GEOTECHNICAL GUIDANCE MANUAL

COMMONWEALTH OF KENTUCKY
TRANSPORTATION CABINET

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Produced by the Organizational Management Branch
Office of Human Resource Management

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OFFICE OF THE SECRETARY

OFFICIAL ORDER 103021

SUBJECT: *Geotechnical Guidance Manual*

This manual has been prepared to provide information and guidance to personnel of the Kentucky Transportation Cabinet. Its purpose is to establish uniformity in the interpretation and administration of laws, policies, regulations, and procedures applicable to the operation of the Geotechnical Branch and its relationship with other units of the Cabinet.

The policies and procedures set forth herein are hereby approved and declared effective unless officially changed.

All previous instructions, written and oral, relative to or in conflict with this manual are hereby superseded.

Signed and approved this 28th day of June, 2005.

Bill Nighbert
Acting Secretary

Approved as to Form and Legality

Office of Legal Services

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GEOTECHNICAL	Chapter INTRODUCTION
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject Design of This Guidance Manual

ORGANIZATION & NUMBERING:

Chapter (Section) Title—The subject matter in the manual is divided into chapters or sections. The chapter (section) title appears in the upper right-hand corner of the first page of a subject and in the upper left-hand corner of any subsequent page.

Subject Title—The title of a subject appears in the upper right-hand corner of the first page of a subject and in the upper left-hand corner of any subsequent page.

"GT" Prefix—Preceding each subject number, this prefix stands for the manual title *Geotechnical.*

Date—The latest issuance date of a subject appears at the bottom of each page of the subject. This date agrees with the latest issuance date shown for the subject in the Table of Contents **(GT-01).**

Page Numbering—Each subject has its own page numbering, which appears at the bottom of each page.

LOCATING INFORMATION:

Indexes—To help you quickly find information in the manual, two indexes appear at the front. Each index entry includes the corresponding subject number in the manual where you will find detailed information for the entry.

Table of Contents (GT-01)—This index lists the titles of the manual's chapters (sections) and their subjects, as well as other information, in numerical order. It includes the latest issuance dates of all the subjects. As the manual matures, these dates change.

Alphabetical Index (GT-02)—This index alphabetically lists key information in the manual. Generally, it directs the user to subject titles and to margin, paragraph, and subparagraph headings within subjects.

CONT.

CROSS-REFERENCES IN MANUAL:

Subject Numbers within Narrative—When you see a subject number within the narrative on a page, refer to that number for more information about the subject.

English and Metric Units of Measurement—The English unit is the primary unit of measurement in this manual. The equivalent metric unit of measurement is in parentheses following the English unit.

QUESTIONS:

Whom to Contact—If you have any questions concerning the contents of the manual, please contact the Division of Materials, Geotechnical Branch, 1236 Wilkinson Boulevard, Frankfort, KY 40601, at **(502) 564-2374.** If you need additional copies of the manual, please contact the Policy Support Branch at **502-564-3670.**

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GEOTECHNICAL

TRANSPORTATION CABINET
Department of Highways
Division of Materials
Geotechnical Branch

Chapter

INTRODUCTION

Subject

Purpose & Content of the Manual

PURPOSE OF MANUAL:

The *Geotechnical Manual* is a guide to be used in conducting geotechnical investigations for roadways and structures. The purpose of geotechnical investigations is to furnish information for an optimum design that will eliminate the need for being overconservative (an uneconomical practice used to compensate for lack of knowledge of subsurface conditions) and minimize the cases of underdesign (and the resulting failures attributed to so-called "unforeseen" soil conditions).

It is to be realized that any subsurface investigation will leave certain areas unexplored. It must be further realized that it would be impractical to attempt to provide a set of rigid specifications for all possible cases. Thus, this manual will not answer all subsurface investigation problems; it leaves many areas where individual engineering judgment must be utilized. It is intended that the procedures set forth herein will establish reasonable, uniform policies and procedures while maintaining sufficient flexibility to permit the application of engineering judgment to the solution of special problems.

REFERENCES TO OTHER PUBLICATIONS:

This manual frequently references other publications, which present specific engineering design and construction procedures or laboratory testing procedures. Among the most commonly referenced materials are the publications of the American Association of State Highway and Transportation Officials (AASHTO), the Federal Highway Administration (FHWA), and the federal government's Naval Facilities design manual (NAVFAC). Relative to testing procedures, the methods presented by AASHTO are often followed. In other instances, modifications to AASHTO procedures, or additional tests not addressed by AASHTO, are required. A companion manual, *Kentucky Methods (KM)*, presents these testing procedures. AASHTO and KM specifications are referenced, but not reproduced, in this manual. Refer to **GT-500s, Laboratory Testing and Material Classification,** for details relating to these testing procedures.

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GEOTECHNICAL	Chapter INTRODUCTION Subject Functions of the Geotechnical Branch

OVERVIEW: The Geotechnical Branch is responsible for all functions relating to geotechnical engineering (with the exception of research) required for the planning, design, construction, and maintenance of roads and bridges under the jurisdiction of the Department of Highways.

DEFINITION: *Geotechnical engineering* is defined as the acquisition, interpretation, and application of the knowledge of materials of the earth's crust to the solution of civil engineering problems. It embraces the fields of soil mechanics, rock mechanics, engineering geology, geophysics, and other related sciences.

FUNCTIONS: The Geotechnical Branch performs geotechnical investigations for:

- Planning studies
- Roadway design
- Structure foundation design
- Landslides
- Special problems on construction and maintenance projects

Investigations may consist of:

- Site inspections
- Photographs (including aerials)
- Drilling
- Sampling
- Instrumentation
- Laboratory testing
- Engineering analysis
- Preparation of geotechnical engineering reports

Reports include:

- Interpretation and analysis of the subsurface data
- Drawings
- Specifications
- Specific engineering recommendations for design
- Recommendations for solutions of anticipated construction problems

CONT.

FUNCTIONS (cont.):

In many cases Geotechnical Branch personnel perform investigations. In-house personnel also perform much of the necessary drilling. Other projects, however, involve assistance from district drilling crews or prequalified geotechnical drilling firms. Prequalified geotechnical engineering consultant firms also perform investigations that the Geotechnical Branch monitors.

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GEOTECHNICAL	*Chapter* INTRODUCTION
	Subject Organization of the Geotechnical Branch

ORGANIZATION: The Geotechnical Branch operates under the direct supervision of the Geotechnical Engineering Branch Manager of the Division of Materials. The Geotechnical Branch is subdivided into the following sections (**Exhibit 01):**

- Soil Survey and Test
- Drilling and Instrumentation
- Engineering Geology
- Structure Foundations
- Construction

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GEOTECHNICAL

Chapter PROJECT INITIATION	*Subject* Introduction

OVERVIEW: This chapter presents recommendations for having a geotechnical investigation performed by the department. In some cases it lists preliminary requirements. For example, a roadway investigation is to be requested after the preliminary line and grade meeting. It also lists the types of information to be submitted with the request. These items typically include project identification (item number, project number, etc.) and project location (county, site map, station limits, etc.). The specific subjects explored in this chapter are as follows.

PLANNING STUDIES: **GT-201** lists the kind of data included in any preliminary geotechnical overview.

ROADWAY DESIGN INVESTIGATIONS: **GT-202** discusses the kind of data specific to a request for a geotechnical report of a proposed roadway project.

STRUCTURAL FOUNDATION INVESTIGATIONS: The following subjects explore the kind of data included in requests for structural foundation investigations:

- **GT-203-1** Data for All Investigations (regardless of structure type)
- **GT-203-2** Bridges
- **GT-203-3** Culverts
- **GT-203-4** Retaining Walls
- **GT-203-5** Noise Barrier Walls

MAINTENANCE INVESTIGATIONS: The following subjects explore the kind of data included in requests for maintenance investigations:

- **GT-204-1** Landslides
- **GT-204-2** Unstable Rock Slopes

CONT.

CONSTRUCTION INVESTIGATIONS: The following subjects explore the kind of data included in requests for construction investigations:

GT-205-1 Landslides
GT-205-2 Rock Cuts
GT-205-3 Excess Material Sites
GT-205-4 Subgrade Stabilization
GT-205-5 Field Instrumentation

PERMITS: The following subjects explore requests for review of permits:

GT-206-1 Right-of-Way Encroachment
GT-206-2 Mining Encroachment

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GEOTECHNICAL

GEOTECHNICAL	*Chapter* PROJECT INITIATION
	Subject Planning Studies

DATA TO BE INCLUDED:

The Division of Planning or others may request a preliminary geotechnical overview. This request should include:

- Ø County name
- Ø Project number
- Ø MARS (Management Administrative and Reporting System) number
- Ø Item number
- Ø Location and limits of project area or corridors on a topographic map (Scale 1 inch = 2,000 feet [1:24,000])
- Ø Class of proposed roadway
- Ø Project manager
- Ø Desired completion date
- Ø Aerial photographs, if available

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GEOTECHNICAL	Chapter: PROJECT INITIATION
	Subject: Roadway Design Investigations

OVERVIEW: This section describes the data that should be included in a request for a geotechnical report. Submittals shall be made by the Division of Highway Design, the District Project Manager, or the design consultant after the preliminary line and grade have been approved.

ROADWAY DESIGN INVESTIGATIONS: The designer may request a geotechnical report for a proposed roadway project. This request should include:

- Ø County name, project number (MARS number), and item number
- Ø Project layout, location, and manuscript sheets
- Ø Location of proposed alignment on a topographic map (1 inch = 2,000 feet [1:24,000]) with stations indicated on maximum 1,000 feet (300 meters) intervals (**Exhibit 02**)
- Ø Datum (sea level/benchmark datum, or assumed datum)
- Ø Preliminary plan and profile sheets (half-size only; minimum of two sets)
- Ø Preliminary cross-section sheets (half-size only; minimum of two sets)
- Ø Property owner strip map (minimum of two sets)
- Ø Upon request, aerial photographs, if available
- Ø Design engineer or consultant responsible for the project

CONT.

ROADWAY DESIGN INVESTIGATIONS (cont.):

- Baseline profile sheets, showing groundline and gradeline, are to be used for developing the soil profile. It is required that all of the above be submitted electronically in Microstation format. The vertical and horizontal scales shall be 1 inch = 10 feet (1:120) and 1 inch = 100 feet (1:1,200), respectively, on English drawings or 1:100 and 1:1,000 on drawings with metric units. If approved by the Geotechnical Branch, the vertical and horizontal scales may be 1 inch = 5 feet (1:60) and 1 inch = 50 feet (1:600), respectively, on English drawings or 1:50 and 1:500 on drawings with metric units. (Refer to the *Highway Design Guidance Manual* for details concerning the preparation of the soil profile sheets.)

The District Branch Manager for Preconstruction shall notify the Division of Materials, Geotechnical Branch, of the estimated date when right-of-way plans are due in the Central Office and the milestone date for final joint inspection. The Geotechnical Branch shall arrange for a drill crew to perform the subsurface investigation. This may be a Geotechnical Branch drill crew, a district drill crew, or a prequalified drilling company.

The Geotechnical Branch will prepare a boring plan and, if necessary, schedule a preliminary meeting at the project site with the District Branch Manager for Preconstruction and the drill crew supervisor. The purpose will be to discuss the scope of work and the proposed boring plan. Drilling operations shall not begin prior to receiving an approved boring plan from the Geotechnical Branch.

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GEOTECHNICAL	Section STRUCTURAL FOUNDATION INVESTIGATIONS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject Data for All Structural Investigations

REQUESTING AN INVESTIGATION: After the approval of the preliminary line and grade, the District Project Manager, the Division of Bridge Design, or, if applicable, the design consultant shall be responsible for submitting to the Geotechnical Branch a request for a structural foundation investigation. Such a request is to include certain data.

DATA TO BE SUBMITTED FOR ALL INVESTIGATIONS: The following data shall be submitted with all requests for geotechnical investigations, regardless of the type of structure:

- County name
- Project number (including MARS number)
- Road number and name
- List of structures on project
- Project manager responsible for project
- Firm or agency responsible for staking boring locations
- Item number
- Type of datum used (sea level/benchmark datum, or assumed)
- All drawings to be submitted electronically in Microstation format
- Location on a 1 inch = 1,000 feet [1:24,000] topographic map

ADDITIONAL DATA FOR SPECIFIC TYPES OF STRUCTURES: Other data to be submitted with requests for specific types of structures are listed in subsequent subjects. Submittals shall be within 10 days after preliminary line and grade have been approved for structure replacement projects.

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GEOTECHNICAL	*Section* STRUCTURAL FOUNDATION INVESTIGATIONS
	Subject Bridges

ADDITIONAL DATA FOR BRIDGE FOUNDATION INVESTIGATIONS: A submittal for a bridge foundation investigation includes the data listed in **GT- 203-1.** In addition, the submittal includes:

- Plan and profile sheets showing structure with abutment and pier stations
- Plan view and natural scale profile view of proposed bridge showing normal pool and high-water elevations, if applicable
- Contour map showing project centerline, with stations and proposed substructure units, if available
- Estimated foundation loading, if available
- Scour analysis, if applicable, presented at each substructure location, as elevations rather than as depths
  - For bridges at wet crossings, if rock is known to be deep and deep foundations are anticipated, a scour analysis is required.
  - If rock is shallow and spread footings are anticipated, a scour analysis is not required.
  - If subsurface investigation subsequently indicates a possibility that piles will be used or that footings might be placed on scourable bedrock, the bridge designer will be informed that a scour analysis is required and that the final report will not be issued until this information is received.
  - If subsurface investigation indicates footings are to be placed on nonscourable bedrock, scour analysis is not required.

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GEOTECHNICAL	*Section* STRUCTURAL FOUNDATION INVESTIGATIONS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Culverts

ADDITIONAL DATA FOR CULVERT FOUNDATION INVESTIGATIONS: A submittal for a culvert foundation investigation includes the data listed in **GT-203-1.** In addition, the submittal includes:

Ø Natural scale section along the centerline of the culvert showing:

- ♦ Roadway grade
- ♦ Fill slopes
- ♦ Existing and proposed profiles (including inlet and outlet elevations)
- ♦ Flowline

Ø Contour map with project centerline with stations and structure baseline, if available

Ø Plan sheet showing structure location

Ø Cross-sections in area of culvert

PIPE CULVERTS: The roadway designer may request subsurface investigations for pipe culverts whenever the fill height at the pipe location, the depth of the foundation soils, or the size of the pipe is sufficient to indicate the possible development of settlement or stability problems. Submittals for pipe culvert investigations shall be the same as above.

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GEOTECHNICAL	*Section* STRUCTURAL FOUNDATION INVESTIGATIONS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Retaining Walls

ADDITIONAL DATA FOR RETAINING WALL FOUNDATION INVESTIGATIONS : A submittal for a retaining wall foundation investigation includes all data listed in **GT-203-1.** In addition, the submittal includes:

- Wall profile showing existing groundline, low-side finished grade, high-side finished grade, and top of wall
- Cross-sections showing the proposed wall, backslope, and foreslope, every 20 feet (6 meters) along the wall
- Plan sheet showing the proposed wall
- Contour map showing project centerline and stations

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GEOTECHNICAL	*Section* STRUCTURAL FOUNDATION INVESTIGATIONS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Noise Barrier Walls

ADDITIONAL DATA FOR NOISE BARRIER WALL FOUNDATION INVESTIGATIONS: A submittal for a noise barrier wall foundation investigation includes all data listed in **GT-203-1.** In addition, the submittal includes:

- Wall profile showing existing groundline and finished grade, including proposed top and bottom of wall
- Centerline cross-sections, every 50 feet (15 meters), showing the proposed wall
- Plan sheet showing the proposed wall
- Contour map showing project centerline and stations

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GEOTECHNICAL	Section MAINTENANCE INVESTIGATIONS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject Landslides

POLICY: A request for the Geotechnical Branch to conduct a preliminary investigation of a landslide shall originate from the Chief District Engineer or from the Director of the Division of Maintenance. If necessary, the requesting party will provide surveying and utility locations and obtain right of entry. The Division of Maintenance will be responsible for obtaining the necessary funds if a comprehensive geotechnical investigation is required. Total funding shall include expenses for surveying, drilling, aerial photography, traffic control, etc. The Geotechnical Branch should be contacted for input on the funds necessary for a geotechnical investigation.

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GEOTECHNICAL	*Section* MAINTENANCE INVESTIGATIONS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Unstable Rock Slopes

POLICY: Requests for the Geotechnical Branch to conduct a preliminary investigation of an unstable rock slope shall originate from the Chief District Engineer or from the Director of the Division of Maintenance. If necessary, the requesting party will provide surveying and utility locations and obtain right of entry. The Division of Maintenance will be responsible for obtaining the necessary funds if a comprehensive geotechnical investigation is required. Total funding shall include expenses for surveying, drilling, aerial photography, traffic control, etc. The Geotechnical Branch should be contacted for input on the funds necessary for geotechnical investigations.

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GEOTECHNICAL	***Section*** CONSTRUCTION INVESTIGATIONS
	Subject Landslides

POLICY: A geotechnical investigation for a landslide that occurs on a construction project shall be conducted at the request of the District Branch Manager for Construction or the Project Engineer. If necessary, the requesting party will provide surveying and utility locations and obtain right of entry.

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# GEOTECHNICAL	*Section* CONSTRUCTION INVESTIGATIONS
	Subject Rock Cuts

POLICY: A geotechnical investigation necessary to revise a rock-cut slope on a construction project shall be conducted at the request of the District Branch Manager for Construction or the Project Engineer. If necessary, the requesting party will provide surveying and utility locations and obtain right of entry.

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GEOTECHNICAL	*Section* CONSTRUCTION INVESTIGATIONS
	Subject Excess Material Sites

POLICY:

The Geotechnical Branch will review the contractor's excess material site proposals upon request of the District Branch Manager for Construction or Project Engineer. All excess material sites meeting any of the conditions specified in the Transportation Cabinet's *Construction Guidance Manual,* **Section 63-07,** shall be considered for investigation. Proposals shall include the following:

- Topographic map (1 inch = 2,000 feet [1:24,000]) showing the limits of the proposed excess material site
- Profiles and cross-sections showing the natural groundline, proposed template, proposed benching, drainage, etc.
- Recommendations for lift thickness, type of material, compaction requirements, etc.

It shall be the contractor's responsibility to engage a prequalified geotechnical engineering consultant, approved by the department, when a geotechnical investigation is required. The department will pay for the geotechnical investigation and analysis of the proposed excess material site when the Project Engineer requests one (see **Section 204** of the *Standard Specifications for Road and Bridge Construction,* current edition). The consultant shall prepare a plan consisting of the proposed borings, plotted on cross-sections, with a discussion of any analysis necessary, and submit it to the Geotechnical Branch for review. Subsurface investigations shall not begin without approval from the Geotechnical Branch.

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GEOTECHNICAL	Section: CONSTRUCTION INVESTIGATIONS
	Subject: Subgrade Stabilization

POLICY: The Geotechnical Branch will conduct investigations of subgrades upon request of the District Branch Manager for Construction or the Project Engineer.

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# GEOTECHNICAL	*Section* CONSTRUCTION INVESTIGATIONS
	Subject Field Instrumentation

POLICY: The District Branch Manager for Construction or the Project Engineer (not the contractor) shall notify the Geotechnical Branch or the geotechnical consultant (if applicable) when the contractor is ready for any instrumentation to be installed. Plan notes shall specify the time necessary for installation from time of notification.

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GEOTECHNICAL	*Section* PERMITS
	Subject Right-of-Way Encroachment

POLICY:

The Permits Branch may request that the Geotechnical Branch review right-of-way encroachment permits and offer comments and recommendations.

Requests for review of a right-of-way encroachment permit should include:

- Ø County name and project number (MARS number), if applicable
- Ø Location of proposed encroachment on a topographic map (1 inch = 2,000 feet [1:24,000])
- Ø Any plan, manuscript, or cross-section sheets showing proposed encroachment
- Ø Any subsurface information obtained or geotechnical report prepared for proposed encroachment
- Ø Any construction procedures to be followed

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GEOTECHNICAL	*Section* PERMITS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Mining Encroachment

POLICY:

The Permits Branch may request that the Geotechnical Branch review mining encroachment permits and offer comments and recommendations.

Requests for review of a proposed mining encroachment permit should include:

- Ø Topographic map (1 inch = 2,000 feet [1:24,000]) showing proposed mine crossing
- Ø Mine production map with crossings and surface features indicated
- Ø Name, elevation, and thickness of coal seam
- Ø Drill logs of borings through the coal seam and rock profiles in the vicinity of crossings
- Ø Proposed mining method
- Ø Sizes of entries, crosscuts, and pillars if room-and-pillar method is proposed
- Ø Secondary recovery plans for the area
- Ø Problems with water or ground control
- Ø Planned subsidence control measures
- Ø Names and/or owners of other known mines in the area

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GEOTECHNICAL	Chapter DRILLING, SAMPLING, & INSTRUMENTATION
	Subject Introduction

OVERVIEW: This chapter addresses drilling procedures and other activities related to drilling. The subsequent chapter covers the scope of drilling for individual projects (that is, how many borings are recommended for a specific structure or landslide, etc.). The specific subjects this chapter explores are as follows.

PRELIMINARY CONSIDERATIONS: The following subjects explore preliminary considerations for drilling:

GT-301-1 Permission to Drill
GT-301-2 Locating and Protecting Utilities
GT 301-3 Hazardous Waste
GT 301-4 Underground Storage Tanks

DRILLING, SAMPLING, & IN-SITU TESTING: The following subjects discuss specific drilling, sampling, and in-situ testing procedures:

GT-302-1 Defining Refusal on Bedrock
GT-302-2 Rockline Soundings
GT-302-3 Disturbed Soil Borings
GT-302-4 Thin-Walled Tube Samples
GT-302-5 Standard Penetration Tests
GT-302-6 Field Vane Shear Tests
GT-302-7 Rock Core Drilling
GT-302-8 Cone Penetration Testing

DOCUMENTATION: The following subjects explore necessary documentation:

GT-303-1 Subsurface Logs and Field Notes
GT-303-2 Handling and Labeling of Soil Samples
GT-303-3 Identification, Storage, and Delivery of Rock Cores

CONT.

FIELD INSTRUMENTATION: The following subjects deal with field instrumentation:

GT-304-1	Slope Inclinometers
GT-304-2	Observation Wells and Piezometers
GT-304-3	Settlement Platforms

SITE RESTORATION: **GT-305** covers the requirements relating to the sealing of geotechnical borings and site reclamation.

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# GEOTECHNICAL	Section: PRELIMINARY CONSIDERATIONS
	Subject: Permission to Drill

OBTAINING PERMISSION TO DRILL: It is the responsibility of the drill crew supervisor to obtain permission from the property owner or government agency prior to any drilling operations on the affected property. The drill crew supervisor shall contact the property owner and receive individual permission even when right of access has been granted to others who may have preceded drilling operations. This permission should cover right of access to conduct the work and any special provisions required by the property owner, such as working hours, avoidance of croplands and wet areas, and cleanup operations.

LETTERS OF REQUESTS FOR BORING LOGS: To request copies of boring logs obtained on their properties, property owners are to send a letter of request addressed to the following:

Commissioner
Department of Administrative Services
Transportation Cabinet Office Building
200 Mero Street
Frankfort, KY 40622

The department's phone number is **(502) 564-3670.**

The letter of request should state the following:

- Ø Information being requested (copies of core logs, etc.)
- Ø Location of project
- Ø Property name from which borings are obtained
- Ø Location of borings (station, offset, and hole number, when applicable)

CONT.

LOG OF CONTACTS: The supervisor shall maintain a log of property owner contacts. The log shall include:

- Ø Dates and names of persons contacted
- Ø Synopsis of each discussion
- Ø Names, addresses, and telephone numbers of property owners along the proposed route whenever possible

DENIAL OF ACCESS: If a property owner denies the drill crews access to his or her property, the drill crew supervisor shall contact the District Branch Manager for Preconstruction for guidance. The District Branch Manager may seek legal assistance in negotiations with the property owner if the Geotechnical Branch deems necessary. The drill crew supervisor should provide a letter (or an e-mail) to the Geotechnical Branch, stating boring locations affected and reasons for denial (crops, etc.).

SPECIAL PERMITS & INSURANCE Certain public and private property—such as navigable waters, railroad property, and public streets—may require special permits for right of entry. These working permits may require a fee or special insurance. Obtaining the permits is the responsibility of the organization performing the drilling. However, prior approval by the department is required before these costs can be reimbursed.

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GEOTECHNICAL	*Section* PRELIMINARY CONSIDERATIONS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Locating & Protecting Utilities

PROCEDURE FOR LOCATING UTILITIES: It is the responsibility of the drill crew supervisor to ascertain the locations of any utilities on the project site before proceeding with drilling operations. The drill crew supervisor shall contact Kentucky Underground at **1-800-752-6007** and the appropriate utility companies and meet with their representatives at the project site to physically locate all utilities in the field prior to any drilling operations on the affected property. The district utility agent may be consulted for assistance in meetings with utility companies.

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GEOTECHNICAL	Section: PRELIMINARY CONSIDERATIONS
Transportation Cabinet, Department of Highways, Division of Materials, Geotechnical Branch	Subject: Hazardous Waste

SIGNS OF HAZARDOUS WASTE:

To protect drilling personnel from potentially adverse effects of hazardous waste, field personnel should always be on the alert for any deposits of material or for sites that could be potentially hazardous. These deposits or sites may show signs of any of the following:

- Liquid breakouts
- Soil discoloration
- Odors
- Abnormalities in vegetation
- Dead animals or vegetation

PROCEDURE FOR EVALUATING SUSPICIOUS MATERIALS:

No one should attempt to investigate or identify the contents of trash dumps, old barrels, and containers of either liquid or dry material other than professionals qualified to evaluate or handle hazardous materials. Upon encountering areas that appear to contain hazardous waste, crews shall immediately halt all drilling in the affected areas and report their findings to the District Branch Manager for Preconstruction. Work shall not recommence in the affected areas until the department grants approval.

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GEOTECHNICAL	*Section* PRELIMINARY CONSIDERATIONS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Underground Storage Tanks

PROCEDURE FOR INVESTIGATING USTs:

An underground storage tank (UST) is a tank system, including its piping, that has at least 10 percent of its volume underground.

No one other than qualified professionals should attempt to investigate or identify the contents of a UST. Upon encountering a UST whose existence was previously unknown, crews shall immediately halt all drilling in the affected area and report their findings to the District Branch Manager for Preconstruction. Work shall not recommence in the affected areas until the department grants approval.

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GEOTECHNICAL	Section: DRILLING, SAMPLING, & IN-SITU TESTING
TRANSPORTATION CABINET, Department of Highways, Division of Materials, Geotechnical Branch	Subject: Defining Refusal on Bedrock

DEFINITIONS: *Refusal* (R), as used in this manual, is generally defined as "the top of bedded material." Bedded materials are rock formations (including shale) that show well-defined planes of separation, divisional lines, or layers.

No refusal (NR) is a term used to indicate that bedded material was not encountered.

Refusal (R) or *no refusal* (NR) shall be indicated on all boring logs.

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GEOTECHNICAL	*Section* DRILLING, SAMPLING, & IN-SITU TESTING
TRANSPORTATION CABINET Department of Highways Division of Materials Geotechnical Branch	*Subject* Rockline Soundings

METHODS USED FOR ROCKLINE SOUNDINGS:

Power augers shall be used for rockline soundings unless the Geotechnical Branch in advance of the work approves other methods. Any preapproved alternative methods used to obtain rockline soundings shall be indicated on the drill logs. Rockline soundings will be advanced to varying depths depending on the situation. (The subjects in **GT-400, Scope of Field Investigations,** provide details.)

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GEOTECHNICAL	Section: DRILLING, SAMPLING, & IN-SITU TESTING
TRANSPORTATION CABINET, Department of Highways, GB, Division of Materials, Geotechnical Branch	Subject: Disturbed Soil Borings

TEST METHODS: Disturbed soil borings shall be made in accordance with the *Standard Method of Progressing Auger Borings for Geotechnical Explorations,* **AASHTO T 306,** with the following exceptions/additions:

Exceptions/Additions: Power-driven equipment shall be used for soil borings unless the Geotechnical Branch in advance of the work approves other methods. Any preapproved alternative methods used to obtain disturbed soil borings shall be indicated on the drill logs. The following points must be considered before the auger boring is made:

- Ø All sod or organic material must be removed from the surface before advancing a hole.
- Ø Auger rotation and down feed must be slow.
- Ø Augers must be cleaned from previous borings so as not to contaminate or mix soil types.
- Ø The material withdrawn must be checked constantly for changes in soil types.

RECORD KEEPING: The procedure for record keeping is as follows:

1. Withdraw the augers at depth intervals small enough to accurately define the boundaries of different soil types.
2. Record the depth, color, texture, and consistency of each soil horizon.
3. Record the immediate water table elevation in each boring.

CONT.

BAG SAMPLES: Bag samples are obtained with conventional drilling equipment after checking the soil types or soil horizons. The soil depths and soil horizon intervals are noted at each boring location and recorded on the TC 64-515 form, *Subsurface Log* **(Exhibit 03).** Once the number of soil horizons has been determined (maximum 1,000-foot [300-meter] lengths), a representative bag sample of each soil horizon is obtained. A sampling site shall be chosen within the 1,000-foot (300-meter) area, preferably where the soil horizons are thickest. After all sod or organic material is removed from the surface, a sample hole is drilled, and representative bag samples are obtained.

Bag samples are difficult to obtain in areas where the soil horizons are thin. More than one sampling hole may be necessary to get the required weight of sample.

Sample Sizes: Bag samples for cuts and fills shall be at least 30 pounds (15 kilograms). Bag samples of bank gravel and similar material shall be at least 60 pounds (30 kilograms).

PACKAGING OF BAG SAMPLES: Bags shall be of clear polyethylene with a minimum wall thickness of 7 mils and shall be dustproof and of a sufficient size to contain the sample.

IDENTIFICATION OF BAG SAMPLES: Bag samples shall be tied securely and identified with reinforced identification tags showing the following information:

- County name
- Project number
- Item number
- MARS number
- Road name
- Hole number (if applicable)
- Sample number
- Depth, station, and offset of sample
- Whether sample represents a cut or fill

MOISTURE SAMPLES: A moisture sample shall be obtained from each 5-foot (1.5-meter) interval in disturbed soil borings. Moisture samples shall be at least one pint and shall be hermetically sealed in glass or plastic jars with screw lids. Identification tags showing information as previously listed for bag samples shall be taped or glued to the jars of samples.

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GEOTECHNICAL	Section: DRILLING, SAMPLING, & IN-SITU TESTING
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject: Thin-Walled Tube Samples

PROCEDURE FOR OBTAINING THIN-WALLED TUBE SAMPLES:

Thin-walled tube samples shall be obtained in accordance with the *Standard Method for Thin-Walled Tube Sampling of Soils,* **AASHTO T 207.** The diameter of thin-walled tubes shall be 3 inches (76 millimeters) unless otherwise approved by the Geotechnical Branch. Tube samples shall be obtained from each 5-foot (1.5-meter) interval of depth in cohesive soil starting 2 to 3 feet (0.6 to 0.9 meter) below the surface, unless continuous samples are specified. A standard penetration test shall be obtained immediately below the elevation of the tube sample if sample recovery is less than 50 percent or if the material in the tube sample is granular.

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GEOTECHNICAL	Section: DRILLING, SAMPLING, & IN-SITU TESTING
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject: Standard Penetration Tests

TESTING METHOD & FREQUENCY: Standard penetration tests shall be performed in accordance with the *Standard Method for Penetration Test and Split Barrel Sampling of Soils,* **AASHTO T 206***.* Standard penetration tests shall be performed and samples obtained from each 5-foot (1.5-meter) interval of depth in granular soil starting 2 to 3 feet (0.6 to 0.9 meter) below the surface, unless continuous samples are specified. If the sample is cohesive, a thin-walled tube sample shall be obtained immediately below the elevation of the standard penetration test. Drill rigs equipped with automatic hammers shall be used on all structure projects to obtain standard penetration tests.

DENSE MATERIALS: In very dense material a test may be terminated prior to completion because of excessive blow counts as described in **AASHTO T 206, Sections 7.2.1 to 7.2.3.** If this occurs, the depth of penetration for the last increment shall always be recorded in the drill log. The "N-Value" shall be reported as the sum of the blow counts beyond the seating increment over the depth of penetration beyond the seating increment. If termination occurs in the seating increment, the "N-Value" shall be reported over the depth of penetration. Examples are presented below.

REPORTING RESULTS OF TERMINATED TESTS:

Reason for Termination	Recorded in Drill Log	Reported "N-Value"
50 Blows in Seating Increment	50/4 in. (50/0.10 m)	R/0.33 ft (R/0.10 m)
50 Blows in 2nd Increment	25-50/4 in. (25-50/0.10 m)	50/0.33 ft (50/0.10 m)
50 Blows in 3rd Increment	25-25-50/4 in. (25-25-50/0.10 m)	75/0.83 ft (75/0.25 m)
Total of 100 Blows	20-40-40/4 in. (20-40-40/0.10 m)	80/0.83 ft (80/0.25 m)

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GEOTECHNICAL	Section DRILLING, SAMPLING, & IN-SITU TESTING
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject Field Vane Shear Tests

TESTING METHOD:

Field Vane Shear Tests are a type of in-situ test and shall be performed in accordance with the *Standard Method for Field Vane Shear Test in Cohesive Soil,* **AASHTO T 223.**

Field Vane Shear Tests are made in conjunction with drill hole explorations in soft clays and are performed when adequate tube samples are unobtainable or the laboratory test results from samples obtained provide inadequate or inconclusive data. The Geotechnical Branch requires prior approval for performing Vane Shear Tests.

2 2 2

GEOTECHNICAL

TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Section* DRILLING, SAMPLING, & IN-SITU TESTING
	Subject Rock Core Drilling

TESTING METHOD: Rock core drilling shall be performed in accordance with the *Standard Method of Diamond Core Drilling for Site Investigation,* **AASHTO T 225,** except as noted below. The use of wire line drilling equipment will be permitted. The diameter of the core should preferably not be less than approximately 2 inches (50 millimeters).

POOR RECOVERY: When soft materials are encountered in a coring run that produces less than 85 percent recovery, changes in the type of barrel or drilling procedure or a change to soil sampling shall be made. When consecutive coring runs produce less than 85 percent recovery, the interval with less than 85 percent will not be acceptable and shall be re-cored, or soil samples shall be obtained from an adjacent boring, as outlined in the section on undisturbed sampling. This requirement may be waived if the Geotechnical Branch determines that subsurface conditions are such that 85 percent recovery is not feasible.

SAMPLES FOR UNCONFINED COMPRESSION: The length of the rock core required for an unconfined sample shall be a minimum of one continuous 5-inch (125-millimeter) piece with no breaks or fractures. A piece of PVC pipe the same length of the unconfined sample will replace the unconfined sample that is removed from the core box. The PVC pipe shall be labeled “sample” and shall show the beginning and ending depths.

Rock cores for unconfined compression tests shall be wrapped with two layers to protect the sample and to prevent loss of moisture, as follows:

1. The first layer is a plastic film wrap. Secure the core by wrapping lengthwise around the core with masking tape. The plastic film wrap shall be taped with masking tape at ends, middle, and all seams.
2. The second layer is aluminum foil. Wrap this layer at ends and middle.
3. Label the sample with the beginning and ending depths. Also label on sample “top” and “bottom” of the core.
4. Place the sample in a resealable plastic bag with a label showing the station, offset, elevation, project number, and depth.

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# GEOTECHNICAL	*Section* DRILLING, SAMPLING, & IN-SITU TESTING
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Cone Penetration Testing

TESTING METHOD: Cone Penetration Testing (CPT) shall be performed in accordance with **ASTM D 3441,** *Mechanical Cone Penetration Tests of Soil*.

2 2 2

# GEOTECHNICAL	*Section* DOCUMENTATION
	Subject Subsurface Logs & Field Notes

POLICY: A typed subsurface log shall be completed for every hole. For any boring location moved, a reason for moving the boring shall be provided in the log. For any boring holes that are deleted or not drilled, a reason for deleting or not drilling the borings shall be provided in the log. Using the TC 64-515 form, *Subsurface Log* **(Exhibit 03),** or equivalent, the drill crew chief shall log disturbed sample borings, undisturbed sample borings, and rock core borings. A qualified geologist or geotechnical engineer shall also log rock cores.

DRILL LOG: The typed subsurface log shall contain information about drilling the hole and descriptions of the materials encountered. (Refer to **Exhibit 04.**) Additional information shall include, but is not limited to, the following items as applicable:

- Ø Loss of water
- Ø Voids
- Ø Broken zones
- Ø Material color and type (brown clay, gray shale, etc.)
- Ø Elevations where above items were encountered
- Ø Sample or core type
- Ø Sample depths or core runs
- Ø Core or sample recovery
- Ø SPT (Standard Penetration Test) blow counts and hammer type

GEOLOGIST'S OR GEOTECHNICAL ENGINEER'S LOG: The geologist's typed log shall describe engineering characteristics of the rock, using numerical values. Slake Durability Index (SDI) numbers and Jar Slake Test (JS) results replace terms such as *soft, medium,* or *hard* for describing shales or siltstones. Rock Quality Designation (RQD) numbers replace *thin, medium,* or *massive* for referring to bedding thickness. Joints or fractures are measured in degrees from horizontal, using a goninometer, and may be defined as continuous or discontinuous. The Geologic Quadrangle and the name of the Formation (including the member when applicable) for the boring hole shall be shown in the log. (Refer to **Exhibits 05 and 06.)**

CONT.

RDZ: Rock Disintegration Zone (RDZ) is the subsurface materials that are composed of weathered and decomposed bedrock. RDZ on roadway projects is simply defined as material deemed "rippable" with a D-9 dozer. The depth to the base of RDZ is generally indicated on the core log. The elevations of the top of rock and base of weathered rock, along with the "Scour to Elevation" and "Allowable Bearing Capacity," are indicated in the core log for structures.

RQD, KENTUCKY METHOD: Rock Quality Designation (RQD), Kentucky Method, is an estimate of in-situ rock quality and is determined by considering only pieces of core that are at least 4 inches (100 millimeters) long, hard, and reasonably difficult to break by hand. Judgment is required, and breaks obviously caused by drilling are ignored. The percentage ratio between the total length of pieces 4 inches (100 millimeters) or longer and the length of core drilled in a given run is the RQD.

PROFILE BORINGS: A typed disturbed soil boring log shall be completed on each boring (**Exhibit 09).** Each log shall contain:

- Ø Points of interest: locations and magnitudes of sinkholes, ponds, creeks, wet areas, springs, wells, talus deposits, existing landslides, limits of wooded areas, crop intervals, etc.

- Ø Description of soil type for each soil horizon by identifying the soil type with the bag sample number corresponding to that specific soil type

  Note: If the soil type did not change from a previous boring (that is, within the 1,000-foot interval), a bag is not required; however, the driller shall note each soil type encountered on every boring by referencing the corresponding bag sample number taken from a previous boring as shown in **Exhibit 09.**

ROCKLINE SOUNDINGS: Results of all rockline soundings shall be typed and submitted on the form TC 64-516, *Summary of Rockline Soundings* **(Exhibit 07*).*** The Remarks column on this form may be used to indicate the presence of boulders above the refusal depth or the suspicion of refusal on a boulder. It may also be used to provide information on observation wells, structure identification on large projects, or various other comments. The coordinates for each rockline sounding hole shall be shown in the log, if requested by the Geotechnical Branch. (Refer to **Exhibit 08.)**

SUBMITTALS: Copies of the typed subsurface logs shall be submitted along with all soil samples and rock cores when delivered to the Geotechnical Branch, Division of Materials, Frankfort, Kentucky.

2 2 2

GEOTECHNICAL	Section: DOCUMENTATION
TRANSPORTATION CABINET Department of Highways, Division of Materials, Geotechnical Branch	Subject: Handling & Labeling of Soil Samples

POLICY: Care shall be taken during handling, labeling, storage, and transportation of soil samples to prevent disturbance of the samples. Refer to **AASHTO T 306, T 206, and T 207** for applicable procedures for handling and labeling soil samples.

Labels shall contain the following information:

- County name
- Project number
- Item number
- MARS number
- Boring number
- Boring location
- Date sampled
- Sample depth
- Sample number

Thin-walled tube samples shall not be kept or stored where the temperature is expected to get below freezing. The thin-walled tube samples shall be stored and transported in an upright position.

Note: A unique sample number shall be given for each sample per project on moisture-content jars and profile bags.

2 2 2

GEOTECHNICAL	Section: DOCUMENTATION
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject: Identification, Storage, & Delivery of Rock Cores

INFORMATION ON CORE BOX:

The outside top of a core box shall include the following information printed with a permanent marker:

- Ø County name
- Ø Project number
- Ø MARS number
- Ø Item number
- Ø Core location (station, offset, and hole number, as applicable)
- Ø Surface elevation
- Ø Box number

The inside of the lid shall contain the above information plus the total depth of the core.

The end of the box shall be labeled with the following information:

- Ø County name
- Ø Project number
- Ø MARS number
- Ø Core location (station, offset, and hole number, as applicable)
- Ø Date

Refer to **Exhibit 10**.

ORIENTATION OF CORE:

Core samples shall be placed in the boxes, beginning with the upper left corner compartment and working toward the right. When this compartment is filled, additional samples are placed in the next upper left hand compartment, etc.

Each core run shall be separated by a 1-inch wooden block showing depth.

Cores from different holes shall not be placed in the same core box.

The beginning and ending depths of the core sample in each box shall be marked on the edge of the box.

CONT.

DRILL LOG: Two typed logs on the TC 64-515 form, *Subsurface Log* **(Exhibits 04 and 05 or 06),** are required in Box 1 for each hole. One log will be completed by the driller, and the other by a qualified geologist or geotechnical engineer, unless otherwise specified by the Geotechnical Branch.

DELIVERY: Rock cores shall be delivered to the Geotechnical Branch, Division of Materials, Frankfort, Kentucky, unless otherwise directed.

2 2 2

GEOTECHNICAL	*Section* FIELD INSTRUMENTATION
	Subject Slope Inclinometers

POLICY: Slope inclinometers shall be installed in accordance with **AASHTO T 254,** *Installing, Monitoring, and Processing Data of the Traveling Type Slope Inclinometer.*

2 2 2

GEOTECHNICAL	Section FIELD INSTRUMENTATION
	Subject Observation Wells & Piezometers

POLICY: Observation wells (refer to **Exhibit 11)** and piezometers shall be installed in accordance with **KM 64-503-03,** *Measurement of Pore Pressure in Soils.*

2 2 2

GEOTECHNICAL	Section FIELD INSTRUMENTATION
	Subject Settlement Platforms

POLICY: Settlement platforms shall be installed and monitored in accordance with **Section 216** of the current *Standard Specifications for Road and Bridge Construction.* See *Standard Drawing* **RGX–015–02.**

2 2 2

GEOTECHNICAL	Chapter DRILLING, SAMPLING, & INSTRUMENTATION
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject Site Restoration

POLICY: All geotechnical borings shall be backfilled in such a manner as to meet the requirements of the *Groundwater Protection Plan for the Kentucky Transportation Cabinet's Central Office Division of Materials, Part IIIB, Plan for Sealing Geotechnical Borings.* This also covers installation requirements relating to observation wells and slope inclinometer casings.

All subsurface borings shall be backfilled or covered upon their completion to prevent damage to property or injury to people or animals.

Reclamation of drill sites and dozer or track-hoe operations shall be protected from erosion by utilizing grass seed and straw. Cutoff trenches, water bars, or ditches may be required for long, steep grades of dozer or track-hoe roads to prevent excessive erosion.

2 2 2

GEOTECHNICAL	Chapter SCOPE OF SUBSURFACE & FIELD INVESTIGATIONS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject Introduction

OVERVIEW: This chapter addresses the scope of drilling for individual projects. It presents guidelines relating to the number and locations of borings typically obtained for roadway projects, landslides, or bridges with various numbers of spans, etc. Information relating to submitting a request to have a subsurface investigation performed is covered in **Chapter GT-200.**

PLANNING STUDIES: **GT-401** discusses the scope of field investigations for planning studies.

ROADWAYS: The following subjects explore the scope of subsurface investigations for roadways:

GT-402-1 Boring Plan
GT-402-2 Soil Profiles
GT-402-3 Rock and Soil Cuts
GT-402-4 Embankments
GT-402-5 Special Geologic Considerations
GT-402-6 Preapproved Borrow Sites
GT-402-7 Preapproved Excess Material Sites

STRUCTURES: The following subjects explore the scope of subsurface investigations for all structures, including bridges, culverts, retaining walls, and noise-barrier walls:

GT-403-1 All Structures
GT-403-2 Bridges
GT-403-3 Culverts
GT-403-4 Retaining Walls
GT-403-5 Noise Barrier Walls

INVESTIGATIONS ON MAINTENANCE PROJECTS: The following subjects cover the scope of investigations on maintenance projects:

GT-404-1 Preliminary Landslide Investigations
GT-404-2 Comprehensive Landslide Investigations
GT-404-3 Unstable Rock Slope Investigations

CONT.

INVESTIGATIONS ON CONSTRUCTION PROJECTS:

The following subjects explore the scope of investigations on construction projects:

GT-405-1 Landslide Investigations
GT-405-2 Rock Cut Investigations
GT-405-3 Investigations of Excess Material Sites
GT-405-4 Subgrade Stabilization Investigations
GT-405-5 Field Instrumentation

PERMITS:

The following subjects explore investigations and reviews of encroachment permits:

GT-406-1 Right-of-Way Encroachments
GT-406-2 Mining

2 2 2

GEOTECHNICAL	*Chapter* SCOPE OF SUBSURFACE & FIELD INVESTIGATIONS
	Subject Planning Studies

PRELIMINARY OVERVIEWS: Preliminary geotechnical overviews are performed on project areas or corridors for proposed roadway projects. In this preliminary stage of project development, site conditions are evaluated by field reconnaissance of surface conditions along with review of available surface and geologic mapping. Other information, such as previous geotechnical studies or investigations, may also be used to supplement the available data.

2 2 2

GEOTECHNICAL	Section ROADWAYS
	Subject Boring Plan

FORMAT & CONTENT OF BORING PLAN: A boring plan for roadways consists of the following:

- Ø 1 inch = 2,000 feet (1:24,000) scale topographic map showing the alignment with stations indicated on maximum 1,000-foot (300-meter) intervals

  Beginning and ending project stations shall also be shown (refer to **Exhibit 02).**

- Ø All proposed boring locations identified by the appropriate symbol and depicted on plan or manuscript sheets
- Ø Rock core boring locations showing top and bottom elevations plotted on cross-sections and profiles
- Ø Rockline sounding locations and maximum depths plotted on cross-sections
- Ø A tabular summary showing station, offset, and maximum depth of proposed boring

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GEOTECHNICAL	Section: ROADWAYS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject: Soil Profiles

OVERVIEW: All investigations necessary to adequately represent existing conditions and to furnish information for engineering recommendations shall be made. Frequencies or intervals of investigation, hereinafter specified, are to be considered typical and may be adjusted to fit the conditions for individual projects with prior approval by the Geotechnical Branch.

SOIL PROFILES: Soil profiles are vertical sections showing the nature and sequence of the various soil horizons as developed by deposition or weathering. A soil horizon is one of the layers of the soil profile distinguished principally by its texture, color, and structure.

DISTURBED SOIL BORINGS: Disturbed soil borings shall typically be obtained at 200- to 400-foot (60- to 122-meter) intervals. Borings typically will be offset to the ditchline in cut areas or near the toe in fill areas. Side-hill conditions with both cut and fill sections may have offset borings on both sides.

Disturbed soil borings shall typically be obtained for all ramps, frontage roads, crossroads, channel changes, etc., that are over 500 feet (150 meters) in length.

DEPTH IN CUT SECTIONS: Disturbed soil borings in cut sections shall extend to the top of bedded material or to 5 feet (1.5 meters) below the proposed ditchline, whichever occurs first.

DEPTH IN FILL SECTIONS: Disturbed soil borings in fill sections shall extend to the top of bedded material or to the depth equal to the maximum vertical fill thickness on the cross-section, whichever occurs first. The minimum depth shall extend 5 feet (1.5 meters) or to the top of bedded material, whichever occurs first.

CONT.

UNDISTURBED SAMPLES: Thin-walled tube samples shall be obtained in any anticipated wet areas where subgrade occurs at or near original ground. Also, thin-walled tube samples shall be obtained under the existing pavement on projects in which the old pavement is to be removed, replaced, or overlaid at approximately the same grade. These undisturbed samples shall be obtained directly below the dense grade aggregate or at the anticipated elevation of the proposed subgrade.

SAMPLE FREQUENCY: One sample is obtained per 500-foot (150-meter) interval—minimum of five samples per project shall be obtained—alternating from one side of the roadway typical section to the other. This spacing may be increased for projects exceeding 5,000 feet (1,500 meters) in length.

SURVEYING: Centerline stakes with stationing are preferred; however, an alternative method is to stake individual borings for soil profile drilling. The district shall perform the surveying unless contract provisions call for the design consultant to provide the service. “Freshening up” the survey may be necessary immediately prior to drilling operations.

SUBMITTAL OF COORDINATE DATA: The designer shall submit latitude and longitude coordinates for all holes drilled on the project. It should be noted that some holes could be moved during the drilling operations. These holes may need to be either resurveyed or possibly adjusted in the field. The designer will receive new station and offset data for field adjusted holes for calculating new coordinates.

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GEOTECHNICAL	Section: ROADWAYS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject: Rock & Soil Cuts

OVERVIEW: All investigations necessary to adequately represent existing conditions and to furnish information for engineering recommendations shall be made. Frequencies or intervals of investigation, hereinafter specified, are to be typical and may be adjusted to fit the conditions for individual projects with prior approval by the Geotechnical Branch.

GATHERING INFORMATION: Cut investigations consist of rock core sampling, open-face logs, undisturbed-soil sampling, rockline soundings, and other drill data necessary to develop the cut stability sections. A sufficient number of sample and core borings shall be made to define the geologic section completely from the highest elevation to the lowest elevation in the cut for the purpose of determining a recommended cut slope configuration.

ROCKLINE SOUNDINGS: Rockline soundings are utilized in cut sections to determine overburden depths in flat or rolling terrain. Generally, rockline soundings are not performed in mountainous terrain except in landslide areas. Typically, soundings are drilled to the top of bedded material or to 5 feet (1.5 meters) below grade at intervals of 100 feet (30 meters) along the ditchlines. Additional soundings may be required to define the rockline where conditions warrant.

CORES: Cuts less than 30 feet (9 meters) high (measured from ditchline to groundline) and less than 500 feet (150 meters) in length normally require a single core boring. The boring is usually placed in the ditchline of the deepest part of the cut and extends to a minimum of 5 feet (1.5 meters) below the ditchline. A core boring may be drilled a maximum depth of 15 feet (4.5 meters) below the ditchline in lieu of drilling an additional core boring to cover the cut interval where steep roadway grades are encountered in mountainous or rolling terrain. Core borings may be placed on the centerline or the ditchline where the groundline is relatively flat.

CONT.

OVERLAPPING CORES: Cuts in side-hill conditions that are greater than 30 feet (9 meters) high (measured from ditchline to groundline intercept of a 1H:1V slope) may require two or more core borings per stability section. The first core should be placed in the ditchline. If the ditchline core boring does not cover the anticipated cut interval, a second core should be placed at the top of projected 1H:1V slope or at the top of the anticipated cut slope. The second core boring should overlap the top of the ditchline core hole a minimum of 15 feet (4.5 meters).

STABILITY SECTIONS: Cuts that exceed 500 feet (150 meters) in length will normally require more than one cut-stability section. These stability sections should be spaced no more than 500 feet (150 meters) apart. The core borings should overlap a minimum of 15 feet (4.5 meters) on the cross-section and along the profile. It may be necessary to space the stability sections closer when steep grades are encountered.

DEFINING TOP OF BEDDED MATERIAL: Standard penetration tests at 5-foot (1.5-meter) intervals may be necessary to locate the top of bedded material whenever the top of the formation is difficult to determine. If rock is not encountered within a minimum of 5 feet (1.5 meters) above the bottom of the hole as specified in the boring plan, the rock core is to be omitted.

OBSERVATION WELLS: The policy regarding observation wells is as follows:

Ø When the overburden depth in the core hole exceeds 10 feet (3 meters) an undisturbed sample boring with an observation well is required.

Ø Observation wells shall never be placed in core holes. These borings are to be drilled uphill and perpendicular to centerline a minimum of 25 feet (8 meters) away from the core hole.

Ø The ideal offset of the cased observation well is a distance corresponding to twice the overburden depth in the core hole.

Ø These borings shall extend to the top of bedded material or 20 feet (6 meters) below proposed ditchline, whichever is less.

Ø An initial water table reading shall be recorded on the drill log.

Ø Another water table reading shall be obtained no sooner than seven days after completion of the boring.

Ø The initial water table depth, the seven day water table depth, and the dates of the readings shall be recorded on the subsurface logs.

Ø Observation wells may be installed, where necessary, in sounding holes with prior approval from the Geotechnical Branch.

CONT.

OPEN-FACE LOGS: The policy regarding open-face logs is as follows:

- Ø Open-face logging of rock exposures shall be performed in lieu of and/or as a supplement to rock coring where rock outcrops are visible.
- Ø Individual lithologic units shall be described in terms of rock type, unit thickness, and range of individual bed thickness (in feet [meters]).
- Ø Elevations of lithologic units are plotted on the cross-sections.
- Ø Direction and dip of fractures and joints should be measured and noted.
- Ø Joints and fractures should be described as continuous or discontinuous, with water staining or mineralization noted.
- Ø Spring lines, cross-bedding, channel features, etc., are also to be indicated.
- Ø Representative samples for Slake Durability Index (SDI) and Jar Slake (JS) tests may be taken from the cut section, with elevations noted on the cross-section of each sample location.

