pile wall, piles shall be pre-drilled and socketed into rock down to the elevation required for stability by the wall designer utilizing in-place rock strength of 10,000 psi. The Geotechnical design requirements and parameters for the proposed retaining wall are as follows:

Wall Data

Shear Strength Data	ϕ	γ **(pcf)**
Select Backfill*	35	---
In situ soil	25	120
Sliding Coefficient of Friction (Concrete on Limestone)	F= 0.6	

Factors of Safety to be used

Condition	**FS**
Overturning	2.0
Sliding	1.5
Bearing Capacity MSE Wall	2.5
Bearing Capacity Other Walls	3.0

Allowable Temporary Construction Slopes in Soil	1:1

Maximum Allowable Bearing

Condition	CIP Concrete Gravity Wall	MSE Wall
Limestone	15 TSF (Allowable) 45 TSF (Ultimate)	18 TSF (Allowable) 54 TSF (Ultimate)

*Select Backfill unit weight to be determined by contractor/wall designer depending on actual backfill material used. Select backfill is defined as material meeting specifications in Section 4.5, Part F, Chapter 3 of TDOT Earth Retaining Structures Manual. In order to utilize ϕ for select backfill design, select backfill must be placed for a minimum zone formed by a 1:1 slope from 2 feet behind the bottom of the back of the wall footing or reinforced soil zone for MSE walls up to finished grade.

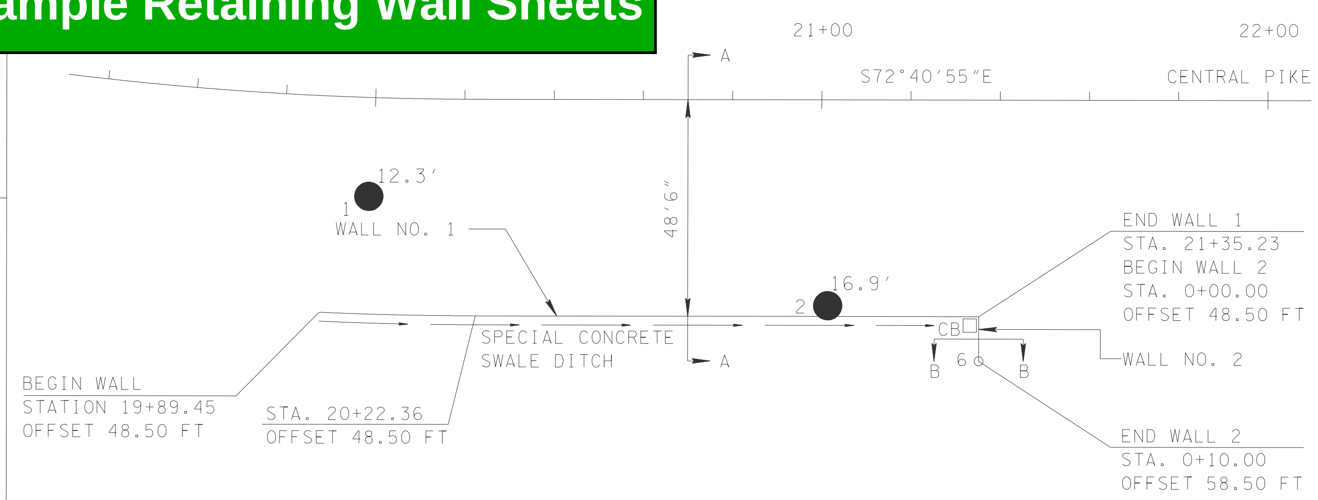
Specific Design Requirements

The wall shall have a drainage gutter at the top designed to carry surface runoff to either or both ends of walls. A drainage gutter typical is shown for reference; however, actual details to be provided in contractor's wall design plans. If a Concrete Cantilever Wall is used, the wall designer must provide for a drainage layer behind the wall stem with adequate drainage provided via weep holes.

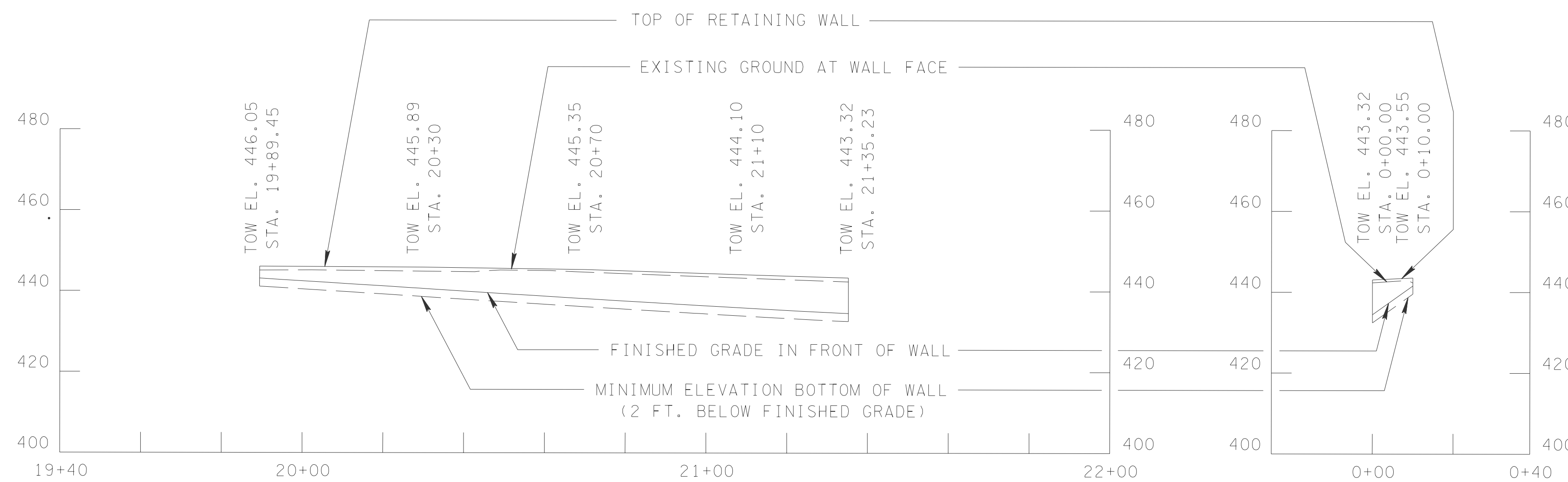
Example Retaining Wall Sheets

TYPE	YEAR	PROJECT NO.	SHEET NO.
R.O.W.	2006	STP-M-4967(1)	12

TENNESSEE D.O.T.
DESIGN DIVISION
FILE NO.

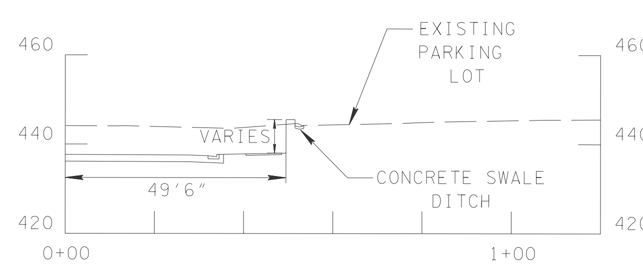


WALL PLAN VIEW (SCALE 1"=20')

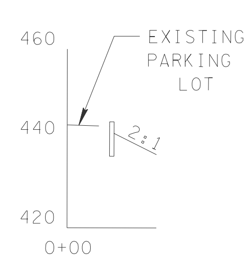


WALL NO. 1
WALL ELEVATION VIEW
WALL FACE AREA = 1233 FT^2

WALL NO. 2
WALL ELEVATION VIEW
WALL FACE AREA = 72.91 FT^2



SECTION A-A



SECTION B-B

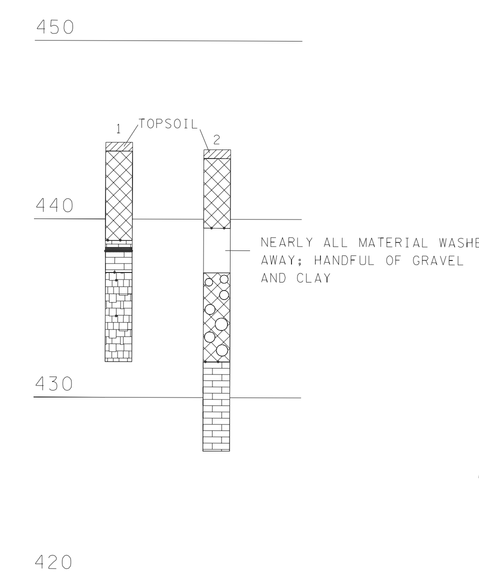
Special Note Regarding Retaining Walls:

Unless specifically stated otherwise in the contract plans, the bidding for, the design of and the construction of retaining walls shown in the plans shall be governed by the TDOT Earth Retaining Structures Manual. This Manual is available on the TDOT Web Site under the Information for Contractors link. This Manual shall be considered as one of those documents which the Bidder/Contractor has examined and made himself familiar with as described in Section 102.04-Examination of the Site, the Work, the Plans, and the Specifications in the TDOT Standard Specifications for Road and Bridge Construction.

NOTE:

BORING DEPICTIONS SHOWN ON FOUNDATION DATA SHEET INDICATE GENERAL SOIL AND ROCK TYPES AT THE SPECIFIC BORING LOCATIONS.

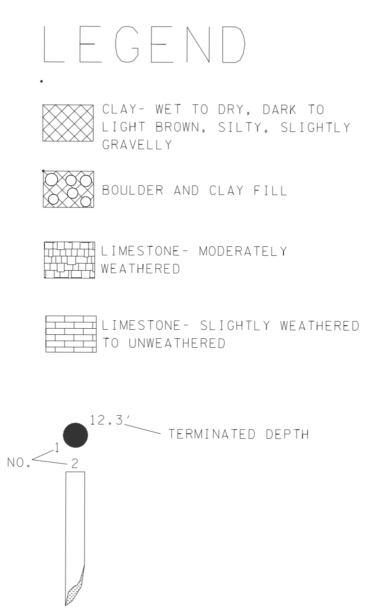
TO ASSIST IN BID PREPARATION FOR FOUNDATION CONSTRUCTION. DETAIL ROCK AND SOIL DESCRIPTION AND, ON SOME PROJECTS, ROCK CORE SAMPLES ARE AVAILABLE FOR INSPECTION AT THE MATERIALS AND TESTS HEADQUARTERS AT 6601 CENTENNIAL BLVD., NASHVILE, TN. (615) 350-4130.



GROUND AND ROCK ELEVATIONS

1. G.444.3
R.438.8

2. G.443.9
R.432.0



STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

RETAINING WALL NO.2
CENTRAL PIKE
STA.0+00.00
TO
STA.0+10.00
DAVIDSON COUNTY

$$$$SYTIME$$$$$
$$$$DGNSPEC$$$$

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Example Retaining Wall Sheets

TYPE	YEAR	PROJECT NO.	SHEET NO.
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.	.	.	.
.	.	.	.
.	.	.	.

Retaining Wall

Geotechnical recommendations provided in this report and on the Retaining Wall Conceptual Drawing are based on information provided to the Geotechnical Engineering Section at the time of the request to conduct the geotechnical investigation. If any design information that may affect wall design or construction is altered after the time of the geotechnical report, this information should be provided to the Geotechnical Engineering Section for review.

Excavation for the wall and/or its footing shall not be accomplished until the contractor has labor and material resources available to begin and continue wall construction immediately after excavation. All walls must follow the design guidelines established in the TDOT Earth Retaining Structures Manual, revised December 2004. All temporary construction slopes shall be placed at a maximum of a 1:1 slope in soil and shall not be left open without shoring for any longer than absolutely necessary. The contractor building the wall shall ensure that these temporary back slopes are not and do not become unstable. If slope is unstable, becomes unstable, is cut steeper than a 1:1 slope or is unacceptable for another reason, then temporary shoring shall be used. Any unusual soil conditions other than those assumed should be reported to the Geotechnical Engineering Section. Specific geotechnical parameters are described in the following recommendations.

Acceptable Wall Types

- Cast-in-Place Concrete Gravity Wall
- Cast-in-Place Concrete Cantilever Wall (including Reverse L)
- Mechanically Stabilized Earth (MSE) Wall – Segmental Precast
- Mechanically Stabilized Earth (MSE) Wall – Modular Block
- Soldier Pile

Based on the drilling, it is recommended that the structure is supported on soil at the minimum embedment depth shown on the conceptual depth. This shall involve some excavation of limestone bedrock near the base of the proposed wall. For soldier pile wall, piles shall be pre-drilled and socketed into rock down to the elevation required for stability by the wall designer utilizing intact rock strength of 30,000 psi. The Geotechnical design requirements and parameters for the proposed retaining wall are as follows:

Wall Data

Shear Strength Data	ϕ	γ (pcf)
Select Backfill*	35	---
In situ soil	25	120
Sliding Coefficient of Friction (Concrete on Limestone)		F= 0.6
Sliding Coefficient of Friction (Concrete on Clay)		F= 0.35

Factors of Safety to be used

Condition	FS
Overturning	2.0
Sliding	1.5
Bearing Capacity MSE Wall	2.5
Bearing Capacity Other Walls	3.0

Allowable Temporary Construction Slopes in Soil	1:1
Allowable Temporary Construction Slopes in Rock	Vertical

Maximum Allowable Bearing

Condition	CIP Concrete Gravity Wall	MSE Wall
Limestone	15 TSF (Allowable) 45 TSF (Ultimate)	18 TSF (Allowable) 54 TSF (Ultimate)
Soil	1 TSF (Allowable) 3 TSF (Ultimate)	1.1 TSF (Allowable) 3.3 TSF (Ultimate)

Earth Pressure Coefficients

Active	0.41
Passive	2.46

*Select Backfill unit weight to be determined by contractor/wall designer depending on actual backfill material used. Select backfill is defined as material meeting specifications in Section 4.5, Part F, Chapter 3 of TDOT Earth Retaining Structures Manual. In order to utilize ϕ for select backfill design, select backfill must be placed for a minimum zone formed by a 1:1 slope from 2 feet behind the bottom of back of wall footing or reinforced soil zone for MSE walls up to finished grade.

Specific Design Requirements

The wall shall have a drainage gutter at the top designed to carry surface runoff to either or both ends of walls. A drainage gutter typical is shown for reference; however, actual details to be provided in contractor's wall design plans. If a Concrete Cantilever Wall is used, the wall designer must provide for a drainage layer behind the wall stem with adequate drainage provided via weep holes.

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

RETAINING WALL NO.2
CENTRAL PIKE
STA.0+00.00
TO
STA.0+10.00
DAVIDSON COUNTY

Example Retaining Wall Sheets

TENNESSEE D.O.T.
DESIGN DIVISION

FILE NO.

TYPE	YEAR	PROJECT NO.	SHEET NO.
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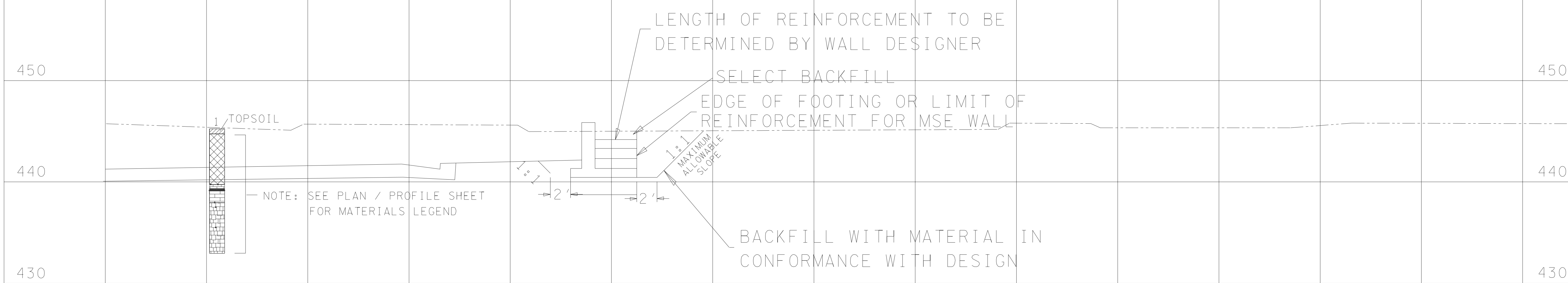


20+00

MECHANICALLY STABILIZED EARTH (MSE)

--SEGMENTAL PRE-CAST

--MODULAR BLOCK FACING

SPREAD FOOTING FOUNDATION ON ROCK

(ELEVATION TO VARY FROM 441' TO 432')

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

RETAINING WALL NO.1
CENTRAL PIKE
STA.19+89.45 TO
STA. 21+35.23
DAVIDSON COUNTY

0 50 100

GEOTECHNICAL REPORT

Intersection Improvement and Signalization
State Route 149 and River Road @ L.M. 13.08
State Project No. 63023-1235-94; PIN No. 104051.00
Montgomery County

Executive Summary

This report summarizes the site investigation for the above referenced project on March 30, 2005. The investigation was in response to a request by TDOT Region 3 Survey and Design to a preliminary right-of-way field review that was held on April 1, 2005. The proposed project is included in the future construction of an extension of State Route 374 between State Route 13 southwest of Clarksville and U.S. 79 (SR-76) west of Clarksville. When completed, this extension will provide the final link for the by-pass that would circle the city of Clarksville.

