STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
MATERIALS & TESTS DIVISION
GEOTECHNICAL ENGINEERING SECTION

GEOTECHNICAL GUIDELINES

October 2023

TDOT - GEOTECHNICAL GUIDELINES

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CHAPTER 1 - GENERAL

1-100.00 FOREWORD

This chapter and the forthcoming chapters in this Tennessee Department of Transportation (TDOT) *Geotechnical Guidelines* provide information to establish uniform and standard procedures regarding geotechnical services provided for TDOT and the TDOT Geotechnical Engineering Section (TDOT GES). These *Guidelines* do not establish legal or administrative interpretations of TDOT's contracts. In the event of a discrepancy in the contract terms and these *Guidelines*, the contract terms govern.

Proper utilization of these *Geotechnical Guidelines* will ensure enhanced uniformity in the execution of geotechnical services for TDOT and TDOT GES. These guidelines are not intended to be reference for unique geotechnical problems encountered, but perhaps these guidelines can be used to locate reference to solve such problems. These *Geotechnical Guidelines* should not be used as a substitute for sound engineering judgement. This document describes the different geotechnical services TDOT provides and establishes a consistent manner and a standard framework of performing and submitting this work.

It should be recognized that TDOT is undergoing administrative transition mechanisms that are intended to improve efficiency. The delivery of projects will be performed differently than previous project delivery. The delivery system TDOT is adopting is referred to as Integrated Project Delivery (IPD). A flow chart of the delivery system is reproduced from the document *Project Delivery Network* (PDN Manual) (July 2023, v. 2.2) as Figure 1 Five PDN Stages of Project Delivery.

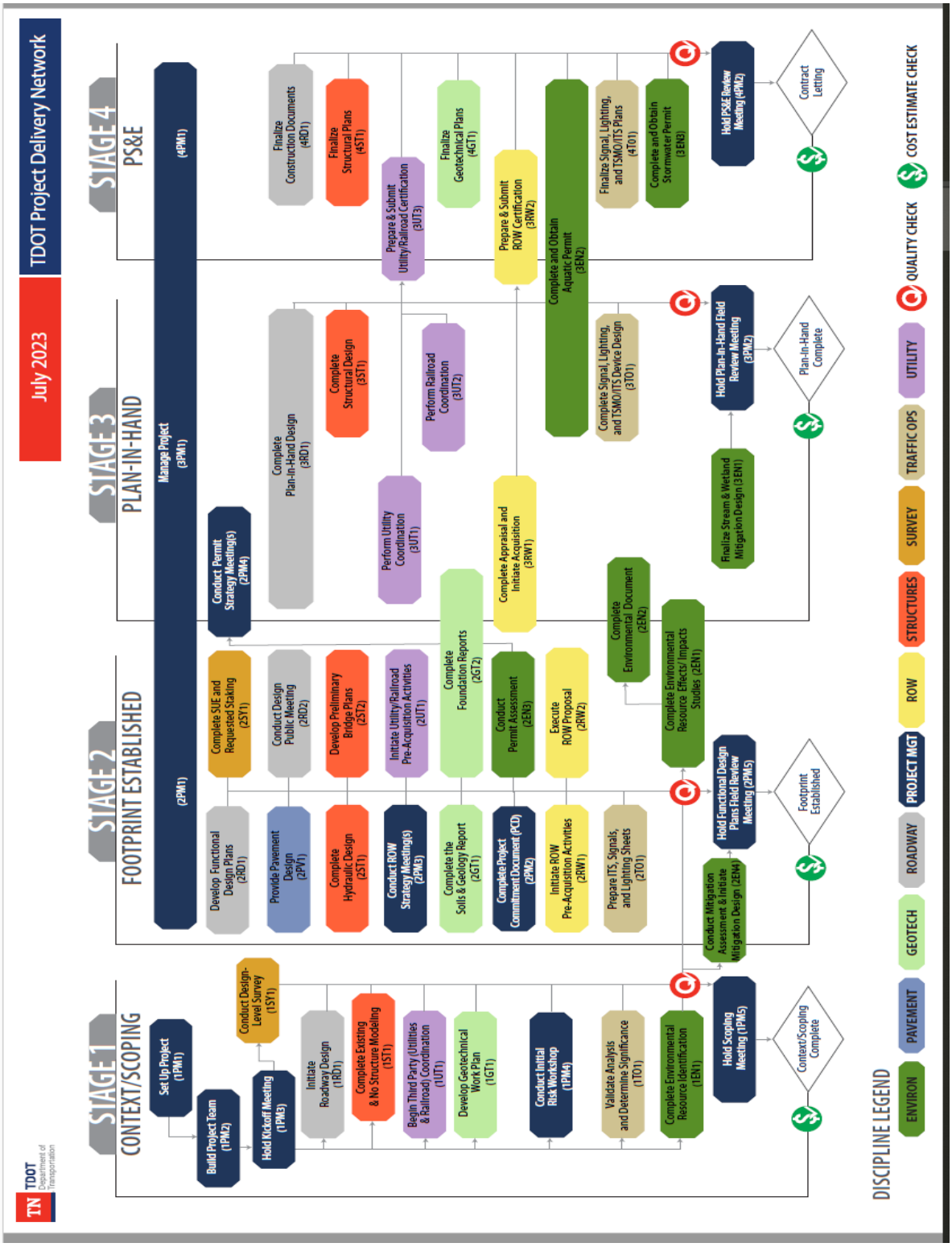

Figure 1 Five PDN Stages of Project Development

1-200.00 RECOGNIZED TDOT REFERENCE DOCUMENTS

It is intended for the *Geotechnical Guidelines* to complement, and not conflict with, other recognized TDOT reference documents, particularly the TDOT *Roadway Design Guidelines* (*DG*), TDOT *Structures Design Guidelines* (SDG), TDOT *Standard Drawing Library* (*Std. Dwg.*), TDOT *Standard Specifications for Road and Bridge Construction* (*TDOT Specifications*), TDOT *Traffic Design Manual*, and the *Special Provisions* (*SP*). All work shall also comply with current AASHTO design documents.

The *DG* is a quite comprehensive document and serves to provide roadway designers the basis for the development of Construction Plans (Plans). Structural policy guidance is contained in the *SDG*.

The *Std. Dwgs*. are actually an appendix to the DG. *Std. Dwgs*. are referenced in the 2 series of the Plans to avoid redundant design typical details. Typical design details for slope development are of particular interest to geoprofessionals.

Another recognized TDOT desk reference is the *TDOT Specifications*. The *TDOT Specifications* are part of project executed contract documents. The *TDOT Specifications* provide legally binding information on earthwork, subgrade, base, pavement, and structures. It should be recognized that many fairly standard earthwork notes developed by AIA and others could be in conflict with the TDOT Specifications, and will take precedent if contained in the Plans.

*SP*s are developed for construction activities that are standard and consisted but so detailed it just makes sense to develop an SP and reference the SP in the plans.

To remain current with the state of the industry, the *Geotechnical Guidelines* are in a state of constant update and improvement. Revisions, additions, deletions, and omissions are necessary from time to time and updates to these *Geotechnical*

Guidelines will be made on a regular basis, or as necessary. Efforts will be made to post the current *Geotechnical Guidelines* to TDOT's internet site.

It should be reiterated that TDOT administrative mechanisms transforming. The delivery of projects will occur in a moderately different way than in the past. Another reference that should be introduced when performing TDOT GES work is the *Project Delivery Network* (PDN) (July 2023, v. 2.2) document. Figure 1 Five PDN Stages of Project Delivery is provided.

1-300.00 ORGANIZATIONAL STRUCTURE

The TDOT Geotechnical Engineering Section (GES) is one functional Section of the Headquarters Materials and Tests Division (HQM&T). HQM&T has three other units: Field Operations, Laboratory Operations, and Research/New Product Evaluations. GES presently maintains an office staff in Region 3 Nashville, and Region 1 Knoxville (see Figure 2). Work flow within Regions 2-4 is typically completed by Nashville office resources, while work within Region 1 is typically completed by Knoxville office resources. Current, TDOT GES key staff contact information is provided:

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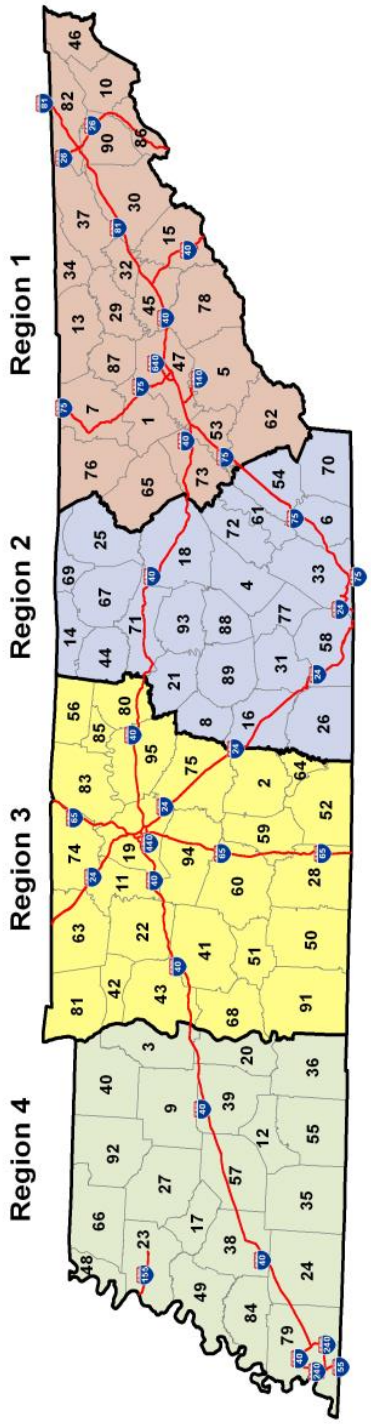

Alphabetical List of Counties in Tennessee

01 Anderson	17 Crockett	33 Hamilton	49 Lauderdale	65 Morgan	81 Stewart
02 Bedford	18 Cumberland	34 Hancock	50 Lawrence	66 Obion	82 Sullivan
03 Benton	19 Davidson	35 Hardeman	51 Lewis	67 Overton	83 Sumner
04 Bledsoe	20 Decatur	36 Hardin	52 Lincoln	68 Perry	84 Tipton
05 Blount	21 DeKalb	37 Hawkins	53 Loudon	69 Pickett	85 Trousdale
06 Bradley	22 Dickson	38 Haywood	54 McMinn	70 Polk	86 Unicoi
07 Campbell	23 Dyer	39 Henderson	55 McNairy	71 Putnam	87 Union
08 Cannon	24 Fayette	40 Henry	56 Macon	72 Rhea	88 Van Buren
09 Carroll	25 Fentress	41 Hickman	57 Madison	73 Roane	89 Warren
10 Carter	26 Franklin	42 Houston	58 Marion	74 Robertson	90 Washington
11 Cheatham	27 Gibson	43 Humphreys	59 Marshall	75 Rutherford	91 Wayne
12 Chester	28 Giles	44 Jackson	60 Maury	76 Scott	92 Weakley
13 Claiborne	29 Grainger	45 Jefferson	61 Meigs	77 Sequatchie	93 White
14 Clay	30 Greene	46 Johnson	62 Monroe	78 Sevier	94 Williamson
15 Cocke	31 Grundy	47 Knox	63 Montgomery	79 Shelby	95 Wilson
16 Coffee	32 Hamblen	48 Lake	64 Moore	80 Smith	

Figure 2 Tennessee Map shown with TDOT Regions and Counties

1-310.00 TDOT PROJECT NUMBERS

GES PIN NUMBER: Perhaps the single most significant project reference TDOT uses is the *PIN* number. This is a unique number arbitrarily assigned to each different project by Program Development and Administration Division. This unique identifier number should be used on all correspondence regarding the project, including but not limited to the subject line of e-mails, letters, memoranda and reports. The PIN number is entered internally to query as it is cross related with all other reference numbers TDOT uses in various databases. It can be used in a quick search function. The *PIN* number for the example project is shown below.

PIN Number Example
100241.03

GES FILE NUMBER: The GES file number is arbitrarily assigned by GES upon a customer request for geotechnical services. The GES number is used internally by the GES unit to cross reference all of the different projects TDOT GES has worked on over the years as a library. This is essentially a file number, either for a paper / cabinet file or an electronic server file. By including the GES file number in documents and correspondence, the administrative resources required are reduced. GES manages hundreds of projects.

GES File Number	County	Sequence	Fiscal Year
4706318	47	063	18

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. See *Figure 1 Tennessee Map shown withTDOT Regions and Counties.*

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 fiscal year.

Fiscal Year – In the state of Tennessee, the fiscal year begins July 1 and ends June 30. So, if the example project's geotechnical services were requested to be performed in August of 2017, the project was given a 18 fiscal year.

TDOT TX (SpeedChart) Number: No timesheet or pay invoice voucher can be made without a TX number. Each different functional business unit of TDOT requests and is assigned this TX number in order to capture and manage costs of project development for that particular business unit.

Federal Project Numbers: Another project number assigned by TDOT Program Development and Administration Division is the Federal Project #. If the project has Federal participation, the Federal Project # is typically the project number that should placed on the upper right hand corner of the plans. If you are internal to TDOT, see your supervisor to determine the correct number to place on your G-Sheets or R-sheets, or if a consultant seek your TDOT project proctor for guidance.

TDOT Contract Number: Lastly, when the construction plans have been turned in for letting, the Construction Division assigns yet another alphanumeric number to the project; three letters and three numbers. This is the number used to administrate all construction and inspection costs. An example of a Contract Number or CN number is CNU224. Typically, the number has three alphabet letters and three numbers that change sequentially.

1-320.00 CORRESPONDENCE WITH TDOT GES

All TDOT correspondence shall include project numbers. Most of TDOT's communication is done through electronic email. The subject line of any email correspondence is expected to include the *PIN* number and the state route number and county number (the construction number should be added if appropriate). TDOT GES staff is engaged in dozens of projects in various stages of project development so if this project information is used on email correspondence administrative time and effort is minimized.

1-400.00 TDOT GEOTECHNICAL CONSULTANTS

TDOT is undergoing an organizational realignment. A new Division of Professional Services (telephone 615-568-1468) has been created, so business will be done slightly differently than previous and change processes are expected. Procurement of TDOT consultant contracts are consistent with the Brooks Act.

TDOT GES oversees On-Call contracts to meet schedule demands or to enhance internal technical capabilities. To streamline administrative processes and allow for expedient payment, TDOT GES uses Appendix 3 TDOT GES Consultant Invoice Checklist as guidance to consistently process standard invoices.

CHAPTER 2 – ROADWAY DESIGN SUPPORT

2-100.00 ROADWAY GEOTECHNICAL SERVICES GENERAL

Geotechnical services are required throughout different stages of a roadway design schedule. It is the purpose of this document to offer the geotechnical professional consistent guidance on providing these services to the roadway designer. This document will hopefully compliment and cross reference where appropriate the *TDOT Roadway Design Guidelines*, the *Project Delivery Network manual document* (*PDN Manual*) and other TDOT documents.

For purposes of standardization and consistency, report document deliverables that summarize geotechnical services in support of roadway design shall be referred to as the *Preliminary Geotechnical Assessment (PDN-0GT1)* or *Soils & Geology Report (PDN-2GT1)*.

The *Preliminary Geotechnical Assessment* is discussed in sub-chapter 2-200.00. It is used early in the schedule to develop a *Concept Report*.

Separately, the *Soils & Geology Report* is delivered. This *Geotechnical Guidelines* makes distinctions in the level or scope of a given transportation improvement project warranting the *Soils & Geology Report*. The following sub-chapters 2-300.00 Extensive Transportation Improvements, 2-400.00 Bridge and Approaches Improvements, and 2-500.00 Limited Extent Improvements discuss this. The *Soils & Geology Report* is the expected deliverable for any of these transportation improvements.

The remaining material comprising this chapter contains guidance necessary to produce consistent geotechnical deliverables.

So, the geotechnical support required for elements of *roadway design* is discussed here in Chapter 2, and Chapter 3 discusses separately the deliverables required of structural elements such as bridges, retaining walls, and high mast lighting along a project improvement. In terms of network delivery, the geotechnical requirements necessary for structures typically begins later in the schedule, though some complex projects require a conceptual discussion of earth retaining structures to complete the *Soils & Geology Report*. Moreover, all geotechnical efforts in PDN Stage 2 are geared toward selecting an appropriate slope design, delivering the *Soils & Geology Report*, establishing the project footprint, and holding the Functional Design Plans Field Review (PDN-2PM5).

As the project progresses through the PDN stages the geotechnical professional should be mindful of the CAD work required to develop the GEOTECHNCIAL sheets (G-Sheets). The G-Sheets shall be inserted into the plans for the Field Reviews at the PDN milestones Functional Design Plans, Plans-in-Hand, and PS&E. Included as Appendix 4 is the TDOT GES Field Review Checklist that shall be used as the standard checklist when reviewing Field Review Plans.

2-200.00 PRELIMINARY GEOTECHNICAL ASSESSMENT (PDN-0GT1)

The Preliminary Geotechnical Assessment (PGA) is a high-level planning stage review document and is well described in the *PDN manual*. The PGA is provided at a stage collectively referred to as Stage Zero.

PGA Deliverable Objective: The PGA provides a preliminary assessment of the the project proposed from a high level geotechnical perspective. The document offers professional opinion regarding geology features existing along the proposed alignment that could impact the project and pose geoenvironmental or geotechnical risk.

Except for the most complex projects, drilling, sampling, and laboratory testing is not typically required. Attention could be paid to obvious “aquatic features” such as sinkholes, streams, wetland locations, springs, and seeps. Additional attention may include a discussion of the risks of processing acid producing material. Other typical geotechnical concerns like landslides, rockfall, subsidence areas, soft or unstable ground, high seismic zones should be recognized because they will assuredly impact the construction schedule and cost.

The PGA request for services is made by the TDOT Strategic Transportation Investments Division (STID). The limits of the project are generally denoted on a rough plan view showing the proposed improvement against aerial photography derived in some manner. The PGA delivery expectations are a formal document or even more simply an electronic mail transmission. The delivery shall be entitled the *Preliminary Geotechnical Assessment* to be clearly distinguished from the *Soils & Geology Report.*

2-250.00 DEVELOP GEOTECHNICAL WORK PLAN (PDN-1GT1)

Before performing activities necessary to complete the *Soils & Geology Report* (PDN-2GT1) and *Foundation Reports* (PDN-2GT2), those activities must be documented and approved in a formal Geotechncial Work Plan (PDN-1GT1). Additional reference for this is contained in the PDN Manual.

Geotechnical Work Plan Deliverable Objective: The Geotechnical Work Plan shall document the scope of work necessary to develop the *Soils & Geology Report* and *Foundation Reports* (PDN-2GT2) and the scheduled date of delivery, based on all information available at that point in the schedule. Other sections in the *Geotechnical Guidelines* should be used as standard guidance to adequately characterize the site and develop the *Soils & Geology Report* and *Foundation Reports* (PDN-2GT2). The Geotechnical Work Plan is a document that is to be delivered to the Project Manager for approval in PDN Stage 1 (Context\Scoping) prior to moving forward to PDN Stage 2 (Footprint Established).

2-300.00 EXTENSIVE ROADWAY IMPROVEMENTS

Extensive Roadway Improvements (ERI) projects are larger in scale and scope than Limited Extent Roadway Improvements (LERI) projects discussed in 2-500.00 or Bridge and Approaches (B&AI) projects discussed in 2-400.00. The ERI projects involve significant improvements to traffic capacity and safety. Examples of typical ERI projects would include a new roadway alignments over “open” ground, or a new or modified roadway interchange, or realignment lane widenings of an existing route.

Extensive Roadway Improvement Deliverable Objective: The objective is to deliver the *Soils & Geology Report* which typically contains geotechnical recommendations to the roadway designer necessary to prepare Functional and Plans-in-Hand plans. Tasks to meet that end typically include drilling of test borings, laboratory analysis, and engineering analysis sufficient to prepare a geotechnical report document with geotechnical sheet drawings.

It is not the intent of these *Geotechnical Guidelines* to be a comprehensive geotechnical engineering reference, but instead be a guide to TDOT GES workflow. Some of the more useful references TDOT GES recognizes and frequently employs are listed below.

- Publication No. FHWA NHI-06-088 December 2006 NHI Course No. 132012 Soils and Foundations Reference Manual
- Training Course in Geotechnical and Foundation Engineering: Rock Slopes 1999 FHWA-HI-99-007
- Advanced Course on Slope Stability, Volume 1 1994 FHWA-SA-94-005
- LRFD Bridge Design Specifications

From the sampling and testing phase, sound engineering judgement must be used in selecting the geotechnical parameters for analysis. Engineering analyses expected in the *Soils & Geology Report* include but are not limited to:

- Compaction Information (maximum density, shrink\swell factors)
- Slope stability for cut slopes in soil
- Slope stability for embankment fills
- Slope stability for rock cuts
- Settlement analyses of embankments
- Rockfall hazard mitigation

The slope stability analysis should be performed with an industry recognized limit equilibrium software and engineering judgement. GES now uses Windows based GEOSTASE4 to analyze slope stability.

TDOT Standard Drawing RD01-S-11 DESIGN AND CONSTRUCTION DETAILS FOR ROADSIDE SLOPE DEVELOPMENT Typical slopes used for TDOT projects are 2H:1V or flatter in soil, but Footnote 4 states slope stability concerns are to be evaluated by TDOT GES. The economic impact of landslides occurring during construction on TDOT embankment slopes is of significant concern. It is recognized that 2:1 fill slopes are used in an attempt to lessen the impact of the roadway footprint, to limit R.O.W. acquisition, and to reduce the quantity of fill placement. It is felt, that the costs of contractor change orders and contractor time delays following a landslide are even more significant, especially if a particular slope segment could have been designed flatter, or with geosynthetic reinforcement. Slope “benches” provide a break in the slope and are often used effectively in slope stability modelling to increase the CDR, but are difficult to construct in the field and differential weathering causes these “benches” to not provide positive drainage, as designed. Slopes

flatter than 2:1 should be recommended as necessary, and it is advised to carefully evaluate 2:1 soil embankment slopes, particularly those 30 ft. or higher.

Surface sloughing and rilling of the sandy soils are such concern in Region 4 projects, it is typical to use 3:1 soil cut and fill slopes.

Structural buttress constructed of Graded Solid Rock on slopes as steep as 1.5:1 with good quality control have been used effectively to reduce the roadway footprint.

Typically, TDOT excavates unweathered (high quality, high RQD) rock cuts on vertical pre-split slopes. There are exceptions, if the rock is weathered and of inferior quality. If the rock is of sufficiently poor quality, if the bedrock elevation is inconsistent, or if the jointing pattern is not conducive to pre-split or steep 0.25:1 slopes, it is often advisable to set the rock slope design on a configuration typically used for soil slopes.

Consider proactive rock fall mitigation as appropriate. This may involve the use of rock bolts, welded wire mesh draping, rockfall catchment fences, shotcrete and other mitigation methods.

CBR test results should be evaluated, and recommendations made.

If poor embankment subgrade drainage conditions exist, consider measures to “bridge” the soft soil using a rock pad or lifts of sandy select fill. If the embankment is not of sufficient height that “bridging” can be accomplished, undercutting of unsuitable material is necessary.

If karst terrain drainage is prevalent, the different TDOT GES typical sinkhole treatment details, with the use of rock pads, should be considered. The *Soils & Geology Report* and drawings is to be forwarded to the TDOT Environmental Division in preparation of permits related to karst features (sinkholes) or acid producing material (See 2-600).

2-400.00 BRIDGE AND APPROACHES IMPROVEMENTS

There are geotechnical services required specifically for the roadway adjacent to the Bridge and Approaches Improvements (B&AI) project. The request for services is for the roadway only, and the request for the bridge foundation investigation is considered separate and will be submitted on a different schedule and to a different owner, the TDOT Structures Division (discussed in Chapter 3). Although all B&AI projects are functionally classified together, the size of the project scope varies widely with the size of waterway or grade that the bridge is crossing. For example, some waterways consist of only a small tributary stream, or a flood plain overflow, but TDOT owns more significant waterway bridge crossings over the Tennessee River or the Cumberland River.

Bridge and Approaches Deliverable Objective: Ultimately, the objective of the bridge approach embankment geotechnical study is to deliver geotechnical recommendations to the roadway designer providing guidance for plans preparation. B&AI projects and ETI projects are both in support of the roadway but differ in size and scope. Refer to ETI Deliverable Objectives for complete guidance on items to include in the B&AI *Soils & Geology Report*, but for most B&AI projects typical geotechnical recommendations such as cut and fill slope ratios, special embankment preparation, and pavement evaluation are all that is required.

2-500.00 LIMITED EXTENT IMPROVEMENTS

The geotechnical services required of a Limited Extent Improvements (LEI) may be relatively smaller in size and scope than other Extensive Roadway Improvements but are functionally grouped together for purposes of discussion. These projects could contain bridges and/or retaining walls, and if so there will be separate tracking mechanisms will be set up for the their delivery. Brief descriptions of these projects are given below.

Intersection Improvement: These projects typically consist of improvement of an existing roadway or highway intersection or interchange to enhance the capacity, efficiency or safety of the facility. The improvements may include lane widenings, lane additions, and\or signalization. Of note to the geotechnical professional is that these projects are usually located in urbanized, high traffic areas with numerous utilities in the project footprint. These conditions potentially limit the extent of subsurface investigation that can be accomplished for the project, without traffic control\impedance.

State Industrial Access (SIA) Projects: As described on the TDOT Website: "The State Industrial Access (SIA) Program" provides funding and technical assistance to improve highway access for new and expanding industries across the state. TDOT partners with local governments and prepares plans for projects that vary in scope from repaving an existing roadway to significant grading. Typically, these projects are developed and let to contract on an accelerated schedule and requires the geotechnical investigation be expedited in order to meet project schedules.

Road Safety Audit Review (RSAR) Projects: These projects result from a RSAR study performed under the TDOT Strategic Transportation Investment Division of a particular section of roadway with recurring safety issues (i.e. a high incidents of guardrail impacts, collisions, etc.). Based on the review there may be recommendations for improvements that can range from installing guardrail (which usually means shoulder\buffer widening), signing, to small alignment modifications of a road. TDOT GES would typically be requested to contribute support if the RSAR project involved excavation.

Limited Extent Projects Deliverable Objective: Providing geotechnical recommendations to the roadway designer is the objective deliverable. Scale is the only difference between smaller LEP projects and larger ETI projects. Therefore, refer to ETI Deliverable Objectives guidance for LEP items guidance.

2-600.00 ACID PRODUCING MATERIAL (APM) GUIDANCE

Naturally occurring acid producing materials (APM) exist in Middle and East Tennessee shales, sandstones, and siltstones. Though a high level of care was being exercised at TDOT in APM processing since the early 1990's, environmental concerns began occurring on TDOT construction projects in the early 2000's. Subsequently, several separate governmental agencies convened to satisfy those environmental concerns and develop strategic compliance measures. This guidance contained herein, with sound engineering geologist or geotechnical engineer judgement, can be used to implement those strategic compliance measures developed to produce reports and prepare GEOTECHNICAL engineering drawings for insertion into Functional Plans \ Plans-in-Hand.

Construction Division's *Special Provision 107L Regarding Potentially Acid Producing Materials* (*SP107L*) provides the Contractor standard contractual guidance of responsibilities

in the APM handling process. The *SP107L* document contains many references to the Plans, in fact it states that the APM "shall be treated and disposed of in accordance with the Plans." The geotechnical engineer or engineering geologist should review the *SP107L* and understand how the document compliments the construction Plans.

TDOT GES is responsible for preparing the APM GEOTECHNICAL engineering sheets (G-Sheets) for the Construction Plans. For consistency in appearance, TDOT GES maintains a set of standardized typical details specifically developed for APM processing. These APM typical details are included as Appendix 6 for your uses and information. The APM typical details are improved as seen appropriate and current information is available upon request in microstation drawing elements from GES. The APM drawings contain typical details, sections, notes, and specifications used to implement the strategic compliance measures. The APM drawings should not be modified without considerable judgement. When APM has been identified in the project limits of construction it is reasonable to include these typical details within the G-sheets submittal package.

Previous TDOT GES APM policy efforts centered around guidance contained in an internal document referred to as the *Standard Operating Procedures For Acid Producing Rock* (July, 2005) (*GES SOP*). Within the general time frame of 2005, environmental concerns occurred on TDOT projects and leaders determined that there was a need to retain an outside consulting firm to collaborate with separate governmental agencies, compile a syntheses of current APM technical literature, and develop best management practices for treating and disposing of APM for TDOT. This effort was finalized and is entitled the *Guideline for Acid Producing Rock Investigation, Testing, Monitoring and Mitigation* (October 2007) (*APR Guidelines*). The *APR Guidelines* replaced the *GES SOP* and formed the cornerstone of the current APM processing methodologies and engineering drawings currently in use.

Prior to the award of a TDOT construction contract where APM is suspected, TDOT Environmental Division typically delivers a set of construction plan drawings to TDEC Division of Solid Waste for approval of a Special Waste Permit. APM treatment and processing is a unique site-specific endeavor that requires case by case engineering judgement. The previous methods and practices employed include blending, full encapsulation, or relocate to an approved landfill. But regardless, all parties must come together initially and work toward the goal of obtaining an executed Special Waste Permit, staying in compliance with that permit, and ultimately being good stewards of the environment. In order to deliver the APM

requirements for treatment and disposal, the engineering geologist or geotechnical engineer should have a thorough understanding of *APR Guidelines* and *SP107L*.

Acid Producing Material Deliverable Objective: APM treatment and disposal recommendations (with G-sheet engineering drawings) are required within the *Soils & Geology Report*. Projects containing potential or known APM in the proposed cut sections must be assessed. If test results reveal acid drainage could be a concern, an APM treatment and disposal plan must be established, and engineering drawings inserted into the field review plans. The APM treatment and disposal plans available are either on-site APM disposal or off-site APM disposal.

An initial desk study and project screening should be conducted on the project in accordance with *APR Guidelines*. If APM potential exists or is probable within the limits of the construction project, notify supervisor \ GES Project Monitor so team meetings can be planned to get insight from Region and Headquarters TDOT Pre-Construction and TDOT Environmental divisions.

Conduct APM sampling in general accordance of *APR Guidelines* as part of the subsurface investigation for the project Soils & Geology Report. TDOT GES maintains on-call APM laboratory testing contracts with qualified firms. APM tests include paste pH, Acid Potential (AP), Neutralization Potential (NP), AP-NP (the calcium carbonate deficiency, or net acid-base account value) as well as tests of total sulfur and pyritic sulfur. Since TDOT requires APM testing be performed by pre-approved laboratories, contact GES for more information on APM laboratory service administration.

APM test results (AP-NP) should be plotted onto soil boring profile sticks against the proposed roadway profile. These test results, along with the roadway cross sections, can be reviewed and evaluated. Initial computations of APM volume required to be treated or disposed will have to be discussed with others. Discussions should also be held that center around construction and bidding practices.

The APM G-Sheets templates contain the current strategic compliance measures and serve as the framework of the APM treatment and disposal plan. These engineering drawings include details of construction which must be clearly understood and must be inserted into the plans with the G-sheets at Field Reviews. These APM guidance sheets are an important part of the deliverable objective as they will be inserted in the Plans. *SP107L* and the Construction

plans are the contractual mechanism directing the APM treatment and disposal plan**.** *SP107L* states APM material shall be, “disposed of under the direction of the Engineer and in accordance with the contract plans and documents.”

As stated in *SP107L*, there are two contractual bid items for the treatment and disposal of APM: on-site and off-site. In the past ten years, off-site treatment and disposal of APM has largely been the preferred contractual method. Perhaps this off-site preference has been due to the substantial embankment heights that are required.

Based on review of *SP107L*, *APR Guidelines*, and APM G-Sheets the following general guidance is summarized for the practicing geoprofessional.

- Per *SP107L*, off-site disposal requires “APM be treated at an off-site waste area in accordance with the contract or hauled to a regulated landfill approved by TDOT Environmental Division.”
- Contractors are responsible for obtaining the off-site waste area SWPPP and grading plan from TDEC
- The grading plan must be developed in accordance with the requirements of the APM G-sheets.
- Material is to be sampled on a “lot” basis, in accordance with *SP107L* guidance, and tested for Net Neutralizing Potential (NNP), and the other test methods of the acid-base accounting tests found in the *APR Guidelines*.
- If pre-construction test results reveal an NNP between -5 and zero, generally the material is considered Potential-APM, in accordance with *APR Guidelines*.
- If pre-construction test results reveal an NNP less than -5, the material is considered moderate to high APM and must be encapsulated on-site or off-site, in accordance with the guidance in the Plans.

2-700.00 DRILLING AND SAMPLING REQUIREMENTS

The level of effort required to characterize the geotechnical conditions of a project site varies with the project scope and design requirements. The level of drilling and sampling resources felt reasonable is discussed in this section. Geophysical testing is also being employed to further characterize the site and compliment the drilling effort. Geophysical testing guidelines and requirements are discussed in section 2-710.00 Geophysical Methods. The site characterization level of effort and resources expended should consider what level of risk the bidder would make on an estimate.

TDOT GES considers the drilling and sampling guidelines found in Publication No. FHWA NHI-01-031 Manual on Subsurface Investigations (2001) and NCHRP Web-Only Document 258 (2018) sound. The extent of a drilling and sampling program should consider the depth of the proposed excavation cuts, the height of the proposed embankment fills, and the variability of the local geological conditions. Smaller project scopes may only require a few test borings be advanced, and only a few days spent in the field, whereas complex project scopes require extensive drilling, and could take multiple months of field testing.

Inevitably, there will be key test boring locations that are inaccessible because the terrain is critically sloped or heavily wooded. In these locations, expensive and time-consuming clearing and leveling is sometimes required to access these proposed test boring locations. The resources spent on clearing access, should approximately equate the amount of subsurface information obtained.

Generally accepted GES practices for test borings and sampling frequency is presented in *Figure 2-1 TDOT Test Boring Frequency*. Test boring frequency is based on proposed geometrics of the roadway cross sections and should be considered a general guideline. This table is intended to be used for preparing a preliminary boring layout plan or to prepare a preliminary scope estimate. The site investigation can be adjusted based upon site conditions as necessary.

It is recognized that flight auger soundings are suitable to rapidly obtain refusal elevations and conduct preliminary soil surveys.

The soil and rock sampling conducted in conjunction with the drilling will also vary greatly depending on the size and nature of the project. Generally, TDOT GES finds the following sampling guidelines to be reasonable:

Bulk bag sample (approximately 50 pounds) of each type soil encountered during auger drilling process. The soil sample is subjected to Proctor Density testing and classification. A moisture content sample is also obtained. Samples should be taken whenever there is a change in sample texture, moisture content. If the soil is consistent, additional samples should be obtained on an approximate 1,500 feet station spacing.

- Bulk bag sample (approximately 80 pounds) of each type soil encountered for Proctor\CBR testing for subgrade evaluation for pavement design. The CBR test sample frequency should be approximately spaced on 2,500 feet of alignment station.

- Standard Penetration Tests and/or Shelby Tube undisturbed sampling. Samples should be AASHTO classified to characterize all of the different soil types on the site. Strength and consolidation properties should be determined, using the appropriate test methods on the undisturbed tube samples. The moisture content should be determined across the site.

- Rock core samples should be obtained in cut areas. The rock is to be properly described in a boring log record. Photographs of rock core shall be taken and made a part of the geotechnical boring log record. Rock core samples collected for purposes of slope design are not intended to be permanently stored. See Appendix 7 Core Storage for guidance.

- If potential Acid Producing Material (APR) is suspected, sampling\testing frequency should be increased and conducted to properly characterize the site in preparation processing in accordance with Special Provision 107L. Also, additional information is found in 2-600.00 ACID PRODUCING MATERIALS GUIDANCE.

Table 2-1 TDOT Test Boring Frequency[1]

Cut or Fill	Depth of Fill \ Height of Cut	Cut \ Fill Length	Number of Borings	Depth
Soil Cut	D < 40	L < 600’	At least 1	Located in deepest portion of the cut, at least 15 feet below ditchline.
	D < 40	L > 600’	Spaced out at no more than 400’ in length	Located in deepest portion of the cut, at least 15 feet below ditchline.
	D > 40	L < 600’	Spaced out at no more than 400’ in length, minimum of 2 borings	Attempt to sample deepest portion of the cut, at least 15 feet below ditchline.
	D > 40	L < 600’	Spaced out at no more than 300’ in length, minimum of 2 borings	Attempt to sample deepest portion of the cut, at least 15 feet below ditchline.
Rock Cuts	D > 10’	L < 200’	At least 2	To 5 feet below ditchline
	D > 10’	L > 200’	Spaced out at no more than 200’ in length. Minimum of 3	To 5 feet below ditchline
Fills	H < 30	L < 600’	At least 1	To 2 x depth of proposed embankment. Core at least 5 feet of rock if refusal is higher than 2 x embankment depth
	H < 30	L > 600’	At least 2, spaced no more than 400 feet apart	To 2 x depth of proposed embankment. Core at least 5 feet of rock if refusal is higher than 2 x embankment depth
	H > 30	L < 600’	At least 2	To 2 x depth of proposed embankment.
	H > 30	L > 600’	At least 2, spaced no more than 300 feet apart	Core at least 5 feet of rock if refusal is higher than 2 x embankment depth

[1] Includes rock core, split spoon sampling and Shelby tube sampling as appropriate. Please note that these guidelines may not be sufficient in structurally complex rock. Additional drilling will be required if needed to predict potential structural failures in rock cuts such as plane shear, wedge failure and toppling failures.

2-710.00 GEOPHYSICAL METHODS

Many testing applications are possible using geophysics. For this discussion, the topic of geophysics will be restricted to surficial methods that attempt to characterize the geotechnical properties of a proposed transportation site. The term surficial geophysical method implies that the measurements are taken from the existing ground surface, and not measured from a drilled test borehole.

TDOT feels geophysical methods are a reasonable manner to supplement conventional drilling on transportation projects geotechnical site characterizations and locate specific utilities on private property. These methods appear minimally invasive and provide value in consideration of major transportation improvement costs. These methods are particularly appealing when conventional drilling methods are unfavored due to environmentally sensitive access clearing, or because of time consuming lane closures in high traffic demand areas, or simply because the terrain is too rugged. In theory, the geophysics technology offers promise in delivering data on a condensed time schedule and can reduce some of the risks becoming associated with conventional drilling methods.

TDOT has used geophysical methods for some time on a limited scale, and it is the intent to utilize this application more as deemed appropriate. TDOT has found the most practical methods to be seismic methods and electrical methods, which will be discussed later in this section. Published guidance on geophysical testing methods has been available for many years, and TDOT finds the following guidance adequate:

- The United States Army Corps of Engineers EM 1110-1-1804 Geotechnical Investigations, 2001.
- NCHRP Syntheses 357 Use of Geophysics for Transportation Projects, 2006.
- FHWA-IF-04-021, Application of Geophysical Methods to Highway Related Problems, August 2004.
- NCHRP Synthesis 547, Advancements in Use of Geophysical Methods for Transportation Projects, 2020.
- NCHRP Web Only Document 258: Manual on Subsurface Investigations, 2018.

Geophysical Methods Deliverable Objective: TDOT delivers *Soils and Geology Reports*, which characterize the site for roadway grading purposes, and delivers *Foundation Reports*, which characterize the site for purposes of a foundation or retention elements. TDOT GES also deliver *Project Memorandums* that characterize site roadway conditions, particularly subsidence due to sinkholes in karst terrain. Geophysical testing data can enhance all of these documents GES delivers.

The principal objective of TDOT GES surface geophysical methods is to further characterize subsurface features for proposed transportation improvement projects. TDOT seeks to supplement traditional drilling techniques, with geophysical methods to evaluate earth retaining structure foundations, bridge foundations, and explore roadway excavation cuts. Many surficial methods of geophysics are available for a range of objectives, but TDOT GES geotechnical investigations typically employ seismic and electrical geophysical methods.

Seismic Methods: It is generally recognized that seismic methods are the most frequently performed geophysical survey for engineering investigations. TDOT GES typically uses seismic refraction methods. Seismic refraction is a geophysical method used for investigating subsurface ground conditions by utilizing seismic waves to determine layer thickness of the subsurface ground structure. Based on a literature review, the seismic refraction method can also be used to find fractures in the bedrock and even voids beneath these fractures. TDOT GES has found seismic refraction a tool that can identify the approximate depth of rock, and other anomalies, particularly when “truthed” with conventional test borings. One drawback to seismic refraction is background noise in urban environments (i.e. near an airport).