SURVEYING: The district shall survey the core hole locations unless contract provisions call for the design consultant to provide the service. The surveyor shall mark the hole number, station, offset, and elevation on the stake and provide a list of all surveyed core holes to the Geotechnical Branch. The list shall include the above data, along with the accompanying latitude and longitude coordinates for each core hole.

SUBMITTAL OF COORDINATE DATA: The designer shall submit latitude and longitude coordinates for all holes drilled on the project. It should be noted that some holes could be moved during the drilling operations. These holes may need to be either resurveyed or possibly adjusted in the field. The designer will receive new station and offset data for field adjusted holes for calculating new coordinates.

2 2 2

# GEOTECHNICAL	*Section* ROADWAYS
	Subject Embankments

OVERVIEW: All investigations necessary to adequately represent existing conditions and to furnish information for engineering recommendations shall be made. Frequencies or intervals of investigation, hereinafter specified, are to be considered typical and may be adjusted to fit the conditions for individual projects with prior approval by the Geotechnical Branch.

GATHERING INFORMATION: Embankment investigations consist of all soundings, disturbed borings, and undisturbed borings necessary to develop the embankment stability sections. Undisturbed sample borings shall be drilled to the top of bedded material or to a depth as otherwise specified in the boring plan. Generally, undisturbed borings should penetrate to approximately twice the anticipated embankment height unless bedded material is encountered above that depth. The depth of embankment investigation borings may be decreased to approximately the height of the embankment if very suitable bearing material, such as dense sand or gravelly soils, is encountered.

OBSERVATION WELLS: Cased observation wells shall be installed in undisturbed sample borings that exceed 5 feet (1.5 meters) in depth. Water table readings shall be obtained no sooner than seven days after completion of the boring and recorded on the subsurface log.

STABILITY: Embankment stability borings are generally obtained for each embankment over 20 feet (6 meters) in height (elevation from toe to grade). However, stability borings may not be needed in embankment areas in which shallow foundations (5 feet [1.5 meters] or less) are encountered. Embankments of lesser height should be investigated if unusual conditions are encountered during preliminary drilling. Typically, one cross-section shall be investigated for stability analysis from each 1,000 feet (300 meters), or fraction, of such embankment. The cross-section to be investigated shall generally consist of the highest embankment in the area represented.

CONT.

UNDISTURBED SAMPLE BORINGS: One or more undisturbed sample borings shall be made for each stability section. Normally, one boring shall be drilled near the shoulder and another at the toe of the embankment. A rockline sounding or a disturbed soil boring may be substituted for one of the undisturbed sample borings for narrow sections on flat terrain or for embankments less than 30 feet (9 meters) in height on suitable foundation soils. Additional offset borings may be necessary for wide or side-hill sections.

DISTURBED SOIL BORINGS: Disturbed soil borings and rockline soundings used to develop embankment stability sections should extend to top of bedded material or a distance equal to twice the embankment height, whichever occurs first.

STRUCTURES: Undisturbed sample borings and/or rockline soundings shall also be drilled for embankment stability and settlement analysis for structures (bridges, culverts, walls) during the roadway investigation. Disturbed soil borings from roadway soil profile investigations shall be used as appropriate. To facilitate embankment stability and settlement analyses, borings should be drilled at the approximate locations of:

- Abutments
- Piers
- Wingwalls
- Culvert inlets/outlets
- Wall faces

These borings shall also be used in developing the structure foundation recommendations when appropriate.

2 2 2

GEOTECHNICAL	Section: ROADWAYS
	Subject: Special Geologic Considerations

OVERVIEW: All investigations necessary to adequately represent existing conditions and to furnish information for engineering recommendations shall be made. Frequencies or intervals of investigation, hereinafter specified, are to be considered typical and may be adjusted to fit the conditions for individual projects with prior approval by the Geotechnical Branch.

Special geologic considerations typically consist of structurally controlled problems, karst terrain, mines, and poor quality rock.

PROBLEMS RELATING TO GEOLOGIC STRUCTURE: Structurally controlled problems may include channel deposits, slump blocks, dipping rock, faults, and joints with unfavorable orientations to the roadway. When applicable, an investigation of these problems includes the following:

- Ø Field reconnaissance to determine the type of structurally controlled problems
- Ø Rock cores and soundings
- Ø Observation wells
- Ø Detailed open-face logs locating all joints and lithologies and identifying the structural domains
- Ø Study of any available maps or reports

KARST TERRAINS: Karst terrains include sinkholes, closed drainage basins, sinking streams, caves, and geohydrological conditions, which pose problems to roadways and related facilities. An investigation of these problems may include several field reconnaissances (during both wet and dry weather) and a study of available maps and reports to determine the geohydrological conditions. Soundings are generally used in closed drainage basins and open-throat sinkholes. In order to help define sinkhole boundaries and/or limits, rockline soundings shall be obtained around the outer edges of the sinkhole and as near as possible to any apparent opening (throat). These borings typically extend to refusal or to a depth as specified by the Geotechnical Branch. Geophysical methods may be employed as a supplemental method of information collection.

CONT.

MINES: Mine investigations are dependent on the type of mining operation (underground longwall, underground room and pillar, contour strip, mountaintop removal, auger, or pit). Field reconnaissance is required to determine the type of mining operation that was performed and existing site conditions. If available, mine production maps and mine plans are helpful in determining the extent of the mining activity and orientation in the roadway corridor. Drilling to determine the extent of surface and/or subsurface disturbances usually consists of observation wells and disturbed soil borings. Coring for underground mines is performed to determine the exact elevation of the mine, associated lithologies, the present condition of the floor and roof, and whether or not subsidence has occurred or is anticipated.

2 2 2

GEOTECHNICAL	*Section* ROADWAYS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Preapproved Borrow Sites

OVERVIEW: All investigations necessary to adequately represent existing conditions and to furnish information for engineering recommendations shall be made.

POLICY: Areas that are designated borrow sites in the design phase shall be investigated during the roadway drilling operations. All necessary borings required to properly analyze the proposed site for the classification of materials and slope configuration shall be in accordance with **GT-402-2, Soil Profiles,** and **GT-402-3, Rock and Soil Cuts**.

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GEOTECHNICAL TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Section* ROADWAYS
	Subject Preapproved Excess Material Sites

OVERVIEW: All investigations necessary to adequately represent existing conditions and to furnish information for engineering recommendations shall be made.

POLICY: Areas that are designated excess material sites in the design phase shall be investigated during the roadway drilling operations. Undisturbed borings and/or soundings shall be obtained as outlined in **GT-402-4, Embankments**. Adequate samples shall be obtained and engineering analyses performed to determine the acceptability of the proposed excess material site and slope configurations.

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# GEOTECHNICAL	*Section* STRUCTURES
Transportation Cabinet, Department of Highways, Division of Materials, Geotechnical Branch	*Subject* All Structures

OVERVIEW: The scope of field investigation items applicable to all structures is discussed in this section. Subsequent subjects address various items relating to specific types of structures.

LAYOUT & SCOPE: Once a request to perform a geotechnical investigation is received (refer to **GT-203),** the Geotechnical Branch shall prepare or approve a boring plan to facilitate making geotechnical design recommendations. This plan shows the locations and types of all proposed borings. (Detailed guidelines as to type and number of borings to obtain for specific types of structures are addressed in subsequent subjects.) Borings that will essentially duplicate drilling previously performed for the roadway investigation or other phase of project development shall be deleted. Each boring will have its own unique hole number on the entire project (no duplicate numbers).

FIELD RECONNAISSANCE: A representative of the Geotechnical Branch may visit the site to determine whether access problems (physical obstructions as opposed to denial of access by property owners) will force the relocation or elimination of some borings. District drillers and/or design personnel may participate in this meeting. Centerline of survey shall be staked prior to this meeting as requested by the Geotechnical Branch.

UTILITIES/ PERMISSION TO DRILL: The driller is responsible for locating utilities and obtaining permission from the property owner. If permission to drill is denied, the drill crew supervisor will request that the district obtain property clearance.

OFFSETTING BORING LOCATIONS: In situations where borings cannot be drilled at the staked locations, the driller may offset the hole as much as 5 feet (1.5 meters) without prior approval. It should be noted on the drill log that the boring location was moved and the revised location and revised elevation presented. The driller shall also note on the log the reason for moving the boring location. A log shall be provided for any boring hole that is deleted or not drilled, along with a reason for not drilling the boring hole. Prior approval is required to move boring locations more than 5 feet (1.5 meters).

CONT.

SURVEYING: The approved boring plan will be forwarded to the district or consultant, requesting that the boring locations be staked by a certain date. The district shall perform the surveying for structures unless contract provisions call for the design consultant to provide the surveying. The surveyor shall stake all boring locations and mark the hole number, station, offset, and surface elevation on the stakes. Hole locations using a "with skew" designation should not be used. A copy of the survey notes, including the type of datum used (sea level, crossroads [refer to **GT-203],** or assumed), shall be forwarded to the Geotechnical Branch.

SUBMITTAL OF COORDINATE DATA: The designer shall submit latitude and longitude coordinates for all holes drilled on the project. It should be noted that some holes could be moved during the drilling operations. These holes may need to be either resurveyed or possibly adjusted in the field. The designer will receive new station and offset data for field-adjusted holes for calculating new coordinates.

SCOUR ANALYSIS: Scour analysis is not typically required when a shallow footing on scour-resistant (nonerodible) rock is anticipated. In such cases, if the drilling indicates the possibility of deep foundations, or shallow foundations on scour-prone bedrock, scour analysis is required. The Geotechnical Branch, or geotechnical consultant, shall then request this information from the district or the design consultant. The geotechnical engineer (branch or consultant) will provide D_{50} and D_{95} values to the designer at the time this request is made.

CBR VALUE: The Geotechnical Branch will provide a CBR (California Bearing Ratio) value for pavement design, if requested, on small projects where a geotechnical roadway report will not be performed.

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GEOTECHNICAL	Section: STRUCTURES
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject: Bridges

UNDISTURBED SAMPLES: One undisturbed sample boring shall be drilled at each abutment and each pier. These borings shall extend to the top of bedded material or to the depth of 100 feet (30 meters), whichever is less. Undisturbed samples shall be obtained to the depth of 80 feet (24 meters). If bedded material is not encountered, augering shall continue to the depth of 100 feet (30 meters).

CORES: Unless longer cores are required for special conditions, 10-foot (3-meter) cores are required at each abutment and pier when bedded material is encountered at less than 60 feet (18 meters). Cores shall be taken in the same boring where the undisturbed samples were obtained.

ROCKLINE SOUNDINGS: Rockline soundings are also taken to better define the rockline. Taking one core and one rockline sounding at the opposite ends of each abutment and pier is adequate for structures 30 feet (9 meters) wide or less. Additional soundings are typically required for wider structures.

One additional sounding shall be obtained at or near the centerline for structures that have widths greater than 30 feet (9 meters). Structures greater than 50 feet (15 meters) in width shall have three soundings at each substructure element to supplement information from the core hole. These soundings are intended to facilitate making recommendations for spread footings on rock. The determination of pile lengths for end-bearing piles is less critical for bridge foundation design. Therefore, in areas where the depth to bedrock is too great to allow the use of spread footings, the additional soundings can be omitted provided the rockline is thought to be relatively level (sloping less than 4H:1V along the centerline of bearing).

STEEPLY SLOPING ROCKLINE: Additional soundings are also required in areas where the bedrock is shallow enough to allow the use of spread footings and the rockline is steeply sloping parallel to the roadway centerline. In situations where a steeply sloping rockline is anticipated, each sounding should be replaced by a pair of soundings taken along the front and back edges of the footing (10 feet [3 meters] ahead and back station from the replaced boring location, if the footing width is not known). Each core should similarly be replaced by one core and one sounding.

CONT.

DRILLED-SHAFT CORES:

Drilled shaft foundations can be an alternative to driven piles or spread footings and should be considered if one or more of the following situations are present:

- Ø The ground surface at a pier location is below the 100-year flood elevation, and the depth to bedrock is more than 20 feet (6 meters), unless the results of preliminary scour analyses are available and show that less than 10 feet (3 meters) of scour is anticipated.
- Ø A pier is located in water.
- Ø Karstic processes have produced a highly irregular rock surface, and/or there is the possibility of voids beneath the rock surface.
- Ø Another foundation type would result in a cofferdam depth exceeding 20 feet (6 meters).
- Ø A proposed pier location is within 10 feet (3 meters) of a highway where a lane closure cannot be allowed, or an active railroad and another foundation alternative would result in a cofferdam depth exceeding 5 feet (1.5 meters).
- Ø A substructure unit is located in close proximity to another structure such that another foundation type would result in a cofferdam depth exceeding 10 feet (3 meters), and/or vibrations associated with pile-driving cannot be tolerated.

Drilled shafts on cabinet projects are typically socketed into bedrock, and the guidelines below were developed for that situation. If drilled shafts are to be founded in soil, then special project specific considerations will be necessary.

PHASE 1 EXPLORATION:

if drilled shafts are being considered at the time the geotechnical exploration is being performed, a phase 1 drilled shaft exploration is conducted as defined below:

- Ø Obtain a 30-foot (9-meter) minimum core at the exterior of each substructure element.
- Ø If piers over 50 feet (15 meters) tall or spans longer than 150 feet (46 meters) are anticipated, obtain a 40-foot (12-meter) minimum core at the exterior of each substructure element.
- Ø *Exterior* is defined as the two outermost shafts along the centerline of the substructure unit. If information is available that indicates a shaft group may be used, *exterior* is defined as the four corner shafts in a group. If specific shaft locations are not known, locate the holes 5 feet (1.5 meters) inside the substructure limits shown on the bridge layout.

CONT.

PHASE 2 EXPLORATION: if the decision has been made to use drilled shaft foundations, a phase 2 drilled shaft exploration may be necessary if sufficient information to complete the foundation design was not obtained in a phase 1 exploration. Prior to performing a phase 2 drilled shaft exploration, the geotechnical engineer should obtain basic design information such as drilled shaft layout, anticipated shaft diameters, and axial and lateral loading information from the structural designer. A phase 2 drilled shaft exploration is defined below:

- Obtain a core extending to a minimum of two shaft diameters below the anticipated shaft tip elevation at each drilled shaft location.

- If the geology is consistent, it may be necessary to obtain cores only at the exterior shafts of each row or the exterior corners of each group of shafts. This will be evaluated on a project specific basis.

It is preferable to complete the drilled shaft explorations during design. However, if a phase 2 drilled shaft exploration is needed and cannot be performed prior to the completion of plans due to accessibility problems or time constraints, then the phase 2 exploration should be performed during construction. This exploration may be included in the construction contract or may be performed by the geotechnical branch or under a statewide drilling contract.

OBSERVATION WELLS: Water-table readings shall be obtained from observation wells in selected borings at the abutments no sooner than seven days from completion of the boring. Observation wells shall not be placed in rock core borings.

STABILITY & SETTLEMENT: Structure borings shall also be utilized in the development of approach embankment stability sections and for settlement computations, whenever possible.

BREASTWALL ABUTMENTS: Special requirements are applicable for bridges incorporating breastwall abutments because these walls require rock foundations at shallow depths. Borings as described above shall be obtained at the proposed abutment locations.

If rock is encountered within 20 feet (6 meters) of roadway grade, no additional drilling is required. If rock is not encountered within this interval, additional rockline soundings shall be obtained 20 to 30 feet (6 to 9 meters) behind the originally proposed abutment locations to facilitate revised design (that is, conversion from a single-span to a three-span structure).

CONT.

SPECIAL CONDITIONS:

In some instances, it may not be possible to get all the requested cores and soundings. Additional cores and soundings may be required in other cases if the elevation of the rock surface is erratic. Deeper cores may be necessary due to various conditions, including the following examples:

- Large foundations (piers over 50 feet [15 meters] tall, or long spans) are anticipated
- Large boulders may be present
- Rock quality is poor
- The rock is karstic
- Drilled shafts are anticipated

The Geotechnical Branch shall be contacted for instructions in these instances.

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# GEOTECHNICAL	*Section* STRUCTURES
Transportation Cabinet, Department of Highways, Division of Materials, Geotechnical Branch	*Subject* Culverts

NUMBER & LOCATIONS OF BORINGS: The number and locations of borings for culverts are dependent upon the size and type of structure and the bedrock type. In general, the number of core borings obtained in karstic areas will be approximately double the number required for nonkarstic areas, although the total number of borings (cores plus soundings) will be the same. **Exhibit 37** is intended to be used as a general guideline in determining the number and spacing of borings to be obtained for box or arch culverts. Borings shall be obtained along the culvert centerline for single-barrel box culverts 8 feet (2 meters) or less in width. Borings shall be located along each bearing line for culverts more than 8 feet (2 meters) wide and for multibarrel box culverts.

ROCK CORES: Rock cores designated on the boring layout may be eliminated if the rock surface is more than 5 feet (1.5 meters) below flowline. If necessary, rock cores, shall extend to 5 feet (1.5 meters) below flowline; however, a minimum of 5 feet (1.5 meters) of core shall be obtained.

SAMPLES FOR ALLOWABLE BEARING OF WINGWALLS: Continuous undisturbed samples shall be obtained from one boring at each end of box culverts from flowline to 6 feet (2 meters) below flowline or to the top of bedded material, whichever is shallower. Rockline soundings shall extend to 5 feet (1.5 meters) below design flowline or to the top of bedded material, whichever is shallower. Borings from roadway design (embankments and soil profile) shall be incorporated into the culvert boring layout whenever possible.

SAMPLES FOR STABILITY & SETTLEMENT ANALYSES: An undisturbed-sample boring under the highest part of the fill is required if the fill is 20 feet (6 meters) or more in height. Samples shall be obtained at 5-foot (1.5-meter) intervals to twice the embankment height or to the top of bedded material, whichever is shallower. This boring and a rockline sounding(s) shall be obtained to allow an evaluation of settlement and slope stability.

CONT.

PIPE CULVERTS: The roadway designer may request subsurface investigations for pipe culverts whenever the fill height at the pipe location, the depth of foundation soils, and the size of pipe are sufficient to indicate possible development of settlement or stability problems. If the Geotechnical Branch deems a geotechnical investigation for a pipe culvert necessary, drilling shall be the same as for small box culverts.

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GEOTECHNICAL	*Section* STRUCTURES
Transportation Cabinet, Department of Highways, Division of Materials, Geotechnical Branch	*Subject* Retaining Walls

STANDARD GRAVITY WALLS: Standard gravity walls may be constructed at locations requiring small walls, less than 6 feet (2 meters) in height, which meet the requirements of Standard Drawing RGX-002 "Retaining Wall, Gravity Type, Non-Reinforced." Standard gravity walls less than 6 feet (2 meters) in height do not require site-specific designs, and no subsurface investigation is required for these structures. Gravity walls with heights in excess of 6 feet (2 meters) will be evaluated on a case-by-case basis to determine if a site-specific design and a subsurface investigation is needed.

ALL OTHER WALLS: All other walls, including cantilever, mechanically stabilized earth (MSE), tieback, and soil nail walls, do require site-specific designs.

ROCKLINE SOUNDINGS: Rockline soundings shall be obtained along the wall face at 50-foot (15-meter) intervals of retaining wall length and at a distance of 70 percent of the wall height (0.7H) behind the wall at 100-foot (30-meter) intervals. The borings behind the wall will indicate whether the rockline is rising from the wall face. This information can be used to facilitate stability analysis and to ensure that the design does not require rock excavation to construct the wall.

UNDISTURBED SAMPLES Undisturbed borings shall be obtained at 100 to 300-foot (30 to 100-meter) intervals. The undisturbed borings shall extend to twice the wall height below the base of the footing or to the top of bedded material, whichever is less.

CORES: Core to 5 feet (1.5 meters) below the proposed footing elevation (5 feet [1.5 meters] minimum) at 100 to 150-foot (30 to 45-meter) intervals if bedded material is encountered 5 feet (1.5 meters) below footing elevation or higher. Greater core intervals shall be used for projects where core information is available from nearby structures. Closer core spacing may be required in karst terrain.

CONT.

OBSERVATION WELLS: An observation well shall be installed if the water table has not been established from previous drilling.

USE OF PREVIOUSLY OBTAINED BORINGS: Borings from roadway design (embankments and soil profile) and other structures in the area shall be incorporated into the layout of the retaining wall boring plan whenever possible.

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GEOTECHNICAL	Section: STRUCTURES Subject: Noise Barrier Walls

OVERVIEW: Noise barrier walls require site-specific foundation designs.

ROCKLINE SOUNDINGS: The following guidelines are applicable to the development of an investigation plan:

- Ø Rockline soundings shall be obtained along the wall face at 100-foot (30-meter) intervals of wall length.
- Ø The cutoff depth for a sounding where no rock is encountered is about 40 feet (12 meters).
- Ø In areas where it is likely that no bedrock will be encountered within 40 feet (12 meters), soundings are not needed.

UNDISTURBED BORINGS: Undisturbed borings shall be obtained at 300-foot (90-meter) intervals. The undisturbed borings shall extend to 50 feet (15 meters) or to the top of bedded material, whichever is less.

CORES: If bedrock is encountered within 40 feet (12 meters), obtain a 5-foot (1.5-meter) core.

USE OF PREVIOUSLY OBTAINED BORINGS: Borings from roadway design (embankments and soil profile) and other structures in the area shall be incorporated into the wall boring layout whenever possible.

2 2 2

GEOTECHNICAL	*Section* INVESTIGATIONS ON MAINTENANCE PROJECTS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Preliminary Landslide Investigations

SCOPE OF INVESTIGATION: A preliminary field inspection shall be made and, if necessary, preliminary drilling performed. A preliminary landslide investigation shall determine whether a:

- Ø Simple solution exists, such as drilled-in railroad rails or revised drainage, etc.
- Ø Comprehensive investigation is required

Preliminary landslide investigations typically include rockline soundings, observation wells, and rock cores. Representatives from the district and the appropriate divisions shall be invited to attend the field inspection. Boring plans shall be approved by the Geotechnical Branch prior to beginning the fieldwork.

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GEOTECHNICAL

TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch

Section

INVESTIGATIONS ON MAINTENANCE PROJECTS

Subject

Comprehensive Landslide Investigations

SCOPE OF INVESTIGATION: The following site information may be necessary for a comprehensive landslide investigation:

- Ø Cross-sections showing all visible scarps, toe bulges, and notable topographic features should be taken every 25 feet (8 meters) unless otherwise requested.
- Ø A plan sheet showing visible scarps, toe bulges, all known utilities, property owners, and prominent landmarks should be developed.
- Ø Where possible, stations shall be referenced to permanent landmarks and roadway mile markers for future identification.
- Ø Disturbed and/or undisturbed samples shall be taken in the failure area and in areas requiring stability analyses for the slide correction. Major soil types shall be identified and any apparent "weak" materials shall be noted.
- Ø The rockline shall be profiled, and rock cores should be taken where applicable.
- Ø Slope inclinometers and observation wells may be installed where information is necessary for project correction.
- Ø After completion of the drilling operations, the district performs the surveying to determine boring locations unless contract provisions call for a consultant to provide this service.
- Ø The designer shall submit latitude and longitude coordinates for all holes drilled on the project. It should be noted that some holes could be moved during the drilling operations. These holes may need to be either resurveyed or possibly adjusted in the field. The designer will receive new station and offset data for field adjusted holes for calculating new coordinates.

The Geotechnical Branch shall approve boring plans prior to beginning the drilling.

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GEOTECHNICAL

Section

INVESTIGATIONS ON MAINTENANCE PROJECTS

Subject

Unstable Rock Slope Investigations

SCOPE OF INVESTIGATION: The preliminary field inspection will determine whether a simple solution exists or a detailed investigation is required. If a detailed investigation is required, the district is responsible for providing plans and cross-sections, staking core hole locations, and obtaining permission to drill on private property. The following site information shall be obtained for a detailed investigation:

- A survey of the failure area, including manuscripts, cross-sections, plan sheets, and maintenance records, shall be made. These drawings shall depict the roadway, top of cut, any breaks or failures, right of way, property owners, and utilities.
- All lithologies, structural discontinuities, wedges, blocks, and areas of instability shall be mapped on an oblique photomosaic of the cut face when structural domains cannot be completely interpreted using cross-sections.
- Rock cores are to be used to supplement open-face logs and identify conditions not apparent from mapping (mines, deep overburden above the cut, or locations where reworking of the slope will expose previously covered terrain).

2 2 2

GEOTECHNICAL	Section INVESTIGATIONS ON CONSTRUCTION PROJECTS
	Subject Landslide Investigations

SCOPE OF INVESTIGATION: A field inspection shall be made to determine what type of geotechnical investigation is necessary. Prior to beginning any investigation, the Geotechnical Branch shall approve scope of work and boring plans.

Borings shall extend to bedded material or to an elevation below the anticipated failure surface. The district may be requested to obtain cross-sections prior to drilling operations. Locations and surface elevations will be obtained after the holes are located or drilled. Slope inclinometers may be required to determine depths of failure surfaces. Cores, undisturbed samples, and observation wells may be required. Additional water level readings are recommended to determine any change in groundwater elevation. Stability analysis may be necessary to determine the most economical solution.

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GEOTECHNICAL

TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch

Section

INVESTIGATIONS ON CONSTRUCTION PROJECTS

Subject

Rock Cut Investigations

SCOPE OF INVESTIGATION: Rock cuts made during construction by blasting are intended to produce a specific template as specified in the roadway plans. Numerous characteristics may all affect how the rock will respond to blasting. Characteristics include:

- Faulting
- Joint frequency and joint spacing
- Localized or extensive fracturing of the rock
- Various other conditions

In design, an attempt is made to determine a slope configuration, which can be realistically constructed. However, after blasting, some rock cuts may be determined unsafe. Measures to correct deficiencies vary too greatly to attempt to provide a set of generic directions. Each condition must be evaluated independently, and a correction that takes into account site-specific conditions must be developed.

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GEOTECHNICAL	*Section* INVESTIGATIONS ON CONSTRUCTION PROJECTS
	Subject Investigations of Excess Material Sites

SCOPE OF INVESTIGATION: The most critical section of an excess material site shall be investigated for slope stability. Additional stability sections may be necessary due to topography of the area, embankment height, and foundation conditions. Rockline soundings, rock cores, and/or undisturbed sample borings shall be obtained along the section typically at 100-foot (30-meter) intervals. This material may need to be sampled and tested to determine its strength parameters. Prior to beginning any investigation, the Geotechnical Branch shall approve the scope of work and boring plans.

2 2 2

GEOTECHNICAL

Section

INVESTIGATIONS ON CONSTRUCTION PROJECTS

Subject

Subgrade Stabilization Investigations

SCOPE OF INVESTIGATION: The extent of the field investigation for unstable subgrade may vary depending on the magnitude of the problem. As necessary, tests using a hand-operated dynamic cone penetrometer shall be performed (in accordance with the manufacturer's procedure), or thin-walled tube samples shall be obtained to determine the undrained shear strength of the soil. Soil classifications shall be obtained on the tested material.

Pavement and subbase (DGA, rock roadbed, etc.) thicknesses for projects involving overlaying existing subgrade shall be obtained. These procedures shall be completed along with sampling of the existing subgrade.

2 2 2

GEOTECHNICAL	Section INVESTIGATIONS ON CONSTRUCTION PROJECTS
	Subject Field Instrumentation

INSTALLING & READING FIELD INSTRUMENTATION: The Geotechnical Branch is responsible for determining the locations and depths of all field instrumentation to be installed. Locations may need to be changed from those indicated on the plans due to construction constraints.

The Project Engineer is responsible for reading the instrumentation upon request by the Geotechnical Branch. Construction shall be halted and the Geotechnical Branch notified immediately if any instrumentation is damaged.

2 2 2

GEOTECHNICAL	Section PERMITS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject Right-of-Way Encroachments

SCOPE OF INVESTIGATION: The reviews for right-of-way encroachment permits may consist of:

- Site inspections
- Subsurface investigation
- Laboratory tests
- Research of available subsurface data for the surrounding area

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GEOTECHNICAL TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Section* PERMITS
	Subject Mining

SCOPE OF INVESTIGATION: The reviews of mining permits may consist of:

- Site visits
- Additional core drilling
- Rock-mechanics tests
- Research of available subsidence records
- Related geological data for the area

A review of other underground crossings with similar geologic conditions may be studied to determine whether the proposed encroachment adversely affects the highway. A review of mine maps is invaluable in determining multiple seam mining conditions or potential subsidence problems for the area. The controlling factors for stability are structural discontinuities such as faults, joints, and fractures. All information on local and regional geological features is utilized. Generally accepted subsidence factors for the different coal basins are utilized to determine the magnitude of potential subsidence. Average draw angles are used to determine safe distances that mining operations shall maintain in order to protect roadway facilities.

2 2 2

GEOTECHNICAL	Chapter: LABORATORY TESTING & MATERIAL CLASSIFICATION
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject: Introduction

OVERVIEW: Laboratory testing and classification of soil and rock samples are important elements in geotechnical engineering. Testing, however, can be expensive and time consuming. The complexity of testing required for a particular project may range from a simple moisture-content determination to specialized strength-testing. Geotechnical engineering experience is needed to determine certain considerations regarding laboratory testing, such as when, how much, and what type. The project manager must schedule or review all testing requests before implementation so as to optimize testing, particularly strength and consolidation testing. Subjects explored in this chapter are as follows:

SOIL SAMPLE PREPARATION: **GT-501** discusses sample preparation of disturbed soils and of undisturbed soils.

STANDARD TEST METHODS FOR SOILS: **GT-502** explores testing procedures and types of tests for soils.

CLASSIFICATION OF SOILS: **GT-503** states the policy for classifying soils.

STANDARD TEST METHODS FOR ROCKS: **GT-504** explores three standard methods for testing rocks.

ROCK TYPES: **GT-505** discusses three types of rocks.

TYPICAL TESTING FREQUENCIES: The following subjects explore testing frequencies of soils and rocks.

GT-506-1 Disturbed Soil Samples
GT-506-2 Undisturbed Soil Samples
GT-506-3 Rock Samples

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GEOTECHNICAL	Chapter LABORATORY TESTING & MATERIAL CLASSIFICATION
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject Soil Sample Preparation

DISTURBED SOIL SAMPLES: Preparation of samples received from the field for mechanical analysis, physical tests, moisture/density relationship tests, and other tests shall be prepared in accordance with **AASHTO T 87,** "Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test."

UNDISTURBED SOIL SAMPLES: Extruded thin-walled tube samples and Standard Penetration Test (SPT) sample jars shall be classified and recorded on the TC 64-531 form, *Thin-Walled Tube and SPT Sample Log* **(Exhibits 12 and 13).** Pocket penetrometer or Torvane tests shall be performed on tube samples, as appropriate, and the results recorded on the request form. Representative samples shall be waxed or otherwise preserved to prevent loss of moisture. A copy of the request form shall be forwarded to the engineer for the purpose of assigning appropriate laboratory tests.

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GEOTECHNICAL	Chapter: LABORATORY TESTING & MATERIAL CLASSIFICATION
	Subject: Standard Test Methods for Soils

OVERVIEW: Many engineering tests that the Department of Highways performs on soil and rock samples follow the procedures of the American Association of State Highway and Transportation Officials (AASHTO). In other instances the department requires modification of the AASHTO procedures, or tests not addressed by AASHTO. The Division of Materials has produced the companion manual *Kentucky Methods* (KM [not reproduced herein]), which presents specifications for the modified testing procedures.

REQUIRED TESTING PROCEDURES: The table on the following page shows the required testing procedures applicable to soil samples:

- Ø Where only an AASHTO standard is designated, the AASHTO procedure is followed in full.
- Ø Where both KM and AASHTO standards are designated, the KM procedure is required, but this procedure represents a relatively minor modification of the AASHTO procedure.
- Ø Where only the KM standard is designated, either the modification is very significant or there is no AASHTO procedure relating to this test.

CONT.

REQUIRED TESTING PROCEDURES (cont.):

TEST PROCEDURE	APPLICABLE STANDARDS	
	AASHTO*	**KM****
DISTURBED SOIL TESTS		
Wash and sieve analysis	***	
Dry preparation of disturbed soil samples	T 87	
Particle size analysis of soils	T 88	64-519
Determining the liquid limit of soils	T 89	
Determining the plastic limit and plasticity index of soil	T 90	
Moisture-density relations of soils using a 5.5 lb (2.5 kg) rammer and a 12 in. (305 mm) drop	T 99	64-511
Specific gravity of soils	T 100	
Laboratory determination of moisture content of soils	T 265	
The California Bearing Ratio of laboratory compacted soils and soil aggregate mixtures		64-501
Subgrade chemical stabilization		64-520
UNDISTURBED SOIL TESTS		
Unconfined compressive strength of cohesive soil	T 208	64-522
One-dimensional consolidation properties of soils	T 216	
Unconsolidated, undrained compressive strength of cohesive soils in triaxial compression	T 296	64-521
Consolidated, undrained triaxial compression test on cohesive soil	T 297	64-502
***AASHTO—American Association of State Highway and Transportation Officials** ****KM—Kentucky Methods** *****Performed according to ASTM D 1140**		

The following pages provide brief descriptions of the tests.

CONT.

WASH & SIEVE ANALYSIS: The wash and sieve analysis is used to determine the amount of material finer than the number 200 (75µm) sieve. The material remaining on the number 200 (75 µm) sieve shall be passed over a sieve stack, as appropriate, to provide better knowledge of the particle size distribution. This test shall be in accordance with ASTM D 1140.

PARTICLE SIZE ANALYSIS: Particle size analysis is used in the classification of soils and includes sieve, hydrometer, and wash gradation tests. These tests shall be performed in accordance with **KM 64-519.**

ATTERBERG LIMITS: Atterberg limits are commonly used for classification of soils. These tests shall be performed in accordance with **AASHTO T 89 and T 90.**

MOISTURE/ DENSITY TEST: The moisture/density or "Proctor" test is used to determine the relationship between water content and dry density for a given compactive effort. This test shall be in accordance with **KM 64-511.**

SPECIFIC GRAVITY TEST: Specific gravity is used to compute the void ratio when unit weight and water content are known. This test shall be in accordance with **AASHTO T 100.**

MOISTURE CONTENT DETERMINATION: Laboratory determination of moisture content of soils is a routine test to measure the amount of water present in a quantity of soil in terms of dry soil weight. This test shall be in accordance with **AASHTO T 265.**

CALIFORNIA BEARING RATIO: The California Bearing Ratio (CBR) test is used as a means of determining the properties of a soil for use in designing pavement structures. This test shall be in accordance with **KM 64-501.**

SUBGRADE STABILIZATION TESTS: The subgrade stabilization tests using chemicals are performed to determine the type of chemical that will be added to the soil subgrade. The percentage of chemical to be added to soil is 6 percent. A standard Proctor test will be run on the chemical soil mixture to determine the optimum moisture and maximum dry density of the chemically stabilized soil. These tests shall be in accordance with **KM 64-520.**

UNCONFINED COMPRESSION TEST: The unconfined compression test is typically used to evaluate the undrained shear strength (total stress) of cohesive soils. This test shall be in accordance with **KM 64-522.** Pocket Penetrometer and/or Torvane tests shall be performed on each sample prior to testing and recorded on the data sheets. Torvane tests shall indicate the size of the vane used. The Pocket Penetrometer and/or Torvane tests shall be performed on a portion of the sample that will be removed during the sample trimming process.

CONT.

ONE-DIMENSIONAL CONSOLIDATION TEST: The results of the consolidation test are used to estimate the magnitude and time rate of consolidation settlement of cohesive soils. This test shall be in accordance with **AASHTO T 216.**

UNCONSOLIDATED-UNDRAINED TOTAL STRESS TRIAXIAL TEST: The unconsolidated-undrained triaxial test is used to evaluate the undrained shear strength (total stress) of cohesive soils. It is typically used for samples with blocky structure, below the water table, fissures, high silt contents, silt seams, sand seams, or other defects. It may also be used for samples where in-situ confining pressures are relatively large (that is, below 20 feet [6 meters] depth) or for samples obtained below the water table. Confining pressure applied to a sample is typically equal to the approximate in-situ effective overburden pressure. This test shall be in accordance with **KM 64-521**. Pocket Penetrometer and/or Torvane tests shall be performed on each sample prior to testing and recorded on data sheets. Torvane tests shall indicate the size of the vane used. The Pocket Penetrometer and/or Torvane tests shall be performed on a portion of the sample that will be removed during the sample trimming process.

CONSOLIDATED-UNDRAINED TRIAXIAL TEST WITH PORE PRESSURE MEASUREMENT: The consolidated-undrained triaxial test with pore pressure measurement is typically used to determine the effective shear strength of a soil. This test shall be in accordance with **KM 64-502.** Pocket Penetrometer and/or Torvane tests shall be performed on each sample prior to testing and recorded on the data sheets. Torvane tests shall indicate the size of the vane used. The Pocket Penetrometer and/or Torvane tests shall be performed on a portion of the sample that will be removed during the sample trimming process.

2 2 2

GEOTECHNICAL	Chapter LABORATORY TESTING & MATERIAL CLASSIFICATION
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject Classification of Soils

POLICY: Soils shall be classified in accordance with **AASHTO* M 145,** *The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes,* and **ASTM** D 2487,** *Standard Test Method for Classification of Soils for Engineering Purposes,* commonly referred to as the Unified Soil Classification System.

*AASHTO—American Association of State Highway and Transportation Officials

****ASTM—American Society for Testing and Materials**

2 2 2

GEOTECHNICAL

Chapter

LABORATORY TESTING & MATERIAL CLASSIFICATION

Subject

Standard Test Methods for Rocks

SLAKE DURABILITY INDEX TEST: The Slake Durability Index (SDI) test is used to classify shale and other sedimentary rocks according to durability. The test shall be performed on samples of shale and may be used on friable sandstone where there is a question of durability. The test shall be performed in accordance with **KM 64-513.**

JAR SLAKE TEST: The Jar Slake (JS) test is used to supplement the SDI test. The test shall be performed in accordance with **KM 64-514.**

UNCONFINED COMPRESSION TEST: The unconfined compression test is a standard method for testing rock cores. The test is used to evaluate the compressive strength of rock. The test shall be performed in accordance with **KM 64-523.**

2 2 2

GEOTECHNICAL	*Chapter* LABORATORY TESTING & MATERIAL CLASSIFICATION
	Subject Rock Types

OVERVIEW: Sedimentary rock classification is based upon physical and chemical properties. Several geologic rock types may have the same properties and, thus, are grouped together. It should be understood that the terminology presented here might vary from other commonly used classification schemes. Included in each grouping is a list of generally recognized equivalents.

LIMESTONE: Limestone is bedded sedimentary rock consisting chiefly of carbonates, including dolomites and dolostones. Limestones containing notable proportions of shale may be noted as argillaceous.

SANDSTONE: A cemented or otherwise compacted detrital sedimentary rock composed primarily of quartz grains larger than .075 millimeters in diameter, including conglomerates. Sandstone should be described as durable or nondurable (friable) for engineering purposes.

SHALE: Shale is a cemented or noncemented sedimentary deposit of various chemical compositions in which the constituent particles are smaller than .075 millimeters in diameter and include siltstone, claystone, and mudstone.

Shale is classified according to Slake Durability Index (SDI) results; however, sedimentary-shale deposits are frequently interbedded with thin sections of carbonates or arenaceous (sandy) partings that can produce distorted SDI values. Jar Slake tests are typically performed to provide additional information about rock disintegration to compare with SDI test results. SDI test results in conjunction with Jar Slake test results must be considered when classifying shale and preparing recommendations.

Results of slaking tests will be used to classify shale as durable (SDI ≥ 95) or nondurable (SDI < 95). Nondurable shale will be subdivided into classes for design purposes only. Classification of shale and typical correlation with Jar Slake test results are in the table below:

CLASSIFICATION	SDI RANGE	SLAKE CATEGORY
Durable	≥ 95	6
Nondurable		
Class I	80 to 94	4 or 5
Class II	50 to 79	3 or 4
Class III	≤ 49	1 or 2

2 2 2

GEOTECHNICAL	*Section* TYPICAL TESTING FREQUENCIES
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Disturbed Soil Samples

OVERVIEW: The following are recommended for laboratory testing of disturbed soil samples for geotechnical purposes. These tests and frequencies do not preclude engineering judgment.

TESTS ON ALL BAG SAMPLES FROM FILL SECTIONS: The following laboratory tests shall be performed on bag samples from fill sections:

- Ø Specific Gravity Test
- Ø Particle Size Analysis
- Ø Atterberg Limits
- Ø Natural Moisture Content (on jar samples only)

ADDITIONAL TESTS ON BAG SAMPLES FROM CUT SECTIONS: The following laboratory tests, in addition to the tests listed above for bag samples from fill sections, shall be performed on bag samples from cut sections:

- Ø Moisture/Density Test
- Ø CBR

FILL SECTIONS OF BORROW PROJECTS: If the project is anticipated to be borrow, bag samples from fill sections may need to be tested, with prior approval of the Geotechnical Branch, as if they were bag samples representing soils from cut sections.

Bag samples shall be classified as outlined in **GT-503, Classification of Soils.**

2 2 2

GEOTECHNICAL	*Section* TYPICAL TESTING FREQUENCIES
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Undisturbed Soil Samples

OVERVIEW: The following are recommended for laboratory testing of undisturbed soil samples for geotechnical purposes. These tests and frequencies do not preclude engineering judgment.

UNDISTURBED SOIL SAMPLES: These tests and frequencies are in regard to samples obtained from Standard Penetration Tests (SPT) and thin-walled tubes. In cases where either there is a scarcity of samples or there is a quantity of apparently identical tube samples, representative samples shall be chosen for testing.

LABORATORY TESTING ON SPT SAMPLES: Testing for Standard Penetration samples:

Ø Wash and Sieve Gradation Tests
Ø Soil Classification Tests

- ♦ Specific Gravity Test
- ♦ Particle Size Analysis
- ♦ Atterberg Limits

Samples obtained by SPT shall be classified in accordance with **GT-503, Classification of Soils.** In some cases a single sample may not provide sufficient material to perform a complete classification of the soil; however, samples from different depths may be combined, when appropriate, to provide adequate quantities of material for testing. Samples shall be tested by performing wash and sieve gradation tests when sufficient quantities of soil are not available or cannot be combined to provide adequate amounts of material for complete classification testing.

CONT.

LABORATORY TESTING ON THIN-WALLED TUBE SAMPLES: Thin-Walled Tube Samples:

- Ø Soil Classification Tests
  - ♦ Specific Gravity Test
  - ♦ Particle Size Analysis Test
  - ♦ Atterberg Limits Test
- Ø Moisture Content Test
- Ø Unconfined Compression Test
- Ø Unconsolidated-Undrained Triaxial Test
- Ø Triaxial Test (consolidated-undrained with pore-pressure measurements)
- Ø Consolidation Test

CLASSIFICATION & MOISTURE CONTENT TESTS: Classification and moisture content tests shall be performed on each thin-walled tube sample. Normally, only one natural moisture test needs to be performed on sample trimmings from each thin-walled tube unless significant material changes are noticed within the tube.

TESTS FOR SHORT-TERM ANALYSES: Unconfined compression or unconsolidated-undrained triaxial tests shall be performed for short-term analyses. The unconsolidated-undrained triaxial method is typically performed on soils with low cohesion (high silt and low clay content), blocky structure, samples obtained from depths greater than 20 feet (6 meters) and/or samples obtained below the water table. Normally one test per tube sample is sufficient unless shallow, variable soils are encountered.

TESTS FOR LONG-TERM ANALYSES: Unconfined compression or unconsolidated-undrained triaxial tests shall be performed, saving adequate samples (if required) for triaxial and consolidation tests. Consolidated-undrained triaxial tests with pore-pressure measurements or drained triaxial tests with pore pressure measurements or drained triaxial tests may be performed for long-term analyses. Representative unconfined compression and triaxial tests shall be performed for each different soil type or horizon when required.

CONSOLIDATION TEST: One-dimensional consolidation tests shall be performed for all bridge approaches greater than 20 feet (6 meters) in height unless the foundation is shallow or granular and for other embankment situations where controlled loading is deemed necessary. A minimum of one consolidation test per soil type per situation shall be performed. Soil horizons exceeding 20 feet (6 meters) in thickness may require more than one test.

2 2 2

GEOTECHNICAL

TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Section* TYPICAL TESTING FREQUENCIES
	Subject Rock Samples

OVERVIEW: The following are recommended for laboratory testing of rock samples for geotechnical purposes. These tests and frequencies do not preclude engineering judgment.

ROCK SAMPLES: These tests shall be performed on rock cores that contain a significant quantity of shale and/or friable sandstone.

- Ø Jar Slake (JS)
- Ø Slake Durability Index (SDI)

TYPICAL TESTING FREQUENCY: Typical testing frequency in rock cut sections shall be one test for each 5 feet (1.5 meters) in shale or one test for each 10 feet (3 meters) of friable sandstone. These tests shall also be performed on the interval just below the footing elevation for structures on which spread footings are anticipated. Jar Slake tests need not be performed on friable sandstone.

UNCONFINED-COMPRESSION TEST: Unconfined compression tests on rock shall be performed when needed for the design of drilled shafts in rock. A typical testing frequency is approximately one sample per 10-foot (3-meter) core run, subject to the availability of suitable samples and/or the judgment of the project engineer or geologist.

2 2 2

GEOTECHNICAL	Chapter: ENGINEERING ANALYSIS Subject: Introduction

OVERVIEW: This chapter provides guidelines for performing engineering analyses. More than one widely accepted method may exist for some types of analyses. A preferred method may be described and/or referenced. Other methods may be appropriate in some instances with prior approval by the Geotechnical Branch.

SLOPE STABILITY: The following subjects present guidelines relating to the evaluation of the stability of earth slopes:

GT-601-1	Slope Stability Analysis
GT-601-2	Strength Parameters
GT-601-3	Target Safety Factors
GT-601-4	Cut Slopes in Soil
GT-601-5	Embankments, Bridge Approach Slopes, & Excess Material Sites
GT-601-6	Landslides
GT-601-7	Controlled Loading
GT-601-8	Ground Improvement
GT-601-9	Groundwater

BEARING CAPACITY FOR SHALLOW FOUNDATIONS: The following subjects discuss guidelines relating to bearing-capacity considerations for shallow foundation design:

GT-602-1	Use of Spread Footings on Soil
GT-602-2	Bearing Capacity on Soil
GT-602-3	Granular Replacement
GT-602-4	Restrictions for Spread Footings on Soil
GT-602-5	Bearing Capacity on Rock

CONT.

SETTLEMENT: The following subjects provide guidelines for performing settlement analysis:

GT-603-1 Overview
GT-603-2 Differential Settlement
GT-603-3 Controlled Loading (Staged Construction)
GT-603-4 Accelerating Consolidation Rates
GT-603-5 Reducing Settlement Magnitudes

RETAINING STRUCTURES & REINFORCED SOIL SLOPES: The following subjects discuss the use of retaining structures and reinforced soil slopes and references some appropriate methods of analysis:

GT-604-1 Overview
GT-604-2 Gravity, Cantilever, & MSE Retaining Walls
GT-604-3 Tieback & Soil Nail Retaining Walls
GT-604-4 Railroad Rail Retaining Structures
GT-604-5 Reinforced Soil Slopes

PILE & DRILLED SHAFT DESIGN: The following subjects explain various considerations relating to the design of deep foundations (piles and drilled shafts):

GT-605-1 Overview
GT-605-2 Tip Elevations of Point Bearing Piles
GT-605-3 Static Capacity of Friction Piles
GT-605-4 Pile Dynamic Analysis & Constructability Considerations
GT-605-5 Axial Capacity of Drilled Shafts
GT-605-6 Evaluating Resistance to Lateral Loads
GT-605-7 Pull-Out Resistance
GT-605-8 Negative Skin Friction (Dragdown)
GT-605-9 Settlement of Friction Piles
GT-605-10 Lateral Squeeze
GT-605-11 Load Testing

SCOUR CONSIDERATIONS: The following subjects discuss design considerations intended to offset the negative effects of severe scour:

GT-606-1 Scour of Soil Foundations
GT-606-2 Scour of Bedrock

SUBGRADES: The following subjects discuss the California Bearing Ratio (CBR), as well as chemical and mechanical stabilization of subgrades:

GT-607-1 CBR Design Values
GT-607-2 Chemical Stabilization of Subgrades
GT-607-3 Mechanical Stabilization of Subgrades

CONT.

CUT SLOPES IN ROCK: The following subjects present guidelines for providing sufficient flexibility to allow the design of slopes in a wide variety of rock formations:

GT-608-1 General Guidelines
GT-608-2 Rock Cut Slope Configurations
GT-608-3 Intermediate & Overburden Bench Widths
GT-608-4 Serrated Slopes
GT-608-5 Roadside Ditch Bench
GT-608-6 Slope Design without Intermediate Benches & with Catchment Areas
GT-608-7 Summary of Rock Quantities

SPECIAL GEOLOGIC CONSIDERATIONS: The following subjects explain design procedures or present guidelines relating to specific geologic or man-made features that might be encountered on highway projects:

GT-609-1 Sinkholes
GT-609-2 Mines
GT-609-3 Dipping Rock
GT-609-4 Faults
GT-609-5 Acid-Producing Shales

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GEOTECHNICAL	*Section* SLOPE STABILITY
	Subject Slope Stability Analysis

SLOPE STABILITY ANALYSIS:

A slope stability analysis yields a safety factor, which is the ratio of available shear strength of the soil to the strength required to maintain equilibrium of the slope. The safety factor obtained from the various methods of analyzing the stability of slopes does not necessarily constitute a reserve of unused strength. Rather, it is a working element of design, where the safety factor is used to allow for uncertainties in modeling the site geometry, characteristics of the soil and construction materials, location of the water table, and construction techniques.

2 2 2

GEOTECHNICAL

TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch

Section

SLOPE STABILITY

Subject

Strength Parameters

OVERVIEW: The subsurface investigation will permit a determination of whether the foundation soils are relatively uniform and homogeneous (in which case a single set of soil parameters could be used) or if soil layers with varying properties are apparent. In a layered foundation, different soils should be defined to allow the stability model developed to be a reasonably close approximation to field conditions.

COHESIVE SOILS: Strength parameters of cohesive foundation soils should be based on laboratory and/or in-situ test results. Total stress parameters shall be based upon unconfined compression tests, unconsolidated-undrained triaxial tests, or consolidated-undrained triaxial tests, as applicable. Effective stress parameters shall be based upon consolidated-undrained triaxial tests.

ESTIMATED PARAMETERS: Tube samples may not be available for testing in some cases due to lack of samples, poor sample recovery, rocky samples, bent tubes, shallow depth to rock, etc. Strength parameters may be estimated in these cases by correlating SPT N-values, in-situ tests, field strength tests such as pocket penetrometers and Torvanes, and soil classifications with published information. Refer to NAVFAC DM-7.2 or the FHWA *Soils and Foundations Workshop Manual* for correlation.

GRANULAR SOILS: Strength parameters of granular foundation soils should be estimated using corrected SPT blow counts and published correlation such as presented in NAVFAC DM-7.1 or the FHWA *Soils and Foundations Workshop Manual.*

EMBANKMENTS: Strength tests are typically not performed on proposed embankment materials because it is usually uncertain where these materials will be obtained. It is generally a reasonable assumption that the embankment material will be similar to, but slightly better than, the foundation soils at the site, since their strength should be improved somewhat by the required compaction. Refer to NAVFAC DM-7.2 for typical strength properties of compacted materials.

CONT.

STRENGTH PARAMETERS FOR ROCK EMBANKMENT: The following parameters may be used as a guide for embankments constructed of rock:

ROCK TYPE	SHORT TERM	LONG TERM
Nondurable Shale Class III	ø = 0º, c = 1000-1500 psf (c = 50-70 kPa)	ø' = 18º-22º, c' = 200 psf (c' = 10 kPa)
Nondurable Shale Class II	ø = 0º, c = 1000-1500 psf (c = 50-70 kPa)	ø' = 23º-27º, c' = 150 psf (c' = 7 kPa)
Nondurable Shale Class I	ø = 0º, c = 1000-1500 psf (c = 50-70 kPa)	ø' = 28º-32º, c' = 100 psf (c' = 5 kPa)
Sandstone, Limestone, Durable Shale, and Granular Embankment*	ø' = 34º-45º, c' = 0	ø' = 34º-45º, c' = 0

***Note:** Granular embankment shall meet the requirements of **Section 805** of the *Standard Specifications for Road and Bridge Construction,* current edition.

2 2 2

GEOTECHNICAL	*Section* SLOPE STABILITY
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Target Safety Factors

GUIDE IN SELECTION:

A target safety factor is a function of many intangibles, such as quality and scope of the subsurface investigation, as well as confidence in construction methods. The following may be used as a guide in selecting target safety factors, depending on confidence in available data, etc.

	SHORT TERM	INTERMEDIATE TERM	LONG TERM	RAPID DRAWDOWN
Roadway embankments	1.1 - 1.3	***	1.4 - 1.6	1.0 - 1.2
Bridge approach slopes, walls, and culverts*	1.2 - 1.4	***	1.6 - 1.8	1.0 - 1.2
Cutslopes in soil	1.2 - 1.4	1.2 - 1.4	1.4 - 1.6	***
Landslide corrections	***	***	1.4 - 1.6	1.1 min.

***Note:** Bridge approach slopes and retaining walls shall have target safety factors of 1.0-1.2 for earthquake design.

2 2 2

# GEOTECHNICAL	*Section* SLOPE STABILITY
	Subject Cut Slopes in Soil

WHEN & WHERE ANALYSES ARE REQUIRED: Stability analyses are generally required when the depth of cut in overburden is greater than 10 feet (3 meters). The analyses shall be made at the location where the overburden soils are deepest. Cuts of lesser depth should be analyzed if unusual conditions are encountered. Also, cut stability analyses may be performed near each end of cuts when problems in the cut-to-fill transitions are expected.

TYPICAL SLOPE CONFIGURATIONS: Cut slope recommendations in overburden and disintegrated rock are usually 2H:1V. However, flatter slopes are occasionally required. In mountainous terrain where overburden depths are shallow (3 feet to 16 feet [1 meter to 5 meters]), it is often necessary to steepen slopes to 3H:2V or 1H:1V.