Slopes on the project shall be placed at no more than 3:1. If 3:1 is not reasonable for Right of way, then 2.5:1 slopes shall be allowed. This is especially important for the Station interval 52+50 to 58+00. For all slopes it is recommended to use an Erosion Control Blanket (Type II) for the highly erosive soil. Debris placed along River Road, from approximate Station 7+00 to Station 9+00, right of centerline, shall be removed. The CBR for pavement design shall be no more than 6.

Introduction

This report summarizes the site investigation for the above referenced project on March 30, 2005. The investigation was in response to a request by TDOT Region 3 Survey and Design to a preliminary right-of-way field review that was held on April 1, 2005. The proposed project is included in the future construction of an extension of State Route 374 between State Route 13 southwest of Clarksville and U.S. 79 (SR-76) west of Clarksville. When completed, this extension will provide the final link for the by-pass that would circle the city of Clarksville.

Geology, Soils and Site Conditions

The project is located in the northwestern portion of Central Tennessee within the Highland Rim Physiographic Region. The topography of the project vicinity is characterized as nearly level with hillsides that fall away to form hollows and wide valleys. The geologic map of the area indicates that the project is underlain by bedrock representing the St. Louis Limestone Formation. The St. Louis Limestone within the region occurs in part as fossil-fragmental limestone and dolomitic siltstone. For this project, the St. Louis has been weathered to a residuum consisting of red- to reddish-brown clay soil with rounded pebbles to angular cobbles (blocks) of chert. The only exposure of in-place rock was at the base of the very deep gully (left of centerline) near the proposed toe of the fill slope at Station 53+00 and at the op of the existing ditch (right of centerline) at Station 67+00.

Surface and Subsurface Exploration

No subsurface exploration was accomplished for the project. Site was examined at surface. Area soils and geologic maps were used in preparation of this report.

The following are observations and comments that may be used for final design plans as no subsurface exploration was accomplished for the project.

Beginning of Project to Station 59+50 – Left of Centerline

The terrain approximates a 2:1 slope with sloughing and shallow slides just below the shoulder of the road and huge erosion gullies down slope. The cherty clay soil is so easily eroded that undermining of the soil beneath the outlet end of the existing corrugated metal pipe has resulted in about 10 feet of the pipe uncoupling into two pieces. The concrete wing wall is still attached to the end of one section of the pipe. With the loss of some of the pipe, a hole developed to about 15 feet in depth and 20 feet in diameter. From this point, erosion created a very deep gully down slope, exposing limestone in one area. At the intersection of State Route 149 and River Road is an undetermined fill area for an unknown depth, surface evidence consisting of piles of construction debris, i.e., bricks, fill dirt, chunks of concrete. A maximum 11 feet of sidehill fill is proposed for this entire section on current design slopes of 2:1 up to Station 58+00. From here, design proposes 3:1 to 6:1 slopes for the remainder of the section.

Station 59+50, Left of Centerline to end of Project

Mainly ditch line cut and fill sections on proposed 4:1 and 6:1 slopes. From a geotechnical standpoint, problems that cannot be compensated for in the design and/or construction phases are not anticipated.

Beginning of project to Station 59+50, Right of Centerline

Adjacent to either side of the unnamed road are Tracts 3 and 8. Scattered gully formation and standing water at the pipe inlet was observed on Tract No. 3 along with soil-infilling of the ditches. Concrete blocks, bricks, rock and gravel mixed with dirt indicate recent in-filling of a section of Tract No. 8 adjacent to the unnamed road. There is little to no grass cover and there is recent cutting of trees and brush within the basin and near the inlet pipe. The majority of this interval will consists of embankment up to 5 feet with minor cuts of approximately 2 feet on slopes ranging from 2:1 to 6:1.

Station 59+50, Right of Centerline to end of Project

Once past the business on Tract No. 8, construction will entail a maximum 5 feet of embankment on current design slopes ranging from 2:1 to 6:1. From near Station 66+00 to the end of the project, there is in-place limestone exposed along the top of the ditch. Tract No. 18 has been recently cleared for a future business revealing the red cherty clay that is present on this project. As with the left side of the proposed project, from a geotechnical standpoint, there does not appear to be any problems that cannot be compensated for during the design and/or construction phases.

Recommendations

It is recommended that the existing embankments are grubbed, slide or sloughed material is removed and the embankment is pre-benched according to Section 205.03 of the Standard Specifications for Road and Bridge Construction prior to additional fill placement. A representative cross section is shown at Station 52+50. Side cast placement of fill down the existing slopes shall not be allowed. Topsoil shall not be stockpiled at the tops of excavated or embankment slopes. It is recommended that the extremely large gullies will require removal of all loose and organic material to a sufficient depth and width to allow construction equipment to place and compact fill material prior to embankment construction. The Geotechnical Engineering Section reiterates the desire to maintain 3:1 or flatter slopes throughout the project. If a 3:1 slope cannot be constructed in place of 2:1 slopes, it is recommended that the Design consultant check and see if 2.5:1 slopes can be used in place of 3:1 slopes. This is especially important for the Station interval 52+50 to 58+00. For all slopes it is recommended to use an Erosion Control Blanket (Type II) for the highly erosive soil.

On River Road, from approximate Station 7+00 to Station 9+00, right of centerline, the property owner has end dumped construction material parallel to the existing highway. The depth of the debris is unknown; however, for construction purposes, it is recommended that the debris is removed to natural ground assuming a minimum 3' depth from the edge of the proposed toe of fill slope up to the edge of existing roadway. This material is considered waste and shall be placed in an appropriate waste area off-site of the project. The project engineer may need to adjust the actual limits during construction. A representative cross section is shown at Station 8+00 (River Road).

A pavement design using a CBR of 6 (county average) is recommended provided the subgrade is compacted according to specifications. Once the project is brought to grade, CBR samples should be obtained to verify the design value.

If there are questions concerning this report, please contact the Geotechnical Engineering Section.

Randall J. Jones
Operations Specialist 2

M. Leonard Oliver, P.E.
Civil Engineering Manager 2

MLO:RJJ:LGW
09/20/05

Example Line Report

GEOTECHNICAL REPORT

State Route 374 (Warfield Blvd.) From South of Dunbar Cave Road
To Stokes Road
Project No. 6311-1216-14
Pin No. 100290.00
Montgomery County

EXECUTIVE SUMMARY

This project may be constructed using a maximum slope ratio of 2:1 where the slopes will be constructed in soil, however, slopes constructed as shown on the cross-sections with slope ratios flatter than 2:1 will result in increased slope stability. Where rock is encountered in the cuts, a vertical slope is recommended for the rock with a 15 feet wide bench at the soil/rock interface and the upper soil laid back on a 2:1 slope. A uniform catchment width of 24 feet from the face of the curb to the face of the rock slope is recommended where rock cuts are proposed. Two areas will require rock pads to protect the proposed embankment from potential standing water and to facilitate drainage of buried sinkholes. Two potential sinkholes exist that will require treatment.

Example Line Report

GEOTECHNICAL REPORT
State Route 374 (Warfield Blvd.) From South of Dunbar Cave Road
To Stokes Road
Project No. 6311-1216-14
Pin No. 100290.00
Montgomery County

INTRODUCTION

This project involves the widening and improvement of an approximately 1.7 mile section of State Route 374. This project is necessary to relieve congestion and improve safety in this area.

GEOLOGY, SOILS, AND SITE CONDITIONS

This project is located in the Western Highland Rim Province of Middle Tennessee and is underlain by cherty clay resting upon limestone indicative of the St. Louis Limestone and Warsaw Limestone.

SURFACE AND SUBSURFACE EXPLORATION

Visual observation was accomplished for the entire project and detailed drilling was done in the area of the buried sinkholes and the proposed rock cuts. The remainder of the project was spot drilled. Refer to boring logs and soils sheets for details.

RECOMMENDATIONS

Station 44+64.53 To Station 51+00

This interval consists of alternating cut and fill sections with cut depths of up to 25 feet and fill heights of up to 10 feet. A maximum slope ratio of 2:1 is recommended for the slopes in the interval. Pre-benching of the existing fill slope prior to fill placement is required for all existing slopes steeper than 4:1. Refer to cross-section station 46+00.

Station 51+00 to Station 66+00

This interval involves alternating cut and fill sections with cut depths of up to 50 feet and fill heights of up to 15 feet. Rock cut slopes are proposed from RT Station 51+50 to RT Station 55+50 and RT Station 57+50 to RT Station 63+00. It is recommended that the rock in this area be placed on a vertical slope. A 24 foot rockfall catchment width is required from the face of the proposed curb to the toe of the rock face. For aesthetic reasons it is recommended that the 24 foot catchment width be carried through the entire cut area. This will result in excessive catchment width in some areas; however, the cut face will appear smooth and consistent. It is recommended that a 15 foot wide bench be constructed on top of the vertical slope at the soil/rock interface with the upper soil material laid back on a 2:1 slope. Refer to cross-section station 54+00, 59+00, and 61+50. A shotcrete wall is proposed from LT Station 58+25 to LT Station 61+75. The cross-sections show this proposed wall to be offset from the existing rock face by a minimum of five feet. The existing rock face appears stable. Sufficient room exists between the existing rock face and the face of the proposed curb to accommodate rock fall catchment requirements. It is recommended that this wall be eliminated and the gap between the back edge of the sidewalk and the existing rock face be backfilled with common roadway embankment to create a flat catchment area. Refer to cross-sections Station 59+00 and 61+50. A maximum slope ratio of 2:1 is recommended for the remainder of the slopes in this interval.

Station 66+00 to Station 91+00

This interval consists of alternating cut and fill sections with cut depths of up to 25 feet and fill heights of up to 30 feet. A maximum slope ratio of 2:1 is recommended for the cut and fill slopes in this interval; however, slopes constructed as shown on the cross-sections with slope ratios flatter than 2:1 will result in increased slope stability. From RT station 84+00 to RT Station 86+50 a 2:1 slope is proposed. The existing slope in this area is a 3:1 slope. A 3:1 slope ratio is recommended at this location to preserve the consistency of the slope and to reduce the possibility of slope stability problems that may develop by keying a 2:1 slope into an existing 3:1 embankment. If a 3:1 slope causes right-of-way issues in this area, use a slope ratio that will cause the toe of the proposed slope to match the toe of the existing slope (approximately 2.6:1). Pre-benching of this existing slope prior to fill placement is required for existing slopes steeper than 4:1; however, pre-benching is recommended for all slopes where sliver type fills are proposed. Refer to cross-section Station 84+00. A retaining wall is proposed from LT Station 69+00 to LT Station 72+50. Specific recommendations for this structure will be made in a separate report when an investigation is requested.

Station 91+00 to Station 118+00

This interval involves alternating cut and fill sections with cut depths of up to 8 feet and fill heights of up to 25 feet. A maximum slope ratio of 2:1 is recommended for the cut and fill slopes in this interval. Pre-benching of the existing fill slopes is required for existing slopes steeper than 4:1; however, pre-benching is recommended for all slopes where sliver type fills are proposed. Refer to cross-section

Station 105+00. A rock pad will be required at LT Station 112+00 to LT Station 116+00. This area is near an existing sinkhole that functions as an outlet for significant surface runoff. It is recommended that this area be cleared of all organic debris. A layer of Geotextile fabric (Type IV, high survivability, Item No 740-10.04) be placed beneath the entire proposed embankment footprint and should extend a minimum of 25 feet up the side of the existing embankment. Graded solid rock shall then be placed on the fabric to a minimum depth of five feet. A layer of Geotextile fabric (Type IV, high survivability, Item No. 740-10-04.) shall then be placed on top of the rock pad. The remainder of the embankment in this area may consist of common roadway embankment. Refer to cross-section 114+50.

Station 118+00 to Station 155+86.85

This interval consists of alternating cut and fill sections with cut depths of up to 18 feet and fill heights of up to 15 feet. A maximum slope ratio of 2:1 is recommended for the slopes in this interval; however, slopes constructed with slope ratios flatter than 2:1 as shown on the cross-sections will result in increased slope stability. The cut area from LT Station 119+00 to LT Station 129+00 may contain several localized pods of pinnacle type rock outcrops. It is recommended that any pinnacle type rock encountered be included with the soil overburden and be laid back on the appropriate slope. Refer to cross-section station 121+00. Evidence of two potential sinkhole openings exist left of station119+10. One exists as an area that has sunk in the existing roadway ditch and has been repaired with aggregate and asphalt. The other is a sunk-in hole in the existing ditch between the outlet of the Pinnacle Lounge and Arcade parking lot drain and the existing under-drain in their entrance. The area has been repaired with rip rap but the opening has re-occurred. Both areas are affected by surface drainage. The opening of the existing roadway ditch is under the proposed roadway in an area of approximately a three foot fill. It is recommended that this area be excavated to rock or as deep as is practical (20' maximum). A layer of Geotexile fabric shall be placed so as to line the excavation. The excavation shall then be backfilled with graded solid rock up to proposed sub-grade elevation. The second opening is located in or near the proposed roadway ditch-line in an area of an approximately 15 foot cut. After the cut has been excavated to proposed ditch-line elevation, it is recommended that the sinkhole be excavated to rock or as deep as is practical (20' maximum). A layer of Geotextile fabric shall be placed so as to line the excavation. The excavation shall then be backfilled with graded solid rock to approximately two feet below proposed ditch-line grade. A layer of Geotextile fabric shall be placed on top of the graded solid rock and the remainder of the fill may consist of common roadway embankment. It is recommended that the proposed roadway ditch be lined with Geo-membrane from the end of the proposed 24" CMP to Station 120+50 to prevent surface runoff from entering the sinkhole. The exact location and the relationship of these two openings to one another will not be fully known until the cut is excavated. Adjustments to these recommendations may be required in the field during construction. A sinkhole/wetland area exists from LT Station 130+50 to LT Station 132+50. This area is currently handling significant surface drainage and will continue to function as drainage when the proposed roadway is completed. It is recommended that the area immediately under the roadway footprint be cleared of all brush and organic debris. A layer of Geotextile fabric (Type IV, high survivability, Item No. 740-10.04) shall then be placed beneath the entire proposed embankment footprint at this location, including a minimum distance of 28 feet up the existing embankment area. This area shall then be backfilled with graded solid rock to a minimum depth of six feet. A layer of Geotextile fabric shall then be placed on top of the Graded Solid Rock. The remainder of the fill material in this area may consist of common roadway embankment. Refer to cross-section Station 132+00. The portion of the sinkhole not affected by the proposed embankment should be left as-is to the extent practical and still achieve embankment/rock pad construction.

PAVEMENT DESIGN RECOMMENDATIONS:

It is recommended that one continuous pavement section be designed using the County average CBR value of CBR = 6.0.

If there are any questions concerning this report please contact the Geotechnical Engineering Section.