Electrical methods: The measurement of voltage drop between multiple electrodes is another empirical method to evaluate subsurface materials. TDOT GES is most familiar with electrical resistivity imaging (ERI) methods, because such a system is owned. The ERI system is frequently used to evaluate karst sinkhole collapse sites. Drawbacks to using ERI methods include erroneous results can be attributed to power lines, buried metallic utilities, and metal fences.

Ground-penetrating radar (GPR) is another common electrical geophysical application. GPR transmits a high-frequency electromagnetic pulse from a radar antenna into the ground subsurface. One principal drawback TDOT GES recognizes is the erroneous GPR data results that can result in clayey soils, since much of Tennessee has deposits of residual clay.

2-800.00 LABORATORY TESTING

Engineering judgement should be used to determine the laboratory testing program assigned to supplement the drilling and sampling data. The objective is to adequately characterize the site.

Listed below are some statements that should be used as general guidance when selecting the appropriate level of soils laboratory testing program for roadway projects.

- General soil behavior can be assessed by performing AASHTO Soil Classification System and natural moisture tests to soil samples. AASHTO Soil Classification requires Liquid and Plastic Limit tests performed in accordance with AASHTO Designation T 89 and AASHTO Designation T 90, respectively. Natural moisture should be performed in accordance with T 265.
- Any rock encountered should be examined or tested to characterize the type of rock and the mineralogy, to the extent necessary for construction of the project.
- Slope stability analysis requires appropriate soil strength and in-situ unit weight test results. Appropriate triaxial testing, direct shear testing and unconfined compression testing should be assigned to evaluate the sampled soils.
- Embankment settlement should be assessed if deemed appropriate by having samples subjected to strength and consolidation tests.
- CBR (California Bearing Ratio) testing is often required to evaluate pavement subgrade conditions. Soil classification is to be performed on all CBR tests, as well as the natural moisture test.
- Lime stabilization tests should be considered if CBR test results consistently yield less than 5.
- Proctor density should be performed on appropriate areas from proposed cut sections so that roadway designers can compute earthwork quantities and inspectors can verify

compaction. Soil classification shall be performed on all Proctor tests, as well as the natural moisture test.

- If felt appropriate, shrink and swell testing should be performed on proposed cut sections.
- In addition to RQD and other appropriate strength correlations, rock core samples could be subjected to compressive strength tests as deemed appropriate.
- If a durable rock such as Graded Solid Rock (per State Standard Specifications Section 203.02 B. 3) is required on the project, and rock in potential cut areas is deemed to meet Graded Solid Rock borrow quality requirements, the material should be sampled appropriately and subjected to sodium sulfate soundness testing (T 104) and LA Abrasion testing (T 96).
- If the rock is suspected of leaching acid drainage off the site, appropriate samples should be subjected to pH testing and other test methods found in Special Provision 107L (see 2-600.00 Acid Producing Materials Guidance for further reference).

2-900.00 *SOILS & GEOLOGY REPORT* STANDARD FORMAT

In general, the geotechnical report referred to as the *Soils & Geology Report* should contain the items below.

- Geologic features characterization.
- Recommended slope design.
- Evaluation of on-site borrow sources in the cut areas for structural fill
- Recommended shrink \ swell factors.
- All areas that require a “rock pad” bridge, prior to embankment fill placement should be identified and quantified.
- All areas that require “undercutting” and “backfilling with more suitable material” should be identified, specified, and quantified.
- Presence of sinkholes, acid producing material, existing landslides, or rockfall risks.
- The pavement subgrade should be evaluated and a design C.B.R. recommended so others can design the pavement section.
- Geotechnical Sheets that illustrate the project in the engineering drawing plans

2-910.00 *SOILS & GEOLOGY REPORT* ELEMENTS

Soils and Geology Report Checklist: This document is included as Appendix 2 and should be filled out and delivered to your Team Lead \ TDOT GES Proctor concurrently with draft.

Executive Summary: This section is a brief one page narrative describing the site. It briefly describes significant geotechnical issues of the project or any significant design requirements.

Introduction: Brief summary of the project and location. Any special site conditions such as limited right of way, topography and geography are noted here.

Geology, Soils and Site Conditions: A complete description of site geology, soils and site terrain conditions should be provided.

Surface and Subsurface Exploration: Provide a summary of the exploration performed such as number and type of test borings, sampling techniques, site access issues, and property owner issues, etc.

Recommendations: This section of the report is best discussed in terms of project station interval segments that share proposed geometric roadway cross section characteristics. Each segment interval discussion should include, but not be limited by:

- Recommended cut slope ratios and/or embankment slope ratios
- Rock pads / Rock buttresses
- Undercutting and replacement of soft soils
- Mitigation of sinkholes
- Settlement issues – and settlement mitigation options
- Earthwork compaction information (maximum density, shrink\swell factors)

Each interval segment should have a corresponding Geotechnical Typical Section Sheet that illustrates the boring profile and other geotechnical recommendations, as necessary. For example, if a Geotechnical Typical Section Sheet is prepared that proposes a fill embankment on a 2:1 slope from interval segment station 30+00 to 36+00, there shall be a section in the

Soils and Geology Report that specifically refers this interval segment, confirms the slope design, illustrates test boring results, and discusses these recommendations in more detail. There will be further guidance on Geotechnical Sheets (G-Sheets) in Section 2-920.00.

Pavement Subgrade Recommendations: The CBR values recommended for design of pavements should be presented and discussed in this section. Any special recommendations regarding the subgrade such as special compaction requirements, drainage requirements, or stabilization requirements should be discussed here.

S&G Report Appendix: Documents and supporting information

- Geotechnical Sheets in tabloid size (See 920.00)
- Boring Logs
- Laboratory Testing Results
- Engineering Analyses
- Other relevant supporting information

2-920.00 ELEMENTS OF THE *GEOTECHNICAL SHEETS*

When the request for the *Soils and Geology Report* is made, it will typically include digital project plans in portable document format (pdf) and also Microstation CAD drawing files (.dgn). The project plans on .dgn files is required so that certain elements can be modified in order to develop the Geotechnical Sheets (G-Sheets). These G-sheets should be entitled GEOTECHNIAL, to match the Index of Sheets description.

In an effort to increase standardization and consistency of plans appearance, current G-Sheet cell templates shall be used. Be certain to create the G-Sheets using the current GES cell templates.

The G-Sheet number, project number text, and year of construction is to be placed in the upper right portion of the sheet cell. At time of Construction plans “turn-in” (see more in TDOT Design Guidelines, the G-Sheets must be processed to pdf, and affixed with an electronic seal of an engineer registered in Tennessee. Field Review plan sets do not require an engineer’s seal to be affixed, but only the final PDN Stage 4 PS&E Review plan sets.

Great emphasis is to be placed on the quality of G-Sheets. Consideration should be given to using as few sheets necessary. Geotechnical recommendations should be clearly recognized. Unnecessary blank "real estate" on any sheet should be avoided. An area beneath the sheet project information (upper right) should be left unused, for any unplanned plans revisions that could become necessary. Referencing other MicroStation files is discouraged. An attempt to keep the drawing files simple is encouraged.

Specific information required on the individual G-sheets is discussed and described below.

GES maintains a library of typical details for frequently performed applications.

GEOTECHNICAL – GEOTECHNICAL NOTES & EST. QTYS: Any geotechnical notes that are felt required to expound upon the 2-series sheets notes that are contained in the Construction Plans or the current *TDOT Standard Specifications for Road and Bridge Construction (Standard Specifications)* should be placed here. In the event of a contradiction in plans notes and the Standard Specifications, per *Standard Specifications* 105.04 the Plans govern. So, study and understand the *Standard Specifications*, and avoid using unclear, ambiguous notes. On less complex projects, there may be no need for this sheet. Often, a note can be added to one of the Soils sheets listed below.

This is the appropriate sheet to place geotechnical related roadway quantities. The quantities should be inserted in a block with standard TDOT item number, description, and unit. Footnotes should be used to further define what costs\work the TDOT item number is to include.

GEOTECHNICAL – BORING LAYOUT A plan view sheet, based on the proposed layout showing test boring locations and geotechnical recommendations. This may show limits of recommended geotechnical work, such as a plan view of undercutting limits, rock pad limits, "select fill" bridges over low lying ground, or sinkhole treatment locations. Acid producing material, if present, should be denoted. Soils data, especially Proctor Density, should be shown. The construction personnel utilize the geotechnical information during the construction phase for material quality control (i.e. proctor density tests for compaction control). This boring layout sheet should not be cluttered with curve information (PI's, PT's, etc.) but appear clean. Unless it is critical to the geotechnical information being conveyed, remove all geometric design information that could be changed in the plans development process. If test borings are limited, consider reducing the sheet scale and limit the number of Geotechnical sheets.

GEOTECHNICAL – BORING PROFILE These sheets provide a profile view of the vertical roadway grade contrasted with boring profile "sticks" along the subject station interval. Actual graphical area patterns of the different soil or rock material shall be standard, and the boring legend provided. Soil layers should be identified in accordance with *Roadway Design Guidelines* DEFINITION OF TERMS USED FOR EARTHWORK GRADING CALCULATIONS

GEOTECHNICAL – TYPICAL SECTIONS Boring profile "sticks" should be placed within the roadway cross sections provided in the Microstation design files to describe the geology encountered along the proposed roadway alignment. Sufficient information should be included to convey to the bidding contractors what material will be encountered. Sufficient information should be included to convey the slope design recommendations to the roadway designer. All Soils Typical Sections should have associated recommendations within the Soils and Geology Report. i.e. if a Soils Typical Section is provided that is a typical representation of the proposed slope geometry and geology from station segment between 30+00 to 34+50, there shall be a section in the Soils and Geology Report that specifically addresses this station segment. For bid preparation identify all soil horizons that will be excavated in accordance with Roadway Design Guidelines Section 4-203.02 DEFINITION OF TERMS USED FOR EARTHWORK GRADING CALCULATIONS.

GEOTECHNICAL – SPECIALTY SHEETS SUCH AS ACID PRODUCING MATERIAL, SINKHOLE TREATMENT, etc The latter sheets can convey to the bidder and the roadway designer any specific recommendations that cannot be adequately captured in earlier sheets.

2-930.00 DELIVERY PROCESS OF SOILS AND GEOLOGY REPORT

The final *Soils and Geology Reports* are to be delivered electronically to the TDOT supervisor \ contract administrator according to the following procedures. .A single deliverable, containing multiple files, should be compressed into a *.zip file. The file naming convention should follow the example below:

xxxxxx-yy-SoilsGeoRpt-GESzzzzzzz.zip

where: xxxxxx-yy is the PIN number

zzzzzzz is the GES number

example: 117511-00-SoilsGeoRpt-GES2504313

The *.zip compressed folder will contain:

- The *Soils and Geology Report Checklist* filled out in pencil and scanned to a pdf.
- The *Soils & Geology Report* (described above) will be combined into a pdf file with the following convention:

xxxxxx-xx-SoilsGeoRpt-GESzzzzzzz.pdf

- The entire set of *Geotechnical Sheets* combined into a single .pdf format in the following naming convention:

xxxxxx-xx-GeoShts-GESzzzzzzz.pdf

- The entire set of Geotechnical Sheets in separate .dgn files. During this stage of plans development, the naming convention of the sheets should follow something similar to the following:

xxxxxx-xx-GeoSht-01,dgn

where: 01 is the sheet number and increases sequentially.

- The estimated geotechnical quantities spreadsheet table using the following file naming convention:

xxxxxx-xx-EstGeoQtys.xls

2-940.00 DELIVERY OF GEOTECHNICAL SHEETS

Each scheduled project has a scheduled date when the Geotechnical Sheets are to be delivered for the Funtional Design Plans. Guidance for delivery of these sheets is found in the *Roadway Design Guidelines* and *IPD Manual*. The Geotechnical sheets are required, among other items, to be modified in the upper right corner of the sheet border to reflect the appropriate sheet number, year of construction, and project number. The Geotechnical sheets will be uploaded onto FileNet by TDOT.

CHAPTER 3 – STRUCTURAL FOUNDATION DELIVERIES

3-000.00 GENERAL

This chapter discusses guidance on GES delivery methods of foundation reports for bridges, retaining walls, and noise walls to TDOT Structures Division. Structures Division's policy document, *Structural Design Guidelines* (*SDG*) should be followed. Efforts to prepare foundation reports at TDOT begin in PDN Stage 2 and are complete for inclusion into the PDN Stage 3 Plan-in-Hand Field Review plans.

Also discussed in the chapter is delivery of foundation design services for the Traffic Operations related to high mast lighting, standard lighting, signing and signal structural foundations.

TDOT construction is funded by FHWA and therefore the guidance of *AASHTO LRFD Bridge Design Specifications* (*AASHTO Bridge Specs*) is to be followed strictly. Where *AASHTO Bridge Specs* specifies a calculation method, this shall be used.

Appropriate subsurface explorations may include techniques, but are not limited to, rock core drilling, roller cone wash borings, SPT samples, auguring and hollow-stem auguring. Rock Quality Designation (RQD) and recovery shall be recorded for all rock samples and photographs shall be taken of all rock cores. Some general guidelines employed at TDOT for sufficient drilling at bridge substructure locations are contained. GES finds it reasonable to supplement test borings with geophysical testing applications with proper site justifications. These recommendations need to be adjusted for each individual project based on engineering judgement, *AASHTO Bridge Specs* and industry accepted geotechnical practice.

The drilling locations and depths performed for the site will vary according to the structure being proposed, the soil variability, and underlying rock conditions, but should generally comply with Table 10.4.2-1 Minimum Number of Exploration Points and Depth of Exploration of *AASHTO Bridge Specs*. TDOT GES generally recommends advancing one to three borings per substructure, and one boring per fifty to one hundred feet of retaining wall length, but this number may be increased when there is significant site variability. Site access difficulties may prevent the location and number of test borings drilled at the site. The geotechnical engineer should consult the appropriate references such as *AASHTO Bridge Specs* or other NHI publications on specific wall types for further details of recommended drilling/sampling/testing requirements.

Laboratory tests required to support and validate the bridge or retaining wall foundation recommendations should be assigned at the direction of the geotechnical engineer, but may include rock unconfined compressive testing, triaxial testing, direct shear, Atterberg limits, gradation-hydrometer analysis, classification, and pH.

3-100.00 BRIDGE FOUNDATION REPORTS

The Structures Division initiates the process of requesting a *Bridge Foundation Report* be produced by contacting the GES. This request is done during PDN Stage 2 (Functional Design Plans) via an email to TDOT.Geotech@tn.gov, and the 'Foundation Data Sheet' is attached. *SDG* - Chapter 18 Form Letters – 'Section 3 Foundation Drilling Requests' documents consistent guidance for this. The 'Foundation Data Sheet' is microstation drawing file containing the bridge layout with any other pertinent foundation information such as estimated scour depths. The request is typically copied to the appropriate Regional Survey Office as notification to perform a proposed bridge stakeout with existing elevations along key points along the abutment and pier(s) \ bent(s). Unless other agreements have been made, the survey stakeout will be provided by TDOT. The *Bridge Foundation Report* will then be assigned an individual GES number which initiates the project and work proceeds.

As a matter of emphasis, geotechnical recommendations for slope development and embankment grading are to be contained in a separate document, the *Soils & Geology Report*. This separate *Soils & Geology Report* document preparation shall be delivered in PDN Stage 2 so the project footprint can be established, and Functional Design Plans prepared. The preparation of the *Soils & Geology Report* is discussed fully in Chapter 2. To be clear, the *Soils & Geology Report* is a separate document and is to be delivered for the Functional Plans Field Review duing PDN Stage 2.

The geoprofessional shall deliver alternate geotechnical design parameters for different foundation types to be considered in the Bridge Foundation Report. *SDG* Chapter 10 Bridge Foundation Design provides reference. The foundation type selected for the Contract Plans is the responsibility of the Structures Division.

Foundations supporting bridges are typically spread footings or deep foundations cast together in a concrete group in some manner. Typically, the abutment is founded upon structural embankment fill and therefore a deep foundation, using driven or pre-drilled piles are typically used. Bridge columns supporting a grade\flood plain crossing are typically

referred to as bents, and bridge columns located within a water body are typically referred to as piers.

TDOT GES, in conformance with AASHTO guidelines generally recommends advancing one to three borings per substructure.

Practically, foundation application alternates have been selected based on the criteria below:

- Shallow foundations upon rock - Considered if rock is encountered within approximately 10 feet below existing ground elevation.
- Driven piles – Considered if rock is encountered greater than 10 feet below proposed foundation elevation. Pre-drilled holes are necessary, as discussed in *TDOT Specifications* Part 6, if pile refusal is encountered between 8-12 feet to meet “fixity” requirements.
- Drilled shafts socketed into rock – Considered if excessive lateral design loads must be resisted or perhaps to reduce required excavation footprint.

Separate sections 3-400 and 3-500 discuss shallow and deep foundations in more detail.

***Bridge Foundation Report* Preparation:** The document is to be formally referred to on the report title, correspondence, and conversation as the *Bridge Foundation Report*. The *Bridge Foundation Report* and Appendix shall include a detailed narrative of the investigation, engineering analysis, recommendations, boring logs, and Foundation Data sheet. Items in the *Bridge Foundation Report* should be contained in the following general 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 design considerations should be noted here.

Geology, Soils and Site Conditions – General narrative of geology, physiographic region, topography, rock \ soils, and site conditions that may affect the structure.

Surface and Subsurface Exploration – General site characterization and narrative of the equipment and tools used during the subsurface exploration.

Recommendations – The recommendations should include all necessary foundation types and parameters deemed necessary for structural design of the foundation types recommended. Innovative foundation types will require rationale as to appropriateness over conventional foundations, as well as all necessary design parameters and possibly specifications for the structural engineer. This section should include as applicable, but not be limited to:

- Type(s) of foundations recommended
- Elevation of foundation bearing strata
- Elevation of initial encounter of rock (or refusal elevation)
- Nominal Bearing Resistance of rock \ soil
- Side friction and base resistance factors (deep foundation)
- Depth of rock socket (deep foundation)
- Lateral capacity of soil or rock (deep foundation)
- Foundation offset from grade separation (rock cut face, rock abutment slope, soil abutment slope, bench, etc.)

Bridge Foundation Report Appendix – Documents and supporting data

- Foundation Data Sheet (see section below)
- Boring Logs - these must include location data on the typed logs.
- Laboratory Testing
- Engineering Analyses (i.e. liquefaction, Lpile, etc.)
- Any other applicable documents

'Foundation Data Sheet' Drawing Format Requirements: The 'Foundation Data Sheet(s)' is the preliminary bridge layout electronic drawing prepared by the Structures Division. The sheet is a CAD drawing file in Microstation format (dgn). During the '*Bridge Foundation Report*' preparation, the 'Foundation Data Sheet' is modified and then delivered *unsealed* in electronic format back to the Structures Division, for further editing (delivery is discussed in 3-700.00). The 'Foundation Data Sheet' will be inserted into the Plans-in-Hand Field Review \ PS&E Plans by the Structures Division. GES maintains a current standard CAD format that must be used (line weight, line style, boring shape, material graphic patterns, etc.). The format is under frequent improvement, so contact GES for current GES CAD standards. The following should be used as a checklist to assure completeness prior to turning in the Foundation Data sheet.

General Boring Layout – Test borings should be drawn onto the bridge layout plan.

Boring Profile – "Boring sticks" depicting some of the information found on drilling logs, such as elevation stratums of different material types. This looks "cleaner" if all the element modifications can be performed on one single design sheet. It is cumbersome in the field to flip sheets. Material types are to be shown as different defined graphical patterns (i.e. sand:dots, clay:forty-five degree lines, etc), with an associated legend on a similar scale. If a driven friction pile is the likely foundation (i.e. Coastal Plain \ West Tennessee) include frictional side resistance (f_s) and end bearing (q_b) values should be shown, along with liquefiable layers labeled with an asterisk. Indicate the boring number on top of each "boring stick". The borings should be shown on an appropriately scaled grid, indicating auger refusal (AR) or boring terminated (BT) as applicable.

Elevation Chart – Table depicting the station, offset, existing ground elevation, refusal\rock elevation of each test boring.

3-200.00 RETAINING WALL REPORTS

Typical wall design workflow, since approximately 1999, follows that TDOT provides a list of 'Acceptable Retaining Walls' and their associated contractual design requirements in the Construction Plans, and the general contractor is responsible for wall selection, wall design, and wall installation. This retaining wall delivery process that TDOT employs, allows Contractors to prepare sealed engineered drawings for proprietary wall systems that have gone through a TDOT's pre-approval process and are listed on the qualified products list. Administering wall installations presents more challenges than simply building a roadway slope.

Under typical preconstruction workflow, the roadway designers of the Regional Preconstruction Division recognize the need for a grade separation while the roadway design is being initiated (1RD1) during PDN Stage 1 Context\Scoping or PDN Stage 2 Establishing Footprint. Upon this recognition, and under guidance from *TDOT Design Guidelines* Chapter 2 Section 12 Retaining Wall Design the roadway designer develops the Retaining Wall Geometric Layout Sheet. Other guidance the roadway designer uses to generate the conceptual layout that the geotechnical engineer may find useful is found in *Design Guidelines* Chapter 12, and the TDOT Standard Drawings W-CIP-1, W-MSE-1, W-MSE-2, W-SG-1, and

W-SP-1. The Retaining Wall Geometric Layout sheet is then distributed electronically to the Structures Division with a request to evaluate if a retaining wall is feasible.

Typically, a retaining wall or some form of slope\grade steepening is recognized. Then a request letter termed PROPOSED RETAINING WALL DESIGN (*Design Guidelines* Figure 2-31) is initiated. Once the type(s) of retaining walls that are deemed acceptable has been determined TDOT GES is responsible for developing a *Retaining Wall Foundation Report.*

Following the retaining wall stake-out the retaining wall subsurface exploration and *Retaining Wall Foundation Report* development can occur. All draft *Retaining Wall Foundation Reports* funded by TDOT must be finalized \ concurred with GES and the Structures Division prior to Construction Plans turn-in.

Typically, the final *Retaining Wall Foundation Report* is delivered to the Structures Division by GES with geotechnical design data and a list of 'Acceptable Wall Types' that are felt practical and constructible for the specific site. The Structures Division will review the deliverable and include additional structural requirements, including but not limited to seismic loading and exterior fascia, and ultimately determine which of the 'Acceptable Wall Types' will be entered into the contract. The Structures Division will then insert the Complete Structural Design (3ST1) package into the Plans-in-Hand \ PS&E Field Review plan sets.

Special Provision 624 Retaining Walls (SP 624) is the policy document that specifies contract administration. Following the award of the construction contract, the contractor prepares and submits for approval retaining wall shop drawings to the Structures Division in compliance with Special Provision 624 - Retaining Walls (SP624). The retaining wall shop drawings must be in strict conformance to the Construction Plans requirements, particularly the RETAINING WALL DETAILS sheets ('R-Sheets'). The R-sheets are discussed in a subsequent section with more detail, but generally stipulate geotechnical design parameters, site notes, and further guidance. It is the intent that all bidding Contractors use the same design parameters, in the same manner, during bid estimation. The Contractor submits retaining wall shop drawings to TDOT Structures Division for review, comment and approval. TDOT GES is copied on this submittal of shop drawings for review of the geotechnical aspects only. The Retaining Wall Review checklist, provided as Appendix 1 of this document, is a standard and consistent document used to review the design elements of the shop drawings. Once the review process is finalized, the Structures Division is responsible for returning the retaining wall shop drawings to the Contractor so installation can begin.

***Retaining Wall Foundation Report* Preparation:** This section will make no attempt to discuss every check that should be considered in retaining wall evaluation, but instead hopes to serve as a general guidance in the process of report preparation. Some of the more common problematic administrative issues that have occurred in the past are discussed. The Contractor will design and install the structure, but TDOT will dictate what type of structure will be constructed by limiting the 'Acceptable Wall Types', and what design parameters, load factors, and resistance factors must be used. The concept of internal and external stability will be discussed, as well as foundation improvement. Finally, standard reporting consistency will also be addressed. TDOT GES finds Appendix 1 Retaining Wall Shop Drawing Checklist a useful resource.

As discussed in the *Design Guidelines* 2-1200.02, the roadway designer prepares the conceptual design geometric layout and denotes a sheet series of R. Title sheets even reserve a slot on the Index of Sheets for retaining walls.

For standardization and consistency GES maintains current MicroStation (dgn) design templates for use in developing the R-sheets. Please contact TDOT GES to receive current CAD files to initially develop the R-sheets, as the sheets are under constant improvement. The 'R-sheet template' file and 'Typical Details' design files contain general notes, special notes, and details useful in R-sheet preparation.

Subsurface explorations are to be conducted in accordance with current industry standards, and the boring layout program should follow *AASHTO Bridge Specs* (Table 10.4.2-1 Minimum Number of Exploration Points and Depth of Exploration). GES generally considers advancing one test boring per fifty to one hundred feet of retaining wall length reasonable, but this general rule of thumb should be adjusted as the engineer deems fit to meet the proposed structure and geologic site variability. Typical TDOT subsurface exploration plans advance borings a depth equal to approximately one and one half times the proposed wall height. If initial drilling indicates soft soil conditions, test borings should extend a depth equal to two times the corresponding proposed wall height, or to rock, or until a firm clay or dense sand is encountered.

Laboratory testing necessary to determine and verify the geotechnical design values shall be assigned. Typical tests GES assigns include classification tests, strength tests and consolidation tests. Generally, more sophisticated testing could be necessary for complex and\or critical wall heights (over 20 ft.). The engineering geologist or geotechnical engineer

is responsible for selecting the appropriate strength parameters for the appropriate loading conditions that are necessary to properly evaluate the proposed retaining wall structure.

All retaining wall design principles are to be in accordance with current industry and the AASHTO BRIDGE SPECS requirements in effect at the time of the evaluation.

Acceptable Wall Type – Preparing plans in this current process TDOT employs is unique. Communication is required between the Divisions of Preconstruction, Structures, GES, and Operations. The roadway designer initially recognizes that there are two grades that can not be separated in a stable manner using a typical roadway slope, and a retaining wall is needed. Then this must be communicated to the other Divisions.

There are many different slope steepening stabilization applications and retaining wall applications available, but recognize the finite time window that the Contractor has to prepare an estimate. Therefore, the number of 'Acceptable Wall Types' should be limited within reason. It has been recognized that the cast-in-place (CIP) concrete gravity walls, CIP concrete cantilever walls, or a mechanically stabilized earth (MSE) walls are consistently the most economical and require the least contract administration resources. In contrast, the top-down constructed walls are the most complex and most expensive.

Internal and External Stability Responsibilities: One of the cornerstones of the current retaining wall delivery process, is the concept whereby TDOT contractually manages external stability risk. External stability risk is managed through quantifying necessary foundation improvement required to satisfy global slope stability and settlement\bearing on the 'R-Geotechnical Design Notes and Requirements' plans sheet. The engineering geologist \ geotechnical engineer actually determines the foundation improvement necessary to meet required external stability requirements and describes this work in terms of bid item descriptions and notes that the Contractor uses to estimate a bid. The Contractor will then design and install a retaining wall that meets internal stability requirements.

The *Retaining Wall Foundation Report* preparer is responsible for determining external stability requirements regarding **nominal bearing resistance**. For example, following preliminary calculations it is determined that the proposed wall would apply excessive vertical bearing pressures to the unimproved ground. Therefore, the foundation improvement required for stability is determined and recommended in detail in the 'R-Geotechnical Design Notes and Requirements' engineering sheet by the *Report* preparer. All foundation improvement must be clearly defined and quantified in the plan sheets. The foundation

improvement detailed in the plan sheets must be sufficient so the proposed wall has an adequate CDR for nominal bearing resistance.

The *Retaining Wall Foundation Report* preparer is responsible for external stability requirements regarding **sliding**. For example, following preliminary calculations if it is determined that the base of the wall would be excessively wide for the given constraints of the site, proposed ground improvement shall be recommended to improve the sliding coefficient. The report preparer must evaluate the sliding coefficient and determine the effect of the size of the wall on the lateral requirements of the project.

The *Retaining Wall Foundation Report* preparer is responsible for external stability requirements regarding **global stability**. For example, following preliminary calculations it is determined that the proposed slope will not meet global stability requirements after the wall is constructed. The *Report* preparer is responsible for specifying the construction effort necessary to prepare a retaining wall building pad or platform that will satisfy global stability requirements. This includes but is not limited to the depth of undercutting required, the material required to backfill the undercut excavation, pile spacing\minimum pile tip elevation, deep foundation design parameters, compacted aggregate piers, soil nails, tie-back anchors, etc. The *Report* preparer shall convey in the 'R-Geotechnical Design Notes and Requirements' engineering sheet the construction effort in terms of item numbers, footnotes, and notes in the sheet.

In summary, evaluate the external and global stability based on the bearing capacity and sliding coefficients of the existing conditions or the improved foundation. For conventional C.I.P. concrete or M.S.E. walls, the base length is to be evaluated based on the sliding coefficients recommended, and if the base length is not constructible for reasons discussed above, then another acceptable wall type must be considered.

Retaining Wall Constructability Considerations - Preparing a *Retaining Wall Foundation Report,* and 'R-Sheets' for TDOT requires careful consideration, and considerably more effort than simply recommending basic design parameters to a retaining wall designer. Considerations must be given to any necessary temporary excavation slopes, utilities, or the traffic control plan. The following factors must be considered in the development of the *Retaining Wall Foundation Report*.

Consideration must be given to the wall types that could be built within the R.O.W. available to the State. Additionally, determination of wall types should consider impact to

natural/environmental features, and whether encroachment is permissible. After all, if R.O.W. were available, or we could fill in an environmental feature, a roadway slope could be constructed, without the need for a retaining wall. When reviewing the Roadway Cross Sections and Present\Proposed Layouts consideration to construction methods should be given. Many wall types are not possible, because there is insufficient area between the R.O.W. line and the proposed wall to cut a temporary excavation behind the wall. Expensive temporary shoring, temporary walls, or even a temporary top-down constructed wall could be required. Evaluation of required easements to build a particular wall type should be given.

During the Field Reviews, discussion should be held, and decisions made to determine which of the traffic control phases the wall can be constructed.

Be cognizant of the location of utilities during the development of the *Retaining Wall Foundation Report*. At the Field Reviews, the retaining wall construction sequence should be described to the stake holders (utility owners) and determine how the public can continue to obtain utility service. During the Functional Design Plans Field Review, verify there will be no conflicts with existing utilities, verify the relocation of utilities schedule, or even resolve issues with relocated utilities that are within the footprint of the proposed wall.

Retaining Wall Foundation Report Requirements: The document is to be formally referred to as the *Retaining Wall Foundation Report.* Below a brief descriptive narrative of the general requirements is made.

Executive Summary or Cover Letter – This section gives a brief summary of the report. It also states if potentially acid producing materials were found or not found on a project.

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

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

Surface and Subsurface Exploration – Description of the site characterization should be made here.

Recommendations – Expound on 'Acceptable Wall Types'. Generally replicate the engineering sheet 'R-Geotechnical Design Notes & Requirements', and do not contradict the sheet. Provide discussion of necessary foundation improvements. Provide recommendations for construction purposes such as allowable temporary cut slopes, special drainage, undercutting or other pertinent recommendations. GES feels reasonable the geotechnical considerations below.

Appropriate Internal Angle of Friction, φ (degrees): Highly plastic clay material shall never be used as backfill. Retaining wall select backfill is graded stone and is not permitted to have a friction angle greater than 34 degrees without independent sampling and testing being performed (see R-sheets template and SP 624 Section F, Part 1).

Unit Weight of In-situ\Retained Soil and Select Backfill (pcf): TDOT GES recognizes on R-sheets template 'Unclassified Site or Borrow Soil' and 'Select Backfill Material'.

Coefficient of Sliding (unitless): AASHTO BRIDGE SPECS Table C3.11.5.3-1 Friction Angle for Dissimilar Materials (8th ed.) contains appropriate guidance on consideration of sliding resistance.

Nominal Bearing Resistance (psf): Based on appropriate bearing capacity analysis in accordance with AASHTO BRIDGE SPECES.

Maximum temporary construction slopes: Review applicable occupational safety regulations. GES typically recommends no steeper than 1:1 unless there is a justifiable reason to be more conservative. Recommendations for shoring can be made as necessary.

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: Foundation improvements needed to adequately meet CDR requirements should be described in the R-sheets in detail.

Settlement: Any detrimental effects to the proposed structure due to settlement should be evaluated according to the AASHTO BRIDGE SPECS.

Global Stability: Check the global slope stability of existing and proposed site conditions. Refer to AASHTO BRIDGE SPECS for further discussion of criteria.

Seismic Considerations: AASHTO BRIDGE SPECS 3.10.3.1 (8th ed.) Seismic site class definition should be provided. Based on the site class definition, TDOT Structures Division will determine the seismic acceleration coefficients per AASHTO BRIDGE SPECS as appropriate. Check liquefaction of soil and seismic stability as required.

Unusual Site Issues: Determine if any exceptional site problems exist that would require analysis. Where retaining walls are founded on soils in a slide complex area, the foundation alternatives shall be clearly evaluated and stated on the report and drawings. Discussion of risks of founding the retaining wall in a slide complex deposit shall be discussed and the potential influence of that slide deposit on the retaining wall and surrounding structures / roadway features shall be analyzed and discussed. Pile lateral squeeze is a concern GES has found reasonable to consider.

Retaining Wall Foundation Report Appendix – R-Sheets, Boring Logs, Test Reports, etc.

3-300.00 NOISE WALL REPORTS

In a similar manner to bridges and retaining walls requests for services, the Structures Division sends a letter along with a set of plans to GES requesting geotechnical services be performed a noise wall. The Geotechnical Section conducts the geotechnical investigation and provides the Structures Division a report which provides subsurface data and foundation recommendations.

While there are various noise wall dimensions, construction methods and material properties, typically noise walls are 12 feet high and constructed of precast concrete panels set in place between precast concrete posts on 20 foot spacings. The typical diameter is 24 inches in diameter, and are essentially drilled shafts which are discussed more fully in 3-500.00. The depth of the foundation hole depends largely on soil or rock conditions. Other common foundation support methods include: 1) constructing the small diameter drilled shafts and then the posts are bolted onto the top of the shaft foundation and 2) constructing a shallow spread foundation with the precast posts then bolted to the shallow spread foundation.

Typically, one test boring is advanced for each proposed noise wall post. Having a test boring advanced for each wall post eliminates many construction administration risks, but the ability to achieve this ideal drilling pattern is influenced by site access conditions at the time of the subsurface exploration program, and not at the time of notice to proceed construction.

The typical subsurface exploration plan consists of drilling test borings and sampling SPT on 5 vertical feet intervals until rock is encountered or until such depth that sufficient foundation design information has been achieved. It may be reasonable to conduct undisturbed “Shelby Tube” sampling to further characterize the site. A maximum depth of 30 feet in soil is typically adequate. Once rock is encountered the rock should be cored until it has been determined that the rock is suitable for foundation support. A depth of rock core of

10 feet is generally sufficient unless significant voids or soil seams are encountered. Consider site grading plan requirements and existing ground elevations when determining the bottom elevation of the proposed noise wall and test boring elevations.

All samples including SPT, Shelby tubes and rock cores should be retained and taken to the laboratory for further inspection by the engineer/geologist. Representative SPT samples collected during drilling should be tested for the suite of classification testing and natural moisture content. Undisturbed samples collected should be tested for classification and unconfined compression, although triaxial testing and consolidation are thought beyond a typical reasonable scope to determine noise wall design values. Rock sample mineralogy composition inspection and perhaps unconfined compression testing is not thought unreasonable for a noise wall scope.

The elements of noise wall design, including the foundation type, post spacing, and panel design will be performed by the structural engineering designer. The geotechnical design values required include determination of nominal axial bearing components; end bearing and side friction bearing for the soil and rock layers.

In addition to the axial bearing geotechnical design values, lateral capacity design values are required. Depending on the structural engineering design method, the lateral design values may include nominal shear strength, modulus values such as E_{50} of the soil or rock, or recommended p-y analysis values. It is reasonable for the geotechnical engineer \ geologist to communicate with the structural engineering designer and discuss the design methodology that will be used so that appropriate information can be presented in the report and drawings.

Noise Wall Foundation Report Format Requirements: The document is to be formally referred to on the report title and in all correspondence as the *Noise Wall Foundation Report*. The *Noise Wall Foundation Report* and Appendix shall include a detailed narrative of the investigation, engineering analysis, recommendations, boring logs, and the engineering plans drawings. Items in the *Noise Wall Foundation Report* should be contained in the following general format:

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

Introduction – Brief summary of purpose of the noise wall, general size, location and known foundation design (i.e. whether it is known that the posts will be on 20 centers and on drilled shafts or footings). Any special constraints such as limited right of way are noted here.

Geology, Soils and Site Conditions – General narrative of geology, physiographic region, topography, rock \ soils, and site conditions that may affect the structure.

Surface and Subsurface Exploration – A summary of the exploration methods such as type drilling and/or coring conducted should be discussed. A description of pertinent subsurface conditions encountered during drilling should be discussed including soil and rock descriptions and discussion of any groundwater encountered. Useful soil and/or rock properties determined from drill testing and laboratory testing should be summarized.

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Recommendations – Based on an understanding of the preferred foundation type, the geotechnical design parameters for the soil and rock layers should be provided here. Expected foundation installation conditions should be discussed such as whether drilling through soil and/or rock layers will be required and whether groundwater is expected. Typical recommendations would include:

- Type of foundations (typically 2 ft. drilled shaft)
- Description of the foundation bearing strata
- Elevation where rock was encountered (or refusal elevation)
- Ultimate shear strength of all materials
- Angle of internal friction of all materials
- Effective unit weight of all materials
- Modulus design values of all materials
- Side friction and base resistance values for axial capacity check
- Recommended rock socket depth

Noise Wall Foundation Report Appendix – Documents supporting the report

- Foundation Detail Sheets – half size pdf replication of engineered drawings as turned in. To be arranged in these three sheets:
  - Boring Layout and Geotechnical Notes Sheet – plan location of borings in relation to site, and any notes that are applicable
  - Boring Profile Sheet – Boring profiles showing numbering scheme, graphic pattern of stratigraphy, soil description, legend, SPT results, water table, and other pertinent information. This sheet should show a

cross section showing the noise wall in relation to ROW line, and perhaps utilities.

- Foundation Details Sheet – This sheet will be typically prepared and inserted by the structural foundation designer.

- Boring Logs – neatly typed boring records
- Laboratory Testing Results
- Engineering Analyses (i.e. liquefaction, Lpile, etc.)
- Any other documents felt applicable

3-400.00 SHALLOW FOUNDATIONS

Structures Division policy does not generally accept bridge spread footings founded on soil. The settlement risk and scour risk of footings founded on soil are felt excessive for consideration. So, for the purposes of this discussion, shallow foundations are assumed to bear upon bedrock.

For bridges where spread footings are the most likely foundation type, bearing capacity analysis is the primary calculation that must be performed. If an abutment is located above/on top of a rock cut TDOT generally accepted policy is to set back the front edge of the abutment substructure from a rock cut face a minimum of 10 feet. This is done to accommodate weathering of the rock cut face over time, reduce the influence of the foundation on the rock cut face and to account for the potential of over-break or mistakes during construction.

Shallow foundations bearing upon rock should be considered as potential foundation application type if rock is encountered within 10 feet below proposed bottom of substructure foundation elevation. Minimum drilling requirements require rock coring of 10 feet of competent bedrock below the footing elevation. Let competent bedrock for this purpose be defined as rock drilled within a 10-foot core run without encountering more than 3 instances of rock discontinuities-voids or very weathered seams-greater than two inches or a single discontinuity greater than 6 inches. If competent bedrock is not encountered for significant depths, the engineer or geologist must determine at what depth the test boring can be terminated.