SHORT-TERM ANALYSES: Short-term (total stress) analyses may be warranted for cut slopes in cohesive soils and are performed using total stress parameters. When the state of total stress is changed in cohesive soils, excess pore pressures develop due to the low permeability of the cohesive soils. These pore pressures are due to two components: change in total confining stress and change in total shear stress. The component resulting from the change in total confining stress is likely to be negative in cut slopes. However, the component of excess pore pressure resulting from change in shear stress may be positive and greater in magnitude than the component resulting from change in confining stress. This effect is likely to occur in soft (that is, normally consolidated or lightly over-consolidated) cohesive soils that have a tendency to develop high positive excess pore pressures during shear. Although the critical condition for cut slopes in cohesive soils is likely to be the intermediate-term or the long-term case, the short-term case may be critical, and the geotechnical engineer should consider performing total stress analyses for cut slopes in soft cohesive soils. The decision to perform such analyses should be made on a case-by-case basis. For granular soils or granular components of layered systems, the short-term condition is identical to the intermediate-term condition and should be performed using effective stress parameters.

CONT.

INTERMEDIATE-TERM ANALYSES: The intermediate-term condition for cut slopes in cohesive soils is the condition after excess pore pressures due to changes in total stress have dissipated. Intermediate-term cut slope stability analyses are based on effective stress strength parameters determined for each different soil type or horizon. Accurate determination of the water table is necessary for a meaningful intermediate-term analysis of a cut slope. The water table for the intermediate-term condition should be positioned at its maximum anticipated height. Even though the water table may be lowered during the time that excess pore pressures dissipate, the maximum elevation should be used to be conservative.

LONG-TERM ANALYSES: Long-term analyses model the condition long after excess pore pressures have dissipated and the groundwater table has been lowered due to the presence of the cut. If the water table is anticipated to be lowered over time, the safety factor may tend to increase. However, swelling of cohesive soils (due to exposure) should be expected. The geotechnical engineer shall account for this condition by reducing the cohesion for long-term analyses to 20 percent (80 percent reduction in cohesion) of the value used in the intermediate-term analysis. The cohesion for long-term analyses may be taken as zero in areas with highly plastic clays, severe swelling or softening, or large potentials for sloughing failures. The long-term safety factor is frequently lower than the short-term and intermediate-term safety factors.

PRESENTATION OF ANALYSES RESULTS: Results of the cut slope stability analyses shall be presented in the Geotechnical Engineering Report and shown on a cut stability section (refer to **Exhibit 32**).

2 2 2

GEOTECHNICAL

TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch

Section

SLOPE STABILITY

Subject

Embankments, Bridge Approach Slopes, & Excess Material Sites

WHEN & WHERE ANALYSES ARE REQUIRED:

Embankment stability sections (including both long-term and short-term conditions) shall be prepared for each embankment over 20 feet (6 meters) high. However, analysis for each section need not be performed if embankment height and foundation conditions are similar for several sections. The embankment height for stability analysis is the difference in elevation from the shoulder to toe measured vertically. Embankments of lesser height should be analyzed if unusual conditions are encountered. One cross-section (typically) shall be chosen for stability analysis from each 1,000 feet (300 meters) of embankment. The cross-section analyzed shall be, in most cases, the highest embankment in the area represented.

SHORT-TERM ANALYSES

Short-term analyses model conditions that will exist immediately after completion of embankment construction. When the state of total stress is changed in cohesive soils, excess pore pressures develop due to the low permeability of the cohesive soils. For the case of embankment construction, these pore pressures are likely to be positive; hence the short-term condition is typically the critical condition for embankment stability. This condition should be modeled using total stress parameters for cohesive soils. In granular soils or granular components of layered systems, excess pore pressures dissipate immediately, and short-term stability analyses should be performed using effective stress parameters.

LONG-TERM ANALYSES:

Long-term analyses model the condition long after the embankment has been constructed and excess pore pressures have dissipated. These analyses should be performed using effective stress parameters for both cohesive and granular soils.

EXCESS MATERIAL SITES:

Excess material sites shall be analyzed using the same procedures and minimum safety factors as are applicable to roadway embankments.

CONT.

RAPID DRAWDOWN ANALYSES: Rapid drawdown analysis is required at stream and river crossings (wet crossings) unless the embankment is granular or not affected by high water. Rapid drawdown analysis may be required for embankments not immediately at the bridges but influenced by adjacent streams or rivers. This analysis should be performed using effective stress parameters for both cohesive and granular soils.

STABILITY ANALYSES AT BRIDGES: Stability analyses shall be performed on all bridge approach embankments over 20 feet (6 meters) in height. The spill-through slope under the bridge will be in most cases more critical than the side slope near the abutment.

GRANULAR FILL: Constructing granular fills may be preferable to other options for increasing the stability safety factors. Free-draining granular fills are an effective method of obtaining adequate safety factors for rapid drawdown analysis. Granular embankment shall be considered for bridge approaches when adequate safety factors cannot be obtained with cohesive embankments. Granular embankments shall be recommended when sufficient quantities of durable rock are available from roadway excavation. Flatter slopes may be more economical than processing or transporting granular material long distances.

PRESENTATION OF ANALYSES RESULTS: Results of the embankment slope stability analyses shall be presented in the Geotechnical Engineering Report and shown on an embankment stability section (refer to **Exhibit 33**).

2 2 2

GEOTECHNICAL	*Section* SLOPE STABILITY
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Landslides

FIELD EVALUATION: Information obtained from a field investigation should be assembled to determine the extent and geometry of landslides. Locations of scarps or breaks, toe bulges, depths of movement in slope inclinometers, and other indications of slope movement should be used to estimate the location and shape of the failure surface. The failure surface should be described as rotational, or translational, to aid the analysis process.

MODELING: The failure surface, along with the water table and the assumed parameters of the various soil layers, should be plotted on the most critical section. The most critical cross-section is usually the section where movement is deepest, and it is often located near the middle of the slide area.

ANALYSES: After the critical section has been determined, the strength parameters of the failed materials shall be determined. All materials within the failure may be considered as homogeneous for purposes of analyses. The strength parameters may be determined by assuming the factor of safety equal to one (FS = 1.0) and "back-calculating" values of c' and ø'. The value of cohesion should be held to (or very near) zero and generally should not exceed 20 psf (1 kPa). The back-calculated values• considered to represent the soil strength along the failure surface• are used in the analyses of the slide corrections.

RECOMMENDATIONS: Several feasible correction alternatives (typically including berm, shear key, flattened slope, excavation/replacement, etc.) should be considered. Other methods (retaining walls, slope reinforcement, lightweight fill, etc.) may also be technically and economically feasible. Constructability issues of the correction alternatives (such as water table elevation, limits on excavation, floodplains, right-of-way limits, etc) shall be addressed in the landslide report.

PRESENTATION OF ANALYSES RESULTS: Results of the landslide slope stability analyses shall be presented in the Geotechnical Engineering Report and shown on a stability section (refer to **Exhibit 34**).

2 2 2

GEOTECHNICAL	Section: SLOPE STABILITY
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject: Controlled Loading

OVERVIEW: This subject presents guidelines pertaining to the use of controlled loading to increase slope stability safety factors.

WHEN TO CONSIDER: Controlled loading (staged construction) may be used in cases where short-term safety factors are too low but long-term safety factors are adequate. This method allows for some pore pressure dissipation, consolidation, and strength gain in the foundation soils to occur prior to placing the full loading conditions on the foundation. As a result, this method can be cost-effective because it eliminates the need to use other methods of increasing stability (granular replacement, berms, flattened slopes, etc.).

RECOMMENDED PROCEDURE: The engineer shall determine the maximum embankment height that can be constructed without allowing the short-term safety factor to fall below 1.3 for structures or 1.2 for roadways. Construction above this elevation shall be subject to controlled loading. Estimates of the rates of consolidation (as described in **GT-603, Settlement)** must be made to allow a determination of an appropriate loading rate. It may be assumed that the strength gain from short-term to long-term is linearly proportional to the percentage of consolidation. However, due to the uncertainty in predicting rates of consolidation, it is recommended that a safety factor of 3.0 be applied to the calculated loading rate to establish the allowable loading rate. Soils that will consolidate very slowly may require methods such as wick drains to accelerate the consolidation rate used in conjunction with controlled loading (see **GT-603, Settlement)**.

ANALYSIS DURING CONSTRUCTION: Monitoring of the pore pressures and settlement rates using piezometers and settlement platforms is an alternative method of controlling the loading rates. The pore pressures as measured by the piezometers during construction are used in the stability analysis (using effective stress parameters). If the factor of safety is less than 1.3 for structures or 1.2 for roadways, construction is halted until pore pressures dissipate.

2 2 2

GEOTECHNICAL	Section: SLOPE STABILITY
Transportation Cabinet, Department of Highways, Division of Materials, Geotechnical Branch	Subject: Ground Improvement

OVERVIEW: Ground improvement methods may be used to modify the ground, soil, and rock to permit construction of earthwork, bridges, earth retaining structures, or other facilities.

GROUND IMPROVEMENT: Ground improvement techniques include but are not limited to:

- Grouting
- Vertical drains
- Stone columns
- Lightweight fill
- Vibro compaction
- Dynamic compaction
- Deep soil mixing
- Column-supported embankments

The engineer should consider the availability and economics of feasible alternatives in determining the method of modification.

REFERENCES: The following FHWA publications can be used as ground improvement references:

- **NHI Course No. 132034A,** *Ground Improvement Techniques*
- **Demonstration Project 116,** *Ground Improvement Technical Summaries*

2 2 2

GEOTECHNICAL	*Section* SLOPE STABILITY
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Groundwater

HIGH GROUNDWATER TABLE: The presence of a high groundwater table will have an adverse effect upon the stability of slopes. For this reason one of the commonly used methods of increasing slope stability safety factors is to provide some means of lowering the water table. All computer models used to evaluate the stability of slopes allow for input of the water surface so that the effect of lowering the water table can be more precisely determined.

RAPID DRAWDOWN ANALYSIS: In the design of embankments that might be affected by a high groundwater table due to flooding, and particularly for the analysis of the approach slopes of bridges crossing rivers or streams, a rapid drawdown analysis is required. The analysis is based upon the following assumptions:

- Ø The water level of the surface stream rises through flooding to the elevation of the 100-year high water.
- Ø The flood level remains that high for a sufficient amount of time to saturate the embankment.
- Ø The water then falls so rapidly that no drainage (fall of the groundwater table within the embankment) can occur.

BRIDGE APPROACH SLOPES: The possibility of all these occurring is quite remote; as a result, a safety factor of 1.0 for stability during rapid drawdown is considered adequate. If the safety factor for rapid drawdown is less than 1.0, modification to the embankment is required. Typically, this modification is handled by requiring that the entire embankment—from the toe of slope back to a distance of half the embankment height behind the abutment (maximum 50 feet) and from the original ground surface up to the elevation of the 100-year flood—be constructed with granular embankment (see Standard Drawings **RGX-100** and **RGX-105**). The granular embankment shall meet the materials requirements of the current edition of **Section 805** of the *Standard Specifications for Road and Bridge Construction,* non-erodible only.

CONT.

LANDSLIDES: In landslides, where the materials involved are in-situ and have already failed, the method used to lower the water table is to install drains (consisting of a small-diameter, slotted plastic tubing) that allow water to flow out of the slope under the influence of gravity. Drains are typically installed near the toe of slope (or sometimes at multiple levels) and are drilled horizontally back into the slope. Horizontal drains are sometimes used in conjunction with vertical drains drilled at (or near) the top of slope. Toe drains may also be installed at a slight inclination (near horizontal).

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GEOTECHNICAL	Section BEARING CAPACITY FOR SHALLOW FOUNDATIONS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject Use of Spread Footings on Soil

GENERAL GUIDELINES:

Generally, spread footings on soil are not used at stream crossings due to scour considerations at bridges. Spread footings are typically the preferred foundation type in the following instances:

Ø For bridges—whenever bedded material (usually less than 20 feet [6 meters] from design roadway grade) or soils are capable of supporting the design loads

Note: Generally, spread footings on soil are used only for simple span bridges (at dry crossings) to limit problems with settlement.

Ø For culverts—whenever bedded material (occurring at shallow depths usually less than 3 feet [1 meter] below flowline) or soils are capable of supporting the design loads.

Ø For walls—whenever bedded material or soils are capable of supporting the design loads

The geotechnical engineer shall provide the structure design engineer with an estimate of allowable bearing capacity.

MINIMUM EMBEDMENT:

The bottom of the spread footings on soil shall be embedded a minimum of 2 feet (0.6 meter) below the finished ground surface as protection against frost heave.

SHALLOW FOUNDATION DESIGN:

Foundations that have widths equal to or greater than the distance from the ground surface to the base of the foundation are considered shallow. Deep foundation analysis methods (such as those for piles) are different from those presented here and are discussed in **GT-605.**

2 2 2

GEOTECHNICAL	Section BEARING CAPACITY FOR SHALLOW FOUNDATIONS
TRANSPORTATION CABINET Department of Highways, Division of Materials, Geotechnical Branch	Subject Bearing Capacity on Soil

ULTIMATE BEARING CAPACITY:

Ultimate bearing capacity is an estimate of the actual load-carrying capacity of the foundation. Ultimate capacity of shallow foundations on soil should be calculated using the method presented in FHWA's *Soils and Foundations Workshop Manual.*

Cohesive Soils—The ultimate bearing capacity of cohesive soils is typically based upon laboratory testing of samples taken at or near the proposed footing location.

Granular Soils—The ultimate capacity of granular soils is typically based upon estimates of soil strength (friction angle), which, in turn, is based upon grain size and blow counts (N-values) recorded from the Standard Penetration Test.

ALLOWABLE BEARING CAPACITY:

The ultimate bearing capacity is divided by an appropriate safety factor to yield the allowable bearing capacity, which is the loading value actually used for design. The recommended safety factor is 2.0 where the soil strength parameters are well defined by in-situ or laboratory tests. The safety factor of 3.0 should be used if strength parameters are estimated or based on very limited test data.

2 2 2

GEOTECHNICAL	*Section* BEARING CAPACITY FOR SHALLOW FOUNDATIONS
	Subject Granular Replacement

APPLICATIONS: Granular replacement of foundation materials may be used in areas where the bearing capacity of the original ground foundation materials is inadequate. When foundation alternatives for bridges are being evaluated and the use of shallow foundations is adversely affected by poor-quality materials, it is almost invariably more economical to switch to deep foundations than it is to modify the soils. However, granular replacement to increase bearing capacity typically is the selected method when poor soils occur beneath retaining walls or culverts. Replacement materials must consist of granular embankment meeting the requirements in **Section 805** of the current edition of the *Standard Specifications for Road and Bridge Construction.*

REQUIRED GEOMETRY: The area of granular replacement must widen with depth on a 1:1 slope as shown in **Exhibit 38.**

CHECKING BEARING CAPACITY AT TWO LEVELS: It will be necessary to check the bearing capacity at two levels if low-strength soils are still present below the granular replacement materials:

- At the base of footing elevation
- At the base of the granular material

PARTIAL REPLACEMENT: Partial replacement may work even though low-strength soils are still present beneath the base of the excavation. The imposed loadings are spread over a larger area as they are transmitted through the granular material; and the greater the depth of granular replacement, the greater the reduction in the required bearing pressures. Also, the allowable bearing of a soil of uniform strength increases with depth.

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GEOTECHNICAL

TRANSPORTATION CABINET
Department of Highways
Division of Materials
Geotechnical Branch

Section

BEARING CAPACITY FOR SHALLOW FOUNDATIONS

Subject

Restrictions for Spread Footings on Soil

BRIDGES: In general, spread footings for bridges on soil will be used only at dry crossings because of the possibility that footings used near streams or rivers could be undermined by scour. Also, in general, single-span bridges are more suited to spread footings on soil versus multi-span bridges due to the potential for differential settlement between substructure units.

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GEOTECHNICAL	Section BEARING CAPACITY FOR SHALLOW FOUNDATIONS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject Bearing Capacity on Rock

POLICY: The allowable bearing capacity of spread footings on rock shall be estimated based upon:

- Ø Visual inspection of the rock cores by a geologist
- Ø Available bearing capacity correlation and mapping
- Ø Slake durability index tests

The federal government's Naval Facilities Design Manual (NAVFAC DM-7.2) shall be used as a guide in estimating the allowable bearing capacity of rock. Estimates are used for rock, rather than the results of laboratory testing on cores, because it is the imperfections in the rock mass (such as inclined bedding, joints, and faults) that limit strength. Base of footing elevations for spread footings on rock may be controlled by scour, as discussed in **GT-606, Scour Considerations*.***

2 2 2

GEOTECHNICAL	*Section* SETTLEMENT
	Subject Overview

ANALYSIS: This subject lists guidelines for performing settlement analyses. More than one widely accepted method may exist for some types of analyses. In this section, a preferred method is referenced.

WHEN ANALYSIS IS REQUIRED: Settlement analysis is performed in cases where the settlement magnitudes could be great enough to damage the structure or embankment. In general, it is recommended that settlement analyses be performed if the bridge approach embankments are greater than 20 feet (6 meters) in height and the thickness of the compressible foundation soil is greater than 10 feet (3 meters). Analyses may be required for smaller approach fills or shallower foundations when the structures are particularly sensitive to settlement or where soils are particularly compressible.

METHODOLOGY: Consolidation tests shall be performed to establish the settlement parameters of cohesive soils. A stiffness value "C" is determined for granular soils based on grain size distribution and corrected SPT blow counts, using the information presented in the FHWA's *Soils and Foundations Workshop Manual.*

The approved method of computing settlement magnitude and rate of settlement is presented in the FHWA's *Soils and Foundations Workshop Manual.* Other methods may be used with the approval of the Geotechnical Branch. Computer programs are available for computation of settlement.

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GEOTECHNICAL	*Section* SETTLEMENT
Transportation Cabinet, Department of Highways, Division of Materials, Geotechnical Branch	*Subject* Differential Settlement

DIFFERENTIAL SETTLEMENT: Differential settlement refers to situations where part of a foundation (or part of a structure) settles more than other parts of the same foundation (structure). Settlements of this type are more likely to damage structures than larger settlements that occur uniformly. A common occurrence of differential settlement in highway construction occurs in lane additions and other widening projects where loading is nonuniform. Differential settlement can occur even under conditions of uniform loading if there is marked variation in the properties, or depths, of foundation soils. In such cases, it is beneficial to compute and plot the settlement at several positions along a profile or cross-section in order to evaluate the magnitude and probable effects of differential settlement.

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GEOTECHNICAL	Section: SETTLEMENT
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject: Controlled Loading

STAGED CONSTRUCTION: Large settlement magnitudes or differential settlements may be potentially detrimental to a structure or embankment and cause failure. To avoid or reduce the effects of such problems, the designer often recommends that some critical phase of construction not proceed until much of the anticipated settlement has occurred. Estimates of the waiting period are necessary in order to make such a recommendation. Because strength gain from short to long-term conditions can be related to percent of consolidation, settlement rates are used with slope stability to determine the optimum loading rate. Waiting periods are also commonly used to control the driving of end-bearing piles to eliminate or minimize dragdown and/or lateral squeeze.

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GEOTECHNICAL

Section

SETTLEMENT

Subject

Accelerating Consolidation Rates

ACCELERATING CONSOLIDATION RATES:

The rate of settlement may be so slow that waiting periods are impractical. Foundation modification, though not limited to the following, may be utilized to accelerate consolidation rates.

Ø The installation of wick drains

The recommended design procedure for wick drains is presented in the FHWA's *Soils and Foundations Workshop Manual.* Refer to **Section 711** in the *Standard Specifications for Road and Bridge Construction,* current edition, and **Exhibits 35 and 36.**

Ø The use of surcharge loading

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GEOTECHNICAL	*Section* SETTLEMENT
TRANSPORTATION CABINET Department of Highways Division of Materials Geotechnical Branch	*Subject* Reducing Settlement Magnitudes

MINIMIZING SETTLEMENT:

Settlement magnitudes anticipated for deep and/or highly compressible foundation soils might be so great that they jeopardize the integrity of the proposed structures. In such cases, modification of the foundation may be required. Ground improvement methods used to reduce settlement magnitudes are the same as those used to improve stability or to increase bearing capacity.

Some techniques utilized to minimize settlement are:

Ø For cohesive soils, the modification usually involves either a full or a partial replacement of the poor foundation materials. Full replacement involves removal of the compressible soil to bedrock and replacement with an incompressible (or less compressible) material. In other cases, only the upper layers of compressible soil can be removed due to the practical difficulties of making deep excavations. In such cases, the geotechnical engineer must determine the depth of removal required to reduce settlement magnitudes to acceptable levels.

Ø Lightweight fill can often be utilized in areas where soils are highly compressible. One area where lightweight fill is often utilized is in the extension of box culverts. In the past, designers utilized a stepped-down method of construction so that toward the end of the culvert the culvert section was reduced and not designed to carry a full embankment height.

Ø In certain situations, dynamic compaction may be used to increase the relative density of the in-place materials.

Ø Another method of partial replacement is the installation of stone columns. Although only a portion of the foundation is removed, this method can extend to greater depths than the excavate-and-replace techniques. It is well suited, therefore, to situations where most of the settlement occurs in layers that are relatively deep.

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GEOTECHNICAL	Section: RETAINING STRUCTURES & REINFORCED SOIL SLOPES
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject: Overview

RETAINING WALLS: Retaining walls are usually recommended in situations where typical embankment or cut slopes are not feasible. These situations usually occur in areas where right-of-way constraints exist.

REINFORCED SOIL SLOPES: Reinforced soil slopes may be used as an alternative to retaining walls if sufficient right of way is available. Reinforced soil slopes incorporate geotextile fabric or geogrids to increase the tensile strength of the soil mass. The reinforcement enables steeper slopes to be used.

Methods for designing retaining walls may be found in foundation engineering texts, in AASHTO's *Standard Specifications for Highway Bridges*, or in FHWA references listed in the succeeding subjects.

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GEOTECHNICAL	*Section* RETAINING STRUCTURES & REINFORCED SOIL SLOPES
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Gravity, MSE, & Cantilever Retaining Walls

OVERVIEW: This subject pertains to Concrete Gravity (modular or cast in place), Mechanically Stabilized Earth (MSE), and Reinforced Concrete Cantilever retaining walls.

WHEN WALL ANALYSIS IS REQUIRED: Small walls that meet the requirements presented in Standard Drawing **RGX-002,** "Retaining Wall, Gravity-Type, Non-Reinforced," generally do not require individual site-specific designs. A geotechnical analysis is not required for these walls for heights of 6 feet (2 meters) or less. Modular block walls are to be used only in noncritical areas and are to be built according to the manufacturer's recommendations. All other walls require individual designs for which the following guidelines are applicable.

INTERNAL STABILITY: The geotechnical engineer will determine whether the walls will be founded on soil or rock and will also estimate the strength parameters of the foundation materials. Internal stability of cantilever walls (concrete and steel reinforcement) is determined by the structure designer. Internal stability of MSE (mechanically stabilized earth) walls, which is dependent on the width of the wall (length of straps, grids, etc) being sufficient to prevent pullout failure, is determined by the proprietary wall designer.

EXTERNAL STABILITY: External stability (overall slope stability, overturning, sliding, bearing capacity, and excessive total or differential settlement) shall be determined by the geotechnical engineer. The structural designer shall verify wall stability based on final wall design dimensions.

MODELING: Target safety factors for slope stability analysis are presented in **Section 601-3, Target Safety Factors.** It is assumed for external stability calculations that the internal stability of the wall is adequate, and very high-strength parameters are used for the wall area to ensure that the failure surface does not pass through the wall. This wall area includes the entire reinforced volume of an MSE wall and the soil above the heel of a cantilever retaining wall.

CONT.

GEOMETRY: The geotechnical engineer shall check sliding, bearing capacity, and overturning by assuming the following:

- For MSE—The reinforced length is 0.7 times the height of the wall or 8 feet, whichever is greater.
- For reinforced concrete cantilever walls—The footing width is two-thirds of the wall height.
- For concrete gravity walls (modular block)—As specified by the supplier.
- For concrete gravity walls (cast in place)—See Standard Drawing **RGX-002.**

If the initial results are unacceptable, there are a number of options that can be utilized to improve stability. Some of these options include, but are not limited to:

- Foundation replacement to increase the allowable bearing pressure (see **Exhibit 38)**
- Adjustment of wall dimensions
- Use of granular backfill to decrease lateral loading
- Consideration of other wall types

The wall design shall conform to the requirements of the *AASHTO Standard Specifications for Highway Bridges* with the following exceptions:

- The minimum factor of safety for sliding shall be either 1.5 neglecting passive resistance, or 2.0 considering passive resistance.
- For internal backfill of MSE walls, refer to the *Standard Specifications for Road and Bridge Construction,* current edition, **Section 805, Reinforced Fill Material.**
- Minimum embedment shall be:
  - 2 feet (0.6 meter) to the bottom of the footing for cast-in-place walls
  - 2 feet (0.6 meter) to the top of the leveling pad for walls with precast panels.

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GEOTECHNICAL	Section RETAINING STRUCTURES & REINFORCED SOIL SLOPES
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject Tieback & Soil Nail Retaining Walls

OVERVIEW:

This subject discusses applications of tieback and soil nail retaining walls and provides some design references.

Tieback and/or soil nail wall structures may be used to retain slopes, to underpin structures, or to correct landslides. Tieback and soil nail walls may be used for temporary or permanent applications.

TIEBACK WALL DESIGN:

Tieback wall design involves both geotechnical and structural aspects. Geotechnical aspects include, but are not limited to, determining soil and rock parameters, choosing proper methods of analysis, calculating lateral loads, performing global stability analyses, and determining the size and scope of the wall to be constructed. Design methods and construction techniques vary but should, in general, agree with FHWA*'s Geotechnical Engineering Circular No. 4 (Ground Anchors and Anchored Systems)* and AASHTO*'s Standard Specifications for Highway Bridges.* The preferred method of contracting is for the Geotechnical Branch or geotechnical consultant to provide loads and geotechnical design parameters and for the specialty wall contractor to perform the detailed structural design.

SOIL NAIL WALL DESIGN:

Soil nail wall design involves both geotechnical and structural aspects. Geotechnical aspects include, but are not limited to, determining soil properties, choosing proper methods of analyses, performing global stability analyses, and determining the size and scope of the wall to be constructed. Design methods and construction techniques vary but should, in general, agree with FHWA*'s Geotechnical Engineering Circular No. 7 (Soil Nail Walls)*. The preferred method of contracting is for the Geotechnical Branch or geotechnical consultant to provide geotechnical design parameters and for the specialty wall contractor to perform the detailed structural design.

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GEOTECHNICAL

TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch

Section

RETAINING STRUCTURES & REINFORCED SOIL SLOPES

Subject

Railroad Rail Retaining Structures

WHEN TO USE RAILS: Railroad rails installed as drilled-in piling may be used for correction of landslides in sidehill sections or embankments involving the roadway shoulder and a limited portion of the driving lanes.

MODELING: Except in cases where slope inclinometers or other instrumentation indicates that a mass of stable soil underlies the failure surface, it will be assumed that the failure surface is located at the top of bedded material. Determination of the depth to bedded material and field soil classifications may be made with disturbed soil borings. Rock cores shall be obtained if disturbed soil borings prove inconclusive in determining top of bedded material. Rails typically should not be used when the distance from the shoulder to the farthest breaks in the pavement is greater than the depth to bedded material.

MINIMUM EMBEDMENT: Minimum embedment into bedded material is approximately half the distance from the ground surface to the bedded material (minimum of 10 feet). A slightly deeper preaugered hole may be necessary to allow for auger cuttings falling into the hole and possibly preventing the rail from extending to the required embedment depth.

CENTER-TO-CENTER SPACINGS: Minimum center-to-center spacing of the rails is 2 feet (0.6 meter). Maximum spacing is 4 feet (1.2 meters), since soil arching between the rails may not develop if larger spacings are allowed.

USE OF MULTIPLE ROWS: Multiple rows of rails may be required when conditions warrant. Use a spacing of approximately 2 feet (0.6 meter) between staggered rows in order to allow the rows to act as a unit in retaining the sliding mass.

ORIENTATION OF THE RAILS: Flanges on the rails are to be positioned perpendicular to the direction of landslide movement to utilize the full strength of the rail cross-section. The Geotechnical Branch will analyze and determine the appropriate design method.

CONT.

BACKFILLING OF HOLES: Installed rails shall be backfilled with concrete, pea gravel, crushed limestone, or crushed sandstone. The backfill material shall have 100 percent passing the ½-inch sieve. Auger tailings are not permitted. Backfill shall be shoveled or dropped in small amounts to prevent voids from forming around the rails.

RETENTION OF SOIL BACKFILL: Rails are not to be damaged when placing or compacting backfill behind the rail wall. Retention of the backfill may require the use of lagging. Lagging may be wood, guardrail, or geogrid. If a geogrid is used, gradation of the backfill material must be large enough to prevent its passing through the geogrid.

EROSION CONTROL: Severe erosion on the slope below a rail structure could be detrimental to its long-term performance. Suitable erosion control must be provided as a part of the initial design if there is a potential for severe erosion.

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GEOTECHNICAL	Section: RETAINING STRUCTURES & REINFORCED SOIL SLOPES
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject: Reinforced Soil Slopes

WHEN TO USE: Situations in which slopes are particularly suited to the use of reinforced soil slopes may include the following cases:

- Ø The on-site materials do not have the necessary strength, and the use of granular materials is not economically feasible.
- Ø Right-of-way restraints require the use of steepened slopes or walls.
- Ø The embankments must span areas of soft foundation soils.

METHODOLOGY: FHWA references that present material characteristics of various reinforcement materials, design consideration and procedures, and cost estimates include: *Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines,* and *Geosynthetic Design and Construction Guidelines Participant Notebook*.

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GEOTECHNICAL	*Section* PILE & DRILLED SHAFT DESIGN
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Overview

USE OF PILES: Driven piles are generally recommended at abutments if the distance from roadway grade to bedded material is greater than 20 feet (6 meters). This allows a supported length in soil of at least 10 to 14 feet (3 to 4 meters) exclusive of the distance from roadway grade to base-of-pile-cap. At abutment and pier locations, the recommended minimum length of pile supported by soil is 10 feet (3 meters). Additional pile lengths may be required in areas subject to scour or in areas where the in-situ soils offer little or no lateral resistance.

TYPES OF PILES: The department generally uses steel H-piles in point-bearing applications. Twelve-inch (310-millimeter) H-piles of various weights per unit length are the most commonly used, although 14-inch (360-millimeter) H-piles are used in cases where they may be required to support large vertical or lateral loads or large bending moments. Steel H-piles or square precast concrete piles (generally prestressed) are used in friction pile applications. The most commonly used concrete pile sizes are 14-inch (356-millimeter) and 16-inch (410-millimeter) nontapered piles. However, in some cases, the subsurface conditions may not be suitable for concrete piles or H-piles. In those circumstances, pipe piles, shell piles, or other pile types may be appropriate.

DRILLED SHAFTS: Drilled shafts are a foundation alternative to driven piles; however, economic comparisons are necessary to determine which alternative is the most cost effective for a specific site. One distinct advantage of drilled shafts is that several large-diameter shafts may be used instead of many small-diameter piles. Much of the noise and vibration associated with pile driving is also eliminated. Drilled shafts are particularly applicable for soils with numerous boulders, steeply sloping rockline, karstic terrain, severe scour, large applied lateral loads, and other situations where construction or use of driven pile foundations may not be practical.

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GEOTECHNICAL

GEOTECHNICAL	*Section* PILE & DRILLED SHAFT DESIGN
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Tip Elevations of Point-Bearing Piles

POLICY: A recommendation for point-bearing piles shall consist of an estimated tip elevation based on rock cores and rockline soundings. If the rockline elevations vary significantly across the width of a pile bent, a recommendation providing elevations on each end of the bent (or at both ends and in the center) is appropriate. The effects of steeply sloping rockline on battered pile lengths shall be considered. It is common practice on construction to drive a "test pile" at each pile bent in order to confirm the predicted pile lengths. Additional test piles may be necessary in some cases such as sloping rockline, karstic areas, etc. The presence of boulders in the overburden or a steeply sloping rockline could require the use of pile points or predrilling.

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GEOTECHNICAL	*Section* PILE & DRILLED SHAFT DESIGN
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Static Capacity of Friction Piles

OVERVIEW: A number of methods have been developed for estimating the driving resistance and load-carrying capacity of friction piles. Currently, the preferred method is that described in the FHWA's *Soils and Foundations Workshop Manual.*

DETERMINING LOAD-CARRYING CAPACITY/DRIVING RESISTANCE: Piles shall have a minimum embedment of 10 feet (3 meters) into natural ground. Additional pile lengths may be required in areas subject to scour or in areas where the in-situ soils offer little or no lateral resistance. All load-carrying capacity, which might be developed within embankment or scourable materials, shall be ignored (see below). The effects of high water or fluctuations in groundwater levels upon capacity should be taken into account.

PRESENTATION OF THE DATA: It is recommended that the pile capacity data be developed and presented in a tabular format in the report recommendations (similar to what is shown below). Appropriate factors of safety shall be applied to the ultimate pile capacity data and the information presented as "Allowable Pile Capacity." Overburden pressures can affect friction piles. Therefore, the placement of additional fill after pile driving will cause the ultimate load-carrying capacity of the piles to be different than the driving resistance. In some cases these may differ sufficiently to require that the designer be provided with both values. The ultimate load-carrying capacity of piles in scour situations or piles passing though newly constructed embankments will be less than the driving resistance. The note below the table further addresses these issues.

CONT.

PRESENTATION OF THE DATA (cont.):

14" Concrete Friction Piles				
	END BENT 1	**Pier 1**	**Pier 2**	**End Bent 2**
Target point of pile elevation for an allowable pile capacity of 50 tons per pile	440	375	375	440
Target point of pile elevation for an allowable pile capacity of 60 tons per pile	430	365	365	430
Target point of pile elevation for an allowable pile capacity of 70 tons per pile	425	355	355	425
Side friction for scour susceptible and embankment layers (ultimate capacity)**	10 tons	8 tons	8 tons	10 tons

** In the pile record for friction piles given in the plans, the EOD (End of Driving) required field bearing will be the side friction for scour and embankment layers plus 1.25 times the design axial load. Likewise, the BOR (Beginning of Restrike) required field bearing will be the side friction for scour susceptible and embankment layers plus 2.0 times the design axial load.

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GEOTECHNICAL	*Section* PILE & DRILLED SHAFT DESIGN
	Subject Pile Dynamic Analysis & Constructability Considerations

ESTIMATING DRIVING STRESS: Piles can be damaged when stresses induced during pile driving exceed the structural capacity of the pile. A wave equation analysis can be used during the design phase (and reevaluated during construction, if necessary) to estimate the pile driving stresses, the pile penetration per blow, and ultimate capacity of the pile.

DYNAMIC PILE TESTING: Dynamic testing with signal matching may be used during construction to measure the energy imparted to the pile by the hammer, the stresses in the pile during driving, and the ultimate capacity of the pile.

DAMAGE AVOIDANCE: In cases where piles must penetrate layers of dense granular soils, resistance to pile driving may become so great that the piles could be damaged by the driving process. Piles that are intended to bear upon rock must reach the bedrock surface. Friction piles will have some minimum tip elevation that must be reached in order to allow the piles to resist anticipated lateral loads and/or to have adequate axial or lateral load-carrying capacity in the event that much of the material in which they are embedded is removed by scour. In such cases, predrilling at the pile locations, or jetting performed during the driving process, may be necessary to allow the pile tips to penetrate the required distance.

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GEOTECHNICAL

TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch

Section

PILE & DRILLED SHAFT DESIGN

Subject

Axial Capacity of Drilled Shafts

OVERVIEW: Analysis methods for estimating the bearing capacities of individual drilled shafts, as well as allowing for group effects, are presented in FHWA IF-99-029*, Drilled Shafts: Construction Procedures and Design Methods.* Typically, only the axial capacity of unweathered bedrock is considered; the overburden and weathered bedrock are usually neglected.

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GEOTECHNICAL	*Section* PILE & DRILLED SHAFT DESIGN
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Evaluating Resistance to Lateral Loads

USE OF BATTERED PILES: Deep foundations are generally subjected to both axial and lateral loadings. Battered piles are commonly employed to resist lateral loads; however, consideration of the resistance of vertical piles to lateral loads is increasing. Battered drilled shafts are seldom used because of the difficulty of constructing them.

METHODOLOGY: Methodology for the design of piles or drilled shafts subjected to lateral loads include "Brom's method" and the "p-y (pressure vs. deflection) method." Design procedures are presented in the FHWA **IF-99-029,** *Drilled Shafts: Construction Procedures and Design Methods.* Computer programs are available to assist in performing these analyses. Many software programs can evaluate the resistance of single shafts/piles, or groups of shafts/piles, to lateral loads.

LATERAL LOADS: Generally foundation configurations, loading conditions, and structural details are not known during the geotechnical investigation. Therefore, the geotechnical information necessary for a lateral load analysis should be provided to the structural engineer for conducting soil/structure interaction analyses. The structural engineer should involve the geotechnical engineer in reviewing and assisting in refinement of the analyses.

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GEOTECHNICAL	*Section* PILE & DRILLED SHAFT DESIGN
TRANSPORTATION CABINET Department of Highways Division of Materials Geotechnical Branch	*Subject* Pull-Out Resistance

POLICY:

Uplift forces may be applied to deep foundations as a result of barge impact, lateral loads, swelling soils, buoyancy, wind loads, etc. Deep foundations must be designed to withstand applicable tensile forces, and adequate pull-out resistance must be provided.

Ultimate pull-out resistance for individual deep foundations (without bells) in clay is equal to the side friction.

The ultimate pull-out resistance for deep foundations in sands is assumed to be equal to 70 percent of the side friction.

A factor of safety of 3 should be applied to the ultimate pull-out resistance to obtain allowable pull-out resistance for deep foundations under sustained uplift forces.

A factor of safety of 2 may be used for deep foundations subjected to temporary uplift forces.

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GEOTECHNICAL

Section

PILE & DRILLED SHAFT DESIGN

Subject

Negative Skin Friction (Dragdown)

METHODOLOGY: Dragdown on the piles may be a problem for structures with slow consolidation rates. In the case of point-bearing piles, the piles are considered to carry dragdown loads if the foundation soils undergo more than ½ inch (12 millimeters) of settlement after the piles are driven. Analysis procedures and design considerations are presented in the FHWA's *Soils and Foundations Workshop Manual*.

WHEN DRAGDOWN IS ASSUMED TO OCCUR: In calculating dragdown, it is assumed that ½ inch (12 millimeters) of settlement is required to mobilize the side friction. Therefore, it is necessary to determine the interval from the rock surface upward to the point where ½ inch (12 millimeters) of settlement occurs after the piles are driven. Dragdown loads are not considered to be applicable over this interval. In some cases dragdown loads on point-bearing piles may be neglected.

METHODS OF REDUCING DRAGDOWN LOADS: The piles will be capable of carrying the bridge loads plus the dragdown loads in many cases. Otherwise, it may be necessary to use a cylindrical steel sleeve or a polypropylene sleeve on the portion of the pile in the new embankment so that the dragdown loading can be either greatly reduced or eliminated.

USE OF WAITING PERIOD: It may be possible to use a waiting period between completion of the embankment and pile driving to reduce the dragdown loads. Dragdown loads are considered eliminated if the remaining settlement after the waiting period is less than ½ inch (12 millimeters). Settlement platforms are required if a waiting period is selected as the method of handling dragdown loads; however, they are not needed if any other method is selected.

DRAGDOWN LOADS ON FRICTION PILES: Friction piles may also be subject to dragdown loads. The magnitudes of the dragdown loads can be approximated once the neutral point has been determined as discussed in NCHRP Report 343**,** *Manuals for the Design of Bridge Foundations*.

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GEOTECHNICAL

TRANSPORTATION CABINET Department of Highways Division of Materials Geotechnical Branch

Section

PILE & DRILLED SHAFT DESIGN

Subject

Settlement of Friction Piles

POLICY: Settlement of friction piles and drilled shafts not founded on bedrock is equal to the settlement of the soil below the neutral plane (as discussed in NCHRP Report 343). Determination of the neutral point permits calculation of settlement magnitudes for foundations on friction piles. Settlement magnitudes for friction piles shall be determined for all dry crossings where embankment settlement analyses are required and for multi-span structures at wet crossings. Settlement determinations for friction piles are not required for single-span bridges at wet crossings.

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GEOTECHNICAL	Section: PILE & DRILLED SHAFT DESIGN
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject: Lateral Squeeze

POLICY: Rotation and horizontal displacement of abutments and piers on piles can be attributed to lateral squeeze. Lateral squeeze is the deformation and displacement of a soft cohesive foundation under embankment loadings. Lateral squeeze shall be checked whenever the weight of the embankment in the vicinity of the bridge abutments is greater than three times the cohesive strength (total stress) of the foundation soils. The determination of lateral squeeze magnitudes and design solutions for preventing damage resulting from lateral squeeze are presented in the FHWA's *Soils and Foundations Workshop Manual*.

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GEOTECHNICAL	*Section* PILE & DRILLED SHAFT DESIGN
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Load Testing

POLICY: Projects incorporating large numbers of drilled shafts or piles may provide an economic justification for conducting a load test to verify the ultimate load capacities as estimated by other methods. Loading procedures and requirements are presented in ASTM **D 1143.**

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GEOTECHNICAL

GEOTECHNICAL	*Section* SCOUR CONSIDERATIONS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Scour of Soil Foundations

DETERMINING SCOUR POTENTIAL: Flowing water can adversely affect highway structures and embankments. The geotechnical engineer, design engineer, structural engineer, and hydraulic engineer must work together to provide a design that will be resistant to scour-related damages. The hydraulic engineer should provide the geotechnical engineer with the calculated scour potential so that appropriate foundation design recommendations can be made.

SPREAD FOOTINGS: For bridges, in general, spread footings on soil are not used at wet crossings because of the potential for scour undermining the footings. The engineer should recognize that bearing capacity calculations take into account any potential cover loss (loss of footing burial depth) that might adversely affect the allowable bearing capacity.

DESIGNING FOR SCOUR: Pile foundations may also be affected by scour. Design procedures addressing scour are as follows:

Ø End Bents—Typically, properly sized slope protection is utilized to neutralize any local scour on bridge approach and spill-through slopes. Deep foundation designs (piles/shafts) should be checked with no lateral support in the worst-case contraction scour conditions. To check for potential exposed lengths, construct a vertical line from the toe of the spill-through slope where the stone slope protection terminates, down to the contraction scour depth for the respective end bent. Then construct a 1:1 (45°) line back toward the end bent until it intercepts the foundation element line. The foundation can either be designed to withstand the potential unsupported length, the cap can be set down to that depth to avoid any unsupported length, or a combination of these measures can be employed.

CONT.

DESIGNING FOR SCOUR (cont.):

- Ø Piers—Foundation elements (piles/shafts) must be designed for total scour (contraction + local scour) conditions. They can either be designed to withstand the potential unsupported length, the cap can be set down to that depth to avoid any unsupported length, or a combination of these measures can be employed.

- Ø Walls—Walls must be analyzed for problems with scour on a case-by-case basis where applicable. Many of the same procedures for dealing with bridges can be utilized in dealing with potential scour at walls.

- Ø Culverts with paved flowline—Typically, with the use of paved flow lines, scour is not detrimental at culverts. However, scour holes at culvert outlets can cause problems with wingwall foundations. The hydraulic engineer should analyze outlet velocities and size riprap or design paved outlets to reduce potential scour problems.

- Ø Three-sided structures—Where three-sided structures are used (such as box or arch culverts with a natural bottom and no paved flowline), scour should be calculated to ensure that the footings are constructed below any potential scour elevation.

D_{50} & D_{95} USED TO EVALUATE RESISTANCE TO SCOUR:

D_{50} and D_{95} values may be required for scour calculations and shall be provided to the drainage engineer. D_{50} and D_{95} values are obtained from the particle size distribution curve from soil testing.

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GEOTECHNICAL

Transportation Cabinet, Department of Highways, Division of Materials, Geotechnical Branch

Section

SCOUR CONSIDERATIONS

Subject

Scour of Bedrock

REQUIREMENTS FOR FOOTINGS ON SCOUR-PRONE FOUNDATIONS: Spread footings on rock above the maximum calculated scour elevation must be evaluated to ensure that the bedrock is regarded as scour-resistant. If the bedrock is regarded to be scour-prone, the footing must be lowered to the maximum scour elevation or to a scour-resistant bedrock layer, whichever is higher.

EVALUATING SCOUR RESISTANCE: Definitive guidelines relating to susceptibility of rock to scour are not currently available. In the absence of a better method for classifying rock as scour-resistant or scour-prone, it is recommended that materials that seem questionable be classified as scour-prone. The following criteria should be considered in evaluating susceptibility to scour.

- Existing field conditions
- Lithology
- Rock Quality Designation, Kentucky Method (KY RQD)
- Slake Durability Index
- Jar Slake Test
- Visual inspection of rock cores

CONT.

EXISTING FIELD CONDITIONS: In evaluating existing field conditions, overall topography of the area should be noted. In areas with steep gradients, flash floods could produce extremely high flow velocities, possibly scouring some rock that would not be prone to scour in less adverse conditions. Limestone slabs and other loose rock in stream beds could simply represent mass wastage of hillsides or cliffs bordering the stream, but if similar materials are likely to be present below flowline, they should be taken as an indication that the stream bed could undergo further degradation. Ponded water in perennial streams will protect their beds from freezing, but the exposed beds of intermittent streams will be subject to freeze-thaw cycles and associated degradation. In the case of bridge replacements, the condition of the existing bridge is a good indication of the probability of scour. Evidence that local or contraction scour has affected the existing structure is good evidence that scour potential is high. Also, joints and fractures in the exposed bedrock should be observed. If present, an evaluation should be made to determine whether their presence and orientation would facilitate the scour process.

LITHOLOGY: Lithology is obviously one of the principal factors relating to whether or not a particular mass of rock is susceptible to scour. Essentially all of the near-surface rock in Kentucky is sedimentary and can be divided into three major groupings: sandstones, limestones, and shales.

- **Sandstone:** Massive, firmly cemented sandstones are considered non-scourable. However, friable (nondurable) sandstones, in which the cements binding individual grains are weak, are susceptible to scour.

- **Limestone:** Massive limestones are considered to be scour-resistant.

- **Shale:** The scour susceptibility of shales relates to their "durability" as defined by SDI test results. The Geotechnical Branch includes siltstones within the broad shale classification. Hard, massive siltstones are considered to be scour-resistant. Shales with SDI values $\geq$ 95, termed "durable," are considered to be scour-resistant. Of the "nondurable" shales, those that have SDI values from 50 through 94 are generally considered potentially scourable. Shale with SDI values less than 50 are considered to be soil-like and, therefore, scourable.

An interbedding of the basic lithologic types also occurs with great frequency. Thinly interbedded units, where shale layers alternate with thin layers of a more resistant rock type (limestone or sandstone) are considered to be potentially scourable. As the percent of resistant beds increases, the susceptibility to scour decreases.

CONT.

CORE RECOVERY: Core recovery, the length of core recovered expressed as a percentage of the length of the interval drilled, can be used as a measure of competency of the rock. When core recoveries of less than 85 percent are obtained, the core should be inspected to determine if loss was due to the poor quality of the material or was due to the drilling procedure. Recovery of less than 85 percent may indicate the material is scour-susceptible if losses were due to material quality.

RQD, KENTUCKY METHOD: Rock Quality Designation, Kentucky Method (KY RQD), is an estimate of the in-situ rock quality. It provides a measure of the massiveness of the rock. The Kentucky Method excludes pieces of core that are easily broken by hand into pieces less than four inches in length. Joints, fractures, and breaks caused by drilling are ignored. Any rock with a KY RQD of less than 25 is considered to be potentially scourable.

SDI & JAR SLAKE: The Slake Durability Index test (SDI) and the Jar Slake test are applicable to shales and friable sandstones. On occasion, they could be applicable to very argillaceous, shaley limestones. The rapid breakdown that occurs when some shales are immersed in water is an obvious indication that those materials would not be capable of resisting scour. The Jar Slake test will readily identify such units. The SDI test, with its losses occurring as a result of abrasion in an aqueous environment, is a somewhat more subtle measure of resistance to weathering.

VISUAL INSPECTION: Visual inspection of rock cores can provide an indication that characteristics such as cross-bedding, interbedding, partings or laminations, joints, or fissility might provide zones of weakness, which might facilitate scour processes.

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GEOTECHNICAL

Section

SUBGRADES

Subject

CBR Design Values

USE OF CBR IN PAVEMENT DESIGN:

An optimal design of roadway pavements must reflect the amount of support that the pavement receives from the underlying subgrade. A firm subgrade, which is rigid and provides good support, will allow the use of a thinner (lower-strength) pavement. Conversely, if the subgrades are poor, providing little or no support, the pavements must be thicker and of higher strength in order to avoid rapid deterioration under applied loads. The CBR (California Bearing Ratio) is a measure of the quality of the subgrade and is used by pavement designers as an indication of how much of the deformation-loading can be transferred to the underlying subgrade and how much must be supported by the pavements. The department uses a modified CBR test method; which is presented in **KM 64-501.**

TYPICAL MATERIALS:

Select Rock Quantities are calculated on roadway projects to assist in determining the availability of rock from roadway excavation. After areas requiring durable rock are satisfied (such as embankment, working platforms, slope protection, channel lining, etc.), additional durable rock (limestone, sandstone, or shale with SDI $\geq$ 95) can be used for a 2-foot rock roadbed (if feasible). If a sufficient quantity of durable rock is not available from roadway excavation, then a 1-foot soil subgrade or rock borrow is recommended. Nondurable shale is not recommended as part of a soil subgrade.

CONT.

DETERMINING CBR DESIGN VALUES:

The pavement design value for a project is determined from laboratory tests on soil samples. CBR and classification tests are performed on bag samples of soil from roadway cut sections. These tests are also performed on bag samples from fill sections whenever applicable. Typically, the lowest CBR value from laboratory tests is recommended (unless it is an isolated value) as the design value, unless rock roadbed or bank gravel is applicable. On large projects (typically more than 20 CBR tests) Yoder's 90th percentile method is used to calculate an optimum CBR design value. Refer to *Principles of Pavement Design* by Yoder and Witczak for additional information. The recommended CBR value is included in the Geotechnical Engineering Report as a design recommendation but not as a geotechnical note. This value is used in determining pavement configurations.

BRIDGE REPLACEMENT PROJECTS:

Bridge replacement projects in which a Geotechnical Roadway Report will not be issued shall include a recommended CBR design value for pavement in the Structure Report.

TYPICAL VALUES:

Following is a range of typical CBR design values. Engineering judgment is important in the selection of an appropriate value.

MATERIAL	ESTIMATED CBR VALUE
Rock (limestone, durable siltstone, durable sandstone)	9 to 11
Rock (durable shale, nondurable sandstone)	7 to 9
Bank gravel	6 to 9
Soil and/or shale mixtures	1 to 5

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GEOTECHNICAL	Section: SUBGRADES
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject: Chemical Stabilization of Subgrades

WHEN STABILIZATION IS NEEDED: Some of the soils along a proposed highway route may have such poor strength characteristics that their occurrence can negatively impact construction operations by rutting and pumping of the subgrade. Stabilization of subgrades is used, when necessary, for the purpose of improving such soils sufficiently to provide an adequate construction platform. The strength of a stabilized subgrade may be considered in design of the pavement structure, at the discretion of the Division of Highway Design. Stabilization of a soil subgrade shall be considered whenever the CBR design value is less than or equal to 6.0.

CHEMICAL STABILIZATION: Chemical stabilization consists of mixing a reactionary agent such as lime or cement with the soil. This mixture cures into a solid cementitious working platform.

TREATMENT WITH LIME: Clayey soils (plasticity indices greater than 20 and more than 35 percent passing a #200 sieve) will normally be treated with lime.

TREATMENT WITH CEMENT: Silty or sandy soils (plasticity indices less than or equal to 20 and less than 35 percent passing a #200 sieve) will normally be treated with cement.

GUIDELINES: The appropriate chemical will be determined in accordance with FHWA's *Soil Stabilization Manual,* **FHWA-IP-80-2.** Guidelines for subgrade construction using lime and cement shall be in accordance with **Section 208** of the current *Standard Specifications for Road and Bridge Construction*.

CHEMICAL MODIFICATION: When drying of the soil subgrade is required, chemical modification of the soil can be considered. Chemical modification consists of mixing a chemical modifier such as kiln dust with the soil. This mixture does not increase soil strength.

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GEOTECHNICAL	*Section* SUBGRADES
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Mechanical Stabilization of Subgrades

STABILIZATION OF SUBGRADES: Soil subgrades with a CBR design value of 6 or less should be considered for stabilization. When chemical stabilization is not deemed practical or economical, one of the following methods of mechanical stabilization may be considered as a viable alternate:

- Ø Rock Stabilization:
  - ♦ 1 foot of rock (KY Coarse Aggregate No. 2s, 3s, or 23s) wrapped with Type IV Geotextile Fabric. This will be treated as an additional pavement layer for pavement design.
  - ♦ 2 feet of rock (KY Coarse Aggregate No. 2s, 3s, or 23s) wrapped with Type IV Geotextile Fabric. This will be treated as a two-foot rock roadbed for pavement design.
- Ø Geogrid Stabilization:
  - ♦ Install a layer of Geogrid covered with the necessary quantity and appropriate size of crushed aggregate. A Type IV Geotextile Fabric needs to be included when a separator is required between the subgrade soil and the aggregate course to prevent the migration of fines.

GUIDELINES: The Geotechnical Branch will determine if stabilization is required and will recommend the appropriate method of treatment. Guidelines are as follows:

CBR 1 to 4	Option 1 – Chemical stabilization using lime or cement as applicable
	Option 2 – 12 inches (minimum) of coarse aggregate (2s, 3s, or 23s) wrapped with a Type IV Geotextile fabric
CBR 4 to 6	Option 3 – Install a layer of Geogrid covered with the necessary thickness and appropriate size of crushed aggregate. Also install a Type IV Geotextile Fabric if a separator is required.