Michael Perkins
Operation Specialist Supervisor 1

M. Leonard Oliver. P.E.
Civil Engineering Manager 2

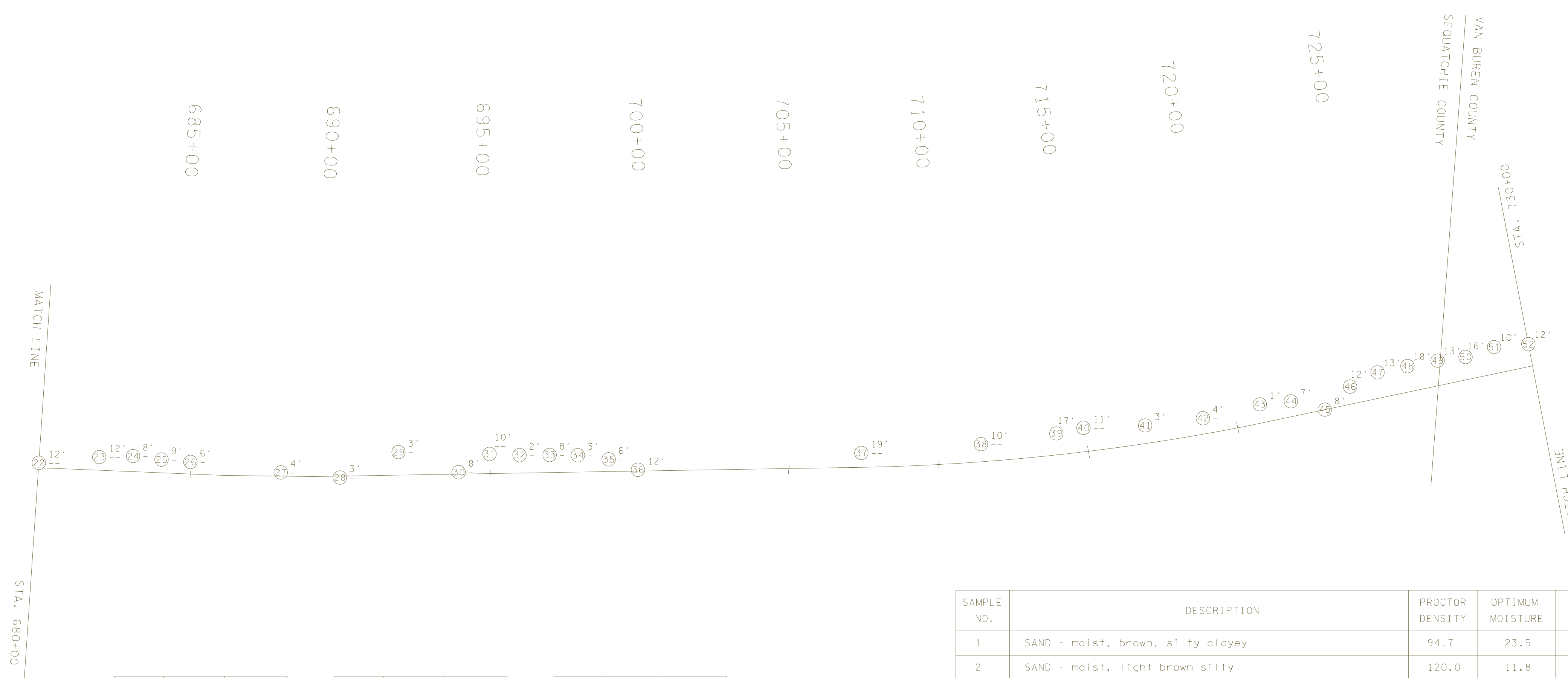
MLO:MP:CJW
02/01/07

Example Line Sheet (Plan View)

TENNESSEE D.O.T.
DESIGN DIVISION

FILE NO.

TYPE	YEAR	PROJECT NO.	SHEET NO.



HOLE NO	SAMPLE NO	DEPTH
22	5	0-1
	6	1-12
23	5	0-2
	6	2-10
	† 7	10-11
	6	11-12
24	6	0-8
25	6	0-9
26	5	0-1
	6	1-6
27	5	0-1
	6	1-4
28	† 8	0-3
29	5	0-2
	6	2-3
30	5	0-2
	† 9	2-8
31	5	0-6
	9	6-9
	2	9-10
32	1	0-2
33	5	0-2
	† 14	2-6
	6	6-8

HOLE NO	SAMPLE NO	DEPTH
34	6	0-3
35	1	0-6
36	5	0-2
	6	2-11
	† 10	11-12
37	8	0-6
	† 11	6-17
	† 12	17-19
38	8	0-8
	† 13	8-10
39	5	0-1
	6	1-9
	11	9-17
40	5	0-1
	6	1-9
	CBR 2	9-11
41	11	0-3
42	11	0-4
43	4	0-1
44	8	0-1
	11	1-7
45	4	0-1
	11	1-7
	9	7-8

HOLE NO	SAMPLE NO	DEPTH
46	13	0-1
	6	1-10
	11	10-12
47	† 15	0-4
	† 16	4-13
48	15	0-4
	16	4-6
	5	6-18
49	† 17	0-2
	16	2-4
	15	4-13
50	15	0-2
	16	2-3
	15	3-16
51	15	0-2
	16	2-8
	† 18	8-10
52	15	0-4
	16	4-6
	15	6-12

SAMPLE NO.	DESCRIPTION	PROCTOR DENSITY	OPTIMUM MOISTURE	MOISTURE RANGE	LL	PI	AASHTO CLASS	USCS CLASS
1	SAND - moist, brown, silty clayey	94.7	23.5	20.2-27.8	21	15	A-4	SC-SM
2	SAND - moist, light brown silty	120.0	11.8	8.8-15.2	NP	--	A-2-4	SM
3	CLAY - dry, gray with mottled sandy, silty	111.2	13.2	9.5-18.0	21	14	A-4	CL-ML
4	CLAY - moist, reddish-brown with gray mottled lean	104.6	19.5	15.6-23.5	37	22	A-6	CL
5	CLAY - moist, brown, sandy. lean	109.6	14.5	9.9-18.5	28	20	A-4	CL
6	SAND - light grayish-brown, silty, clayey	119.4	11.2	8.5-14.8	17	13	A-4	SC-SM
7	SAND - dry, grayish, silty	109.0	14.5	7.8-19.4	NP	--	A-2-4	SM
8	CLAY WITH SAND - wet, stiff, grayish-brown, lean	102.2	20.2	14.1-24.4	34	22	A-6	CL
9	CLAY - wet, greenish-brown, lean	111.0	15.2	11.2-18.7	28	19	A-4	CL
10	SAND - moist, black, silty, clayey	111.0	12.6	7.8-17.5	18	14	A-4	SC-SM
11	SHALE - cry, gray	-----	----	--------	--	--	---	--
12	SHALE - wet, gray	-----	----	--------	--	--	---	--
13	CLAY - wet, reddish-brown, sandy, silty	113.0	13.8	11.2-17.4	22	16	A-4	CL-ML
14	CLAY - dry, reddish-brown, sandy, lean	108.0	17.5	13.0-21.1	29	18	A-6	CL
15	CLAY - moist, reddish-brown, sandy, silty	113.3	13.3	9.2-17.5	22	16	A-4	CL-ML
16	CLAY WITH SAND - moist, gray, lean	107.2	14.2	8.2-19.2	27	18	A-4	CL
17	CLAY WITH SAND - reddish-brown, lean	105.1	17.2	14.2-21.6	37	23	A-6	CL
18	SHALE- dry, gray	-----	----	--------	--	--	---	--

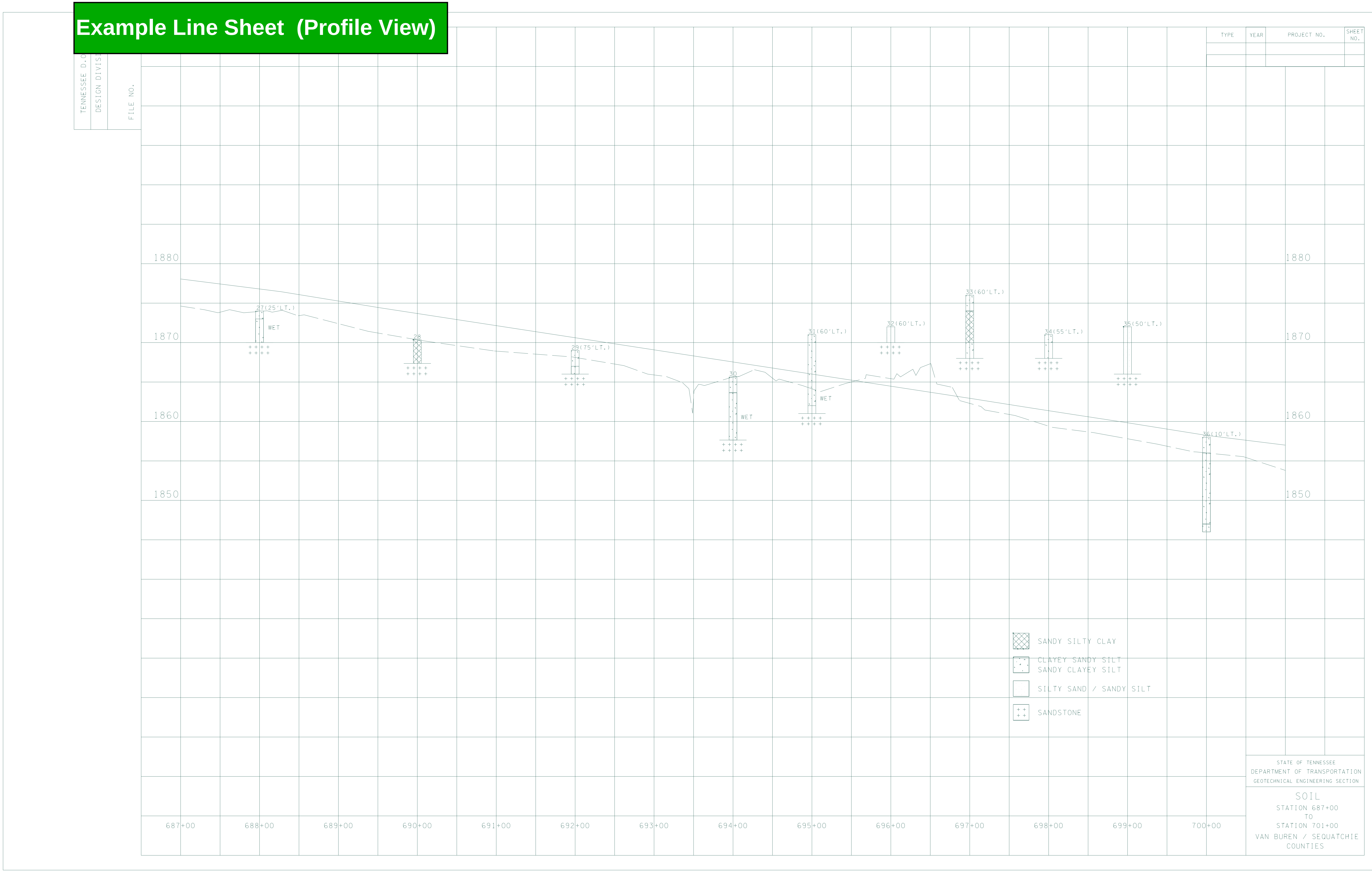
CBR NO.	DESCRIPTION	DENSITY	OPTIMUM MOISTURE	MOISTURE RANGE	LL	PI	AASHTO CLASS	USCS CLASS	CBR
2	SHALE - grayish-brown	-----	----	---------	----	--	----	-----	---

† INDICATES LOCATION WHERE SAMPLE WAS TAKEN AND LAB TEST PERFORMED.
ALL OTHER SAMPLE NUMBER LABELS INDICATE AN APPARENT SIMILARITY
BASED ON VISUAL IDENTIFICATION IN THE FIELD.

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

SOIL
STATION 680+00
TO
STATION 730+00
VAN BUREN / SEQUATCHIE
COUNTIES

Example Line Sheet (Profile View)



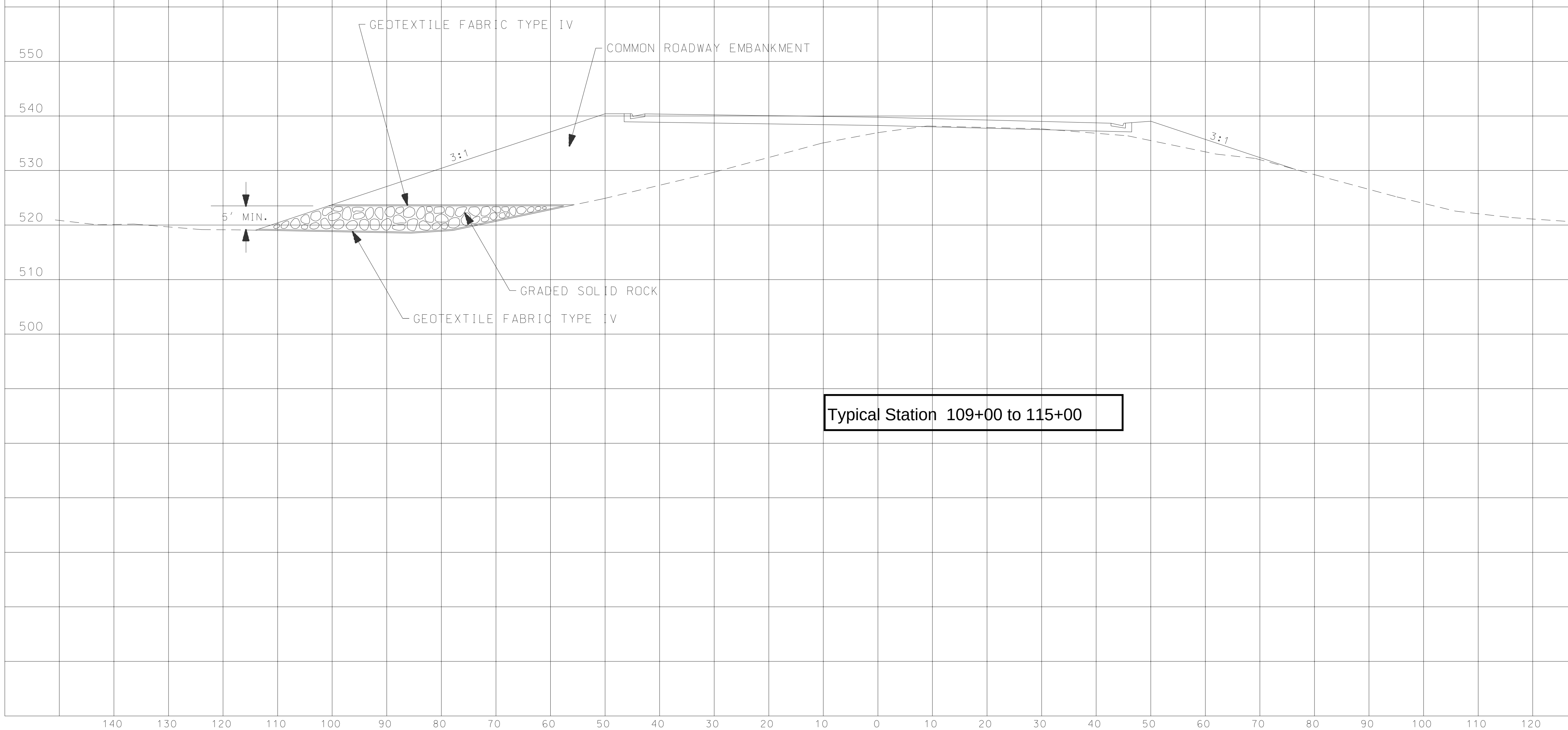
Example Line Sheet (Cross Section)

TYPE	YEAR	PROJECT NO.	SHEET NO.
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.

TENNESSEE D.O.T.
DESIGN DIVISION
FILE NO.

GRADED SOLID ROCK

BORROW EXCAVATION (GRADED SOLID ROCK) SHALL CONSIST OF THE REMOVAL AND SATISFACTORY PLACEMENT OF SOUND, NON-DEGRADABLE ROCK WITH A MAXIMUM SIZE OF 3 FEET (1 METER). AT LEAST 50 PERCENT OF THE ROCK SHALL BE UNIFORMLY DISTRIBUTED BETWEEN 1 FOOT (30 CENTIMETERS)AND 3 FEET (1 METER) IN DIAMETER AND NO GREATER THAN 10 PERCENT SHALL BE LESS THAN 2 INCHES (50 MILLIMETERS) IN DIAMETER. THE MATERIAL SHALL BE ROUGHLY EQUI-DIMENSIONAL IN SHAPE. THIN, SLABBY MATERIAL WILL NOT BE ACCEPTED. THE CONTRACTOR SHALL BE REQUIRED TO PROCESS THE MATERIAL WITH AN ACCEPTABLE MECHANICAL SCREENING PROCESS THAT PRODUCES THE REQUIRED GRADATION. WHEN THE MATERIAL IS SUBJECTED TO FIVE ALTERATIONS OF THE SODIUM SULFATE SOUNDNESS TEST (AASHTO T-104), THE WEIGHTED PERCENTAGE OF LOSS SHALL NOT BE MORE THAN 12. THE MATERIAL SHALL BE APPROVED BY THE ENGINEER BEFORE USE.



STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

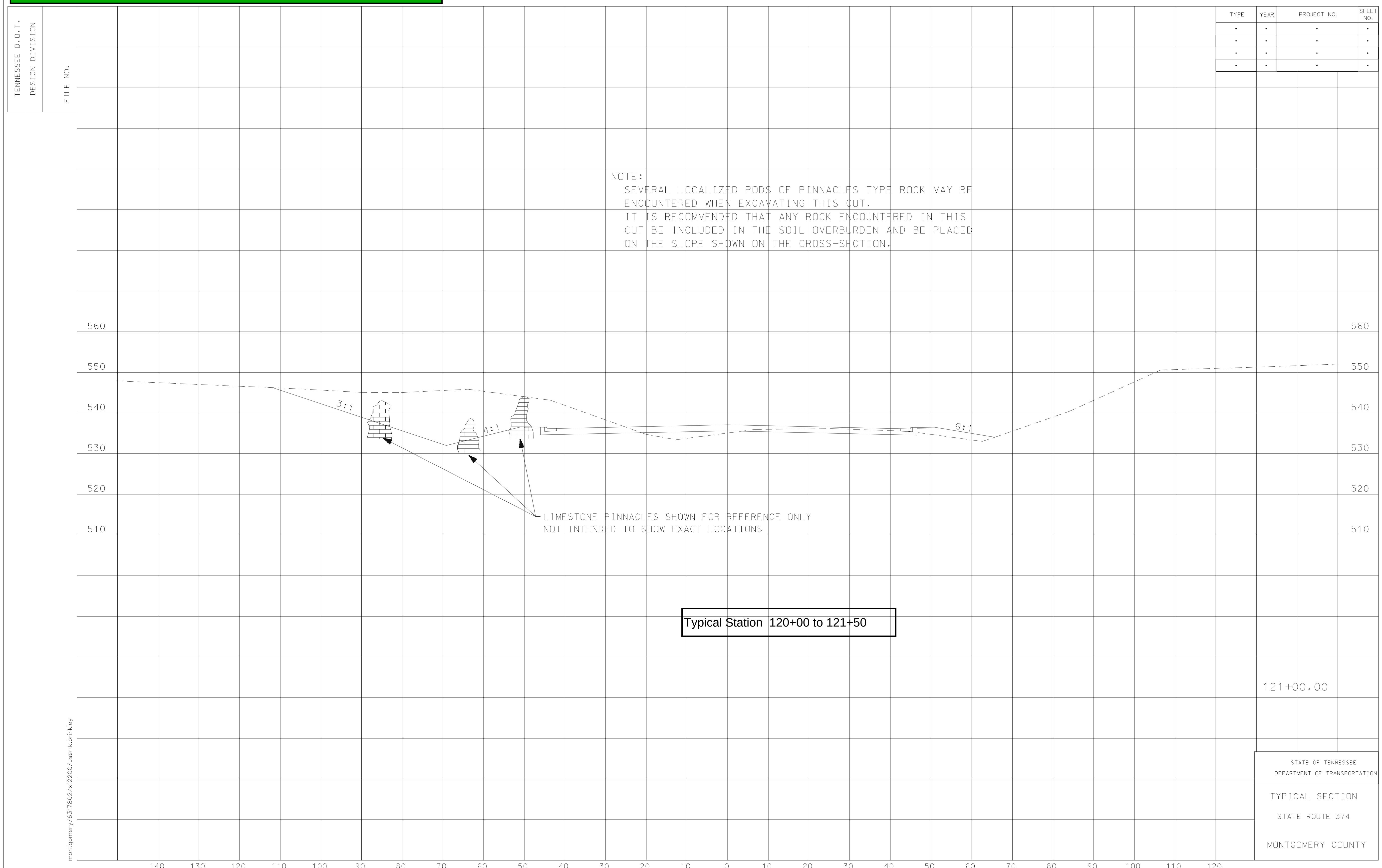
TYPICAL SECTION

STATE ROUTE 374

MONTGOMERY COUNTY

montgomery/6317802/x11450/user\k.brinkley

Example Line Sheet (Cross Section)



Example Rockfall Report

PRELIMINARY GEOTECHNCIAL REPORT
Rockfall Mitigation Assessment
State Route 25
From Approximate L.M. 8.5 to L.M. 8.9, Left of Centerline
Project No. 80000-4200-04
Smith County

Introduction

This report summarizes the preliminary evaluation of possible design considerations required to mitigate the rockfall events at the referenced site. The project is located in an inside curve of a side hill cut above the Cumberland River and has a latest available 2005 ADT of 9560. It is also opposite of the scenic overlook. The TDOT Rockfall Hazard Rating System has rated the cut as an "A" type hazard, which means that there is a moderate-to-high potential for rockfall activity, but a moderate Rockfall Closure impact.

Discussion

The rockfall history of the cut is that rockfall events occur often and have been since the initial roadway construction. Bedrock along the existing slope consists of flat-lying limestone and interbedded shale that is very thin- to medium-bedded. The predominant geologic structure that controls the stability of the rock cut is columnar jointing coupled with tension cracks. Differential weathering of these two rock types results in the undermining of tall triangular wedges that pull loose from the slope and topple onto the roadway. Maintenance reports that this slope is most problematic during the winter months due to freeze and thaw changes.

The most recent field inspection of the site took place on February 12, 2007. Several photographs were taken of the slope and observations were noted of recent rock raveling of the cut face into the ditch. Another area of concern was the potential for one large wedge failure near the eastern end of the cut that will result in closure of the road for a short period of time. There is rock debris in the existing ditch that was piled up against the rock wall by previous fall material.

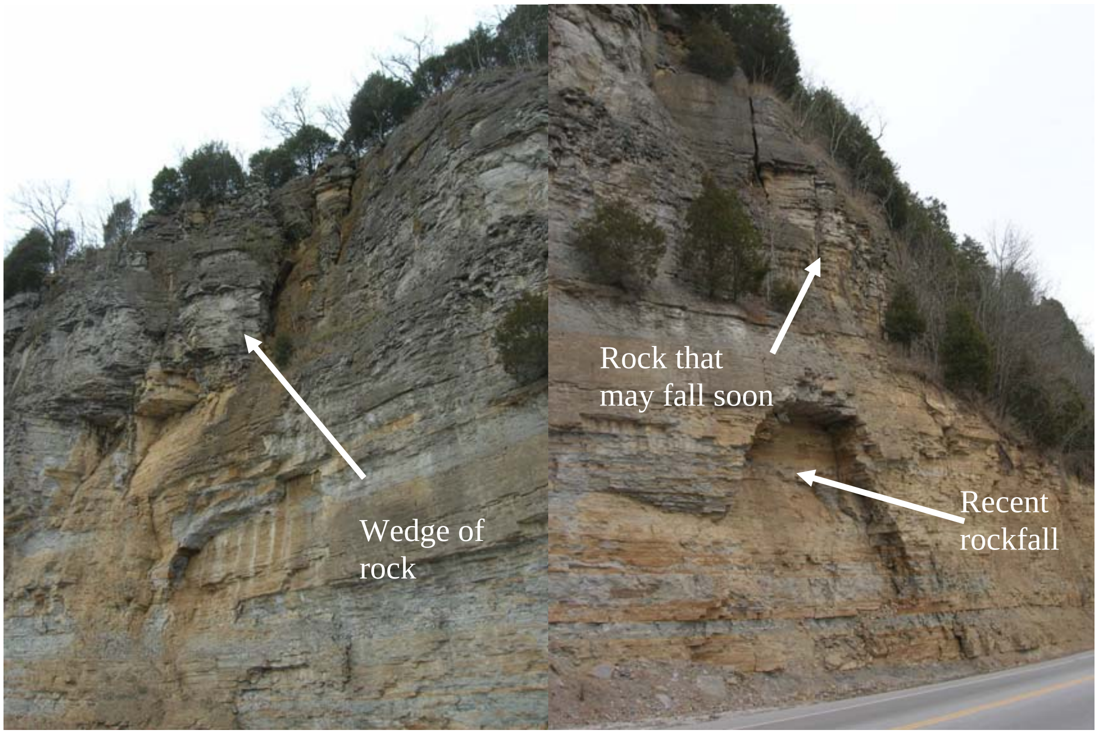


Figure 1: A. View of Wedge of rock at upper edge of slope. B. View of recent rock failure and upper area of rock that may fall.

<u>Recommendations</u>

There are several possible mitigation methods that could be used on this site. These vary in cost and effectiveness.

- Move the roadway toward the river. There is a very large paved shoulder/overlook area for much of the rock cut.
- Add a couple of additional Falling Rock signs along the road. This will do nothing to prevent rocks from landing in the roadway but should better alert the public to the hazard. At the moment there are two signs, one on either side of the cut. Many drivers may miss the one sign that they see from their direction.

- Scaling and trim blasting could be performed along the cut to remove all loose material. This will include removal of all rock debris from the limited catchment area at the base of the rock cut. All trees should be removed from the cut and also from at least 6 feet from the edge of the cut. Scaling would be used to bring down rock that may fall. This will not remove the entire hazard and does not address the ditch width. Also, this work cannot be performed with a standard backhoe. Special equipment will be needed to remove the material safely.
- A combination Jersey barrier and 10 foot high rockfall fence could be used at the edge of the current ditch. This would reduce some of the rockfall problems. If used in combination with Scaling and Trim Blasting, this would provide a significant reduction in rockfall hazard. However, this will not prevent all of the rocks from getting in the road. When tall triangular wedges of rock fail, a significant amount of rockfall could topple over the fence and into the paved roadway.
- Installation of a draped wire mesh hung on the face of a rock slope can be an effective method of containing rock falls close to the face and preventing them from bouncing on to the road. Because the mesh absorbs some of the energy of the falling rock, the existing dimensions of the ditch at the toe of this slope would still be tolerable. Periodic removal of rock may be required if there are large rockfall events.
- The most effective treatment for this site is to re-cut the slope to the latest TDOT rockfall standard design which would require a minimum of a 41-foot ditch width at the base of a .25:1 slope over 80 feet in height. A clean, presplit face would significantly reduce the amount of rockfall and the ditch should be adequate to catch over 90% of the rockfall from the slope. If a safety shaped Jersey barrier were added at the edge of the ditch the catchment should increase to over 95%.

The following table provides general cost comparisons for the various alternatives.

Rockfall Site
File Number: 80SR025000008.5L
Location: SR 25, Log Mile 8.5 to 8.9, Left of Centerline
County: Smith

Slope Height	up to 110 feet
Slope Length	1467 feet
Existing Ditch Width	up to 12 feet including shoulder slope
Ditch Width needed*	45 feet including shoulder slope

Preferred Option – Re-cutting of Slope

Element	$ Cost	Per unit	Needed at site	Unit	Total cost per Element
Excavation Unclassified	$2.57	yd^3	269,000	yd^3	$691,500
Presplitting of Rock Excavation	$8.72	yd^2	18,000	yd^2	$162,000
Traffic Control	$200.00	Day	30		$6,000.00
					$859,500

Other Options

Element	$ Cost	Per unit	Needed at site	Unit	Total cost per Element
Jersey Barrier	$50.00	yd^2	1467	yd^2	$73,350
Machine Scaling	$25.00	yd^2	18,000	yd^2	$450,000
Rockfall Control Fence	$250.00	LF	1467	LF	$366,750
Vegetation Removal	$10.00	yd^2	18,000	yd^2	$180,000
Wire Mesh	$35.00	yd^2	18,000	yd^2	$630,000

*Ditch width that would need to be added to conform to the Tennessee Department of Transportation's Rockfall Catchment Ditch guidelines

The recommended solution for this site is a re-cut of the slope. This will bring the cut up to current design standards for rockfall catchment. Posting signs is the least expensive option but provides no hazard reduction. Re-cutting the slope is likely the most expensive option but provides the best mitigation.

Example Rockfall Report

GEOTECHNICAL REPORT
Preliminary Geotechnical Study of State Route 112
From State Route 12 (Ashland City Highway)
To State Route 115 (Briley Parkway)
State Project No. 19046-1214-14, PIN No. 103764.00
Davidson County

Executive Summary

The Geotechnical Engineering Section has completed a site investigation for the referenced subject project. The existing cuts slopes indicate future construction will consists of shaly, cobbly rubble with thin slabs of limestone and phosphatic clay. There may be the occasional medium-bedded limestone represented as boulders. There were no noticeable wetland areas within the proposed right-of-way that will require fill material to reach the proposed subgrade elevation. In summary, there are no geotechnical or geologic conditions along the proposed roadway widening that would require altering the current functional plans. Therefore, it is recommended to design slopes of 2:1 or flatter for right-of-way considerations.

Example Rockfall Report

Introduction

This report summarizes the site investigation for the proposed widening of State Route 112 on February 27-28, 2007. The project begins just north of the intersection of State Route 12 (Ashland City Highway) and continues north to State Route 155 (Briley Parkway). The project will consist of 5 twelve foot traffic lanes and four foot shoulders to include curb and gutter with eight foot sidewalks. Included are bikeways and grass utility strips all within a 92-foot right-of-way. The increased lane widths and overall carrying capacity will result in the removal and replacement of the existing bridge structure spanning Whites Creek. It is our understanding that most of the proposed widening will be symmetrical to the present roadway centerline except for those areas that will require shifting the roadway to minimize property damage.

Geology, Soils and Site Conditions

The project area is located within a physiographic region known as the Central Basin, (the outer part of the Nashville Basin) which is characterized by gently rolling to hilly uplands. The majority of the widening is along an urban corridor cover with buildings of various types and isolated wooded/pastured fields. Available geologic mapping (USGS Geologic Map of the Nashville West Quadrangle, 1966) indicates the site is underlain by the phosphatic limestone, representing the Ordovician Geologic Period. Residual soil formed by the in-place weathering of the parent limestone is brown phosphatic clay. Exposed level bedded limestone is highly weathered, thin-bedded to slabby and interbedded with gray calcareous shale. Near the southern approach to Whites Creek and across from the fire hall, thicker bedded limestone is exposed. The soil overburden appears relatively shallow, even within the multiple solution zones that are another characteristic of rock lithologies.

Recommendations and Discussions

The existing cut slopes involve both soil and rock that range from vertical to near 2:1. From the north side of Whites Creek to E. Hamilton Road, left of the existing roadway embankment, is a narrow floodplain currently being utilized for dumping construction debris consisting of boulder rock and clay soil. Judging from the natural ground line adjacent to the man-made fill, it is approximately 5-6 feet in depth and the top of the material approximates the existing roadway grade.

In summary, there are no geotechnical or geologic conditions along the proposed roadway widening that would require altering the current functional plans. It is recommended to design cut and fill slopes of 2:1 or flatter for right-of-way considerations. Pavement costs may be slightly higher than average due to the expected low CBR values of the phosphatic clay soil.

If there are questions concerning this report, please contact the Geotechnical Engineering Section.

Randall J. Jones, P.G.
Operations Specialist 2

M. Leonard Oliver, P.E.
Civil Engineering Manager 2

MLO:RJJ:CJW
March 6, 2007

Rock slope Standard Drawing

REV. 10-15-02: NEW SHEET.