Some bridge approaches and abutments are located in roadway cuts either at bridge level or below bridge level for an underpass situation. These cuts may involve soil material or

rock. If an abutment is located above/on top of a rock cut TDOT generally accepted policy is to set back the front edge of the abutment substructure from a rock cut face a minimum of 10 feet. This is done to accommodate weathering of the rock cut face over time, reduce the influence of the foundation on the rock cut face and to account for the potential of over-break or mistakes during construction. Whether part of the bridge and approach investigation or the bridge foundation investigation, every rock cut shall be drilled and/or investigated sufficiently to determine if this "default" offset of 10 ft. is adequate at the bridge location. Rock structure and potential structural failure modes shall be investigated, and the rock shall be assessed for soundness. Where rock shows a high potential of weathering (shales, claystones, argillaceous limestones etc.) the weathering rate shall be assessed, and a further offset may be required. Any potential structural failure of the rock, such as plane shear failures, wedge failures or toppling failures shall be clearly discussed and analyzed. The likelihood of raveling failures at the top of the rock cut due to blasting error or discontinuous slabs of rock shall also be assessed. If a further offset is required due to site conditions, this shall be clearly discussed in the report and accounted for in the geotechnical drawings and subsequently the project construction plans.

If barge mobilization is necessary, advance one boring at the corner of each proposed seal footing.

3-500.00 DEEP FOUNDATIONS

The deep foundations TDOT Structures Division designs are typically driven pre-cast concrete \ steel pipe piles, steel H piles driven to refusal or pre-drilled to proposed pile tip elevation, drilled shafts, or micro-piles.

Driven Pre-Cast Concrete\Steel Pipe Piles*:* Bridges in the Coastal Plain Physiographic region of West Tennessee, west of the Tennessee River in TDOT Region 4, typically are designed for driven concrete "friction" piles or sometimes steel pipe (or even H piles). Bedrock depth is far greater than 100 feet in depth in the Coastal Plain Physiographic region, and driven concrete piles are a very straight forward foundation alternative. The design and inspection is very straightforward. Prime contractors typically have cranes and pile driving hammers available, so subcontractors are not necessary. Local pre-stressed concrete producers can economically deliver piles to the site. If a pile can be driven free of refusal for 50-75' in depth, friction piles should be considered as the recommended foundation application.

For structures having relatively small span lengths, a typical subsurface investigation for a driven pile foundation involves drilling only two test borings a depth of 80 feet below pile cap \ existing ground elevation. Longer bridge structures could require drilling at least one test boring of 80 feet per abutment and pier\bent depending on site access limitations. The borings must be advanced and sampled at least 10 feet below any layers that are predicted to liquefy, based on field classification and standard penetration test (SPT). TDOT GES typically drills and samples between 75-90 feet in depth. Engineering judgement and SPT sampling should be performed to arrive at design parameters for the purposes of:

- Pile capacity
- Liquefaction Analysis
- Scour calculations
- Corrosion potential tests

Samples shall be taken at least every 5 feet for a driven pile foundation investigation. Where CPT testing is performed, an adjacent SPT test boring shall be conducted for verification of soil type. All layers of soil shall be logged, and appropriate parameters recorded during exploration.

All dissimilar SPT samples shall have gradation, hydrometer, Atterberg limits, pH and Resistivity tests performed. Each sample shall be classified to AASHTO and USCS systems. Other testing may be performed as needed to provide enough information for the prediction of liquefaction and corrosion.

Engineering analysis for a driven pile foundation project should include a static pile capacity analysis. The capacity of a driven pile is composed of F_s (side friction) and Q_b (end bearing). There are many empirical methods to determine these values, GES and Structures Division uses the values presented in Table 3-1 Static Pile Capacity. The chart uses maximum values of F_s and Q_b achieved with N=30. For blow counts above this value, GES does not extrapolate further values, but uses the values for N=30. These values were developed through research of the correlation between SPT values and field load tests. The values were developed for CME drill rigs using automatic hammers calibrated to 60% energy (N_{60}), so note other equipment may yield different results. These charts yield ultimate\nominal bearing values. The F_s and Q_b values should be reported alongside test boring profiles on the 'Foundation Data Sheet'.

Drilling and sampling should be accomplished such that a computational value of at least 100 T (ultimate\nominal) is achieved when considering one 14-inch square concrete pile. For steel or pipe piles, GES reduces the F_s values given by one third to account for roughness \ smoothness.

Ultimate pile load capacity should consider the estimated scour depth provided on the Foundation Data Sheet. GES simply neglects frictional contributions above the scour depth elevation shown.

West Tennessee is influenced by the New Madrid Seismic Zone, particularly near Reelfoot Lake, and pile length \ ultimate bearing capacity analyses should consider liquefaction analyses. Liquefaction analysis must be performed on all coarse-grained materials and TDOT Geotechnical typically performs these for every appropriate SPT sample taken. AASHTO requires that this analysis be performed within a seismic risk area for all multi-span. TDOT utilizes a Mathcad program incorporating the elements of Seed and Idris liquefaction charts to determine liquefaction potential for each layer. All layers that have the potential for liquefaction must be clearly noted on the foundation data sheet supplied with the foundation report. Critical and interstate bridges may require more complex analyses, please see current AASHTO guidelines for guidance. These analyses may justify the up-front costs of a site specific seismic analysis, CPT testing, soil-structure interaction considerations among others. If liquefaction analyses indicate significant liquefaction potential the engineer must determine and provide recommendations for mitigation. This may include recommendations for limiting or extending pile depths to avoid liquefaction layers, discounting bearing of piles in liquefaction layer, or ground improvement at the site. More liquefaction analysis and mitigation guidance is provided in the Publication FHWA-NHI-11-032, LRFD Seismic Analysis and Design of Transportation Geotechnical Features and Structural Foundation Reference Manual.

Typically, the Structures Division uses guidance from the Bridge Foundation Report and computes an estimated test pile length, and that test pile is driven in accordance with the ENR equation (*TDOT Standard Specifications for Road and Bridge Construction* Section 606) and subjected to a static load test. Load test results are evaluated by the Structures Division, and production pile lengths are verified \ evaluated prior to production pile driving.

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

End Area of a 14" square Pile = 1.36 ft2
Surface Area of a one foot length of Pile = 4.67 ft2
A bearing of 100 Tons is required when piles end in sand (70' min. depth for liquef.)
A bearing of 125 tons is required when piles end in clay
Friction = 4.67*Depth*Fs (T)
End Bearing = 1.36*Qb (T)

Metric Units

End Area of a .356 m square Pile = .1265 m2
Surface Area of a 1 m length of Pile= 1.422 m2
A bearing of 890kN is required when piles end in sand (21.5 m min. depth for liquef.)
A bearing of 1100 kN is required when piles end in clay
Friciton = 1.422*Depth*Fs (kN)
End Bearing = .1265*Qb (kN)

Table 3-1 Static Pile Capacity Chart

H-Piles Driven to Refusal: When rock can be reached economically, support from an end bearing steel H-pile is a common deep foundation alternative. Driven piles in rock should be considered as a potential foundation type where rock is generally encountered greater than 10 feet below proposed bottom of substructure. Where end bearing H-piles are the most likely foundation type, analysis of pile tip elevation and pile installation issues are the predominant concerns.

When rock is encountered around 10 feet below the proposed footing elevation, and the structural engineer does not desire a spread footing but is concerned with the “fixity” length of a driven H-pile, there is guidance in the TDOT Spec Book for drilling a hole to a minimum pile depth and inserting the “H” pile into that hole, and then backfilling the anulus of the drilled hole with graded stone.

To enable an adequate penetration into sound rock, often a protective tip is affixed to the end of the pile. This is particularly applicable in some of the dipping rock formations of East Tennessee.

Depending upon the geologic formation of the site, the “approximate rock line” is highly variable in the dipping, fractured, and jointed rock in Tennessee. And appropriate subsurface explorations could include flight augering to refusal, but it is important to core drill as many borings as felt required to verify bedrock elevation and make certain that auger refusal elevation was not an anomaly such as a “floating” boulder or karst pinnacle. The structural engineer uses the subsurface site characterization as a basis to estimate total pile length. Core at least 10 feet of competent bedrock. Let competent bedrock for this purpose be defined as rock drilled within a 10-foot core run without encountering more than 3 instances of rock discontinuities\voids, or weathered seams\fractures greater than two inches, or a single discontinuity greater than 6 inches. If competent bedrock is not encountered for significant depths, the engineer or geologist must use professional judgement to determine the depth of test boring termination. Core recovery percentage and RQD should be computed and documented.

Drilled Shafts: As driven piles, drilled shaft axial design capacity is based on a frictional component and an end bearing component. Design of drilled shafts is typically conservatively restricted to relying on one or the other component, and TDOT typically designs for end bearing. GES recommends both frictional bearing resistance and end bearing resistance be recommended in the Foundation Report.

Large river crossings have used drilled shaft foundations previously. This is attributed to excessive barge impact loads that must be resisted laterally. Therefore, soil modulus values and often a p-y analysis shall be provided when deep foundations are considered.

Special Provision 625 'Drilled Shafts' is the contractual specification document used to administer drilled shafts. The practitioner should review and understand the current SP 625. Among the many requirements the document states:

- Minimum qualification of the contractor
- "Work plan" must be submitted to the Engineer by the Contractor.
- The document stipulates there must be a preconstruction conference to discuss the inspection requirements. Construction requirements also include that self-consolidating concrete must be used on drilled shafts.
- Though an initial drilled shaft tip elevation based on the Foundation Report is provided in the construction plans for bidding purposes, additional test borings of verification (NQ or NX size) are typically advanced to establish the final drilled shaft tip elevation. These test borings are to be drilled into the precise field location the drilled shafts are proposed.
- Following verification drilling completion, these borings are to be evaluated by GES and Structures Division, until each shaft required has a final verified shaft tip elevation.
- The process of drilled shaft verification drilling and rock core storage\retention is discussed fully in Appendix 7 Core Retention Policy.

Drilled shaft subsurface explorations require a minimum of one test boring per abutment shaft or bent/pier shaft. Great effort is to be made to achieve drilling access on the proposed drilled shaft location. In exploring the subsurface for use of drilled shafts, the rock should be cored at least 20-30 feet into competent bedrock for consideration of the initial shaft tip elevation. Let competent bedrock for this purpose be defined as rock drilled within a 10 foot core run without encountering more than 3 instances of rock discontinuities\voids, or weathered seams\fractures greater than two inches, or a single discontinuity greater than 6 inches. If competent bedrock is not encountered for significant depths, the engineer or geologist must use professional judgement to determine the depth of test boring termination. Core recovery percentage and RQD should be computed and documented.

Micropiles: Micropile foundations have applications in low-head room environments. TDOT has used micropiles in this application for Structures Division bridge rehabilitation projects. Another application that TDOT has used micropiles is to add additional capacity

adjacent to an existing foundation. Micropile foundations have been used on certain TDOT 'innovative contracting projects' such as Design-Build and CMGC. The Special Provision 625MP Micropiles is the contractual document that offers guidance on micropiles. The same drilling guidance used for drilled shafts should be used in drilling for micropiles.

3-600.00 STANDARD LIGHTING AND HIGH-MAST LIGHTING REPORTS

Signs, Lighting, and Signal Foundations: Foundation design for standard signs, lighting, and signal foundations are to be performed by the contractor. Shop drawings are to be sealed by an engineer registered in Tennessee and must be delivered to the Structures Division for concurrence prior to installation. If the engineer of record feels a subsurface investigation or geotechnical report is warranted to deliver these shop drawings, that work shall be the responsibility of the Contractor.

GES is typically given the opportunity to review and comment on geotechnical issues at the Field Reviews.

- If light standards are included in the Construction Plans, it is suggested that the designer place a clarifying footnote alongside the bid item 714-08.20 FOUNDATION (ONLY) FOR LIGHT STANDARDS stating, "INCLUDES THE COST OF THE FOUNDATION DESIGN AND ANY SOIL SUBSURFACE EXPLORATION FELT REQUIRED FOR THE DESIGN OF THE __ FOUNDATION."

- If signal poles are included in the Construction Plans, Traffic Operation Memo No. 1702 should be reviewed, and it is suggested that the bid item series 730-23.XX be footnoted with the following text, "THIS BID ITEM INCLUDES THE COST OF THE FOUNDATION DESIGN AND, IF NECESSARY, THE SOIL EXPLORATION REQUIRED FOR THE DESIGN OF THE SIGNAL POLE FOUNDATION."

High Mast Lighting (HML) Foundations: GES is responsible for providing and delivering a *High Mast Lighting Foundation Report* (*HML Foundation Report*) to the Traffic Division in accordance with the TDOT Traffic Design Manual 15.4.5. The *HML Foundation Report* is prepared for the use of the HML foundation designer. The *HML Foundation Report* shall recommend design requirements to be used by others to design the HML foundation. GES will also typically be given the opportunity to review and comment on plans at Field Reviews.

Typically, HML structures are defined as structures being of heights greater than 55 feet above grade surface. Foundation design guidance for HML structures are found in Chapter 13 of AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, AASHTO BRIDGE SPECS, and NCHRP Report 411 Structural Supports for Highway Signs, Luminaries, and Traffic Signals. Further guidance can be found TDOT Traffic Design Manual; TDOT Traffic Division Standard Drawing T-L-1 *Standard Lighting Foundation Details*; Structure Division TDOT Standard Drawing STD-8-4 *Sign, Luminaire and Traffic Signal Supports*.

Under normal workflow, the Traffic Division initiates the process of requesting an *HML Foundation Report* by contacting the GES. Typically, this request is done with an email to TDOT.Geotech@tn.gov, with necessary electronic drawing files attached. The request is typically copied to the appropriate Regional Survey Office as notification to perform a proposed structure stakeout. Unless other agreements are clearly made, the survey stakeout will be provided by TDOT. The *HML Foundation Report* request will then be assigned an individual GES number which initiates the project, so a task i.d. (TX#) can be assigned, and work shall proceed.

Foundation Report Format Requirements: The document is to be formally referred to on the report title and in all correspondence as the *High Mast Lighting Foundation Report*. The Foundation Report and Appendices shall include a detailed narrative of the investigation, engineering analysis, design recommendations, boring logs, and Foundation Data sheet. According to the Traffic Manual, the typical foundation is a 4-foot diameter drilled shaft. Items included in the *HML Foundation Report* should be arranged in the following general format:

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

Introduction – Brief summary of the project and location. Any special design considerations should be noted here.

Geology, Soils and Site Conditions – General narrative of geology, physiographic region, topography, rock \ soils, and site conditions that may affect the structure.

Surface and Subsurface Exploration – General site characterization and narrative of the equipment and tools used during the subsurface exploration. Standard test methods of any field tests are to be included.

Recommendations – Generally includes as applicable:

- Type of foundations (typically 4-foot diameter drilled shaft)
- Description of the foundation bearing strata
- Elevation where rock was encountered (or refusal elevation)
- Ultimate shear strength of all foundation materials
- Angle of internal friction of all foundation materials
- Effective unit weight of all materials
- Side friction and base resistance values for axial capacity check
- Recommended rock socket depth (typical minimum is a factor of drilled shaft diameter and 1.5-2.0)

HML Foundation Report Appendix – Documents supporting the report

- Foundation Detail Sheets – half size pdf replication of engineered drawings as turned in. To be arranged in these three sheets:
  - Boring Layout and Geotechnical Notes Sheet – plan location of borings in relation to site, and any pertinent notes that are applicable to foundation construction
  - Boring Profile Sheet – Boring profiles showing numbering scheme, graphic pattern of stratigraphy, soil description, legend, SPT results, water table, and other pertinent information
  - Foundation Details Sheet(s) – Inserted separately by the structural foundation designer (Structures Division or Engineering Consultant)
- Boring Logs – neatly typed boring records
- Laboratory Testing Results
- Engineering Analyses (i.e. liquefaction, Lpile, etc.)
- Any other documents felt applicable

3-700.00 FOUNDATION REPORTS STANDARD DELIVERY

Final TDOT GES *Foundation Reports* documents are to be turned in to the Structures Division or the Traffic Division in a standardized electronic delivery format described herein. The *Foundation Reports* will be sent as an email attachment unless the files are too large and then other file sharing systems are typically used. The general delivery process is described below.

- Standard email template form should be used. The subject should include the pin number and project description. The email should be sent and copied to the

appropriate recipients. Standard GES email templates are kept current and should be requested.

- Combine digitally sealed report with attachments (boring logs, test results, bridge \ retaining wall \ noise wall \ HML sheets, etc.) into a single *.pdf file. If multiple walls or bridges, separate deliveries are required. Standard file naming convention for a bridge, retaining wall, noise wall, or high mast lighting project is as follows:

  xxxxxx-yy-GeoFoundRptBrX-GESzzzzzzz.pdf
  xxxxxx-yy-GeoFoundRptRWX-GESzzzzzzz.pdf
  xxxxxx-yy-GeoFoundRptNoiseX-GESzzzzzzz.pdf
  xxxxxx-yy-GeoFoundRptHMLX-GESzzzzzzz.pdf
  where: xxxxxx-yy - the PIN number
  zzzzzzz - the GES number
  X – the bridge \ retaining wall \ noise wall number, if multiple structures.
  example: 117511-00-GeoFoundRptRW02-GES2504313

- Unsealed cad drawing sheets in (*.dgn) format. The file name is to follow the convention below:

  xxxxxx-yy-GeoFoundRptBrX-GESzzzzzzz.dgn
  xxxxxx-yy-GeoFoundRptRWX-GESzzzzzzz.dgn
  xxxxxx-yy-GeoFoundRptNoiseX-GESzzzzzzz.dgn
  xxxxxx-yy-GeoFoundRptHMLX-GESzzzzzzz.dgn
  where: xxxxxx-yy - the PIN number
  zzzzzzz - the GES number
  X – the bridge \ retaining wall \ noise wall *number*, if multiple structures.
  example: 117511-00-GeoFoundRptRW02-GES2504313.dgn

CHAPTER 4 – OPERATIONS \ MAINTENANCE SUPPORT

4-000.00 GENERAL

This chapter discusses TDOT GES support of the Operations Division. TDOT Operations Division has a regional Maintenance component and a regional Construction component. GES supports the Operations Division - Maintenance by being available upon request to offer solution recommendations for geohazards including karst sinkholes, rockfalls, or landslides. Additionally, TDOT GES is available to make site visits upon request and offer support to the Operations Division - Construction to clarify any geotechnical recommendations made in the Construction Plans or any other geotechnical problems that might arise during the construction phase of a project.

As a matter of record, TDOT GES assigns an internal file number to track unplanned support given to Maintenance for landslides and rockfalls. Records of geotechnical support given during the construction phase are stored under the file number for that associated construction project.

4-100.00 LANDSLIDES AND ROCKFALLS

Unplanned landslide and rockfall occurrences affect state routes. The project size and project scale ranges from small soil failures that are noticed as cracks in the road, to large slope failures that occur on heavily trafficked routes and demand immediate action.

Different methods are employed to mitigate or repair roads unable to safely use due to landslides and rockfalls. TDOT often suggests alternative solutions for short term mitigation and long term mitigation repair. The work is site specific and no standard solution is available.

Landslides and Rockfalls Deliverables Objective: Proposed landslide and rockfall risks within the project limits of a scheduled PPRM project are to be addressed in the *Soils and Geology Report*.

All too often, unplanned slope instabilities arise and upon discovery the Operations Division – Maintenance contacts TDOT GES for support or advisement, or if it is deemed beyond internal capabilities. TDOT GES will make a site visit and deliver an internal Project

Memorandum to the requesting parties offering up recommended slope mitigation recommendations.

Statewide contract SWC191 Slope Stabilization, administered through the Engineering Operations office, has been used as a tool to stabilize slopes, particularly side hill template sections. Landslide risks are often first discovered by Regional Operations Division – Maintenance (TDOT Maintenance) staff. Then notification will be made to TDOT GES for an on site meeting to discuss the slope failure, and come to a concurrence on particular slope mitigation measures that should be used. Often a rock buttress installation or even a smaller "deep patch" installation will be an adequate solution. Other more complicated and costly mitigation measures that include soil nail wall or rail steel installations are considered as well. This contract compliments the TDOT Asset Management Plan effort to stabilize slopes in Tennessee.

4-150.00 TDOT UNSTABLE SLOPE MANAGEMENT PROGRAM

Rockfall and landslide risk within TDOT is also continuously being monitored using guidance found in the *TDOT Unstable Slope Management Program* (USMP) document. Initially, individual sites are located where slope risk is a concern. Then some of these slopes are evaluated further using recognized rating systems. Some of these sites are entered into a database inventory and visualized in a GIS platform. A list of high-risk sites is further scrutinized, perhaps resulting in a site being elevated to a funded mitigation project, depending upon availability of funds. USMP projects are administered by the Project Management Division – Statewide Programs. The USMP document is included within this document as Appendix 8.

4-200.00 SINKHOLES AND SUBSIDENCE

When sinkholes and subsidence issues occur inside TDOT R.O.W., TDOT GES performs further investigation, evaluation, and make mitigation recommendations. Because of underlying karst geology, there are areas of Tennessee prone to sinkhole drop-outs or collapses. Conversely, in urban areas sinkhole drop-outs can occur due to ruptured utility water lines. It is likely that sinkhole "domes" already existed in the natural geology, and after a triggering mechanism, like a roadway excavation that changes drainage, or a dramatic rainfall event, are exacerbated.

Roadway subsidence also could be due to differential settlement of soils. In West Tennessee erodible soils, soil piping, and poor drainage cause subsidence. Typically, it is the TDOT GES unit that evaluates subsidence that impacts the roadway, and determines what contributing factors are at work.

Normally, these project types are considered on an "emergency basis" and not assigned to consultants since a rapid response is required.

Sinkholes and Subsidence Deliverables Objective: Proposed mitigation for a recognized sinkhole within the project limits of a scheduled PPRM projects are addressed in the *Soils and Geology Report* and all guidance and details shown in the Geotechnical sheets. TDOT GES maintains a set of typical sinkhole drawing detail sheets devoted to karst sinkholes. The drawings have gained the approval of TDOT Environmental Division and TDEC in the past, so any deviations or modifications from accepted standards are scrutinized. In fact, the section discussing sinkholes in the *Soils and Geology Report* is used by TDOT Environmental Division to obtain environmental documents necessary for the project. These typical sinkhole mitigation typical detail drawing sheets contain typical details and notes that are common to most sinkhole mitigation plans and are included as Appendix 5 <u>for information only</u>.

Sinkholes and subsidence problems occurring on a state or federal route outside of a scheduled PPRM project are considered maintenance issues and as such are often initially discovered by TDOT Maintenance staff. Notification is typically made to TDOT GES and an on-site meeting is scheduled to investigate the sinkhole or subsidence and discuss remediation methods. After the on-site meeting, TDOT GES delivers a Project Memorandum to the TDOT Maintenance staff discussing the problem and recommending remediation alternatives.

Recommended sinkhole and subsidence mitigation alternatives can be driven by the impact to travelling users of the roadway, and the proposed traffic control plan required. Treatment methods found in the TDOT typical sinkhole drawing detail sheets provide a relatively permanent mitigation treatment but require using an excavator to expose the sinkhole "throat" before backfilling with graded solid rock. These typical treatment methods are generally preferred because the subsurface hydrogeology is not changed appreciably. However, little is generally known initially of the location of the sinkhole "throat" or other

geometries of the excavation. If the “throat” is deep in the subsurface, a rather large excavation is possible, and haul time of spoil material becomes a factor.

Alternative methods to the TDOT treatments shown on the typical sinkhole drawing details for remediation have been used where an immediate, short-term repair is advisable. An immediate, short-term repair such as compaction grouting has been used with success. Using a remediation treatment such as compaction grouting allows the roadway to be opened to traffic rather quickly, but the subsurface hydrogeology is altered, and there is risk of another sinkhole “dome collapse” occurring elsewhere.

There is a statewide contract for Compaction Grouting & Slab Stabilization which is administered through the Engineering Operations office. This contract has been used to remediate sinkholes. TDOT SP 204CG – Compaction Grouting has been developed to serve as contractual guidance to contractors.

APPENDIX 1

RETAINING WALL SHOP DRAWING CHECKLIST

TDOT Geotechnical Engineering Section

Retaining Wall Shop Drawing Checklist

Retaining Wall Information			
Project:			Wall No.:
Contractor Name:			Contact:
Wall Supplier/Designer:			Date :
Structures Contact:			Reviewer:
PE Number:	Pin No.:	GES File No.:	Contract No.:

	Yes	No	N/A	Comments
Is wall type submitted one of the "Acceptable Wall Types" listed in the contract plans?	☐	☐	☐	
For proprietary walls only- Is the wall system and/or installer listed on the Qualified Products List, QPL 38: Retaining Wall Systems ?	☐	☐	☐	
Does wall geometry conform to plans (begin & end station limits, centerline offset, top of wall elevation, bottom of wall elevation, minimum embedment depth?)	☐	☐	☐	
Are contract plans and shop drawings plans wall geometry (Plan view, elevation) the same as provided for during original geotechnical investigation?	☐	☐	☐	
Do wall calculations provide assumed soil/rock parameters used in design?	☐	☐	☐	
Is the soil/rock parameters in conformance with contract plans requirements?	☐	☐	☐	
Do calculations and construction drawings show the most critical wall sections and any unique design cases (culvert passing through wall face, barrier rail, moment slab, bridge abutment, traffic loading, seismic design, etc) ?	☐	☐	☐	
Do wall calculations use the appropriate load and resistance factors as specified in the contract plans?	☐	☐	☐	
Do wall calculations indicate bearing stability is satisfied per LRFD and contract parameters? Does the nominal bearing capacity used comply with the contract plans? Is the CDR=>1.0	☐	☐	☐	
Do wall calculations indicate sliding stability is satisfied per LRFD and contract parameters? Is the appropriate coefficient of sliding friction used as specified in the contract plans? Is the CDR=>1.0 ?	☐	☐	☐	
Do wall calculations indicate the eccentricity is within the requirements specified in contract plans?	☐	☐	☐	
Do wall calculations include seismic analysis sections for external stability (bearing, sliding, eccentricity) ?	☐	☐	☐	
Do shop drawing construction drawings show required foundation improvement (i.e. undercutting/rock replacement/aggregate piers/piles?) Ensure foundation improvement details and dimensions are shown correctly on the shop drawing's details.	☐	☐	☐	

	Yes	No	N/A	Comments
Do plans clearly define what type of backfill will be used (retained and select backfill) ? Does gradation meet SP624 or other requirements?	☐	☐	☐	
Do calculations use the appropriate internal angle of friction for design (phi angle)? Do shop drawing construction drawings show required excavation and backfill zone, labeled "required" for select backfill zone, in order to use the design friction angle of select backfill (if required), or is the internal angle of friction for the retained fill utilized?	☐	☐	☐	
If the wall designer utilizes an effective angle of friction for the select backfill is greater than 34 degrees, has appropriate documentation of independent testing been submitted by the wall designer.	☐	☐	☐	
Do calculations use the appropriate foreslope and backslope angles, unit weight, traffic loading, etc?	☐	☐	☐	
Do shop drawing construction drawings and calculations show improvements required to ensure global stability is met?	☐	☐	☐	
Do shop drawing construction drawings show the retaining wall square footage? Is the square footage within an appropriate range in comparison to the contract plans estimate?	☐	☐	☐	
Are all wall elements within TDOT right of way? (anchors, straps, select backfill, etc must not infringe on drainage, slope, or construction easements)	☐	☐	☐	
Is the wall constructible as shown in the shop drawings with respect to traffic control and construction phasing?	☐	☐	☐	
Do shop drawing construction drawings show the drainage gutter (if required)?	☐	☐	☐	
Do shop drawing construction drawings show the appropriate wall finish/ fascia (if required, also check project commitments sheet)?	☐	☐	☐	
CIP walls Only -Do shop drawing construction drawings show or note required expansion and contraction joints ?	☐	☐	☐	
MSE walls only: Are the reinforcement lengths at least the minimum as required by the contract plans?	☐	☐	☐	
MSE walls only: Is the spacing of the reinforcement acceptable per contract documents and LRFD Design Spec. 11.10.2.3.1 ?	☐	☐	☐	
MSE walls only: Are the reinforcement lengths all the same length for each design section?	☐	☐	☐	
ANCHOR and SOIL NAIL Walls Only: Are all required proof/verification/other testing requirements clearly shown on the shop drawing construction drawings?	☐	☐	☐	
RETAINING WALL DATABASE ENTRY: Has Shp Dwg Submittal been entered in the ms access RW database? See link below	☐	☐	☐	

THIS FORM IS FOR INTERNAL USE ONLY. FOLLOWING COMPLETION OF THIS FORM AND DISCUSSION WITH SUPERVISOR, PREPARE AN EMAIL TO SUBMIT TO STRUCTURES.

RETAINING WALL DATABASE ENTRY HERE: Geotech Projects Go to "Forms"-> "Retaining Walls"

USE EMAIL TEMPLATE FOUND HERE: Shop Drawing Review- Email Template

SEE HERE FOR STRUCTURES PERSONNEL: TDOT Structures Personnel

Revised on 11.19.18

APPENDIX 2

SOILS AND GEOLOGY REPORT CHECKLIST

TDOT Geotechnical Engineering Section *Soils and Geology Report Checklist*

General Project Information		
Project Description:		**Phone Number:**
GES:		**Date:**
Pin Number:	**Geo/Consultant:**	**TDOT Oversight:**

General – For all sheets except first, develop a page header/footer containing brief description of project.

	Yes	No	N/A
Coversheet includes:			
• County	☐	☐	☐
• *Correct* Project Description	☐	☐	☐
• P.E. Project No.	☐	☐	☐
• PIN No.	☐	☐	☐
• Geotechnical Engineering File No.	☐	☐	☐
Sealed Scope & Liability Limitations on Letterhead (if applicable)	☐	☐	☐
Table of Contents (if applicable)	☐	☐	☐
Executive Summary: Brief Description of Project to include:			
• General slope recommendations	☐	☐	☐
• CBR value for pavement design	☐	☐	☐
• Describe special construction considerations recommended (rock pads, buttresses, undercut, grouting, acid producing material, etc.)	☐	☐	☐
Introduction:			
• Brief summary of project and any unusual considerations	☐	☐	☐
• Vicinity Location Map	☐	☐	☐
Existing Site Conditions and Geology:			
Existing geological conditions and effects on project (geography, topography, physiographic Region, geologic formations, unusual geologic conditions.	☐	☐	☐
Description of any geologic hazards present (rockfalls, sinkholes, wetlands, APR, seismic)	☐	☐	☐
Recommendations:			
• Specific recommendations presented in station to station format	☐	☐	☐
• Cut slope/fill slope recommendations	☐	☐	☐
• Unsuitable soil recommendations	☐	☐	☐
• Sinkhole treatment recommendations	☐	☐	☐
• APR mitigation recommendations	☐	☐	☐
• Do referenced typical cross sections correspond to intervals where treatment occurs	☐	☐	☐
Pavement Design Recommendations:			
• Was CBR test performed	☐	☐	☐
• Actual recommended CBR value for pavement design given in bold type	☐	☐	☐
Appendix:			
• Typed Boring Logs	☐	☐	☐
• Laboratory Test Results	☐	☐	☐
• Slope Stability Analysis Results	☐	☐	☐
• Site Specific Seismic Study (as required)	☐	☐	☐
• Unsealed Soils Sheets (see separate Soils Sheets checklist) w/app. Proj. phase stamp	☐	☐	☐

Electronic submittal to be loaded on TDOT FileNet server archiving: .zip files containing:

Sealed Soils & Geology Report combined with Appendix (PDF)

- File Naming Convention nnnnnn-nn-SoilsGeoRpt-GESyyyyyy.zip
- Where nnnnnn-nn represents the project pin no.
- Where yyyyyy represents the project GES no.

Un-Sealed Soils Sheets Folder for insertion to Field Review Plans (individual. Dgn files)

- File naming convention nnnnnn-nn-Soils-YYY-Descr.dgn
- Where nnnnnn-nn represents the project pin no.
- Where YYY represents the sequential sheet number (first to last)
- Where Descr represents the title block abbreviated sub-name (i.e. Notes, TypicalSec, Plan, SoilProf)

Separate Gint file folder with project pin no. contained in the file name

APPENDIX 3

TDOT GES CONSULTANT INVOICE CHECKLIST

TDOT GEOTECHNICAL CONSULTANT INVOICE CHECKLIST

Reference project's initial executed work order and any previous progress billing invoices.

- ☐ Verify the invoice is in the correct format.
- ☐ Verify no personal or private information is shown (social security numbers, personal tax information, bank routing numbers, Federal ID numbers)
- ☐ Verify "Received" stamp is present and properly dated and signed at the bottom
- ☐ Verify vendor's local office is shown (consultant name, address & telephone)
- ☐ Verify correct GES File Number (matches Work Order)
- ☐ Verify correct Contract Number and Work Order Number (matches Work Order)
- ☐ Verify Pay Terms are clearly stated upon receipt
- ☐ Verify if Final Invoice is marked NO or YES
- ☐ Verify Invoice Date generally agrees with "Invoice Period" and is not duplicate of prior invoices.
- ☐ Make sure "Invoice Period" period does not span two fiscal years (June into July)
- ☐ Verify "Progress Billing No." is correct and does not duplicate previous "progress billing"
- ☐ Verify correct TDOT State Project Number (matches Work Order)
- ☐ Verify correct Federal Project Number (matches Work Order, some projects have no Federal funding)
- ☐ Verify correct TDOT PIN Number (matches Work Order)
- ☐ Verify correct TDOT project description (matches Work Order)
- ☐ Verify county (matches Work Order)
- ☐ Is the "Expense Category Total" in agreement with "Total Amount Due This Invoice"?
- ☐ Does the "Not-to-Exceed" amount agree with executed work order?
- ☐ Is "Amount Remaining After Invoice" in agreement with "Total Invoiced Thru ___"?
- ☐ Is the Invoice signed by vendor?
- ☐ ***Invoices prepared using the 2021 Invoice Format must have the Fixed Fee Worksheet attached to the Invoice.***

TDOT GEOTECHNICAL CONSULTANT INVOICE CHECKLIST

"Invoice Expense Category" box

☐ Review Invoice Expense Category box and make sure the services/costs listed have matching sheets with a breakdown of items and charges.

- ☐ Verify *Category I-Direct Labor Total* matches Schedule No.1 Direct Labor Summary sheet
- ☐ Verify *Category II-Overhead Total* and Rate are correct
- ☐ Verify *Category III-Fixed Fee* Not-To-Exceed amount agrees with the amount on the Work Order
  - ☐ Verify 'Fee Previously Billed' matches the previous progressive bill
- ☐ Verify *Category IV-Drilling Services* total matches Schedule No. 2 Drilling Services sheet
- ☐ Verify *Category V-Laboratory Services* total matches Schedule No. 3 Laboratory Services sheet
- ☐ Verify *Category VI-Direct Costs* total matches Schedule No. 4 Direct Costs sheet
- ☐ Verify *Category VII-Other Costs* total matches Schedule No. 5 Other Costs sheet
- ☐ Verify *Category VIII-Extra Category* total (if provided) matches up with sheets of the same name

Verify all attached documents:

☐ Check for allowable charges, maximum allowable rates, taxes, and other calculations.

☐ Review "Direct Labor Summary" sheet and cross reference employee total hours with required labor attachment including dates worked

- ☐ **Verify no consultant has a Direct Pay Rate greater than $77.84 per hour (or does not exceed the allowable annual salary as written in contract)**

☐ Review "Drilling Services" sheet for quantities and compare to work order, assess reasonableness (ProjectMonitor only)

☐ Review "Laboratory Services" sheet, testing quantities and compare to work order, assess reasonableness(Project Monitor only)

☐ Verify "Other Cost" Invoice Page.

- ☐ Verify Travel Expenses and Mileage \ Transportation Expenses rates are in accordance with current limitations for the State of Tennessee travel requirements
- ☐ ALL Receipts must be legible with no "highlighting"
- ☐ Check each individual log sheet listed below for all required attachments

☐ Travel Expenses

Per Diem – Completed Per Diem Log attached for each individual claiming an expense. Must have

hotel receipt attached to invoice for verification – per diem reimbursement requires overnight travel. The per diem is 75% of the per diem rate on travel days

Lodging - Completed Hotel Log attached for each individual claiming an expense. Must have hotel receipts attached. Hotel receipt must show a zero balance and have the hotel address. If the room is shared, this should be noted on the receipt with the names of the individuals (if not the individuals not listed on the receipt cannot claim per diem). If room rate is more that State rate receipt must be noted with the State rate charge along with the change in the tax amount (this will be the reimbursement amount).

☐ Mileage/Transportation Expenses – Consultant can add to this section Rental Vehicle, Fuel for Rental Vehicle, Airfare, Airport Parking or other Parking Expenses, Taxi charges.

Passenger Vehicle – Completed Mileage Log for each individual claiming mileage reimbursement. Each day with a claim must be listed by date, destination, mileage amount and purpose of travel on the Mileage Log.

Rental Vehicle – Completed Rental Vehicle Log must be attached along with rental receipts. Must have back-up verification for rental dates – hotel receipt, verification of meeting, etc. If hotel receipt, can use receipt that is with the Hotel Receipt Log for verification.

Fuel for Rental Vehicle – Completed Fuel for Rental Vehicle log must be attached. A copy of the original fuel receipt with notation of individuals name is required. Verification for fuel receipts would be the Rental Vehicle receipts.

Airfare – Completed Airfare Log must be attached. This log will include airfare and baggage Handling. The airline receipt and/or baggage handling receipt is required. These receipts can be verified with hotel receipts, verification of meeting, etc.

Airport Parking and/or Parking Expenses – Completed Airport Parking or Parking Expenses log must be attached. Parking receipts are required. Receipts can be verified with airfare receipts, hotel receipts, verification of meeting, etc.

Taxi – Completed Tax Log must be attached. Taxi receipts are required. Receipts can be verified with airfare receipts, hotel receipts, verification of meeting, etc.

☐ Equipment Rental

Completed Equipment Rental Log must be attached. Verify equipment was used for the particular project and the usage dates. If rented, rental receipts must be attached. If equipment rental charge is for consultant owned equipment a breakdown of equipment used, dates, hours and charges for each item listed.

☐ Plans Reproduction Costs

Full Size Bond; Half Size Bond; Photocopies
Completed Plans Reproduction Cost Log must be attached. Receipts for these expenses attached for verification.

☐ Other Expenses – Consultant can add any other expenses in this section.

Shipping Costs – Completed Shipping Cost Log must be attached. Receipts for these expenses attached for verification.

Sub-consultants' invoices are listed in this section. Attach completed Sub-Consultant Log for each sub-consultant. Invoices from sub-consultants attached for verification.

If sub-consultant charges expense those expenses must follow same verification requirements.

APPENDIX 4

TDOT GES FIELD REVIEW CHECKLIST

TDOT Geotechnical Engineering Section
GES Field Review Checklist
For Internal use only.

REVIEW TYPE: ☐ Functional ☐ Plans-in-Hand ☐ PS&E

COUNTY:	
GES NUMBER:	
P.E. NO.:	
PIN NO.:	
DESCRIPTION:	
DESIGNER/SUPERVISOR:	
DATE OF REVIEW:	
DATE OF FILED REVIEW/BID:	
PROJECTED LETTING DATE:	

REVIEW THE FIELD REVIEW REPORT WITH RESPECT TO GES COMMENTS.

SAVE PDF OF THE COMPLETED CHECKLIST IN PROJECT FOLDER-> 04-Filenet -> 02-Plans

A. INDEX SHEET

- ☐ Verify GEOTECHNICAL sheets are listed in the Index of sheets.
- ☐ Check GEOTECHNICAL sheet numbers for accuracy.
- ☐ Verify any typically geotech Std. Drawings req'd are listed (RD01-S-11B, Rock slope catchment, etc.)
- ☐ Any proposed signs, signal, or lighting? Refer to *Signs_Signal_Lighting Plans Checklist* and *TDOT Geotechnical Manual* for guidance.

B. ESTIMATED ROADWAY QUANTITIES

- ☐ Verify items shown in Soils-Geotechnical Notes & Est. Qtys. are shown .
- ☐ Footnotes provided as appropriate.
- ☐ If the Item Number 730-23.XX (Pole/Signal Support) series is used, is it appropriately footnoted (See *TDOT Geotechnical Manual* for guidance)?

C. GENERAL NOTES / SPECIAL NOTES

- ☐ Review Grading notes and any scope of work notes for suitability.
- ☐ Will notes included by others cause geotechnical issues during construction?

D. TYPICAL SECTIONS

- ☐ Review for details of retaining walls, sinkhole repair or any other geotechnical issue.

E. PRESENT LAYOUT SHEET

☐ Relevant geohazard limits shown coincide with treatment limits in report and what is shown on G sheets.