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GEOTECHNICAL	*Section* CUT SLOPES IN ROCK
TRANSPORTATION CABINET Department of Highways Division of Materials Geotechnical Branch	*Subject* General Guidelines

GUIDELINES:

Some cuts may expose several different types of rock (limestones, shales, sandstones, coal seams, etc.), and these lithologies will dictate which slope configuration is selected.

Each cut shall be independently designed by using all subsurface information or field mapping available. This information is used to determine cut slope angles, lift heights, bench widths, base of rock disintegration zone, soil overburden thickness, and overburden bench requirements. Cut slopes in overburden and weathered rock have been previously discussed in **GT 601-4, Cut Slopes in Soil.**

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GEOTECHNICAL

TRANSPORTATION CABINET Department of Highways Division of Materials Geotechnical Branch

Section

CUT SLOPES IN ROCK

Subject

Rock Cut Slope Configurations

BASIS FOR ROCK CUT SLOPE CONFIGURATION: Cut slopes in rock are influenced by lithology but are primarily based on joint inclination and continuity. Benches, where possible, are located at the top of the least resistant lithologic unit in a given rock cut section. Careful consideration must be given to SDI numbers and Jar Slake test results when designing a cut slope.

CLASS III NONDURABLE SHALE WITH OR WITHOUT LAMINATIONS: Typical cut slope recommendations for Class III nondurable shale are 2H:1V (or flatter) slope from groundline to ditchline. Normally these slopes are designed without a roadside ditch bench, intermediate benches, or overburden benches. (Refer to **Exhibit 14.)**

CLASS II NONDURABLE SHALE: Typical cut slope recommendations for Class II nondurable shale vary from 1H:1V to 3H:2V with roadside ditch benches, intermediate benches typically 18 feet (5.5 meters) wide, and approximate lift heights of 30 feet (9 meters) depending on rock competency. (Refer to **Exhibit 15.)**

CLASS I NONDURABLE SHALE: Typical cut slope recommendations for Class I nondurable shale vary from 3H:4V to 1H:4V, with approximate 30-foot (9-meter) lift heights, intermediate benches typically 18 feet (5.5 meters) wide, and a roadside ditch bench. (Refer to **Exhibit 16.)**

DURABLE SHALE: Typical cut slope recommendations for durable shale vary from 1H:2V to 1H:4V (depending on fractures) with roadside ditch benches, typical intermediate benches 18 to 20 feet (5.5 to 6 meters) wide, and approximate lift heights of 30 to 45 feet (9 to 14 meters). (Refer to **Exhibit 17.)**

CONT.

MASSIVE LIMESTONE OR SANDSTONE: Typical cut slope recommendations for massive limestone or sandstone vary from 1H:2V to 1H:20V. This material is usually stable; however, presence of joints, fractures, solution features, cross bedding, etc., will have as much influence on slope design as lithology. Materials placed on 1H:20V slopes may have lift heights up to 60 feet (18 meters), with intermediate benches 18 to 20 feet (5.5 to 6 meters) wide. It is desirable to design the first lift above grade on a slope flatter than 1H:20V. (Refer to **Exhibit 18.)**

SHALEY LIMESTONE & SANDSTONES: Typical cut slope recommendations for shaley limestone and sandstone vary from 1H:1V to 1H:2V slope with lift heights from 30 to 45 feet (9 to14 meters) and intermediate benches 18 to 20 feet (5.5 to 6 meters) wide. Flatter slopes may be required depending upon the percent and type of shale present. (Refer to **Exhibit 19.)**

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GEOTECHNICAL	*Section* CUT SLOPES IN ROCK
	Subject Intermediate & Overburden Bench Widths

INTERMEDIATE & OVERBURDEN BENCH WIDTHS:

The elevation of most intermediate benches is determined by changes in lithology, with the bench being on top of the least resistant material, where possible. The width of intermediate benches may vary from 15 to 25 feet (4 to 8 meters). Typical bench widths are 18 feet (5.5 meters). Intermediate bench widths may be 20 to 25 feet (6 to 8 meters) when lifts exceed 30 feet (9 meters) in height or in situations where shale is expected to weather rapidly and undercut a massive bedded material. Coal mine openings with weak roof material or other unstable slopes with an anticipated heavy rock fallout may also require wider intermediate benches.

Intermediate benches that intercept ditch grade should be transitioned out within a distance of 150 to 200 feet (45 to 60 meters) to avoid leaving a transverse rock wall in the cut slope.

Overburden benches are placed on top of rock cuts at the base of the Rock Disintegration Zone (RDZ). Typical overburden benches are 15 feet (5 meters) wide and may be wider in areas where instability is anticipated. The depth to the base of RDZ is measured vertically from groundline and may be highly variable. Overburden benches are drawn horizontally on cross-sections and will have some grade through the cut depending on variations in depth of material. These benches are sometimes omitted in mountainous terrain or in cuts where the overburden is less than 10 feet (3 meters) deep.

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GEOTECHNICAL

Section

CUT SLOPES IN ROCK

Subject

Serrated Slopes

USE OF SERRATED SLOPES:

Serrated slopes are utilized as a means of controlling erosion and establishing vegetation on soft rock formations, shale, or other material that can be excavated by bulldozing or ripping. Serrations may be recommended for 1H:1V or flatter cut slopes. Typical step risers will vary from 2 to 4 feet (0.6 to 1.2 meters) and shall be plotted on the cut stability sections. (Refer to **Exhibit 20.)**

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GEOTECHNICAL	*Section* CUT SLOPES IN ROCK
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Roadside Ditch Bench

USE OF ROADSIDE DITCH BENCH: When cut slopes are steeper than 3H:2V and the 30-foot (9-meter) safety clear zone from edge of pavement to the cut slope is not required, a roadside ditch bench is recommended. Typically the width of the roadside ditch bench from outside edge of shoulder to the cut slope will be 12 feet (3.5 meters) for cuts less than 30 feet (9 meters) in height, and 14 feet (4.3 meters) for cuts over 30 feet (9 meters) in height.

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GEOTECHNICAL

Division of Materials Geotechnical Branch

Section

CUT SLOPES IN ROCK

Subject

Slope Design without Intermediate Benches & with Catchment Areas

POLICY: Design of a rock cut slope without intermediate benches should be used with a roadside ditch catchment area. The continuous cut slope design should be considered under the following circumstances:

- Ø Rock is homogenous.
- Ø Rock consists of limestones of low KY RQD numbers that are interbedded with shale of low SDI numbers.
- Ø Intermediate benches will accumulate debris rapidly, making them ineffective.
- Ø Joints are discontinuous, and massive failures are unlikely.

The roadside ditch catchment area **(Exhibit 21)** is to be designed using the guidelines outlined in the "Rockfall Catchment Area Design Guide" Final Report, which was published by the Oregon Department of Transportation Research Group and FHWA (November 2001) [SPR-3-032 (Report # FHWA-OR-RD-02-04)].

The "Rockfall Catchment Area Design Guide" is a current state-of-the-practice reference for sizing rockfall catchment areas for 40- to 80-foot (12- to 24-meter) high cut slopes. A copy of the guidelines is available upon request from the Kentucky Department of Highways, Division of Materials, Geotechnical Branch.

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GEOTECHNICAL

Section

CUT SLOPES IN ROCK

Subject

Summary of Rock Quantities

SUBMITTAL OF QUANTITIES:

A Form TC 64-532, *Summary of Rock Quantities* **(Exhibit 22),** will be completed by the design engineer and submitted to the Geotechnical Branch (and the geotechnical consultant, if applicable) after the rock core inspection and prior to the final geotechnical meeting. Typically, the rock types to be calculated and tabulated on the summary sheet are limestone, sandstone, durable shale, nondurable shale Class I, and nondurable shale Class II (excluding thin seams [less than 8 feet {2.5 meters}] that cannot be practically separated during construction). (Refer to **Exhibits 22 and 23.)** A two-foot rock roadbed shall be calculated and shown on the summary sheet assuming the rock extends from shoulder to shoulder in the fills and from ditchline to ditchline in the cuts. In areas where curb and gutter are proposed, the limits of the rock roadbed will extend under the curb and gutter.

OVERALL SITE CONDITIONS:

While information derived from each core is important, it should be recognized that there are cases where individual cores may not be representative of the site as a whole. The most common cases where this is true relate to lapies and/or other karstic features developed in limestones.

CALCULATION OF QUANTITIES:

Projects that are anticipated to have sufficient quantities of desirable materials (i.e., sandstone or limestone) along with less desirable materials may require calculation of only the quantity of available desirable material. Questions as to the type and thickness of rock to be considered will be resolved at the rock core inspection. Reduced (11-inch x 17-inch [280-millimeter x 430-millimeter]) cut stability sections, with lithology divisions indicated, shall be submitted with the minutes of the rock core meeting. (Refer to **Exhibit 24.)** The lithology divisions are to assist the design engineer in calculating and tabulating the select rock quantities on the TC 64-532 form. The division lines are not to be indicated on final plans.

CONT.

STABILITY CONSIDERATIONS: Knowledge of the quantity of rock available will permit the geotechnical engineer to effectively make realistic embankment slope stability analyses. The geotechnical engineer will complete the stability analyses and determine where rock is required. The design engineer will calculate, tabulate, and resubmit these quantities on the TC 64-532 form, *Summary of Rock Quantities* **(Exhibits 22 and 23),** as necessary to verify the final quantities of rock required for the geotechnical recommendations.

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GEOTECHNICAL	*Section* SPECIAL GEOLOGIC CONSIDERATIONS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Sinkholes

USE OF SINKHOLES:

All pertinent subsurface information concerning sinkholes shall be shown on the soil profile sheets.

Sinkholes Not Used for Drainage—Construction procedures for stabilizing open sinkholes that are not to be utilized for drainage shall be in accordance with the current methods outlined in the “Treatment of Open Sinkholes” sepia sheet on the Division of Highway Design's sepia sheet list.

The plan sheet presenting the guidelines for sinkholes not used for drainage will be placed in the plans by the Division of Highway Design, as applicable.

Sinkholes Used for Drainage—Sinkholes that will be used for drainage shall have special recommendations and guidelines to follow during construction that have been approved by the Division of Highway Design.

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GEOTECHNICAL	*Section* SPECIAL GEOLOGIC CONSIDERATIONS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Mines

DESIGN CONSIDERATIONS FOR MINES: Design considerations relating to mines must include a determination of whether the mines are below, at, or above grade.

Below Grade—Mines below grade that do not show signs of subsidence are generally left undisturbed.

At Grade—Mines at or near grade may be excavated and replaced with suitable backfill.

Above Grade—Cut slope designs for mines above grade utilize wider benches, shorter lifts, and pneumatic backstowing and leave as much pillar as possible. If the slope is determined to be unstable during construction, the unstable material is excavated, the benches are widened, and the remaining openings are pneumatically backstowed.

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GEOTECHNICAL

TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch

Section

SPECIAL GEOLOGIC CONSIDERATIONS

Subject

Dipping Rock

IMPACT UPON DESIGN: Lithologic variations will be more complicated in highly tilted strata depending upon the apparent dip. Therefore, a complete field reconnaissance of each cut section is required prior to slope design. Apparent dip of strata along centerline and cross-sections as well as lithology and character of the strata influence recommendations.

SETTING SLOPES: Normal design criteria for slopes may be utilized when the apparent dip along centerline is less than two degrees and apparent dip on the cross-section is away from the roadway. Intermediate bench elevations should follow apparent dip and will have a slight grade. These benches are drawn horizontally on cross-sections and will cross cut strata in one direction.

INTERMEDIATE BENCHES: Intermediate benches with widths from 18 feet to 25 feet (5.5 meters to 8 meters) may be utilized and should be designed as horizontal in cuts where the apparent dip along centerline is more than two degrees and the apparent dip on the cross-section is away from the roadway. The benches will cross cut strata in two directions. Cut slopes with a maximum vertical lift of 60 feet (18 meters) are recommended according to the strata encountered in that particular lift.

OMISSION OF BENCHES: Intermediate benches are to be omitted and one pre-split slope is recommended from the top of rock to grade in cuts where the apparent dip on the cross-sections is toward the roadway. Lithology and character of the strata determine this slope. In some areas where a large mass of material could create a major landslide, the design slope should follow the dip of the strata.

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GEOTECHNICAL	*Section* SPECIAL GEOLOGIC CONSIDERATIONS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Faults

DESIGN CONSIDERATIONS FOR FAULTS: Site-specific design considerations relating to faults must include:

- Ø Location of fault
- Ø Type of fault
- Ø Width of fault or area influenced
- Ø Competence of faulted materials
- Ø Amount of displacement

The effect of the fault on the roadway or structure then must be determined, and appropriate designs and recommendations developed.

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GEOTECHNICAL	Section: SPECIAL GEOLOGIC CONSIDERATIONS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject: Acid-Producing Shales

DESIGN CONSIDERATIONS FOR ACID-PRODUCING SHALES: Special design considerations relating to acid-producing shales shall be addressed during design of projects.

Special design considerations shall be addressed for acid-producing shales when the geologic formations are encountered in cut sections and/or when the shale is used in embankment fill sections. The geologic formations of acid-producing shales include: the **New Albany Shale,** the **Chattanooga Shale,** and the **Ohio Black Shale.**

In general, the cut slope for cut sections is overexcavated a minimum of 4.5 feet, using a serrated slope on a 1½ :1 or 2:1 slope (**Exhibit 20**) and covered with 4 feet of clay soil or nondurable shale to prevent production of acidic run-off and covered with 0.5 feet of top soil to support vegetation.

In general, when the shales are used in embankment fill sections, the acidic shale is encased inside the embankment. The encasement of the acidic shale includes using 2.5 feet (parallel to fill slope) of nondurable shale or clay soil as a barrier to protect the acidic shale from the weathering elements such as water and air. However, a minimum of 4 feet of nondurable shale or clay soil is recommended on top of the embankment to control corrosion of guardrail and/or sign post, etc., from the acidic shale. If available, the side slopes shall be dressed with 0.5 feet of top soil to support vegetation.

These are general guidelines and do not cover all of the specific recommendations that are needed in a geotechnical report or cover other options available to mitigate the production of acidic runoff conditions.

GEOTECHNICAL	*Chapter* MEETINGS & SUBMITTALS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Introduction

OVERVIEW: This chapter describes the purpose, content, and conduct of meetings typically held in conjunction with a project. During the course of a project, additional meetings may be required to deal with problems that arise.

PRELIMINARY MEETINGS & SUBMITTALS: **GT-701** explores the following subjects:

GT-701-1 Preliminary Meetings
GT-701-2 Laboratory Testing Plan
GT-701-3 Engineering Analysis Plan

INTERIM MEETINGS: **GT-702** discusses the purpose of meeting during progress of project.

ROCK CORE MEETINGS: **GT-703** discusses the scheduling of rock core meetings.

FINAL GEOTECHNICAL MEETINGS: **GT-704** explains the purpose of final geotechnical meetings.

LANDSLIDE OR UNSTABLE ROCK SLOPE MEETINGS: **GT-705** addresses the need for landslide or unstable rock slope meetings.

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GEOTECHNICAL	*Section* PRELIMINARY MEETINGS & SUBMITTALS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Preliminary Meetings

PURPOSE OF A PRELIMINARY MEETING:

If necessary, the Geotechnical Branch may schedule a preliminary meeting for roadway/structure projects by notifying representatives of the design consultant, Division of Highway Design, and District Design. The branch may conduct this meeting at the project site. The meeting may consist of a discussion of the scope of work, with an anticipated completion date, and a field/office review of the preliminary boring plan plotted on the plan/profile and cross-sections. The Geotechnical Branch may request that the centerline of survey be staked prior to the meeting. The minutes of the meeting, prepared or approved by the Geotechnical Branch, shall constitute the approved boring plan and authority to begin the subsurface investigation.

SERVICES PROVIDED BY GEOTECHNICAL CONSULTANT:

The above procedures, along with the following additions, shall also apply when a geotechnical consulting engineer provides the geotechnical services. The geotechnical consultant shall submit to the Geotechnical Branch for review a preliminary boring plan for roadway/structure projects, along with a request for a preliminary meeting upon approval of the engineering agreement or contract modification. If necessary, the Geotechnical Branch will schedule the preliminary meeting after reviewing the boring plan.

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GEOTECHNICAL	Section: PRELIMINARY MEETINGS & SUBMITTALS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject: Laboratory Testing Plan

SCOPE OF PLAN:

Prior to conducting any laboratory tests, the geotechnical consultant shall submit a laboratory testing plan to the Geotechnical Branch for review. The branch will review the plan and take appropriate action. The laboratory testing plan (for large projects with significant field work) may be submitted in several sections in order to facilitate the laboratory work.

The laboratory testing plan shall consist of:

- Ø County name
- Ø Project number
- Ø MARS number
- Ø Station
- Ø Hole number
- Ø Item number
- Ø Date
- Ø Sample numbers
- Ø Visual descriptions
- Ø Numbers of samples of various lengths
- Ø Borings logs (unless previously submitted)
- Ø Proposed laboratory tests

Refer to the TC 64-531 form, *Thin-Walled Tube and SPT Sample Log* **(Exhibit 13).**

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GEOTECHNICAL	Section PRELIMINARY MEETINGS & SUBMITTALS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject Engineering Analysis Plan

SCOPE OF PLAN:

After laboratory testing is complete and prior to beginning any analyses, the geotechnical consultant shall submit an engineering analysis plan to the Geotechnical Branch for review. The branch will review the plan and take appropriate action. For large projects with significant work, the consultant may submit the engineering analysis plan in stages in order to facilitate the engineering analyses.

The engineering analysis plan shall consist of:

Ø Soil profile and stability sheets showing all relevant borings and laboratory data for roadways and structures (refer to **GT-701-2, Laboratory Testing Plan)**

Note: The consultant need not submit laboratory test data sheets unless the Geotechnical Branch requests them.

Ø A tabular summary indicating:

- Station limits
- Critical analysis station (with appropriate offsets, locations, etc., as applicable)
- Type of analysis to be performed

Ø A tabular summary of areas that were anticipated to require analyses in the preliminary stage but did not undergo analysis as a result of the information obtained from the field and laboratory work

Note: This summary should indicate station limits, critical analysis station (with appropriate offsets, locations, etc., as applicable), type of analysis previously thought to be necessary, and a very brief statement explaining why analysis is not necessary.

2 2 2

GEOTECHNICAL

GEOTECHNICAL	*Chapter* MEETINGS & SUBMITTALS
	Subject Interim Meetings

PURPOSE OF MEETING: If deemed necessary, the Geotechnical Branch will schedule an interim meeting to discuss progress of the project or address any complications that have developed. The branch will invite, as applicable, any or all of the following:

- Ø Design consultant
- Ø Division of Highway Design
- Ø District Design
- Ø Division of Construction
- Ø District Construction

The minutes of the meeting shall reflect discussions that occurred.

SERVICES PROVIDED BY GEOTECHNICAL CONSULTANT: The consultant will be responsible for the completed minutes.

2 2 2

GEOTECHNICAL

Chapter

MEETINGS & SUBMITTALS

Subject

Rock Core Meetings

PURPOSE OF MEETING:

If deemed necessary, the Geotechnical Branch will schedule a rock core inspection after rock coring and open-face logging have been completed and cut slope recommendations have been prepared. The branch will invite to the meeting representatives of the:

- Design consultant
- Division of Highway Design
- District Design
- Division of Construction
- District Construction

The purpose of the meeting is to:

- Review the rock cores and open-face logs
- Recommend rock cut slope configurations
- Resolve questions as to the type and thickness of rock to be considered for select quantities

The minutes of the meeting shall constitute the recommended rock cut slope configurations. Slope stability analyses may be necessary prior to final design of cut slopes in the overburden; however, the analyses need not be completed prior to the rock core meeting.

If deemed necessary, the Geotechnical Branch may hold a rock core meeting for structures.

SERVICES PROVIDED BY GEOTECHNICAL CONSULTANT:

When a consulting engineer provides geotechnical services, the consultant shall submit a written summary of the cut slope recommendations with cut limits defined to the Geotechnical Branch prior to the rock core inspection. The consultant shall plot the recommendations with lithology divisions on the critical cross-sections. If necessary, the Geotechnical Branch will schedule a rock core meeting after reviewing the cut slope recommendations.

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GEOTECHNICAL	Chapter: MEETINGS & SUBMITTALS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject: Final Geotechnical Meetings

PURPOSE OF MEETING: If deemed necessary, the Geotechnical Branch will schedule a final meeting. The branch shall invite to the meeting representatives of the:

- Design consultant
- Division of Highway Design
- Division of Construction
- District Design
- District Construction

The purpose of this meeting is to discuss and recommend geotechnical plan notes for roadway/structure projects.

SUBMITTAL BY A CONSULTANT: When a geotechnical consultant provides services, the consultant shall submit the following information to the Geotechnical Branch for review prior to the final geotechnical meeting:

- Roadway Projects:
  - Cut stability sheets
  - Embankment stability sheets
  - Soil profile sheets
  - Other sheets depicting special procedures
  - Draft copy of the geotechnical recommendations
- Structure Projects
  - Single copy of the letter portion of the report
  - Copies of the subsurface data and other sheets (one each)
  - Copies of the geotechnical design calculations and test results (pile capacities, stabilities, triaxial failure envelopes, e-log p-curves, settlement calculations, negative skin friction, axial loads on drilled shafts, etc.)

CONT.

SUBMITTAL OF REPORT:

If necessary, the Geotechnical Branch will schedule the final geotechnical meeting after reviewing the submittals. Following the final geotechnical meeting/review, the consultant will make any necessary revisions and submit the finalized report (with required copies) along with electronic files. The Geotechnical Branch will then distribute the report as outlined in **GT-807, Report Distributions.**

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GEOTECHNICAL	*Chapter* MEETINGS & SUBMITTALS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Landslide or Unstable Rock Slope Meetings

PURPOSE OF MEETING:

The Geotechnical Branch will notify either the Chief District Engineer or the Director of the Division of Maintenance that the proposed methods of correction and the accompanying cost estimates have been completed. The branch will arrange a meeting of the appropriate representatives to discuss the project. Representatives may include those of the:

- Ø State Highway Engineer's Office
- Ø Division of Maintenance
- Ø Office of Rural and Secondary Roads
- Ø Division of Highway Design
- Ø Division of Construction
- Ø Geotechnical Branch
- Ø Chief District Engineer
- Ø Others

The purpose of the meeting is to select a method for correction. Representatives will discuss approximate quantities and estimated costs for each alternative. The Geotechnical Branch will prepare a final report upon approval by the requesting party.

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GEOTECHNICAL	*Chapter* REPORT DEVELOPMENT
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Introduction

OVERVIEW: This chapter presents recommendations and guidelines relating to the development of various types of geotechnical engineering reports and the distribution of those reports. Many of the exhibits referenced in the text are example subsurface data sheets similar to the drawings, which should accompany the plans in the roadway and structure reports.

PLANNING: **GT-801** discusses geotechnical overviews for planning.

ROADWAYS: The following subjects pertain to the development of a geotechnical engineering roadway report:

GT-802-1 Design of Report
GT-802-2 Soil Profiles
GT-802-3 Rock and Soil Cuts
GT-802-4 Embankments
GT-802-5 Special Geologic Considerations

STRUCTURES: The following subjects provide guidelines for preparing reports of the various types of structures commonly encountered on highway projects:

GT-803-1 General Project Information
GT-803-2 Bridges
GT-803-3 Culverts
GT-803-4 Retaining Walls
GT-803-5 Noise Barrier Walls

MAINTENANCE: **GT-804** discusses the development of reports on various investigations for maintenance projects.

CONSTRUCTION: **GT-805** discusses the submission of reports applicable to construction projects.

PERMITS: **GT-806** addresses the reports for both utility and mining encroachment permits.

REPORT DISTRIBUTIONS: **GT-807** provides the distribution lists of the various reports.

2 2 2

GEOTECHNICAL	Chapter: REPORT DEVELOPMENT
	Subject: Planning

GEOTECHNICAL OVERVIEWS:

Geotechnical overviews for planning should address issues that may affect transportation decisions within the project area. The geotechnical overviews should present a description of the topography of the project area, including regional and structural geology. The geotechnical overviews should also include discussion concerning the impacts of the various features and any potential mitigation actions, including cost, that would be necessary if the feature is encountered. This information will be utilized to help determine whether or not to impact a feature, particularly in the situation when there are competing issues (that is, historic, environmental, cultural, etc.) and it is not possible to avoid impacting a resource of the feature. The issues discussed may include:

- Problematic geologic formations
- Presence of springs, landslides, mines, karst, faulted strata, acidic shale, mineral deposits, or other topographic or subsurface features that could affect construction and maintenance of a roadway
- Foundation types for structures
- Possible issues with cut and fill slopes resulting from the known soil and rock conditions

  Note: This should be in a broad sense, that is, flatter or steeper slopes than normal so that the impacts to cost resulting from the need for more earthwork or right of way can be considered.)
- Possible issues with pavement subgrade and the need for modification
- Seismic zones for earthquake design and possible mitigation actions
- Availability of suitable materials from excavation (that is, rock from excavation) to use in the subgrade and embankments

CONT.

GEOTECHNICAL OVERVIEWS (cont.):

Maps of the project areas should be included with as many as possible of the above features noted. Areas of particular concern should be clearly noted on the maps. When possible, this information should be provided in GIS (Geographic Information System) layers so that they can be incorporated with other features for visual display as well as to aid in the determination of the recommended corridors. If alternatives are available, then an evaluation of each alternative discussing the geologic conditions, both beneficial and adverse, should be included.

Whenever possible the report should be presented in layman's terms, since the overview will be included in the reports or other displays that will be available to the general public.

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# GEOTECHNICAL	*Section* ROADWAYS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Design of Report

TYPICAL FORMAT: The following typical table of contents illustrates the general format for developing a geotechnical engineering roadway report.

Chapters:

I. Location and Description
II. Topography and Drainage
III. Geology
IV. Drilling and Sampling
V. Laboratory Testing
VI. Engineering Analyses
VII. Recommendations

APPENDICES:

A. Location on a 1-inch = 2,000-foot (1:24,000) scale topographic map
B. Triaxial test failure envelopes*
C. Void ratio and coefficient of consolidation/log pressure curves, settlement versus time curves, and settlement calculation sheets*
D. Geotechnical symbol sheet
Geotechnical note sheet
Soil profile sheets
Cut stability sections
Embankment stability sections
Applicable sheets for wick drains, stone columns, slope reinforcement, etc.

* Included only in the three paper copies submitted to the Geotechnical Branch

FORMAT REQUIREMENTS: Reports shall be typed and drawings made on 8.5-inch x 11-inch (215-millimeter x 278-millimeter) sheets, with the exception of those specified in Appendix D. The roadway alignment shall be depicted on a 1-inch = 2,000-foot (1:24,000) scale topographic map, with stations indicated at a minimum of 1,000-foot (300-meter) intervals (refer to **Exhibit 2**). The sheets in Appendix D shall be reduced to scale on 11-inch x 17-inch (278-millimeter x 432-millimeter) sheets and included in the report.

CONT.

COVER & TITLE SHEET: The cover and title sheet shall include the following project identification:

- Ø County name
- Ø Project number
- Ø Route number and/or road name
- Ø Stations of termini
- Ø Section number
- Ø MARS number
- Ø Item number
- Ø Date

GENERAL REPORT REQUIREMENTS: The following paragraphs outline general report requirements; however, additional chapters may be needed to fully document a project:

Chapter I—Location and Description provides specific and detailed information such as project termini, major stream crossings, and intersections referenced to landmarks. The design objectives of the proposed roadway will be described.

Chapter II—Topography and Drainage presents a discussion of the major terrain features. A short general discussion will be followed by significant details giving approximate stations of anomalies.

Chapter III—Geology discusses the major geologic features. Items requiring special consideration—faults, sinkholes, landslides, mines, etc.—will be discussed.

Chapter IV—Drilling and Sampling provides a complete description of the drilling and sampling program, including drill equipment, drilling and sampling methods, and dates. Observations will be made concerning soil types, depths, water tables, springs, etc., with reference to stations.

Chapter V—Laboratory Testing presents the number of each type of laboratory test along with the test methods. A discussion of the test results, including averages and range of values, will be presented. Approximate station limits of areas with unusual soil conditions shall be discussed. The significance of the test values, especially unusual values, should be discussed and referenced in the appropriate appendices. A summary of all test data shall be shown on soil profile and stability section sheets.

Chapter VI—Engineering Analyses includes discussions of each stability, settlement analysis, etc. References should be made to appropriate stability sections and calculation sheets in appendices. Derivations of strength parameters as well as safety factors, special analysis procedures (that is, wick drains, stone columns, slope reinforcement), etc., and their significance will be discussed.

CONT.

GENERAL REPORT REQUIREMENTS (cont.):

Chapter VII—Recommendations consists of a list of geotechnical recommendations. These recommendations shall become the geotechnical notes after departmental approval. The CBR design value and any subgrade modification are included as design recommendations and shall not be shown on the geotechnical note sheet. The geotechnical notes will be placed on a geotechnical note sheet and included in the roadway plans (refer to **Exhibit 30**). Appropriate notations making reference to specific geotechnical notes and stability section sheets will be made on the soil profile at the applicable locations. Geotechnical considerations applicable to structures on the project shall be incorporated into the roadway report whenever possible.

Appendices include triaxial test failure envelopes, void ratio, coefficient of consolidation/log pressure curves (refer to **Exhibits 27 and 28**), and settlement calculation sheets, paper copies only.

ABBREVIATED FORMAT:

An abbreviated geotechnical engineering roadway report, with prior approval by the Geotechnical Branch, may be used when conditions warrant. This format shall include:

- Brief discussion of detrimental soil and subsurface conditions
- Geotechnical recommendations
- Roadway alignment depicted on a 1-inch = 2,000-foot (1:24,000) scale topographic map showing 1,000-foot (300-meter) minimum station intervals
- Symbol sheet, geotechnical note sheet, soil profile sheets, cut and embankment stability sections, and special application sheets (that is, wick drains, stone columns, slope reinforcement). These drawings shall be reduced to scale on 11-inch x 17-inch (278-millimeter x 432-millimeter) sheets.

2 2 2

GEOTECHNICAL	*Section* ROADWAYS
	Subject Soil Profiles

SYMBOL SHEET: The soil profile sheets shall be prefaced with a symbol sheet (refer to **Exhibit 29**).

GEOTECHNICAL NOTES: A geotechnical note sheet is to be included. All pertinent notes shall be listed along with any applicable stations and/or station limits (refer to **Exhibit 30**). The department disclaimer note shall be placed on the first sheet of the soil profile (refer to **Exhibit 31**).

DISTURBED SOIL BORINGS: All disturbed soil borings shall be plotted on the soil profile. Offset borings shall be identified as to offset distance and drawn at the proper station and elevation, whenever possible. Where offset borings left and right of the same station would overlap, both borings shall be plotted at the proper station, one at the proper elevation, and the surface elevation of the other boring shall be identified. Channel changes and special ditches shall be shown on the same sheet with the mainline profile when space permits.

NONDURABLE SHALES: In special cases where nondurable shales (soil-like shales that are soft and may be drilled easily with an auger) were sampled and tested, the nondurable shale symbol shall be used when plotting, and the samples shall be identified by the same procedure as those used for soil.

PRESENTING TEST RESULTS: All applicable laboratory test results shall be depicted on the soil profile sheets (refer to **Exhibit 31**). Laboratory test data sheets (except those specified in **GT-802-1**). and subsurface logs shall not be included in the geotechnical engineering report.

MINIMUM PROJECT IDENTIFICATION: The following information shall be on all soil profile sheets, as applicable:

- County name
- Road name
- MARS and item numbers
- Stream crossings and roadway intersections identification
- Reference to any applicable geotechnical notes and critical stability sections

2 2 2

GEOTECHNICAL	*Section* ROADWAYS
	Subject Rock & Soil Cuts

POLICY:

The proposed slope configuration for all critical rock and soil cuts shall be depicted on a cut stability section. Included on the section shall be all relevant borings and data necessary to develop this configuration. A tabulation of rockline soundings through the entire referenced cut shall be included when necessary. All applicable subsurface information shall be shown on the cut stability section (refer to **Exhibits 25, 26, and 32**).

Any special recommendations and construction requirements necessary to obtain a stable cut slope design shall be depicted on the cut stability section, that is, soil nailing, rock bolts, special rock fall ditches, horizontal drains, etc.

2 2 2

GEOTECHNICAL

Section

ROADWAYS

Subject

Embankments

STABILITY: The critical section(s) for each embankment with the proposed slope configuration shall be plotted on an embankment stability section sheet. All relevant borings, data, and results of analyses shall be shown on these sheets (refer to **Exhibit 33**).

SETTLEMENT: In situations where settlement magnitudes are critical, a note addressing settlement should be included on the embankment stability sheet. For example:

NOTE: Settlement analysis indicates 24 inches of settlement with 90 percent consolidation in 6 years.

SPECIAL RECOMMENDATIONS: Any special recommendations and construction requirements necessary to obtain a stable embankment slope design shall be depicted on the section, that is, slope reinforcement, rock toe drains, wick drains, horizontal drains, geotextile fabric, etc. (Refer to **Exhibits 35 and 36** for example of wick drains).

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GEOTECHNICAL	*Section* ROADWAYS
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Special Geologic Considerations

POLICY: Special geologic considerations shall be presented on sheets depicting procedures (that is, mine subsidence treatment, rock bolts, dipping rock, etc.). Additional information in the form of special notes, special provisions, and/or specifications shall be attached to the report.

2 2 2

GEOTECHNICAL	Section: STRUCTURES
TRANSPORTATION CABINET, Department of Highways, GB, Division of Materials, Geotechnical Branch	Subject: General Project Information

OVERVIEW: Structure foundation investigations consist of all functions necessary to develop the subsurface data sheets and the geotechnical report. A separate report shall be written for each structure on the project, except for twin bridges and bridges with short attached wingwalls. The following instructions shall be used as guidelines in preparing reports for the various types of structures commonly encountered.

GUIDELINES FOR REPORTS: Structure reports shall consist of a letter containing the recommendations, site map, latitude and longitude coordinates for each hole, and accompanying drawings (if applicable), most of which are intended to be included in the structure plans. The final recommendations are to be placed at the end of the body of the report in a numbered format. The body of the report should be in the following format:

- Brief description of the proposed structure location
- Identification of the name and number of the 7.5-minute geologic quadrangle in which the structure is located, along with the rock formation and geologic member
- List of the entities that performed the drilling and the soil testing
- Brief discussion of the conclusions pertaining to the overall site geology and in-situ soils, along with any irregularities encountered during the investigation
- Brief discussion of the criteria, results, and conclusions of any stability analyses

  Note: If stability analyses are not warranted, an explanation of why this is the case (for example, low embankment heights or shallow foundation soils) should be included in the report.

CONT.

GUIDELINES FOR REPORTS (cont.):

- Brief discussion of the criteria, results, and conclusions of any settlement analyses

  Note: If settlement analyses are not warranted, an explanation of why this is the case (for example, low embankment heights or shallow foundation soils) should be included in the report.

- Where applicable, scour data and a brief discussion of possible solutions if scour is excessive

- Where applicable, a brief description of pile driveability or drilled shaft analyses and conclusions

COORDINATE DATA:

Latitude and longitude coordinates for each boring location should be submitted in tabular form in the appendix of the report (refer to **Exhibit 41**).

2 2 2

GEOTECHNICAL

Section	Subject
STRUCTURES	Bridges

OVERVIEW: Foundation investigation reports for bridges shall meet the general requirements presented in **GT-803-1**, which are applicable to all structures. Additional requirements, below, are specific to bridges.

MINIMUM REPORT RECOMMENDATION DEVELOPMENT: The recommendation portion of the report shall address, at a minimum, recommendations for the following items (where applicable):

- Foundation type with the anticipated bearing elevations (typically pile tip and/or base of footing elevations)
- Allowable bearing capacity for spread footings

  Note: In cases where a deeper footing embedment will allow significantly higher bearing pressures, it may be advantageous to present allowable bearing for more than one elevation (for example, at the top and base of the weathered rock).

- Settlement
- Negative skin friction
- Scour
- Pile capacity
- Pile driveability (for example, minimum and maximum hammer size)
- Slope protection
- Drilled shaft foundations
- Any instrumentation or construction procedures necessary or advantageous to a safe and economical geotechnical design

CONT.

DEEP VS. SHALLOW FOUNDATIONS: Spread footings are generally recommended when suitable bedrock is encountered within 20 feet (6 meters) of finished grade. Deep foundations are generally more economical when the distance from finish grade to the bedrock surface is greater than 20 feet (6 meters). The approximate roadway grade at each abutment should be indicated on the subsurface data sheet to allow a comparison with the rock elevation (refer to **Exhibit 39**). Estimated pile tip elevations are specified in the recommendations but are not presented on the plan sheet.

BEDROCK CONTOURS: It may be desirable to prepare a bedrock contour sheet for bridge sites where the bedrock surface is steeply sloping or where karst features have produced a highly irregular rock surface (refer to **Exhibit 40**).

PRESENTING STABILITY ANALYSIS RESULTS: The results of stability analyses performed for the Geotechnical Engineering Structure Foundation Report may be shown and/or discussed in the report (refer to **Exhibit 42**). The soil strength parameters assumed for analyses and the safety factors determined from analyses shall be presented on the drawing. The stability analyses shall not be duplicated in cases where stabilities performed for investigation of the roadway are applicable to the embankment at the structures. However, if the stability analyses were performed and shown in the roadway report, a brief discussion of the results along with any mitigation procedures is required for the structure report.

PRESENTING SETTLEMENT ANALYSIS RESULTS: The results of all settlement analyses (including those previously performed in the roadway phase of the investigation) indicating the estimated settlement magnitude and rate of settlement shall be presented in the roadway Geotechnical Note Sheet and the Geotechnical Engineering Structure Foundation Report. Where an existing embankment is being widened and significant differential settlements are anticipated, settlement analyses shall be performed across the width of the embankment.

SPECIAL REQUIREMENTS: Procedures such as controlled loading, waiting periods, or wick drains may be necessary based upon the results of stability and/or settlement analysis. Instrumentation procedures may also be required. All of these items shall be called for specifically in the recommendation section of the report. The Division of Bridge Design will include the appropriate recommendations on a general note sheet. The reasons for the use of a waiting period, instrumentation, wick drains, etc., shall be discussed in the report. It may be necessary to also include these requirements in the geotechnical notes of the roadway plans (refer to **Exhibit 30**).

CONT.

LATERAL SQUEEZE: For bridges with moderate to large settlement magnitudes for which deep foundations are proposed, the geotechnical engineer shall determine, using the method presented in the *Soil and Foundations Workshop Manual*, if lateral squeeze is a potential problem. In such cases, the geotechnical engineer shall address the use of a waiting period between completion of embankment construction and the foundation installation, or other feasible methods of eliminating potential damage to the foundation. In addition to the abutments, foundations at piers immediately adjacent to the abutments could be affected by lateral squeeze.

DRAGDOWN: Dragdown on the deep foundations may be a problem for structures with moderate or large settlement magnitudes and slow consolidation rates. The geotechnical engineer must suggest alternative methods of handling dragdown loads. The dragdown load without a waiting period, with a waiting period, and after treatment (with or without waiting period) shall be presented in the Geotechnical Engineering Structure Foundation Report.

SETTLEMENT PLATFORMS: The geotechnical engineer shall instruct the designer to add a note to the plans specifying settlement platforms if a waiting period is selected as the method of handling dragdown loads or lateral squeeze. If settlement platforms are required, a note shall be added to the Geotechnical Note Sheet produced for the Geotechnical Engineering Roadway Report for inclusion in the roadway plans.

METHODS OF HANDLING DRAGDOWN: The designer shall be instructed to indicate on the plan sheet (showing the piles and the pile-driving records) whether or not the foundations have been designed to support the dragdown loads. If the foundations cannot be designed to handle the dragdown loads, alternative methods may have to be employed to counteract any negative impact to the piles.

ALTERNATIVE DESIGNS: The designer may submit alternative designs for a structure. A separate subsurface data sheet may be prepared for each alternative. All of the subsurface data obtained for all alternatives shall be presented on each sheet (refer to **Exhibit 39**). The sheets shall not be labeled as alternatives. The drawing for the rejected alternative can be discarded and that for the selected structure included in the plans. Subsurface data sheets for both single-span and three-span alternatives shall be developed when breastwall abutments are proposed *(*refer to **GT-403-1**, "**Bridges")** and rock is in excess of 20 feet (6 meters) below proposed roadway grade.

CONT.

CBR DESIGN VALUES: Bridge replacement projects in which a Geotechnical Roadway Report will not be issued shall include a recommended CBR design value for pavement in the Geotechnical Engineering Structure Foundation Report.

SUBSURFACE DATA SHEETS: A subsurface data sheet presenting a plan view of the bridge and a profile view of the borings is necessary. Subsurface data sheets showing the relative positions of other structures and nearby borings may be developed. Additional drawings illustrating the results of analyses or locations of specialty items (wick drains, stone columns, geogrids, etc.) may be required (refer to **Exhibits 35 and 36** for examples involving wick drains).

PLAN SCALE: Bridge plan views shall be drafted as follows:

- For English unit drawings, a scale of 1"=10', 1"=20', 1"=30', 1"=40', 1"=50', or 1"=60' should be used.
- For metric unit drawings, a scale of 1:100, 1:200, 1:300, 1:400, or 1:500 should be used.
- The largest of the scales that will conveniently fit on the plan sheet should be used.
- The plan view for large structures may be plotted on two or more sheets in lieu of using a smaller plan scale.
- The plan sheet shall present the following information:
  - Roadway bearing
  - North arrow
  - Location and station of each pier and abutment
  - Name (if known) of any roadway, railroad, or stream, etc., that the bridge crosses
  - Roadway skew (if any)
  - Types and locations of all borings
- The location of any borings specified in the boring layout but not drilled shall not be plotted on the plan sheet.

PROFILE: A graphical depiction of the borings in profile view shall be presented beneath the bridge plan. The profile view vertical scale shall always be 1 inch = 10 feet for English unit drawings and 1:100 for metric unit drawings, regardless of the scale used for the plan. Use of horizontal scale on the profile view is not necessary.

TYPE OF DATUM: The type of datum should always be indicated. (Refer to **Exhibit 43,** which indicates a "sea level datum." Alternatively, the drawing could indicate an "assumed datum.")

CONT.

REQUIRED INFORMATION ON PROFILE: Headings for borings shall include hole number, station, offset, and surface elevation.

CLASSIFICATION DATA: The types and locations of undisturbed samples are shown with the holes plotted on the profile view, but the Unified Soil Classification symbols as presented on **Exhibit 29** need not be shown. "N-values" shall be indicated for all samples obtained through standard penetration testing. The following items shall be listed for all classified samples:

- Ø S+C (silt plus clay) percentages from hydrometer or wash gradation tests
- Ø AASHTO and Unified Soil Classifications
- Ø Liquidity index
- Ø Natural moisture contents
- Ø D_{50} and D_{95} (millimeters)—needed for bridges at wet crossing only

WATER TABLE: Water table elevations accompanied by the date of the readings shall be depicted on the boring profile.

REPORTING RESULTS OF LAB TESTING: Results of unconfined compression and/or unconsolidated-undrained triaxial testing are typically plotted beside the sample tested (refer to **Exhibit 46, sheet 3**). Results of other types of tests such as consolidated-undrained triaxial testing are usually listed in a table (refer to **Exhibits 32 and 49**). D_{50} and D_{95} values should be presented for soil samples for structures at wet crossings (refer to **Exhibit 45**).

ROCK DESCRIPTIONS: Rock descriptions from the geology logs shall be presented on the subsurface data sheets as illustrated in the exhibits.

ROCK TEST RESULTS: The Rock Quality Designation—Kentucky Method (KY-RQD) and the percentage of recovery (REC) (from the geologist's log, not the driller's log) are given for each core run. For some projects, including those incorporating drilled shafts, the Rock Quality Designation—Standard Method (Std-RQD) are also required (refer to **Exhibit 46, sheet 3**). Results of the Slake Durability Index tests and Jar Slake tests are also shown.

REFUSAL ELEVATIONS: Refusal elevations of rockline soundings shall be shown in parentheses. All core logs shall identify top of rock (bedded material) elevation and, if applicable, the elevation of the base of weathered rock. Subsurface data sheets shall state “no weathered rock” where geology logs indicate none is present (refer to **Exhibit 43**).

CONT.

USING PREVIOUSLY DEVELOPED DATA: The subsurface data sheet presented in **Exhibit 44** is an example of existing data from a previous report being included in the Geotechnical Engineering Structure Foundation Report and in the Structure Plans.

2 2 2

GEOTECHNICAL	*Section* STRUCTURES
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Culverts

OVERVIEW: Foundation investigation reports for culverts shall meet the general requirements presented in **GT-803-1,** which are applicable to all structures. Additional requirements, below, are specific to culverts.

MINIMUM REPORT DEVELOPMENT: Recommendations presented in the letter portion of the report shall include, at a minimum, the following items:

- Ø Whether the culvert is to be designed as yielding (soil bearing) or nonyielding (rock bearing)
- Ø Allowable bearing pressure for wingwalls
- Ø Settlement (for yielding culverts, if applicable)

ALLOWABLE BEARING PRESSURE: The allowable bearing pressure for yielding culverts is applicable only to the wingwalls since the barrel of the culvert is confined.

EQUIVALENT FLUID PRESSURE: The structure designer can use the equivalent fluid pressure values directly or use Soil Type 3 of **Exhibit 66-04-13** in the *Division of Bridge Design Guidance Manual*.

SETTLEMENT: Culverts on deep soil foundations, and also under high embankments, can be affected by large magnitudes of settlement. Assuming that the foundation conditions are uniform, settlement will be greatest near the center of the culvert, under the highest portions of the embankment. This differential settlement can adversely affect drainage through the culvert. Prior to settlement the flowline will fall continuously from culvert inlet to outlet. If the center of the culvert settles more than the outlet, the center of the culvert in its post-settlement configuration can be lower than the outlet, causing water to pond in the culvert.

USE OF CAMBER: To prevent ponding from occurring, a cambering (or arching) of the flowline is sometimes employed. In cases where settlements are anticipated to be a potential concern, the geotechnical engineer shall alert the structure designer to this condition to determine whether camber is necessary.

CONT.

CBR DESIGN VALUES: Culvert replacement projects in which a Geotechnical Engineering Roadway Report will not be issued shall include a recommended CBR design value for pavement in the Geotechnical Engineering Structure Report.

SUBSURFACE DATA SHEET: A subsurface data sheet presenting a plan view of the culvert and a profile view of the borings (plotted to vertical scale) showing their position relative to flowline is preferred. The information on the plan view should be similar to that shown in **GT-803-2.** Flowline inlet and outlet elevations (including existing inlet and outlet elevations for extensions) shall also be indicated on the subsurface data sheet (refer to **Exhibit 47**).

PRESENTING RESULTS OF SETTLEMENT & STABILITY ANALYSIS: The results of settlement and stability analyses, if applicable, shall also be presented. Settlement shall be plotted along culvert centerline when nonuniform loading or nonuniform foundation conditions are anticipated to cause significant differential settlements (refer to **Exhibit 48**). The results can be presented as a note rather than in a graphic format if uniform loading conditions exist.

2 2 2

GEOTECHNICAL	*Section* STRUCTURES
	Subject Retaining Walls

OVERVIEW: Foundation investigation reports for retaining walls shall meet the general requirements presented in **GT-803-1,** which are applicable to all structures. Additional requirements, below, are specific to retaining walls.

MINIMUM REPORT DEVELOPMENT: Recommendations presented in the letter portion of the report shall include, at a minimum, the following items:

Ø Wall types that were analyzed for this location

Ø Listing of parameters that can be utilized in the wall design

Each possible wall type analyzed for the location should have a separate list of parameters. This list shall include, where applicable:

- Effective stress friction angle of granular backfill
- Effective stress friction angle of in-situ soils
- Total stress cohesion of in-situ foundation soils
- Effective stress friction angle of backfill (internal backfill for MSE must conform to "Reinforced Fill Material" as specified in **Section 805** of the *Standard Specifications for Road and Bridge Construction,* current edition)
- Unit weight of backfill
- Unit weight of foundation material
- Unit weight of MSE internal backfill
- Allowable bearing capacity of granular replacement
- Allowable bearing capacity of bedrock
- Minimum strap length for MSE walls = greater of 8 feet or 70% of the wall height (0.7H)
- Friction angle for sliding calculation
- Equivalent depth of soil surcharge
- Allowable bearing capacity of spread footings founded on top of the MSE wall
- Any other geotechnical parameter necessary for the design of the wall

CONT.

MINIMUM REPORT DEVELOPMENT (cont.):

- Ø The required minimum factor of safety requirements for:

    - ♦ Sliding = 2 including passive pressures or 1.5 not including passive pressures
    - ♦ Overturning = 2
    - ♦ Bearing capacity = 2 to 3, depending on amount and credibility of test data
    - ♦ External slope stability analyses

- Ø Whether or not the analyses performed meet the minimum required safety factors and any additional measures (shear key, granular replacement, granular backfill, etc.), if any, that had to be employed to meet those factors

- Ø A plan view of the retaining wall, sample borings, rockline soundings, rock cores, observation well data, and laboratory test results on the subsurface data sheet for all walls where a subsurface investigation is performed

    Note: Plotting the wall profile on the subsurface data sheet with the borings is not required for walls that obviously bear either on soil or on rock throughout. The profile shall be indicated on the subsurface data sheet if the rockline is near the proposed wall footing elevation, or if replacement of the foundation soils with granular materials (either partial replacement or replacement to bedrock) is required.

STABILITY: Stability sections shall be prepared for retaining walls, where applicable. The wall designer shall check internal stability of retaining walls. The geotechnical engineer shall perform analyses necessary to ensure that safety factors for external stability are adequate. Analyses for external stability shall include, at a minimum, allowable bearing capacity, sliding, overturning, and overall slope stability.

2 2 2

GEOTECHNICAL	*Section* STRUCTURES
	Subject Noise Barrier Walls

OVERVIEW: Foundation investigation reports for noise barrier walls shall meet the general requirements presented in **GT-803-1,** which are applicable to all structures. Additional requirements, below, are specific to the walls.

MINIMUM REPORT DEVELOPMENT: Recommendations presented in the letter portion of the report shall include, at a minimum, the following items:

Ø A listing of parameters that can be utilized in the wall design, including, where applicable:

- ♦ Effective stress friction angle of granular in-situ soils
- ♦ Total stress cohesion of in-situ soils
- ♦ Unit weight of foundation materials
- ♦ Allowable bearing capacity at bearing elevation for spread footing option

Note: The walls could be on rock, in-situ soils, or new embankment.

- ♦ Any information necessary to define the design criteria for drilled shafts (allowable end-bearing and allowable side friction capacities, allowable lateral resistance, etc.)

Note: The shafts could be founded in rock, in-situ soils, or new embankment.

Ø Any other geotechnical parameter necessary for the design of the wall

Ø A plan view of the wall, sample borings, rockline soundings, rock cores, observation well data, and laboratory test results on the subsurface data sheet for all walls where a subsurface investigation is performed

2 2 2

GEOTECHNICAL

TRANSPORTATION CABINET Department of Highways Division of Materials Geotechnical Branch

Chapter

REPORT DEVELOPMENT

Subject

Maintenance

PRELIMINARY LANDSLIDE INVESTIGATIONS: The Geotechnical Branch shall prepare a report outlining possible correction methods, possible risks, and rough cost estimates after the preliminary investigation. The Geotechnical Branch may need assistance from the district and/or the appropriate divisions in developing cost estimates. The report may recommend a geotechnical investigation to examine possible alternatives. Preliminary borings may be necessary to determine whether a simple solution exists. An estimated cost to perform a comprehensive investigation will be included in the report.

COMPREHENSIVE LANDSLIDE INVESTIGATIONS: The Geotechnical Branch shall issue a report based upon the method chosen to correct the landslide (refer to **GT-704, Landslide or Unstable Rock Slope Meetings**). The report shall consist primarily of data, analyses, estimated quantities, and costs with recommendations resulting from the comprehensive geotechnical investigation. Plans developed as part of the report should include the following:

Ø Location map (1 inch = 2,000 feet [1:24,000]) showing project location

Ø Plan sheets indicating extent of slide correction, boring layout, locations of scarps or breaks, right-of-way limits, property owners, and locations of all known utilities

Ø Subsurface data sheet(s) including data from driller's and geologist's logs

Ø Landslide stability sheet including cross-section(s) depicting assumed existing conditions and the landslide correction

Note: The assumed rockline, failure surface, water table, etc., shall be included on the cross-section(s) (refer to **Exhibit 34**).

Ø Cross-sections of the slide correction area (usually on 25-foot or 50-foot [10-meter or 20-meter] centers) depicting the correction on each cross-section

CONT.

UNSTABLE ROCK SLOPES:

The Geotechnical Branch will be responsible for providing a report outlining the possible methods of correction, risks, and estimated costs. Plans developed as a part of this report should include the following:

- Ø Location map (1 inch = 2,000 feet [1:24,000]) showing project location
- Ø Plan sheet indicating the roadway, top of cut, any breaks or failures, right of way, property owners, and utilities
- Ø Correction methods depicted on an oblique photomosaic as a supplement to the cross-sections when necessary
- Ø Critical cut stability sections showing geotechnical data and proposed alternatives (one alternative per sheet)

2 2 2

GEOTECHNICAL	*Chapter* REPORT DEVELOPMENT
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Construction

LANDSLIDES: A report outlining possible methods of correction, risks, and cost estimates will be furnished to applicable construction personnel after completion of the preliminary or comprehensive investigation, whichever applies.

ROCK CUT REVISIONS: A report outlining possible methods of correction, revisions to slopes, risks, and items to be considered in development of cost estimates will be furnished to applicable construction personnel after completion of the inspection or a completed investigation, whichever applies.