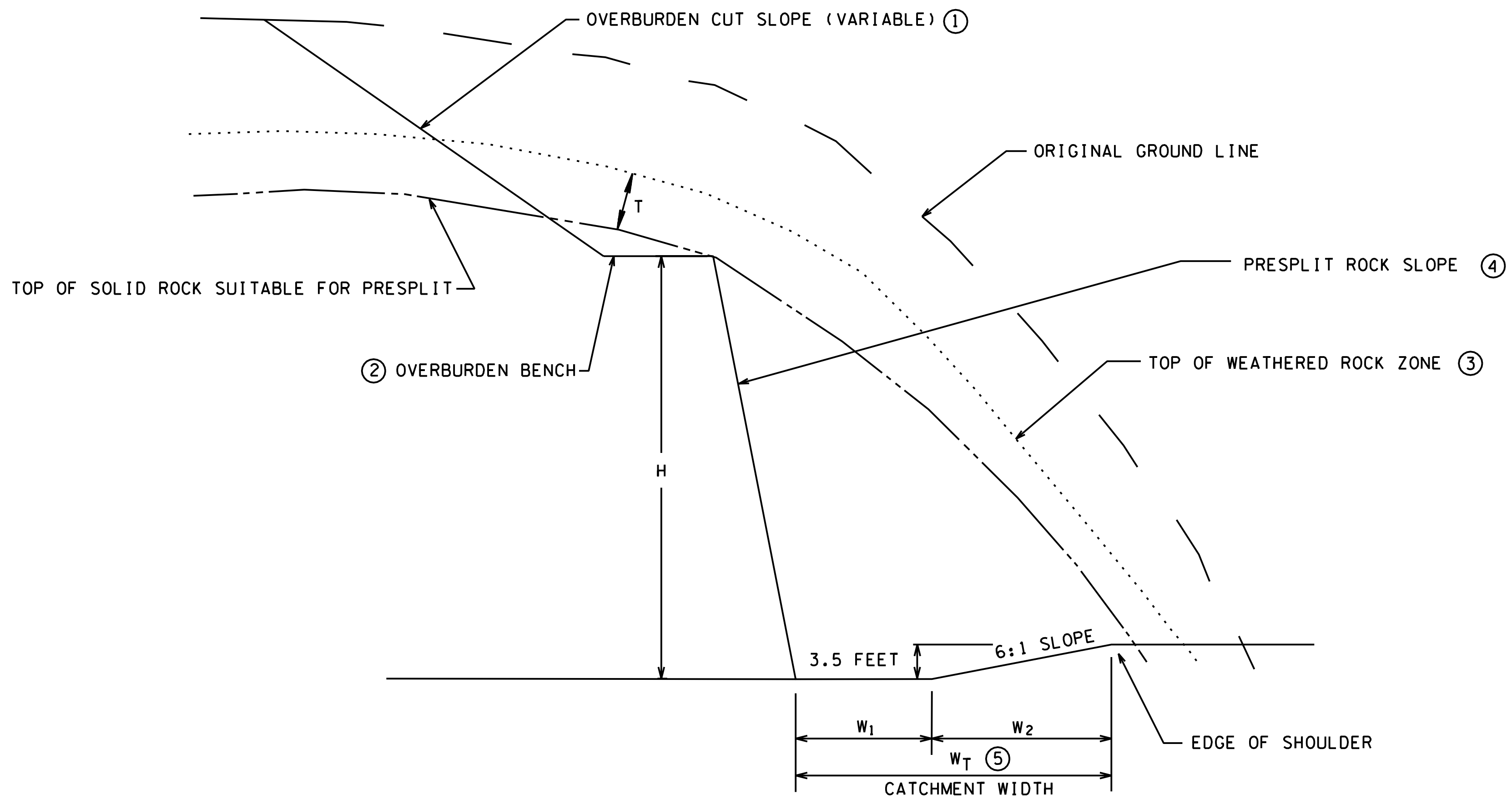


FIGURE 1. ROCK CUT SLOPE AND CATCHMENT WIDTH DETAILS

PRESPLIT ROCK SLOPE				
H (FT)	VERTICAL		0.25 H : 1 V OR FLATTER	
	⑤ W_T (FT)	W_1 (FT)	W_T (FT)	W_1 (FT)
0-40	21	0	21	0
40-50	21	0	27	6
50-60	24	3	33	12
60-70	28	7	37	16
70-80	32	11	41	20
80-120	36	15	45	24
120-160	40	19	51	30
160-200	52	31	63	42

TABLE 1. ROCK CUT PRESPLIT SLOPES

FOOTNOTES

① SEE GEOTECHNICAL REPORT FOR ALLOWABLE OVERBURDEN CUT SLOPE RECOMMENDATIONS.

② OVERBURDEN BENCH TO BE MINIMUM OF 10' WIDE AS SPECIFIED IN GEOTECHNICAL REPORT. NO INTERMEDIATE BENCHES ARE TO BE USED UNLESS RECOMMENDED IN THE REPORT.

③ TOP OF WEATHERED ROCK ZONE (HENCE, THE THICKNESS -T) WILL BE VARIABLE. GEOTECHNICAL REPORT WILL PROVIDE PROJECT SPECIFIC GUIDANCE ON THICKNESS TO USE IN THE CROSS-SECTION DEVELOPMENT. THIS ZONE MAY CONTAIN ROCK PINNACLES, ROCK LENSES, OR WEATHERED ROCK MIXED WITH SOIL. BLASTING MAY BE REQUIRED TO REMOVE. CONSIDER EXCAVATION ITEM IN THIS ZONE TO BE UNCLASSIFIED, COMMON.

④ PRESPLIT SLOPE TO BE PROVIDED FOR SPECIFIC ROCK CUT INTERVALS IN GEOTECHNICAL REPORT. IT IS ASSUMED PRESPLIT FACES WILL BE FORMED OR SCALED OF LOOSE ROCKS AND OVERHANGS IN ACCORDANCE WITH TDOT STANDARD SPECIFICATIONS.

⑤ W_T IS HORIZONTAL DISTANCE FROM SHOULDER (MID-POINT OF SLOPE ROUNDING) TO BASE OF PRESPLIT ROCK SLOPE. W_T WILL BE 21 FEET OR GREATER IN ALL CASES. FOR ALL FORESLOPES OTHER THAN 6:1, SEE GEOTECHNICAL REPORT.

GENERAL NOTES

Ⓐ IF W_T CANNOT BE ACHIEVED DUE TO RIGHT-OF-WAY RESTRICTIONS OR EXCESSIVE EXCAVATION, THEN A COMBINATION OF A NARROWER ROCKFALL DITCH (W_1), ROCKFALL CATCHMENT FENCE OR BARRIER, OR ROCKSLOPE MESHING WILL BE REQUIRED. CONTACT GEOTECHNICAL ENGINEERING SECTION OR GEOTECHNICAL CONSULTANT FOR GUIDANCE.

Ⓑ A UNIFORM CATCHMENT WIDTH (W_T) BASED ON THE HIGHEST ROCK CUT SLOPE (H), SHOULD BE USED.

Ⓒ FOR LONG CUT SLOPES WHERE A PREDOMINANT CUT HEIGHT EXISTS FOR SEVERAL STATIONS, UTILIZE W_T FOR THAT GIVEN CUT HEIGHT (H). TRANSITION TO VARIOUS CATCHMENT WIDTHS ON A RATIO NO GREATER THAN 4 FEET HORIZONTAL W_T PER 100 FOOT STATION INTERVAL.

☒ MINOR REVISION -- FHWA APPROVAL NOT REQUIRED.

STATE OF TENNESSEE DEPARTMENT OF TRANSPORTATION

DESIGN AND CONSTRUCTION DETAILS FOR ROCK CUT SLOPE AND CATCHMENT

10-15-02 | RD01-S-11B

$FILE$ $TIME$ $DATE$ 2/4/2005

Example Sinkhole Sheet (Cross Section)

TENNESSEE D.O.T.
DESIGN DIVISION

FILE NO.

TYPE	YEAR	PROJECT NO.	SHEET NO.
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.

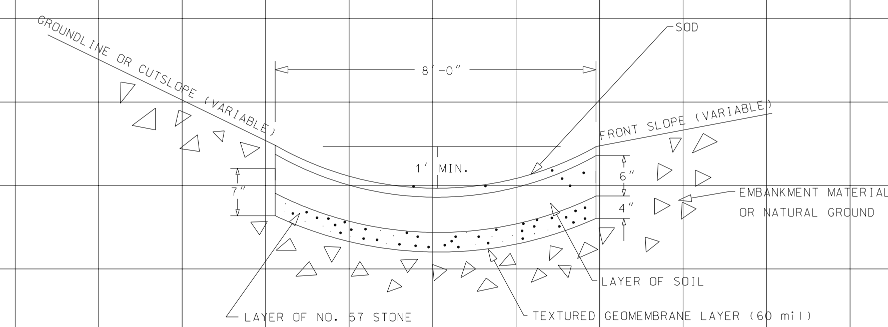
SINKHOLE TREATMENT 2 AND 2A . INACTIVE

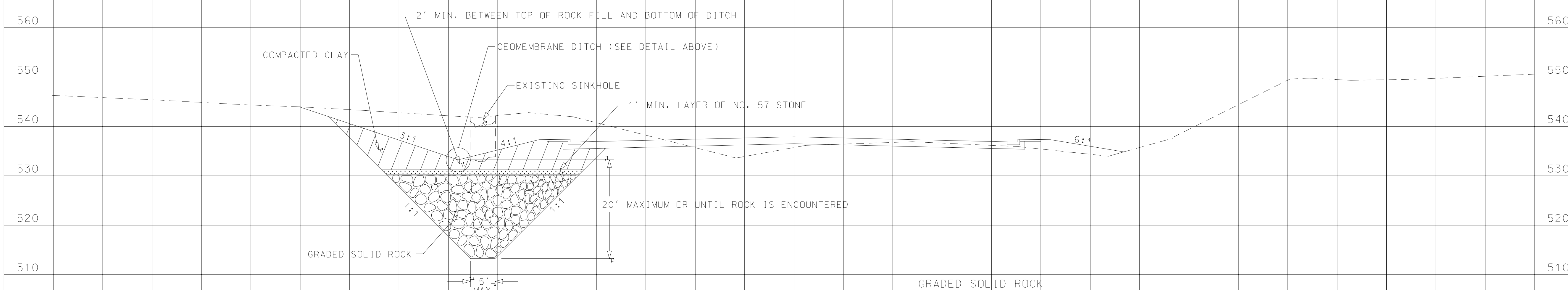
NOTE: AFTER EXCAVATION IS COMPLETE AND ROCK OPENING IS EXPOSED, THE SITE AND TREATMENT METHOD SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS. ANY CHANGE IN THE NO. 57 STONE FILL OR THE CLAY CAP SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS.

SEQUENCE OF CONSTRUCTION:

1. EXCAVATE SINKHOLE TO DEFINE OPENING IN BEDROCK MAKING SURE TO REMOVE ALL SOIL AND DEBRIS.
2. FIT THE OPENING WITH KEYSTONE ROCK, WHICH SHALL BE OF SUFFICIENT SIZE TO LOCK IN PLACE WITHOUT CREATING AN AIRBLOCK TO SUBSURFACE DRAINAGE.
3. BACKFILL WITH GRADED SOLID ROCK (CLASSIFICATION 203.02, BORROW EXCAVATION) UP TO SPECIFIED GRADE.
4. PLACE TYPE IV GEOTEXTILE ON TOP OF GRADAED SOLID ROCK. PLACE NO. 57 STONE ON TOP OF GEOTEXTILE.
5. CONSTRUCT COMPACT CLAY CAP. SOIL SHOULD BE OF TYPE AASHTO A-6 OR A-7-6.
6. PLACE GEOMEMBRANE ON TOP OF SOIL CAP BEFORE CONSTRUCTION OF ANY OVERLYING STRUCTURES OR EMBANKMENTS. THERE SHOULD BE A MINIMUM OF 1.5 FT. OF SOIL PLACED OVER THE MEMBRANE.
7. DITCH SHOULD BE PAVED OR LINED WITH A GEOMEMBRANE.

GEOMEMBRANE LINED SOD DITCH





GRADED SOLID ROCK

BORROW EXCAVATION (GRADED SOLID ROCK) SHALL CONSIST OF THE REMOVAL AND SATISFACTORY PLACEMENT OF SOUND, NON-DEGRADABLE ROCK WITH A MAXIMUM SIZE OF 3 FEET (1 METER). AT LEAST 50 PERCENT OF THE ROCK SHALL BE UNIFORMLY DISTRIBUTED BETWEEN 1 FOOT (30 CENTIMETERS)AND 3 FEET (1 METER) IN DIAMETER AND NO GREATER THAN 10 PERCENT SHALL BE LESS THAN 2 INCHES (50 MILLIMETERS) IN DIAMETER. THE MATERIAL SHALL BE ROUGHLY EQUI-DIMENSIONAL IN SHAPE. THIN, SLABBY MATERIAL WILL NOT BE ACCEPTED. THE CONTRACTOR SHALL BE REQUIRED TO PROCESS THE MATERIAL WITH AN ACCEPTABLE MECHANICAL SCREENING PROCESS THAT PRODUCES THE REQUIRED GRADATION. WHEN THE MATERIAL IS SUBJECTED TO FIVE ALTERATIONS OF THE SODIUM SULFATE SOUNDNESS TEST (AASHTO T-104), THE WEIGHTED PERCENTAGE OF LOSS SHALL NOT BE MORE THAN 12. THE MATERIAL SHALL BE APPROVED BY THE ENGINEER BEFORE USE.

120+00.00

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

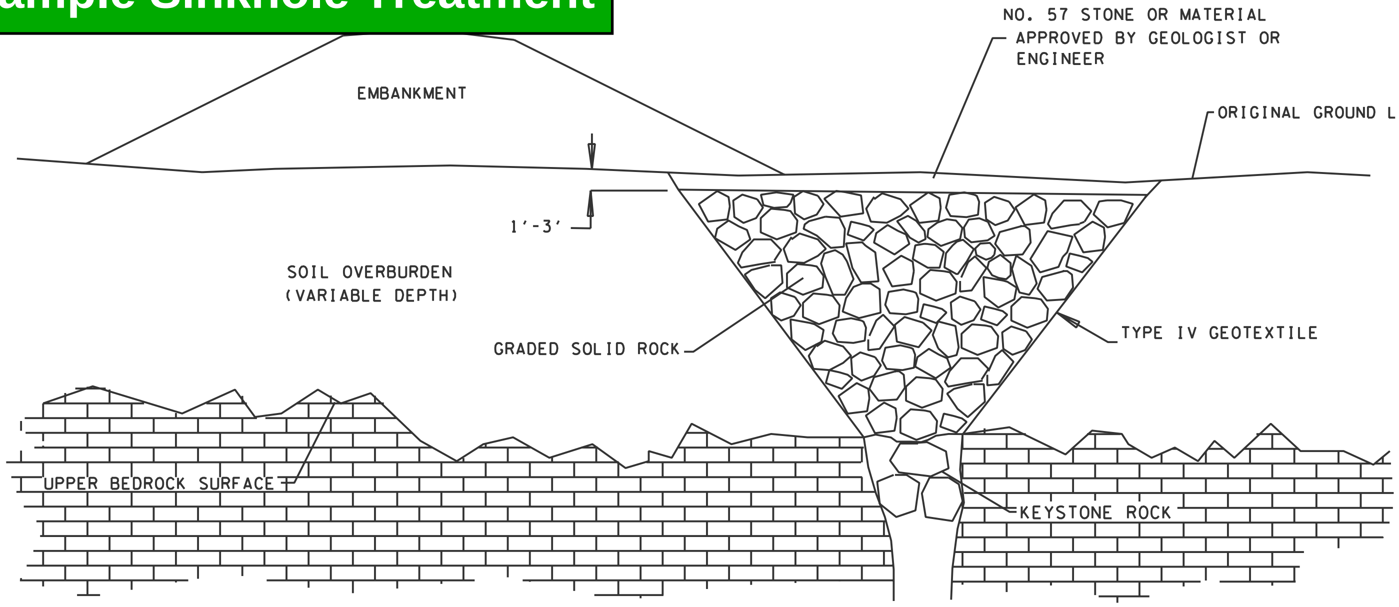
TYPICAL SECTION
STATE ROUTE 374

MONTGOMERY COUNTY

montgomery/6317802/x12000/userk.brinkley

...\Working Files\6317802.dgn 3/16/2007 3:08:35 PM

Example Sinkhole Treatment



SINKHOLE TREATMENT 1

SINKHOLE TREATMENT 1, ACTIVE

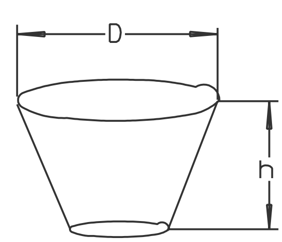
NOTE: AFTER EXCAVATION IS COMPLETE AND ROCK OPENING IS EXPOSED, THE SITE AND TREATMENT METHOD SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS. THE TOP 1-3 FT. OF MATERIAL SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS.