F. PROPOSED LAYOUT SHEET

☐ Proposed treatment limits shown (rock pads, undercutting, sinkholes etc.).

G. G SHEETS

☐ Verify G sheets are same version we delivered.
☐ Verify G sheets are sealed (if PS&E Plans).

H. ROADWAY CROSS SECTIONS

☐ Slope recommendations followed as indicated in GEOTECHNICAL-Typical Sections.
☐ Verify designer slope design is not unreasonable.
☐ Slopes higher than 45 feet high are 2:1 benched or 3:1.
☐ Rock pads, buttresses should be shown.

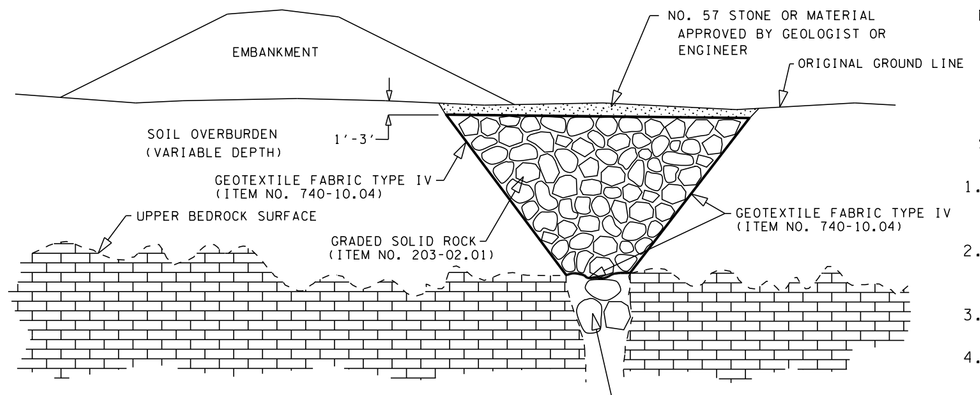
Review Summary/Action Steps:

APPENDIX 5

TYPICAL SINKHOLE DRAWING DETAILS

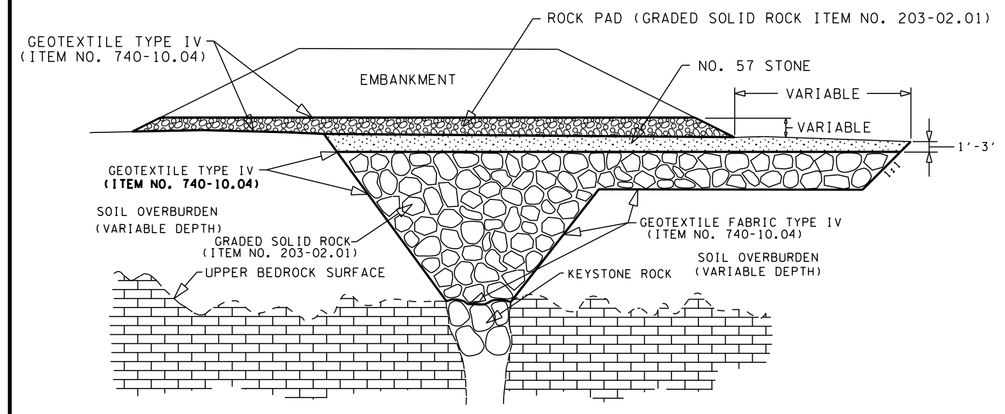
TENNESSEE D.O.T.
DESIGN DIVISION
FILE NO.

TYPE	YEAR	PROJECT NO.	SHEET NO.

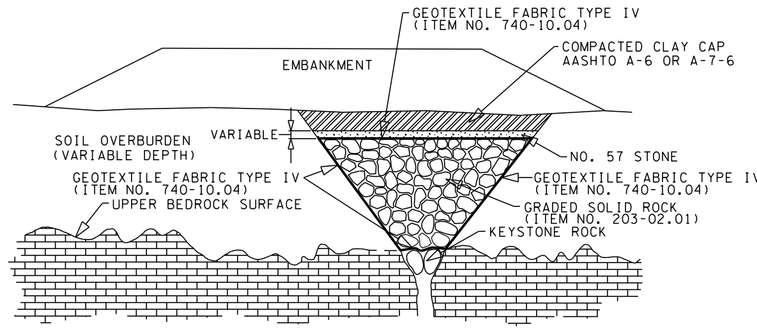


SINKHOLE TREATMENT 1

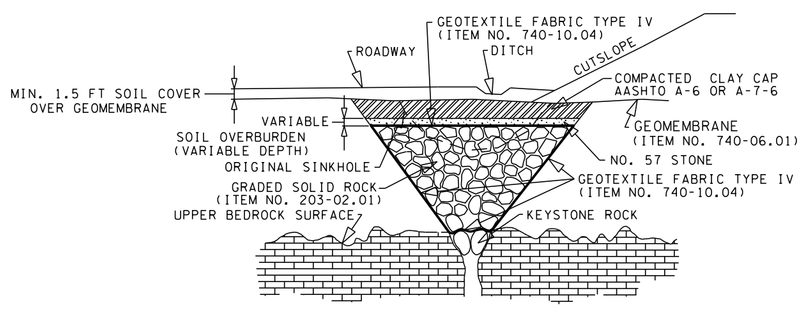
VARIABLE



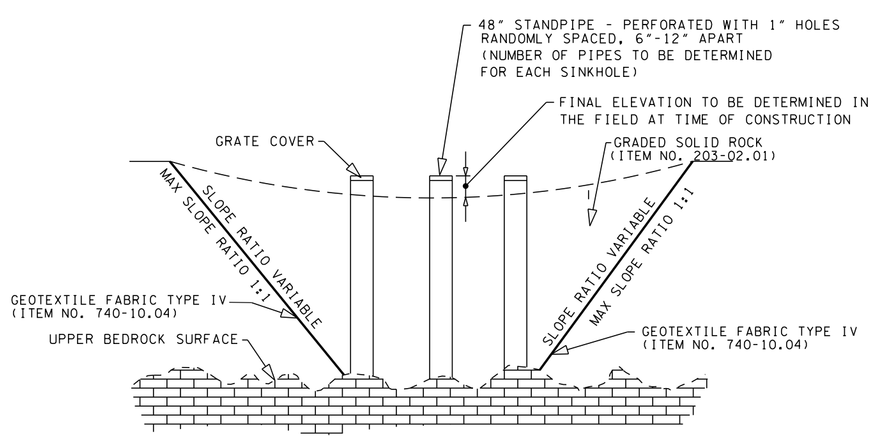
SINKHOLE TREATMENT 1A



SINKHOLE TREATMENT 2



SINKHOLE TREATMENT 2A



SINKHOLE TREATMENT 3

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 GEOTEXTILE FABRIC TYPE IV ON EXCAVATED SLOPES AND BASE OF SINKHOLE.
4. BACKFILL TO A MAXIMUM OF 1 FT. OF THE SPECIFIED GRADE WITH GRADED SOLID ROCK (CLASSIFICATION 203.02.01 BORROW EXCAVATION).
5. BACKFILL TO GRADE WITH A MINIMUM OF 1 FT. OF NO.57 STONE ON TOP OF THE GRADED SOLID ROCK AND GEOTEXTILE FABRIC TYPE IV.

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 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 GEOTEXTILE FABRIC TYPE IV ON EXCAVATED SLOPES AND BASE OF SINKHOLE.
4. BACKFILL TO WITHIN 1.5-3 FT.OF THE SPECIFIED GRADE WITH GRADED SOLID ROCK (CLASSIFICATION 203-02.01 BORROW EXCAVATION).
5. PLACE THE GEOTEXTILE FABRIC TYPE IV ON TOP OF GRADED SOLID ROCK.
6. BACKFILL TO GRADE WITH NO. 57 STONE.
7. CONSTRUCT EMBANKMENT INCLUDING ANY REQUIRED ROCK PAD IN ACCORDANCE WITH CONTRACT PLANS AND CROSS-SECTIONS.

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. PLACE THE GEOTEXTILE FABRIC TYPE IV ON EXCAVATED SLOPES AND BASE OF SINKHOLE.
4. BACKFILL WITH GRADED SOLID ROCK (CLASSIFICATION 203-02.01 BORROW EXCAVATION) UP TO SPECIFIED GRADE.
5. PLACE GEOTEXTILE FABRIC TYPE IV ON TOP OF GRADED SOLID ROCK. PLACE NO. 57 STONE ON TOP OF GETEXTILE FABRIC.
6. CONSTRUCT COMPACTED CLAY CAP. SOIL SHOULD BE OF TYPE AASHTO A-6 OR A-7-6.

FOR 2A INACTIVE ONLY

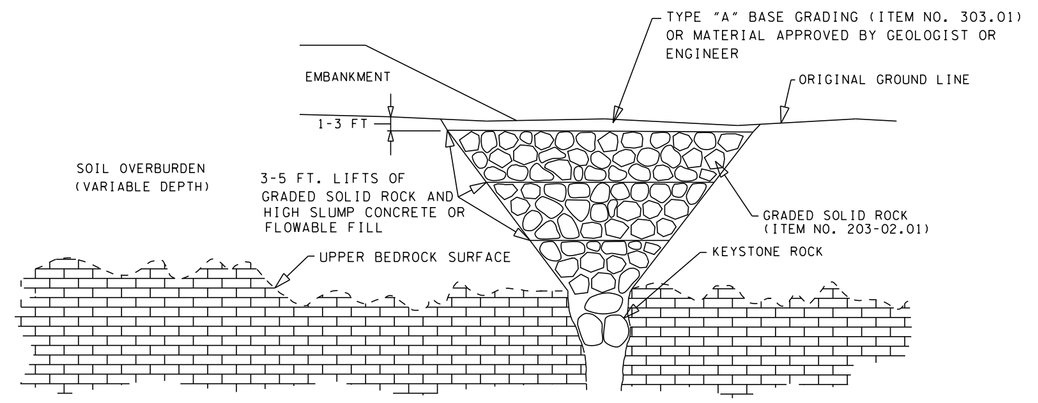
7. PLACE GEOMEMBRANE ON TOP OF SOIL CAP BEFORE CONSTRUCTION OF ANY OVERLYING STRUCTURES OR EMBANKMENTS. THERE SHOULD BE A MINIMUM OF 1.5 FT. OF SOIL PLACED OVER THE MEMBRANE.
8. DITCH SHOULD BE PAVED OR LINED WITH A GEOMEMBRANE.

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 OR 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 PERFORATED FOR AT LEAST THE LOWER 5 FT. WITH 1" HOLES SPACED 6-12" APART.
4. PLACE GEOTEXTILE FABRIC TYPE IV AS SHOWN OR AS DIRECTED BY THE ENGINEER OR GEOLOGIST TO PREVENT THE LATERAL INFLOW OF FINES.
5. BACKFILL WITH A GRADED SOLID ROCK (203-20.01) TO A HEIGHT OF 3.5 FT. BELOW THE TOP OF THE STANDPIPE.
6. THE GRADED SOLID ROCK SHALL BE PLACED WITH A CLAMSHELL. NO END DUMPING WILL BE PERMITTED.



SINKHOLE TREATMENT 4, INACTIVE

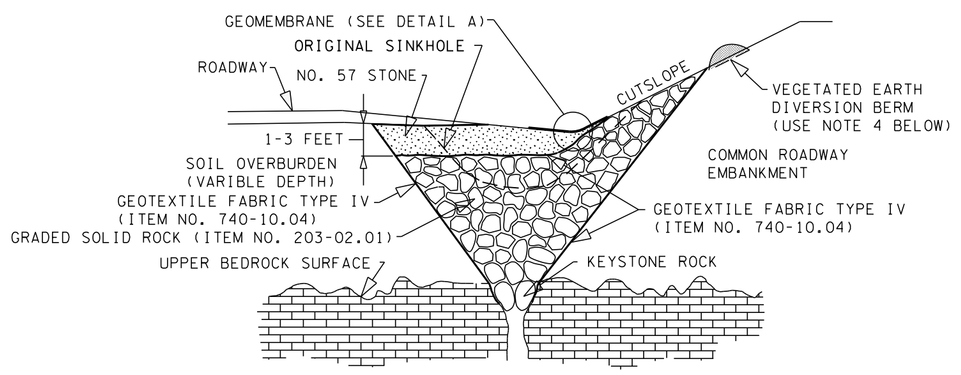
NOTE: AFTER EXCAVATION IS COMPLETE AND ROCK OPENING IS EXPOSED, THE SITE AND TREATMENT METHOD SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL ENGINEERING SECTION OF THE DIVISION OF MATERIALS AND TESTS. ANY CHANGE IN THE THE NO.57 STONE FILL SHALL BE APPROVED BY A REPRESENTATIVE OF THE GEOTECHNICAL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

SEQUENCE OF CONSTRUCTION

1. EXCAVATE SINKHOLE TO DEFINE OPENING IN BEDROCK 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 203-02.01 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.



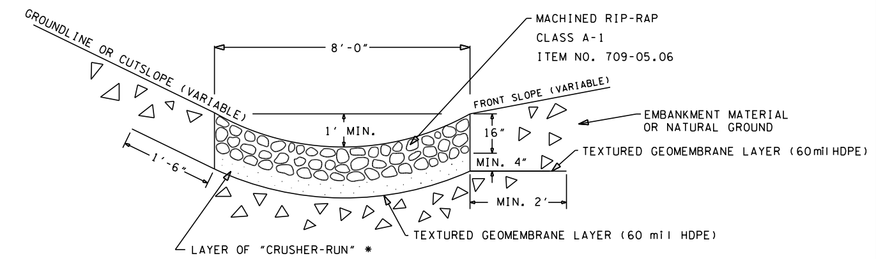
SINKHOLE TREATMENT 5 ACTIVE

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. ANY CHANGE IN 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 MAKING SURE TO REMOVE ALL SOIL AND DEBRIS. COVER ALL EXPOSED SOIL SURFACES WITH GEOTEXTILE FABRIC (ITEM NO. 740-10.04) PRIOR TO BACKFILLING.
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 203.02.01 BORROW EXCAVATION) UP TO 1-3 FEET OF EXISTING DITCHLINE GRADE. CONTINUE FILLING THE EXCAVATION SLOPE WITH GRADED SOLID ROCK ABOVE THE PLANNED EDGE OF THE GEOMEMBRANE LINER EDGE, GRADING THE ROCK TO CONFORM WITH THE SLOPE PROFILE AS SHOWN IN THE ABOVE ILLUSTRATION.
4. WHEN THE GRADED SOILD ROCK PLACMENT IS COMPLETE, A SMALL DRAINAGE DIVERSION BERM OF COMPACTED SOIL SHALL BE CONSTRUCTED AROUND THE TOP OF THE EXCAVATION LIMITS TO TO DIVERT SURFACE RUNOFF AROUND THE REPAIR TO THE DITCH BELOW. THE BERM SHALL BE NO MORE THAN 3-FEET WIDE AT THE BASE AND 1 FOOT TALL ABOVE THE SURROUNDING SLOPE. THE BERM SHALL BE KEYED INTO THE SOIL APPROXIMATELY 0.5-FOOT AND NOT PLACED ON TOP OF THE EXISTING VEGETATION. AFTER CONSTRUCTION OF THE BERM IS COMPLETED, SEED AND STRAW WILL BE REQUIRED TO CONTROL EROSION.
5. PLACE GEOTEXTILE FABRIC TYPE IV ON TOP OF GRADED SOLID ROCK. PLACE NO.57 STONE ON TOP OF GEOTEXTILE FABRIC.
6. DITCH SHOULD BE LINED WITH A GEOMEMBRANE AND COVERED WITH A MINIMUM OF 16 INCHES OF MACHINED RIP-RAP (CLASS A-1) OR MATERIAL APPROVED BY HYDRAULIC DESIGN.

GEOMEMBRANE LINED RIP-RAP DITCH

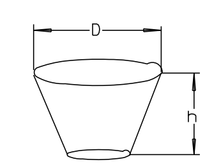


DETAIL A

ITEM NO. 203-02.01 GRADED SOLID ROCK (TONS)
BORROW EXCAVATION (GRADED SOLID ROCK) SHALL CONSIST OF THE REMOVAL AND SATISFACTORY PLACEMENT OF SOUND, NON-DEGRADABLE ROCK WITH A MAXIMUM SIZE OF 3 FT. (1 M). AT LEAST 50 PERCENT OF THE ROCK SHALL BE UNIFORMLY DISTRIBUTED BETWEEN 1 FT. (30 CM) AND 3 FT. (1 M) IN DIAMETER AND NO GREATER THAN 10 PERCENT SHALL BE LESS THAN 2 IN. (50 MM) IN DIAMETER. THE MATERIAL SHALL BE ROUGHLY EQUI-DIMENSIONAL IN SHAPE. THIN, SLABBY MATERIAL WITH AN ACCEPTABLE MECHANICAL SCREENING PROCESS THAT PRODUCES THE REQUIRED GRADATION. WHEN THE MATERIAL IS SUBJECTED TO FIVE ALTERATION OF THE SODIUM SULFATE SOUNDNESS TEST (AASHTO T 104), THE WEIGHTED PERCENTAGE OF LOSS SHALL BE NOT MORE THAN 12. THE MATERIAL SHALL BE APPROVED BY THE ENGINEER BEFORE USE.

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

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



FOR ESTIMATION PURPOSES, USE

$$1.7636 \ \frac{\text{TONS}}{\text{C.Y.}}$$

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

SINKHOLE STANDARD DRAWINGS SINKHOLE TREATMENT ILLUSTRATIONS 1,1A,2,2A,3,4 AND 5

8/29/2017 9:03:11 AM
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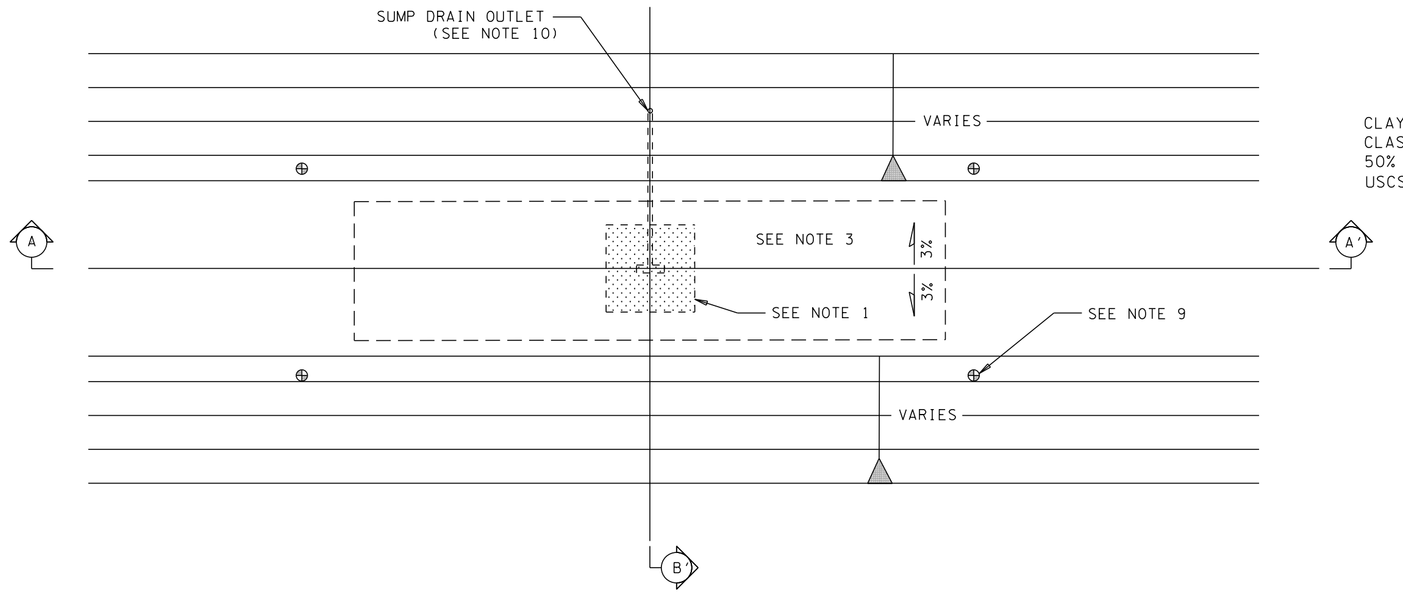
APPENDIX 6

ACID PRODUCING MATERIALS TYPICAL DETAILS

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

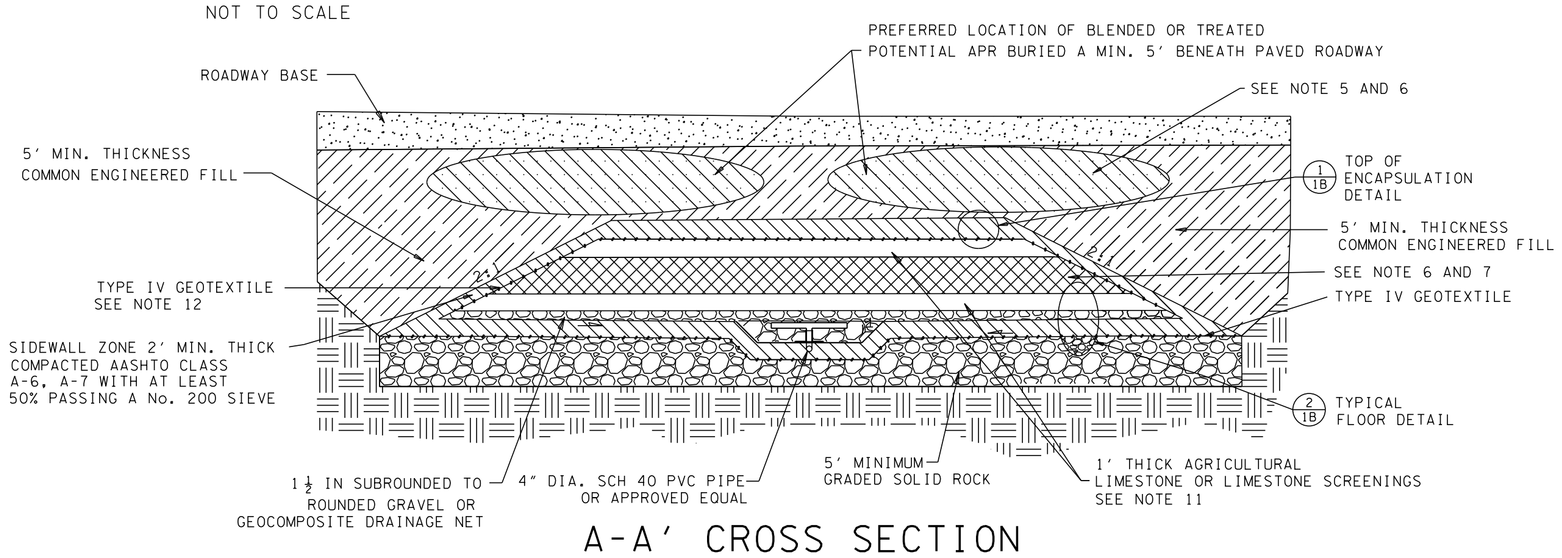
TYPE	YEAR	PROJECT NO.	SHEET NO.

REVISION: 11-10-14 NOTE NO. 6



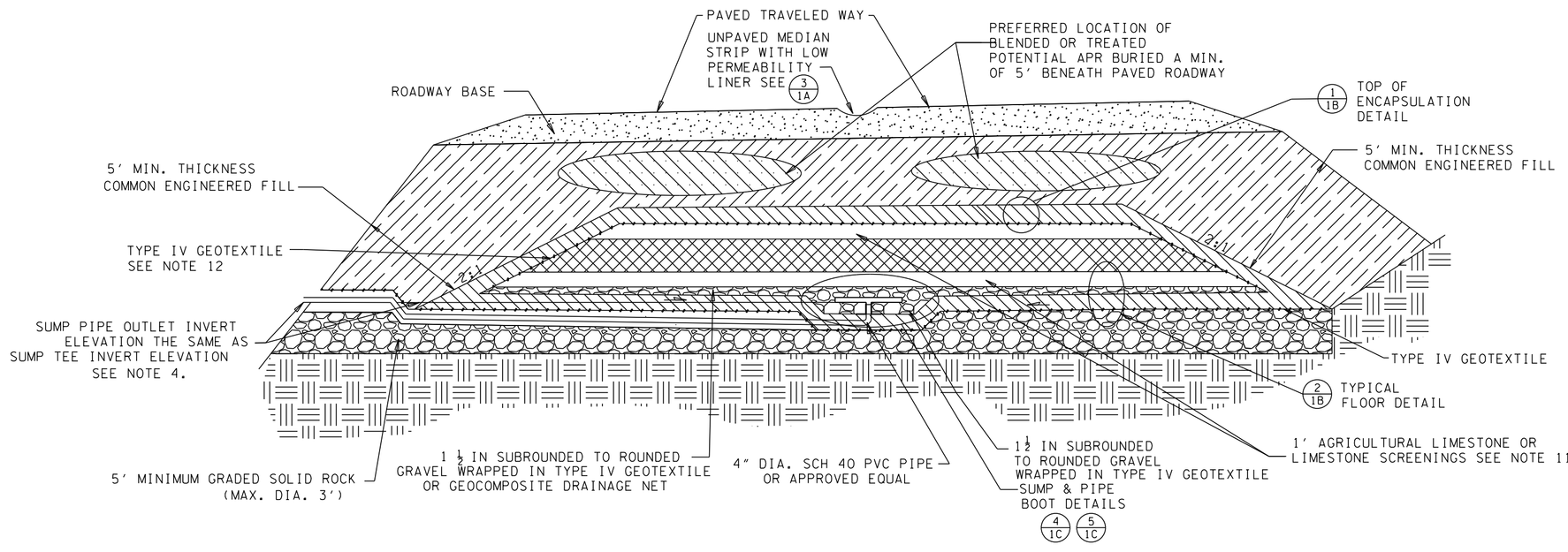
ROADWAY EMBANKMENT CLAY ENCAPSULATION PLAN VIEW

NOT TO SCALE



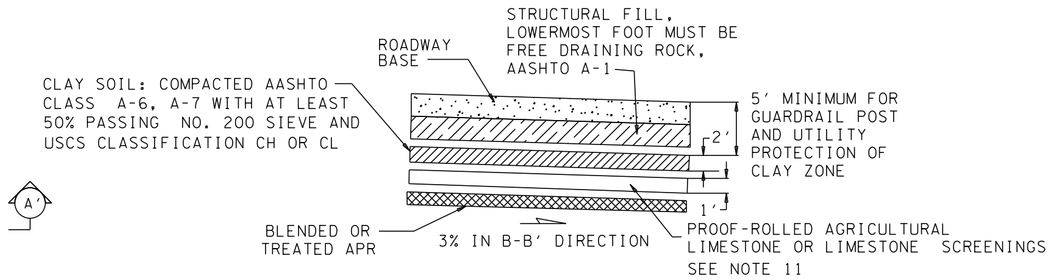
A-A' CROSS SECTION

NOT TO SCALE



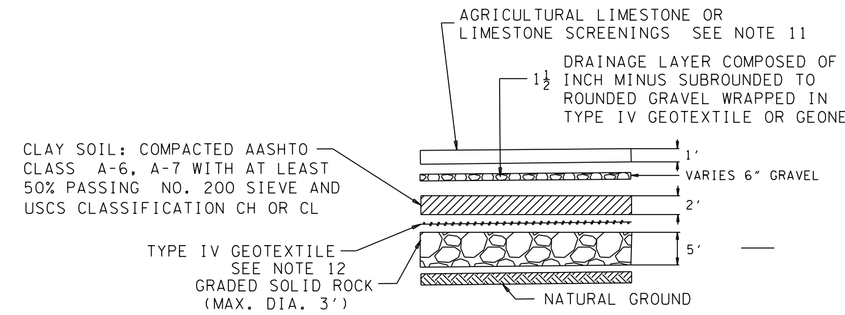
B-B' CROSS SECTION

NOT TO SCALE



1/1B TOP OF CLAY ENCAPSULATION DETAIL

NOT TO SCALE



2/1B TYPICAL FLOOR DETAIL

NOT TO SCALE

LEGEND

- COMMON ENGINEERED FILL
- BLENDED OR TREATED ACID PRODUCING ROCK (APR)
- AGRICULTURAL LIMESTONE OR LIMESTONE SCREENINGS
- BLENDED OR TREATED POTENTIAL APR (BLENDING RATE SPECIFIED IN NOTE 6)
- GRADED SOLID ROCK (3' MAX. DIA.) - ITEM NO. 203-02.01
- DRAIN ROCK WRAPPED IN TYPE IV GEOTEXTILE OR GEONET
- 60 MIL. GEOMEMBRANE- ITEM NO. 740-06.01
- COMPACTED AASHTO CLASS A-6, A-7 WITH AT LEAST 50% PASSING A No. 200 SIEVE
- TYPE IV GEOTEXTILE - ITEM NO. 740-10.04
- PIPE BEDDING MATERIAL
- NATURAL GROUND
- ROADWAY BASE
- FOOTPRINT OF DISPOSAL AREA
- DRAIN PIPE
- SUMP
- 2:1 SLOPE RATIO INDICATORS
- 2/1A DETAIL NUMBER / PAGE WHERE DETAIL IS CALLED OUT
- TDOT-APPROVED ENCAPSULATION MONUMENT/MARKER (GIS REGISTERED)

NOTES

1. SUMP SHALL BE LOCATED IN THE MIDDLE OF THE EXCAVATION/FILL BUT SHALL IN ALL CASES BE LOCATED AT THE LOWEST POINT IN THE BOTTOM OF THE ENCAPSULATION.
2. THIS DRAWING IS A GENERIC REPRESENTATION OF THE APR ENCAPSULATION CONCEPT. FINAL ENCAPSULATION LOCATION AND LIMITS SHALL BE SHOWN ON THE GEOTECHNICAL SHEETS.
3. TOP OF ENCAPSULATION SHALL HAVE A MINIMUM 3% SLOPE IN B-B' DIRECTION (TO LEFT OR RIGHT OF CENTERLINE) FOR AN ENCAPSULATION PLACED AS SHOWN. FOR ANY ENCAPSULATION, THE TOP SHALL BE AT A MINIMUM LEVEL AND GRADED TO DRAIN WITH A MINIMUM OF 3% IN THE SMALL PLAN VIEW DIMENSION.
4. THE SUMP PIPE OUTLET ELEVATION DESIGNED TO KEEP THE PIPE FULL OF WATER TO PREVENT AIR ENTRY INTO THE ENCAPSULATION. THE SUMP PIPE SHALL BE FILLED AFTER THE ENCAPSULATION CONSTRUCTION IS COMPLETE.
5. BLENDED APR MATERIAL MAY BE PLACED ABOVE ENCAPSULTATION IF NECESSARY. THIS MATERIAL SHALL ONLY BE PLACED WITH THE CONCURRENCE OF THE GEOTECHNICAL ENGINEERING SECTION.
6. BLENDED OR TREATED POTENTIAL APR SHALL BE COMPACTED TO CONFORM TO TDOT STANDARD SPECIFICATIONS. BLENDING RATE SHALL BE (SPECIFIC FOR EACH PROJECT) LBS PER 1000 SQ. FT. OF LIFT AREA FOR NO MORE THAN 2 FOOT LIFTS.
7. MATERIAL SUBSTITUTIONS ALLOWED WITH THE CONCURRENCE OF TDOT GEOTECHNICAL ENGINEERING SECTION.
8. SUBSTITUTION OF THE MINIMUM TWO FOOT THICK LAYER OF COMPACTED CLAY PLACED IN 10" THICK UNCOMPACTED LIFTS COMPACTED TO 95% PROCTOR DENSITY WITH GEOMEMBRANE, GEOTEXTILE AND FINE GRAINED SOIL AS PER DRAWING 1A IS ALLOWED.
9. TDOT - APPROVED ENCAPSULATION MONUMENT/MARKERS SHOULD BE LOCATED AT ALL 4 CORNERS OF ENCAPSULATION ZONE. SIGNS TO BE PLACED IN CONJUNCTION WITH ENCAPSULATION CORNER MONUMENT/MARKERS. (SEE SIGN DETAIL DWG 1C)
10. IN SOME DESIGN SITUATIONS, A SUMP DRAIN MAY NOT BE PRACTICAL WHEREBY SUBSTITUTION OF A MONITORING WELL WITH A 4 INCH DIAMETER SCHEDULE 40 PVC CASING IS REQUIRED. THE MONITORING WELL SCREENED INTERVAL SHALL NOT EXTEND ABOVE THE AGRICULTURAL LIMESTONE ZONE IN THE BOTTOM OF THE ENCAPSULATION CELL.
11. LIMESTONE SCREENINGS SHALL HAVE A CALCIUM CARBONATE ($CaCO_3$) CONTENT OF AT LEAST 95% AND SHALL BE PRE-APPROVED BY THE GEOTECHNICAL ENGINEERING SECTION. LESSER $CaCO_3$ CONTENT MAY BE ACCEPTABLE; HOWEVER, THIS WILL INCREASE THE BLENDING RATE. IN NO CASE WILL $CaCO_3$ CONTENT BE LESS THAN 80%. BLENDING RATES FOR LIMESTONE SCREENINGS WITH $CaCO_3$ CONTENT FROM 80% TO LESS THAN 95% WILL BE GIVEN AFTER SUBMISSION OF LIMESTONE SCREENING SAMPLES TO THE GEOTECHNICAL ENGINEERING SECTION.
12. ONLY GEOTEXTILE FABRIC (TYPE IV) LISTED ON THE QUALIFIED PRODUCTS LIST SHALL BE USED.
13. SIDE SLOPES OF ENCAPSULATION AREA MAY BE INVERTED WHERE THE TOP OF THE ENCAPSULATION IS WIDER THAN THE BASE WITH APPROVAL AND CONCURRENCE OF THE TDOT GEOTECHNICAL ENGINEERING SECTION AND ENGINEER.
14. SEE SPECIAL PROVISION 107L FOR ADDITIONAL REQUIREMENTS.
15. GEOMEMBRANE MATERIAL AND INSTALLATION SHALL MEET THE REQUIREMENTS SPECIFICED IN SPECIAL PROVISIONS 740D.

ITEM NO. 203-02.01 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 FT. (1 M) . AT LEAST 50 PERCENT OF THE ROCK SHALL BE UNIFORMLY DISTRIBUTED BETWEEN 1 FT.(30 CM) AND 3 FT. (1 M) IN DIAMETER AND NO GREATER THAN 10 PERCENT SHALL BE LESS THAN 2 IN. (50 MM) 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 BE NOT MORE THAN 12. THE MATERIAL SHALL BE APPROVED BY THE ENGINEER BEFORE USE.

LAST UPDATE: 02/27/2014

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

ROADWAY EMBANKMENT ENCAPSULATION AND DETAILS CLAY OPTION
DWG 1B

11/10/2014 @7:32 PM
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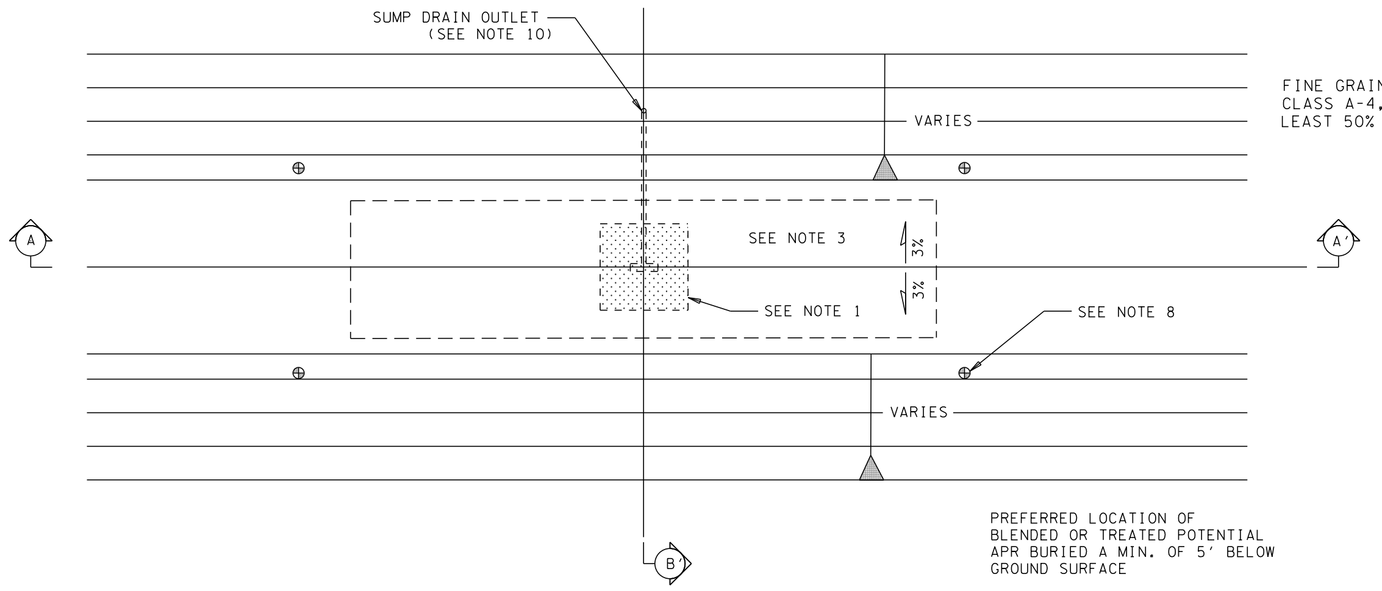
TENNESSEE D.O.T.
DESIGN DIVISION
FILE NO.

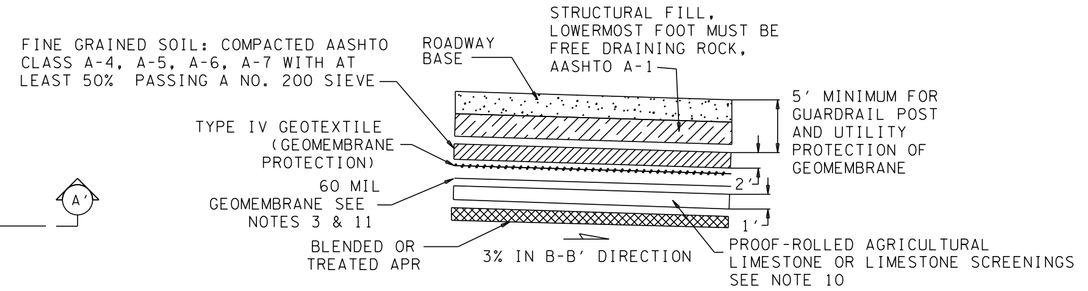
TYPE	YEAR	PROJECT NO.	SHEET NO.