EXCESS MATERIAL SITES: The Geotechnical Branch will prepare a memo to the applicable construction personnel after reviewing the contractor's proposed excess material site design. The Geotechnical Branch shall concur with the proposal as presented or recommend changes and/or additions.

SUBGRADE STABILIZATION: The Geotechnical Branch will prepare a report to applicable construction personnel with recommendations for subgrade stabilization. The recommendations shall address the type of additive, percent of additive, length of treatment, and depth of treatment.

FIELD INSTRUMENTATION: The Geotechnical Branch will maintain a file of all field instrumentation data (settlement, piezometer and inclinometer readings).

2 2 2

GEOTECHNICAL	*Chapter* REPORT DEVELOPMENT
	Subject Permits

UTILITIES: The report for utility encroachment permits shall describe the geology and known subsurface hazards in the area. Recommendations and/or comments shall address construction practices, hazards to roadway facilities, mitigation measures, risk to the traveling public, etc. The Geotechnical Branch may recommend that the party requesting the permit provide additional information or conduct a geotechnical investigation prior to permit approval.

MINING: The report for mining encroachment permits shall describe the geology, mining method, and any subsidence in the area. Recommendations shall address size of openings and pillars, number of crossings, maximum subsidence potential, draw angle, angle of crossing to highway, risk to the traveling public, and subsidence mitigation measures.

2 2 2

GEOTECHNICAL

GEOTECHNICAL	*Chapter* REPORT DEVELOPMENT
	Subject Report Distributions

REPORT SUBMISSION: For consultant-produced reports the following will be submitted to the Geotechnical Branch:

- Ø Three paper copies of the completed report with attachments (maximum paper size of 11 inches x 17 inches)
- Ø Electronic copy of the report body and the site map, in a read-only format (that is, Adobe .pdf)
- Ø Electronic copy of the drawings in a Microstation format and a read-only format (that is, Adobe .pdf)

REPORT DISTRIBUTIONS: The Geotechnical Branch will distribute the reports as shown below:

Planning Reports:

- Ø Division of Planning
- Ø District Branch Manager for Preconstruction
- Ø District Branch Manager for Planning
- Ø Consultant (if applicable)

Roadway Reports:

- Ø Division of Highway Design (Project Management Coordinator)
- Ø Division of Highway Design (Pavement Design)
- Ø Division of Highway Design (Plan Processing Section)
- Ø Division of Construction
- Ø District Branch Manager for Construction
- Ø District Branch Manager for Preconstruction
- Ø Kentucky Transportation Center
- Ø Design Consultant (if applicable)

Permit Reviews:

- Ø Permits Branch
- Ø Chief District Engineer

CONT.

REPORT DISTRIBUTIONS (cont.):

Construction Reports:

- Ø Division of Construction (Liaison)
- Ø District Branch Manager for Construction
- Ø Project Resident Engineer
- Ø Consultant (if applicable)

Structure Foundation Reports:

- Ø Division of Bridge Design
- Ø Division of Highway Design (Project Management Coordinator)
- Ø Division of Highway Design (Plan Processing Section)
- Ø Division of Highway Design (Pavement Design)
- Ø Division of Highway Design (Drainage Section)(if applicable)
- Ø Division of Construction
- Ø District Branch Manager for Construction
- Ø District Branch Manager for Preconstruction
- Ø District Project Manager
- Ø Design Consultant (if applicable)

Landslide and Unstable Rock Slope Reports:

- Ø Chief District Engineer
- Ø Division of Maintenance
- Ø District Branch Manager for Maintenance
- Ø District Branch Manager for Construction (if applicable)
- Ø District Branch Manager for Preconstruction (if applicable)
- Ø Division of Bridge Design (if applicable)
- Ø Division of Construction (if applicable)
- Ø Division of Highway Design (if applicable)
- Ø Office of Rural and Secondary Roads (if applicable)

2 2 2

GEOTECHNICAL

GEOTECHNICAL	*Chapter* CONSULTANT SERVICES
	Subject Introduction

OVERVIEW: This chapter addresses the various methods by which the department retains the services of geotechnical consulting engineers, including:

- Prequalifications
- Types of services provided
- Scope of work
- Payment structures
- Compensation to consultants

POLICY FOR GEOTECHNICAL CONSULTANTS: The department may retain prequalified geotechnical consultants to provide geotechnical drilling, engineering, or laboratory testing services. **GT-901** discusses the Policy for Geotechnical Consultants.

PREQUALIFICATION: The following subjects pertain to prequalification:

GT-902-1	General Requirements
GT-902-2	Geotechnical Drilling Services
GT-902-3	Geotechnical Engineering Services
GT-902-4	Geotechnical Laboratory Testing Services

AGREEMENT TYPES: Agreements for services provided by geotechnical consulting engineers and drilling firms may be one of the following:

- Agreement for Design Engineering Services with Provisions for Geotechnical Services

GT-903-1	Prenegotiation Conference
GT-903-2	Consultant Invoice
GT-903-3	Compensation

- Agreement for Statewide Geotechnical Engineering and Laboratory Testing Services

GT-904-1	Announcement for Engineering Services
GT-904-2	General Specifications
GT-904-3	Explanation for Tabulation of Quantities for Invoices

CONT.

AGREEMENT TYPES (cont.):

- Agreement for Statewide Geotechnical Drilling Services

GT-905-1	Regions
GT-905-2	Vendor Acceptance of Project
GT-905-3	General Specifications

PERFORMANCE EVALUATION:

GT-906 discusses the procedure for evaluating geotechnical consultants.

2 2 2

GEOTECHNICAL	Chapter: CONSULTANT SERVICES Subject: Policy for Geotechnical Consultants

SUBCONTRACTING: Services performed by consulting engineers shall be in accordance with the engineering agreement for the particular project. All work under an agreement shall at all times be subject to the general supervision and direction of the engineer and shall be subject to his or her review and approval. The term *engineer* shall mean and include the State Highway Engineer or an authorized representative. Work can be subcontracted only to prequalified vendors or firms (unless in areas not covered by prequalification), and then only with prior approval from the department.

Geotechnical consultants are responsible for monitoring services performed by their subconsultants to the same extent that they monitor their own services and for ensuring that all services performed conform to Cabinet policies and project-specific requirements.

POLICY & PROCEDURE: The policy and procedures for geotechnical investigation as set forth in this manual will be followed by geotechnical consulting engineers unless otherwise instructed by contract or written instructions signed by an authorized representative of the department. Even though a paragraph may not be addressed directly to a consultant, the instructions still apply.

2 2 2

GEOTECHNICAL

Section

PREQUALIFICATION

Subject

General Requirements

OVERVIEW: Departmental policy requires all geotechnical engineering firms that desire to be considered for work with the Transportation Cabinet be prequalified in accordance with **Chapter 15-03** of the *Professional Services Guidance Manual*. Consultants may be prequalified to perform one or more of the following geotechnical services:

- Ø Drilling
- Ø Engineering
- Ø Laboratory testing

Firms must be prequalified with the Cabinet at the time they respond to an announcement.

FORMS: In order to apply for prequalification, the firm must submit the applicable forms, listed below, which may be obtained from the Division of Professional Services:

- Ø TC 64-540, *Prequalification Requirements for Geotechnical Drilling Services* **(Exhibit 51)**
- Ø TC 64-541, *Prequalification Requirements for Geotechnical Engineering Services* **(Exhibit 52)**
- Ø TC 64-542, *Prequalification Requirements for Geotechnical Laboratory Testing Services* **(Exhibit 53)**

SUBMITTALS: Firms are required to provide their submittals to the Division of Professional Services. In addition to the forms above, firms are to submit any other forms required by the Division of Professional Services.

The department requires prequalified firms to submit updated qualifications and performance data annually or they will be removed from the prequalified list. Firms must advise the department within 30 days of any changes in the firm's status that affect the type of work and capacity of the firm.

2 2 2

# GEOTECHNICAL	*Section* PREQUALIFICATION
	Subject Geotechnical Drilling Services

REQUIREMENTS: This section presents prequalification requirements relating to Geotechnical Drilling Services. Firms must submit the TC 64-540 form, *Prequalification Requirements for Geotechnical Drilling Services* **(Exhibit 51)**, to the Division of Professional Services to document that they meet these requirements.

EXPERIENCE: The vendor must provide evidence of experience in the last five years performing drilling services for highway projects (roadways and bridges). The evidence shall include a listing of:

- Projects illustrating this type of experience
- References (agency, project engineer, or consultant) with addresses and phone numbers

EQUIPMENT: The vendor must provide a list of available equipment (drill rigs and accessories) for soil sampling and rock coring. The vendor must have at least one drill rig equipped with an automatic hammer in order to be prequalified.

PERSONNEL: Drill crew supervisors must be experienced in the following:

- Obtaining rock cores for rock cut slope and bridge foundation design
- Performing a soil profile
- Performing rock line soundings
- Performing standard penetration tests
- Obtaining thin-walled tube samples
- Installing cased observation wells

Evidence must be provided that the drill crew supervisors have a minimum of three years' experience in the above-mentioned operations for highway projects (roadways and bridges). A drill crew supervisor is defined as the person on the drill crew field party who is responsible for the drilling operations mentioned above.

INSURANCE: Vendors must have Workers' Compensation and Liability Insurance as required by the Division of Professional Services.

2 2 2

GEOTECHNICAL	*Section* PREQUALIFICATION
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Geotechnical Engineering Services

GENERAL REQUIREMENTS: Firms must submit the TC 64-541 form, *Prequalification Requirements for Geotechnical Engineering Services* **(Exhibit 52)**, to the Division of Professional Services to document that they meet the requirements of having:

- Ø A firm permit issued by the Kentucky Board of Licensure for Professional Engineers and Land Surveyors
- Ø Sufficient geotechnical engineering experience as demonstrated by having performed geotechnical engineering on a minimum of three transportation projects (or other projects where related engineering tasks were performed) in the last five years
- Ø MicroStation CADD software

PERSONNEL REQUIREMENTS: The firm must have personnel meeting the following requirements:

- Ø At least one professional engineer licensed in Kentucky with a minimum of three years of geotechnical engineering experience applicable to the design and/or construction of highway facilities (demonstrated by performing tasks included on Page 3 of the TC 64-541 form). The firm will be required to assign at least one person meeting these requirements to actively participate in KYTC geotechnical projects in the capacity of project manager, project engineer, etc.
- Ø At least one professional geologist licensed in Kentucky with a minimum of three years of engineering geology experience applicable to the design and/or construction of highway facilities (demonstrated by performing tasks included on Page 3 of the TC 64-541 form).

CONT.

PERSONNEL REQUIREMENTS (cont.):

- Staff with sufficient experience to perform geotechnical engineering tasks for KYTC, as demonstrated by experience in a minimum of 9 of the 12 areas of "conventional" experience included on Page 3 of the TC 64-541 form. (Seismic experience is not required.)
- A minimum of one CADD operator proficient with MicroStation.

2 2 2

GEOTECHNICAL	*Section* PREQUALIFICATION
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Geotechnical Laboratory Testing Services

GENERAL REQUIREMENTS: Firms must submit the TC 64-542 form, *Prequalification Requirements for Geotechnical Laboratory Testing Services* **(Exhibit 53)** to the Division of Professional Services to document that they meet these requirements.

ACCREDITATION: Accreditation by the AASHTO Materials Reference Laboratory (AMRL) is required for the following AASHTO Test Methods:

- a T87
- a T88
- a T89
- a T90
- a T99
- a T100
- a T193
- a T208
- a T265

The Geotechnical Branch will verify accreditation on the AMRL Web site during the prequalification review.

PERSONNEL: Management and staff are to meet the requirements for AASHTO R18 accreditation and have experience performing all the above-referenced tests.

LOADING DEVICE: Vendors are required to have a loading device with a movable head or base such that it is capable of applying a compressive load up to 60,000 pounds (267 kilonewtons), as required for the compaction portion of **KM 64-501** (Kentucky Method for performing the California Bearing Ratio Test).

CONT.

ADDITIONAL TEST METHODS:

In addition to the above-referenced test methods, the Geotechnical Branch considers the following to be highly desirable:

- Ø AMRL accreditation for the following tests:
  - a T216
  - a T296
  - a T297
- Ø Capability to perform the following tests:
  - a Unconfined Compressive Strength of Rock
  - a Slake Durability
  - a Jar Slake

Although these tests are not required for prequalification, the Geotechnical Branch strongly recommends that labs be accredited for and/or have the ability to perform these tests.

ADDITIONAL DOCUMENTS:

Although the Geotechnical Branch does not always require that additional documents be submitted for prequalification, the vendor is to be prepared to provide such documents upon request. Accreditation documents that may be requested include:

- Ø *Quality Manual*
- Ø On-Site Assessment Reports
- Ø Proficiency Sample Test Results
- Ø Other applicable documentation

2 2 2

GEOTECHNICAL

Section	
AGREEMENT FOR DESIGN ENGINEERING WITH PROVISIONS FOR GEOTECHNICAL SERVICES	

Subject

Prenegotiation Conference

PURPOSE: A prenegotiation conference with representatives of the design and geotechnical consulting engineering firms may be held when deemed necessary by the Geotechnical Branch. The design engineering firm's agreement may include geotechnical services or it may be added by contract modification. The purpose of this conference shall be to review the following:

- Scope of the project
- Estimated unit items of work
- Scheduling requirements
- Pertinent procedures

SCHEDULING: The geotechnical consultant shall contact the Geotechnical Branch to schedule a conference. Preferably, the conference shall be held in the appropriate district office or at a location near the project. Invited to this meeting will be representatives of:

- Geotechnical consultant
- Division of Highway Design
- District Design Office
- Geotechnical Branch
- Design consultant

PLANS, PROFILES, & CROSS-SECTIONS: The geotechnical consultant shall be provided with copies of all available plans, profiles, and cross-sections prior to the meeting. The geotechnical consultant shall use this information to develop estimated unit items of work, which will be reviewed and revised during the meeting.

COST ESTIMATE SUBMITTAL: The consultant shall complete the TC 64-521 form, *Unit Cost Items for Geotechnical Services* **(Exhibit 54),** using the unit items of work developed during the prenegotiation conference, and submit it with supportive calculations to the design engineering consultant and the Geotechnical Branch. The Geotechnical Branch will review the submittal and provide comments to the Division of Professional Services for negotiation purposes.

2 2 2

GEOTECHNICAL	Section: AGREEMENT FOR DESIGN ENGINEERING WITH PROVISIONS FOR GEOTECHNICAL SERVICES
Transportation Cabinet, Department of Highways, Division of Materials, Geotechnical Branch	Subject: Consultant Invoice

SUBMITTALS: Invoices for geotechnical investigations that are included in the *Agreement for Design Engineering Services* shall be submitted directly to the Geotechnical Branch.

ITEMS REQUIRED FOR INVOICE SUBMITTAL: The following information shall be submitted with each invoice:

- TC 64-521 form, *Unit Cost Items for Geotechnical Services* **(Exhibit 54)**
- TC 64-525 form, *Tabulation of Quantities for Invoices* **(Exhibit 55)**

The location (station, offset, and hole numbers), sheet totals, invoice totals, and accumulated totals for all invoices shall be shown for all items where applicable. Each drafting sheet shall also be listed by station on this form.

- Invoices that have been signed and assigned an invoice number
- Typed drilling logs, laboratory test data, embankment and cut slope stability sheets, soil profile sheets, subsurface data sheets, and foundation and/or structure analyses
- Documentation of time records for the bulldozer and/or trackhoe working time or an invoice of subcontracted bulldozer and/or trackhoe working time
- Documentation of time records for the working time of a company-owned barge or the invoice of a subcontracted towboat and/or barge
- Documentation of time records for traffic-control working time or an invoice of working time from a subcontracted traffic control firm

CONT.

VERIFICATION: Sufficient information shall be submitted with the invoice to verify the quantities prior to payment. Failure to follow these instructions will delay approval of the invoice. If the invoice is unsatisfactory, the geotechnical consultant shall be notified. In order to expedite the invoice, unit items in question may be omitted and will be reconsidered if the questions are resolved. A memo and a copy of the approved TC 64-521 form, *Unit Cost Items for Geotechnical Services* **(Exhibit 54),** will be submitted to the department's design engineer responsible for approving the consultant's invoice. Copies will also be submitted to the design and geotechnical engineering consultant, when applicable.

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GEOTECHNICAL	*Section* AGREEMENT FOR DESIGN ENGINEERING WITH PROVISIONS FOR GEOTECHNICAL SERVICES
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	*Subject* Compensation

METHOD OF PAYMENT: The method of payment shall be based on cost per unit of work or lump sum. Each unit of work or lump sum item is included on the TC 64-521 form, *Unit Cost Items for Geotechnical Services* (**Exhibit 54**). Unless otherwise specified, the price per unit of work or lump sum item shall include all engineering, labor, personnel, equipment, materials, etc., necessary to complete that unit of work. Failure to follow the procedures as stated in this manual will result in nonpayment of the unit price item.

UTILITY & RIGHT OF ENTRY: Compensation for obtaining utility locations and right of entry from property owners shall be included in the following units of work for drilling operations.

DRILLING PRICES: The ceiling price (maximum allowable unit price) for drilling items on land shall be calculated using the average of accepted bids within one standard deviation plus 15 percent from the Statewide Geotechnical Drilling Services Agreements for the applicable region. Drilling items on floating equipment shall be calculated using the average of accepted bids on land within one standard deviation plus 50 percent. These ceiling prices for drilling items will be provided to the vendor on negotiated agreements.

Note: Drilling operations on property of the railroad, Forest Service, Corps of Engineers, etc., may require additional time and effort. Any required costs or fees (i.e., flagmen) shall be invoiced as charged. Also, an administrative fee will be allowed for the time of dealing with these entities as specified in the Statewide Geotechnical Drilling Services Agreements.

LABORATORY TESTING: Production rates (maximum unit hours) for laboratory testing items have been established and are specified in the announcement to bid for Statewide Geotechnical Engineering and Laboratory Testing Services.

ENGINEERING ANALYSIS: The ceiling rates (maximum allowable hours) for engineering analysis items have been established and can be found in the announcement to bid for the Statewide Geotechnical Engineering and Laboratory Testing Services Agreements.

CONT.

ENGINEERING ANALYSIS (cont.):

1. **Rock Coring** will be paid at a unit price per vertical foot for English unit projects (or per vertical meter for metric unit projects) from the top of the rock core to the bottom of the rock core. Drilling and sampling in the overburden as specified by the department will be paid at the contract unit price for:

   - Standard penetration tests
   - Thin-walled tube samples
   - Soil borings
   - Rock soundings

2. **Rock Coring on Floating Equipment** shall be paid as specified in Item 1, Rock Coring. Compensation for drilling through water (from the water surface elevation down to the top of soil or rock) shall be paid at 50 percent of the established unit price for rock sounding on floating equipment.

3. **Rock Sounding** shall be paid from the top of ground to the bottom of the hole or a change in drilling operations at a unit price per vertical foot for English unit projects (or per vertical meter for metric unit projects).

4. **Rock Sounding on Floating Equipment** shall be paid as specified in Item 3, Rock Sounding. Compensation for drilling through water (from the water surface elevation down to the top of soil or rock) shall be paid at 50 percent of the established unit price for rock sounding on floating equipment.

5. **Visual Inspection and Logging of Rock Exposure** shall be paid from the top to the bottom of the rock exposure at a unit price per vertical foot for English unit projects (or per vertical meter for metric unit projects. Task shall include the cost of a geologist and laborer based on an eight-hour day plus expenses, equipment, and travel time.

6. **Disturbed Soil Borings** shall be paid from the top of ground to the bottom of the hole at a unit price per foot for English unit projects (or per meter for metric unit projects).

7. **Bag Samples** shall be paid at a unit price per sample.

CONT.

ENGINEERING ANALYSIS (cont.):

8. **Standard Penetration Tests** shall be paid at the unit price per test. If more than one standard penetration test or thin-walled tube sample is necessary per 5-foot (1.5-meter) interval, each extra test or tube will be paid at one-half the contract unit price per test or tube. The unit price per test includes all drilling to advance the hole to the required depth. Payment depth intervals are from 0 to 5 feet, 5 to 10 feet, 10 to 15 feet, (0 to 1.5 meters, 1.5 to 3 meters, 3 to 4.5 meters) etc. The depth of the top of the test will be used to determine the payment interval of the test. If continuous sampling is requested for a boring, the tests will be paid at the unit price per each standard penetration test.

9. **Standard Penetration Tests on Floating Equipment** shall be paid as specified in Item 8, Standard Penetration Tests. Compensation for drilling through water (from the water surface elevation down to the top of soil or rock) shall be paid at 50 percent of the established unit price for rock sounding on floating equipment.

10. **Thin-Walled Tube Samples** shall be paid at a unit price per tube. If more than one thin-walled tube sample or standard penetration test is necessary per 5-foot (1.5-meter) interval, each extra tube or test will be paid at one-half the contract unit price per tube or test. The unit price per tube includes all drilling to advance the hole to the required depth. Payment depth intervals are from 0 to 5 feet, 5 to 10 feet, 10 to 15 feet, (0 to 1.5 meters, 1.5 to 3 meters, 3 to 4.5 meters) etc. The depth of the top of the tube will be used to determine the payment interval of the tube. If continuous sampling is requested for a boring, the samples will be paid at the unit price per each thin-walled tube.

11. **Thin-Walled Tube Samples on Floating Equipment** shall be paid as specified in Item 10, Thin-Walled Tube Samples. Compensation for drilling through water (from the water surface elevation down to the top of soil or rock) shall be paid at 50 percent of the established unit price for rock sounding on floating equipment.

12. **Field Vane Shear Tests** shall be paid at a unit price per test. The unit price includes all drilling and equipment necessary per 5-foot interval.

13. **Field Vane Shear Tests on Floating Equipment** shall be paid as specified in Item 12, Field Vane Shear Tests. Compensation for drilling through water (from the water surface elevation down to the top of soil or rock) shall be paid at 50 percent of the established unit price for rock sounding on floating equipment.

CONT.

ENGINEERING ANALYSIS (cont.):

14. **Cased Observation Wells** shall be paid at a unit price per well. The unit price does not include drilling. Drilling and/or sampling shall be paid at the contract unit price for standard penetration tests, thin-walled tube samples, soil borings, or rock soundings as specified by the department. The unit price includes a water table reading obtained no sooner than seven days after installation of the well.

15. **Slope Inclinometer Casing Holes** shall be paid at a unit price per foot for English unit projects (or per meter for metric unit projects) for drilling the hole. The drilling includes costs for hollow stem augers, drill casing, and/or roller bits and shall include cost of "down time" for a drill and drill crew while the department or consultant installs the slope inclinometer casing. The department will furnish the slope inclinometer casing. An open hole (minimum 6-inch [150-millimeter] diameter) shall be maintained by casing or hollow stem augers until the slope inclinometer casing is installed. Payment interval is from the top to the bottom of the 6-inch (150-millimeter) diameter hole. Samples and/or rock cores requested by the department will be paid for at contract prices, and they are in addition to the price of the slope inclinometer casing hole.

16. **Pavement Cores** shall be paid at a unit price per foot for English unit projects (or per meter for metric unit projects). Unit bid price covers all diameter-size samples (4-inch, 6-inch, 8-inch, and 10-inch). The price shall include back-filling the hole with asphalt or concrete.

17. **Grouting of Six-Inch Auger Holes** shall be paid at a unit bid price per foot for English projects (or unit bid price per meter for metric unit projects). Unit bid price includes all labor and materials necessary to seal the hole.

18. **Grouting of Four-Inch Auger Holes** shall be paid at a unit bid price per foot for English projects (or unit bid price per meter for metric unit projects). Unit bid price includes all labor and materials necessary to seal the hole.

19. **Grouting of Rock Core** shall be paid at a unit bid price per foot for English projects (or unit bid price per meter for metric unit projects). Unit bid price includes all labor and materials necessary to seal the hole.

20. **Moisture Content Sample** shall be paid at a unit price per sample. The price shall include all operations and materials necessary to obtain the sample.

CONT.

ENGINEERING ANALYSIS (cont.):

21. **Moisture Content Tests** shall be paid at a unit price per test. The price shall include all operations and materials necessary to perform the test. Cost for obtaining the sample shall be reimbursed as stated in Item 20. Moisture contents required for other tests such as unconfined compression, etc., will be reimbursed under those test costs and will not be paid under this item.

22. **Logging Rock Cores** shall be paid at a unit price per foot for English projects (or unit bid price per meter for metric unit projects). Task shall include the costs of a geologist based on an eight-hour day (no payment if an engineer or geologist is assigned to the field during drilling operations).

23. **Soil Classifications** shall be paid at a unit price per sample. The following will be required on each sample:

    - Ø Gradation
    - Ø Specific Gravity
    - Ø Atterberg Limits
    - Ø Liquidity Index
    - Ø Activity Index
    - Ø AASHTO Classification
    - Ø Unified Classification

24. **Wash and Sieve Analyses** shall be paid at a unit price per test. This item applies when adequate material was not available to perform a full soil classification or the sample material is nonplastic. Samples classified in accordance with **GT-505** shall be paid for under Item 23, Soil Classifications, and shall not also receive payment under this item.

25. **Moisture/Density Test, CBRs, and Soil Classifications** (as previously specified) shall be paid at a unit price per sample.

26. **Moisture/Density Test** shall be paid at unit price per sample as necessary to determine a moisture density curve.

27. **Slake Durability Index and Jar Slake Tests** shall be paid at a unit price per test. The unit price includes performing both a Jar Slake and a Slake Durability Index test on each sample.

28. **Unconfined Compression Tests on Soil** shall be paid at a unit price per test.

29. **Unconfined Compression Tests on Rock** shall be paid at a unit price per test.

CONT.

ENGINEERING ANALYSIS (cont.):

30. **One-Dimensional Consolidation Tests** shall be paid at a unit price per test.

31. **Consolidated-Undrained Triaxial Tests with Pore Pressure Measurements** shall be paid at a unit price per test.

32. **Unconsolidated-Undrained Triaxial Tests** shall be paid at a unit price per test.

33. **Slope Stability Analyses** shall be paid at a unit price per stability section. This shall be in addition to drafting at the unit price per sheet.

34. **Settlement Analyses** shall be paid at a unit price per analysis. Each analysis shall include, if applicable, the following for a particular subsurface profile in question:

    Ø Ultimate settlements, differential settlements, and rate of settlement calculations for:
    - a A given embankment profile
    - a Embankment cross-section
    - a Approach embankment
    - a Substructure unit
    - a Culvert
    - a Retaining wall

    Ø Calculations for ultimate settlement at different locations along the profile or cross-section for the purpose of defining differential settlements

    Ø All calculations necessary to adjust the footing size for spread footings

    Analyses may be presented in the form of a drawing showing the embankment, footing, or retaining wall as well as the soil layers, parameters, and calculations. All necessary drafting will be paid at the contract unit price per sheet. Wick drain analyses, if applicable, shall be paid at the unit price for settlement analysis in addition to the initial settlement analysis.

CONT.

ENGINEERING ANALYSIS (cont.):

35. **Deep Foundation Analyses** shall be paid at a unit price per static analysis. Each static analysis shall include calculations for all applicable sizes and/or types of piles or shafts, for a particular subsurface profile in question. It may represent one or more bents depending on the variability of subsurface conditions, etc. Static analyses performed for evaluation of driveability or wave equation analysis shall be paid as a separate analyses from that for design pile capacity. Drilled shaft analyses in soil or rock will be paid for under this item and shall be paid for as separate analyses from that for piles. Recommendations for H-piles driven to rock will not be paid for under this item, but any static analyses necessary for evaluating driveability (wave equation analyses) of H-piles to rock will be paid for under this item. Conclusions from analyses shall be presented in the form of a table depicting allowable capacity (with appropriate factors of safety applied) as a function of pile/shaft tip elevation and size.

36. **Wave Equation Driveability Analyses** shall be paid at a unit price per analysis. Each analysis shall include calculations for several different sizes of pile hammers and for several sizes and/or types of piles driven into a particular soil profile. Static analyses required for evaluation of driveability shall be paid for at the contract unit price for deep foundation analyses.

37. **Negative Skin Friction Analyses** shall be paid at a unit price per analysis. The analysis shall include all pile sizes and/or types that might be selected. It should also indicate, if applicable, the amount of negative skin friction remaining after a waiting period or after the use of sleeves, bitumen coating, etc. The analysis shall be presented in the form of a table indicating the magnitude of negative skin friction on each pile size and/or type at various spacings.

38. **Bearing Capacity Analyses** for spread footings on soil shall be paid at a unit price per analysis. Each analysis shall include calculations for all sizes considered and may represent one or more abutments or piers (or culverts) depending on the variability of soil conditions, etc. Analyses shall be presented in the form of a calculation sheet showing safety factor calculations for the recommended footing. Bearing capacity determinations for retaining walls shall be included in the unit price for retaining wall analyses.

CONT.

ENGINEERING ANALYSIS (cont.):

39. **Retaining Wall Analyses** shall be paid at a unit cost per wall stability section. Retaining wall analyses shall include all pressure calculations and overturning, sliding, and bearing capacity safety factor determinations sufficient to size the wall and recommendations regarding granular backfill, foundation modification, etc. Analyses of additional wall sections, if approved by the Geotechnical Branch, shall be paid for as separate analyses. Settlement and slope stability analyses required for a retaining wall shall be paid for at the contract unit price for those items. The consultant shall prepare a drawing of each wall stability section on a standard size plan sheet. This drawing will show boring logs, test results, layer boundaries, and soil parameters, along with safety factors. As many sections as practical shall be placed on each sheet. All necessary drafting will be paid at the contract unit price per sheet.

40. **Drafting** for sheets to be included in the roadway and/or structure plans shall be paid at a unit price per sheet.

41. **Dozer Working Time (John Deere 450 or equivalent), Including Operator,** shall be paid at a unit price per hour of actual dozer working time at the job site.

42. **Trackhoe Working Time, Including Operator,** shall be paid at a unit price per hour of actual trackhoe working time at the job site.

43. **Mobilization (including demobilization) of Drill Equipment** to (and from) the project site shall be paid at a lump sum price per drill. This lump sum price shall include all equipment necessary to perform drilling operations <u>except dozer, trackhoe, and floating equipment.</u> This task shall be paid as follows: an administrative fee plus a set per-mile dollar amount (to be established by the Geotechnical Branch at the start of each contract fiscal year) as specified in the Statewide Drilling Contracts. Mileage shall be calculated from the company's nearest drilling equipment facility using the state mileage map and is not to exceed a maximum of 500 miles (round trip). The consultant must have written permission from the Geotechnical Branch prior to mobilization of each drill in order to authorize payment.

44. **Mobilization (including demobilization) Costs for a Subcontracted Dozer or Trackhoe and Operator** shall be paid at the hourly rate for a total of two hours for each project.

CONT.

ENGINEERING ANALYSIS (cont.):

45. **Mobilization (including demobilization) Costs for a Company-Owned Dozer or Trackhoe and Operator** shall be paid at a lump sum price per dozer or trackhoe. This lump sum price shall include all equipment necessary to perform required operations. This task shall be paid as follows: an administrative fee plus a set per-mile dollar amount (to be established by the Geotechnical Branch at the start of each contract fiscal year) as specified in the Statewide Drilling Contracts. Mileage shall be calculated from the company's nearest drilling equipment facility using the state mileage map and is not to exceed a maximum of 500 miles (round trip). The consultant must have written permission from the Geotechnical Branch prior to mobilization of each dozer or trackhoe in order to authorize payment.

46. **Mobilization (including demobilization) Costs for Company-Owned Floating Equipment** shall be paid at a lump sum price per "floating plant." This lump sum price shall include all equipment necessary to provide a mobile working platform for the drill and its crew. The consultant must have written permission from the Geotechnical Branch prior to mobilization of each "floating plant" in order to authorize payment.

47. **Subcontracted Towboat and/or Barge and Crew** shall be paid for at cost (include invoiced billing[s]). Time shall not be included for drill or drill crew. Cost of floating equipment shall include mobilization and demobilization, insurance, layover time, and working time for all equipment and personnel necessary to provide a working platform for the geotechnical drill and crew. An administrative fee (to be established by the Geotechnical Branch at the start of each contract fiscal year) shall be allowed to cover communications with the towboat/barge contractor and all necessary coordination, permits, etc., required with the Corps of Engineers and/or others.

48. **Company-Owned Towboat and/or Barge and Its Crew** shall be paid at a unit price per working day at the job site. This price shall include insurance, layover time, and working time for all equipment and personnel necessary to provide a working platform for the drill and crew. An administrative fee (to be established by the Geotechnical Branch at the start of each contract fiscal year) shall be allowed to cover all necessary coordination, permits, etc.,required with the Corps of Engineers and/or others.

49. **Reclamation** of disturbed sites by drilling operations shall be paid at a daily (eight-hour) rate for two laborers including expenses, equipment, and travel time plus the cost of materials as listed below in Item 50. Any other materials are incidental. Reclamation activity includes all labor and equipment required to reclaim the site.

CONT.

ENGINEERING ANALYSIS (cont.):

50. **Reclamation Materials** are paid for at actual cost (with receipts for materials) plus 10 percent markup to account for any overhead or administrative expenses. These materials include:

    - Ø Seed
    - Ø Straw
    - Ø Rock (crushed aggregate #57)

    The following materials or others may also be used when necessary but require written approval from the department. Materials are paid for at actual cost plus 10 percent (with receipts for materials).

    - Ø Temporary silt fence
    - Ø Bagged topsoil
    - Ø Sheets of plywood
    - Ø Pipe

51. **Traffic Control (in-house)** requires that personnel meet all applicable rules and regulations and shall be paid at a daily (eight-hour) rate/price for two laborers, including expenses, equipment, and travel time.

52. **Traffic Control (subcontracted)** shall be paid as invoiced by the vendor, plus an administrative fee of 10 percent to account for any overhead or administrative expenses.

53. **Preliminary Plans** preparation shall be paid at a lump sum price. This price shall include preliminary exploration, laboratory testing, and engineering analysis plans for all roadways and structures.

54. **Preliminary Meetings** attendance shall be paid at a lump sum price. This price shall include all meetings with the department, both field and office, necessary to review and discuss the boring plan for all roadways and structures.

55. **Rock Core Meetings** attendance shall be paid at a unit price per meeting. This price shall include all meetings with the department, both field and office, necessary to design, review, and discuss cut slopes for roadways or review rock cores for structure foundations.

56. **Interim Meetings** attendance shall be paid at a unit price per meeting. The unit price shall include all items and personnel to conduct the meeting.

57. **Final Meetings** attendance shall be paid at a lump sum price. This price shall include any meetings with the department necessary to review and discuss the subsurface investigation and recommendations for the design of structures and roadways.

CONT.

ENGINEERING ANALYSIS (cont.):

58. **Report Writing** shall be paid at a lump sum price. The price shall include all items not included in other units or work that are necessary for preparing recommendations (design, construction, rock slope, etc.), reports (draft, interim, final, etc.), letters, correspondence, etc., for roadways and structures. This item shall also include all work necessary for project coordination and project team interaction not covered under items for "Meetings."

59. **Publication** of geotechnical engineering reports for roadway shall be paid at a lump sum price.

Note: All aforementioned unit descriptions of service pay items apply to most projects; however, there may be exceptions, and those will be handled on a project-by-project basis.

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GEOTECHNICAL

Section

AGREEMENT FOR STATEWIDE GEOTECHNICAL ENGINEERING & LABORATORY TESTING SERVICES

Subject

Announcement for Engineering Services

OVERVIEW: The department may select firms for statewide geotechnical engineering and laboratory testing services in accordance with **Chapter 4** of the *Professional Services Guidance Manual*. Firms responding to announcements for statewide geotechnical engineering and laboratory testing services are evaluated by a consultant selection committee. Normally, up to four firms are selected for the department to negotiate with for their services. These services consist of geotechnical engineering and laboratory testing.

ANNOUNCEMENT FOR ENGINEERING SERVICES: Pursuant to Kentucky Revised Statute (KRS) 45A.205, a public announcement will be made that the Transportation Cabinet intends to contract for engineering services.

SCOPE OF WORK: Consultant agreements will be negotiated to provide complete geotechnical engineering and laboratory testing services on a statewide basis. These services may include:

- Conventional geotechnical engineering analyses
- Seismic geotechnical engineering analyses
- Drafting
- Preliminary exploration plans
- Attending meetings
- Logging rock cores
- Designing rock cut slopes
- Writing geotechnical reports
- Geotechnical laboratory testing
- Rural roadway design and surveying

A prequalified subconsultant may be used to perform roadway design and surveying. The work cannot be subcontracted without prior written approval from the Division of Professional Services and the Geotechnical Branch. In addition, special engineering services may be required, depending on the department's needs. The contract period is one year with the option of extending the period for an additional year.

CONT.

EVALUATION FACTORS: The evaluation factors are as follows:

- Ø Project approach and proposed procedures to accomplish the services for the project
- Ø Relative experience of consultant personnel assigned to project team with highway projects for KYTC and/or for federal, local, or other state governmental agencies
- Ø Capacity to comply with project schedule
- Ø Past record of performance on project of similar type and complexity
- Ø Consultant offices in Kentucky where work is to be performed

SUBMITTALS: Engineering firms that are prequalified for Geotechnical Engineering and Geotechnical Laboratory Testing and desire to provide these statewide services should submit seven copies (or the number specified in the advertisement) of the TC 40-15 form*, Response for Engineering/Related Services as Prime Consultant*, to the Kentucky Transportation Cabinet, Division of Professional Services, Frankfort, Kentucky 40622, by the time and date specified in the announcement.

PREQUALIFICATION SUBMITTALS Firms must be prequalified with the Cabinet at the time they respond to the announcement. In order to apply for prequalification, the firm must submit the following forms:

- Ø TC 64-541 form, *Prequalification Requirements for Geotechnical Engineering Services* **(Exhibit 52)**
- Ø TC 64-542 form, *Prequalification Requirements for Geotechnical Laboratory Testing Services* **(Exhibit 53)**

PROFESSIONAL LIABILITY INSURANCE: Firms must provide proof of $1 million of professional liability insurance in order to receive a statewide geotechnical engineering and laboratory testing contract.

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# GEOTECHNICAL	*Section* AGREEMENT FOR STATEWIDE GEOTECHNICAL ENGINEERING & LABORATORY TESTING SERVICES
	Subject General Specifications

SPECIFICATIONS: The general specifications for Statewide Geotechnical Engineering Services are as follows:

SUBCONTRACTING: The work cannot be subcontracted without prior written approval from the Division of Professional Services and the Geotechnical Branch. The work can be subcontracted only to a prequalified vendor.

PROJECT INITIATION: Geotechnical work shall begin on a project within 10 calendar days after the consultant accepts the work unless otherwise noted.

GEOTECHNICAL MANUAL Geotechnical analyses, recommendations, lab testing reports, drafting, and engineering reports shall be in general conformance with the *Geotechnical Manual,* unless differences are agreeable to the Geotechnical Branch and the consultant.

COMPLETION DATE: A time or date of completion will be established for each project.

TERM: The agreement is effective for one year, and the expiration date may be extended for up to one additional year if agreeable to the department and the firm.

PAYMENT STRUCTURE: Payment for engineering and laboratory testing services will be based on the current audited hourly average rates, including overhead and applicable escalation factors, for the personnel classifications approved by the Geotechnical Branch, plus 10 percent. The production rates (hours per unit of work) will be specified in the Announcement for Statewide Geotechnical Engineering and Laboratory Testing Services.

- For engineering services, the department will pay the actual hours worked, up to the specified ceiling rates (maximum allowable hours). Time records will be required.
- For laboratory testing services, the department will pay the specified production rates per test. Time records will not be required.

CONT.

PAYMENT STRUCTURE (cont.): The department will reimburse expenses at the actual cost (with receipts) plus 10 percent markup.

INVOICE SUBMITTAL: Invoices for the work shall be submitted directly to the Geotechnical Branch, Division of Materials. The following requirements apply:

- Invoice shall include:
  - TC 64-527 form, *Summary of Cost Items for Statewide Geotechnical Engineering Services* **(Exhibit 59)**
  - TC 64-526 form, *Tabulation of Quantities for Cost Items for Statewide Geotechnical Engineering Services* **(Exhibit 60)**
  - Time records with task identified for hourly labor items
- Separate signed and appropriately numbered invoices and forms shall be submitted for each project.
- The invoices may be submitted monthly if desired.
- A percent of retainage will not be applicable to this contract.
- Payment for lab testing, engineering analyses, reports, and drafting will be permitted only after review and approval by the Geotechnical Branch.

ROADWAY PLANS, CROSS-SECTIONS, & DATA: The department will provide the consultant with electronic files or hard copies of roadway plans, cross-sections, and (if applicable) lab and field logs.

MONITORING: The Geotechnical Branch will monitor work under this agreement through procedures in accordance with the *Geotechnical Manual.*

PERSONNEL CLASSIFICATION: The department may specify classifications of personnel on a project-by-project basis.

OVERHEAD: Overhead rate will be determined by an external audit and as agreed by the Division of Professional Services. The overhead rate used in the negotiations will be acceptable for the invoicing until the final audit is conducted after the work has been completed. Payment may be adjusted in accordance with this final audit.

Note: Terms and conditions stated in the announcement for services will supersede terms and conditions stated herein. Terms and conditions stated in the actual agreement will supersede terms and conditions stated herein or in the announcement for services.

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GEOTECHNICAL

	Section AGREEMENT FOR STATEWIDE GEOTECHNICAL ENGINEERING & LABORATORY TESTING SERVICES
	Subject Explanation for Tabulation of Quantities for Invoices

EXPLANATION OF FORM:

The explanations listed below refer to the TC 64-526 form, *Tabulation of Quantities for Cost Items for Statewide Geotechnical Engineering Services* **(Exhibit 60).**

Note: Preliminary plans, meetings, report-writing, and publication shall include all labor costs including overhead plus 10 percent. Payment of laboratory items shall include all labor including overhead, materials, and expenses necessary to complete the tests.

- **Analysis** (Items 13 through 19) shall represent total hours for all engineering time necessary to perform and review the analysis not to exceed the ceiling production rates specified in the Statewide Geotechnical Engineering and Laboratory Testing Services advertisement. Estimating the time for each analysis to the nearest one-half hour may be necessary when working on several analyses in certain phases. The total hours shall equal the number of hours reported for payment.

- **Drafting** (Item 20) shall include hours for drafting sheets (soil profile, structures, and analyses) and review not to exceed the ceiling production rates specified in the Statewide Geotechnical Engineering and Laboratory Testing Services advertisement. Miscellaneous drafting man-hours not covered under Item 20 shall be included under the appropriate operation (preliminary plans, etc.).

- **Laboratory Testing** shall be the total number of tests times the established hourly rates necessary to perform each test, as noted in the advertisement for Statewide Geotechnical Engineering and Laboratory Testing Services.

- **Preliminary Plans** (Item 21) shall include all hours necessary to perform the operation. Hours may include draftsperson's and engineer's time necessary to prepare a preliminary set of exploration plans.

CONT.

EXPLANATION OF FORM (cont.):

- **Preliminary Meetings** (Item 22) shall include all hours necessary to prepare for and conduct a preliminary meeting.
- **Rock Core Meetings** (Item 23) shall include all hours necessary to prepare for and conduct a meeting.
- **Interim Meetings** (Item 24) shall include all hours necessary to prepare for and conduct an interim meeting.
- **Final Meetings** (Item 25) shall include all hours necessary to prepare for and conduct a final meeting.
- **Publication of Reports** (Item 27) shall include all man-hours necessary to publish a report.
- **Report Writing** (Item 26) shall incorporate all items not included in other units, including all work that is necessary for preparation of recommendations, reports, letters, correspondence, etc., for roadway and/or structure projects. This shall also include all necessary work associated with project coordination and/or project correspondence not previously covered.
- **Direct Cost** (expenses) shall be itemized as applicable.

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GEOTECHNICAL	Section: AGREEMENT FOR STATEWIDE GEOTECHNICAL DRILLING SERVICES
TRANSPORTATION CABINET Department of Highways GB Division of Materials Geotechnical Branch	Subject: Regions

POLICY: The Division of Professional Services will let and award the Agreements for Statewide Geotechnical Drilling Services.

REGIONS: The state is divided into three regions that include various highway districts. The regions' boundaries are based upon general topography and geology. (Refer to **Exhibit 56.)**

REGION	TERRAIN	DISTRICTS
I	Level	1, 2, 3, 4
II	Level to rolling	5, 6, 7, 8, 9
III	Mountainous	10, 11, 12

Prequalified firms are invited to bid on the region or regions of their choice. The Announcement for Statewide Geotechnical Drilling Services is published on the Division of Professional Services Web site. The proposal sheets with estimated units are shown in the announcement for each region.

Floor (lowest allowable) bids will be established by the Geotechnical Branch to prevent skewed bids in each region. These will be included in the announcement. Bids below these rates will be deemed unacceptable, and vendors' bids will not be accepted.

2 2 2

GEOTECHNICAL	Section AGREEMENT FOR STATEWIDE GEOTECHNICAL DRILLING SERVICES
	Subject Vendor Acceptance of Project

VENDOR ACCEPTANCE: The following policies apply to vendor acceptance of a project:

- Ø The drilling firm with the number-one agreement in each region will have the first option for all projects within that region.
- Ø If the drilling firm ranked first in any region declines a project or does not respond to an invitation to perform service within two working days from the date the department offers the project, the drilling firm with the number-two contract in that region will have the option, and so forth, until a firm is found that can begin and complete the project within the required time.
- Ø The TC 64-523 form, *Notification for Drilling Services* **(Exhibit 57),** must be signed indicating acceptance or rejection of vendor's option and returned to the Geotechnical Branch.
- Ø Failure to follow this procedure within the time limit established by the department in the *Notification of Drilling Services* constitutes rejection of vendor's option for that project.

2 2 2

GEOTECHNICAL

Section

AGREEMENT FOR STATEWIDE GEOTECHNICAL DRILLING SERVICES

Subject

General Specifications

RESPONSIBILITY OF DEPARTMENT & CONSULTANTS: Unless otherwise noted, the department will be responsible for traffic control, the boring plan, and staking of holes for the projects. If the department cannot provide traffic control, the drilling firms shall provide their own traffic control. The traffic control shall be provided by traffic control personnel (either in-house or from an outside firm) that can meet all established rules and regulations. This shall be paid as either:

- A pass-through cost (with billing receipts from the traffic control firm) plus 10 percent to account for any overhead or administrative expenses. The drilling firm must obtain written permission from the department prior to retaining a traffic control firm.
- As a daily eight-hour rate for two laborers, including expenses, equipment, and travel time. All established rules and regulations must be met.

Requests for traffic control by the department require a minimum of two days' advance notice.

The drilling firm will be responsible for obtaining all utility locations.

The drilling firm shall be responsible for obtaining right of entry from property owners; however, in cases of refusal by the owner, the drilling firm should request assistance from the department.

SUBCONTRACTING: The work cannot be subcontracted without prior written approval from the Division of Professional Services and the Geotechnical Branch. The work can be subcontracted only to a prequalified vendor.

PROJECT INITIATION: Drilling shall begin on a project within 10 calendar days from the date of notification unless otherwise agreed to by the department.

USE OF MULTIPLE CREWS: If the vendor and the department are agreeable, more than one drill crew may be utilized at the same time on larger projects. A minimum crew is considered two people, drill, and all equipment needed to perform drilling operations.

CONT.

GEOTECHNICAL MANUAL: Drilling and sampling procedures, materials, and all items necessary to complete the work shall meet the specifications as outlined in the *Geotechnical Manual* or agreements.

TIME OF COMPLETION: A time or date of completion will be established in writing for each project, and vendors are responsible for completing the scope of work on time. If the department delays drilling operations six months beyond the expiration date of the contract, the vendor is not obligated to complete the scope of work.

LENGTH OF CONTRACT: The contract is effective for one year. However, the expiration date may be extended one additional year if agreeable to the department and vendor.

METHOD OF PAYMENT Drilling unit prices will be calculated from the applicable region as established in the statewide drilling contract. Refer to **GT-902-3, Compensation,** for additional description of unit work items.

SAMPLE DELIVERY: Rock cores and samples with typed logs shall be delivered to the Geotechnical Branch in Frankfort no later than seven calendar days after the completion of the project unless otherwise specified by the Geotechnical Branch.

INVOICES: The following applies to submission of invoices:

- Invoices for the work shall be submitted directly to the Geotechnical Branch, Division of Materials.
- The invoice may be submitted monthly if desired.
- Invoices must be signed and numbered.
- Final payment will be permitted only after delivery of all cores, samples, logs, and observation well data and a field review of the project site by the Geotechnical Branch.
- The Geotechnical Branch shall be contacted by the drilling firm one week before drilling operations end. This will allow the Geotechnical Branch to review the project in the field with the consultant prior to the vendor’s departure.

CONT.

INVOICES (cont.):

- The invoices shall include the following where applicable:
  - TC 64-525 form, *Tabulation of Quantities for* Invoices **(Exhibit 55)**
  - TC 64-521 form, *Unit Cost Items for Geotechnical Services* **(Exhibit 54),** signed by authorized personnel
  - Typed subsurface logs
  - Cased observation well data
  - Summary of mobilization/demobilization, including miles (kilometers), drill rig(s), dozer, trackhoe, and dates
  - Documentation of time records for the dozer and/or trackhoe working time or an invoice of subcontracted dozer and/or trackhoe working time

WORK QUANTITIES: The department does not guarantee the amount of work that will be drilled under this contract. The unit quantities listed for the proposal are only estimates, and the department does not guarantee their accuracy. The quantities may overrun or underrun.

UNIT PRICE METHOD: Payment for labor, materials, equipment, and all items necessary to complete the work shall be made only through the contract unit price.

RESTRICTION ON RELOCATING BORINGS Hole locations cannot be moved more than five feet without prior approval from the Geotechnical Branch. Hole locations moved more than five feet without prior approval of the Geotechnical Branch are subject to be redrilled. The unapproved hole location will not be eligible for payment.

DRILL CREW SUPERVISORS: Drill crew supervisors shall be subject to the approval of the Geotechnical Branch. The company shall submit a completed “Drill Crew Supervisor Information” for each supervisor. (Refer to page 4 of the TC 64-540 form, **Exhibit 51)**

PROJECT ACCEPTANCE OR REJECTION: The TC 64-523 form, *Notification for Drilling Services* **(Exhibit 57),** must be signed indicating acceptance or rejection of the option and returned to the Geotechnical Branch within two working days from date the department offers the project to the firm.

CONT.

TERMS OF CANCELLATION: Failure to comply with the *General Specifications* may result in cancellation of the contract.

2 2 2

GEOTECHNICAL	Chapter: CONSULTANT SERVICES
	Subject: Performance Evaluation

PERFORMANCE EVALUATION: The Geotechnical Branch shall evaluate the performance of the geotechnical consultant after completion of the project. The TC 64-522 form, *Performance Evaluation for Geotechnical Services* **(Exhibit 50)**, shall be utilized for this evaluation. The Geotechnical Branch shall retain the evaluation, and a copy of the evaluation shall be submitted to the geotechnical engineering or drilling firm.

2 2 2

GEOTECHNICAL

Chapter

EXHIBITS

Subject

Table of Exhibits

CONT.

CONT.

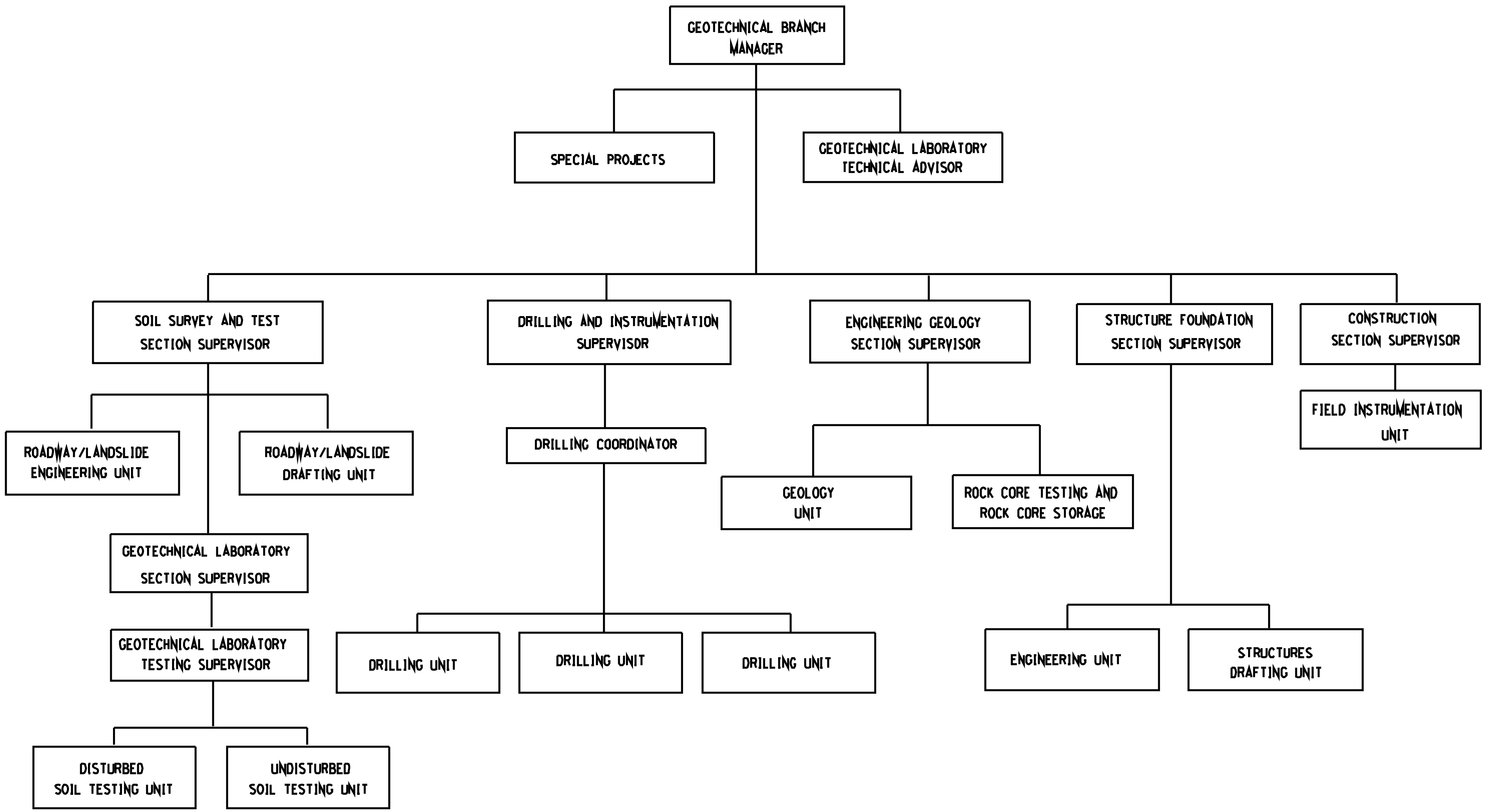
EXHIBIT NUMBER	FORM TITLE	FORM NUMBER
37	Typical Boring Layouts for Culverts	*(none)*
38	MSE Wall Detail Sheet & Cantilever Wall Detail Sheet	*(none)*
39	Subsurface Data Sheet: Two Alternate Positions for a Substructure	*(none)*
40	Subsurface Data Sheet: Interpolated Bedrock Contour Sheet	*(none)*
41	Coordinate Data Submission Form	*(none)*
42	Subsurface Data Sheet: Bridge Approach Slope Stability Schematic	*(none)*
43	Subsurface Data Sheet: Bridge	*(none)*
44	Sounding Layout Sheet: Old & New Data for a Bridge Replacement	*(none)*
45	Subsurface Data Sheet: D50 & D95 Values	*(none)*
46	Drilled Shaft Design Data	*(none)*
47	Subsurface Data Sheet: Culvert	*(none)*
48	Typical Settlement Plot for a Culvert	(none)
49	Subsurface Data Sheet: Stability Schematic for a Culvert	*(none)*
50	Performance Evaluation for Geotechnical Services	TC 64-522
51	Prequalification Requirements for Geotechnical Drilling Services	TC 64-540
52	Prequalification Requirements for Geotechnical Engineering Services	TC 64-541
53	Prequalification Requirements for Geotechnical Laboratory Testing Services	TC 64-542

CONT.