SEQUENCE OF CONSTRUCTION:

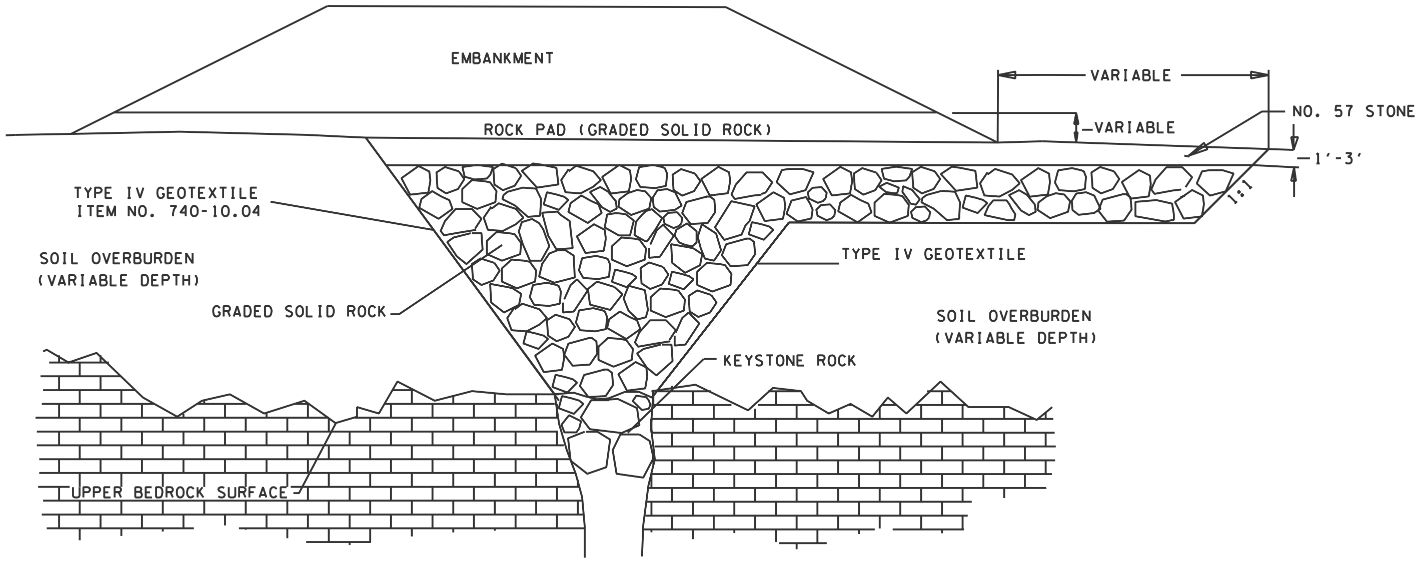
1. EXCAVATE SINKHOLE TO DEFINE OPENING IN BEDROCK MAKING SURE TO REMOVE ALL SOIL AND DEBRIS.
2. FIT THE OPENING WITH KEYSTONE ROCK, WHICH SHALL BE OF SUFFICIENT SIZE TO LOCK IN PLACE WITHOUT CREATING AN AIRBLOCK TO SUBSURFACE DRAINAGE.
3. PLACE THE TYPE IV GEOTEXTILE FABRIC ON EXCAVATED SLOPES AND BASE OF SINKHOLE.
4. BACKFILL TO A MAXIMUM OF 1 FT. OF THE SPECIFIED GRADE WITH GRADED SOLID ROCK (CLASSIFICATION 203.02, BORROW EXCAVATION).
5. BACKFILL TO GRADE WITH A MINIMUM OF 1 FT. OF NO.57 STONE ON TOP OF THE GRADED SOLID ROCK AND TYPE IV GEOTEXTILE.

EQUATION FOR ESTIMATING SINKHOLE VOLUME, WHERE THE SIDES OF THE SINKHOLE ARE AT 1:1 SLOPES.

$$\text{VOL. } 1{:}1 \approx 0.13D^3 - (0.5D - h)^3$$



Example Sinkhole Treatment



SINKHOLE TREATMENT 1A

SINKHOLE TREATMENT 1A ACTIVE

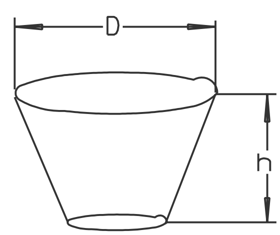
NOTE: AFTER EXCAVATION IS COMPLETE AND ROCK OPENING IS EXPOSED, THE SITE AND TREATMENT METHOD SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS. THE TOP 1-3 FT. MATERIAL SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS.

SEQUENCE OF CONSTRUCTION:

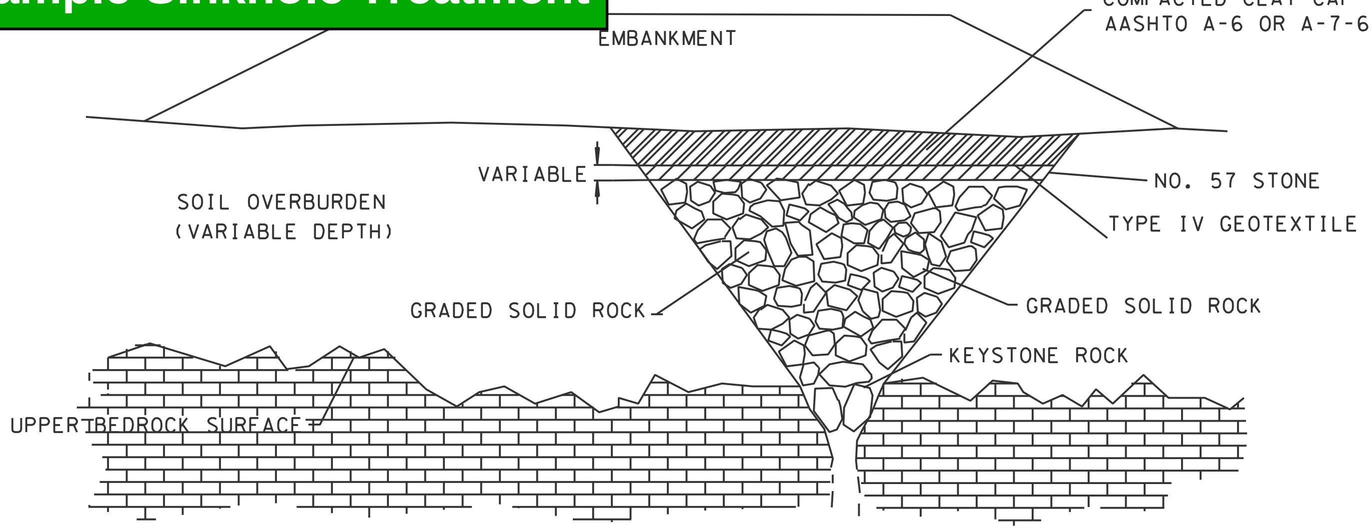
1. EXCAVATE SINKHOLE TO DEFINE OPENING IN BEDROCK AND EXCAVATE TONGUE DOWN TO THE DEPTH SHOWN MAKING SURE TO REMOVE ALL SOIL AND DEBRIS FROM THESE EXCAVATIONS.
2. FIT THE OPENING WITH KEYSTONE ROCK, WHICH SHALL BE OF SUFFICIENT SIZE TO LOCK IN PLACE WITHOUT CREATING AN AIRBLOCK TO SUBSURFACE DRAINAGE.
3. PLACE THE TYPE IV GEOTEXTILE FABRIC.
4. BACKFILL TO WITHIN 1.5-3 FT.OF THE SPECIFIED GRADE WITH GRADED SOLID ROCK.
5. PLACE THE TYPE IV GEOTEXTILE ON TOP OF GRADED SOLID ROCK.
6. BACKFILL TO GRADE WITH NO. 57 STONE.

EQUATION FOR ESTIMATING SINKHOLE VOLUME, WHERE THE SIDES OF THE SINKHOLE ARE AT 1:1 SLOPES.

$$\text{VOL. } 1{:}1 \approx 0.13D^3 - (0.5D - h)^3$$



Example Sinkhole Treatment



SINKHOLE TREATMENT 2

SINKHOLE TREATMENT 2 AND 2A , INACTIVE

NOTE: AFTER EXCAVATION IS COMPLETE AND ROCK OPENING IS EXPOSED, THE SITE AND TREATMENT METHOD SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS. ANY CHANGE IN THE NO. 57 STONE FILL OR THE CLAY CAP SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS.

SEQUENCE OF CONSTRUCTION:

1. EXCAVATE SINKHOLE TO DEFINE OPENING IN BEDROCK MAKING SURE TO REMOVE ALL SOIL AND DEBRIS.

2. FIT THE OPENING WITH KEYSTONE ROCK, WHICH SHALL BE OF SUFFICIENT SIZE TO LOCK IN PLACE WITHOUT CREATING AN AIRBLOCK TO SUBSURFACE DRAINAGE.

3. BACKFILL WITH GRADED SOLID ROCK (CLASSIFICATION 203.02, BORROW EXCAVATION) UP TO SPECIFIED GRADE.

4. PLACE TYPE IV GEOTEXTILE ON TOP OF GRADAED SOLID ROCK. PLACE NO. 57 STONE ON TOP OF GEOTEXTILE.

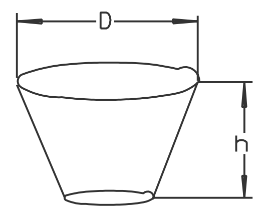
5. CONSTRUCT COMPACTED CLAY CAP. SOIL SHOULD BE OF TYPE AASHTO A-6 OR A-7-6.

6. PLACE GEOMEMBRANE ON TOP OF SOIL CAP BEFORE CONSTRUCTION OF ANY OVERLYING STRUCTURES OR EMBANKMENTS. THERE SHOULD BE A MINIMUM OF 1.5 FT. OF SOIL PLACED OVER THE MEMBRANE.

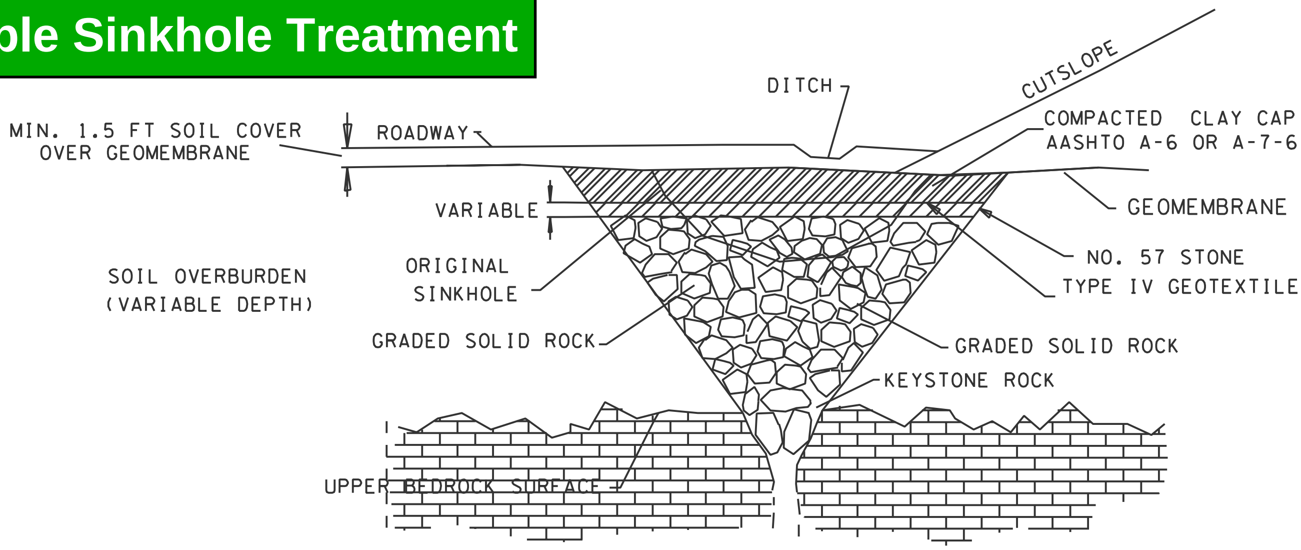
7. DITCH SHOULD BE PAVED OR LINED WITH A GEOMEMBRANE.

EQUATION FOR ESTIMATING SINKHOLE VOLUME, WHERE THE SIDES OF THE SINKHOLE ARE AT 1:1 SLOPES.

VOL. 1:1 $\approx 0.13D^3 - (0.5D - h)^3$



Example Sinkhole Treatment



SINKHOLE TREATMENT 2A

SINKHOLE TREATMENT 2 AND 2A , INACTIVE

NOTE: AFTER EXCAVATION IS COMPLETE AND ROCK OPENING IS EXPOSED, THE SITE AND TREATMENT METHOD SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS. ANY CHANGE IN THE NO. 57 STONE FILL OR THE CLAY CAP SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS.

SEQUENCE OF CONSTRUCTION:

1. EXCAVATE SINKHOLE TO DEFINE OPENING IN BEDROCK MAKING SURE TO REMOVE ALL SOIL AND DEBRIS.

2. FIT THE OPENING WITH KEYSTONE ROCK, WHICH SHALL BE OF SUFFICIENT SIZE TO LOCK IN PLACE WITHOUT CREATING AN AIRBLOCK TO SUBSURFACE DRAINAGE.

3. BACKFILL WITH GRADED SOLID ROCK (CLASSIFICATION 203.02, BORROW EXCAVATION) UP TO SPECIFIED GRADE.

4. PLACE TYPE IV GEOTEXTILE ON TOP OF GRADAED SOLID ROCK. PLACE NO. 57 STONE ON TOP OF GEOTEXTILE.

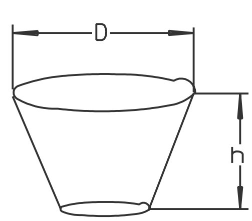
5. CONSTRUCT COMPACTED CLAY CAP. SOIL SHOULD BE OF TYPE AASHTO A-6 OR A-7-6.

6. PLACE GEOMEMBRANE ON TOP OF SOIL CAP BEFORE CONSTRUCTION OF ANY OVERLYING STRUCTURES OR EMBANKMENTS. THERE SHOULD BE A MINIMUM OF 1.5 FT. OF SOIL PLACED OVER THE MEMBRANE.

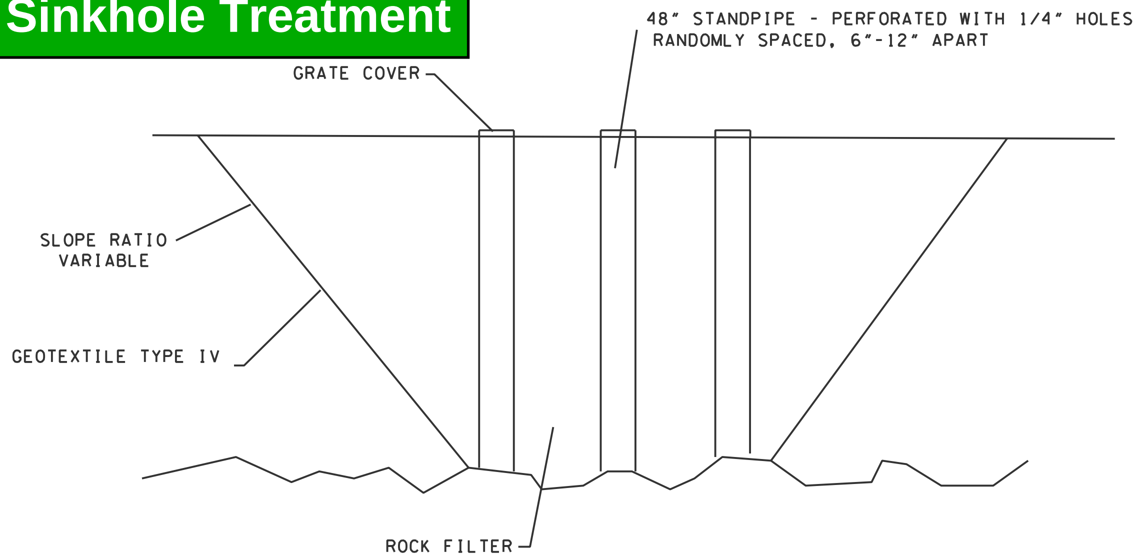
7. DITCH SHOULD BE PAVED OR LINED WITH A GEOMEMBRANE.

EQUATION FOR ESTIMATING SINKHOLE VOLUME, WHERE THE SIDES OF THE SINKHOLE ARE AT 1:1 SLOPES.

$$\text{VOL. } 1{:}1 \approx 0.13D^3 - (0.5D - h)^3$$



Example Sinkhole Treatment



SINKHOLE TREATMENT 3

SINKHOLE TREATMENT 3, ACTIVE

NOTE: AFTER EXCAVATION IS COMPLETE AND ROCK IS EXPOSED, THE SITE AND TREATMENT METHOD SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS.

SEQUENCE OF CONSTRUCTION

1. EXCAVATE SOIL DOWN TO BEDROCK TO LIMITS SPECIFIED BY THE ENGINEER OR GEOLOGIST.

2. LOCATE ALL OPENINGS WITHIN THE PITS, REMOVE ALL LOOSENED MATERIAL. ALL EXCAVATED MATERIALS SHALL BE REMOVED FROM THE BASIN.

3. INSTALL 48" DIAMETER VERTICAL STANDPIPES OVER THE LOCATED OPENINGS. THESE PIPES SHOULD BE PERFOFATED FOR AT LEAST THE LOWER 5 FT. WITHIN 1/4" HOLES SPACES 6-12" APART.

4. PLACE TYPE IV GEOTEXTILE FABRIC AS SHOWN OR AS DIRECTED BY THE ENGINEER OR GEOLOGIST TO PREVENT THE LATERAL INFLOW OF FINES.