REVISION: 11-10-14 NOTE NO. 6



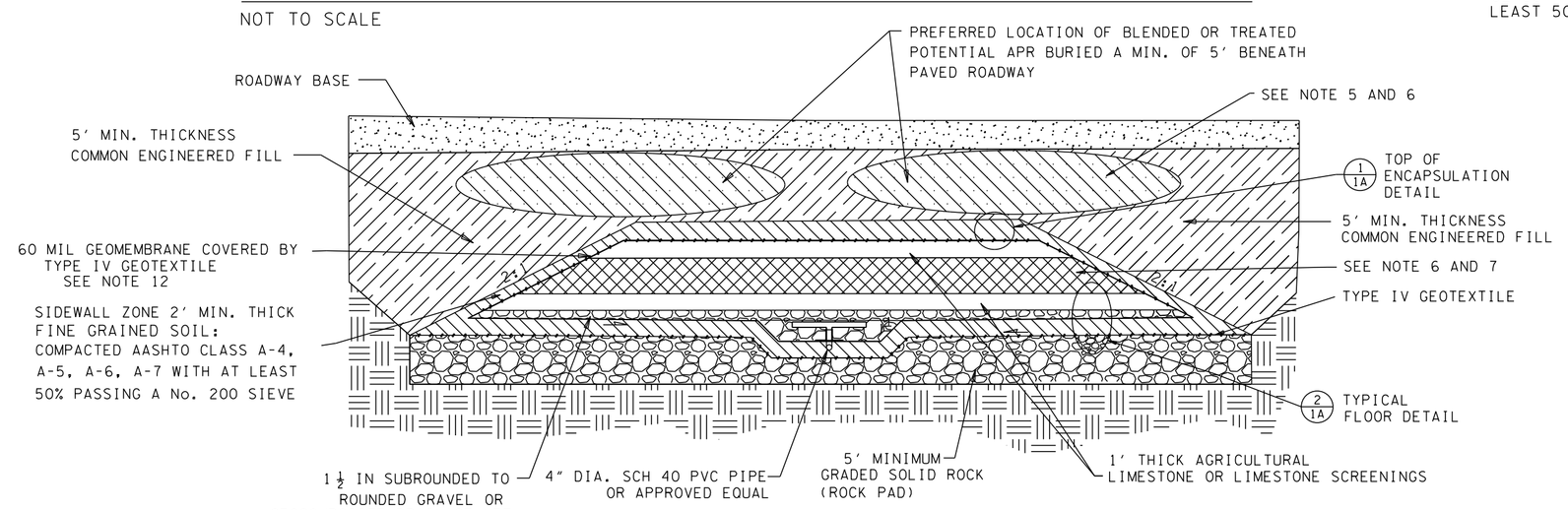
ROADWAY EMBANKMENT ENCAPSULATION PLAN VIEW

NOT TO SCALE



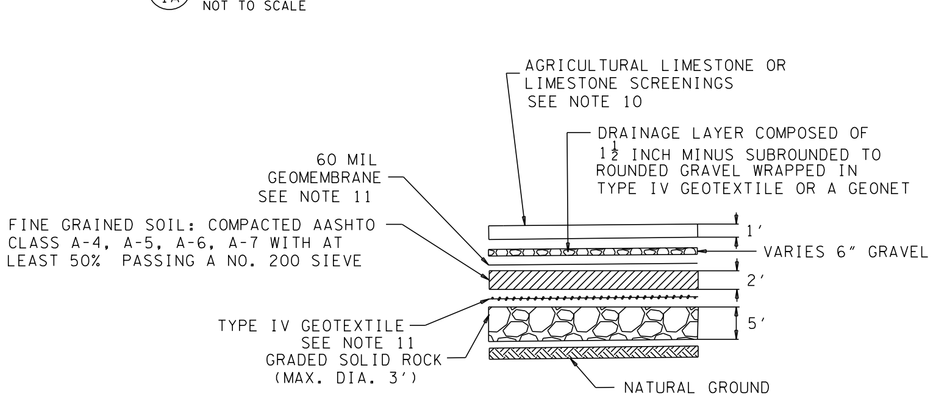
1/1A TOP OF ENCAPSULATION DETAIL

NOT TO SCALE



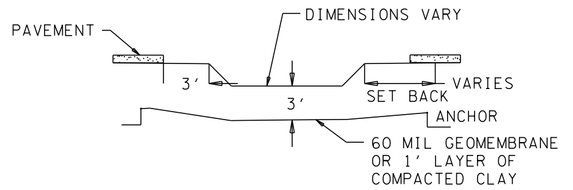
A-A' CROSS SECTION

NOT TO SCALE



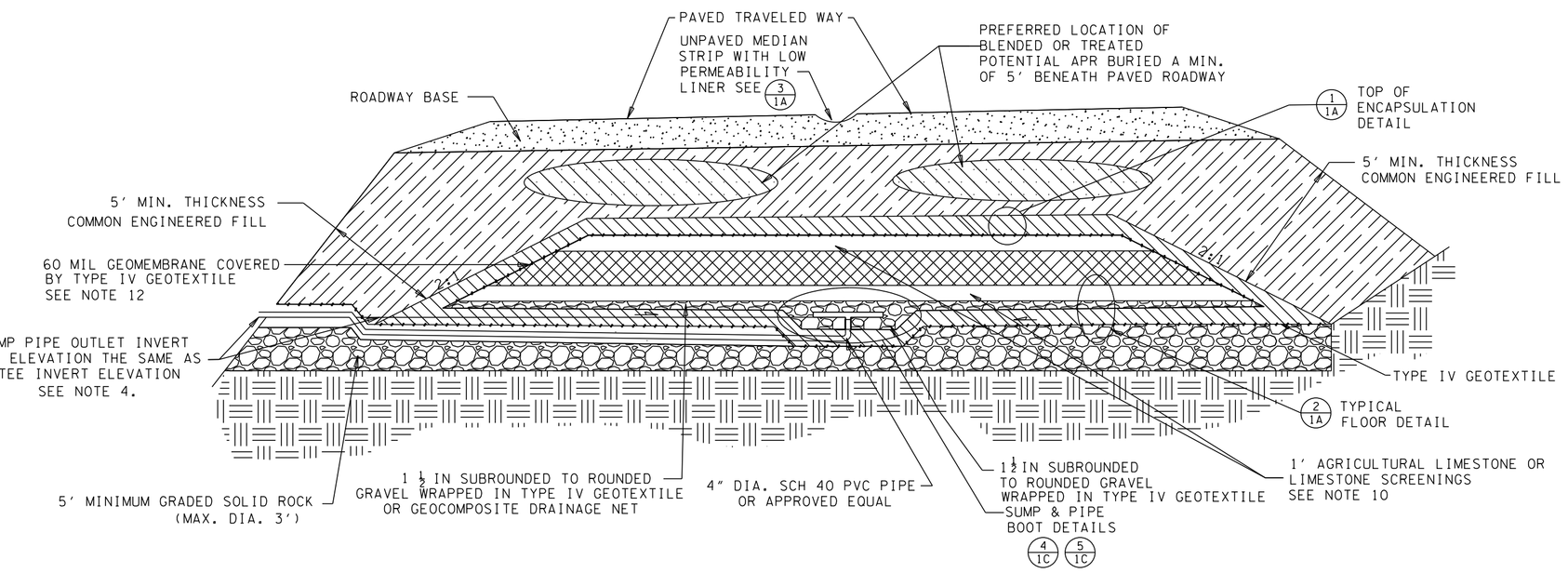
2/1A TYPICAL FLOOR DETAIL

NOT TO SCALE



3/1A MEDIAN STRIP DAINAGE ENHANCEMENT

NOT TO SCALE (REQUIRED WHEN THERE IS A MEDIAN PRESENT OVER THE ENCAPSULATION AREA)



B-B' CROSS SECTION

NOT TO SCALE

ITEM NO. 203-02.01 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 FT. (1 M) . AT LEAST 50 PERCENT OF THE ROCK SHALL BE UNIFORMLY DISTRIBUTED BETWEEN 1 FT.(30 CM) AND 3 FT. (1 M) IN DIAMETER AND NO GREATER THAN 10 PERCENT SHALL BE LESS THAN 2 IN. (50 MM) 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 BE NOT MORE THAN 12. THE MATERIAL SHALL BE APPROVED BY THE ENGINEER BEFORE USE.

LAST UPDATE: 02/27/2014

LEGEND

- COMMON ENGINEERED FILL
- BLENDED OR TREATED ACID PRODUCING ROCK (APR)
- AGRICULTURAL LIMESTONE OR LIMESTONE SCREENINGS
- BLENDED OR TREATED POTENTIAL APR (BLENDING RATE SPECIFIED IN NOTE 6)
- GRADED SOLID ROCK (3' MAX. DIA.) - ITEM NO. 203-02.01
- DRAIN ROCK WRAPPED IN TYPE IV GEOTEXTILE OR GEONET
- 60 MIL. GEOMEMBRANE- ITEM NO. 740-06.01
- COMPACTED AASHTO CLASS A-4, A-5, A-6, A-7 WITH AT LEAST 50% PASSING A No. 200 SIEVE
- TYPE IV GEOTEXTILE - ITEM NO. 740-10.04
- PIPE BEDDING MATERIAL
- NATURAL GROUND
- ROADWAY BASE
- FOOTPRINT OF DISPOSAL AREA
- DRAIN PIPE
- SUMP
- 2:1 SLOPE RATIO INDICATORS
- 2/1A DETAIL NUMBER / PAGE WHERE DETAIL IS CALLED OUT
- TDOT-APPROVED ENCAPSULATION MONUMENT/MARKER (GIS REGISTERED)

NOTES

1. SUMP SHALL BE LOCATED IN THE MIDDLE OF THE EXCAVATION/FILL BUT SHALL IN ALL CASES BE LOCATED AT THE LOWEST POINT IN THE BOTTOM OF THE ENCAPSULATION.
2. THIS DRAWING IS A GENERIC REPRESENTATION OF THE APR ENCAPSULATION CONCEPT. FINAL ENCAPSULATION LOCATION AND LIMITS SHALL BE SHOWN ON THE GEOTECHNICAL SHEETS.
3. TOP OF ENCAPSULATION SHALL HAVE A MINIMUM 3% SLOPE IN B-B' DIRECTION (TO LEFT OR RIGHT OF CENTERLINE) FOR AN ENCAPSULATION PLACED AS SHOWN. FOR ANY ENCAPSULATION, THE TOP SHALL BE AT A MINIMUM LEVEL AND GRADED TO DRAIN WITH A MINIMUM OF 3% IN THE SMALL PLAN VIEW DIMENSION.
4. THE SUMP PIPE OUTLET ELEVATION DESIGNED TO KEEP THE PIPE FULL OF WATER TO PREVENT AIR ENTRY INTO THE ENCAPSULATION. THE SUMP PIPE SHALL BE FILLED WITH WATER AFTER THE ENCAPSULATION CONSTRUCTION IS COMPLETE.
5. BLENDED APR MATERIAL MAY BE PLACED ABOVE ENCAPSULTATION IF NECESSARY. THIS MATERIAL SHALL ONLY BE PLACED WITH THE CONCURRENCE OF THE GEOTECHNICAL ENGINEERING SECTION.
6. BLENDED OR TREATED POTENTIAL APR SHALL BE COMPACTED TO CONFORM TO TDOT STANDARD SPECIFICATIONS. BLENDING RATE SHALL BE (SPECIFIC FOR EACH PROJECT) LBS PER 1000 SQ. FT. OF LIFT AREA FOR NO MORE THAN 2 FOOT LIFTS.
7. MATERIAL SUBSTITUTIONS ALLOWED WITH THE CONCURRENCE OF TDOT GEOTECHNICAL ENGINEERING SECTION.
8. TDOT - APPROVED ENCAPSULATION MONUMENT/MARKERS SHOULD BE LOCATED AT ALL 4 CORNERS OF ENCAPSULATION ZONE. SIGNS TO BE PLACED IN CONJUNCTION WITH ENCAPSULATION CORNER MONUMENT/MARKERS. (SEE SIGN DETAIL DWG 1C)
9. IN SOME DESIGN SITUATIONS, A SUMP DRAIN MAY NOT BE PRACTICAL WHEREBY SUBSTITUTION OF A MONITORING WELL WITH A 4 INCH DIAMETER SCHEDULE 40 PVC CASING IS REQUIRED. THE MONITORING WELL SCREENED INTERVAL SHALL NOT EXTEND ABOVE THE AGRICULTURAL LIMESTONE ZONE IN THE BOTTOM OF THE ENCAPSULATION CELL.
10. LIMESTONE SCREENINGS SHALL HAVE A CALCIUM CARBONATE ($CaCO_3$) CONTENT OF AT LEAST 95% AND SHALL BE PRE-APPROVED BY THE GEOTECHNICAL ENGINEERING SECTION. LESSER $CaCO_3$ CONTENT MAY BE ACCEPTABLE; HOWEVER, THIS WILL INCREASE THE BLENDING RATE. IN NO CASE WILL $CaCO_3$ CONTENT BE LESS THAN 80%. BLENDING RATES FOR LIMESTONE SCREENINGS WITH $CaCO_3$ CONTENT FROM 80% TO LESS THAN 95% WILL BE GIVEN AFTER SUBMISSION OF LIMESTONE SCREENING SAMPLES TO THE GEOTECHNICAL ENGINEERING SECTION.
11. ONLY GEOTEXTILE FABRIC (TYPE IV) LISTED ON THE QUALIFIED PRODUCTS LIST SHALL BE USED.
12. SEE SPECIAL PROVISION 107L FOR ADDITIONAL REQUIREMENTS.
13. SIDE SLOPES OF ENCAPSULATION AREA MAY BE INVERTED WHERE THE TOP OF THE ENCAPSULATION IS WIDER THAN THE BASE WITH APPROVAL AND CONCURRENCE OF THE TDOT GEOTECHNICAL ENGINEERING SECTION AND ENGINEER.
14. GEOMEMBRANE MATERIAL AND INSTALLATION SHALL MEET THE REQUIREMENTS SPECIFICED IN SPECIAL PROVISIONS 740D.

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

ROADWAY EMBANKMENT ENCAPSULATION AND DETAILS GEOMEMBRANE OPTION
DWG 1A

11/10/2014 4:22:25 PM
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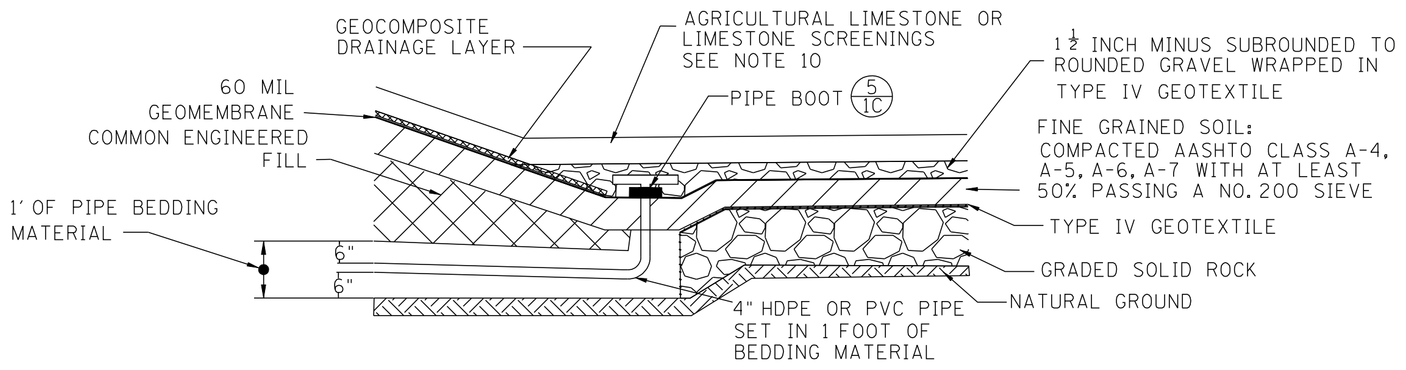
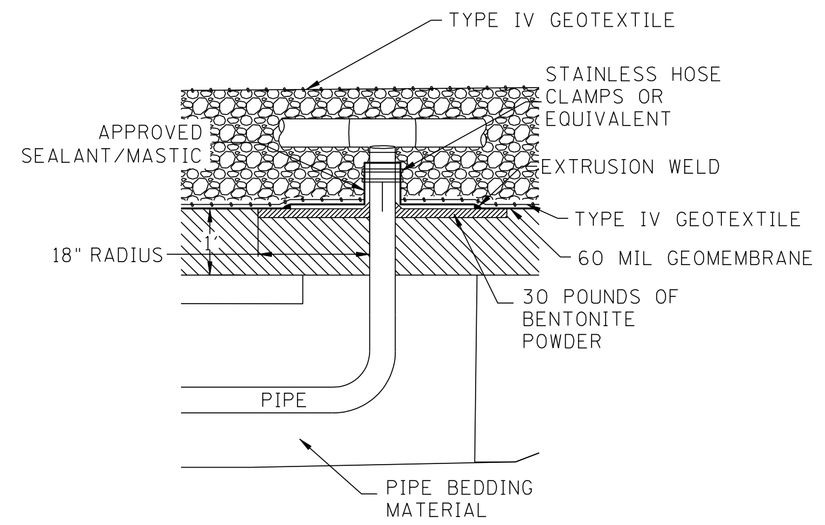
TENNESSEE D.O.T.
DESIGN DIVISION
FILE NO.

TYPE	YEAR	PROJECT NO.	SHEET NO.



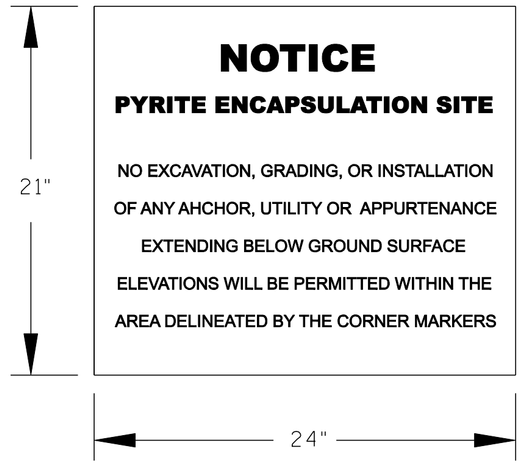
4/1C TYPICAL SUMP DETAIL
NOT TO SCALE



5/1C PIPE BOOT DETAIL
NOT TO SCALE

LEGEND

- COMMON ENGINEERED FILL
- TOPSOIL
- 3" MINUS COVER MATERIAL
- BLENDED OR TREATED ACID PRODUCING ROCK (APR)
- AGRICULTURAL LIMESTONE OR LIMESTONE SCREENINGS
- GEOCOMPOSITE DRAINAGE LAYER
- DRAIN ROCK WRAPPED IN TYPE IV GEOTEXTILE
- 60 MIL. GEOMEMBRANE - ITEM NO. 740-06.01
- COMPACTED AASHTO CLASS A-4, A-5, A-6, A-7 WITH AT LEAST 50% PASSING A NO. 200 SIEVE
- TYPE IV GEOTEXTILE - ITEM NO. 740-10.04
- GRADED SOLID ROCK (20302)
  50% > 1' TO 3'
  100% > 2"
- PIPE BEDDING MATERIAL
- NATURAL GROUND
- 2:1 / 1.3:1 SLOPE RATIO INDICATORS
- GROUNDWATER LEVEL
- 1/1C DETAIL NUMBER
  PAGE WHERE DETAIL IS CALLED OUT



SEE NOTE 8 ON DWG 1A OR NOTE 9 DWG 1B

SIGN DETAIL

SEALED BY

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

ROADWAY EMBANKMENT
ENCAPSULATION AND DETAILS
DWG 1C

LAST UPDATE: 02/27/2014

3/11/2014
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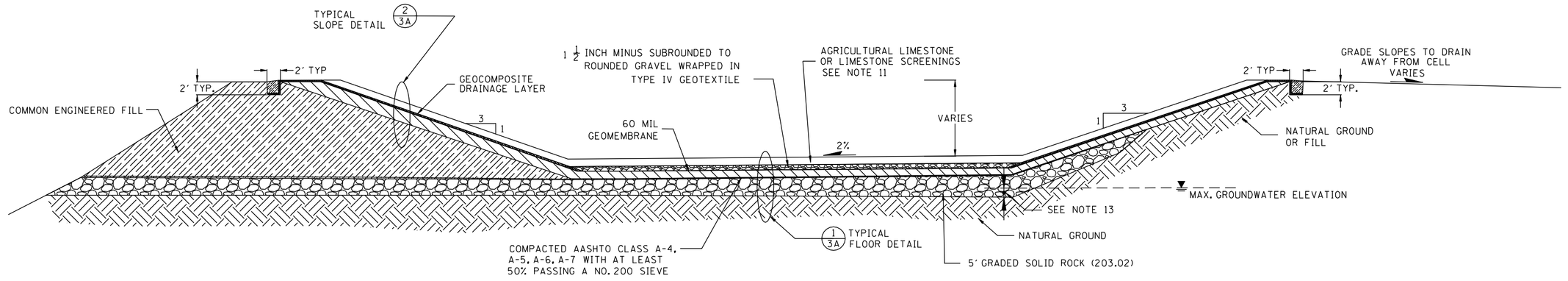
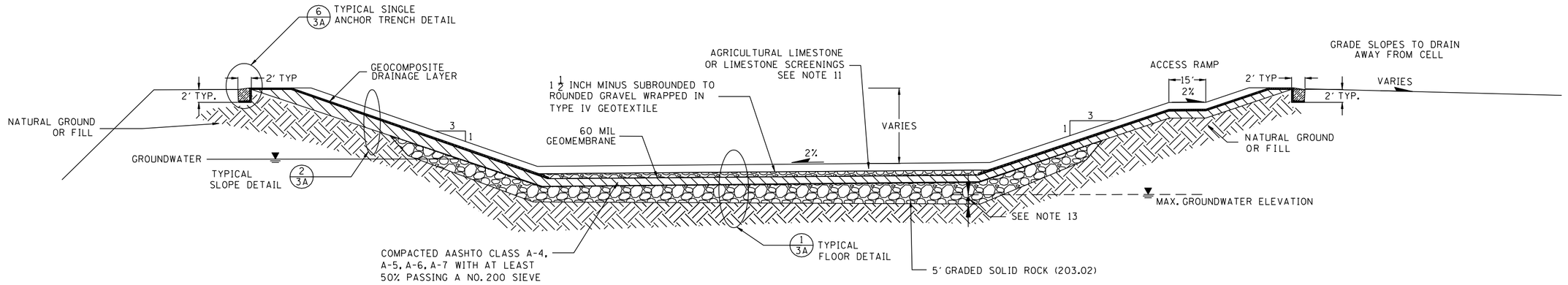
TENNESSEE D.O.T.
DESIGN DIVISION
FILE NO.

TYPE	YEAR	PROJECT NO.	SHEET NO.



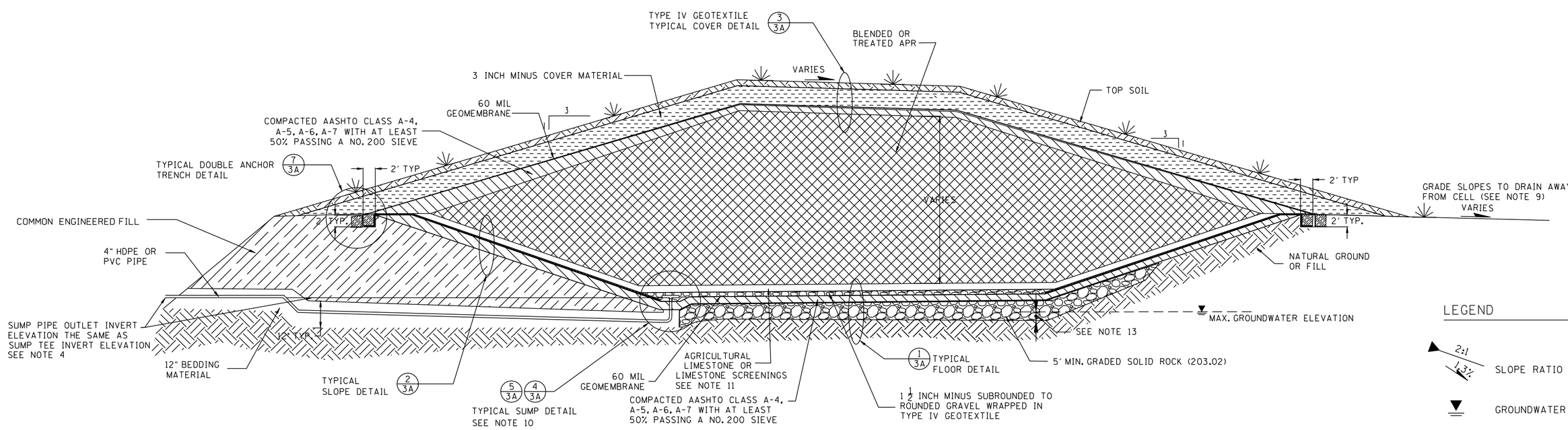
A-A' TYPICAL CROSS SECTION

NOT TO SCALE



B-B'' TYPICAL CROSS SECTION

NOT TO SCALE



C-C' TYPICAL FINISHED GRADE CROSS SECTION

NOT TO SCALE

ITEM NO. 203-02.01 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 FT. (1 M) . AT LEAST 50 PERCENT OF THE ROCK SHALL BE UNIFORMLY DISTRIBUTED BETWEEN 1 FT.(30 CM) AND 3 FT. (1 M) IN DIAMETER AND NO GREATER THAN 10 PERCENT SHALL BE LESS THAN 2 IN. (50 MM) 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 BE NOT MORE THAN 12. THE MATERIAL SHALL BE APPROVED BY THE ENGINEER BEFORE USE.

NOTICE

PYRITE ENCAPSULATION SITE

NO EXCAVATION, GRADING, OR INSTALLATION OF ANY AHCHOR, UTILITY OR APPURTENANCE EXTENDING BELOW GROUND SURFACE ELEVATIONS WILL BE PERMITTED WITHIN THE AREA DELINEATED BY THE CORNER MARKERS

21"

24"

SIGN DETAIL

NOTES

1. DEPTH OF EXCAVATION / FILL VARIES DEPENDING ON LOCATION.
2. SUMP SHALL BE ON DOWN GRADIENT SIDE OF GROUNDWATER.
3. TOP OF ENCAPSULATION SHALL HAVE A MINIMUM 3% SLOPE IN B-B' DIRECTION (TO LEFT OR RIGHT OF CENTERLINE) FOR AN ENCAPSULATION PLACED AS SHOWN. FOR ANY ENCAPSULATION, THE TOP SHALL BE AT A MINIMUM LEVEL AND GRADED TO DRAIN WITH A MINIMUM OF 3% IN THE SMALL PLAN VIEW DIMENSION.
4. THE SUMP PIPE OUTLET ELEVATION DESIGNED TO KEEP THE PIPE FULL OF WATER TO PREVENT AIR ENTRY INTO THE ENCAPSULATION. THE SUMP PIPE SHALL BE FILLED AFTER THE ENCAPSULATION CONSTRUCTION IS COMPLETE.
5. BLENDED APR MATERIAL MAY BE PLACED ABOVE ENCAPSULATION IF NECESSARY. THIS MATERIAL SHALL ONLY BE PLACED WITH THE CONCURRENCE OF THE GEOTECHNICAL ENGINEERING SECTION.
6. BLENDED OR TREATED POTENTIAL APR SHALL BE COMPACTED TO CONFORM TO TDOT STANDARD SPECIFICATIONS. BLENDING RATE FOR STATION _(SPECIFIC)_ TO STATION _(FOR EACH)_ SHALL BE _(PROJECT)_ LBS. PER 1000 SQ. FT. OF LIFT AREA FOR NO MORE THAN 2 FOOT LIFTS.
7. MATERIAL SUBSTITUTIONS ALLOWED WITH THE CONCURRENCE OF TDOT GEOTECHNICAL ENGINEERING SECTION.
8. TDOT - APPROVED ENCAPSULATION MONUMENT/MARKERS SHOULD BE LOCATED AT ALL 4 CORNERS OF ENCAPSULATION ZONE. SIGNS TO BE PLACED IN CONJUNCTION WITH ENCAPSULATION CORNER MONUMENT/MARKERS.
9. DIVERSION CHANNEL MAY BE REQUIRED, (SEE DWG 2).
10. IN SOME DESIGN SITUATIONS, A SUMP DRAIN MAY NOT BE PRACTICAL WHEREBY SUBSTITUTION OF A MONITORING WELL WITH A 4 INCH DIAMETER SCHEDULE 40 PVC CASING IS REQUIRED. THE MONITORING WELL SCREENED INTERVAL SHALL NOT EXTEND ABOVE THE AGRICULTURAL LIMESTONE ZONE IN THE BOTTOM OF THE ENCAPSULATION CELL.
11. LIMESTONE SCREENINGS SHALL HAVE A CALCIUM CARBONATE ($CaCO_3$) CONTENT OF AT LEAST 95% AND SHALL BE PRE-APPROVED BY THE GEOTECHNICAL ENGINEERING SECTION. LESSER $CaCO_3$ CONTENT MAY BE ACCEPTABLE; HOWEVER, THIS WILL INCREASE THE BLENDING RATE. IN NO CASE WILL $CaCO_3$ CONTENT BE LESS THAN 80%. BLENDING RATES FOR LIMESTONE SCREENINGS WITH $CaCO_3$ CONTENT FROM 80% TO LESS THAN 95% WILL BE GIVEN AFTER SUBMISSION OF LIMESTONE SCREENING SAMPLES TO THE GEOTECHNICAL ENGINEERING SECTION.
12. ONLY GEOTEXTILE FABRIC (TYPE IV) LISTED ON THE QUALIFIED PRODUCTS LIST SHALL BE USED.
13. MAX GROUNDWATER ELEVATION EXPECTED SHALL BE NO MORE THAN ½ THE HEIGHT OF THE GRADED SOLID ROCK LAYER MEASURED FROM THE BASE OF THE GRADED SOLID ROCK LAYER AT THE BOTTOM OF THE ENCAPSULATION.
14. GEOMEMBRANE MATERIAL AND INSTALLATION SHALL MEET THE REQUIREMENTS SPECIFICED IN SPECIAL PROVISION 740D.

LEGEND

- SLOPE RATIO INDICATORS (2:1, 1.5:1)
- GROUNDWATER LEVEL
- DETAIL NUMBER (1/3A)
- PAGE WHERE DETAIL IS CALLED OUT
- COMMON ENGINEERED FILL
- TOPSOIL
- 3" MINUS COVER MATERIAL
- BLENDED OR TREATED ACID PRODUCING ROCK (APR)
- AGRICULTURAL LIMESTONE OR LIMESTONE SCREENINGS
- GEOCOMPOSITE DRAINAGE LAYER
- DRAIN ROCK WRAPPED IN, TYPE IV GEOTEXTILE
- 60 MIL. GEOMEMBRANE - ITEM NO. 740-06.01
- COMPACTED AASHTO CLASS A-4, A-5, A-6, A-7 WITH AT LEAST 50% PASSING A NO. 200 SIEVE
- TYPE IV GEOTEXTILE - ITEM NO. 740-10.04
- GRADED SOLID ROCK (203.02) 50% > 1' TO 3' 100% > 2"
- PIPE BEDDING MATERIAL
- NATURAL GROUND

SEALED BY

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

APR OFF-SITE DISPOSAL CELL
CROSS SECTIONS
DWG 3

LAST UPDATE: 02/27/2014

3/11/2014
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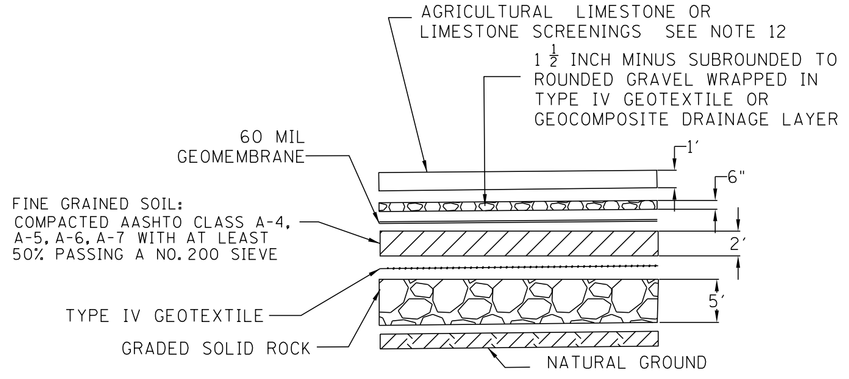
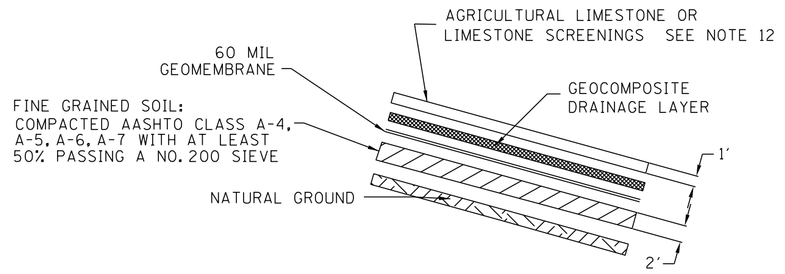
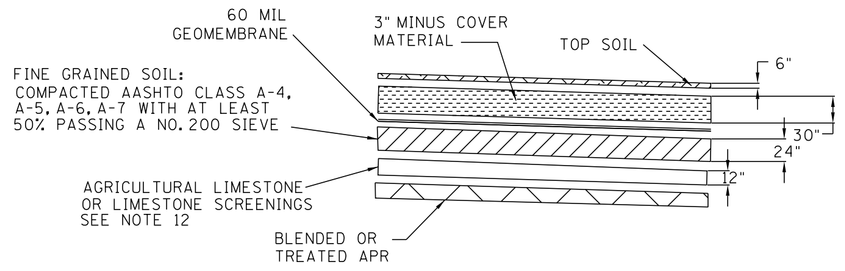
DESIGN DIVISION
FILE NO.



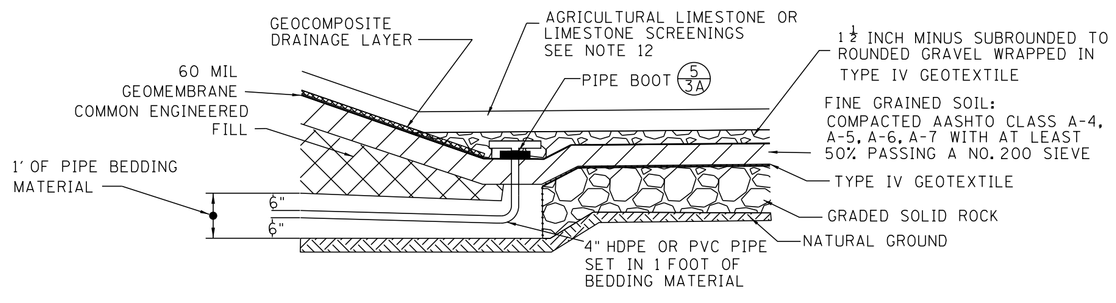
1 / 3A TYPICAL FLOOR DETAIL (SEE NOTE 8)
NOT TO SCALE



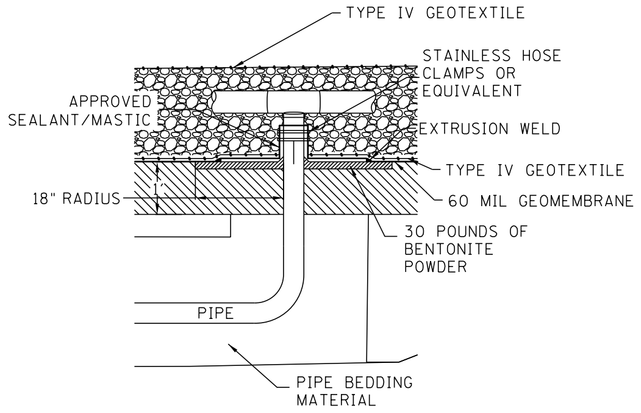
2 / 3A TYPICAL SLOPE DETAIL
NOT TO SCALE



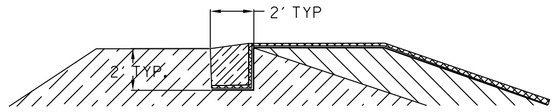
3 / 3A TYPICAL COVER DETAIL
NOT TO SCALE



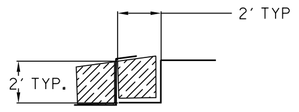
4 / 3A TYPICAL SUMP DETAIL
NOT TO SCALE



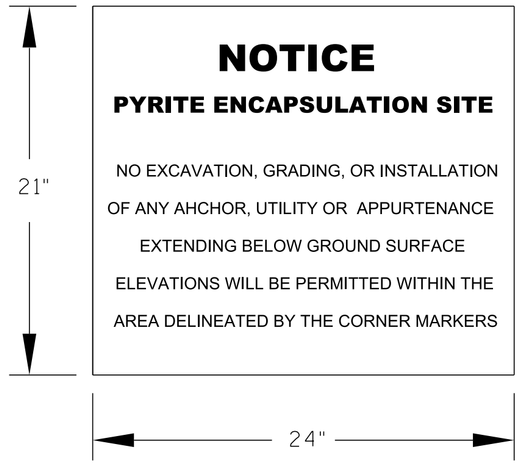
5 / 3A PIPE BOOT DETAIL
NOT TO SCALE



6 / 3A TYPICAL ANCHOR TRENCH DETAIL
NOT TO SCALE



7 / 3A DOUBLE ANCHOR TRENCH DETAIL
NOT TO SCALE



SIGN DETAIL

TYPE	YEAR	PROJECT NO.	SHEET NO.

REVISION: 11-10-14 NOTE NO. 6

LEGEND

- COMMON ENGINEERED FILL
- TOPSOIL
- 3" MINUS COVER MATERIAL
- BLENDED OR TREATED ACID PRODUCING ROCK (APR)
- AGRICULTURAL LIMESTONE OR LIMESTONE SCREENINGS
- GEOCOMPOSITE DRAINAGE LAYER
- DRAIN ROCK WRAPPED IN TYPE IV GEOTEXTILE
- 60 MIL. GEOMEMBRANE - ITEM NO. 740-06.01
- COMPACTED AASHTO CLASS A-4, A-5, A-6, A-7 WITH AT LEAST 50% PASSING A NO. 200 SIEVE
- TYPE IV GEOTEXTILE - ITEM NO. 740-10.04
- GRADED SOLID ROCK (20302)
  50% > 1' TO 3'
  100% > 2"
- PIPE BEDDING MATERIAL
- NATURAL GROUND
- 2:1 / 33% SLOPE RATIO INDICATORS
- GROUNDWATER LEVEL
- 1 / 3A DETAIL NUMBER / PAGE WHERE DETAIL IS CALLED OUT

ITEM NO. 203-02.01 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 FT. (1 M) . AT LEAST 50 PERCENT OF THE ROCK SHALL BE UNIFORMLY DISTRIBUTED BETWEEN 1 FT.(30 CM) AND 3 FT. (1 M) IN DIAMETER AND NO GREATER THAN 10 PERCENT SHALL BE LESS THAN 2 IN. (50 MM) 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 BE NOT MORE THAN 12. THE MATERIAL SHALL BE APPROVED BY THE ENGINEER BEFORE USE.

NOTES

1. DEPTH OF EXCAVATION / FILL VARIES DEPENDING ON LOCATION.
2. SUMP SHALL BE ON DOWN GRADIENT SIDE OF GROUNDWATER.
3. TOP OF ENCAPSULATION SHALL HAVE A MINIMUM 3% SLOPE IN B-B' DIRECTION (TO LEFT OR RIGHT OF CENTERLINE) FOR AN ENCAPSULATION PLACED AS SHOWN. FOR ANY ENCAPSULATION, THE TOP SHALL BE AT A MINIMUM LEVEL AND GRADED TO DRAIN WITH A MINIMUM OF 3% IN THE SMALL PLAN VIEW DIMENSION.
4. THE SUMP PIPE OUTLET ELEVATION DESIGNED TO KEEP THE PIPE FULL OF WATER TO PREVENT AIR ENTRY INTO THE ENCAPSULATION. THE SUMP PIPE SHALL BE FILLED AFTER THE ENCAPSULATION CONSTRUCTION IS COMPLETE.
5. BLENDED APR MATERIAL MAY BE PLACED ABOVE ENCAPSULTATION IF NECESSARY. THIS MATERIAL SHALL ONLY BE PLACED WITH THE CONCURRENCE OF THE GEOTECHNICAL ENGINEERING SECTION.
6. BLENDED OR TREATED POTENTIAL APR SHALL BE COMPACTED TO CONFORM TO TDOT STANDARD SPECIFICATIONS. BLENDING RATE SHALL BE SPECIFIC FOR EACH PROJECT LBS PER 1000 SQ. FT. OF LIFT AREA FOR NO MORE THAN 2 FOOT LIFTS.
7. MATERIAL SUBSTITUTIONS ALLOWED WITH THE CONCURRENCE OF TDOT GEOTECHNICAL ENGINEERING SECTION.
8. SUBSTITUTION OF THE MINIMUM TWO FOOT THICK LAYER OF COMPACTED CLAY PLACED IN 12" THICK UNCOMPACTED LIFTS COMPACTED TO 95% PROCTOR DENSITY WITH GEOMEMBRANE AND GEOTEXTILE AS PER DRAWING 1A IS ALLOWED.
9. TDOT - APPROVED ENCAPSULATION MONUMENT/MARKERS SHOULD BE LOCATED AT ALL 4 CORNERS OF ENCAPSULATION ZONE. SIGNS TO BE PLACED IN CONJUNCTION WITH ENCAPSULATION CORNER MONUMENT/MARKERS.
10. DIVERSION CHANNEL MAY BE REQUIRED, (SEE DWG 2).
11. IN SOME DESIGN SITUATIONS, A SUMP DRAIN MAY NOT BE PRACTICAL WHEREBY SUBSTITUTION OF A MONITORING WELL WITH A 4 INCH DIAMETER SCHEDULE 40 PVC CASING IS REQUIRED. THE MONITORING WELL SCREENED INTERVAL SHALL NOT EXTEND ABOVE THE AGRICULTURAL LIMESTONE ZONE IN THE BOTTOM OF THE ENCAPSULATION CELL.
12. LIMESTONE SCREENINGS SHALL HAVE A CALCIUM CARBONATE ($CaCO_3$) CONTENT OF AT LEAST 95% AND SHALL BE PRE-APPROVED BY THE GEOTECHNICAL ENGINEERING SECTION. LESSER $CaCO_3$ CONTENT MAY BE ACCEPTABLE; HOWEVER, THIS WILL INCREASE THE BLENDING RATE. IN NO CASE WILL CaCO CONTENT BE LESS THAN 80%. BLENDING RATES FOR LIMESTONE SCREENINGS WITH $CaCO_3$ CONTENT FROM 80% TO LESS THAN 95% WILL BE GIVEN AFTER SUBMISSION OF LIMESTONE SCREENING SAMPLES TO THE GEOTECHNICAL ENGINEERING SECTION.
13. ONLY GEOTEXTILE FABRIC (TYPE IV) LISTED ON THE QUALIFIED PRODUCTS LIST SHALL BE USED.
14. GEOMEMBRANE MATERIAL AND INSTALLATION SHALL MEET THE REQUIREMENTS SPECIFICED IN SPECIAL PROVISION 740D.