2 2 2

Kentucky Transportation Cabinet - Division of Materials
Organizational Chart For Geotechnical Branch

1236 Wilkinson Boulevard; Frankfort KY 40601-1200
PH (502) 564-2374 FAX (502) 564-4839



SPRINGFIELD CO ALBANY NW BYPASS

Exhibit 2

1" = 2000'

SPRINGFIELD COUNTY
US 555 ALBANY NW BYPASS
FD52 126 0555 005-023 009 D
MARS # 68594 01D
ITEM # 13-765.00

01/01/05

KENTUCKY TRANSPORTATION CABINET

Division of Materials

Geotechnical Branch

TC 64-515

SUBSURFACE LOG

Page 1 of ___

County ____________ Item No. ________	Location ____________________
Project No. ____________________	Latitude ____________ Longitude ____________
Mars No. ____________ Surface Elevation ________ Ft.	Hole Number ________ Total Depth ______ Ft.
Road Number ____________________	Date Started ________ Date Completed ________
Project Type ____________________	Depth to Water (Immediate) ____________
Driller's Name ____________ Geologist ____________	Depth to Water (7 Day) ________ Date ________

Lithology		Description: Overburden	Sample No.	Depth	Rec. (Ft.)	SPT Blows	Sample Type	Remarks
Elevation	Depth	Description: Rock Core	RQD	Run	Rec. (Ft.)	Rec. (%)	SDI (JS)	

KENTUCKY TRANSPORTATION CABINET

Exhibit 3

Division of Materials

Geotechnical Branch

TC 64-515

SUBSURFACE LOG *(Continued)*

Page ___ of ___

Surface Elev. ________ Ft.   Location ______________________________   Hole No. ____________

Lithology		Description	Overburden	Sample No.	Depth	Rec. (Ft.)	SPT Blows	Sample Type	Remarks
Elevation	Depth		Rock Core	RQD	Run	Rec. (Ft.)	Rec. (%)	SDI (JS)	

KENTUCKY TRANSPORTATION CABINET

TC 64-515

Division of Materials

Geotechnical Branch

SUBSURFACE LOG *(Continued)*

Surface Elev. *0.0* Ft. Location *0* Hole No. *0*

Lithology		Description	Overburden	Sample No.	Depth	Rec. (Ft.)	SPT Blows	Sample Type	Remarks
Elevation	Depth		Rock Core	RQD	Run	Rec. (Ft.)	Rec. (%)	SDI (JS)	

KENTUCKY TRANSPORTATION CABINET

Division of Materials

Geotechnical Branch

SUBSURFACE LOG *(Continued)*

Surface Elev. *0.0* Ft. Location *0* Hole No. *0*

Lithology		Description		Sample No.	Depth	Rec. (Ft.)	SPT Blows	Sample Type	Remarks
Elevation	Depth		Overburden / Rock Core	RQD	Run	Rec. (Ft.)	Rec. (%)	SDI (JS)	

KENTUCKY TRANSPORTATION CABINET

Division of Materials

Geotechnical Branch

TC 64-515

SUBSURFACE LOG

County: *Springfield*	Item No.: *13-765.00*	Location: *Station 63+50, 25 Feet Left*	
Project No.: *FD52 126 0555 005-023 009 D*		Latitude:	Longitude:
Mars No.: *6859401D*	Surface Elevation: *956.3* Ft.	Hole Number: *1A*	Total Depth: *35.0* Ft.
Road Number: *New Albany NW Bypass (US 555)*		Date Started: *02/02/75*	Date Completed: *02/02/75*
Project Type: *Roadway*		Depth to Water (Immediate):	
Driller's Name: *B. Jones*	Geologist:	Depth to Water (7 Day): *N/A*	Date:

Lithology: Elevation	Lithology: Depth	Description (Overburden / Rock Core)	Sample No. / RQD	Depth / Run	Rec. (Ft.)	SPT Blows / Rec. (%)	Sample Type / SDI (JS)	Remarks
	3.0	*Brown, clayey-silt, sandy lenses, dry*						
	7.5	*Gray, silty-clay, moist, w/ sandstone boulders (Auger Refusal)*	#1	5.0-6.5	1.5	5-7-4	SPT	
	11.6	*Weathered brown sandstone*		2.5	2.1	84		10.0
				5.0	4.7	94		15.0
	21.1	*Brown and gray sandstone w/ shale layers (Lost water @ 15.0')*		10.0	9.8	98		25.0
	32.0	*Gray sandy shale*		10.0	9.9	99		
	35.0	*Gray sandstone (End of Core 35.0')*						

KENTUCKY TRANSPORTATION CABINET

Division of Materials
Geotechnical Branch

TC 64-515

Springfield South Quadrangle
GQ #4567
Dakota Formation

SUBSURFACE LOG

County	*Springfield*	Item No.	*13-765.00*
Project No.	*FD52 126 0555 005-023 009 D*		
Mars No.	*6859401D*	Surface Elevation	*469.5* Ft.
Road Number	*New Albany NW Bypass (US 555)*		
Project Type	*Bridge Over Buckhill River*		
Driller's Name	*B. Jones*	Geologist	*A. Smith*

Location	*Station 415+06.52, 22.5 Feet Right*		
Latitude	85° 55' 28"	Longitude	38° 28' 46"
Hole Number	*#13*	Total Depth	*36.0* Ft.
Date Started	*04/01/04*	Date Completed	*04/01/04*
Depth to Water (Immediate)	*11.0 Ft.*		
Depth to Water (7 Day)	*N/A*	Date	

Lithology: Elevation	Lithology: Depth	Description (Overburden / Rock Core)	Sample No. / RQD	Depth / Run	Rec. (Ft.) / Rec. (Ft.)	SPT Blows / Rec. (%)	Sample Type / SDI (JS)	Remarks
		Overburden	*#1*	*2.0-4.0*	*1.4*		*ST*	
			#2	*5.0-7.0*	*1.7*		*ST*	
456.5	*13.0*		*#3*	*10-11.5*		*21-22-10*	*SPT*	
450.3	*19.2*	*Limestone: light gray, coarse crystalline, w/ many shale laminations and limited partings*	*42*	*3.0*	*2.8*	*93*		*16.0* **Clay Shale @ 17.5-18.4**
		Limestone: light gray, fine to coarse crystalline, argillaceous with wavy to nodular bedding, fossiliferous	*20*	*10.0*	*9.7*	*97*		*26.0*
433.5	*36.0*		*31*	*10.0*	*10.0*	*100*		

Top of Rock = 13.0
Elevation 456.5

Base of Weathered Rock = 13.5
Elevation 456.0

The Allowable Bearing Capacity is 10 tons/square foot
at Elevation 456.0

KENTUCKY TRANSPORTATION CABINET

Division of Materials

Geotechnical Branch

TC 64-515

Springfield South Quadrangle GQ #5689 Nevada Formation, Elm member

SUBSURFACE LOG

County	*Springfield*	Item No.	*13-765.00*
Project No.	*FD52 126 0555 005-023 009 D*		
Mars No.	*6859401D*	Surface Elevation	*964.2* Ft.
Road Number	*New Albany NW Bypass (US 555)*		
Project Type	*Roadway*		
Driller's Name	*B. Jones*	Geologist	*A. Smith*
Location	*Station 32+00, 80 Feet Right*		
Latitude	82^{o} 34' 22"	Longitude	37^{o} 48' 12"
Hole Number	*2C*	Total Depth	*42.0* Ft.
Date Started	*11/26/02*	Date Completed	*11/27/02*
Depth to Water (Immediate)	*N/A*		
Depth to Water (7 Day)	*N/A*	Date	

Lithology: Elevation	Lithology: Depth	Description (Overburden / Rock Core)	Sample No. / RQD	Depth / Run	Rec. (Ft.) / Rec. (Ft.)	SPT Blows / Rec. (%)	Sample Type / SDI (JS)	Remarks
960.4	3.8	*Overburden w/ sandstone boulders*						
			0	*5.0*	*4.5*	*90*		*8.8*
951.0	13.2	*Shale: brown to dark gray, clayey to silty, carbonaceous zones, occasional sandstone partings, slickensided throughout, highly fractured and weathered above 7.4'*						
			12	*10.0*	*9.8*	*98*		***75° Joint @ 18.3-20.2*** *18.8*
947.2	17.0	*Sandstone: gray, fine grain, numerous shale laminations, cross bedded, non-durable*						
942.9	21.3	*Shale (siltstone): gray, sandy, with iron nodules, rooted, coal spars*						
			34	*10.0*	*9.2*	*92*		***Shale zone @ 28.7-29.8*** *28.8*
940.1	24.1	*Coal Seam w/ 0.5' shale parting (Recovered 2.3 Ft.)*						
938.1	26.1	*Shale (claystone): gray, plastic, slickensided*						
			71	*10.0*	*10.0*	*100*		***Conglomerate @ 36.5-37.1*** *38.8*
			82	*3.8*	*3.8*	*100*		***80° Water Stained Joint @ 40.3-42.0***
922.2	42.0	*Sandstone: light gray, medium to coarse grain, few shale laminations, shale clasts in zones, crossbedding, intermittent water stains, durable*						
		RDZ = 7.4 Ft.						

KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch

TC 64-516

SUMMARY OF ROCKLINE SOUNDINGS

Page 1 of ___

County ____________ Item No. ________	Road Number ____________
Project No. ____________	Project Type ____________
Mars No. ________ Driller's Name ________	Date Started ______ Date Completed ______

Hole Number	Station	Offset	Depth to Refusal	Surface Elevation	Refusal Elevation	Latitude	Longitude	Remarks

KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch

TC 64-516

SUMMARY OF ROCKLINE SOUNDINGS

County: *Springfield* Item No.: *13-765.00*	Road Number: *New Albany NW Bypass (US 555)*
Project No.: *FD52 126 0555 005-023 009 D*	Project Type: *Bridge, Culvert and Wall*
Mars No.: *6859401D* Driller's Name: *B. Jones*	Date Started: *4/20/1991* Date Completed: *4/27/1991*

Hole Number	Station	Offset	Depth to Refusal	Surface Elevation	Refusal Elevation	Latitude	Longitude	Remarks
Bridge @ 24+00								
3	23+50	CL	5.7	526.1	520.4	85° 45'01"	38° 07'30"	
5	24+50	CL	5.2	522.0	516.8	85° 44'13"	38° 07'36"	
6	24+50	30' Rt.	6.6	522.6	516.0	85° 44'14"	38° 07'36"	
8	25+50	30' Lt.	8.6	529.2	520.6	85° 43'07"	38° 07'41"	Boulders @ 1.5-2.0
9	25+50	CL	9.0	528.4	519.4	85° 43'08"	38° 07'41"	
10	26+50	30' Rt.	7.2	530.1	522.9	85° 43'11"	38° 07'45"	
Culvert @ 30+00								
11	30+00	CL	7.6	530.2	522.6	85° 42'23"	38° 07'48"	
12	30+00	30' Rt.	32.0 NR	529.2	497.2	85° 42'24"	38° 07'48"	O.W. installed Immediate - Dry
Wall right of Ramp 1								
14	20+00	30' Rt.	10.9	537.1	526.2	85° 45'16"	38° 06'45"	
16	21+50	30' Rt.	9.2	535.3	526.1	85° 45'30"	38° 06'58"	

KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch

TC 64-515

SUBSURFACE LOG

County: *Springfield*	Item No.: *13-765.00*	Location: *Station 61+00, 25 Feet Left*	
Project No.: *FD52 126 0555 005-023 009 D*		Latitude:	Longitude:
Mars No.: *6859401D*	Surface Elevation: Ft.	Hole Number: *#16*	Total Depth: *17.0* Ft.
Road Number: *New Albany NW Bypass (US 555)*		Date Started: *11/10/04*	Date Completed: *11/10/04*
Project Type: *Profile*		Depth to Water (Immediate): *N/A*	
Driller's Name: *B. Jones*	Geologist:	Depth to Water (7 Day): *N/A*	Date:

Lithology: Elevation	Lithology: Depth	Description (Overburden / Rock Core)	Sample No. / RQD	Depth / Run	Rec. (Ft.) / Rec. (Ft.)	SPT Blows / Rec. (%)	Sample Type / SDI (JS)	Remarks
	11.0	*Brown, silty clay, moist, firm* ****Bag #4***					*NMC #6 @ 4'* *NMC #7 @ 9'*	
	17.0	*Gray, silty, wet, soft* *****Soil Type #3***					*NMC #8 @ 14'*	
		(No Refusal)						

Note: *Pond Located at station 61+20, 20 feet left. Pond is approximately 30 feet wide and runs to station 61+40.*

Note: *Possible landslide between stations 61+50 - 64+00.*

******* *Indicates bag was obtained in this boring.*

******** *References soil type from a bag sample obtained from a previous boring.*

KENTUCKY TRANSPORTATION CABINET

SPECIFICATIONS FOR CORE BOX

Format for Labeling Lid

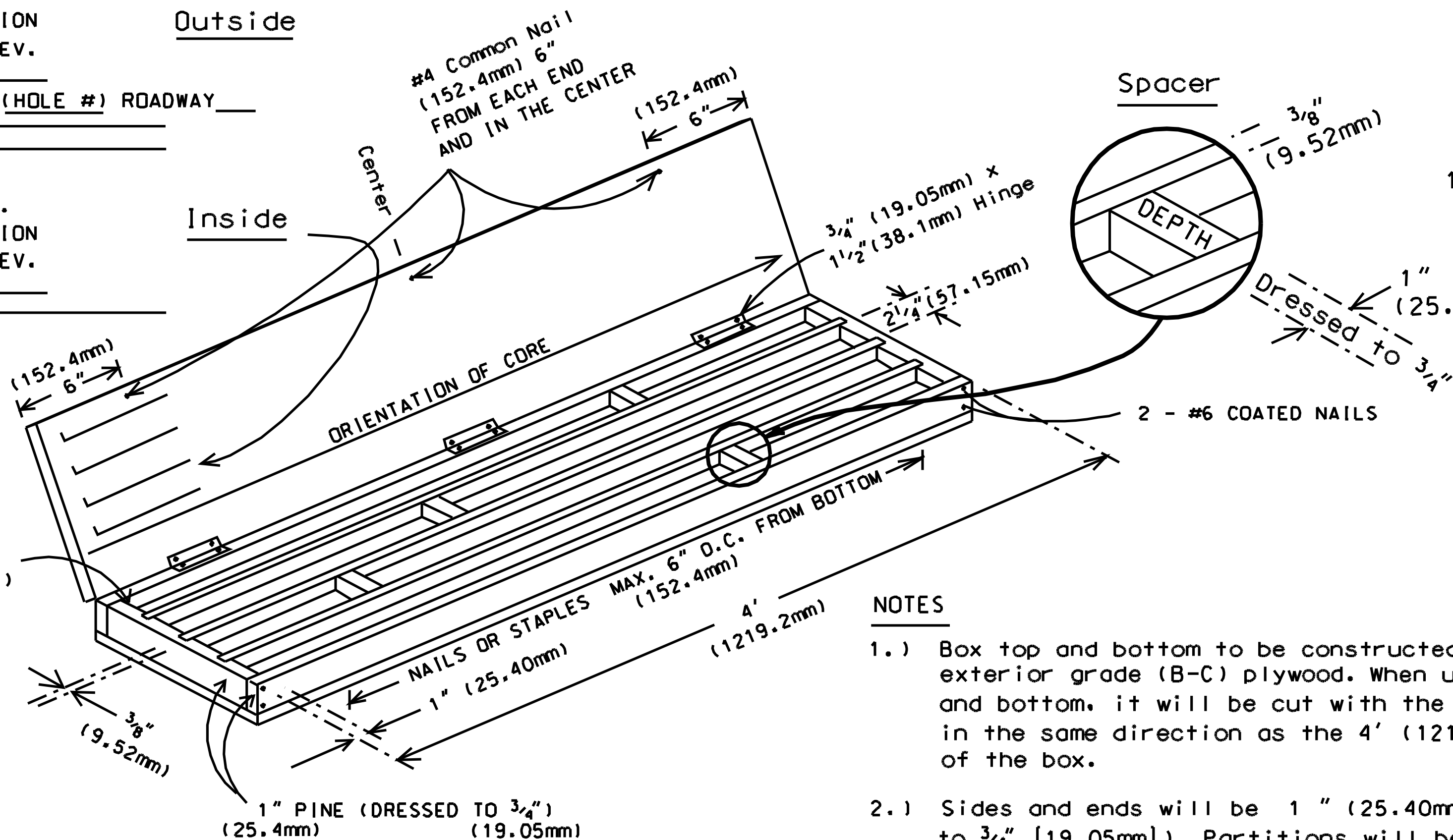
Outside

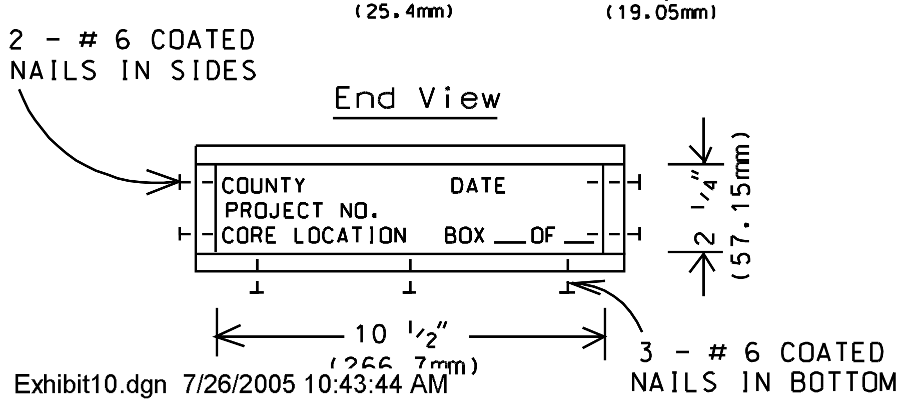
COUNTY
PROJECT NO.
CORE LOCATION
SURFACE ELEV.
BOX ___ OF ____
STRUCTURE (HOLE #) ROADWAY___

Inside

COUNTY
PROJECT NO.
CORE LOCATION
SURFACE ELEV.
BOX ___ OF ____

English		Metric
3/8"	=	9.52mm
1/2"	=	12.70mm
3/4"	=	19.05mm
1 1/2"	=	38.1mm
1"	=	25.40mm
2 1/4"	=	57.15mm
6"	=	152.4mm
10 1/2"	=	266.7mm
4'	=	1219.2mm





NOTES

1.) Box top and bottom to be constructed of 1/2" (12.70mm) exterior grade (B-C) plywood. When using plywood for top and bottom, it will be cut with the grain of plywood in the same direction as the 4' (1219.2mm) length of the box.

2.) Sides and ends will be 1" (25.40mm) pine: (dressed to 3/4" [19.05mm]). Partitions will be 3/8" (9.52mm) pine.

3.) #6 cc (penny) coated sinker nails or coated staples are required to assemble parts of the box.

4.) Top lid will have 3 hinges secured with 4 - # 6 screws 1/2" (12.70mm) into lid and 3/4" (19.05mm) into sides.

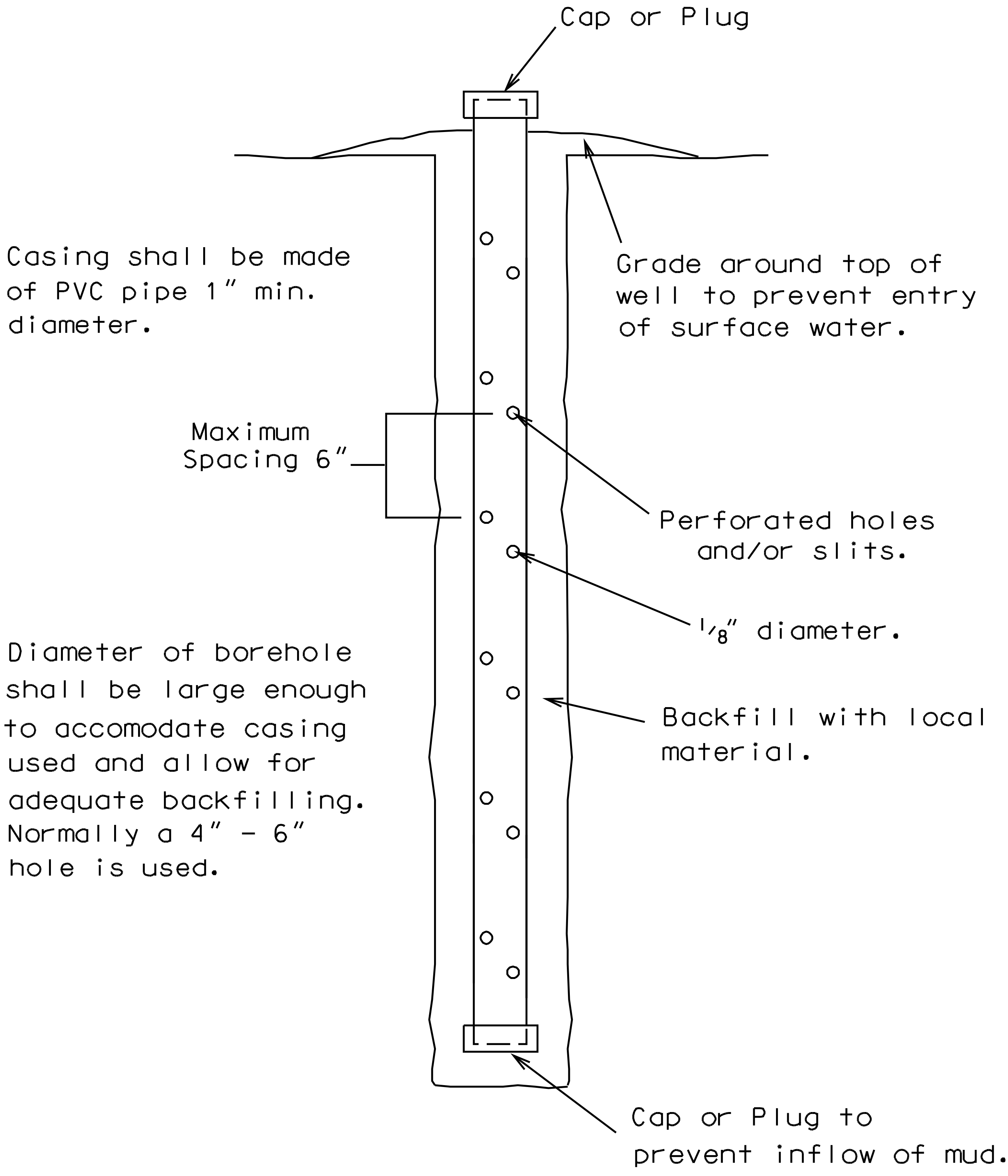
5.) All partitions and spacers to be removable.

6.) Letter box as shown. Letters to be bold and indelible.

7.) Enclose copy of Geologist and Driller's log inside Box No. 1.

8.) Closure of lid shall be secured with 3 - # 4 common nails.

CASED OBSERVATION WELL



TC 64-531

KENTUCKY TRANSPORTATION CABINET

Division of Materials
Geotechnical Branch

THIN-WALLED TUBE & SPT SAMPLE LOG

Assigned By: ____________________

Date: ______________ Mars # ____________________ Item # __________ Logged By: _______________ Date __________

County ______________ Project # ___________________________________ Page _____ of _____

				Moisture Content AASHTO T 265								Request for Testing					
Location	Hole No.	Sample No.	Depth	Can No.	Tare	Wet Weight + Tare	Dry Weight + Tare	% Water	Visual Description	No. of Samples	Pene-trometer /Torvane	Uncon-fined	Consoli-dation	Type of Test	No. of Samples	Pressure	Classify / Wash

Exhibit 13

TC 64-531

KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch

THIN-WALLED TUBE & SPT SAMPLE LOG

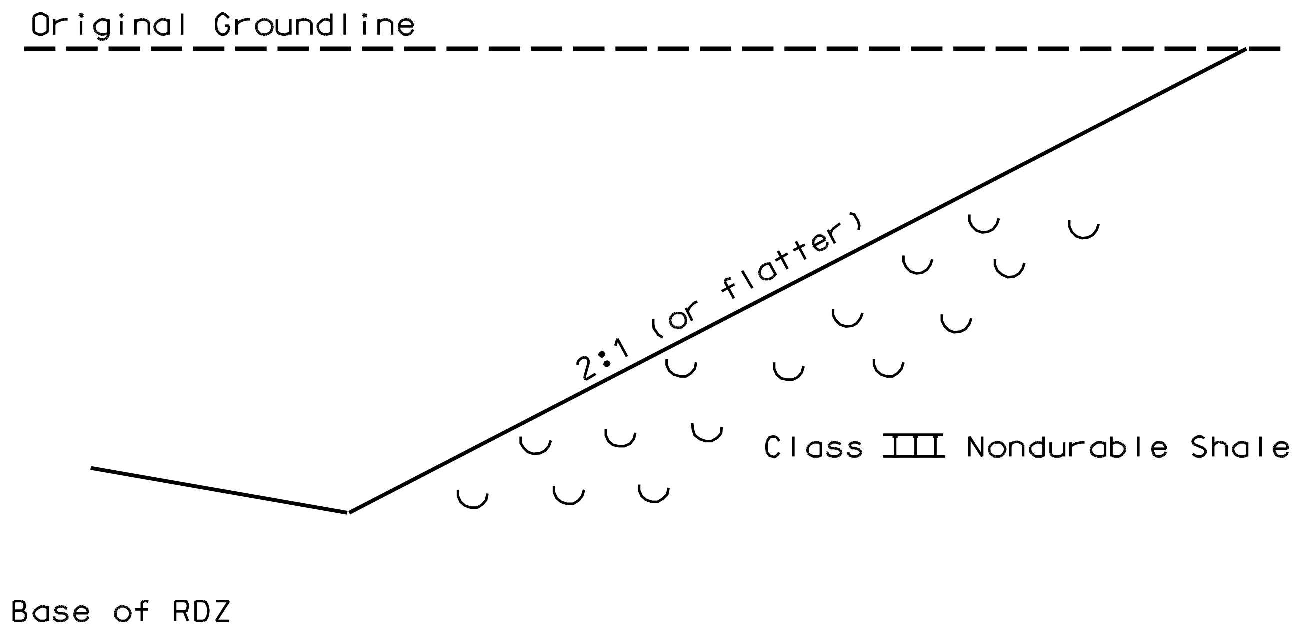
Assigned By: B. King

Date: 2/30/04 Mars # 6895401D Item # 13-765.00 Logged By: R. McDonald Date 2/30/04

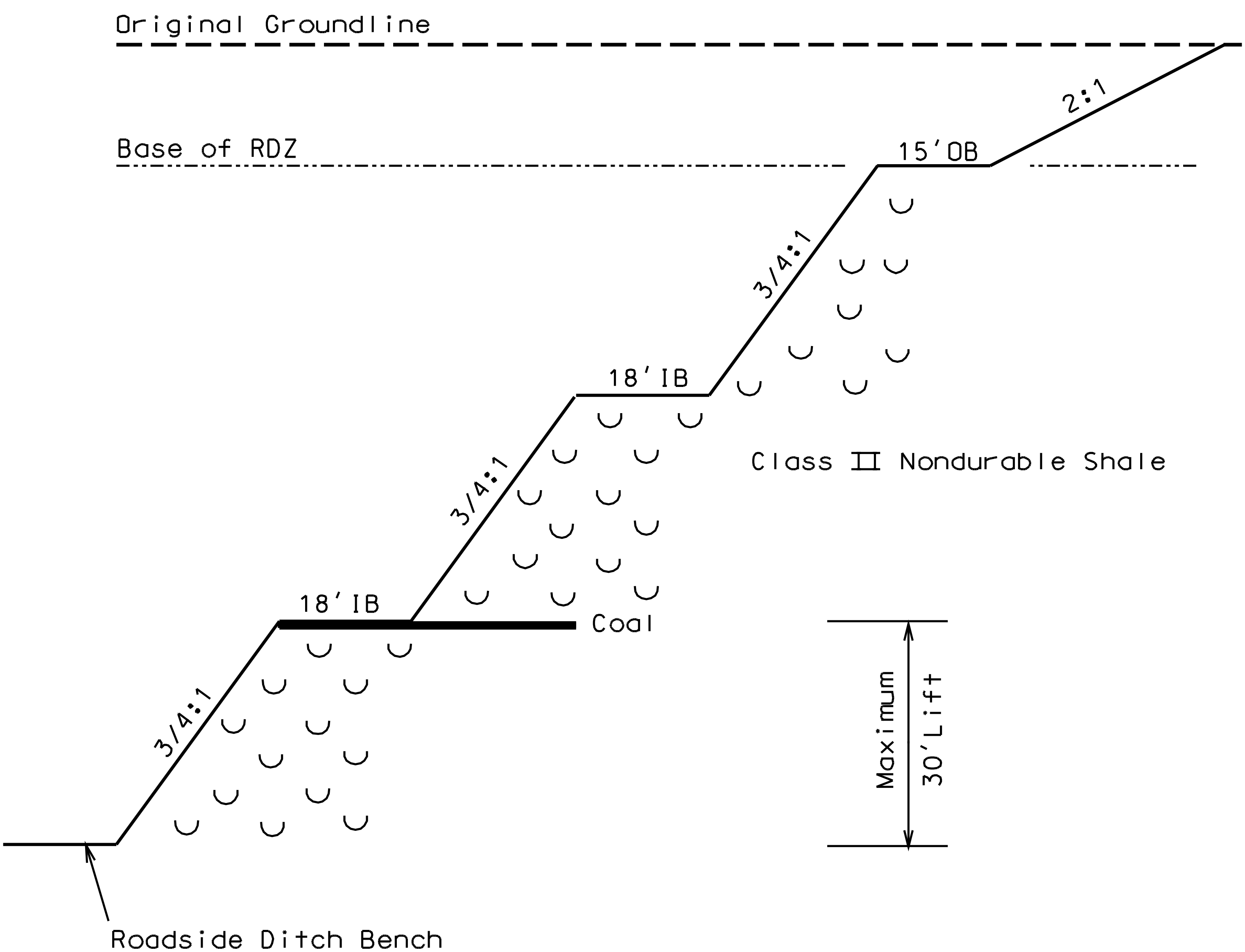
County Springfield Project # FD52 126 0555 005-023 009 D Page 1 of 1

				Moisture Content AASHTO T 265								Request for Testing					
Location	Hole No.	Sample No.	Depth	Can No.	Tare	Wet Weight + Tare	Dry Weight + Tare	% Water	Visual Description	No. of Samples	Pene-trometer /Torvane	Uncon-fined	Consoli-dation	Type of Test	No. of Samples	Pressure	Classify / Wash
40+50, 20' Lt.	35	1	5-7.5	22	46.4	221.7	198.0	15.6	Gray Silty - Clay	1	1.0	1					X
		2	10-12.5	110	46.8	312.9	258.0	26.0	Gray Silty - Clay	2	0.5			A-CU	2	15 25	X
		3	15-17.5	105	46.3	336.2	286.9	20.5	Gray Clay	1	0.5			B-CU	1	15	X
40+00, CL	36	1	5-7.5	42	46.6	270.3	229.9	22.0	Brown Silty - Clay	2	1.5	1					X
		2	10-12.5	45	46.5	323.1	264.6	26.8	Gray Silty - Clay	2	1.0	1	1				X
		3	15-17.5	3	48.0	339.0	296.0	17.3	Gray Clay	1	0.5			B-CU	1	25	X
		4	20-22.5	25	46.4	283.2	245.0	19.2	Gray Clay	1	0.5			B-CU	1	35	X
40+50, 20' Rt.	37	1	5-7.5	K	46.5	198.9	175.8	17.9	Gravel, Brown Silty - Clay	Pan	1.0						X
		2	10-12.5	107	47.4	283.1	241.7	21.3	Brown Silty - Clay	1	0.5	1					X
		3	15-17.5	104	47.3	264.2	236.0	14.9	Gray Silty - Clay	2	0.5	1		UU	1	15	X

Typical Slope Configuration
Class III Nondurable Shale

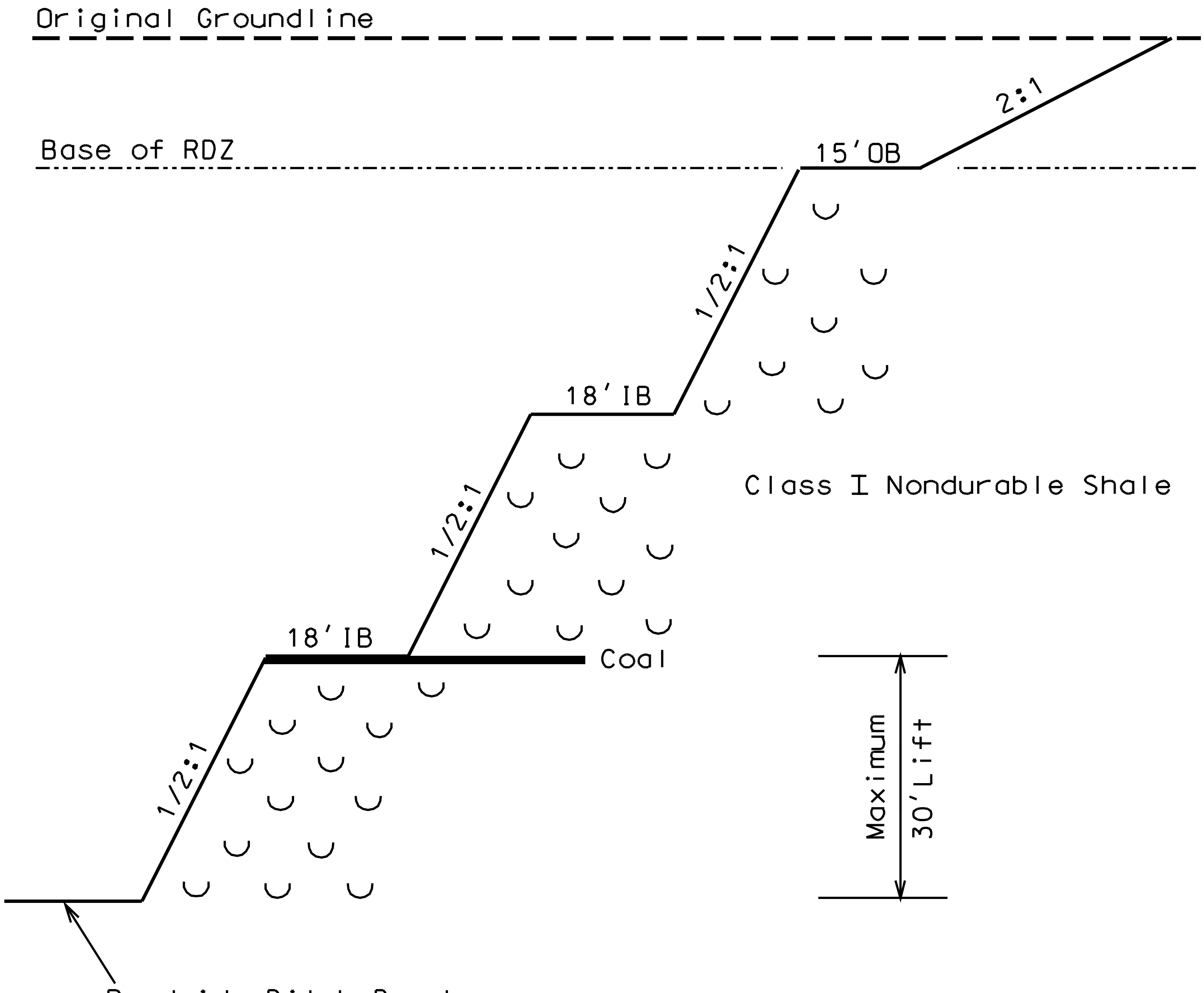


Typical Slope Configuration
Class II Nondurable Shale



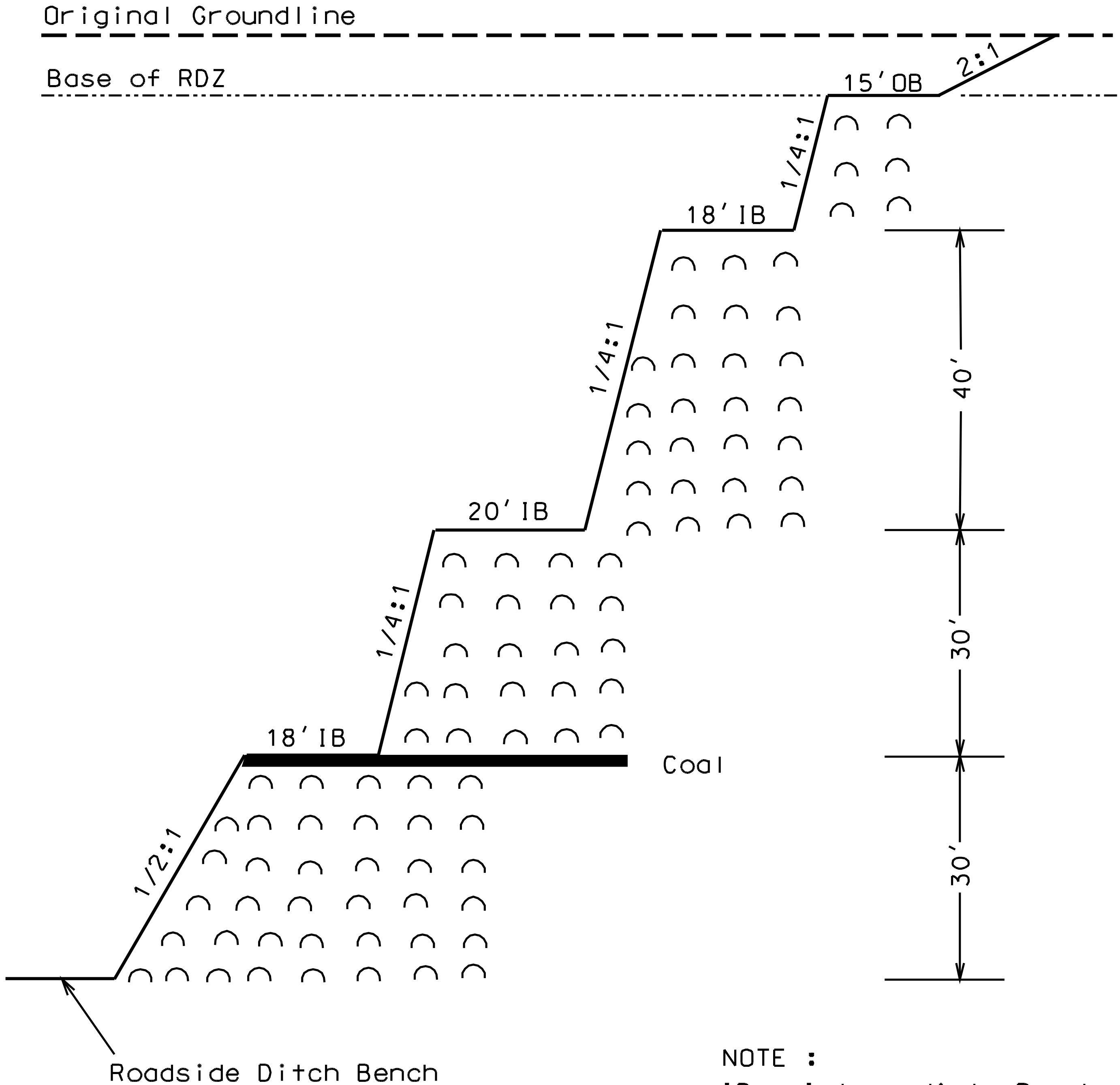
NOTE :
IB = Intermediate Bench
OB = Overburden Bench

Typical Slope Configuration
Class I Nondurable Shale



NOTE :
IB = Intermediate Bench
OB = Overburden Bench

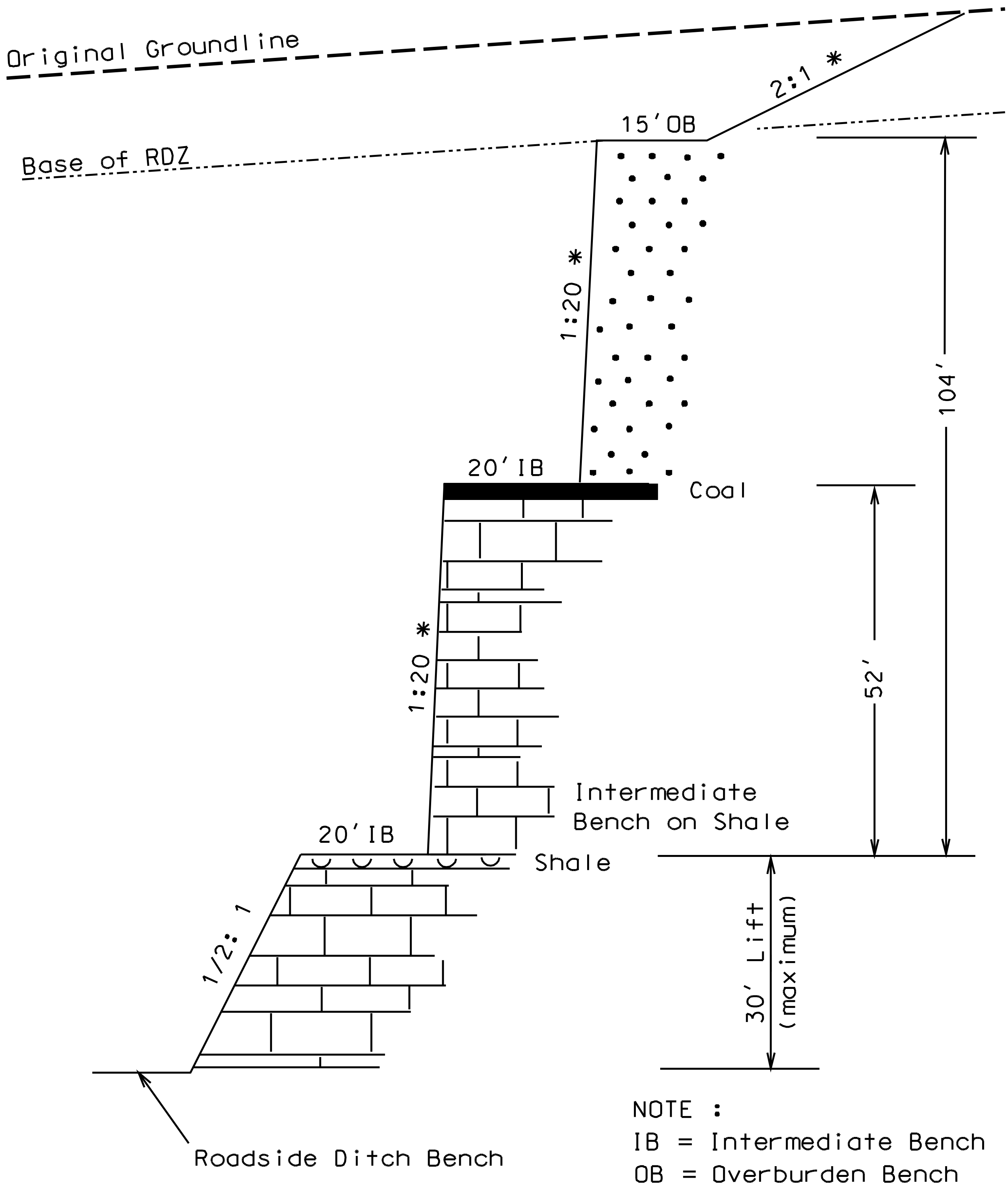
Typical Slope Configuration
Durable Shale



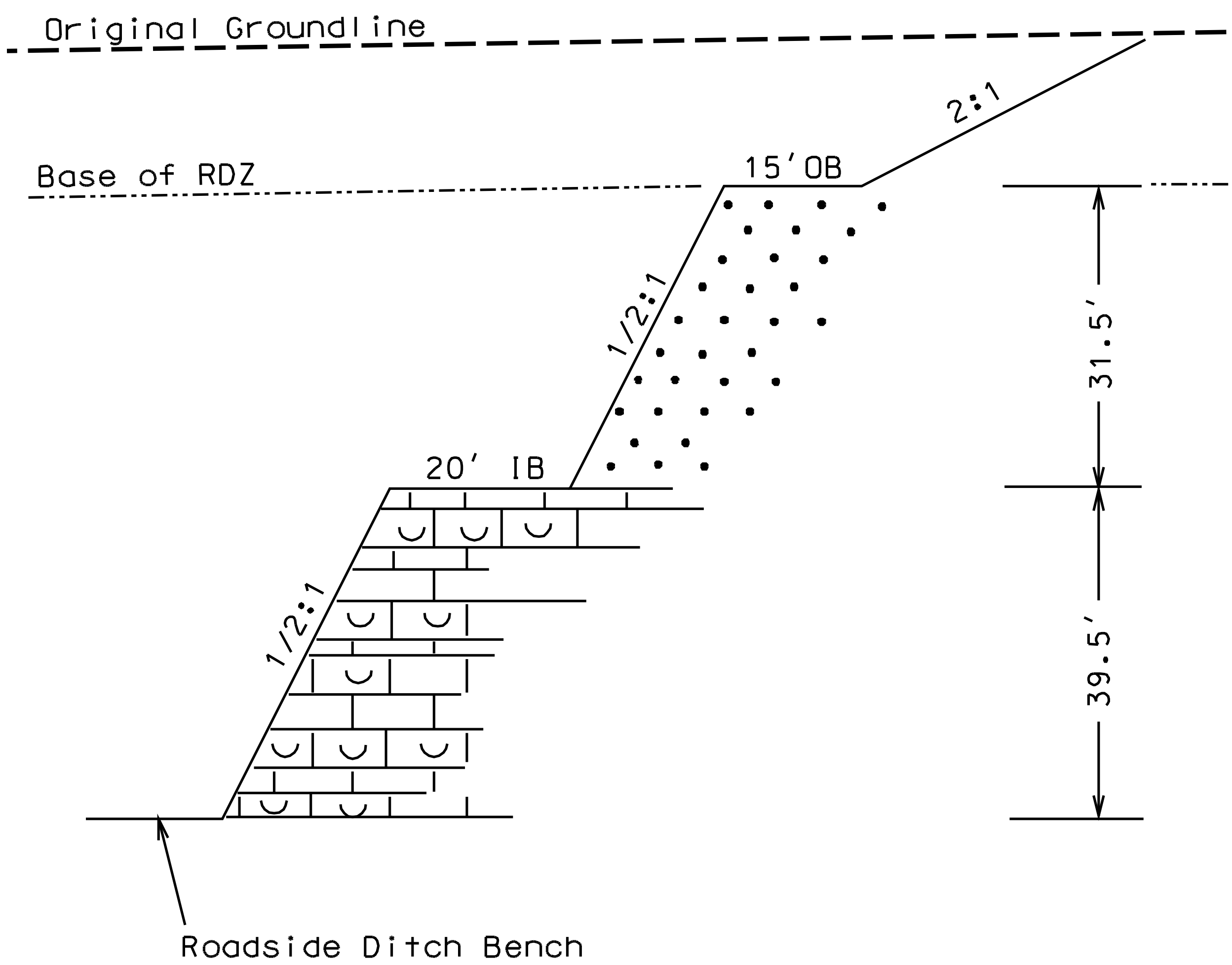
NOTE :
IB = Intermediate Bench
OB = Overburden Bench

Typical Slope Configuration
Massive Limestone or Sandstone

* Slopes are shown at maximum steepness

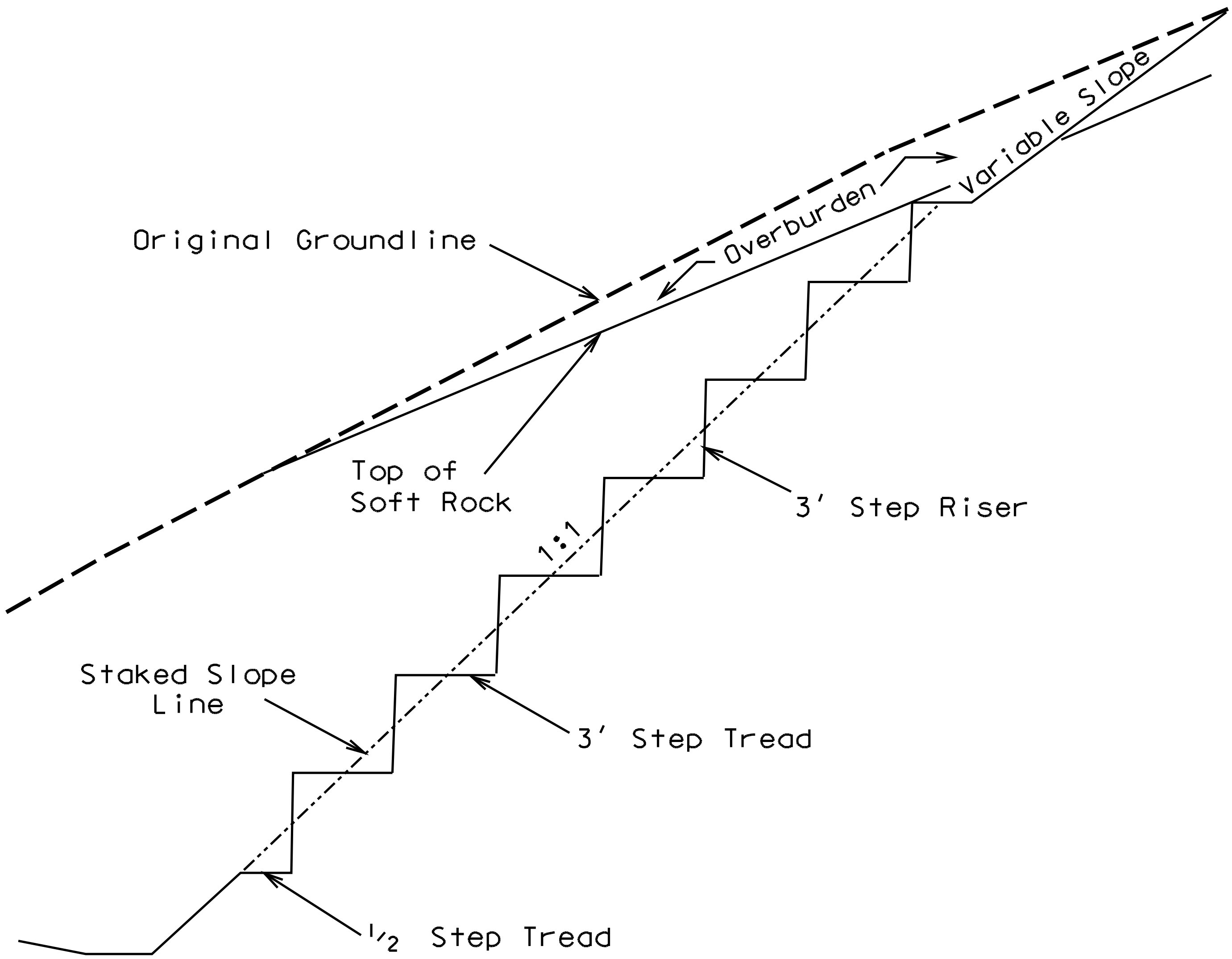


Typical Slope Configuration
Shaley Limestone or Sandstone



NOTE :
IB = Intermediate Bench
OB = Overburden Bench

Typical Slope Configuration
1:1 Serrated Slopes



NOTE :
1:1 slope configuration shown.
For a 1 1/2:1 slope (not shown)
use 2′ riser with a 3′ tread
or 4′ riser with a 6′ tread.