5. BACKFILL WITH A ROCK FILTER TO A HEIGHT OF 3.5" BELOW THE TOP OF THE STANDPIPE.

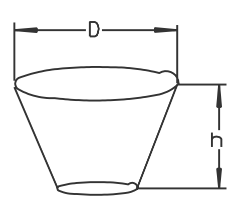
THE ROCK FILTER MATERIAL SHALL CONSIST OF A MIXTURE OF LIMESTONE SHOT ROCK AND CRUSHED STONE TO MEET THE FOLLOWING GRADATION:

SIZE RANGE (ALONG ITS MAXIMUM DIMENSION)	VOLUME
2'-1'	60-40%
1'-6"	40-20%
6"-2"	20-10%
LESS THAN 2"	5-0%

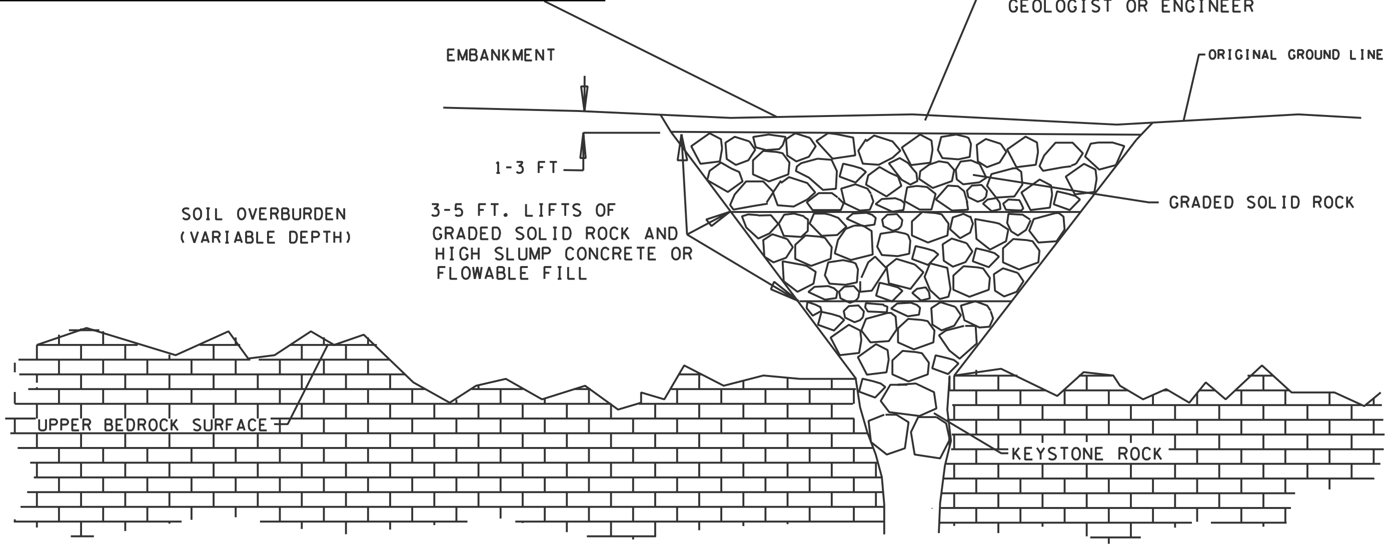
6. THE ROCK FILTER MATERIAL SHALL BE PLACED WITH A CLAMSHELL. NO END DUMPING WILL BE PERMITTED.

EQUATION FOR ESTIMATING SINKHOLE VOLUME, WHERE THE SIDES OF THE SINKHOLE ARE AT 1:1 SLOPES.

$$\text{VOL. } 1:1 \approx 0.13D^3 - (0.5D - h)^3$$



Example Sinkhole Treatment



SINKHOLE TREATMENT 4

SINKHOLE TREATMENT 4, INACTIVE

NOTE: AFTER EXCAVATION IS COMPLETE AND ROCK OPENING IS EXPOSED, THE SITE AND TREATMENT METHOD SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS. ANY CHANGE IN THE THE NO.57 STONE FILL SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS.

SEQUENCE OF CONSTRUCTION

1. EXCAVATE SINKHOLE TO DEFINE OPENING IN BEDROCK AS DEFINED BY THE ENGINEER OR GEOLOGIST MAKING SURE TO REMOVE ALL SOIL DEBRIS.

2. FIT THE OPENING WITH KEYSTONE ROCK, WHICH SHALL BE OF SUFFICIENT SIZE TO LOCK IN PLACE WITHOUT CREATING AN AIRBLOCK TO SUBSURFACE DRAINAGE.

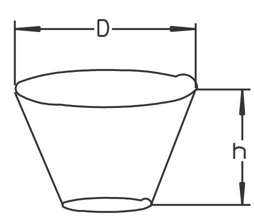
3. ALTERNATE LAYERS OF GRADED SOLID ROCK (CLASSIFICATION 203.02, BORROW EXCAVATION) (3-5 FT. IN DEPTH) AND HIGH SLUMP CONCRETE (OR FLOWABLE FILL).
   HIGH SLUMP CONCRETE SHALL BE CONCRETE WITH A SLUMP OF 7-9"

   HIGH SLUMP CONCRETE OR FLOWABLE FILL SHALL BE APPLIED AFTER A LAYER OF GRADED SOLID ROCK UNTIL THE CONCRETE (OR FLOWABLE FILL) JUST COVERS THE GRADED ROCK LAYER. THE NEXT LAYER OF GRADED SOLID ROCK SHALL BE PLACED IMMEDIATELY AFTER THE PLACEMENT OF THE CONCRETE (OR FLOWABLE FILL). THE PURPOSE OF THIS IS TO INTERMIX THE MATERIALS. THE WORK SHALL NOT BE INTERRUPTED AFTER THE PLACEMENT OF CONCRETE (OR FLOWABLE FILL) EXCEPT FOR THE TOP LAYER. IF WORK CANNOT BE FINISHED IN A SPECIFIED INTERVAL, WORK MAY BE STOPPED ONLY AFTER A COMPLETE LAYER OF GRADED SOLID ROCK HAS BEEN PLACED.

4. AFTER THE FINAL LAYER OF CONCRETE (OR FLOWABLE FILL) HAS BEEN SET, BACKFILL TO GRADE WITH TYPE "A" BASE GRADING (ITEM NO. 303.01) OR OTHER MATERIAL APPROVED BY THE ENGINEER OR GEOLOGIST.

EQUATION FOR ESTIMATING SINKHOLE VOLUME, WHERE THE SIDES OF THE SINKHOLE ARE AT 1:1 SLOPES.

$$\text{VOL. } 1{:}1 \approx 0.13D^3 - (0.5D - h)^3$$



Example Preliminary Report

Preliminary Geotechnical Report
State Route- 317 (Apison Pike), From Old Lee Highway
2.30 miles to East of State Route-321 West of Collegedale
Project No. 33070-1228-14
Pin No. 107637.01
Hamilton County

Summary

This project may be constructed as shown in the transmitted sheets of aerial photographs and drawings using the proposed route. The proposed project consists of widening and improvements along 2.30 miles of State Route-317 (Apison Pike) from the intersection of Old Lee Highway east to a point west of the intersection with State Route-321. The project area is described as “Section 1” on the provided Project Corridor map and Functionals. No pyritic rock was observed in the investigation area. Several stream crossings will be required and the proposed route may encroach on existing streams that are immediately adjacent to the existing roadway. A small sinkhole was noted near the proposed centerline of the project near the western end. Colluvial soils may be present on the slopes of hills from near the beginning to the center of the project. No other specific geologic hazards were observed or noted during the field investigation and literature review. No pyritic rock is expected to be excavated on the project

Example Preliminary Report

Preliminary Geotechnical Report
State Route- 317 (Apison Pike), From Old Lee Highway
2.30 miles to East of State Route-321 West of Collegedale
Project No. 33070-1228-14
Pin No. 107637.01
Hamilton County

Introduction

The proposed project consists of widening and improvements along 2.30 miles of State Route-317 (Apison Pike) from the intersection of Old Lee Highway east to a point west of the intersection with State Route-321. The project area is described as "Section 1" on the provided Project Corridor map and Functionals.

Geology, Soils, and Site Conditions

This project is located in the western portion of the Valley and Ridge Physiographic Province of Southeastern Tennessee and is underlain by cherty clays and clays resting upon easterly dipping Cambrian to Ordivician age dolomites and limestones. The western portion of the project ascends, crosses, and decends a low ridge. The eastern section of the project crosses a small valley that contains the flood plain of Wolftever Creek.

Surface and subsurface Exploration

Visual observation was accomplished for the entire project along with review of the available literature for this area. No Geotechnical difficulties are anticipated other than those listed in the following discussion.

Discussion

Several areas of potential concern were noted along the proposed route. These included a sinkhole, possible colluvial soil mantels above small to medium sized cuts and several stream crossings and encroachment areas.

A sinkhole was noted near the centerline of the proposed improvements approximately 0.15 miles east of the intersection of S.R.-317 and Pattentown Road. The sinkhole, estimated to be 25 feet across and 10 feet deep, did not appear active. No other sinkholes were noted in the project foot print, however several large sinkholes were noted near the site on the USGS topographic map. Further investigation, along with possible sinkhole mitigation efforts, of this area will be required.

Possible colluvial soil mantels were noted in two areas that may be expected to be in roadway cuts. The first area is a saddle between two hills that may require a cut to lower the grade. The area begins at the intersection Pattentown Road and proceeds east a distance of approximately 0.2 miles. Cuts in this area may require flatter slopes and benches to prevent slope failures. The second area is located in a left hand curve on the north side of S.R. -317 between approximately 0.3 miles and 0.6 miles east of the intersection with Branston Road. The existing roadway is in a small cut of thin bedded nodular, cherty, weathered, dolomite of the Chepultepec Dolomite. The proposed centerline shown in the photos and maps is at least 100 feet north of the existing centerline and may have cuts of at least 20 feet in height. Cuts in this area may require flatter slopes and benches to prevent slope failures. Further investigation of these areas is recommended for this route prior to beginning this project.

An unnamed tributary to Wolftever Creek crosses, and abuts, S.R.-317 along several portions of the eastern two thirds of the proposed project. Construction, as planned, will encroach on the unnamed tributary and may require realignment of the stream channel or the road.

No other geotechnical difficulties are anticipated or were observed during field reconnaissance or in the literature review. A thorough geotechnical investigation of the alignment, any bridge and approaches, and bridge foundations will be needed to confirm the results of this report.

Example Preliminary Report

Any questions concerning this report should be directed to the Geotechnical Engineering Section.

Samuel P. Williams, P.G.
Geologist 2

M. Leonard Oliver, P.E.
Civil Engineer, Manager II

MLO:SPW:CJW
September 21, 2007

Example Preliminary Report

Preliminary Geotechnical Report,

Intersection of State Route 34 with State Route 37
Bluff City,
Project No. 82100-1203-14
Sullivan County

Executive Summary

A preliminary geotechnical study of the Intersection of State Route 34 with State 37 in Sullivan County was conducted. The proposed improvements consist of five options. There does not appear to be any significant geotechnical problems along the proposed interchange boundaries that cannot be addressed in the design or construction phase. No pyritic rock is expected to be excavated on the project.

Example Preliminary Report

Preliminary Geotechnical Report,

Intersection of State Route 34 with State Route 37
Bluff City,
Project No. 82100-1203-14
Sullivan County

Introduction

The Tennessee Department of Transportation (TDOT) is planning to improve the intersection of State Route 34 (US-11E) and State Route (US-19E) in Sullivan County in the vicinity of Bluff City in East Tennessee. The intersection is to be improved for the anticipated increase of traffic volume in the future and to improve the safety of the intersection.

Five improvement options have been proposed for the intersection of State Route 34 and State Route 37. They are a diamond interchange, a trumpet interchange, a signalization, a roundabout, and a single point urban interchange. The intersection is in a rural area with rolling hills and surrounded by farm land, except for a couple of nearby businesses. This report concerns the preliminary evaluation of the geotechnical engineering aspects for the improvement.

Geology

The project site is in a rural area located in the Valley and Ridge Province. The underlying geology consists of the Knox Group, which consists of thick bedded siliceous dolomite and interbedded limestone. The Knox Group is one of the most important aquifers in East Tennessee.

Example Preliminary Report

Conclusions

Based on the observation in the field, there does not appear to be any significant geotechnical problems along the proposed interchange boundaries that cannot be addressed in the design or construction phase. If any further information is needed regarding the proposed project, please contact the Geotechnical office.

Lori McDowell
Operations Specialist 1

Harry Moore
Transportation Manager 1

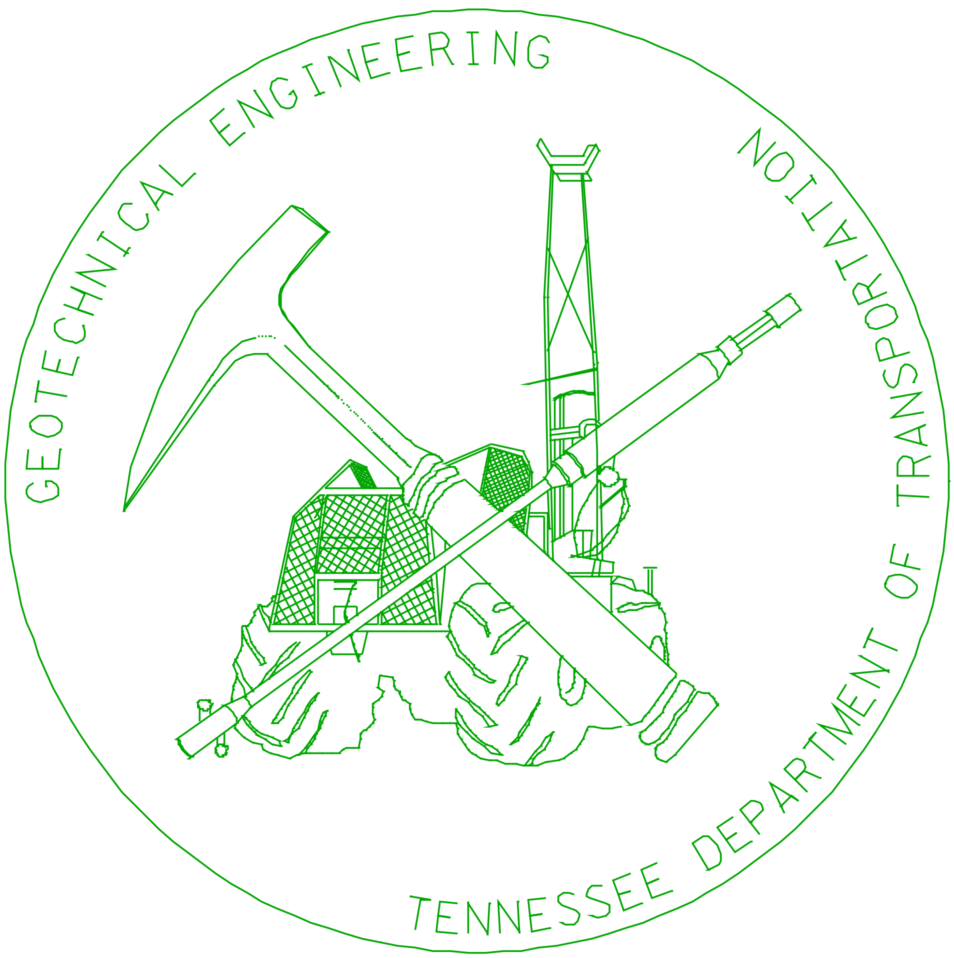
M. Leonard Oliver,
Civil Engineering Manager 2

Attachment
March 12, 2007

Figure 1 Photo shows the intersection of SR 34 and SR 37and the direction of view is to the north.