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

APR OFF-SITE DISPOSAL CELL DETAILS
DWG 3A

LAST UPDATE: 02/27/2014

11/10/2014 1:19:21 PM
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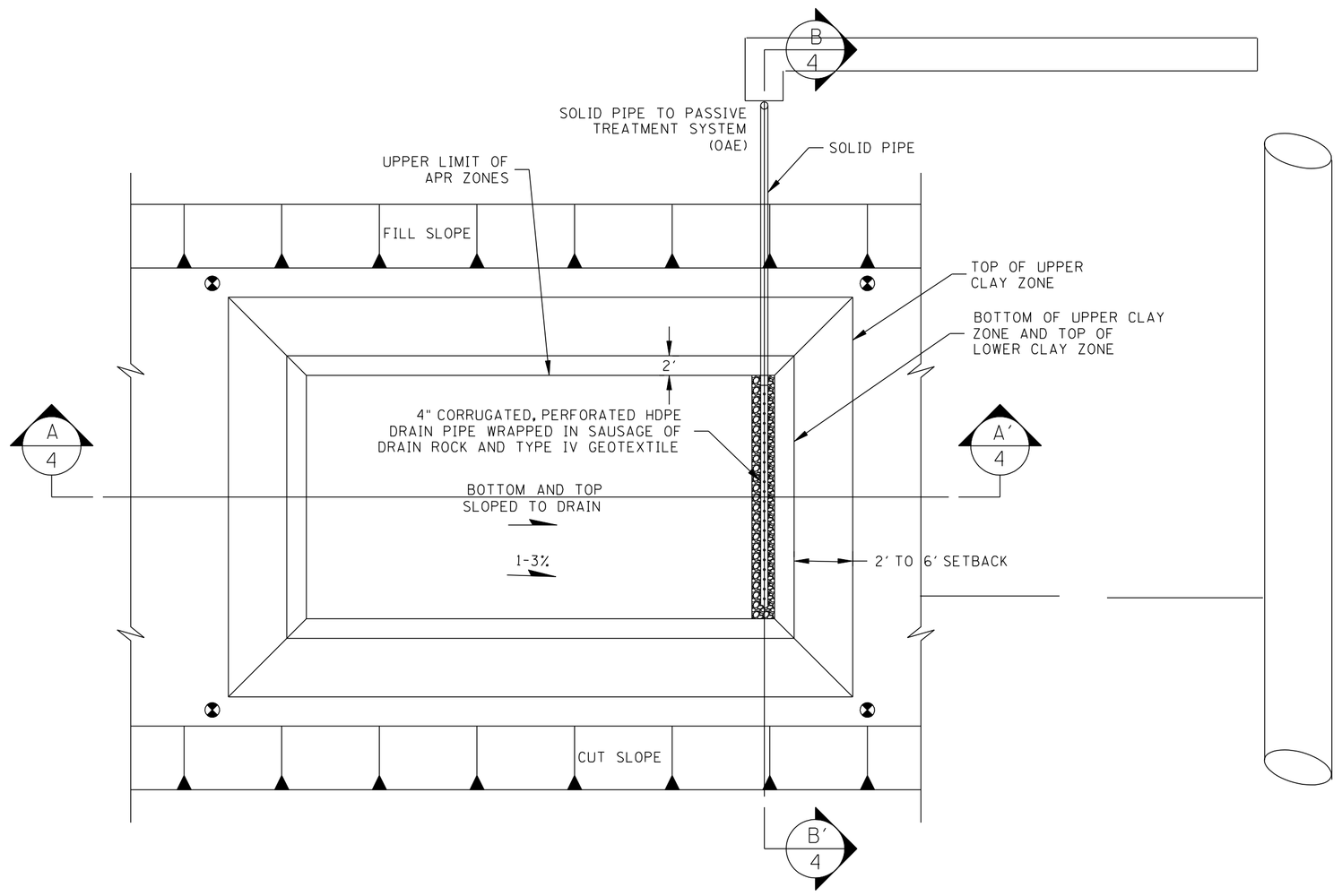
TENNESSEE D.O.T. | DESIGN DIVISION | FILE NO.

TYPE	YEAR	PROJECT NO.	SHEET NO.



1/4 PLAN VIEW OF FOR PARTIAL CAY ENCAPSULATION

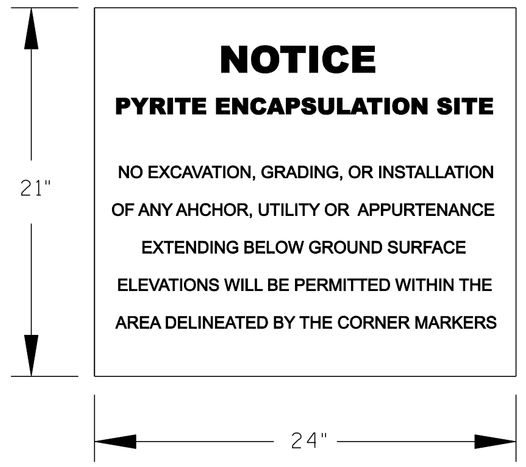
NOT TO SCALE

ITEM NO. 203-02.01 GRADED SOLID ROCK

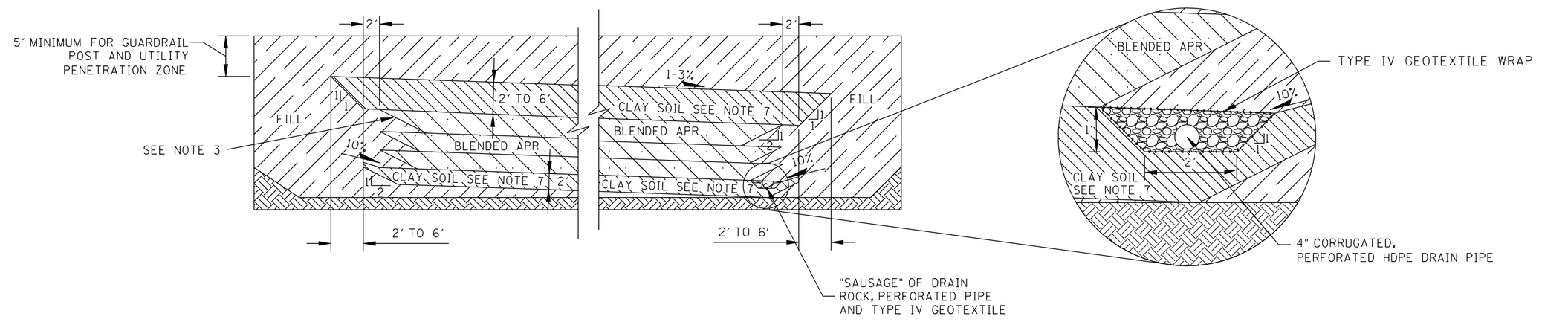
BORROW EXCAVATION (GRADED SOLID ROCK) SHALL CONSIST OF THE REMOVAL AND SATISFACTORY PLACEMENT OF SOUND, NON-DEGRADABLE ROCK WITH A MAXIMUM SIZE OF 3 FT. (1 M) . AT LEAST 50 PERCENT OF THE ROCK SHALL BE UNIFORMLY DISTRIBUTED BETWEEN 1 FT.(30 CM) AND 3 FT. (1 M) IN DIAMETER AND NO GREATER THAN 10 PERCENT SHALL BE LESS THAN 2 IN. (50 MM) 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 BE NOT MORE THAN 12. THE MATERIAL SHALL BE APPROVED BY THE ENGINEER BEFORE USE.

NOTES

1. SCHEMATIC SHOWN ASSUMES GROUNDWATER IS NOT PRESENT WITHIN 10 VERTICAL FEET FROM BOTTOM LOWER CLAY ZONE. IF IT IS PRESENT, A GRADED SOLID ROCK PAD SHALL BE PLACED BENEATH THE PARTIAL ENCAPSULATION. THICKNESS DEPENDS ON DEPTH TO GROUNDWATER WITH A MINIMUM 3' PAD REQUIRED. MAXIMUM EXPECTED GROUNDWATER ELEVATION SHALL BE NO MORE THAN ½ THE HEIGHT OF THE GRADED SOLID ROCK PAD MEASURED FROM THE BASE OF THE PAD AT THE BOTTOM OF THE PARTIAL ENCAPSULATION.
2. BOTTOM OF UPPER CLAY ZONE SHALL BE OFFSET AT LEAST 2 FEET OUTSIDE OF APR ZONE LIMITS.
3. THE APR PROFILE SHOWN PRESUMES THAT THE FILL ZONE LIFT IS PLACED TO GRADE PRIOR TO APR PLACEMENT. IF THE PLACEMENT SEQUENCE WAS REVERSED, A SLIGHTLY DIFFERENT PROFILE WOULD RESULT.
4. TDOT - APPROVED ENCAPSULATION MONUMENT/MARKERS SHALL BE LOCATED AT ALL 4 CORNERS OF ENCAPSULATION ZONE.
   SIGNS TO BE PLACED IN CONJUNCTION WITH ENCAPSULATION CORNER MONUMENT/MARKERS.
5. POTENTIAL APR SHALL BE BLENDED WITH AGRICULTURAL LIME. BLENDED POTENTIAL APR SHALL BE COMPACTED TO CORFORM TO TDOT STANDARD SPECIFICATIONS. BLENDING RATE SHALL BE _(SPECIFIC FOR EACH PROJECT)_ LBS PER 1000 SQ, FT. OF LIFT AREA FOR NO MORE THAN 2 FOOT LIFTS.
6. LIMESTONE SCREENINGS SHALL HAVE CALCIUM CARBONATE ($CaCO_3$) CONTENT OF AT LEAST 95% AND SHALL BE PRE-APPROVED BY THE GEOTECHNICAL ENGINEERING SECTION. LESSER $CaCO_3$ CONTENT MAY BE ACCAPTABLE; HOWEVER, THIS WILL INCREASE THE BLENDING RATE. IN NO CASE WILL $CaCO_3$ CONTENT BE LESS THE 80%. BLENDING RATES FOR LIMESTONE SCREENINGS WITH $CaCO_3$ CONTENT FROM 80% TO LESS THAN 95% WILL BE GIVEN AFTER SUBMISSION OF LIMESTONE SCREENING SAMPLES TO THE GEOTECHNICAL ENGINEERING SECTION.
7. COMPACTED AASHTO CLASS A-6 OR A-7 WITH AT LEAST 50% PASSING THE NO. 200 SIEVE AND USCS CLASSIFICATION OF CH AND CL.

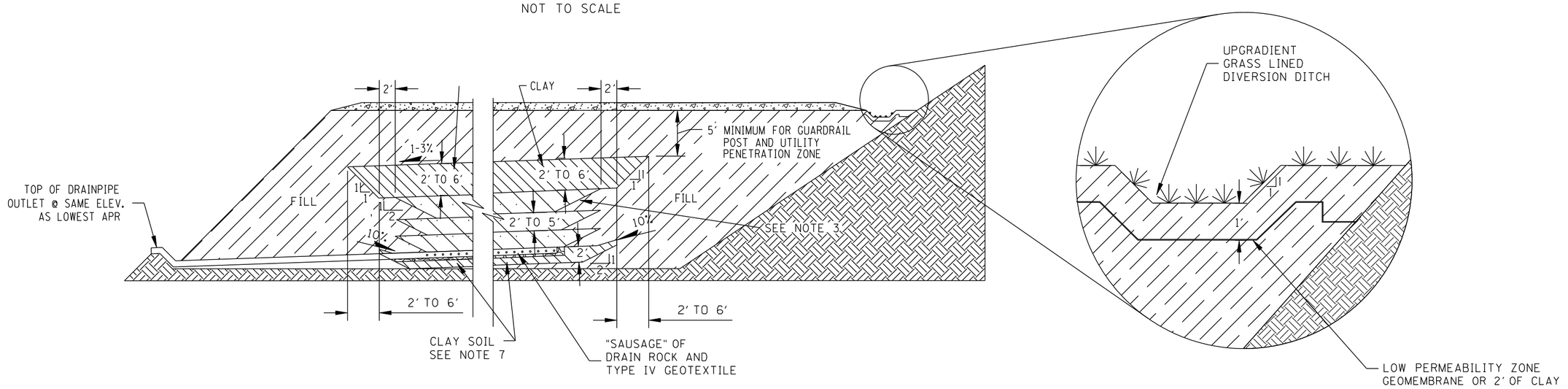


SIGN DETAIL



A-A' SECTION

NOT TO SCALE



B-B' SECTION

NOT TO SCALE

LEGEND

- COMMON ENGINEERED FILL
- BLENDED OR TREATED ACID PRODUCING ROCK (APR)
- DRAIN ROCK WRAPPED IN TYPE IV GEOTEXTILE
- GEOMEMBRANE - ITEM NO. 740-06.01
- TYPE IV GEOTEXTILE - ITEM NO. 740-10.04
- CLAY
- SUBGRADE
- ROADWAY BASE
- SLOPE RATIO INDICATORS
- 5/3 — DETAIL NUMBER / PAGE WHERE DETAIL IS CALLED OUT
- TDOT-APPROVED ENCAPSULATION MONUMENT/MARKERS (GIS REGISTERED)
- GRASS

SEALED BY

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

ROADWAY EMBANKMENT PARTIAL ENCAPSULATION PLAN AND SECTIONS
DWG 4

LAST UPDATE: 02/27/2014

3/11/2014
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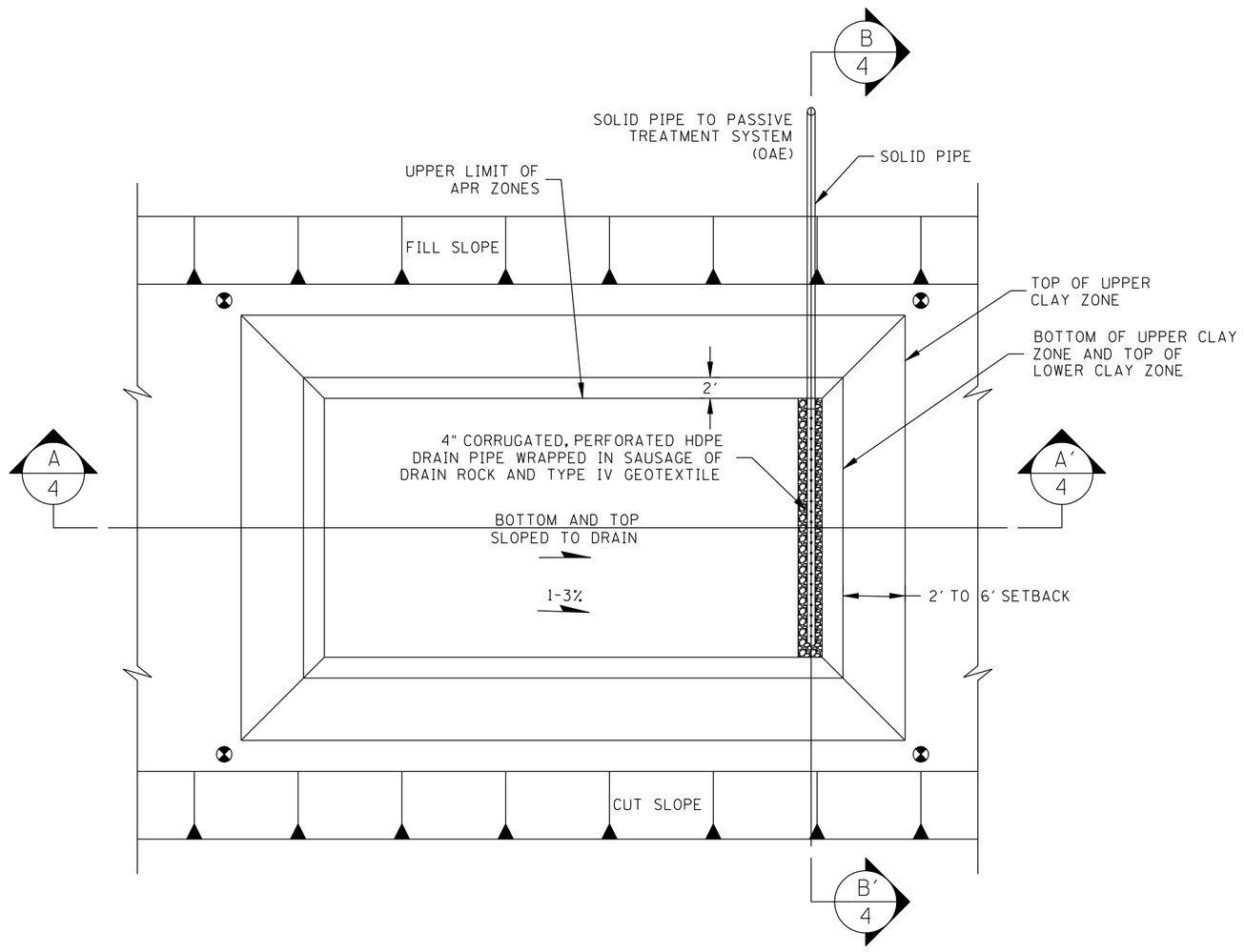
TENNESSEE D.O.T. | DESIGN DIVISION | FILE NO.

TYPE	YEAR	PROJECT NO.	SHEET NO.

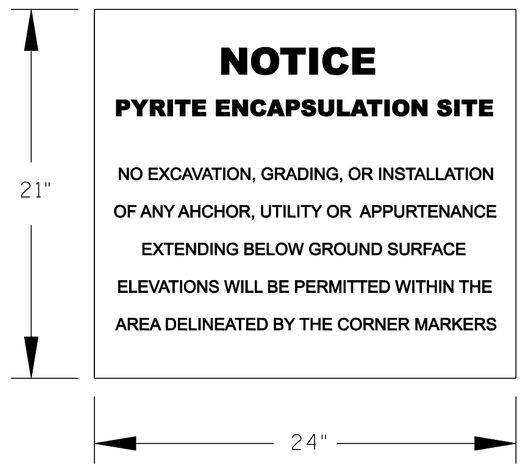


1/4 PLAN VIEW OF FOR PARTIAL CAY ENCAPSULATION

NOT TO SCALE

ITEM NO. 203-02.01 GRADED SOLID ROCK

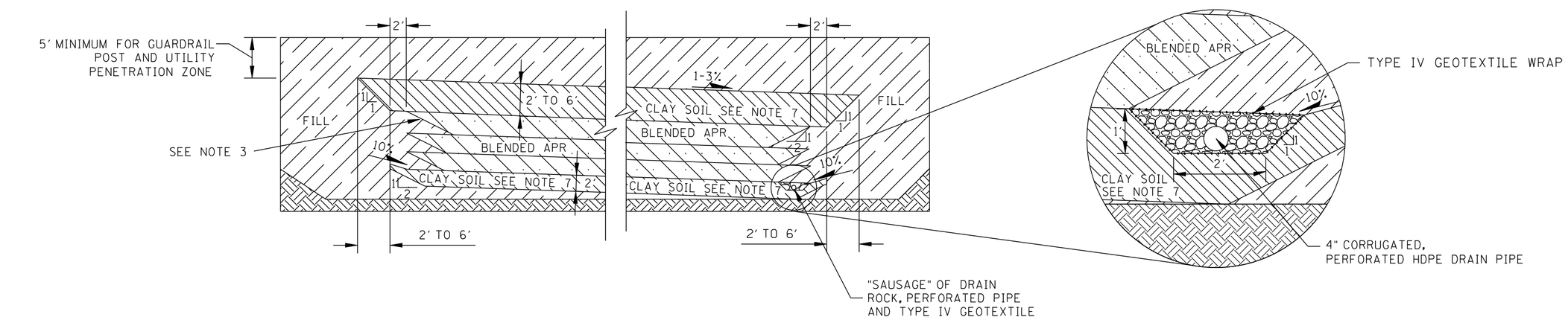
BORROW EXCAVATION (GRADED SOLID ROCK) SHALL CONSIST OF THE REMOVAL AND SATISFACTORY PLACEMENT OF SOUND, NON-DEGRADABLE ROCK WITH A MAXIMUM SIZE OF 3 FT. (1 M) . AT LEAST 50 PERCENT OF THE ROCK SHALL BE UNIFORMLY DISTRIBUTED BETWEEN 1 FT.(30 CM) AND 3 FT. (1 M) IN DIAMETER AND NO GREATER THAN 10 PERCENT SHALL BE LESS THAN 2 IN. (50 MM) 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 BE NOT MORE THAN 12. THE MATERIAL SHALL BE APPROVED BY THE ENGINEER BEFORE USE.



SIGN DETAIL

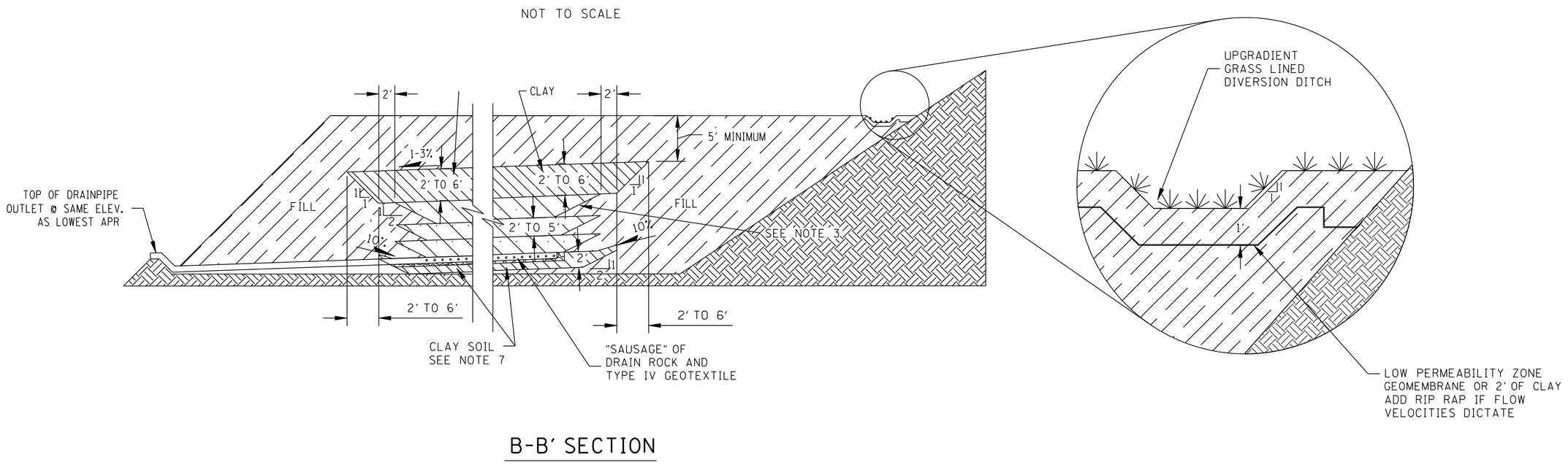
NOTES

1. SCHEMATIC SHOWN ASSUMES GROUNDWATER IS NOT PRESENT WITHIN 10 VERTICAL FEET FROM BOTTOM LOWER CLAY ZONE. IF IT IS PRESENT, A GRADED SOLID ROCK PAD SHALL BE PLACED BENEATH THE PARTIAL ENCAPSULATION. THICKNESS DEPENDS ON DEPTH TO GROUNDWATER WITH A MINIMUM 3' PAD REQUIRED. MAXIMUM EXPECTED GROUNDWATER ELEVATION SHALL BE NO MORE THAN ½ THE HEIGHT OF THE GRADED SOLID ROCK PAD MEASURED FROM THE BASE OF THE PAD AT THE BOTTOM OF THE PARTIAL ENCAPSULATION.
2. BOTTOM OF UPPER CLAY ZONE SHALL BE OFFSET AT LEAST 2 FEET OUTSIDE OF APR ZONE LIMITS.
3. THE APR PROFILE SHOWN PRESUMES THAT THE FILL ZONE LIFT IS PLACED TO GRADE PRIOR TO APR PLACEMENT. IF THE PLACEMENT SEQUENCE WAS REVERSED, A SLIGHTLY DIFFERENT PROFILE WOULD RESULT.
4. TDOT - APPROVED ENCAPSULATION MONUMENT/MARKERS SHALL BE LOCATED AT ALL 4 CORNERS OF ENCAPSULATION ZONE.
   SIGNS TO BE PLACED IN CONJUNCTION WITH ENCAPSULATION CORNER MONUMENT/MARKERS.
5. POTENTIAL APR SHALL BE BLENDED WITH AGRICULTURAL LIME. BLENDED POTENTIAL APR SHALL BE COMPACTED TO CORFORM TO TDOT STANDARD SPECIFICATIONS. BLENDING RATE SHALL BE _(SPECIFIC FOR EACH PROJECT)_ LBS PER 1000 SQ, FT. OF LIFT AREA FOR NO MORE THAN 2 FOOT LIFTS.
6. LIMESTONE SCREENINGS SHALL HAVE CALCIUM CARBONATE ($CaCO_3$) CONTENT OF AT LEAST 95% AND SHALL BE PRE-APPROVED BY THE GEOTECHNICAL ENGINEERING SECTION. LESSER $CaCO_3$ CONTENT MAY BE ACCAPTABLE; HOWEVER, THIS WILL INCREASE THE BLENDING RATE. IN NO CASE WILL $CaCO_3$ CONTENT BE LESS THE 80%. BLENDING RATES FOR LIMESTONE SCREENINGS WITH $CaCO_3$ CONTENT FROM 80% TO LESS THAN 95% WILL BE GIVEN AFTER SUBMISSION OF LIMESTONE SCREENING SAMPLES TO THE GEOTECHNICAL ENGINEERING SECTION.
7. COMPACTED AASHTO CLASS A-6 OR A-7 WITH AT LEAST 50% PASSING THE NO. 200 SIEVE AND USCS CLASSIFICATION OF CH AND CL.



A-A' SECTION

NOT TO SCALE



B-B' SECTION

NOT TO SCALE

LEGEND

- COMMON ENGINEERED FILL
- BLENDED OR TREATED ACID PRODUCING ROCK (APR)
- DRAIN ROCK WRAPPED IN TYPE IV GEOTEXTILE
- GEOMEMBRANE - ITEM NO. 740-06.01
- TYPE IV GEOTEXTILE - ITEM NO. 740-10.04
- CLAY
- SUBGRADE
- SLOPE RATIO INDICATORS (2:1, 1.35:1)
- 5/3 — DETAIL NUMBER / PAGE WHERE DETAIL IS CALLED OUT
- TDOT-APPROVED ENCAPSULATION MONUMENT/MARKERS (GIS REGISTERED)
- GRASS

SEALED BY

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

OFF-SITE PARTIAL ENCAPSULATION PLAN AND SECTIONS

DWG 5

LAST UPDATE: 02/27/2014

3/11/2014
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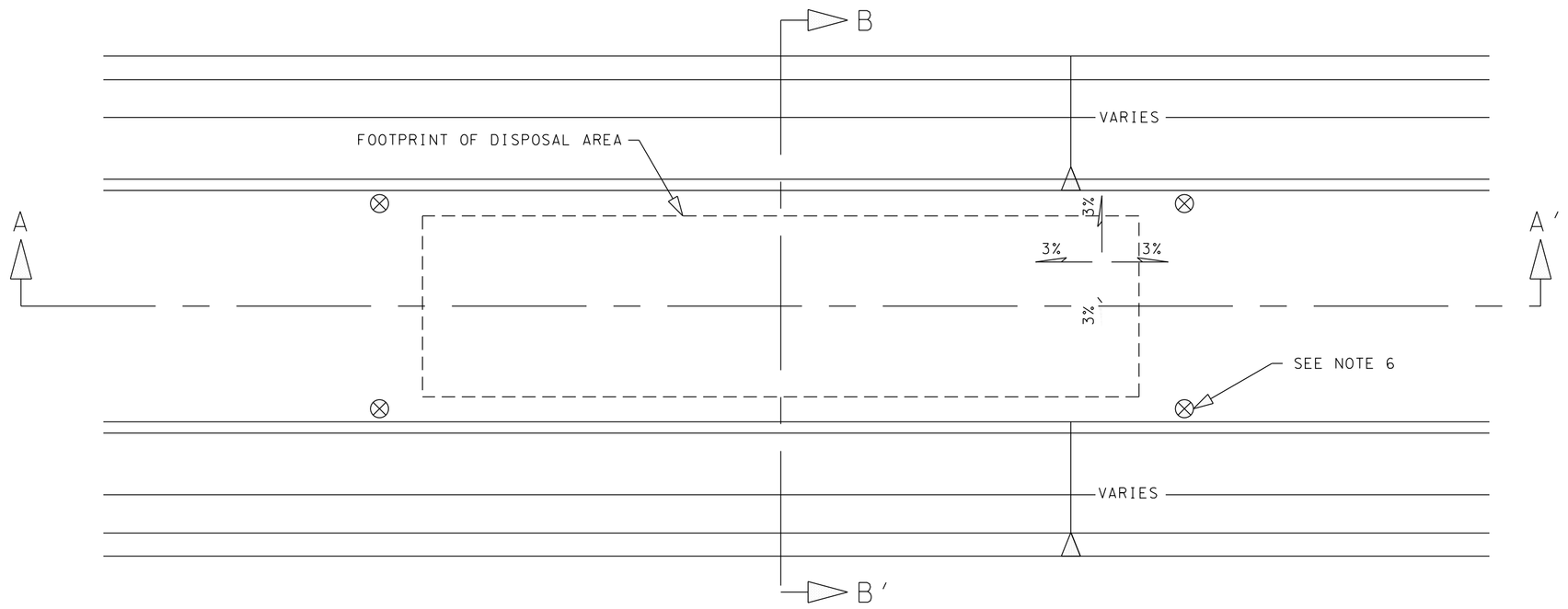
TENNESSEE D.O.T.
DESIGN DIVISION
FILE NO.

TYPE	YEAR	PROJECT NO.	SHEET NO.

REVISION: 11-10-14 NOTE NO. 9

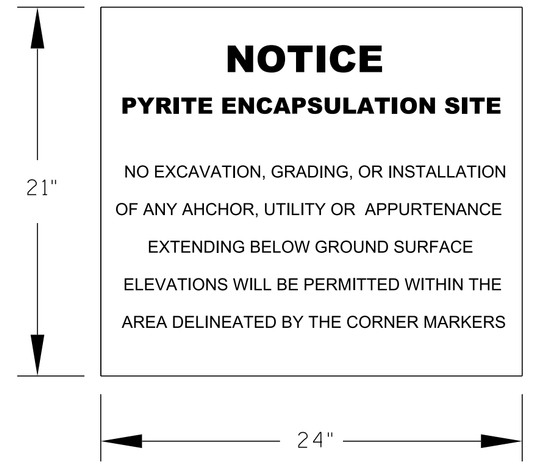


ROADWAY EMBANKMENT BLENDING AREA PLAN VIEW

NOT TO SCALE

ITEM NO. 203-02.01 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 FT. (1 M) . AT LEAST 50 PERCENT OF THE ROCK SHALL BE UNIFORMLY DISTRIBUTED BETWEEN 1 FT.(30 CM) AND 3 FT. (1 M) IN DIAMETER AND NO GREATER THAN 10 PERCENT SHALL BE LESS THAN 2 IN. (50 MM) 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 BE NOT MORE THAN 12. THE MATERIAL SHALL BE APPROVED BY THE ENGINEER BEFORE USE.



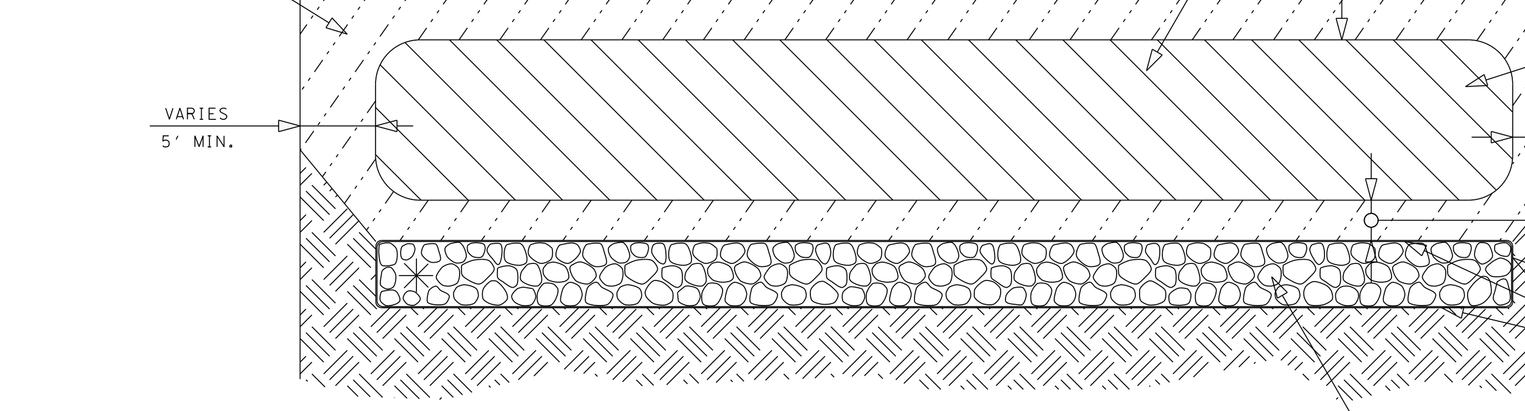
SIGN DETAIL

① MEDIAN STRIP DRAINAGE ENHANCEMENT

NOT TO SCALE

NOTES

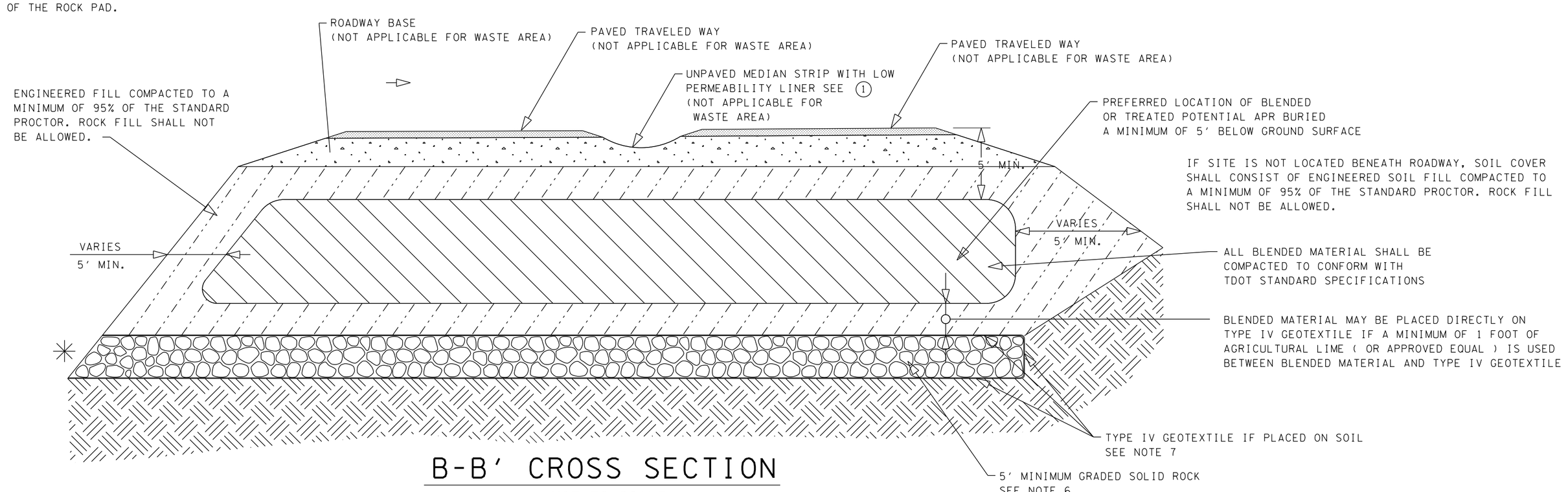
1. THIS DRAWING IS A GENERIC REPRESENTATION OF THE APR BLENDING CONCEPT, NOT TO BE USED FOR CONSTRUCTION PURPOSES, BEYOND CONCEPTUAL GUIDANCE.
2. TOP OF BLENDED AREA SHALL HAVE MINIMUM 3% SLOPE IN ANY DIRECTION.
3. BLENDED OR TREATED POTENTIAL APR SHALL BE COMPACTED TO COMFORM WITH TDOT STANDARD SPECIFICATIONS.
4. MATERIAL SUBSTITUTIONS ALLOWED WITH REGISTERED PROFESSIONAL ENGINEER CONCURRENCE AND CONCURRENCE OF TDOT GEOTECHNICAL ENGINEERING SECTION.
5. TDOT - APPROVED ENCAPSULATION MONUMENT/MARKERS SHALL BE LOCATED AT ALL 4 CORNERS OF ENCAPSULATION ZONE. SIGNS TO BE PLACED IN CONJUNCTION WITH ENCAPSULATION CORNER MONUMENT/MARKERS.
6. DRAWING ASSUMES A SHALLOW GROUNDWATER TABLE. IF GROUNDWATER IS NOT PRESENT AS EVIDENCED BY NO LESS THAN THREE DRY BOREHOLES EXTENDED AT LEAST 10 FEET BELOW THE PLANNED BOTTOM OF THE CELL WITHIN THE CELL FOOTPRINT AND SEASONALLY HIGH WATER TABLE IS NOT EXPECTED WITHIN AT LEAST 10' OF THE BOTTOM OF THE BLENDED AREA GRADED SOLID ROCK MAY NOT BE NECESSARY. ELIMINATION OF THE GRADED SOLID ROCK PAD SHALL BE AT THE APPROVED CONCURRENCE OF THE TDOT GEOTECHNICAL ENGINEERING SECTION.
7. TYPE IV GEOTEXTILE IS USED AS A SEPARATOR LAYER BETWEEN GRADED SOLID ROCK PAD AND IN-PLACE SOIL OR PLACED ENGINEERED SOIL FILL. GEOTEXTILE LAYER IS NOT NEEDED WHERE GRADED SOLID ROCK PAD IS PLACED DIRECTLY ON ROCK.
8. ALL REQUIREMENTS FOR WASTE AREAS AS REQUIRED IN SECTION 203.07 OF STANDARD SPECIFICATIONS AND IN THE STATEWIDE STORMWATER MANAGEMENT PLAN, PROCEDURES FOR PROVIDING OFF-SITE WASTE AND BORROW.
9. BLENDED OR TREATED POTENTIAL APR SHALL BE COMPACTED TO CONFORM TO TDOT STANDARD SPECIFICATIONS. BLENDING RATE SHALL BE _(SPECIFIC FOR EACH PROJECT)_ LBS. PER 1000 SQ.FT. OF LIFT AREA FOR NO MORE THAN 2 FOOT LIFTS.
10. ROCK TO BE USED IN THE BASE OF THE ENCAPSULATION CELL SHALL MEET THE GRADED SOLID ROCK SPECIFICATION WITH THE ADDITIONAL REQUIREMENT THAT PYRITIC MATERIAL CANNOT BE PRESENT IN SUFFICIENT AMOUNTS TO CAUSE THE WET ACID/BASE ACCOUNT VALUE OF THE ROCK TO BE LESS THAN 0.
12. GEOMEMBRANE MATERIAL AND INSTALLATION SHALL MEET REQUIREMENTS SPECIFICED IN SPECIAL PROVISION 740D.