Roadside Ditch Catchment Area

For a Copy of Guidelines Contact the
Kentucky Department of Highways
Division of Materials
Geotechnical Branch

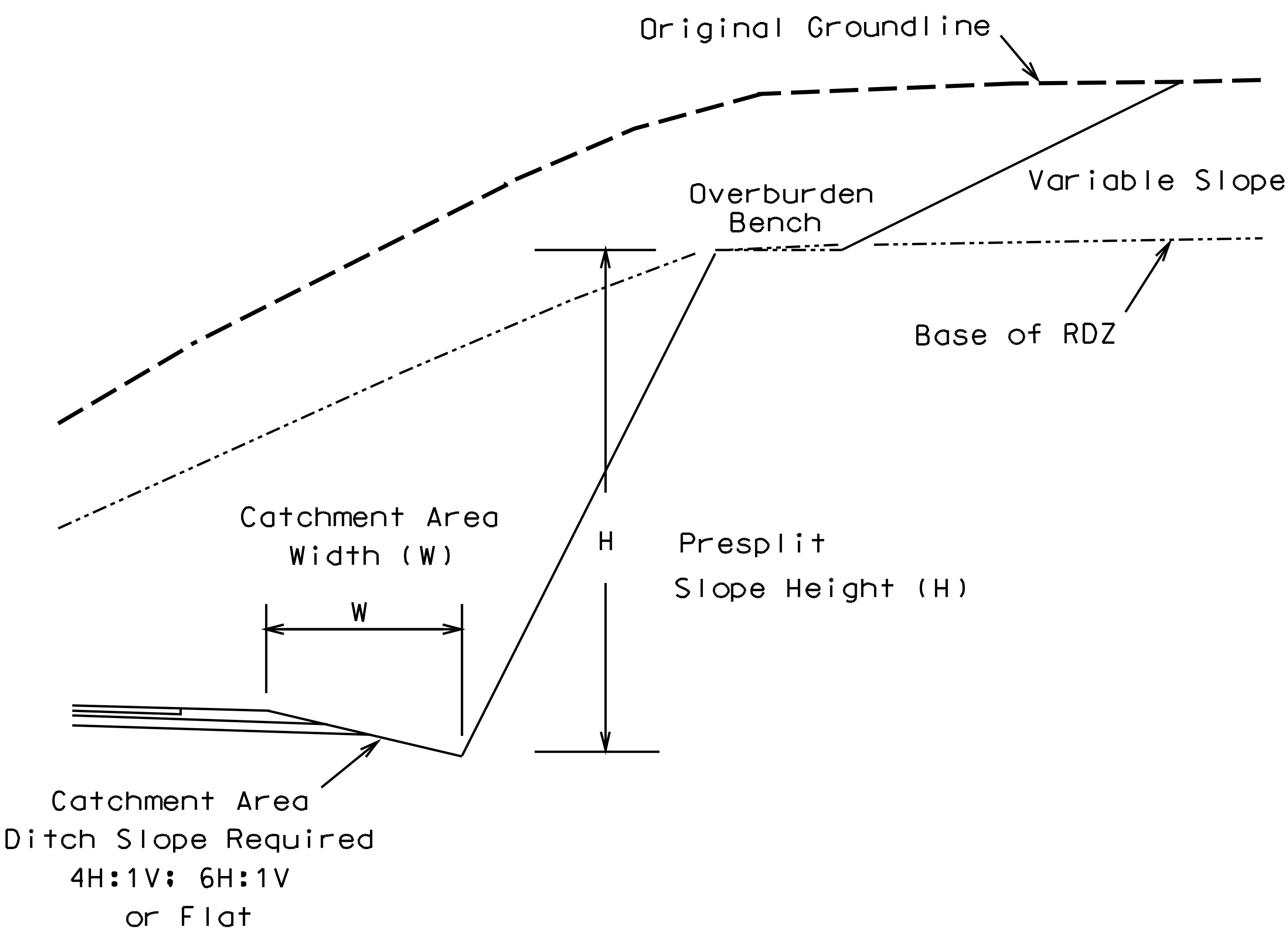


Exhibit 22

KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch

TC 64-532

County ____________________ Page _____ of _____

Item No. ____________________

SUMMARY OF ROCK QUANTITIES

Submittal No. ____________________

Project No. ____________________ Date ____________________

Sheet Totals	2 Foot Rock Roadbed (Required)	Rock Embankment (Required)	Channel Lining (Required)	Type of Excavated Material			
				Sandstone or Limestone	Durable Shale	Nondurable Shale	
STA: To STA:						Class I	Class II
Sheet Total (Cubic Yards)							
Accumulated Total							

TC 64-532

KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch

County: *Springfield*

Page *1* of *1*

Item No.: *13-765.00*

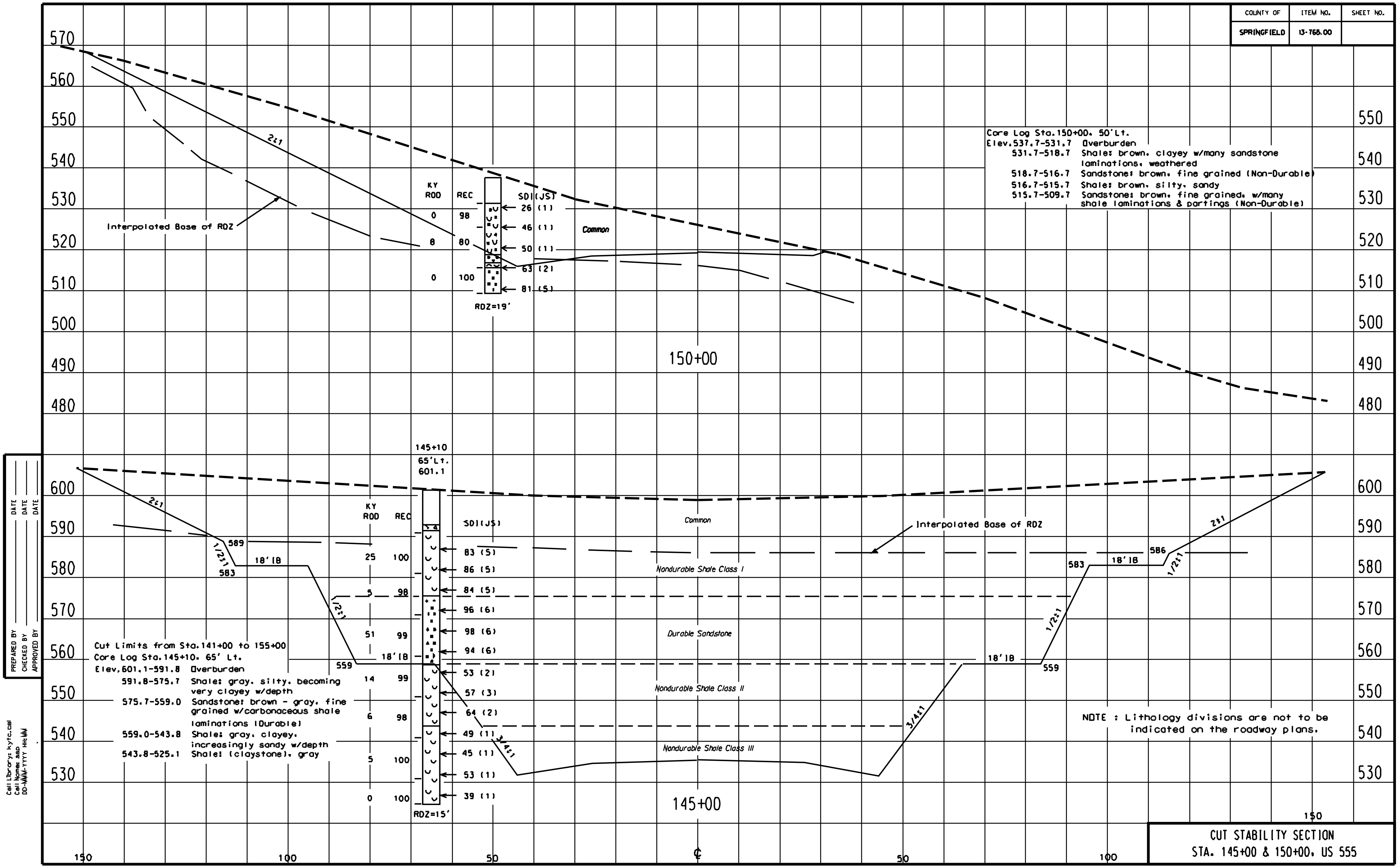
SUMMARY OF ROCK QUANTITIES

Submittal No.: *1*

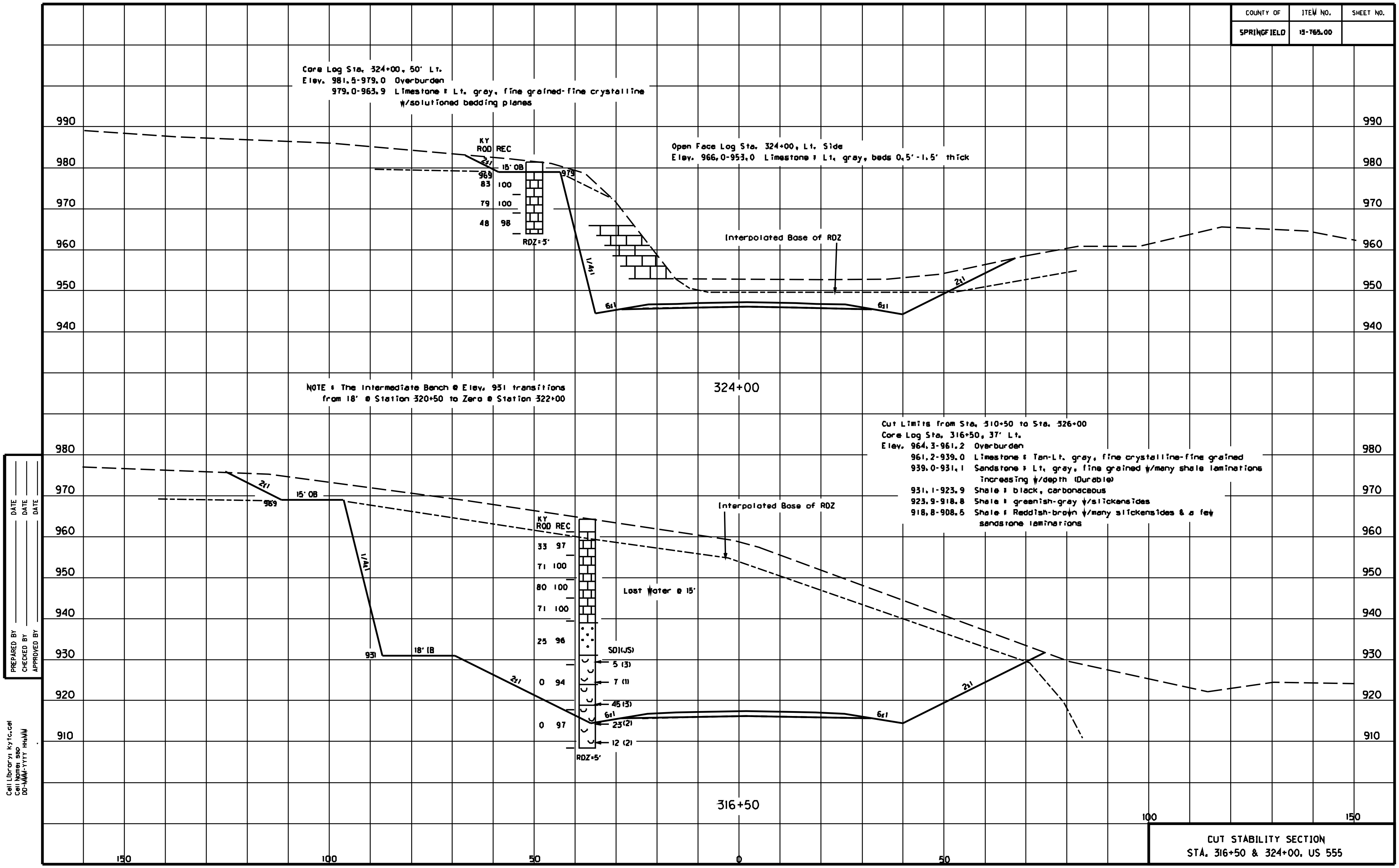
Project No.: *FD52 126 0555 005-023 009 D*

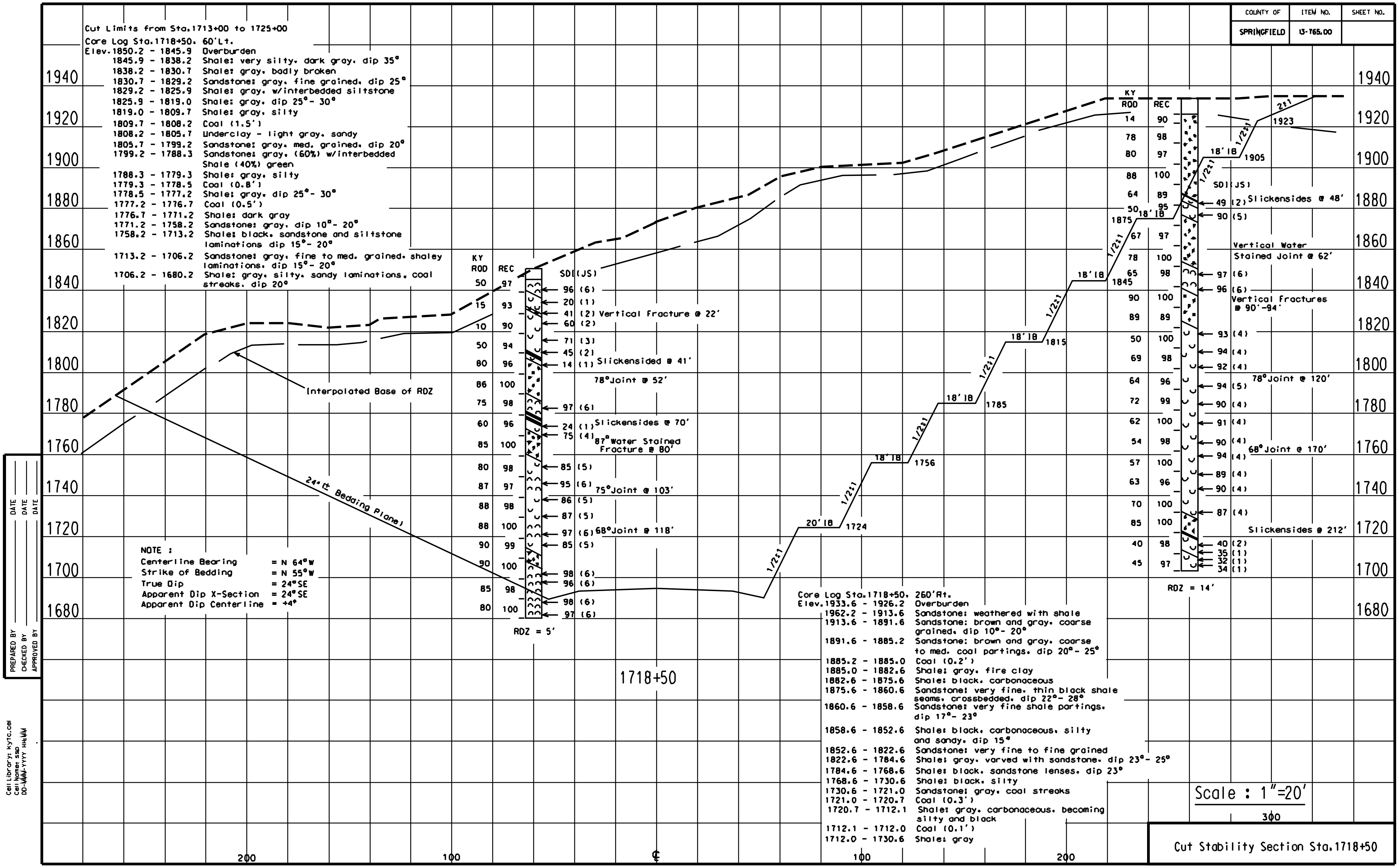
Date: *5/6/2003*

Sheet Totals	2 Foot Rock Roadbed	Rock Embankment	Channel Lining	Type of Excavated Material			
				Sandstone or Limestone	Durable Shale	Nondurable Shale	
STA: To STA:	(Required)	(Required)	(Required)			Class I	Class II
391+00 - 395+00	1,704	17,000					
395+00 - 410+00	6,390	4,000	4,231		1,259		
410+00 - 425+00	6,390				62,240		
425+00 - 440+00	6,390	5,000			1,712		
440+00 - 455+00	6,390				1,209	5,923	17,933
455+00 - 470+00	6,390	4,000				194	1,023
470+00 - 485+00	6,390				128,247	172,935	59,525
485+00 - 500+00	6,390	45,000					
500+00 - 515+00	6,390	61,000					
515+00 - 530+00	6,390	72,000					
530+00 - 545+00	6,390	65,000	10,971				
545+00 - 560+00	6,390			17,484	556		10,841
560+00 - 575+00	6,390			2,232	7,023	9,567	10,086
575+00 - 590+00	6,390			17,364	73,640	68,136	4,052
590+00 - 605+00	6,390			53,158	56,582	25,245	
Sheet Total (Cubic Yards)	91,164	273,000	15,202	90,238	332,468	282,000	103,460
Accumulated Total	91,164	273,000	15,202	90,238	332,468	282,000	103,460



COUNTY OF
SPRINGFIELD
ITEM NO.
13-768.00
SHEET NO.
Core Log Sta.150+00, 50'Lt.
Elev.537.7-531.7 Overburden
531.7-518.7 Shale: brown, clayey w/many sandstone laminations, weathered
518.7-516.7 Sandstone: brown, fine grained (Non-Durable)
516.7-515.7 Shale: brown, silty, sandy
515.7-509.7 Sandstone: brown, fine grained, w/many shale laminations & partings (Non-Durable)
Interpolated Base of RDZ
KY ROD
REC
SDI(JS)
Common
RDZ=19'
150+00
145+10
65'Lt.
601.1
Interpolated Base of RDZ
Nondurable Shale Class I
Durable Sandstone
Nondurable Shale Class II
Nondurable Shale Class III
Cut Limits from Sta.141+00 to 155+00
Core Log Sta.145+10, 65' Lt.
Elev.601.1-591.8 Overburden
591.8-575.7 Shale: gray, silty, becoming very clayey w/depth
575.7-559.0 Sandstone: brown - gray, fine grained w/carbonaceous shale laminations (Durable)
559.0-543.8 Shale: gray, clayey, increasingly sandy w/depth
543.8-525.1 Shale: (claystone), gray
RDZ=15'
145+00
NOTE : Lithology divisions are not to be indicated on the roadway plans.
CUT STABILITY SECTION
STA. 145+00 & 150+00, US 555
PREPARED BY
CHECKED BY
APPROVED BY
DATE
Cell Library: kytc.cel


COUNTY OF
ITEM NO.
SHEET NO.
SPRINGFIELD
13-765.00
Core Log Sta. 324+00, 50' Lt.
Elev. 981.5-979.0 Overburden
979.0-963.9 Limestone : Lt. gray, fine grained-fine crystalline w/solutioned bedding planes
Open Face Log Sta. 324+00, Lt. Side
Elev. 966.0-953.0 Limestone : Lt. gray, beds 0.5'-1.5' thick
KY
ROD REC
15' OB
969
979
83 100
79 100
48 98
RDZ=5'
Interpolated Base of RDZ
1/4:1
6:1
2:1
324+00
NOTE : The Intermediate Bench @ Elev. 931 transitions from 18' @ Station 320+50 to Zero @ Station 322+00
Cut Limits from Sta. 310+50 to Sta. 326+00
Core Log Sta. 316+50, 37' Lt.
Elev. 964.3-961.2 Overburden
961.2-939.0 Limestone : Tan-Lt. gray, fine crystalline-fine grained
939.0-931.1 Sandstone : Lt. gray, fine grained w/many shale laminations increasing w/depth (Durable)
931.1-923.9 Shale : black, carbonaceous
923.9-918.8 Shale : greenish-gray w/slickensides
918.8-908.5 Shale : Reddish-brown w/many slickensides & a few sandstone laminations
Interpolated Base of RDZ
33 97
71 100
80 100
71 100
25 96
0 94
0 97
SDI(JS)
5 (3)
7 (1)
45 (3)
23 (2)
12 (2)
Lost Water @ 15'
18' IB
931
316+50
990
980
970
960
950
940
930
920
910
150
100
50
0
PREPARED BY
CHECKED BY
APPROVED BY
DATE
Cell Library: kytc.cel
Cell Name: sbp
DD-MMM-YYYY HH:MM
CUT STABILITY SECTION
STA. 316+50 & 324+00, US 555



COUNTY OF | ITEM NO. | SHEET NO.
SPRINGFIELD | 13-765.00
Cut Limits from Sta.1713+00 to 1725+00
Core Log Sta.1718+50, 60'Lt.
Elev.1850.2 - 1845.9 Overburden
1845.9 - 1838.2 Shale: very silty, dark gray, dip 35°
1838.2 - 1830.7 Shale: gray, badly broken
1830.7 - 1829.2 Sandstone: gray, fine grained, dip 25°
1829.2 - 1825.9 Shale: gray, w/interbedded siltstone
1825.9 - 1819.0 Shale: gray, dip 25°- 30°
1819.0 - 1809.7 Shale: gray, silty
1809.7 - 1808.2 Coal (1.5')
1808.2 - 1805.7 Underclay - light gray, sandy
1805.7 - 1799.2 Sandstone: gray, med. grained, dip 20°
1799.2 - 1788.3 Sandstone: gray, (60%) w/interbedded Shale (40%) green
1788.3 - 1779.3 Shale: gray, silty
1779.3 - 1778.5 Coal (0.8')
1778.5 - 1777.2 Shale: gray, dip 25°- 30°
1777.2 - 1776.7 Coal (0.5')
1776.7 - 1771.2 Shale: dark gray
1771.2 - 1758.2 Sandstone: gray, dip 10°- 20°
1758.2 - 1713.2 Shale: black, sandstone and siltstone laminations dip 15°- 20°
1713.2 - 1706.2 Sandstone: gray, fine to med. grained, shaley laminations, dip 15°- 20°
1706.2 - 1680.2 Shale: gray, silty, sandy laminations, coal streaks, dip 20°
1940
1920
1900
1880
1860
1840
1820
1800
1780
1760
1740
1720
1700
1680
KY RQD
REC
SDI(JS)
Vertical Fracture @ 22'
Slickensided @ 41'
78°Joint @ 52'
Slickensides @ 70'
87° Water Stained Fracture @ 80'
75°Joint @ 103'
68°Joint @ 118'
RDZ = 5'
Interpolated Base of RDZ
24°± Bedding Plane)
NOTE :
Centerline Bearing = N 64°W
Strike of Bedding = N 55°W
True Dip = 24°SE
Apparent Dip X-Section = 24°SE
Apparent Dip Centerline = +4°
1718+50
1/2:1
20' IB
1724
18' IB
1756
1785
1815
1845
1875
1905
1923
2:1
Slickensides @ 48'
Vertical Water Stained Joint @ 62'
Vertical Fractures @ 90'-94'
78°Joint @ 120'
68°Joint @ 170'
Slickensides @ 212'
RDZ = 14'
Core Log Sta.1718+50, 260'Rt.
Elev.1933.6 - 1926.2 Overburden
1962.2 - 1913.6 Sandstone: weathered with shale
1913.6 - 1891.6 Sandstone: brown and gray, coarse grained, dip 10°- 20°
1891.6 - 1885.2 Sandstone: brown and gray, coarse to med. coal partings, dip 20°- 25°
1885.2 - 1885.0 Coal (0.2')
1885.0 - 1882.6 Shale: gray, fire clay
1882.6 - 1875.6 Shale: black, carbonaceous
1875.6 - 1860.6 Sandstone: very fine, thin black shale seams, crossbedded, dip 22°- 28°
1860.6 - 1858.6 Sandstone: very fine shale partings, dip 17°- 23°
1858.6 - 1852.6 Shale: black, carbonaceous, silty and sandy, dip 15°
1852.6 - 1822.6 Sandstone: very fine to fine grained
1822.6 - 1784.6 Shale: gray, varved with sandstone, dip 23°- 25°
1784.6 - 1768.6 Shale: black, sandstone lenses, dip 23°
1768.6 - 1730.6 Shale: black, silty
1730.6 - 1721.0 Sandstone: gray, coal streaks
1721.0 - 1720.7 Coal (0.3')
1720.7 - 1712.1 Shale: gray, carbonaceous, becoming silty and black
1712.1 - 1712.0 Coal (0.1')
1712.0 - 1730.6 Shale: gray
Scale : 1"=20'
200
100
℄
100
200
300
Cut Stability Section Sta.1718+50
PREPARED BY ____ DATE ____
CHECKED BY ____ DATE ____
APPROVED BY ____ DATE ____
Cell Library: kytc.cel
Cell Name: ssd
DD-MMM-YYYY HH:MM

CU TRIAXIAL TEST

Project Data:
County: Springfield
Route: US 555

Date: 08/02/04
Operator: B. King

Project #: FD52 129 0555 005-023 009 D
Item #: 13-765.00

Failure Criterion: Maximum Obliquity
Values at Failure:

Circle Number	Time (min)	PWP (psi)	Cell Pressure (psi)	Δ L (in)	Piston Force (P) (lbs)	ε -Vertical Strain	Deviator Stress (psi)	σ_1 (psi)	σ_3 (psi)
1	150	68.37	75	0.3904	133.6348	0.069777	19.54	94.54	75
2	207	62.99	75	0.5342	207.9203	0.095838	29.68	104.68	75
3	210	56.8	75	0.5443	286.1745	0.098143	41.2	116.2	75

Calculated Values:
PQ:

• (deg)	a(psi)
25.7	1.9

% Difference PQ vs. Mohr:

•'(deg)	c'(psf)	•'(deg)	c'(psf)
28.8	305.7	0.31%	0.21%

Test Results Based on Mohr Circle Analysis:

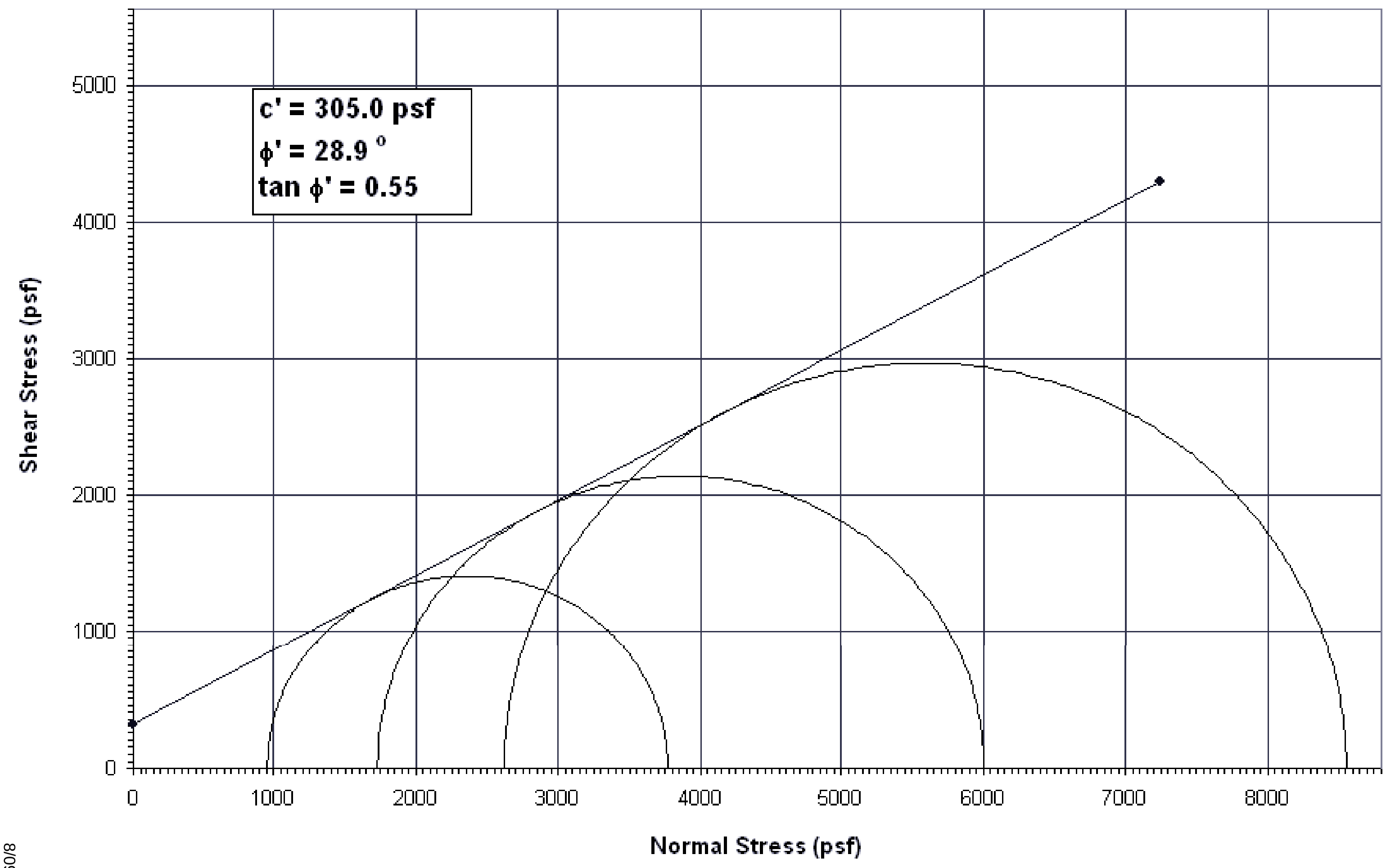
•'(deg)	c'(psf)
28.9	305.0

Comments:

Specimen Data:

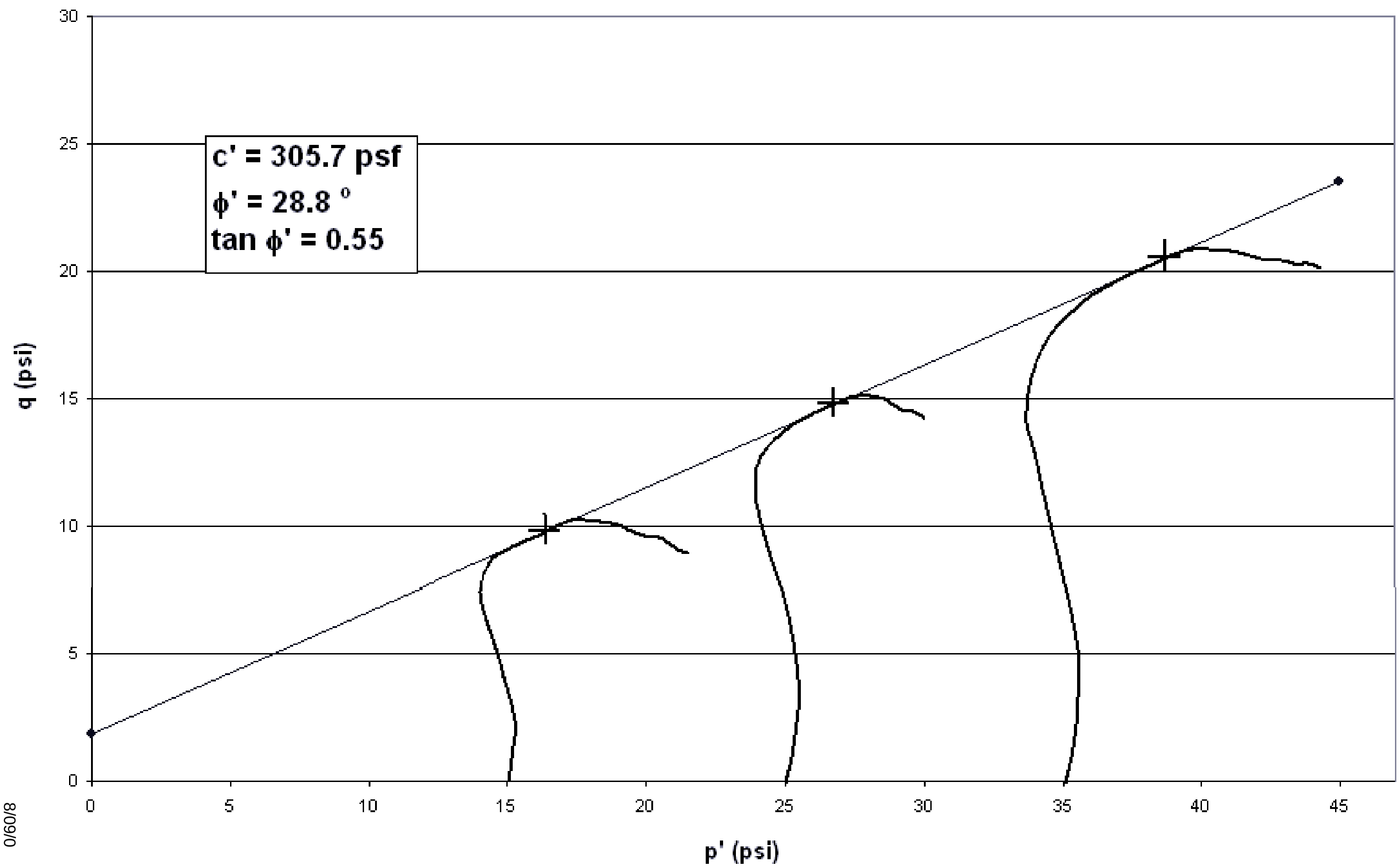
Circle #	Station	Depth	Desription	KMIM #	Initial Pressures: Cell	Initial Pressures: Back	Moisture Content
1	40+50, 20 LT.	15-17.5'	Gray Clay	0019	75	60	20.5%
2	40+50, CL	15-17.5'	Gray Clay	0022	75	50	17.3%
3	40+50, CL	20-22.5'	Gray Clay	0023	75	40	19.2%

CU Triaxial Test - Mohr Circle Analysis



8/09/0

CU Triaxial Test - p'-q Diagram Analysis



0/60/8

KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch
1236 Wilkinson Blvd.
Frankfort, KY 40601
Tested by: Chris Groves
Technical Responsibility: Dean Clements
Consolidated, Undrained Triaxial Compression Test
AASHTO T 297-94

Date:	7/26/2004	County:	Springfield
Operator:	B. King	Station:	40+50
File Name:	Spring_15	Offset:	20' LT.
Item #:	13-765.00	Hole #:	35
Project #:	FD52 129 0555 005-023 009 D	Depth:	15-17.5'
Mars #:	6895401D	Visual Description:	Gray Clay
Load Frame #:	1	Panel #:	1
Cell #:	1		

Penetrometer/Torvane Readings:

1.)	0.5
2.)	0.7
3.)	0.4
Avgerage:	0.5

Moisture Content:

	Initial	Final
Can #:	105	28
Tare (g):	46.3	55.12
Wet Sample + Tare (g):	336.2	113.96
Dry Sample + Tare (g):	286.9	102.63
Moisture Content:	20.5	23.8

Sample Diameter (# . # # # in.):

1.)	2.723
2.)	2.891
3.)	2.798
Avgerage:	2.804

Initial Weight (g): 1238.4

Sample Height (# . # # # in.):

1.)	5.862
2.)	5.731
3.)	5.815
Avgerage:	5.803

Saturation Pressure:

Cell (psi): 62
Back (psi): 60

B-Value Determination:

Pressure, ***u***, before increasing $\bullet_3$ (psi):	59.5
Pressure, ***u***, after increasing $\bullet_3$ (psi):	69.3
B-Value (Δ***u***/$\Delta\bullet_3$):	98 %

Consolidation Pressure:

Cell (psi): 75
Back (psi): 60

Shear:

20%
0.0025 in./min.

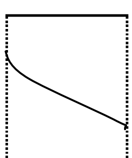
Piston Measurement (in.): 5.176 (before saturation)

Consolidation Data:

Start Date: 7/27/04
Start Time: 8:00 AM

Time (Min.)	Alternate Units	Burette Reading	Piston Reading
0	0 (sec)	49.3	5.190
0.1	6 (sec)	48.5	
0.2	12 (sec)	47.2	
0.5	30 (sec)	46.9	
1	1 (min)	46.5	
2	2 (min)	46.0	
4	4 (min)	45.3	
8	8 (min)	44.2	
15	15 (min)	42.8	5.126
30	30 (min)	41.1	5.109
60	1 (hr)	38.7	5.085
120	2 (hr)	36.1	5.060
240	4 (hr)	33.5	5.034
480	8 (hr)	31.2	5.011
1440	24 (hr)	29.6	4.995

Failure Sketch:



Remarks:

KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch
1236 Wilkinson Blvd.
Frankfort, KY 40601
Tested by: Chris Groves
Technical Responsibility: Dean Clements
Consolidated, Undrained Triaxial Compression Test
AASHTO T 297-94

Date:	7/26/2004	County:	Springfiled
Operator:	B. King	Station:	40+50
File Name:	Spring_15	Offset:	CL
Item #:	13-765.00	Hole #:	36
Project #:	FD52 129 0555 005-023 009 D	Depth:	15-17.5'
Mars #:	6895401D	Visual Description:	Gray Clay
Load Frame #:	1	Panel #:	1
Cell #:	2		

Penetrometer/Torvane Readings:

1.)	0.8
2.)	0.3
3.)	0.4
Avgerage:	0.5

Moisture Content:

	Initial	Final
Can #:	3	60
Tare (g):	48	54.52
Wet Sample + Tare (g):	339	116.01
Dry Sample + Tare (g):	296	102.27
Moisture Content:	17.3	28.8

Sample Diameter (# . # # # in.):

1.)	2.753
2.)	2.855
3.)	2.796
Avgerage:	2.801

Initial Weight (g): 1210.5

Sample Height (# . # # # in.):

1.)	5.891
2.)	5.828
3.)	5.811
Avgerage:	5.843

Saturation Pressure:

Cell (psi):	62
Back (psi):	60

B-Value Determination:

Pressure, ***u***, before increasing • 3 (psi):	59.4
Pressure, ***u***, after increasing • 3 (psi):	69.3
B-Value (Δ***u***/Δ• 3):	99 %

Consolidation Pressure:

Cell (psi):	75
Back (psi):	50

Shear:
20%
0.0025 in./min.

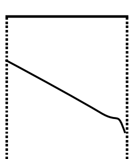
Piston Measurement (in.): 5.178 (before saturation)

Consolidation Data:

Start Date: 7/28/04
Start Time: 8:00 AM

Time (Min.)	Alternate Units	Burette Reading	Piston Reading
0	0 (sec)	49.2	5.193
0.1	6 (sec)	47.7	
0.2	12 (sec)	47.4	
0.5	30 (sec)	47.0	
1	1 (min)	46.5	
2	2 (min)	46.0	
4	4 (min)	45.2	
8	8 (min)	44.3	
15	15 (min)	43.0	5.132
30	30 (min)	41.4	5.116
60	1 (hr)	39.4	5.096
120	2 (hr)	37.4	5.076
240	4 (hr)	36.0	5.062
480	8 (hr)	35.7	5.059
1440	24 (hr)	35.4	5.056

Failure Sketch:



Remarks:

KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch
1236 Wilkinson Blvd.
Frankfort, KY 40601

Tested by: B. King

Technical Responsibility: R. Mcdonald

Consolidated, Undrained Triaxial Compression Test
AASHTO T 297-94

Date:	7/26/2004	County:	Springfield
Operator:	C. Doe	Station:	40+50
File Name:	Spring_15	Offset:	CL
Item #:	13-765.00	Hole #:	36
Project #:	FD52 129 0555 005-023 009 D	Depth:	20-22.5'
Mars #:	6895401D	Visual Description:	Gray Clay
Load Frame #:	1	Panel #:	1
Cell #:	3		

Penetrometer/Torvane Readings:

1.)	0.6
2.)	0.5
3.)	0.4
Avgerage:	0.5

Moisture Content:

	Initial	Final
Can #:	25	63
Tare (g):	46.4	55.42
Wet Sample + Tare (g):	283.2	159.68
Dry Sample + Tare (g):	245	141.76
Moisture Content:	19.2	20.8

Sample Diameter (# . # # # in.):

1.)	2.823
2.)	2.894
3.)	2.806
Avgerage:	2.841

Initial Weight (g): 1227.3

Sample Height (# . # # # in.):

1.)	5.862
2.)	5.799
3.)	5.828
Avgerage:	5.830

Saturation Pressure:

Cell (psi):	62
Back (psi):	60

B-Value Determination:

Pressure, ***u*** , before increasing • $_3$ (psi):	60.2
Pressure, ***u*** , after increasing • $_3$ (psi):	70.2
B-Value (Δ***u*** /Δ• $_3$):	100 %

Consolidation Pressure:

Cell (psi):	75
Back (psi):	40

Shear:
20%
0.0025 in./min.

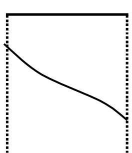
Piston Measurement (in.): 5.147 (before saturation)

Consolidation Data:

Start Date: 7/29/04
Start Time: 8:00 AM

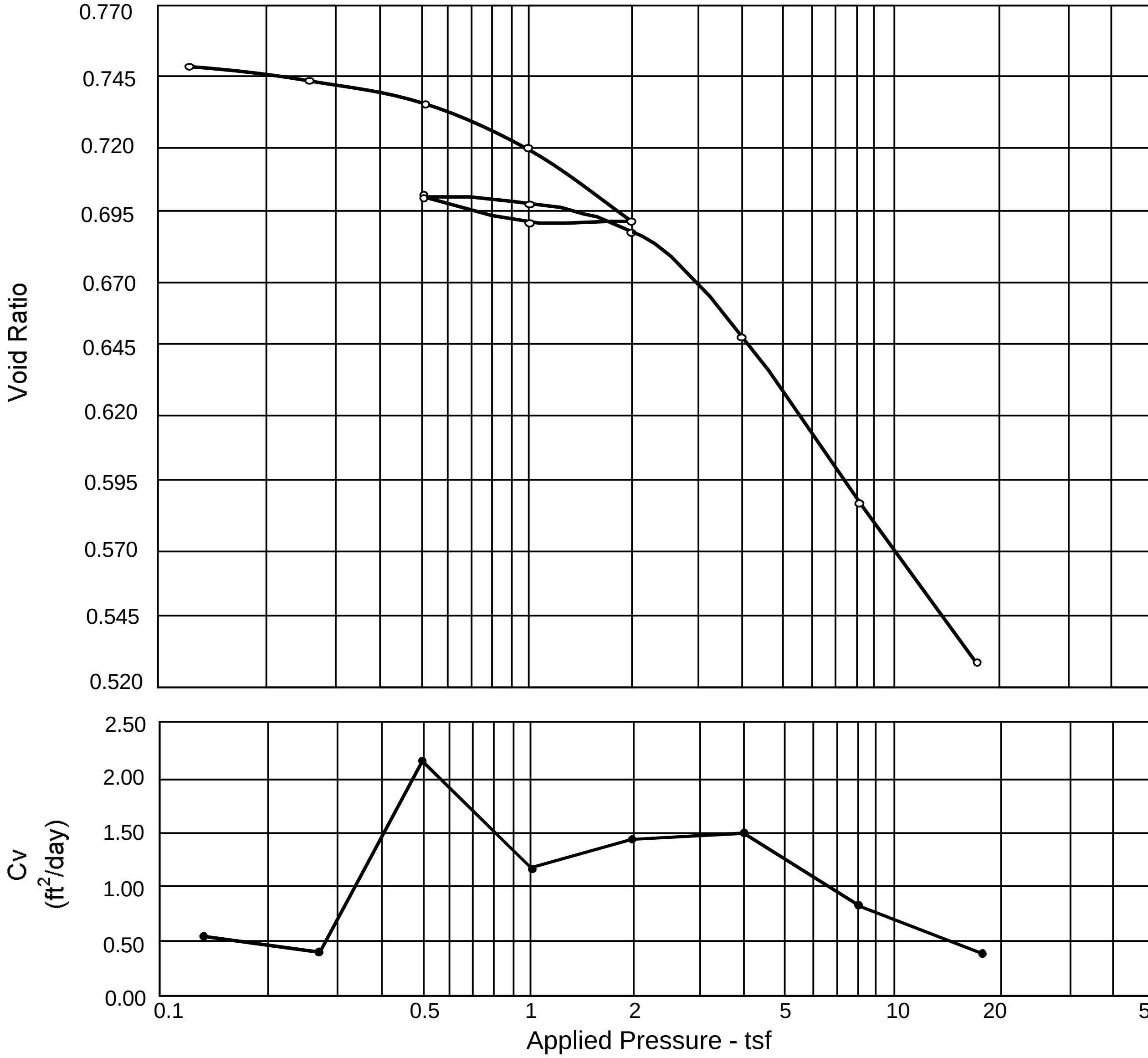
Time (Min.)	Alternate Units	Burette Reading	Piston Reading
0	0 (sec)	49.3	5.161
0.1	6 (sec)	43.0	
0.2	12 (sec)	42.1	
0.5	30 (sec)	40.2	
1	1 (min)	38.5	
2	2 (min)	36.6	
4	4 (min)	34.8	
8	8 (min)	33.3	
15	15 (min)	32.5	4.999
30	30 (min)	32.1	4.995
60	1 (hr)	31.9	4.993
120	2 (hr)	31.7	4.992
240	4 (hr)	31.5	4.990
480	8 (hr)	31.4	4.989
1440	24 (hr)	31.4	4.989

Failure Sketch:



Remarks:

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_0
Sat.	Moist.											
100.0%	26.8%	78.6	43	19	2.75	0.6	1.7	0.26	0.02			0.7551

MATERIAL DESCRIPTION	USCS	AASHTO
Gray Silty - Clay	CL	A-7-6(19)

Project No. 0023 Client: Brown County
Project: FD52 121 0158 005-008 01 D

Location: 40+50 CL Hole No. 36

Remarks :

Consolidation Test Report

Kentucky Transportation Cabinet, Div. Of Materials

GEOTECHNICAL SYMBOL SHEET

AASHTO Classification of Soils and Soil-Aggregate Mixtures

General Classification	Granular Materials (35% or less passing 0.075 mm)							Silt-Clay Materials (More than 35% passing 0.075 mm)			
Group Classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 A-7-6
Sieve Analysis, Percent Passing											
2.00 mm (No. 10)	50 max	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
0.425 mm (No. 40)	30 max	50 max	51 min	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
0.075 mm (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of Fraction Passing 0.425 mm (No. 40)											
Liquid Limit	- - -		- - -	40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity Index	6 max		N.P.	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min

Unified Soil Classifications

MAJOR DIVISIONS		SYMBOL		NAME
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW		Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP		Poorly graded gravels or gravel-sand mixtures, little or no fines.
		GM		Silty gravels, gravel-sand-silt mixtures.
		GC		Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW		Well graded sands or gravelly sands, little or no fines.
		SP		Poorly graded sands or gravelly sands, little or no fines.
		SM		Silty sands, sand-silt mixtures.
		SC		Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS LL IS LESS THAN 50	ML		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays silty clays, lean clays.
	SILTS AND CLAYS LL IS GREATER THAN 50	MH		Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH		Inorganic clays of high plasticity, fat clays.
UNCLASSIFIED MATERIAL		NONE		Non-classified material(i.e. overburden, pavement, slag, etc.) Include visual description.

PI	Plasticity Index
AI	Activity Index
LI	Liquidity Index
S+C	Silt + Clay (% finer than No.200 Sieve)
	Rockline Soundings
	Disturbed Sample Boring
	Undisturbed Sample Boring
	Undisturbed Sample Boring & Rock Core
	Rock Core
	Slope Inclinometer Installation typical applications:
OW	Observation Well
(Date)	Water Elevation
VS (psf)	Field Vane Shear Strength
	Thin-walled Tube Sample
<	Standard Penetration Test Sample
N	Penetration Resistance
Qu (psf)	Unconfined Compressive Strength
UU (psf)	Unconsolidated Undrained Triaxial Strength
W%	Moisture Content
KY RQD	Rock Quality Designation (Kentucky Method)
Std RQD	Rock Quality Designation (Standard Method)
SDI(JS)	Slake Durability Index (Jar Slake Test)
REC	Core Recovery
ϕ	Angle of Internal Friction (Total Stress)
$\bar{\phi}$	Angle of Internal Friction (Effective Stress)
c (psf)	Cohesion (Total Stress)
$\bar{c}$ (psf)	Cohesion (Effective Stress)
γ (pcf)	Total Unit Weight
RDZ	Rock Disintegration Zone
OB	Overburden Bench
IB	Intermediate Bench
R	Refusal
NR	Refusal Not Encountered

LIMESTONE

SANDSTONE

DURABLE SHALE (SDI ≥95)

NONDURABLE SHALE (SDI< 95)

COAL

TALUS, MINE WASTE, FILL MATERIAL, BOULDERS, & ETC.

GRANULAR EMBANKMENT

STRUCTURE GRANULAR BACKFILL

SLOPE PROTECTION

GEOTECHNICAL SYMBOL SHEET

PREPARED BY ____ DATE ____
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APPROVED BY ____ DATE ____

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COUNTY OF	ITEM NO.	SHEET NO.
SPRINGFIELD	15-765.00	

GEOTECHNICAL NOTES

1). In accordance with Section 206 of the current Standard Specifications, the moisture content of embankment material shall not vary from the optimum moisture content as determined by KM 64-511 by more than +2 percent or less than -2 percent. This moisture content requirement shall have equal weight with the density requirement when determining the acceptability of embankment construction. Refer to the Family of Curves for moisture/density correlation.

2). All soils, whether from roadway or borrow, may require manipulation to obtain proper moisture content prior to compaction. Direct payment shall not be permitted for rehandling, hauling, stockpiling, and/or manipulating soils.

3). Excavation of surface ditches and channel changes adjacent to embankment areas shall be performed prior to the placement of the adjacent embankments. The material excavated for the channel changes and surface ditches is suitable for embankment construction if dried to proper moisture content in accordance with Section 206 of the current Standard Specifications.

4). The contractor is responsible for conducting any operations necessary to excavate the cut areas to the required typical section. These operations shall be incidental to the roadway price.

5). Perforated pipe for subgrade drainage shall be placed in vertical sags in accordance with RDP-005 at the following approximate locations and/or where designated by the Engineer.

<u>MAINLINE</u>
Station 219+75 — Station 292+00 — Station 374+00

<u>Bushong Rd.</u> Station 52+50
<u>Connection #1</u> Station 50+50
<u>KY 678 West</u> Station 47+00

6). The contractor shall construct foundation embankment benches and transverse benches as indicated on the plans and/or as directed by the Engineer, prior to placement of embankments in areas requiring such benches.

7). Transverse benching and/or perforated pipe underdrains shall be installed at the following approximate locations and any others designated by the Engineer. Contrary to Standard Drawing RDP-006, transverse benches and perforated pipe underdrains shall be placed on both the upgrade and downgrade cut to fill transitions.

<u>MAINLINE</u>

Station 224+90	Station 238+10	Station 247+50	Station 263+00
Station 268+40	Station 278+00	Station 282+80	Station 289+30
Station 303+90	Station 307+75	Station 316+80	Station 330+90
Station 342+60	Station 346+40	Station 352+00	Station 361+50
Station 368+75	Station 370+30	Station 373+60	Station 387+50
Station 393+75	Station 412+50	Station 422+25	Station 433+80
Station 443+70			

<u>Rockbridge School Rd.</u> Station 49+90
<u>KY 678 East</u> Station 56+25

8). Foundation embankment benches shall be placed in accordance with Standard Drawing RGX-010 at the locations listed below and/or as directed by the Engineer.

<u>MAINLINE</u>

Stations 242+75 to 243+25 Rt.	Stations 243+75 to 246+75 Lt.
Stations 264+75 to 266+75 Rt.	Stations 316+25 to 317+25 Lt.
Stations 330+75 to 334+75 Lt.	Stations 348+75 to 354+75 Rt.
Stations 373+25 to 374+25 Lt.	Stations 409+25 to 412+75 Rt.
Stations 426+25 to 431+75 Rt.	Stations 432+75 to 433+75 Lt.
Stations 443+75 to 444+25 Rt.	

9). The contractor shall conduct grading operations in such a manner that limestone and/or durable shale (SDI ≥ 95) from roadway excavation be stockpiled separately or otherwise manipulated so that ample quantities are available for those areas requiring said material. No direct payment will be allowed for such necessary manipulating as stockpiling, hauling and/or handling the material.

10). The contractor shall conduct grading operations in such a manner that soil from roadway excavation be stockpiled separately or otherwise manipulated so that ample quantities are available for a chemically stabilized roadbed meeting the specifications in Section 208 of the current Standard Specifications for Road and Bridge Construction. No direct payment will be allowed for such necessary manipulating as stockpiling, hauling and/or handling the material.

11). Any saturated, unstable material encountered in existing creek beds and/or drainage swales within embankment foundation limits shall be drained and stabilized with 3-ft. of limestone and/or durable shale from roadway excavation or as directed by the Engineer. Positive drainage shall be maintained to prevent trapping water within the roadway embankment. The placement of this material is incidental to the unit bid price for roadway excavation or embankment-in-place.

12). Some of the soil horizons and slopes on the project are subject to erosion. Necessary procedures in accordance with Sections 212 and 213 of the current Standard Specifications shall be followed on construction.

13). The following cut intervals shall be constructed with 2 1/2:1 or flatter slopes.

<u>MAINLINE</u>

Stations 247+50 to 263+00	Stations 268+50 to 276+50
Stations 304+00 to 308+00 Left Side	Stations 342+50 to 346+50 Right Side
Stations 361+50 to 368+50	Stations 370+50 to 373+50
Stations 412+50 to 422+00	Stations 434+00 to 443+50

<u>KY 678 West</u> Stations 46+50 to 50+00
<u>John Eaton Rd.</u> Stations 44+50 to 56+50

14). The following cut intervals shall be constructed with 3:1 or flatter slopes. Stability Sheets are attached.

<u>MAINLINE</u>
Stations 225+00 to 238+50 — Stations 316+50 to 331+50

15). Appropriate treatment, as outlined in the Standard Specifications, shall apply to all cisterns, septic tanks, and associated lateral lines within the construction limits.