Section 1: Appendix B

Supporting Documentation



6601 Centennial Boulevard
Nashville, TN 37243-0360
(615) 350.4132

Static Pile Capacity Charts

Static Pile Capacity

for 5 ft or 1.524 m length 14" square concrete Piles

Clay					Silt					Sand				
	English Units		Metric Units			English Units		Metric Units			English Units		Metric Units	
N	Fst (T)	Qbt (T)	Fst (kN)	Qbt (kN)	N	Fst (T)	Qbt (T)	Fst (kN)	Qbt (kN)	N	Fst (T)	Qbt (T)	Fst (kN)	Qbt (kN)
1	1	0	13	0	1	1	0	9	0	1	0	0	2	0
2	3	0	24	0	2	2	0	17	0	2	1	0	7	0
3	4	0	33	0	3	3	0	24	0	3	1	0	11	0
4	5	0	41	0	4	4	0	35	0	4	2	0	15	0
5	6	3	52	24	5	5	7	46	61	5	2	15	20	133
6	7	4	63	36	6	6	10	54	85	6	3	18	24	157
7	8	4	74	36	7	7	11	63	97	7	3	20	26	182
8	9	5	82	48	8	8	12	69	109	8	3	23	28	206
9	11	5	93	48	9	8	14	74	121	9	4	26	33	230
10	12	7	104	61	10	9	15	82	133	10	4	30	37	267
11	13	7	113	61	11	10	16	91	145	11	5	33	41	291
12	14	8	121	73	12	11	18	100	157	12	5	35	46	315
13	14	8	128	73	13	12	19	106	170	13	6	38	50	339
14	15	10	137	85	14	13	20	113	182	14	6	41	54	363
15	16	10	145	85	15	14	22	121	194	15	7	44	59	388
16	17	10	154	85	16	14	23	128	206	16	7	48	63	424
17	18	11	163	97	17	15	26	137	230	17	7	50	67	448
18	19	11	171	97	18	16	27	145	242	18	8	53	72	472
19	20	12	178	109	19	17	29	154	254	19	8	56	74	497
20	21	12	186	109	20	18	30	160	267	20	9	58	78	521
21	22	14	193	121	21	19	31	167	279	21	9	61	82	545
22	22	14	199	121	22	20	33	173	291	22	10	65	87	581
23	23	15	208	133	23	20	34	180	303	23	10	68	91	605
24	24	15	217	133	24	21	35	186	315	24	11	71	95	630
25	25	16	223	145	25	22	37	193	327	25	11	73	100	654
26	26	16	228	145	26	22	38	197	339	26	12	76	104	678
27	26	18	234	157	27	23	39	202	351	27	12	79	108	703
28	27	18	241	157	28	23	42	208	376	28	13	83	113	739
29	28	19	249	170	29	24	44	215	388	29	13	86	117	763
30	29	19	258	170	30	25	45	221	400	30	14	88	121	787

English Units	Metric Units
End Area of a 14" square Pile = 1.36 ft^2	End Area of a .356 m square Pile = .1265 m^2
Surface Area of a one foot length of Pile = 4.67 ft	Surface Area of a 1 m length of Pile = 1.422 m^2
A bearing of 100 Tons is required when piles end in sand (70' min. depth for lique	A bearing of 890kN is required when piles end in sand (21.5 m min. depth for lique
A bearing of 125 tons is required when piles end in clay	A bearing of 1100 kN is required when piles end in clay
Friction (Fst) = 4.67*Depth*Fs (T)	Friciton (Fst) = 1.422*Depth*Fs (kN)
End Bearing (Qbt) = 1.36*Qb (T)	End Bearing (Qbt)= .1265*Qb (kN)

Note: All values of Fst and Qbt are figured according to the above formulas at **5 ft** or **1.524 m** in depth

Static Pile Capacity

Unit Length Concrete Piles

Clay					Silt					Sand				
	English Units		Metric Units			English Units		Metric Units			English Units		Metric Units	
N	Fs (TSF)	Qb (TSF)	Fs (kPa)	Qb(kPa)	N	Fs (TSF)	Qb (TSF)	Fs (kPa)	Qb(kPa)	N	Fs (TSF)	Qb (TSF)	Fs (kPa)	Qb(kPa)
1	0.06	0	6	0	1	0.04	0	4	0	1	0.01	0	1	0
2	0.11	0	11	0	2	0.08	0	8	0	2	0.03	0	3	0
3	0.16	0	15	0	3	0.12	0	11	0	3	0.05	0	5	0
4	0.20	0	19	0	4	0.17	0	16	0	4	0.07	0	7	0
5	0.25	2	24	192	5	0.22	5	21	479	5	0.09	11	9	1053
6	0.30	3	29	287	6	0.26	7	25	670	6	0.11	13	11	1245
7	0.35	3	34	287	7	0.30	8	29	766	7	0.13	15	12	1436
8	0.40	4	38	383	8	0.33	9	32	862	8	0.14	17	13	1628
9	0.45	4	43	383	9	0.36	10	34	958	9	0.16	19	15	1819
10	0.50	5	48	479	10	0.40	11	38	1053	10	0.18	22	17	2107
11	0.54	5	52	479	11	0.44	12	42	1149	11	0.20	24	19	2298
12	0.58	6	56	575	12	0.48	13	46	1245	12	0.22	26	21	2490
13	0.62	6	59	575	13	0.51	14	49	1341	13	0.24	28	23	2681
14	0.66	7	63	670	14	0.54	15	52	1436	14	0.26	30	25	2873
15	0.70	7	67	670	15	0.58	16	56	1532	15	0.28	32	27	3064
16	0.74	7	71	670	16	0.62	17	59	1628	16	0.30	35	29	3352
17	0.78	8	75	766	17	0.66	19	63	1819	17	0.32	37	31	3543
18	0.82	8	79	766	18	0.70	20	67	1915	18	0.34	39	33	3735
19	0.86	9	82	862	19	0.74	21	71	2011	19	0.36	41	34	3926
20	0.90	9	86	862	20	0.77	22	74	2107	20	0.38	43	36	4118
21	0.93	10	89	958	21	0.80	23	77	2202	21	0.40	45	38	4309
22	0.96	10	92	958	22	0.84	24	80	2298	22	0.42	48	40	4596
23	1.00	11	96	1053	23	0.87	25	83	2394	23	0.44	50	42	4786
24	1.04	11	100	1053	24	0.90	26	86	2490	24	0.46	52	44	4980
25	1.08	12	103	1149	25	0.93	27	89	2586	25	0.48	54	46	5171
26	1.10	12	105	1149	26	0.95	28	91	2681	26	0.50	56	48	5363
27	1.13	13	108	1245	27	0.97	29	93	2777	27	0.52	58	50	5554
28	1.16	13	111	1245	28	1.00	31	96	2969	28	0.54	61	52	5841
29	1.20	14	115	1341	29	1.03	32	99	3064	29	0.56	63	54	6033
30	1.24	14	119	1341	30	1.06	33	102	3160	30	0.58	65	56	6224

English Units	Metric Units
End Area of a 14" square Pile = 1.36 ft^2	End Area of a .356 m square Pile = .1265 m^2
Surface Area of a one foot length of Pile = 4.67 ft	Surface Area of a 1 m length of Pile= 1.422 m^2
A bearing of 100 Tons is required when piles end in sand (70' min. depth for lique	A bearing of 890kN is required when piles end in sand (21.5 m min. depth for lique
A bearing of 125 tons is required when piles end in clay	A bearing of 1100 kN is required when piles end in clay
Friction = 4.67*Depth*Fs (T)	Friciton = 1.422*Depth*Fs (kN)
End Bearing = 1.36*Qb (T)	End Bearing = .1265*Qb (kN)

Soil and Subgrade Report

TENNESSEE DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS
GEOTECHNICAL ENGINEERING SECTION
NASHVILLE, TENNESSEE

SOIL AND SUBGRADE CONDITION AND EVALUATION REPORT

PROJECT NO. ________________ COUNTY: ____________________________ REGION: ________
LOCATION: ____

					T-99: (Proctor)	
Station or Sample No.	Percentage Passing No. 200	Predominant Soil Type	Group Index	CBR	Density (lb/ft^3)	Optimum Moisture (%)

M. Leonard Oliver, Civil Engineering Manager 2
Geotechnical Engineering Section

MLO::LGW

GES File No.

Soil Description Sheet

County: ______________________ **Proj. No:** ______________________

Book ______________________ **File No.** ______________________

Project: ______________________

____

Sample Data

Sample No.	Description	In-Situ Moist	Density	Opt Moist	Moisture range	PL	LL	AASHTO Class	USCS Class

Soil Description Sheet

CBR Data

CBR No.	Description	In-Situ Moist	Density	Opt moist	Moisture range	PL	LL	AASHTO Class	USCS Class	CBR

Spoons/Tubes Data

Sample No.	Station	Depth	Description	In situ Moist	LL	PI	AASHTO Class	USCS Class

Manhour Requirements and Cost Estimate

TDOT

version 1.1

TENNESSEE DEPARTMENT OF TRANSPORTATION

DIVISION OF MATERIALS AND TESTS
GEOTECHNICAL ENGINEERING SECTION

SOIL AND GEOLOGICAL SURVEY REPORT

MANHOUR REQUIREMENTS AND COST ESTIMATE

Instructions:
(Enter state route number, project description,county, consultant's name, prepared by name, and date prepared. This information will be transferred to all other sheets. The date prepared must be entered in the appropriate cell on this sheet to remove these instructions prior to printing.)

<COUNTY>

<ROUTE NUMBER>

<DESCRIPTION>

<GEOTECHNICAL CONSULTANT>

Prepared By: <NAME>

Date prepared: <TODAY'S DATE>

Project No. <PROJECT NO.>

Geotechnical Office No. <GEOTECH OFFICE NO.>

<CONTACT NAME>
<CONTACT ADRESS>
<CONTACT ADRESS>
<CONTACT ADRESS>
<BUSSINESS TELEPHONE>
<EMAIL ADRESS>

Section III

Standard Cost Estimate For Soil And Geological Survey Report

1.00 Drilling Services

County: <COUNTY>
Route: <ROUTE NUMBER>
Description: <DESCRIPTION>
Project No.: <PROJECT NO.>
Geotechnical Office No.: <GEOTECH OFFICE NO.>
Consultant: <GEOTECHNICAL CONSULTANT>
Prepared By: <NAME>
Date Prepared: <TODAY'S DATE>

For further explanation of Item No. and Description refer to attached "Pay Item Numbers and Methods of Measurement for Cost Estimates".

Item No.	Description	Estimated Quantities	Basis of Payment		Price	Amount
1.01	Mobilization		each	@		$0.00
1.03	Drill Rig Moving \ Standby Time		hour	@		$0.00
1.04	Soil Auger Drilling		vertical foot	@		$0.00
1.05	Wash Boring		vertical foot	@		$0.00
1.06	Soil Drilling and Split Barrel Type Sampling on Land		vertical foot	@		$0.00
1.07	Soil Drilling and Thin Wall Tube Type Sampling on Land		vertical foot	@		$0.00
1.08	Rock Coring		vertical foot	@		$0.00
1.10	Water Hauling		working day	@		$0.00
1.11	Bulldozer		operating hour	@		$0.00
1.12	Traffic Control		direct cost	@		$0.00

Total Estimated Drilling Costs	**$0.00**

Section III

Standard Cost Estimate for Soil and Geological Survey Report

2.00 Laboratory Services

County: <COUNTY>
Route: <ROUTE NUMBER>
Description: <DESCRIPTION>
Project No.: <PROJECT NO.>
Geotechnical Office No.: <GEOTECH OFFICE NO.>
Consultant: <GEOTECHNICAL CONSULTANT>
Prepared By: <NAME>
Date Prepared: <TODAY'S DATE>

For further explanation of Item No. and Description refer to attached "Pay Item Numbers and Methods of Measurement for Cost Estimates".

Item No.	Description	Estimated Quantities	Basis of Payment		Rate	Amount
2.01	Atterberg Limits		each	@		$0.00
2.02	Natural Moisture Content		each	@		$0.00
2.03	Particle Size Analysis		each	@		$0.00
2.04	AASHTO Classification		each	@		$0.00
2.05	Proctor Density Test		each	@		$0.00
2.06	California Bearing Ratio		each	@		$0.00
2.07	pH		each	@		$0.00
2.31	Acid-Base		each	@		$0.00
2.40	Sulfate Soundness		each	@		$0.00
2.09	Consolodation Properties		consolodation properties	@		$0.00
2.1	Triaxial Compression UU		strength properties	@		$0.00
2.11	Triaxial Compression CU		strength properties	@		$0.00
2.1	Unconfined Compression		per test	@		$0.00
2.63	CD Direct Shear		strength properties	@		$0.00
Total Estimated Laboratory Services Cost:						**$0.00**

Section III

Standard Cost Estimate for Soil and Geological Survey Report

3.00 Manpower Requirements

County: <COUNTY>
Route: <ROUTE NUMBER>
Description: <DESCRIPTION>
Project No.: <PROJECT NO.>
Geotechnical Office No. <GEOTECH OFFICE NO.>
Consultant: <GEOTECHNICAL CONSULTANT>
Prepared By: <NAME>
Date Prepared <TODAY'S DATE>

See "Pay Item Numbers and Methods of Measurement for Cost Estimates" for further description of services required by state.

Item No.	ACTIVITY	PRINCIPAL	SENIOR ENGINEER	STAFF ENGINEER	GEOLOGIST	TRAINING ENGINEER	SUPERVISING DRILLER	STAFF CADD TECHNICIAN
		MAN-HOUR	MAN-HOUR	MAN-HOUR	MAN-HOUR	MAN-HOUR	MAN-HOUR	MAN-HOUR
3.10	Project Planning and Coordination							
3.20	Field Activities							
3.30	Data Assimilation							
3.40	Engineering Analyses							
3.50	Report Preparation							
3.60	Drawing Preparation							
3.70	Post-Report Confrence and Review							
Total Estimated Hours								
Hourly Rate		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Subtotal of Estimated Man-hour Costs		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00

Total Estimate of Man-hour Requirements:	**$0.00**

Section III

Standard Cost Estimate for Soil and Geological Survey Report

3.00 Manpower Requirements, Hourly Rate Breakdown

County: <COUNTY>
Route: <ROUTE NUMBER>
Description: <DESCRIPTION>
Project No.: <PROJECT NO.>
Geotechnical Office No. <GEOTECH OFFICE NO.>
Consultant: <GEOTECHNICAL CONSULTANT>
Prepared By: <NAME>
Date Prepared <TODAY'S DATE>

Hourly Rate Breakdown	PRINCIPAL MAN-HOUR	SENIOR ENGINEER MAN-HOUR	STAFF ENGINEER MAN-HOUR	GEOLOGIST MAN-HOUR	TRAINING ENGINEER MAN-HOUR	SUPERVISING DRILLER MAN-HOUR	STAFF CADD TECHNICIAN MAN-HOUR
Direct Pay Rate	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Maximum Overhead Rate (no more than 1.45)	1.45	1.45	1.45	1.45	1.45	1.45	1.45
Profit Multiplier	2.35	2.35	2.35	2.35	2.35	2.35	2.35
Profit Rate * (supplied in decimals)	0.12	0.12	0.12	0.12	0.12	0.12	0.12
* use the same rate as with the desigr contract for the project.							
Hourly Rate	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00

Section III
Standard Cost Estimate for Soil and Geological Survey Report
4.0 Other Expenses

County: <COUNTY>
Route: <ROUTE NUMBER>
Description: <DESCRIPTION>

Project No.: <PROJECT NO.>
Geotechnical Office No.: <GEOTECH OFFICE NO.>
Consultant: <GEOTECHNICAL CONSULTANT>
Prepared By: <NAME>
Date Prepared: <TODAY'S DATE>

Distance to Jobsite:

Company Headquarters: <CITY,STATE>	Job Site: <CITY,STATE>

Travel Expenses				
Item No.	Description	Days	Rate*	Total
4.10	Travel Day Per Diem			$0.00
4.11	Non Travel Day Per Diem			$0.00
4.12	Lodging			$0.00

*Must be in accordance with applicable TDOT Travel Regulations

Milage\Transportation Expenses				
Item No.	Description	Miles	Milage Rate*	Total
4.20	Passenger Truck			$0.00
4.21	Tractor Trailer Truck			$0.00
4.22	Water Truck			$0.00
4.23	Truck Mounted Drill			$0.00
4.24	Other Mileage			$0.00

*Must be in accordance with applicable TDOT Travel Regulations

Equipment Rental				
Item No.	Description	Days	Daily Rate	Total
4.30	Equipment Rental			$0.00

Plans Reproduction Costs				
Item No.	Description	Units	Unit Price	Total
4.40	Full Size Bond			$0.00
4.41	Half-Size Bond			$0.00
4.42	Full Size Mylar			$0.00
4.43	Photocopies			$0.00

Other Expenses				
Item No.	Description	Units	Unit Rate	Total
4.50	Other Expenses			$0.00

Total Estimate of Other Expenses:	**$0.00**

Section III

Standard Cost Estimate for Soil and Geological Survey Report

SUMMARY OF COST ESTIMATES

County: <COUNTY>
Route: <ROUTE NUMBER>
Description: <DESCRIPTION>
Project No.: <PROJECT NO.>
Geotechnical Office No.: <GEOTECH OFFICE NO.>
Consultant: <GEOTECHNICAL CONSULTANT>
Prepared By: <NAME>
Date Prepared: <TODAY'S DATE>

1.00 Drilling Services	$0.00
2.00 Laboratory Services	$0.00
3.00 Manpower Requirements	$0.00
4.00 Other Expenses	$0.00

Total Not-to-Exceed Costs	$0.00