A-A' CROSS SECTION

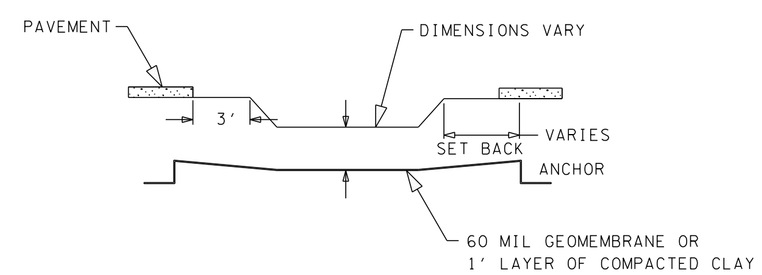
NOT TO SCALE

✳ GRADED SOLID ROCK PAD TO BE PLACED IN SUCH A MANNER AS TO ALLOW FOR POSITIVE DRAINAGE TO AT LEAST ONE AREA WHERE WATER CAN FREELY DRAIN AWAY FROM THE BASE OF THE ROCK PAD.



B-B' CROSS SECTION

NOT TO SCALE



LEGEND

2:1
1.3%
SLOPE INDICATORS

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

CONCEPTUAL DRAWING
OF
EMBANKMENT
AND/OR
WASTE AREA
BLENDING AND DETAILS
DWG 6

LAST UPDATE: 02/27/2014

11/10/2014 11:38:18 AM
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TENNESSEE D.O.T.
DESIGN DIVISION
FILE NO. ——

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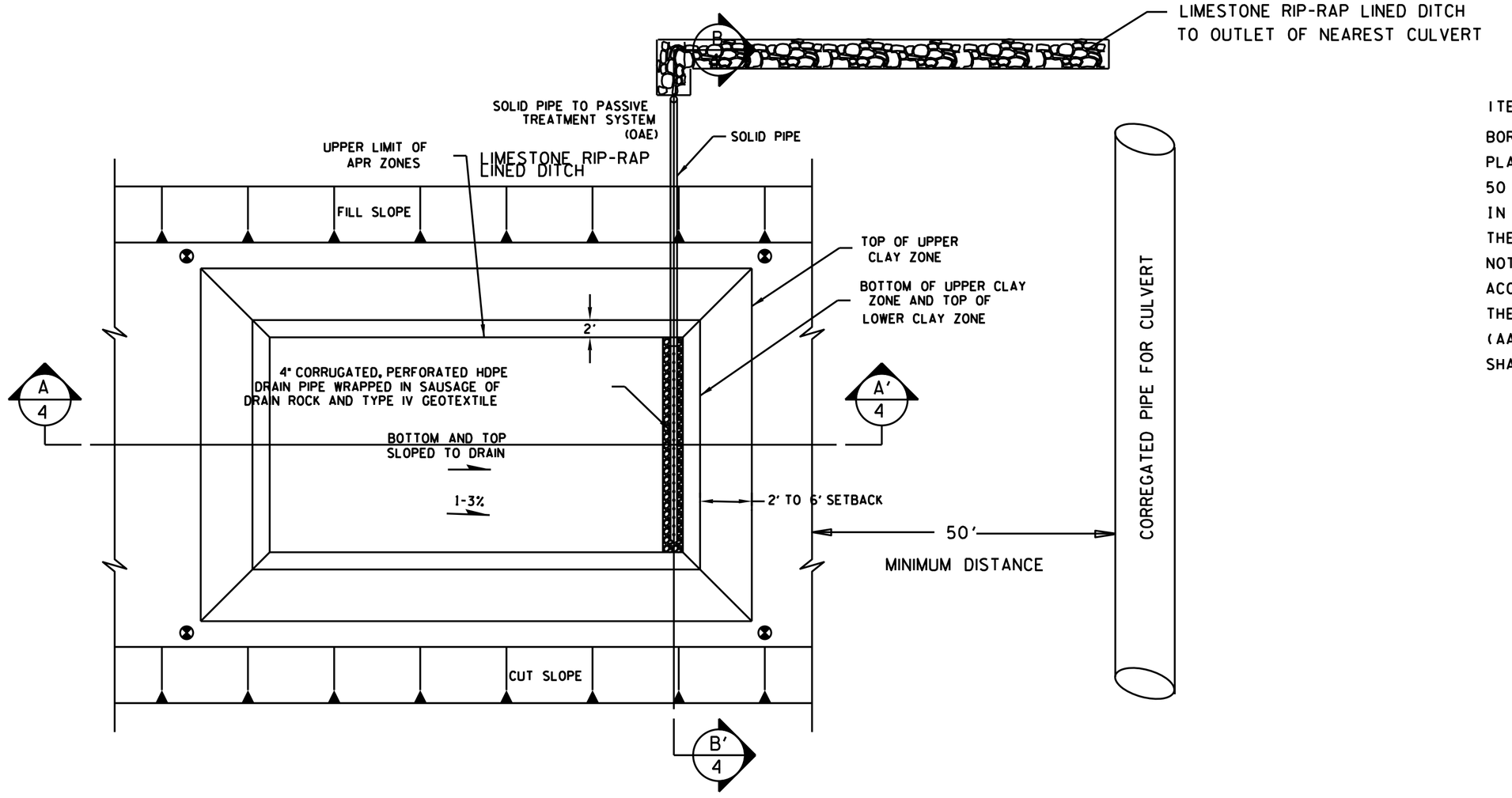
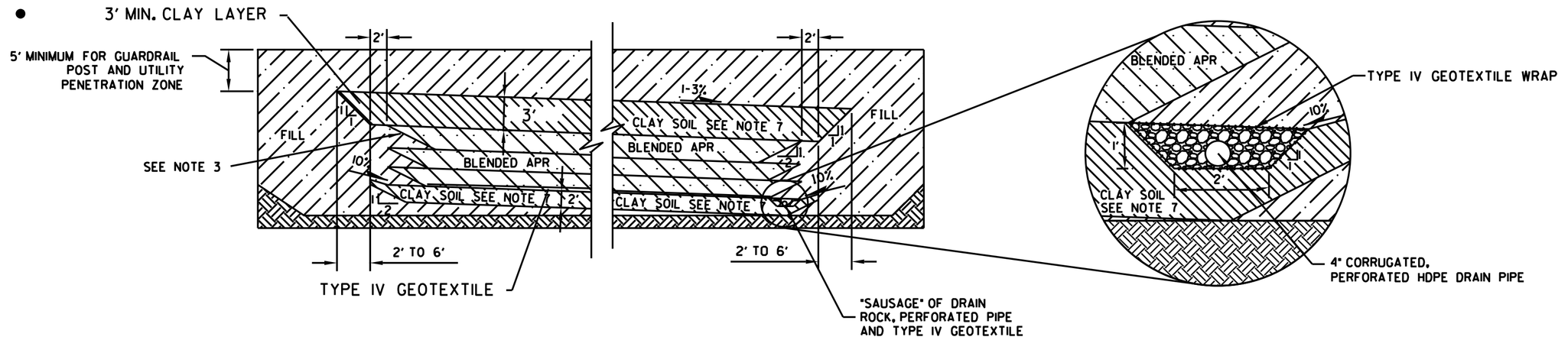


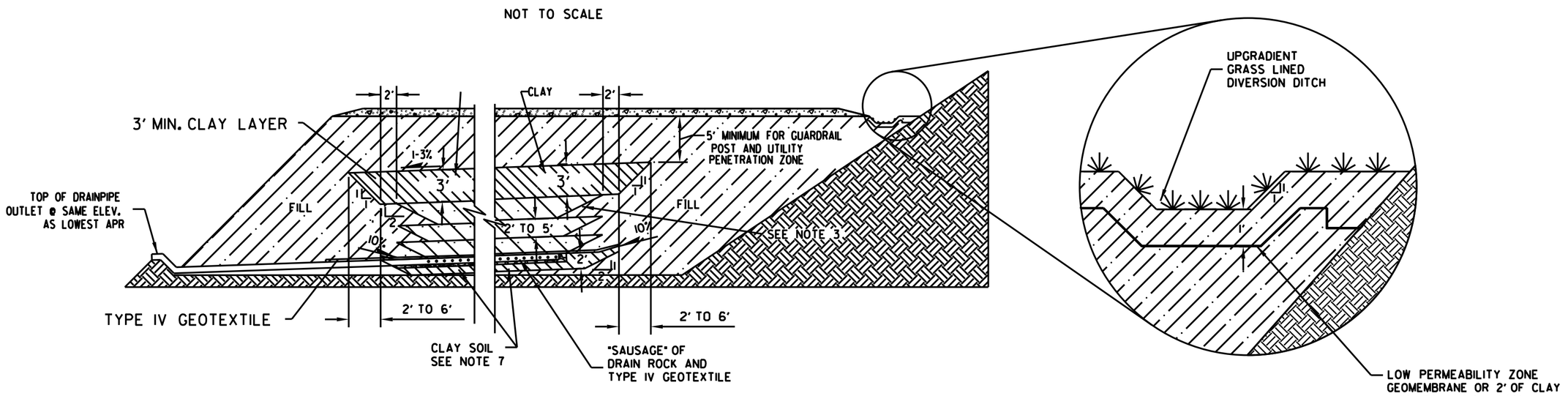
1/4 **PLAN VIEW OF FOR PARTIAL CAY ENCAPSULATION**

NOT TO SCALE



A-A' SECTION

NOT TO SCALE



B-B' SECTION

NOT TO SCALE

ITEM NO. 203-02.01 GRADED SOLID ROCK

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2. BOTTOM OF UPPER CLAY ZONE SHALL BE OFFSET AT LEAST 2 FEET OUTSIDE OF APR ZONE LIMITS.

3. THE APR PROFILE SHOWN PRESUMES THAT THE FILL ZONE LIFT IS PLACED TO GRADE PRIOR TO APR PLACEMENT. IF THE PLACEMENT SEQUENCE WAS REVERSED, A SLIGHTLY DIFFERENT PROFILE WOULD RESULT.

4. TDOT - APPROVED ENCAPSULATION MONUMENT/MARKERS SHALL BE LOCATED AT ALL 4 CORNERS OF ENCAPSULATION ZONE.

5. POTENTIAL APR SHALL BE BLENDED WITH AGRICULTURAL LIME OR APPROVED LIMESTONE SCREENINGS. BLENDED POTENTIAL APR SHALL BE COMPACTED TO CORFORM TO TDOT STANDARD SPECIFICATIONS. BLENDING RATE SHALL BE 750 LBS PER 1000 SQ.FT. OF LIFT AREA FOR NO MORE THAN 2 FOOT LIFTS.

6. LIMESTONE SCREENINGS SHALL HAVE CALCIUM CARBONATE ($CaCO_3$) CONTENT OF AT LEAST 95% AND SHALL BE PRE-APPROVED BY THE GEOTECHNICAL ENGINEERING SECTION. LESSER $CaCO_3$ CONTENT MAY BE ACCAPTABLE; HOWEVER, THIS WILL INCREASE THE BLENDING RATE. IN NO CASE WILL $CaCO_3$ CONTENT BE LESS THE 80%. BLENDING RATES FOR LIMESTONE SCREENINGS WITH $CaCO_3$ CONTENT FROM 80% TO LESS THAN 95% WILL BE GIVEN AFTER SUBMISSION OF LIMESTONE SCREENING SAMPLES TO THE GEOTECHNICAL ENGINEERING SECTION.

7. COMPACTED AASHTO CLASS A-6 OR A-7 WITH AT LEAST 50% PASSING THE NO. 200 SIEVE AND USCS CLASSIFICATION OF CH AND CL.

LEGEND

- COMMON ENGINEERED FILL
- BLENDED OR TREATED ACID PRODUCING ROCK (APR)
- DRAIN ROCK WRAPPED IN TYPE IV GEOTEXTILE
- GEOMEMBRANE - ITEM NO. 740-06.01
- TYPE IV GEOTEXTILE - ITEM NO. 740-10.04
- CLAY
- SUBGRADE
- ROADWAY BASE
- 2:1 / 1.5:1 SLOPE RATIO INDICATORS
- 5/3 DETAIL NUMBER / PAGE WHERE DETAIL IS CALLED OUT
- TDOT-APPROVED ENCAPSULATION MONUMENT/MARKERS (GIS REGISTERED)
- GRASS

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

PARTIAL ENCAPSULATION SITE

•

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APPENDIX 7

CORE RETENTION POLICY

APPENDIX 7 – CORE RETENTION GUIDELINES

GENERAL GUIDANCE

This document provides standard guidance on rock and concrete core sample labeling, photography, storage, and retention to be used in TDOT GES operations. The guidelines are to be used as reference to standard retention policy of rock and concrete core samples, as well as consistent storage procedures. This document is intended to apply to both rock and concrete core obtained by internal geotechnical personnel, drill crews, geotechnical consultants, and contractors.

Delivery: The following guidance applies to non-internal TDOT deliveries. Prior to core samples delivery (rock or concrete) e-mail a delivery request to TDOT Geotech TDOT.Geotech@tn.gov 48 hours in advance and an individualized response email will be returned with scheduling arrangements. If drilled shaft concrete core is being delivered, arrangements shall be solely coordinated through TDOT GES to ensure adequate personnel are available to unload (courtesy copy TDOT Structures TDOT.Structures@tn.gov in this email). The e-mail should contain the Pin No., CN number, and all other project information sufficient to identify the appropriate GES Project Monitor for that particular project. Depending upon the location of the project, the core sample delivery will be made to TDOT Region 1 Complex or Region 3 Complex (Building D\G). The delivery should arrive with the individualized email response affixed to the box. The delivery will be entered into the respective "GES Core Ledger" upon arrival. The core samples will be staged temporarily inside the Region 3 geotechnical drill shop or at Region 1 Materials and Tests testing laboratory. Under no circumstance should core be delivered or unloaded without approval from the GES. Improperly labeled core samples, or core that has not been fully documented, will not be accepted. See the following section on *Labeling, Orientation, and Photography of the Rock Core and Boxes* for accepted guidance.

Inspection: Any request to *inspect* concrete or rock core should also be scheduled and coordinated beforehand with TDOT GES, prior to inspection, using the e-mail TDOT Geotech TDOT.Geotech@tn.gov. All activity related to inspection shall be noted in the "GES Core Ledger" kept on-site.

Testing: Any rock or concrete samples that require testing by a laboratory shall be photographed indicating the sampling location in the core box, and then should be removed and an appropriate note should be permanently affixed to and within that box, and further denoted in the GES Core Ledger. Rock/concrete core samples should be placed in a suitable sample container and appropriately labeled. Any core samples to be tested in the TDOT Materials & Tests Division - Laboratory Section should be logged in at the receiving dock and the appropriate test should be assigned (for rock - ASTM D7012, Method C, and for concrete - ASTM C42/C42M). All core submitted for testing shall be photographed indicating the condition of the sample after preparation prior to compressive testing, and following compressive testing.

Safety: Due to the possibility of an allergic reaction to bites/stings, it should be noted that wasps and spiders are present at the current storage facilities. Delivery of samples to the drill crew shop bay should not be an issue. Two people shall be present when searching for or moving rock core in the storage area. Accessing of core shall be accomplished using forklift operation, limited to certified TDOT personnel.

STORAGE, INVENTORY, AND DISPOSAL OF CORE

General:

Prior to Pre-Construction Rock Core (from geotechnical investigations) being delivered for storage, the GES Project Monitor shall ensure adequate records of the final boring logs and photographs are saved in the electronic project file under the project Boring Logs folder. In addition, rock core samples required for testing shall be extracted prior to storage. Wooden blocks or other spacers, with pertinent information, shall be inserted to replace the core sample(s).

When any core is delivered, the GES Project Monitor shall coordinate with the GES Drill Crew Supervisor to ensure all core project information is recorded properly into the "GES Core Ledger". The specific location within the storage facility shall be recorded in the "GES Core Ledger."

All core boxes from the same project are to be stacked and stored together, with the project information easily visible. Pallets shall be labelled in such a manner that they can be readily retrieved if desired.

It is the responsibility of the GES Project Monitor to identify core for disposal and coordinate with the GES Drill Crew Supervisor. GES personnel will review PPRM quarterly to identify core for disposal. No core should be disposed of without approval from the GES Project Monitor.

Rock core or drilled shaft concrete core can be disposed in the concrete cylinder dump truck parked at the back dock. Core boxes can be placed in the dumpster near the sign shop.

Pre-Construction Rock Core - Roadway Alignment:

Storage\retention is generally **not required** for rock core samples collected for the purpose of roadway alignment investigations, such as those for slope design. Nor is the storage\retention of rock core required for purposes of sign or signal support or high mast lighting foundation designs. The rock core shall be properly boxed, labeled, and photographed in a consistent manner described in the guidance document. Once a test boring for a Roadway Alignment, as defined herein, is complete and the core properly boxed and photographed per the guidance provided herein, the rock core can be disposed on-site by placing the rock core back down the bore hole or otherwise properly disposed.

Pre-Construction Rock Core - Foundations:

Rock Core samples collected during the pre-construction phase for design of Foundations (including landslide retention structures) shall be delivered and in accordance with guidance herein. The core samples are then to be retained in one of the "Geotechnical Shop Bay" racks for bidding contractors to inspect and evaluate. After the contract has been awarded, the Pre-Construction Rock Core – Foundation samples may be disposed, *with the exception of those samples specifically associated with drilled shaft design*.

Construction – Drilled Shaft Verification Rock Core:

Prior to drilled shaft installation, the Contractor typically core drills each proposed drilled shaft foundation using NX or NQ size tooling or 4" PQ size. The purpose of these Drilled Shaft Verification Rock Core samples is to verify with greater certainty and accuracy the proposed drilled shaft tip elevation. The Drilled Shaft Verification Rock Core is to be delivered in accordance with this guidance document. Following GES evaluation, a drilled shaft tip elevations discussion will be delivered to TDOT Structures Division with recommendations of suitability in regard to quality. Following discussion and concurrence with these recommendations, TDOT Structures Division will deliver final drilled shaft tip elevations to TDOT Operations. The GES Project Monitor shall photograph the Construction – Drilled Shaft Verification Rock Core samples per guidance contained herein and SP 625.33. The samples are required to be retained in storage on one of the racks of the "Geotechnical Shop Bays." After the drilled shaft foundation pile tip elevation is accepted by the TDOT Structures Division the Drilled Shaft Verification Rock Core shall be disposed.

Construction – Drilled Shaft Concrete Core:

Drilled Shaft Concrete Core samples taken during the construction phase, for the purpose of this guideline, is defined as concrete core obtained by the Contractor and delivered per guidance contained herein for purposes of evaluation and temporary storage. Drilled Shaft Concrete Core shall be retained until the TDOT PPRM "Project Status" reflects "Closed".

LABELING, ORIENTATION, AND PHOTOGRAPHY OF THE ROCK CORE AND BOXES

Labeling of Pre-Construction Rock Core Boxes

Mandatory information for the outer sides of all boxes/lids:

- State Route, County, and Project Description (as given in the Work Order)
- Sub-description (Bridge No., Retaining Wall No., Pier No, Column No., etc.)
- PIN (Ex. 123456.00)
- Boring Number
- Station & Offset
- Box No.__ of ___
- Date Drilled (MM/DD/YY)
- GES Project Monitor

Labeling of Construction – Drilled Shaft Verification Rock Core Boxes

Special Provision 625 shall be followed. The tops and sides of all boxes should be clearly and permanently labeled.

Orientation and Labeling of Rock Core in Core Box

- Material arrangement shall start with the top of the hole at the upper left corner of the box (for hinged boxes, begin placement at row closest to the hinge line).
- Clearly mark the Run Number, beginning and end depths for each run, and other notable discontinuities' depth intervals (mud seams, voids, weathered zones, pyrite, etc.). Appropriate methods include labeling on the box or rock core, and inclusion of labeled wooden blocks and foam pipe insulation.
- Tape a resealable plastic (Ziploc) bag to the inside of the core box (Box No. 1), containing a copy of the completed boring log.

Photography of Core Boxes

- Photograph ALL rock core materials and ALL core boxes from EVERY boring
- The following information shall be included in the final photograph of the cores. This mandatory information may be written on the core box lid and included in the frame of the photograph, or may be inserted post-photographing, using photo editing software (PowerPoint, Adobe PDF, etc.). Ensure the entire core is visible after the insertion of any labels:
    - State Route, County, and Project Description (as given in the Work Order)
    - Sub-description (Bridge No., Retaining Wall No., Pier No, Column No., etc.)
    - PIN (Ex. 123456.00)
    - GES File Number- for pre-construction rock core (Ex. 1234567)
    - Boring Number

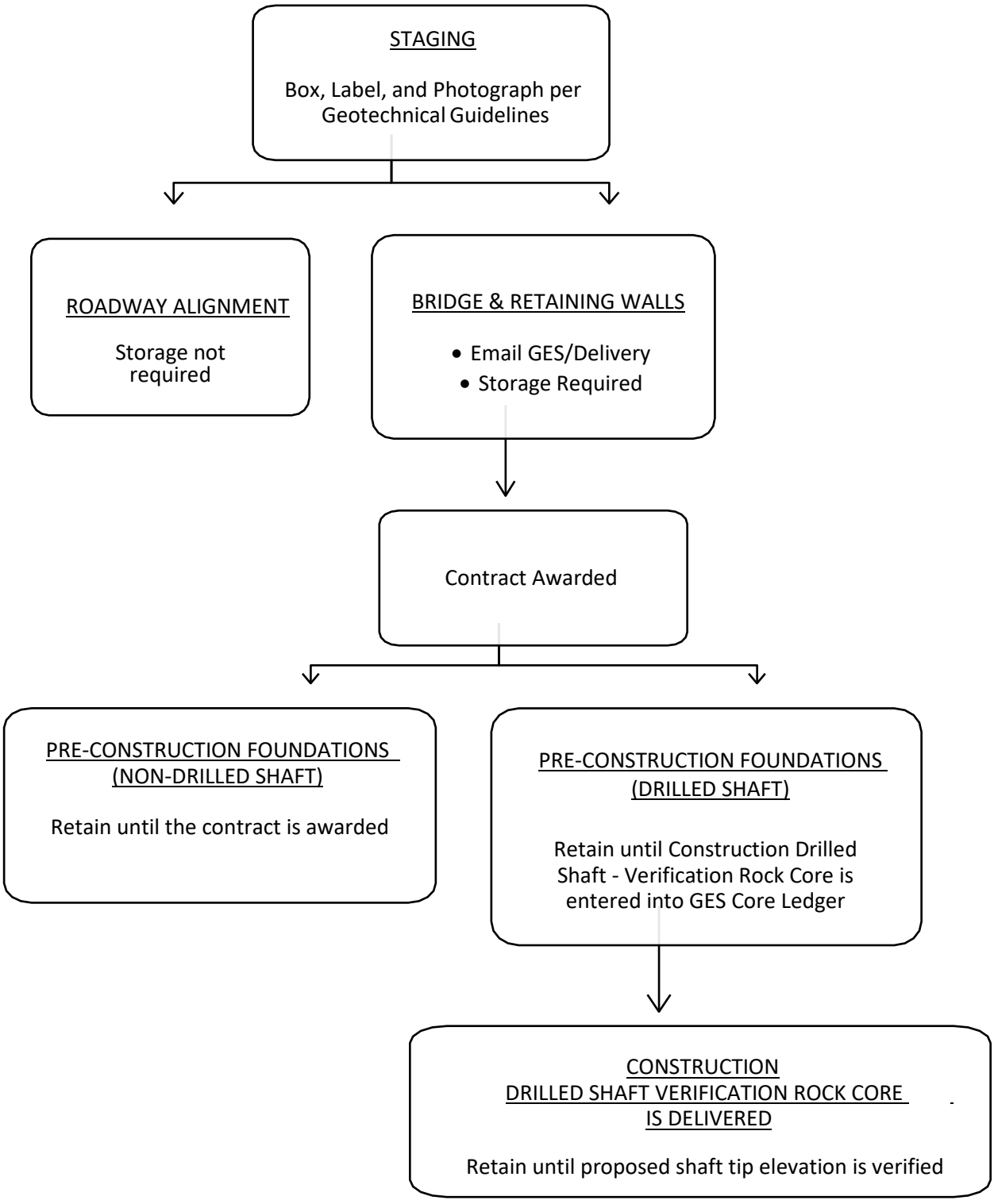
- Station & Offset
- Box No. __ of ____
- Date Drilled (MM/DD/YY)
- GES Project Monitor

- All core boxes should be photographed under natural light conditions. Shadows should not be seen in the photographs.
- To reduce distortion, the camera lens view of the core box should be perpendicular to, and centered between the ends of the box.
- Camera distance from the core box should be so that all information is clear and readable.
- A measuring scale should be shown on the top edge of every core box for size reference.
- All cores should be photographed before any samples are removed from the core box. Sections of core to be used as samples for rock core testing (strength, pyrite analysis, etc.) should be properly marked in the photograph.
- Any core removed from the box for testing shall be photographed indicating the sampling location, condition of the sample after preparation prior to compressive testing, and following compressive testing.

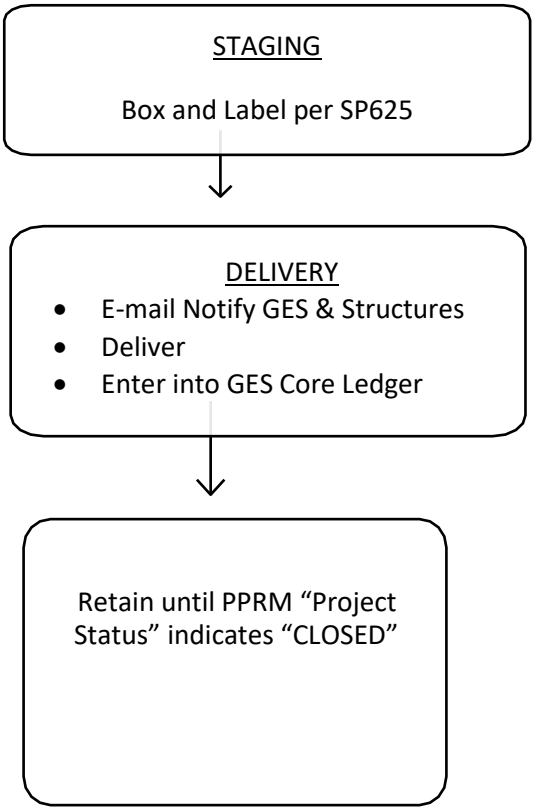
Figure 1. Properly labeled core box (top and sides) ready for storage

Figure 2. Properly labeled core and core box for photographic records

ROCK CORE RETENTION GUIDELINES



DRILLED SHAFT CONCRETE CORE RETENTION



APPENDIX 88

UNSTABUNSTABLE SLOPE MANAGEMENT PROGRAM

UNSTABLE SLOPE MANAGEMENT PROGRAM

TDOT MATERIALS & TESTS DIVISION, GEOTECHNICAL ENGINEERING SECTION

July 16, 2021

Geotechnical Engineering Section 6601 Centennial Boulevard Nashville, TN 37243-0360 **T** 615-350-4132 **F** 615-350-4128

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TDOT Unstable Slope Management Program

July 16, 2021

Tennessee Department of Transportation
Geotechnical Engineering Section
6601 Centennial Boulevard
Nashville, TN 37243-0360
615-350-4132

Executive Summary	This document describes the Tennessee Department of Transportation (TDOT) Unstable Slope Management Program (USMP). This program is dedicated to the mitigation of rock slope cuts and also include efforts to mitigate slope movements due to landslides on TDOT rights-of-way. The program intends to place priority on stabilizing slopes with the greatest risk to the public safety. Standardized rating procedures recognized by TDOT are presented. This document will be assessed and updated as required to meet the program needs and objectives of TDOT.

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CHAPTER 1: GENERAL

1.1 Unstable Slopes – Public Safety Threat

Roadway excavation cuts in rock can release loose debris and causing rock to fall into the roadway. Natural rock slopes also release loose rock debris into the roadway. This is attributed to weathering along existing joints and discontinuities. Freezing and thawing cycles often serve as the trigger that cause rockfall.

Three examples that lead rockfalls to be a public safety threat are described below:

1. Rock can strike a vehicle or person directly.
2. Rock can fall within the roadway and create an obstruction. In an attempt to avert the rock obstruction, automobile collisions occur.
3. Rockfall mitigation projects often require road closure and traffic is detoured onto non-arterial roads that have inadequate traffic capacity.

Slopes that consist of soil or soil \ rock debris can become unstable, as well. These unstable slopes can occur in compacted roadway embankment fills or excavation cuts. Slope movements precipitated by instability in soil \ rock debris are generally described as a landslide but may be described more specifically by industry professionals.

A great deal of Tennessee topography consists of mountainous terrain with an extreme vertical grade. To limit material usage, many roadways are built using a side-hill template roadway design. The side-hill template utilizes excavated cut slope material (soil, rock, debris) from one side of the roadway and uses it as embankment fill material on the other side of the roadway. With many Tennessee roadways built using this side-hill roadway template design approach, it is not uncommon to have risk for rockfall on one side of the road and risk for landside on the other.

1.2 Rock Slope Management History

Perhaps, it can be said that the TDOT Rockfall Management Program (RMP) began in earnest with the delivery of NHI course No. 13219 (1994) *Rockfall Hazard Mitigation Methods* to the TDOT Geotechnical Engineering Section staff in December 2000. FHWA developed the course and encouraged state DOT's to begin evaluating the rock slope hazard potential using a *standardized* rating system. The data derived from the rating system would be used as a decision tool to set funding priorities of rockfall mitigation projects.

Around the same time, research statements were being formulated between TDOT and the University of Tennessee for an inventory of TDOT rock slopes with accompanying rockfall risk ratings using the standardized system of FHWA, with minor modifications. Over two-thousand Tennessee rockfall sites were organized in a searchable database inventory. The research project began in 2001 and was then supplemented later to include a GIS component. Figure 1 –

Locations of “A” and “B” Sites and Table 1 – TDOT Regional Hazardous Rockfall Sites illustrate partial findings. The information collected from that research project began being used by TDOT to make informed decisions to identify rockfall mitigation projects to budget.

In 2007, TDOT programmed its first project described as a “Rockfall Remediation Project.” Programmatically, the rockfall remediation was categorized within “Safety” projects. Between then and about 2014, TDOT programmed twelve “Safety” contracts to remediate hazardous slopes proactively. During that period dozens of other rock slopes released rock into roadway and were mitigated reactively using whatever emergency funding sources were available.

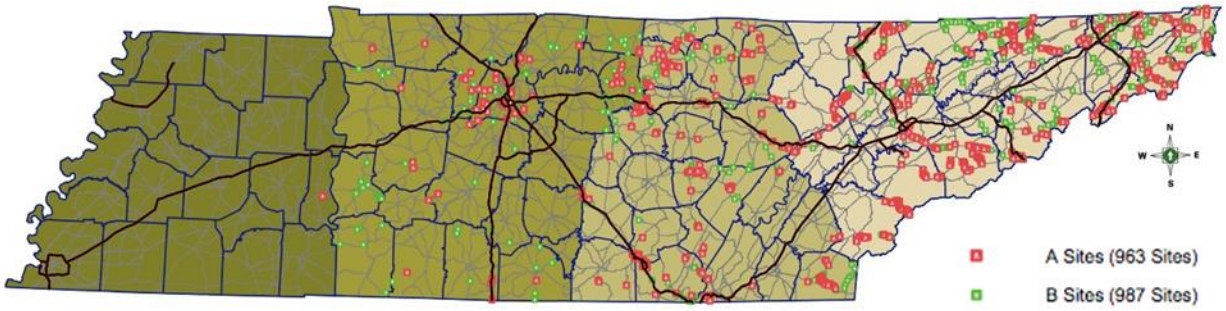


Figure 1
Locations of "A" and "B" Sites

Table 1
TDOT Regional Hazardous Rockfall Sites

Region	“A” Sites (High to Very High Risk)	“B” Sites (Moderate to High Risk)
1	582	629
2	288	166
3	100	188
4	2	1

Around 2013, TDOT procured a rockfall engineering consultant to re-rate the most hazardous rock slopes and evaluate any change in risk. The list became known internally as the “Top 46.” After years of unreliable funding mechanisms, Department leadership made a commitment in 2016 to reset the RMP, and rockfall mitigation project plans development began concentrating on the highest rated slopes from the “Top 46.” Since then three rockfall sites have been remediated, two other rockfall mitigation contracts have been let, and three additional sites are due for final plans turn-in the year of 2021.

1.3 Landslide Management History

Over years of roadway construction, TDOT has had many notable landslides occurring during construction and otherwise that impacted state roadways. Perhaps two of the most notable landslides to occur were related to the construction of I-40. The “Hartford Slide” in Cocke County (near the North Carolina state line) was activated soon after interstate construction in 1962. Afterward, in 1968, many landslides were activated in both the excavated cut slopes and embankment fill slopes near the city of Rockwood in Roane County as the alignment progressed up a great vertical grade. Over the years, TDOT has continued to react to stabilizing unstable landslide slopes after they occur.

In the year 2002, research performed by the University of Tennessee delivered a database to inventory landslides that occur on TDOT roadways statewide. And using this database structure delivered in that 2002 research, sites that reveal landslide risk could be given evaluation ratings and inventoried for mitigation work as funding becomes available, just as rockfall risks.

1.4 Need for Overall Slope Management Recognized

Following the floods of late February 2019, the first edition of the TDOT *Transportation Asset Management Plan* (TAMP) was released June 2019. The February 2019 floods triggered over a hundred slope movements due to landslides. The TDOT TAMP states an “organizational gap” exists between rock fall risks and landslide risks and directs a ‘Landslide Mitigation Program’ be established to address the unstable slopes due to landslides. With this direction an *Unstable Slope Management Program* (USMP) will be created.

This USMP effort has been made one of TDOT’s program initiatives for the state’s Office of Customer Focused Government (CFG). The work effort was even included as one of the few TDOT Strategic Goals of a TDOT employee’s Performance Plan. So, work outcome metrics are written specifically for tasks performed to support the “Landslide Mitigation Program.” So, filling this “organizational gap” and merging landslide risks into the Rockfall Management Program is felt important to TDOT.

CHAPTER 2: TDOT UNSTABLE SLOPE MANAGEMENT PRIORITIES

2.1 Rockfall Hazards Rating Score (RHRS)

To consistently evaluate the relative hazard "score" of rock slopes in a standardized manner, FHWA introduced a Rockfall Hazard Rating System (RHRS). The RHRS was introduced through an NHI instructional course offered to various state DOTs with rockfall hazards. As a result of the NHI course, TDOT modified the methods slightly, and adopted the TDOT Rockfall Hazard Rating System (TDOT RHRS). Subsequently, the TDOT RHRS Field Sheet, shown in Figure 2, was developed and this system shall be used exclusively on TDOT rock slopes.

Each potential rockfall site is rated individually using the TDOT RHRS Field Sheet. The field sheet gives eight different evaluation criteria. These criteria are an indication of the individual rockfall site characteristics. Even though the geologic characteristics of a site may be considered subjective between different raters, many of the other characteristics are straightforward objective observations such as ADT, ditch width, slope height, curve data, and site distance.

Using the TDOT RHRS Field Sheet, a total score is given relative to the hazardous condition of the rock slope. These scores range from 0 to a maximum of 800. Higher scores are indicative of greater rock slope hazard risks. Scores are further broken down by descriptive terms of risk potential in Table 2.

Table 2
Rockfall Rating Score and Corresponding Risk Potential

Score Range	Risk Description
<200	Low
200 - 350	Moderate
350 - 500	High Risk
>500	Very High

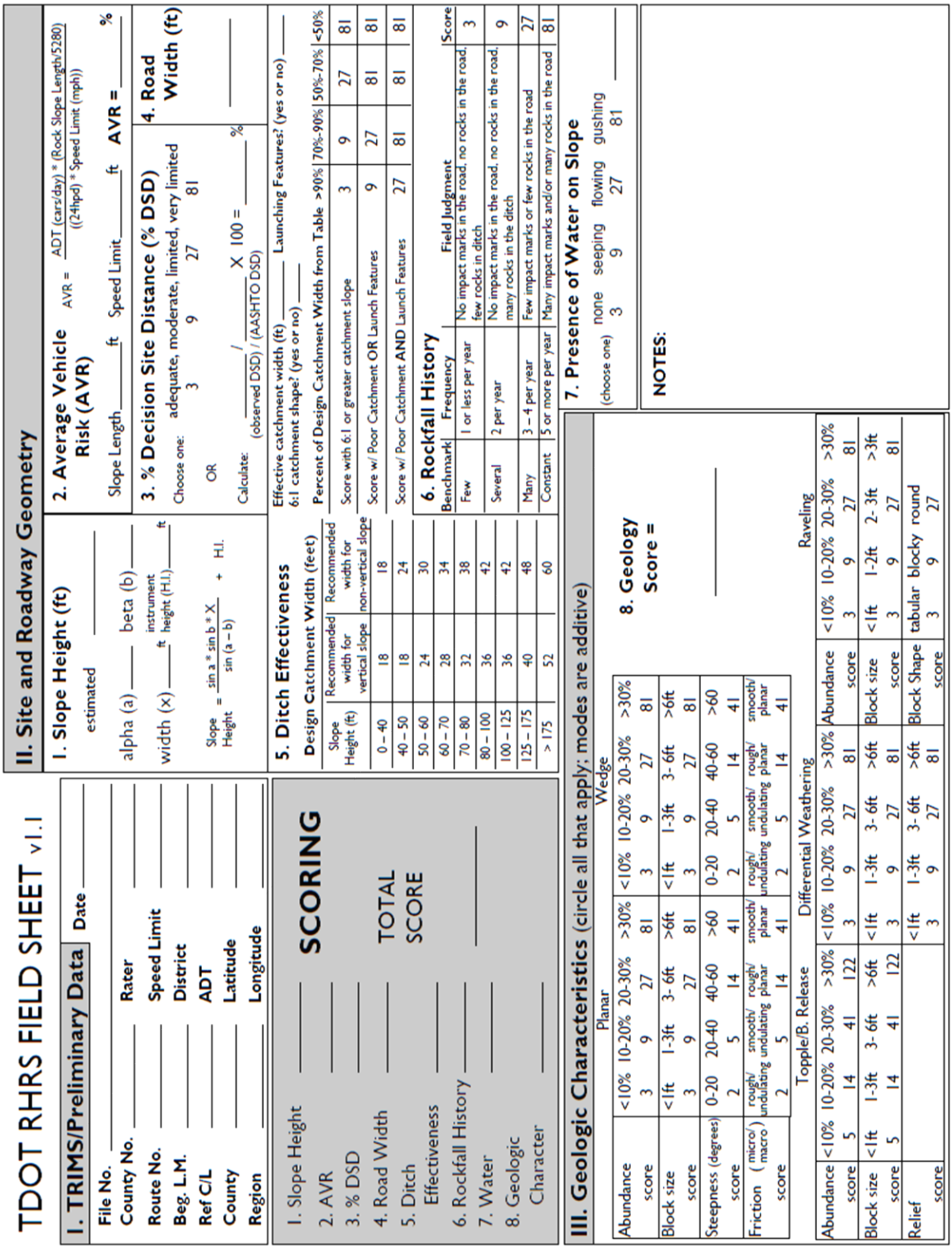


Figure 2
TDOT Rockfall Hazard Rating System Field Sheet

2.2 Landslide Rating Score

Unstable slope management programs (USMP) have been discussed since the 1990's and successfully implemented by a number of state DOT's. FHWA sponsored a research program and established the Federal Land Management Agencies (FLMA) USMP. The FMLA USMP that was created contains rating criteria for both rock slopes and soil\debris slope. TDOT chooses to adopt the FMLA USMP slope rating form for landsides and continue to use the standard RHRS system to rate rockfalls.

The FMLA USMP established a Landslide Field Rating Form in 2017 (Figure 3). It contains a scoring mechanism for landslide potential by rating different categories of risk. Notice that the Landslide Field Rating Form shown is divided into a Preliminary Rating on the left portion of Figure 3, and a Detailed Risk Rating on the right portion of Figure 3.

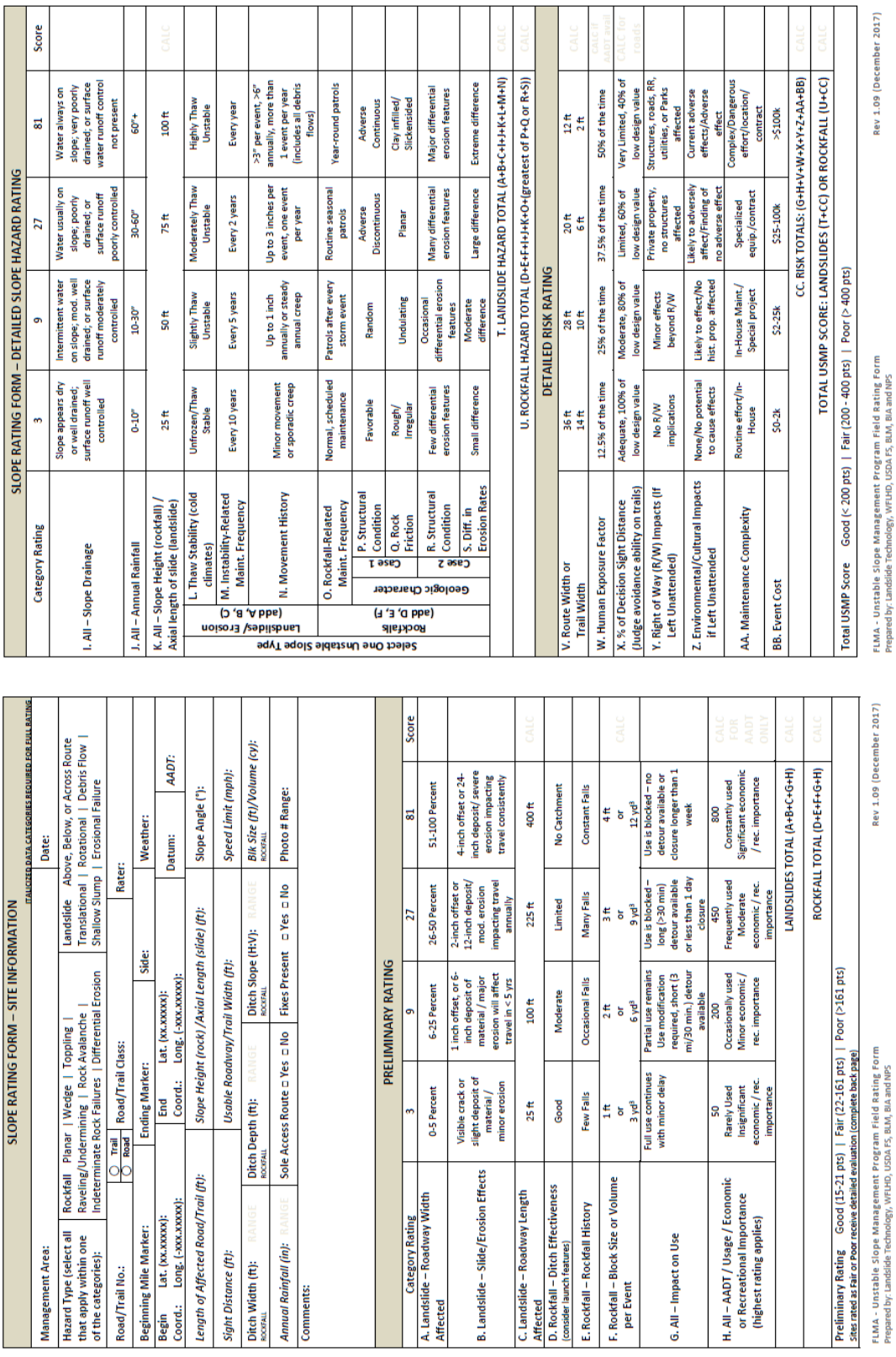
The Preliminary Rating considers characteristics in terms of categories such as roadway width affected by the distress, effects to the roadway surface, roadway length affected by the distress, and usage impacts. Note, how the risk category score increases exponentially. If a Preliminary Rating is evaluated 21 or higher, the Detailed Risk Rating is then also used.

The Detailed Risk Rating sums the Preliminary Rating with other Category Ratings including slope drainage, rainfall, slope height, maintenance history, movement history, and estimated cost of repair. General roadway geometric information like roadway width, AADT, exposure, sight distance, speed limit, right of way and environmental impacts are also considered in the Detailed Risk Rating. The score summation yields the Total USMP Score. Table 2A defines the degrees of slope stability with the associated slope's Total USMP Score.

The Rockfall Hazards Rating Score (RHRS) and the Total USMP Score both provide relative ratings that quantify risk relative to their respective slope type, but the two scores employ slightly different numerical rating systems and should not be considered numerically equivalent. The RHRS and the Total USMP Scores are risk tools that should be used with engineering judgement.

Table 2A
Total USMP Score: Landslides

Score Range	Description of Slope Stability
< 200	Good
200 - 400	Fair
> 400	Poor



SLOPE RATING FORM – SITE INFORMATION

(*ITALICIZED DATA CATEGORIES REQUIRED FOR FULL RATING*)

Management Area: Date:

Hazard Type (select all that apply within one of the categories): Rockfall | Planar | Wedge | Toppling | Raveling/Undermining | Rock Avalanche | Indeterminate Rock Failures | Differential Erosion | Landslide | Above, Below, or Across Route | Translational | Rotational | Debris Flow | Shallow Slump | Erosional Failure

Road/Trail No.: ○ Trail ○ Road | Road/Trail Class: | Rater:

Beginning Mile Marker: | Ending Marker: | Side: | Weather:

Begin Coord.: Lat. (xx.xxxxx): Long. (-xxx.xxxxx): | End Coord.: Lat. (xx.xxxxx): Long. (-xxx.xxxxx): | Datum: | *AADT:*

Length of Affected Road/Trail (ft): | *Slope Height (rock) /Axial Length (slide) (ft):* | Slope Angle (°):

Sight Distance (ft): | *Usable Roadway/Trail Width (ft):* | *Speed Limit (mph):*

Ditch Width (ft): RANGE ROCKFALL | Ditch Depth (ft): RANGE ROCKFALL | Ditch Slope (H:V): RANGE ROCKFALL | *Blk Size (ft)/Volume (cy):* ROCKFALL

Annual Rainfall (in): RANGE | Sole Access Route ☐ Yes ☐ No | Fixes Present ☐ Yes ☐ No | Photo # Range:

Comments:

PRELIMINARY RATING

Category Rating	3	9	27	81	Score
A. Landslide – Roadway Width Affected	0-5 Percent	6-25 Percent	26-50 Percent	51-100 Percent	
B. Landslide – Slide/Erosion Effects	Visible crack or slight deposit of material / minor erosion	1 inch offset, or 6-inch deposit of material / major erosion will affect travel in < 5 yrs	2-inch offset or 12-inch deposit/ mod. erosion impacting travel annually	4-inch offset or 24-inch deposit/ severe erosion impacting travel consistently	
C. Landslide – Roadway Length Affected	25 ft	100 ft	225 ft	400 ft	CALC
D. Rockfall – Ditch Effectiveness (consider launch features)	Good	Moderate	Limited	No Catchment	
E. Rockfall – Rockfall History	Few Falls	Occasional Falls	Many Falls	Constant Falls	
F. Rockfall – Block Size or Volume per Event	1 ft or 3 yd³	2 ft or 6 yd³	3 ft or 9 yd³	4 ft or 12 yd³	CALC
G. All – Impact on Use	Full use continues with minor delay	Partial use remains Use modification required, short (3 mi/30 min.) detour available	Use is blocked – long (>30 min) detour available or less than 1 day closure	Use is blocked – no detour available or closure longer than 1 week	
H. All – AADT / Usage / Economic or Recreational Importance (highest rating applies)	50 Rarely Used Insignificant economic / rec. importance	200 Occasionally used Minor economic / rec. importance	450 Frequently used Moderate economic / rec. importance	800 Constantly used Significant economic / rec. importance	CALC FOR AADT ONLY
LANDSLIDES TOTAL (A+B+C+G+H)					CALC
ROCKFALL TOTAL (D+E+F+G+H)					CALC

Preliminary Rating Good (15-21 pts) | Fair (22-161 pts) | Poor (>161 pts)

Sites rated as Fair or Poor receive detailed evaluation (complete back page)

FLMA - Unstable Slope Management Program Field Rating Form
Prepared by: Landslide Technology, WFLHD, USDA FS, BLM, BIA and NPS

Rev 1.09 (December 2017)

SLOPE RATING FORM – DETAILED SLOPE HAZARD RATING

Select One Unstable Slope Type				Category Rating	3	9	27	81	Score
				I. All – Slope Drainage	Slope appears dry or well drained; surface runoff well controlled	Intermittent water on slope; mod. well drained; or surface runoff moderately controlled	Water usually on slope; poorly drained; or surface runoff poorly controlled	Water always on slope; very poorly drained; or surface water runoff control not present	
				J. All – Annual Rainfall	0-10"	10-30"	30-60"	60"+	
				K. All – Slope Height (rockfall) / Axial length of slide (landslide)	25 ft	50 ft	75 ft	100 ft	CALC
Landslide/ Erosion (add A, B, C)				L. Thaw Stability (cold climates)	Unfrozen/Thaw Stable	Slightly Thaw Unstable	Moderately Thaw Unstable	Highly Thaw Unstable	
				M. Instability-Related Maint. Frequency	Every 10 years	Every 5 years	Every 2 years	Every year	
				N. Movement History	Minor movement or sporadic creep	Up to 1 inch annually or steady annual creep	Up to 3 inches per event, one event per year	>3" per event, >6" annually, more than 1 event per year (includes all debris flows)	
Rockfalls (add D, E, F)	Geologic Character	Case 1	O. Rockfall-Related Maint. Frequency		Normal, scheduled maintenance	Patrols after every storm event	Routine seasonal patrols	Year-round patrols	
			P. Structural Condition		Favorable	Random	Adverse Discontinuous	Adverse Continuous	
		Case 2	Q. Rock Friction		Rough/ Irregular	Undulating	Planar	Clay infilled/ Slickensided	
			R. Structural Condition		Few differential erosion features	Occasional differential erosion features	Many differential erosion features	Major differential erosion features	
			S. Diff. in Erosion Rates		Small difference	Moderate difference	Large difference	Extreme difference	
T. LANDSLIDE HAZARD TOTAL (A+B+C+I+J+K+L+M+N)									CALC
U. ROCKFALL HAZARD TOTAL (D+E+F+I+J+K+O+(greatest of P+Q or R+S))									CALC

DETAILED RISK RATING

V. Route Width or Trail Width	36 ft 14 ft	28 ft 10 ft	20 ft 6 ft	12 ft 2 ft	CALC
W. Human Exposure Factor	12.5% of the time	25% of the time	37.5% of the time	50% of the time	CALC AADT avail
X. % of Decision Sight Distance (Judge avoidance ability on trails)	Adequate, 100% of low design value	Moderate, 80% of low design value	Limited, 60% of low design value	Very Limited, 40% of low design value	CALC AADT avail
Y. Right of Way (R/W) Impacts (If Left Unattended)	No R/W implications	Minor effects beyond R/W	Private property, no structures affected	Structures, roads, RR, utilities, or Parks affected	
Z. Environmental/Cultural Impacts if Left Unattended	None/No potential to cause effects	Likely to effect/No hist. prop. affected	Likely to adversely affect/Finding of no adverse effect	Current adverse effects/Adverse effect	
AA. Maintenance Complexity	Routine effort/In-House	In-House Maint./ Special project	Specialized equip./contract	Complex/Dangerous effort/location/ contract	
BB. Event Cost	$0-2k	$2-25k	$25-100k	>$100k	
CC. RISK TOTALS: (G+H+V+W+X+Y+Z+AA+BB)					CALC
TOTAL USMP SCORE: LANDSLIDES (T+CC) OR ROCKFALL (U+CC)					CALC

Total USMP Score Good (< 200 pts) | Fair (200 - 400 pts) | Poor (> 400 pts)

FLMA - Unstable Slope Management Program Field Rating Form
Prepared by: Landslide Technology, WFLHD, USDA FS, BLM, BIA and NPS

Rev 1.09 (December 2017)

Figure 3
Landslide Field Rating Form

2.3 Construction Plans Preparation for Rockfall \ Landslide Mitigation

Based on the data driven scores of the TDOT RHRS and Total USMP Score, with collaboration of key personnel of TDOT Regional Operations Divisions, a list of unstable slope mitigation projects is made. The list of projects are to be programmed in PPRM. Like most transportation improvement projects, the plans development of the unstable slope mitigation projects is driven by TDOT's Project Development Division (PDD). After selection and programming of a particular project, a kickoff meeting is scheduled so PDD can begin making arrangements to develop a schedule, securing necessary permits, acquiring necessary R.O.W., develop a temporary traffic control plan, and all other roadway design issues. At any time during the plans development, GES will be available to provide assistance to these unique projects, but at the appropriate schedule, GES will provide the Soils & Geology Report and insert Geotechnical Sheets and Estimated Quantities into the R.O.W. and\or Construction Plans.

Guidance documents to be used in developing plans for unstable slope mitigation projects include usual references such as TDOT Standard Specifications for Roadway and Bridge Construction (TDOT Standard Specifications), TDOT Design Guidelines, TDOT Standard Drawings, and relevant Special Provisions (SPs). In addition, other TDOT reference guidance necessary for geo-professionals is contained in this document and the TDOT Geotechnical Guidelines.

Appendix B describes common rockfall mitigation methods.

Special Provisions (SPs) have been developed for some of the common rockfall stabilization applications. These SPs are presented in Table 3. Refer to the SPs for standardization, convenience, consistency, and clarity. SPs establish the contractual basis of payment, in terms of the unit bid item numbers and the unit of quantity measurement. If ever a discrepancy, the TDOT Standard Specifications Section 105.4 stipulates the SPs supersede the Construction Plans and the TDOT Standard Specifications. For this reason, repetition of notes or other information between the Construction Plans and SPs should be carefully considered. So, if any of the applications contained in Table 3 are to be used in the scope of work, the SPs should be thoroughly reviewed and understood.

Table 3
TDOT Special Provisions for Rockfall Mitigation

Designation	Title
SP203E	Regarding Scaling and Trimming
SP707D	Regarding Rockfall Slope Drape
SP707E	Regarding Pinned Rockfall Slope Mesh
SP707H	Regarding Rockfall Barrier Systems

Table 4 lists the bid items found in the SPs and provides other useful bid items that are often used on unstable slope mitigation projects. If there is ever information that is felt necessary clarify a bid item's intent, it should be appropriately footnoted on one of the Estimated Quantities sheets.

2.4 Statewide Contract 191 (SWC-191) Slope Stabilization

Since about 2014, TDOT's Engineering Operations Division has administered a contract to stabilize landslide slopes that are rated Poor. The slopes stabilized are relatively small in scale. Typically, the stabilization application is a soil nail wall, constructed top-down, with a shotcrete face. Many roadways in the state are constructed with a hill side template geometry. Over years of lane widening, the fill embankment side becomes over steepened which causes sloughing and leads to a slope failure on the outside. Many embankments have been stabilized and guardrail safely installed using this contract. SWC-191 will be strategically used to repair slopes rated as having Fair or Poor stability.

Table 4
Rockfall Mitigation Pay Item Numbers

COMMON ROCKFALL MITIGATION ITEM NUMBERS		
ITEM NO.	**DESCRIPTION**	**UNIT**
PAY ITEMS FOR SP203E "REGARDING SCALING AND TRIMMING"		
203-01	ROAD & DRAINAGE EXCAVATION (UNCLASSIFIED)	C.Y.
203-11	SCALING AND TRIMMING	S.Y.
PAY ITEMS FOR SP707D "REGARDING ROCKFALL SLOPE DRAPE"		
707-02.41	ROCK ANCHOR, TYPE I	EACH
707-02.42	ROCK ANCHOR, TYPE II	EACH
707-02.43	ROCK ANCHOR, TYPE I	L.F.
707-02.44	ROCK ANCHOR, TYPE II	L.F.
707-10.05	ROCKFALL DRAPE (TYPE I)	S.Y.
707-10.06	ROCKFALL DRAPE (TYPE II)	S.Y.
707-10.07	ROCKFALL DRAPE (TYPE III)	S.Y.
707-10.21	ROCKFALL DRAPE TYPE IV (A)	S.Y.
707-10.22	ROCKFALL DRAPE TYPE IV (B)	S.Y.
PAY ITEMS FOR SP707E "REGARDING PINNED ROCKFALL SLOPE MESH"		
203-40.01	ROCK ANCHORS (FOR PINNED MESH)	EACH
203-40.02	ROCK ANCHORS (FOR PINNED MESH)	L.F.
707-02.41	ROCK ANCHOR, TYPE I	EACH
707-02.42	ROCK ANCHOR, TYPE II	EACH
707-02.43	ROCK ANCHOR, TYPE I	L.F.
707-02.44	ROCK ANCHOR, TYPE II	L.F.
707-10.05	ROCKFALL DRAPE (TYPE I)	S.Y.
707-10.06	ROCKFALL DRAPE (TYPE II)	S.Y.
707-10.07	ROCKFALL DRAPE (TYPE III)	S.Y
PAY ITEMS FOR SP707H "REGARDING ROCKFALL BARRIER SYSTEMS"		
707-10.01	ROCKFALL FENCE (TYPE I)	L.F.
707-10.02	ROCKFALL FENCE (TYPE II)	L.F.
707-10.03	ROCKFALL FENCE (TYPE III)	L.F.
707-10.04	ROCKFALL FENCE (TYPE IV)	L.F.
707-10.08	WIRE MESH (DESCRIPTION)	S.Y.
OTHER USEFUL ROCKFALL MITIGATION PAYMENT ITEM NUMBERS		
203-01	ROAD & DRAINAGE EXCAVATION (UNCLASSIFIED)	C.Y.
203-01.01	ROAD & DRAINAGE EXCAVATION (SLIDE AREA)	C.Y.
203-01.07	RD & DRNG EXCV (ACID PRODUCING- OFF SITE	C.Y.
203-01.08	RD & DRNG EXCV (ACID PRODUCING- ON SITE	C.Y.
203-01.09	ACID PRODUCING MATERIAL HAUL & TIP FEE	TON
203-01.11	PRESPLITTING OF ROCK EXCAVATION	S.Y.
203-01.12	ORIENTED PRESPLITTING OF ROCK EXCAVATION	S.Y.
203-02.01	BORROW EXCAVATION (GRADED SOLID ROCK)	TON
203-02.02	BORROW EXCAVATION (GRADED SOLID ROCK)	C.Y.
203-40.02	ROCK ANCHORS (DESCRIPTION)	L.F.
203-40.03	ROCK ANCHORS (DESCRIPTION)	L.F.
203-40.04	ROCK ANCHORS (DESCRIPTION)	L.F.
203-40.05	DRILLING	L.F.
203-40.15	POST TENSION ROCK BOLT	L.F.
203-40.16	ROCK BOLT PULL TEST	EACH
203-40.17	ROCK DOWEL	L.F.
610-12.01	HORIZONTAL DRAINS AND CASING	L.F.
610-12.02	HORIZONTAL DRAINS	L.F.
610-12.03	HORIZONTAL DRAIN OUTLET	EACH
622-01.01	SHOTCRETE BUTTRESS	C.Y.
622-01.02	STEEL REINFORCEMENT- SHOTCRETE BUTTRESS	LB.
622-01.05	SHOTCRETE 6 IN THICKNESS	S.F.
622-01.06	SHOTCRETE 12 IN THICKNESS	S.F.
622-02.01	STEEL MESH & PLATES	S.F.
805-05.01	LAUNCHED SOIL NAIL	EACH
805-05.02	SOIL NAIL STABILIZATION	L.F.
805-05.03	REINFORCED SHOTCRETE FACING	S.F.
805-10.01	ROCK SLOPE WIRE MESH W/EROSION BLANKET	S.F.

CHAPTER 3: MONITORING OF TDOT UNSTABLE SLOPE SITES

3.1 Reassessment of Rock Slope Risk Ratings

TDOT GES is responsible for keeping the rockfall database inventory current. The frequency that rated rock slopes will be monitored by re-rating will be determined in general accordance with Table 5.

Table 5
USMP: Rockfall Score Reevaluation Frequency

TDOT RHRS	Reevaluate
<300	As Requested
300 - 500	Every 5 years
>500	Every 3 years

3.2 Assessment of Landslide Slope Risk Ratings

TDOT GES will be responsible for keeping the landslide database inventory current. As landslide ratings are accumulated, different courses of action are likely to occur. Immediate courses of action, such as full-scale mitigation contract or in-house maintenance could be required. Otherwise, the frequency that rated landslide slopes will be monitored by re-rating will be determined in general accordance with Table 6.

Table 6
Total USMP Score: Landslides

Total USMP: Landslide Score	Description
< 200	As Requested
200 - 400	Every 5 years
> 400	Every 3 years

3.3 Unstable Slopes without Risk Rating

Though over 2,000 rockfall sites are monitored in the GES rockfall database, it is not uncommon to be notified of a non-monitored slope posing risk. Typical notifications arrive from the TDOT Operations Division - Maintenance forces, but concerned motorists also provide useful notifications. When notified of an unstable slope, TDOT GES standard procedure is to make an initial site visit and preliminarily evaluate the slope conditions. The subsequent steps could vary from immediate slope repair or perform a slope rating.

3.4 Unstable Slope Monitoring

Often, fiscal resources are not immediately available to repair rock slopes described as having high to very high risk, or soil\debris slopes described as having fair or poor stability. In many cases, slope monitoring should be implemented.

The level of slope monitoring required is dependent upon the data sought. Slope monitoring objectives should be made on a site by site basis. Visual monitoring is adequate for most slopes. Other higher risk slopes should justify sophisticated monitoring using advanced instrumentation. The level of slope monitoring required should generally correspond to level of risk of the slope and the consequences of the slope failing.

Most slope assets owned by TDOT are monitored visually. Over two-thousand rock slopes have been monitored based on the standard rating system recommended by FHWA. TDOT GES maintains a slope inclinometer monitoring system for a few sites, to primarily identify the pace of and the depth of slope movement. As water is a key component in slope movements, piezometers are used by TDOT GES to understand water level\pressure, as well.

It seems that fiscal resources for transportation projects will always be limited, and there will always be a need to “do more with less.” Many advances in slope monitoring applications that are available were not available ten years ago, and this trend will likely not change. Using guidance from documents such as NCHRP Synthesis 554 *Advances in Unstable Slope Instrumentation and Monitoring* (2020), TDOT intends to implement slope monitoring as another tool to manage TDOT slope assets.

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APPENDICES

Appendix A

Memorandum – Re: TDOT Rockfall Management Program
and Project Development

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
BUREAU OF ENGINEERING
SUITE 700, JAMES K. POLK BUILDING
505 DEADERICK STREET
NASHVILLE, TENNESSEE 37243-1402
(615) 741-0791

JOHN C. SCHROER
COMMISSIONER

BILL HASLAM
GOVERNOR

MEMORANDUM

DATE: July 12, 2017

TO: Assistant Chief Engineers/Regional Directors
Regional Directors of Project Development

FROM: Paul D. Degges, P.E.
Deputy Commissioner and Chief Engineer

RE: **TDOT Rockfall Management Program and Project Development**

TDOT implemented its Rockfall Management Program (RMP) in 2007 to address potentially hazardous sites where rock, dirt and other slope materials may fall into the roadway. The program had been funded at $2 million per year. Beginning this year however, I have already appropriated $10 million in State funds and an additional $10 million dollars in Federal funds will be appropriated in each of the next three years in the FY2018-2020 Comprehensive Multimodal Program. The Headquarters Materials and Tests Division/Geotechnical Engineering Section (GES) is responsible for implementing the RMP. This includes regular monitoring of the ~2,000 sites already evaluated and identification of new potential rockfall sites. The GES is also responsible for developing the prioritized list of mitigation projects and developing the rockfall mitigation measures for these projects.

The Regional Directors of Project Development will be responsible for the project development and delivery of the projects in PPRM and serve as the primary point of contact. These projects are to be included in the Top Management Report for proper monitoring and schedule delivery. Rockfall mitigation projects will also need to be coordinated with other projects under development within the regions. It is my intention that these mitigation projects be streamlined as efficiently as possible so that the available funds are spent on eliminating and minimizing these potential risks as soon as possible. It is also my intent that we have several mitigation projects completed and "on the shelf" ready for letting if additional funding, state or federal, becomes available. Most, if not all, projects will be environmentally classified as Categorical Exclusions, and many will be on existing TDOT Right of Way (ROW).

Therefore, the GES section will coordinate with regions to finalize the lists of prioritized projects for development and the anticipated letting schedules. The RMP is a working document and due to reevaluation of potential rockfall sites, priority projects may change during the annual re-assessments. The GES and Regions will also work together to establish the budgeted costs for Preliminary Engineering, ROW, and Construction so the available funding is proficiently utilized.
While this program is only a small portion of our funding, it is essential that we complete these projects to keep our roadways as safe as possible and potential hazardous locations are mitigated.

PDD/WR/jj

Cc: Mr. Jeff Jones, Mr. Will Reid, Mr. Brian Egan, Ms. Jennifer Lloyd, Mr. Jerry Hatcher, Ms. Susannah Kniazewycz, Mr. Jeff Hoge, Mr. Ronnie Porter

Appendix B

Description of Rockfall Mitigation Technique

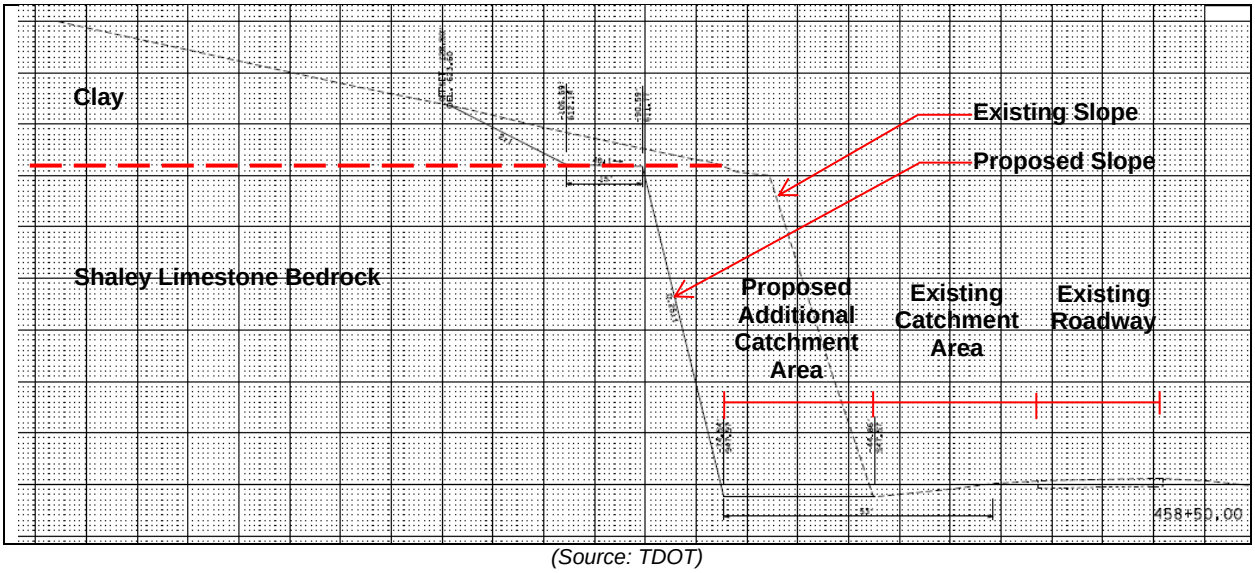
Description of Mitigation Techniques

For highway applications, the purpose of rockfall mitigation is to reduce the potential for rockfall to occur (stabilization), or to control rockfalls once they occur, thereby reducing the potential for rockfall to enter the roadway or other facility (protection). Because protection methods allow rockfall to occur, periodic maintenance of the slope and catchment area is required. Descriptions and illustrations of several rockfall mitigation techniques are presented in this appendix.

Mitigation Method: Cut Back Slope

Mitigation Category: Stabilization

This technique can be used to "shift" the rock slope further from the roadway. Blasting is used to cut the slope further from the existing roadway, thereby creating additional rockfall catchment area at the base of the slope (Figure 1). Another common technique is to flatten the existing slope to a more stable configuration. These techniques frequently require purchase of additional right-of-way. Other considerations may include utility relocation and traffic maintenance during construction.



(Source: TDOT)

Figure 1

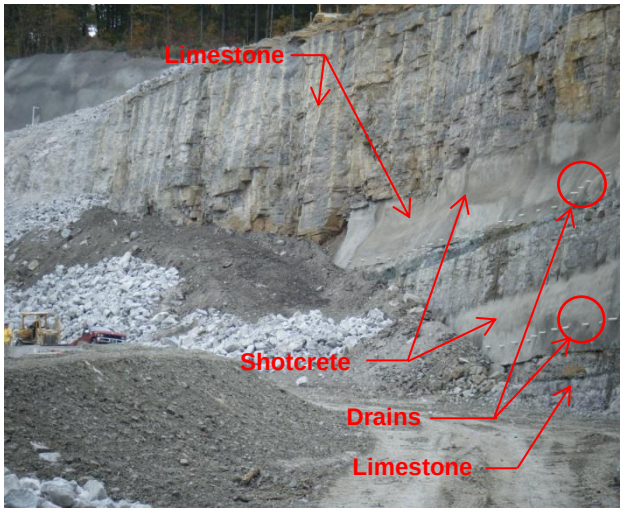
Mitigation Method: Rock Bolting
Mitigation Category: Stabilization

Rock bolting may be used to stabilize a large unstable piece of rock in place, rather than bringing it down using blasting or other mechanical means. Rock bolts are long anchor bolts which are installed through the large unstable piece rock and into the massive bedrock behind the unstable rock, thereby attaching the unstable piece to the larger rock mass. Rock bolts are typically installed in a series with design lengths and spacing specified in the project plans. Figure 2 depicts installation of rock bolts.	

(Source: Transportation Research Board, Rockfall Characterization and Control, 2012)

Figure 2

Mitigation Method: Shotcrete
Mitigation Category: Stabilization

Shotcrete (a concrete or mortar that is spray-applied) may be applied to the face of highly erodible rock units (such as shale), particularly when the highly erodible unit underlies a more competent rock unit (such as a stable face of limestone or sandstone). Exposure to air and water accelerates the weathering process, and the shotcrete protects the highly erodible rock from exposure. Shotcrete provides little structural support. Drains are installed through the shotcrete face to prevent buildup of water pressure behind the shotcrete. The lifespan of this type of treatment varies, but future reapplication of shotcrete should be expected.	

(Source: TDOT)

Figure 3

Mitigation Method: Scaling
Mitigation Category: Stabilization

Scaling is the removal of overhanging, protruding, loose, and unstable rock from an existing slope. Scaling may be selected as the only treatment for a particular project. However, scaling is always performed following selected stabilization measures, such as cutting back the slope, and prior to installation of other stabilization measures, such as slope drape, pinned mesh, rockfall fence, and shotcrete.

Hand-scaling (Figures 4-6) is performed by experienced personnel hanging from ropes or working from a basket on a crane, and using pry bars, hydraulic splitters, air bags, or chemical expanders (expansive grout).

Mechanical scaling is performed using power equipment, such as trackhoes. Another common mechanical scaling method is dragging a heavy object, such as a blasting mat, crawler track (Figure 7), or slusher (Figure 8), across the slope, or up and down the slope, to abrade loose rocks.

Personnel are hand-scaling from ropes.	

(Source: FHWA Rockfall Hazards Mitigation Methods Participant Workbook, March 1994)

Figure 4

Mitigation Method: Scaling (Continued)

Personnel are hand-scaling from a basket mounted on a telescoping boom vehicle.	

(Source: FHWA Rockfall Hazards Mitigation Methods Participant Workbook, March 1994)

Figure 5

In Figure 6, personnel are positioning an air pillow in the crack between a large piece of potentially unstable rock and the intact rock face behind it. Once in position, the air pillow will be inflated, thereby dislodging the potentially unstable rock.

(Source: YouTube, WSDOT Rock Scaling on Sherman Pass)

Figure 6

Mitigation Method: Scaling (Continued)

Crawler tracks (e.g., tracks found on a bulldozer or an excavator) are being dragged across the rock face with a crane to abrade or slough larger loose rocks. Final hand scaling may be required to remove smaller rocks.	

(Source: FHWA Rockfall Hazards Mitigation Methods Participant Workbook, March 1994)

Figure 7

A slusher is a bucket-type device that has cutting teeth on one edge, similar to a trackhoe bucket. A cable and pulley system is used to raise and lower the slusher on a slope, dislodging loose rock and other debris. Figure 8 depicts a slusher on its trip down the slope.	

(Source: TDOT)

Figure 8

Mitigation Method: Trimming
Mitigation Category: Stabilization

Trimming is the process of removing overhangs of loose rock, unstable rock, or both, from a slope by mechanical percussion (e.g., hydraulic rock breakers) and/or blasting methods.

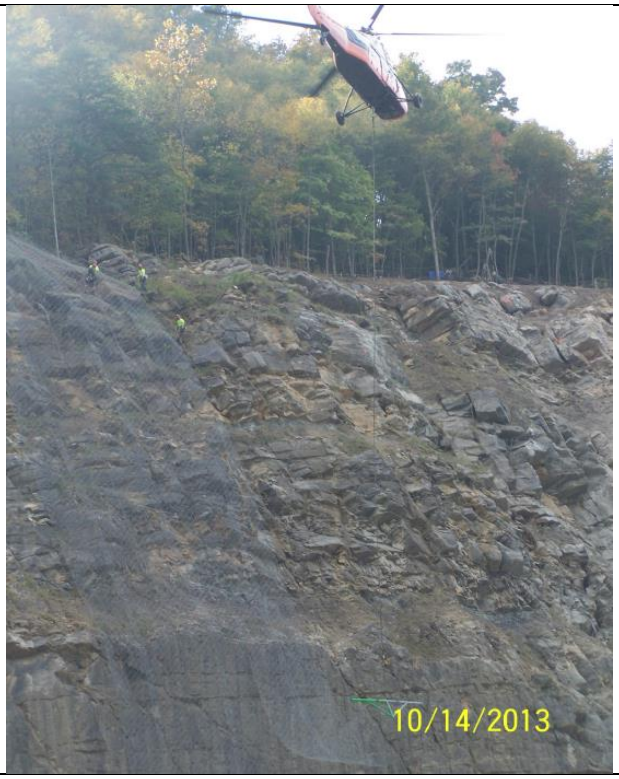
Long-reach excavators (trackhoes) fitted with hydraulic rock breakers ("hoe rams") are operating from the top of the slope (mid-photo) and from the bottom of the slope (boom arm is mid-photo, cab is to the right, out of photo) to remove loose and protruding rock from the slope.	

(Source: FHWA Rockfall Hazards Mitigation Methods Participant Workbook, March 1994)

Figure 9

Mitigation Method: Rockfall Slope Drape
Mitigation Category: Protection

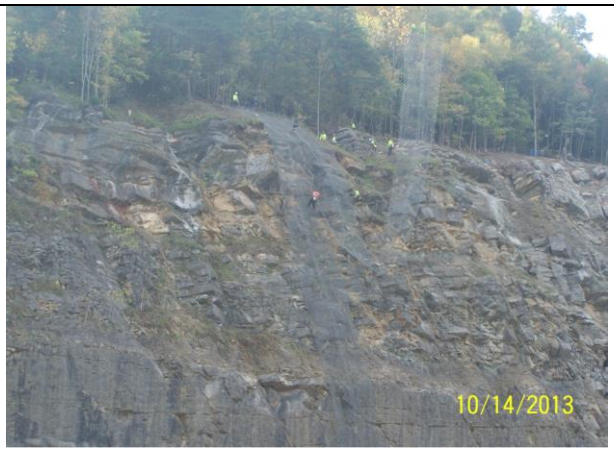
Rockfall slope drape, typically consisting of wire mesh, cable net, or rope net, is draped across a rock slope to prevent rock fall from entering the roadway. The slope drape hangs loose just above the bottom of the slope, thereby directing rock fall to the catchment area at the base of the slope where it is removed by maintenance forces.

A long rectangular panel of wire mesh is being attached to ground anchors above the crest of the slope and draped down the rock face with the assistance of a helicopter.	

(Source: TDOT)

Figure 10

Mitigation Method: Rockfall Slope Drape (Continued)

The fellow in the orange shirt is placing fasteners to connect the current panel of mesh to the previous panel of mesh. Each panel will be joined to its adjacent panels in this manner, resulting in one continuous drapery panel across the rock face. The completed mesh drapery will allow any loose rock that falls from the rock face to ravel down behind the mesh to the catchment area (without bouncing out into the roadway) for removal by maintenance forces.	

(Source: TDOT)

Figure 11

A rockfall slope drape project on SR-115 in Blount County nearing completion.	

(Source: TDOT)

Figure 12

Mitigation Method: Pinned Rockfall Slope Mesh
Mitigation Category: Protection

Pinned rockfall slope mesh takes the rockfall slope drape system and “pins” it to the slope using anchors installed into the slope face. The anchors are installed on a pattern, and the anchor length and location are indicated on the project plans. Unlike the free-hanging rockfall slope drape, the pinned mesh retains pieces of rock that dislodge from the rock face. Depending upon the size of the dislodged rock piece, it cannot fall any further than the closest downslope anchor location. Drills suspended from cranes are typically required to drill holes in the rock face for installation of the anchors.

Personnel are using a ‘wagon drill’ suspended from a crane to drill holes in the rock face for the anchors that will be used to pin the mesh to the rock slope face.	

(Source: TDOT)

Figure 13

The pinned mesh retains unstable rock fragments between anchor locations.	

(Source: Caltrans Rockfall Mitigation Design Packet))

Figure 14

Mitigation Method: Rockfall Barrier Systems
Mitigation Category: Protection

Rockfall barrier systems are commonly referred to as rockfall fence. The rockfall fence is placed between the base of the rock slope and the roadway (or other zone requiring protection) to prevent fallen rock from entering the roadway or other protected zone. The height and location of the rockfall fence are based in part upon the expected travel distance and bounce height of the fallen rock.

Ring net rockfall fence placed at the bottom of the rock slope prevents fallen rock from entering the adjacent roadway.	

(Source: TDOT)

Figure 15

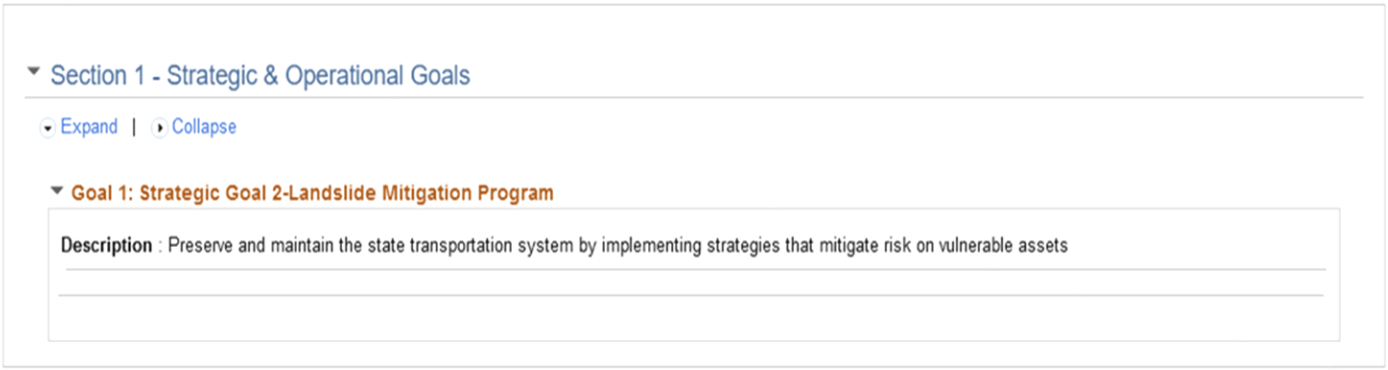
Wire mesh placed behind the ring net prevents small rock particles from entering the roadway.	

(Source: TDOT)

Figure 16

Appendix C

Individual Performance Goal- Strategic Goal for Landslide Mitigations


Section 1 - Strategic & Operational Goals
Expand | Collapse
Goal 1: Strategic Goal 2-Landslide Mitigation Program
Description : Preserve and maintain the state transportation system by implementing strategies that mitigate risk on vulnerable assets