16). A possible spring and or pump house was noted during the field investigation at the following approximate locations. A spring box with a pipe outlet at the toe of slope shall be constructed if the Engineer determines that a defined area of flow can be located. If not, a two- (2) foot thick drainage blanket wrapped in Geotextile Fabric, Type IV shall be placed approximately 12 feet wide to the toe of the embankment to assure positive drainage. The fabric shall be in accordance with Section 214 & 843, Type IV of the current edition of Standard Specifications for Road and Bridge Construction. The drainage blanket material shall consist of "Coarse Aggregate for Rock Drainage Blanket" in accordance with the current edition of Section 805 of the Standard Specifications for Road and Bridge Construction, except natural sand will not be permitted.

<u>MAINLINE</u>
Station 264+50 25' Rt. — Station 346+65 Centerline — Station 425+75 Centerline

17). The ponds at the following approximate locations are within roadway cut limits and shall be drained. Any soft, saturated material excavated from this cut area may not be suitable for use in embankments. Use of this material shall be limited to final dressing of roadway slopes, as directed by the Engineer.

<u>MAINLINE</u>
Station 235+50 100' Rt. — Station 252+30 40' Lt.

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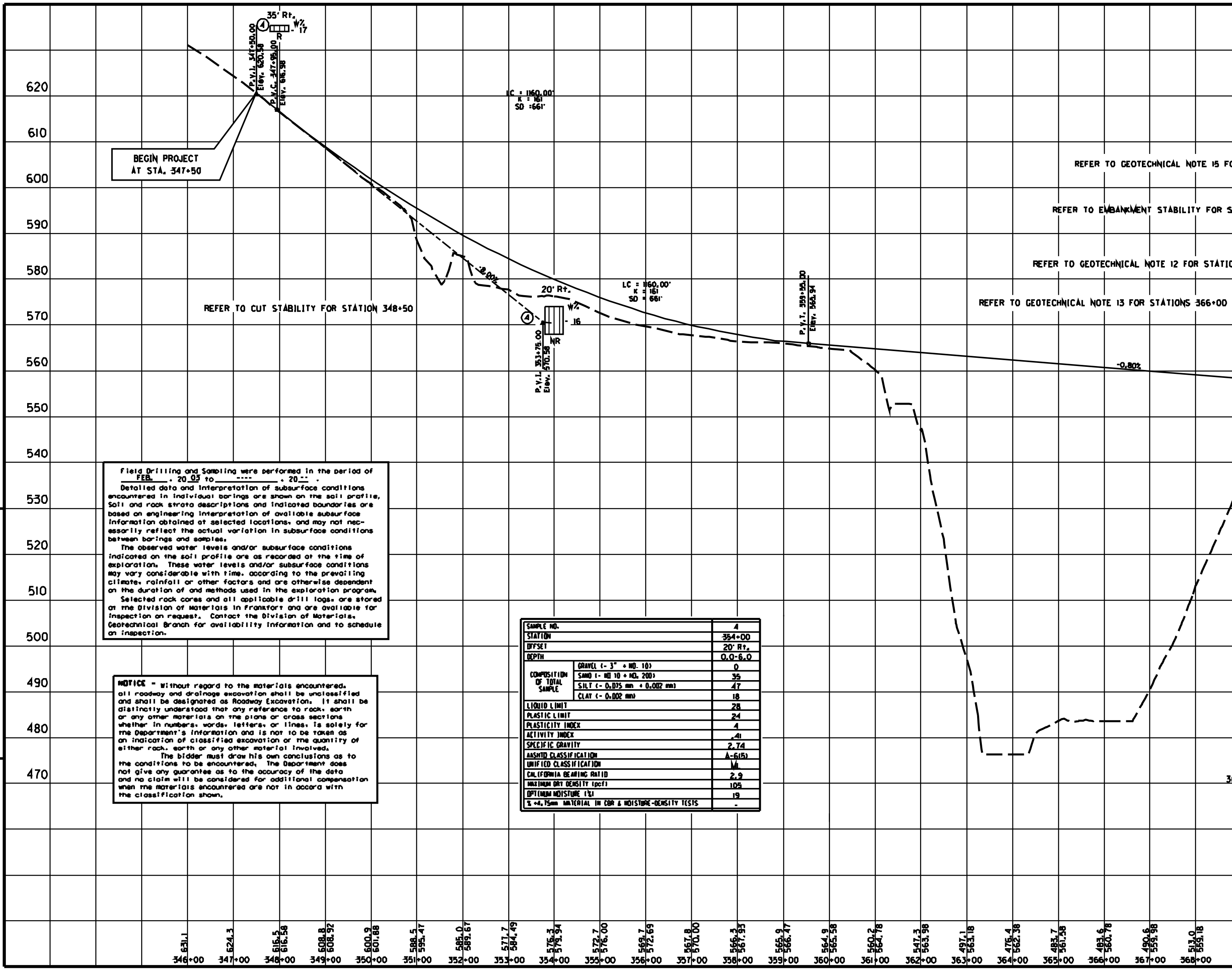
KENTUCKY
DEPARTMENT OF HIGHWAYS
COUNTY OF
SPRINGFIELD

PROJECT NUMBERS ____

GEOTECHNICAL NOTES

COUNTY OF	ITEM NO.	SHEET NO.
SPRINGFIELD	13-765.00	



Field Drilling and Sampling were performed in the period of FEB. , 20 05 to ________ , 20 __ .
Detailed data and interpretation of subsurface conditions encountered in individual borings are shown on the soil profile. Soil and rock strata descriptions and indicated boundaries are based on engineering interpretation of available subsurface information obtained at selected locations, and may not necessarily reflect the actual variation in subsurface conditions between borings and samples.
The observed water levels and/or subsurface conditions indicated on the soil profile are as recorded at the time of exploration. These water levels and/or subsurface conditions may vary considerable with time, according to the prevailing climate, rainfall or other factors and are otherwise dependent on the duration of and methods used in the exploration program.
Selected rock cores and all applicable drill logs, are stored at the Division of Materials in Frankfort and are available for inspection on request. Contact the Division of Materials, Geotechnical Branch for availability information and to schedule an inspection.

NOTICE - Without regard to the materials encountered, all roadway and drainage excavation shall be unclassified and shall be designated as Roadway Excavation. It shall be distinctly understood that any reference to rock, earth or any other materials on the plans or cross sections whether in numbers, words, letters, or lines, is solely for the Department's information and is not to be taken as an indication of classified excavation or the quantity of either rock, earth or any other material involved.
The bidder must draw his own conclusions as to the conditions to be encountered. The Department does not give any guarantee as to the accuracy of the data and no claim will be considered for additional compensation when the materials encountered are not in accord with the classification shown.

SAMPLE NO.		4
STATION		354+00
OFFSET		20' Rt.
DEPTH		0.0-6.0
COMPOSITION OF TOTAL SAMPLE	GRAVEL (- 3" + NO. 10)	0
	SAND (- NO 10 + NO. 200)	35
	SILT (- 0.075 mm + 0.002 mm)	47
	CLAY (- 0.002 mm)	18
LIQUID LIMIT		28
PLASTIC LIMIT		24
PLASTICITY INDEX		4
ACTIVITY INDEX		.41
SPECIFIC GRAVITY		2.74
AASHTO CLASSIFICATION		A-6(5)
UNIFIED CLASSIFICATION		ML
CALIFORNIA BEARING RATIO		2.9
MAXIMUM DRY DENSITY (pcf)		105
OPTIMUM MOISTURE (%)		19
% +4.75mm MATERIAL IN CBR & MOISTURE-DENSITY TESTS		-

PREPARED BY ________ DATE ________
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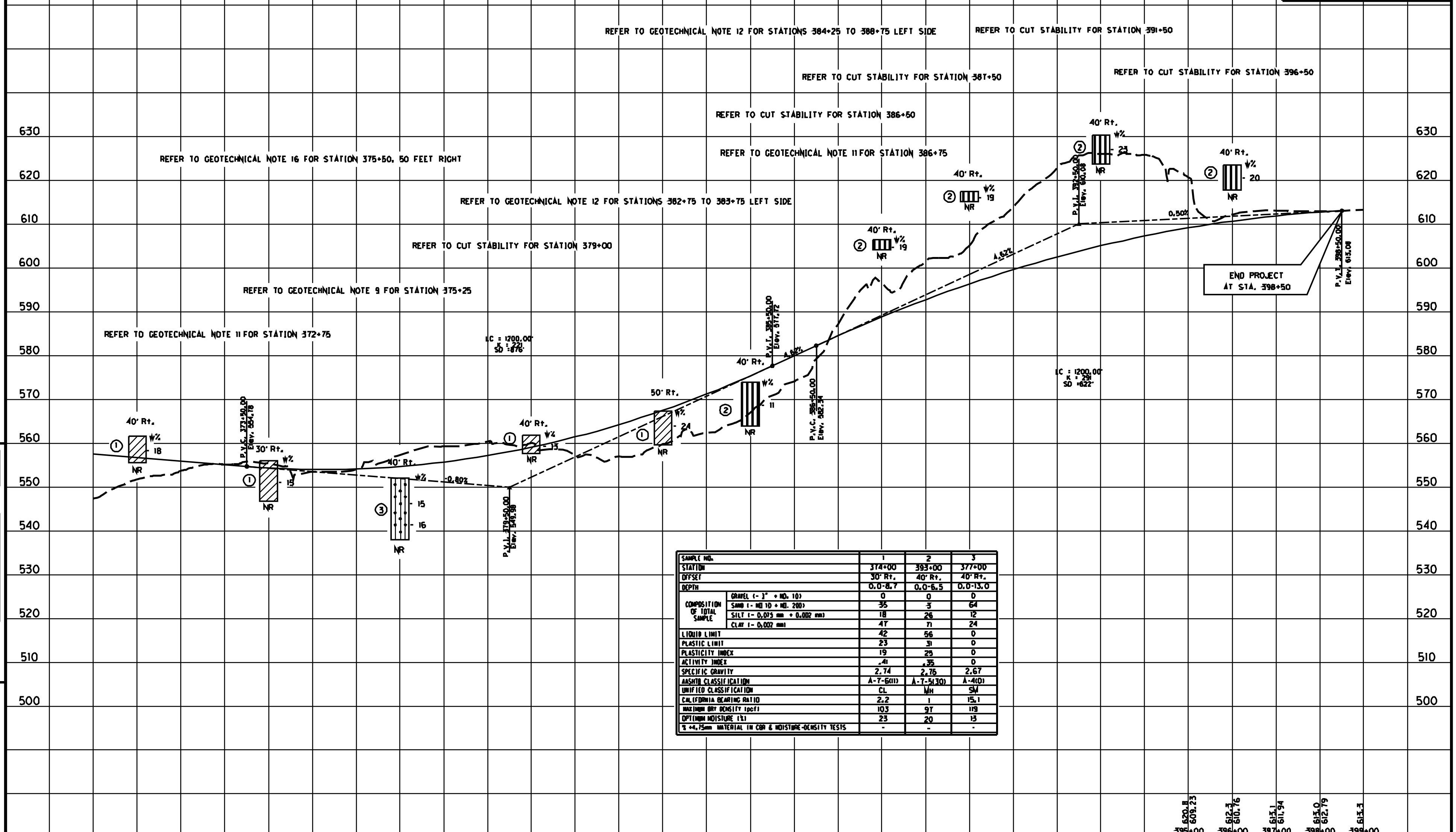
KENTUCKY
DEPARTMENT OF HIGHWAYS
COUNTY OF
SPRINGFIELD

PROJECT NUMBERS ________

SOIL PROFILE, STA. 347+50 TO 370+00



SAMPLE NO.		1	2	3
STATION		374+00	393+00	377+00
OFFSET		30' Rt.	40' Rt.	40' Rt.
DEPTH		0.0-8.7	0.0-6.5	0.0-13.0
COMPOSITION OF TOTAL SAMPLE	GRAVEL (- 3" + NO. 10)	0	0	0
	SAND (- NO 10 + NO. 200)	35	3	64
	SILT (- 0.075 mm + 0.002 mm)	18	26	12
	CLAY (- 0.002 mm)	47	71	24
LIQUID LIMIT		42	56	0
PLASTIC LIMIT		23	31	0
PLASTICITY INDEX		19	25	0
ACTIVITY INDEX		.41	.35	0
SPECIFIC GRAVITY		2.74	2.75	2.67
AASHTO CLASSIFICATION		A-7-6(11)	A-7-5(30)	A-4(0)
UNIFIED CLASSIFICATION		CL	MH	SM
CALIFORNIA BEARING RATIO		2.2	1	15.1
MAXIMUM DRY DENSITY (pcf)		103	97	119
OPTIMUM MOISTURE (%)		23	20	13
% +4.75mm MATERIAL IN CBR & MOISTURE-DENSITY TESTS		-	-	-

Station	Elevations
370+00	547.4 / 557.58
371+00	551.8 / 556.78
372+00	553.8 / 555.98
373+00	555.2 / 555.18
374+00	555.5 / 554.44
375+00	553.6 / 554.09
376+00	554.1 / 554.19
377+00	557.4 / 554.75
378+00	559.3 / 555.76
379+00	560.4 / 557.22
380+00	560.1 / 559.13
381+00	557.5 / 561.49
382+00	557.0 / 564.31
383+00	559.8 / 567.57
384+00	562.4 / 571.29
385+00	567.1 / 575.46
386+00	574.2 / 580.03
387+00	587.4 / 584.61
388+00	596.7 / 588.89
389+00	601.6 / 592.83
390+00	605.2 / 596.42
391+00	614.1 / 599.67
392+00	622.9 / 602.57
393+00	626.1 / 605.13
394+00	625.9 / 607.35
395+00	620.8 / 609.23
396+00	612.3 / 610.76
397+00	613.1 / 611.94
398+00	613.0 / 612.79
399+00	613.3

SOIL PROFILE, STA. 370+00 TO 398+50

PAGE 2

PREPARED BY ________ DATE ________
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COUNTY OF	ITEM NO.	SHEET NO.
SPRINGFIELD	13-T66.00	

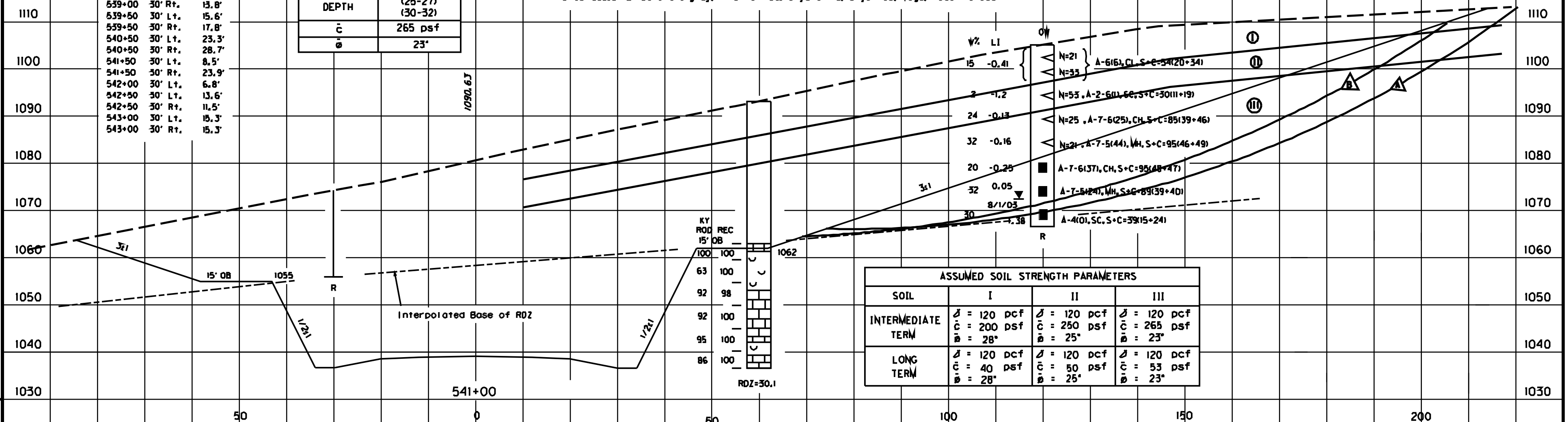
Additional Rockline Soundings

Station	Offset	Depth to Refusal
538+00	30' Lt.	25.1'
538+50	30' Lt.	31.3'
538+50	30' Rt.	6.8'
539+00	30' Lt.	7.3'
539+00	30' Rt.	13.8'
539+50	30' Lt.	15.6'
539+50	30' Rt.	17.8'
540+50	30' Lt.	23.3'
540+50	30' Rt.	28.7'
541+50	30' Lt.	8.5'
541+50	30' Rt.	23.9'
542+00	30' Lt.	6.8'
542+50	30' Lt.	13.6'
542+50	30' Rt.	11.5'
543+00	30' Lt.	15.3'
543+00	30' Rt.	15.3'

SUMMARY OF TRIAXIAL TEST DATA	
STATION	541+00
OFFSET	120' Rt.
DEPTH	(25-27) (30-32)
c̄	265 psf
ø̄	23°

Core Log Sta. 541+00, 60' Rt.
Elev. 1095.0-1064.9 Overburden
1064.9-1063.3 Limestone : gray, fine crystalline w/irregular shale laminations
1063.3-1055.0 Shale : (Siltstone) gray, w/limestone partings & lenses
1055.0-1044.1 Limestone : gray, fine to coarse crystalline, small vugs, fossiliferous zones
1044.1-1041.3 Shale : (Siltstone) gray w/Limestone lenses
1041.3-1038.5 Limestone : gray, fine to med. crystalline, styolites, vugs, fossiliferous

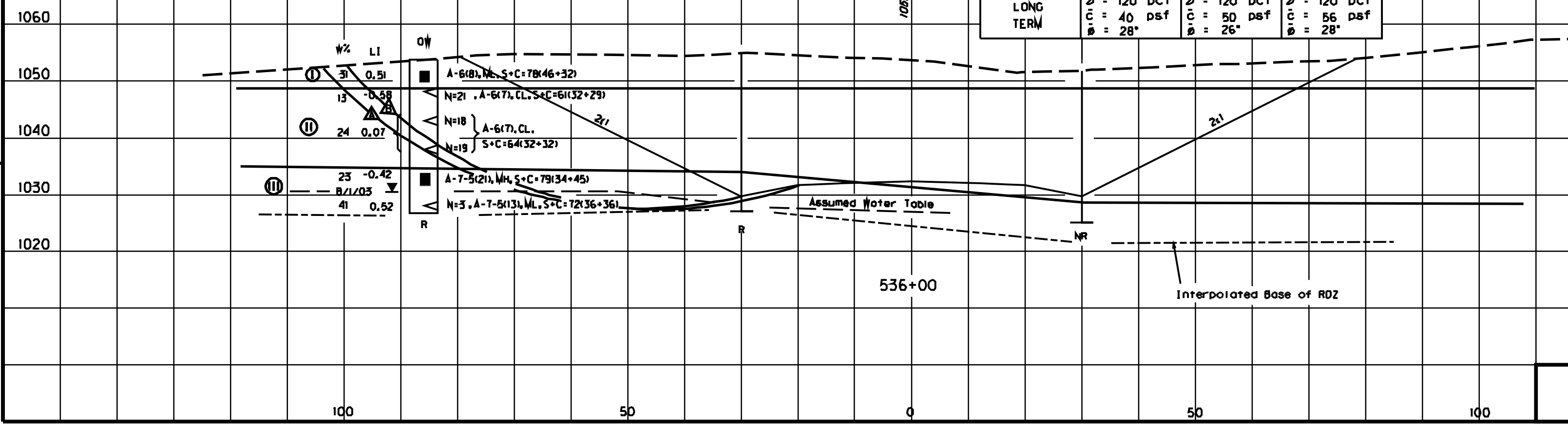
FACTORS OF SAFETY		
INTERMEDIATE TERM	A	1.9
LONG TERM	B	1.5



ASSUMED SOIL STRENGTH PARAMETERS			
SOIL	I	II	III
INTERMEDIATE TERM	γ = 120 pcf c̄ = 200 psf ø̄ = 28°	γ = 120 pcf c̄ = 250 psf ø̄ = 25°	γ = 120 pcf c̄ = 265 psf ø̄ = 23°
LONG TERM	γ = 120 pcf c̄ = 40 psf ø̄ = 28°	γ = 120 pcf c̄ = 50 psf ø̄ = 25°	γ = 120 pcf c̄ = 53 psf ø̄ = 23°

FACTORS OF SAFETY		
INTERMEDIATE TERM	A	2.1
LONG TERM	B	1.4

ASSUMED SOIL STRENGTH PARAMETERS			
SOIL	I	II	III
INTERMEDIATE TERM	γ = 120 pcf c̄ = 200 psf ø̄ = 28°	γ = 120 pcf c̄ = 250 psf ø̄ = 25°	γ = 120 pcf c̄ = 280 psf ø̄ = 22°
LONG TERM	γ = 120 pcf c̄ = 40 psf ø̄ = 28°	γ = 120 pcf c̄ = 50 psf ø̄ = 26°	γ = 120 pcf c̄ = 56 psf ø̄ = 28°



Additional Rockline Soundings

Station	Offset	Depth to Refusal
533+00	30' Lt.	9.3'
533+00	30' Rt.	19.3'
533+50	30' Lt.	15.0'
533+50	30' Rt.	21.2'
534+50	30' Lt.	18.1'
534+50	30' Rt.	24.8'
535+00	30' Lt.	14.4'
535+50	30' Lt.	21.3'
535+50	30' Rt.	26' NR
536+50	30' Lt.	32' NR
536+50	30' Rt.	29' NR
537+00	30' Lt.	32' NR
537+00	30' Rt.	22.4'
537+50	30' Lt.	31.6'
537+50	30' Rt.	28.1'

150

CUT STABILITY SECTION
STA. 536+00 & 541+00

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APPROVED BY ______ DATE ______

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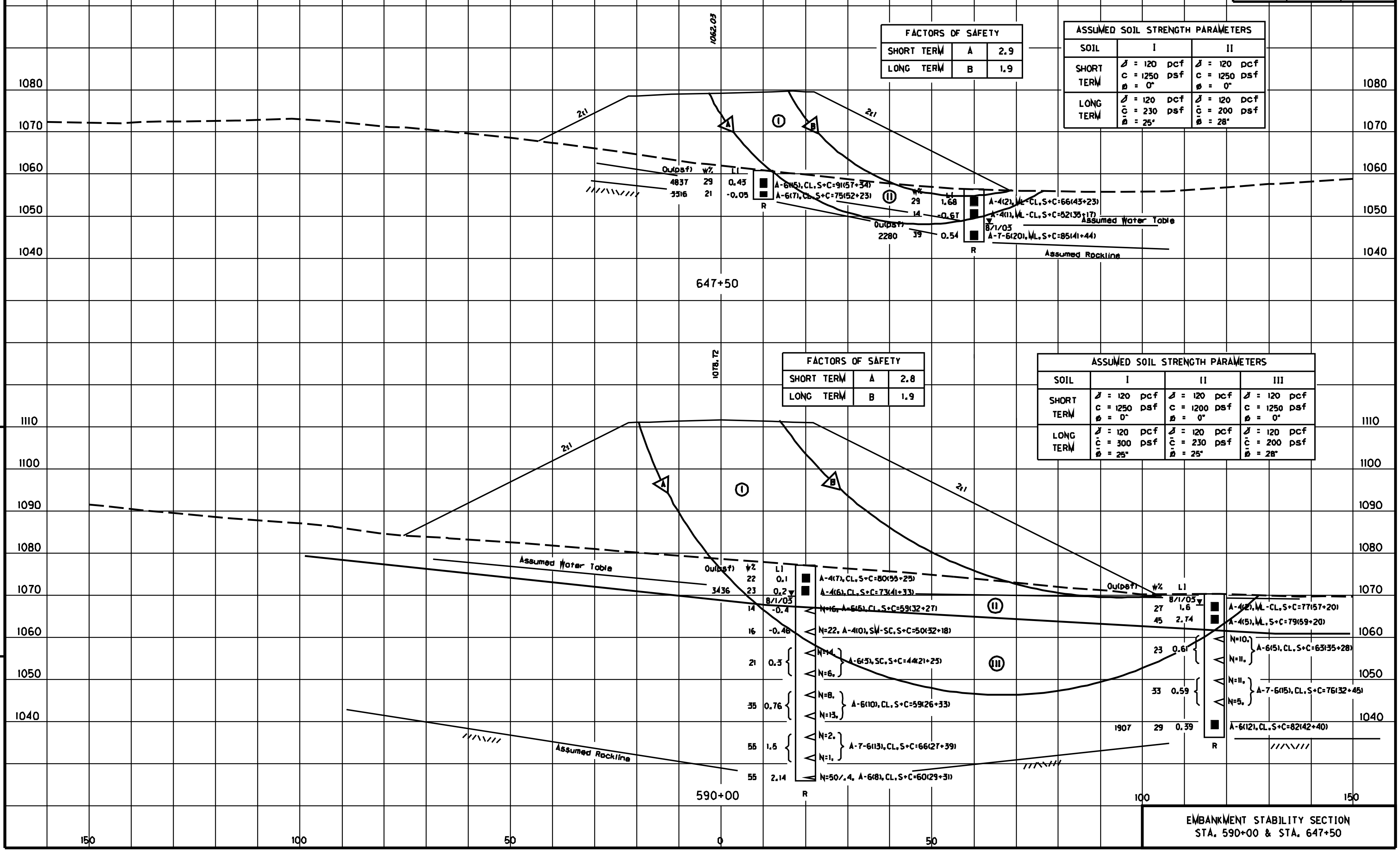
COUNTY OF	ITEM NO.	SHEET NO.
SPRINGFIELD	13-765.00	



FACTORS OF SAFETY (Sta. 647+50)

SHORT TERM	A	2.9
LONG TERM	B	1.9

ASSUMED SOIL STRENGTH PARAMETERS (Sta. 647+50)

SOIL	I	II
SHORT TERM	γ = 120 pcf c = 1250 psf ø = 0°	γ = 120 pcf c = 1250 psf ø = 0°
LONG TERM	γ = 120 pcf c̄ = 230 psf ø̄ = 25°	γ = 120 pcf c̄ = 200 psf ø̄ = 28°

FACTORS OF SAFETY (Sta. 590+00)

SHORT TERM	A	2.8
LONG TERM	B	1.9

ASSUMED SOIL STRENGTH PARAMETERS (Sta. 590+00)

SOIL	I	II	III
SHORT TERM	γ = 120 pcf c = 1250 psf ø = 0°	γ = 120 pcf c = 1200 psf ø = 0°	γ = 120 pcf c = 1250 psf ø = 0°
LONG TERM	γ = 120 pcf c̄ = 300 psf ø̄ = 25°	γ = 120 pcf c̄ = 230 psf ø̄ = 25°	γ = 120 pcf c̄ = 200 psf ø̄ = 28°

EMBANKMENT STABILITY SECTION
STA. 590+00 & STA. 647+50

PREPARED BY ______ DATE ______
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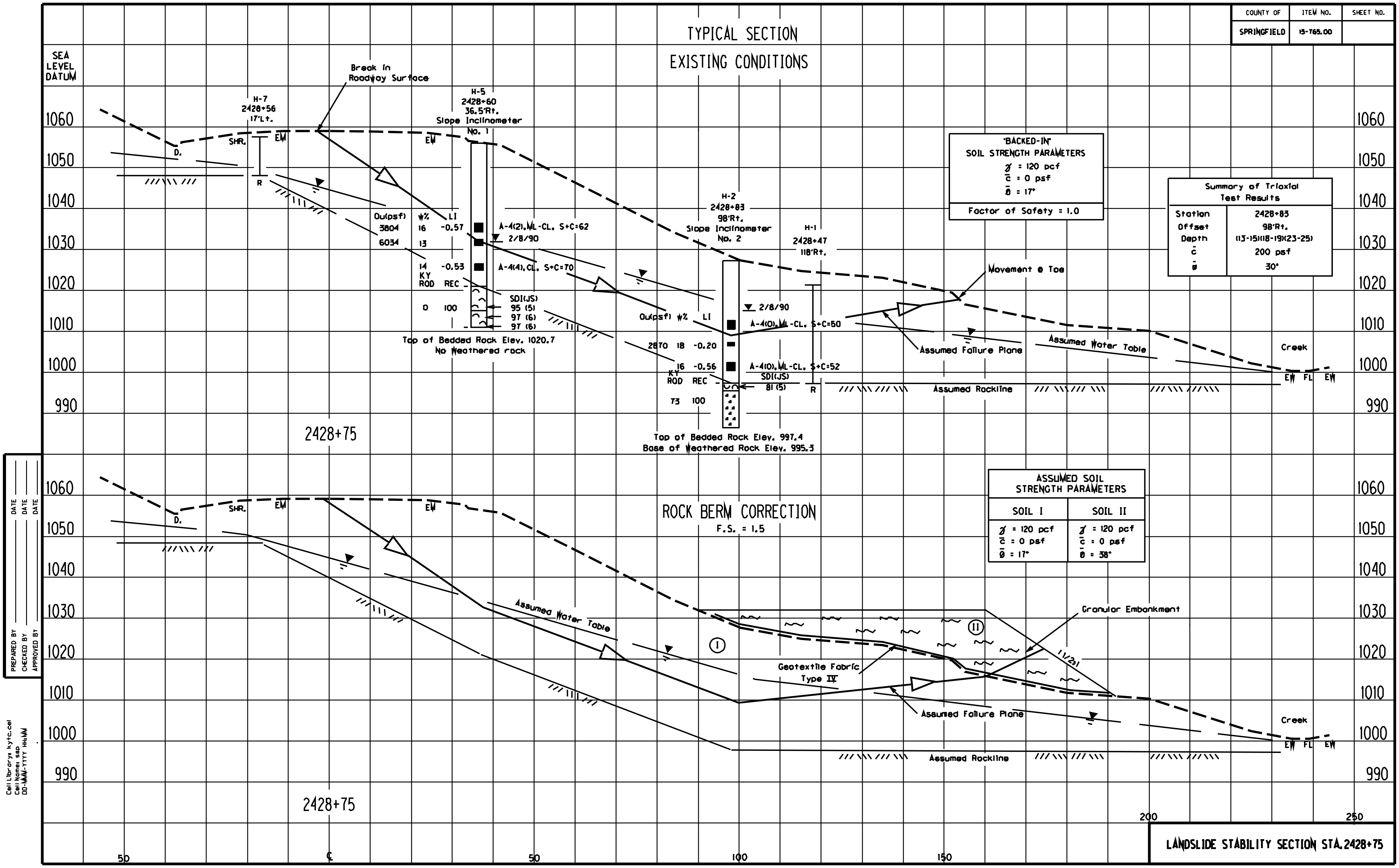
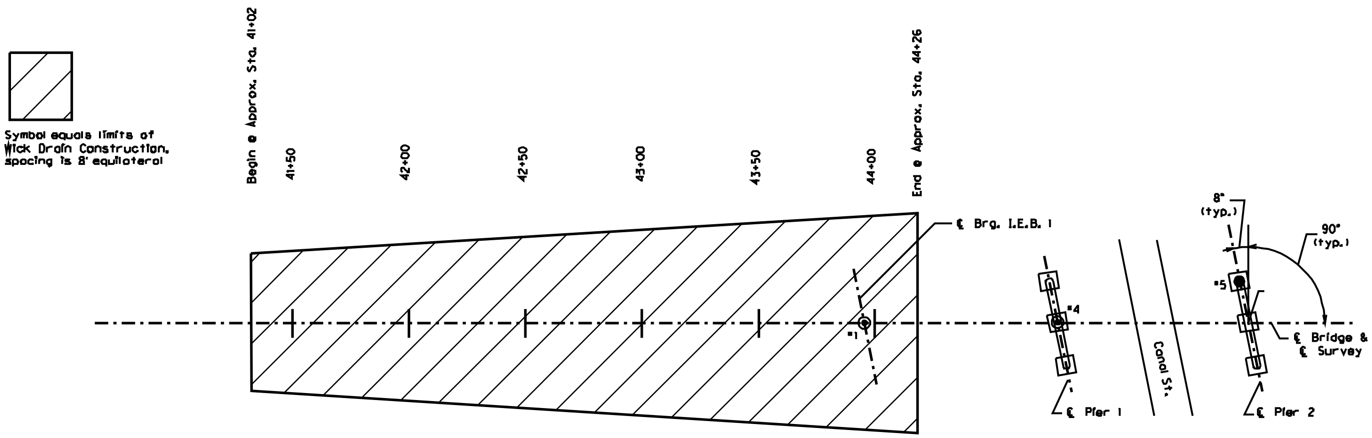
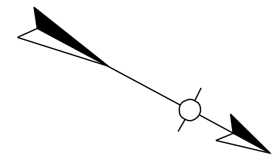

COUNTY OF: SPRINGFIELD
ITEM NO.: 15-765.00
SHEET NO.
TYPICAL SECTION
EXISTING CONDITIONS
SEA LEVEL DATUM
1060
1050
1040
1030
1020
1010
1000
990
Break in Roadway Surface
H-7
2428+56
17'Lt.
SHR.
EW
D.
R
H-5
2428+60
36.5'Rt.
Slope Inclinometer No. 1
Qu(psf)
3804
6034
W%
16
13
14
LI
-0.57
-0.53
KY ROD
REC
0
100
A-4(2),ML-CL, S+C=62
2/8/90
A-4(4),CL, S+C=70
SDI(JS)
95 (5)
97 (6)
97 (6)
Top of Bedded Rock Elev. 1020.7
No Weathered rock
H-2
2428+83
98'Rt.
Slope Inclinometer No. 2
H-1
2428+47
118'Rt.
Qu(psf) W% LI
2870 18 -0.20
16 -0.56
KY ROD REC
73 100
2/8/90
A-4(0),ML-CL, S+C=50
A-4(0),ML-CL, S+C=52
SDI(JS)
81 (5)
Top of Bedded Rock Elev. 997.4
Base of Weathered Rock Elev. 995.3
"BACKED-IN" SOIL STRENGTH PARAMETERS
γ = 120 pcf
c̄ = 0 psf
ø̄ = 17°
Factor of Safety = 1.0
Summary of Triaxial Test Results
Station: 2428+83
Offset: 98'Rt.
Depth: (13-15)(18-19)(23-25)
c̄: 200 psf
ø̄: 30°
Movement @ Toe
Assumed Failure Plane
Assumed Water Table
Assumed Rockline
Creek
EW FL EW
2428+75
ROCK BERM CORRECTION
F.S. = 1.5
ASSUMED SOIL STRENGTH PARAMETERS
SOIL I: γ = 120 pcf, c̄ = 0 psf, ø̄ = 17°
SOIL II: γ = 120 pcf, c̄ = 0 psf, ø̄ = 38°
Granular Embankment
1 1/2:1
I
II
Geotextile Fabric Type IV
Assumed Failure Plane
Assumed Water Table
Assumed Rockline
Creek
2428+75
50
℄
50
100
150
200
250
LANDSLIDE STABILITY SECTION STA. 2428+75
PREPARED BY — DATE
CHECKED BY — DATE
APPROVED BY — DATE
Cell Library: kytc.cel
Cell Name: ssp
DD-MMM-YYYY HH:MM

COUNTY OF	ITEM NO.	SHEET NO.
SPRINGFIELD	13-765.00	

WICK DRAIN LAYOUT

Not To Scale

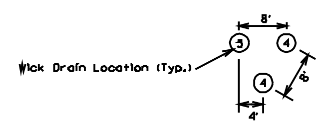




PLAN VIEW - WICK DRAIN LOCATIONS

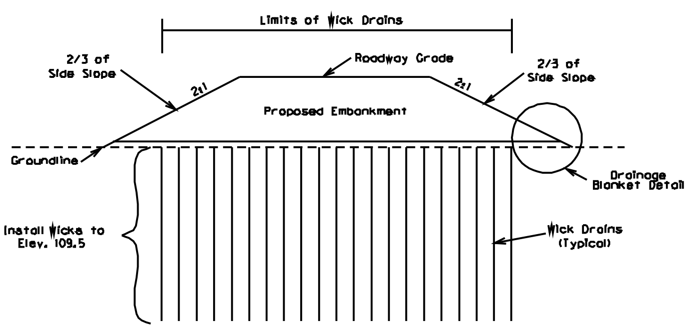
DETAIL - TRIANGULAR SPACING

NOT TO SCALE



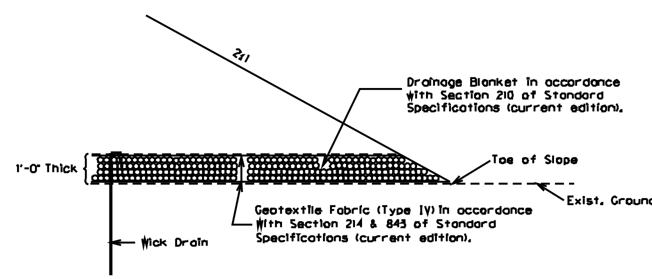
TYPICAL SECTION - WICK DRAINS

Not To Scale



DRAINAGE BLANKET DETAIL

Not To Scale



PREPARED BY ____ DATE ____
CHECKED BY ____ DATE ____
APPROVED BY ____ DATE ____

Cell Library: kytc.cel
Cell Name: sspl
DD-MMM-YYYY HH:MM

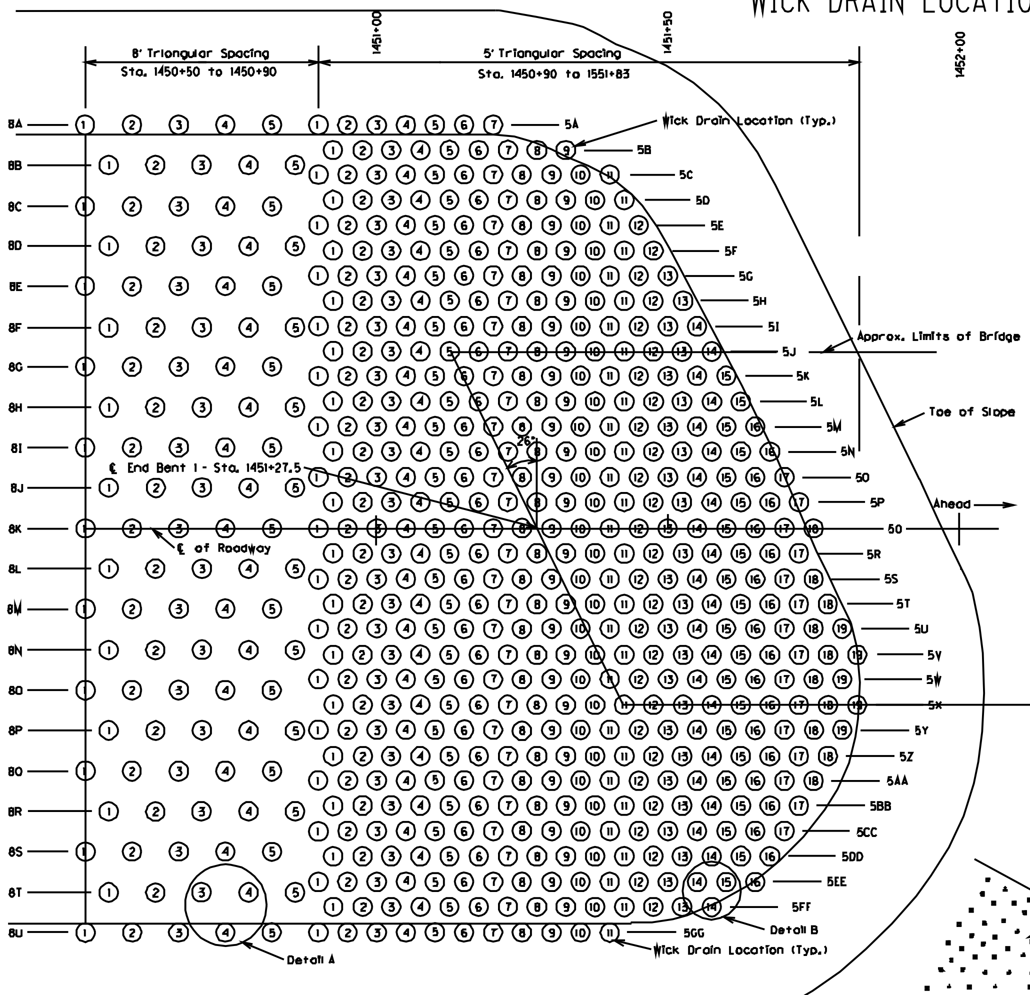
KENTUCKY
DEPARTMENT OF HIGHWAYS
COUNTY OF
SPRINGFIELD

PROJECT NUMBERS

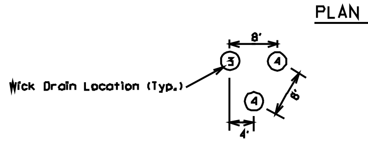
WICK DRAIN DETAILS

COUNTY OF	ITEM NO.	SHEET NO.
SPRINGFIELD	13-765.00	

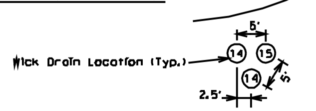
WICK DRAIN LOCATIONS



PLAN VIEW - WICK DRAIN LOCATIONS



DETAIL A - TRIANGULAR SPACING



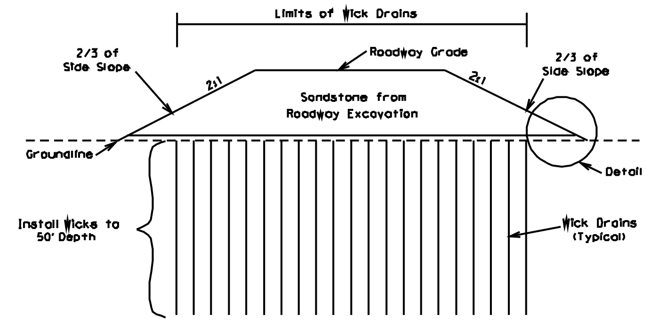
DETAIL B - 5' TRIANGULAR SPACING

5' TRIANGULAR WICK DRAIN SPACINGS

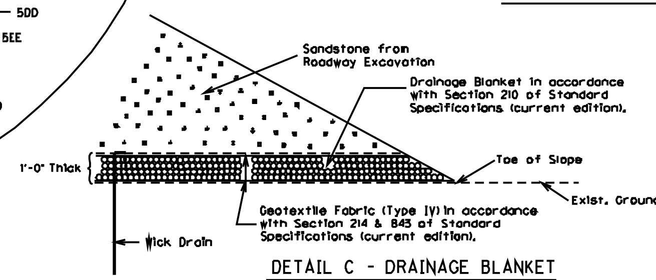
ROW	OFFSET LEFT OF ℄ (FT.)	ROW	OFFSET RIGHT OF ℄ (FT.)
5A	69.3	5R	4.3
5B	65.0	5S	8.7
5C	60.6	5T	13.0
5D	56.3	5U	17.3
5E	52.0	5V	21.7
5F	47.6	5W	26.0
5G	43.3	5X	30.3
5H	39.0	5Y	34.6
5I	34.6	5Z	39.0
5J	30.3	5AA	43.3
5K	26.0	5BB	47.6
5L	21.7	5CC	52.0
5M	17.3	5DD	56.3
5N	13.0	5EE	60.6
5O	8.7	5FF	65.0
5P	4.3	5GG	69.3
5Q	0.0	-	-

8' TRIANGULAR WICK DRAIN SPACINGS

ROW	OFFSET LEFT OF ℄ (FT.)	ROW	OFFSET RIGHT OF ℄ (FT.)
8A	69.3	8L	6.9
8B	62.4	8M	13.9
8C	55.4	8N	20.8
8D	48.5	8O	27.7
8E	41.6	8P	34.6
8F	34.6	8Q	41.6
8G	27.7	8R	48.5
8H	20.8	8S	55.4
8I	13.9	8T	62.4
8J	6.93	8U	69.3
8K	0.0	-	-



TYPICAL SECTION - WICK DRAINS



DETAIL C - DRAINAGE BLANKET

KENTUCKY
DEPARTMENT OF HIGHWAYS
COUNTY OF
SPRINGFIELD

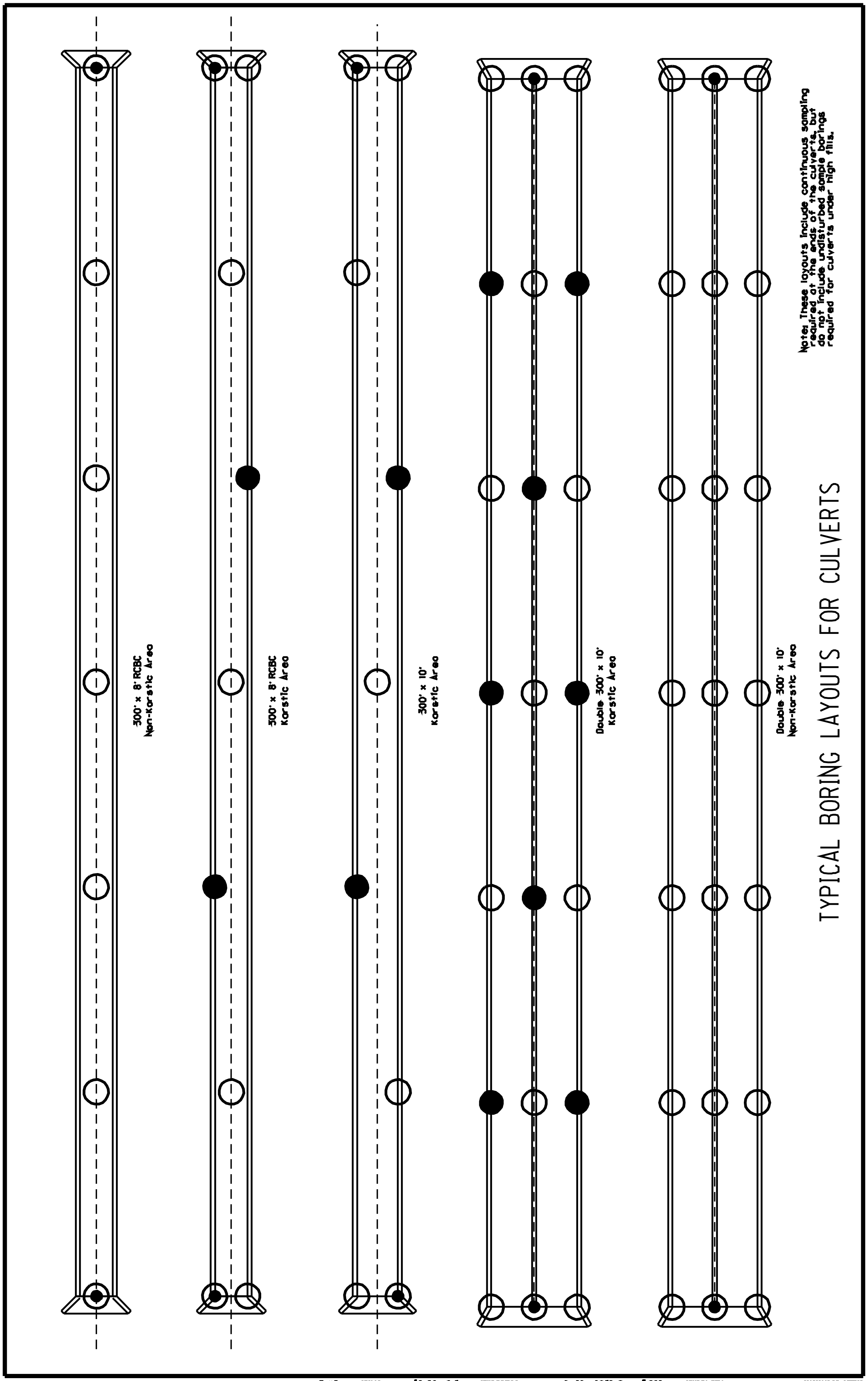
PROJECT NUMBERS

WICK DRAIN DETAILS

PREPARED BY ______ DATE ______
CHECKED BY ______ DATE ______
APPROVED BY ______ DATE ______

Cell Library: kytc.cel
Cell Name: sspl
DD-MMM-YYYY HH:MM

Exhibit 37


Note: These layouts include continuous sampling required at the ends of the culverts, but do not include undisturbed sample borings required for culverts under high fills.
300' x 8' RCBC Non-Karstic Area
300' x 8' RCBC Karstic Area
300' x 10' Karstic Area
Double 300' x 10' Karstic Area
Double 300' x 10' Non-Karstic Area
TYPICAL BORING LAYOUTS FOR CULVERTS

GEOTECHNICAL NOTES

for MSE Walls

If the Contractor elects to use an MSE Wall as allowed by the Contract Documents, design the wall (or walls) in accordance with the AASHTO Standard Specifications for Highway Bridges. The Contract Documents control where a requirement which is not covered by, or is contrary to, AASHTO exists.

Use only MSE Walls with inextensible reinforcement.

Granular replacement depths (D) versus wall height (H):
For H <= 10 ft, D= 0
For H>10 ft and <= 20 ft, D= 2.0 ft.

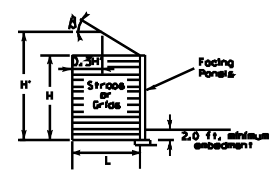
Station Interval	Bearing Surface	Allowable Bearing Capacity
10+20 - 11+15	Soil	- ksf
11+15 - 12+15	Gran. Repl.	- ksf

Use the following soil strength parameters for design:

	Cohesion (psf)	Friction Angle (degrees)	Unit Weight (pcf)
Internal Backfill (in reinforced volume)	0	34	115
External Backfill			
Soil Embankment	-	-	-
Granular Embankment	-	-	-
Foundation Soils			
Existing	-	-	-
Granular Replacement	-	-	-

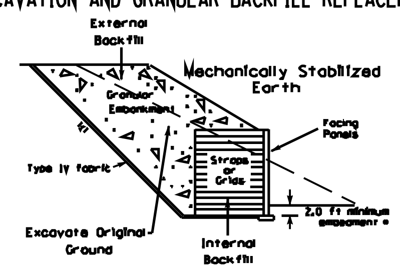
Where granular replacement of existing foundation materials is required, excavate the existing foundation soil and replace with granular material as shown below. Use granular material meeting the requirements of "granular embankment" in Section 805 of the Standard Specifications, current edition, except that the maximum size is 4 inches. Use material that is classified as non-erodible, as defined in Section 805 of the Standard Specifications, current edition. Place Type IV fabric in accordance with Sections 214 and 843 of the Standard Specifications, current edition, as shown below.

Where external granular backfill is required, place granular material as shown below. Use granular material meeting the requirements of "granular embankment" in Section 805 of the Standard Specifications, current edition, except that the maximum size is 4 inches. Use material that is classified as non-erodible, as defined in Section 805 of the Standard Specifications, current edition. Place Type IV fabric in accordance with Sections 214 and 843 of the Standard Specifications, current edition, as shown below.

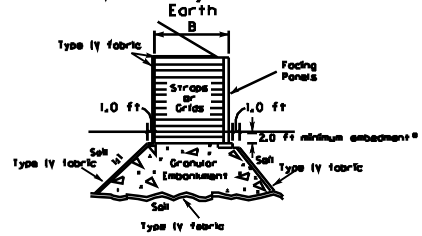


The minimum reinforcment length (L) shall be the greater of:
L > 0.7 H' (where H' is the effective wall height)
L > 8 ft
H' = H/(1-0.3 tan β) for sloping backfill
H'=H for level backfill

EXCAVATION AND GRANULAR BACKFILL REPLACEMENT

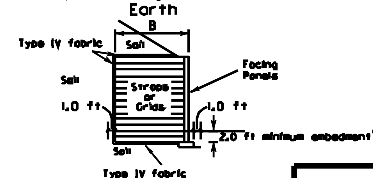


EXCAVATION AND GRANULAR FOUNDATION REPLACEMENT



Type IV Fabric required only where there is a soil-granular material interface.

MSE WALL ON SOIL



* - Unless Otherwise Noted

REVISION	DATE
DATE: 25-SEPTEMBER-2004	CHECKED BY
DESIGNED BY:	
DETAILED BY: D.CONWAY	J. WOLEN

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY SPRINGFIELD

ROUTE US 555 CROSSING

S-005-04

ITEM NUMBER 13-765.00

PREPARED BY Division of Materials Geotechnical Branch

SHEET NO.

DRAWING NO. 00000

GEOTECHNICAL NOTES

for Granular Replacement at Reinforced Concrete Cantilever Retaining Walls

The minimum embedment shall be 2 ft. to the bottom of footing for cast in place walls.

As required by AASHTO, footings constructed on slopes shall be embedded sufficiently to provide the minimum horizontal distance of 4.0 ft., measured at top of footing, between the near face of the footing and the face of the finished slope.

The minimum factor of safety for sliding shall be either 1.5 neglecting passive resistance or 2.0 considering passive resistance.

Granular replacement depths (D) versus wall height (H):
For H <= 10 ft, D= 0
For H>10 ft and <= 20 ft, D= 2.0 ft.

Station Interval	Bearing Surface	Allowable Bearing Capacity
10+20 - 11+15	Soil	- ksf
11+15 - 12+15	Gran. Repl.	- ksf

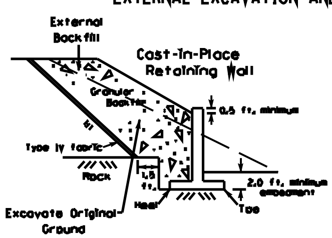
Use the following soil strength parameters for design:

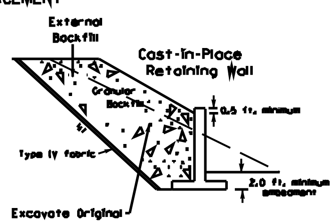
	Cohesion (psf)	Friction Angle (degrees)	Unit Weight (pcf)
External Backfill			
Soil Embankment	-	-	-
Granular Embankment	-	-	-
Foundation Soils			
Existing	-	-	-
Granular Replacement	-	-	-

Where granular replacement of existing foundation materials is required, excavate the existing foundation soil and replace with granular material as shown below. Use granular material meeting the requirements of "granular embankment" in Section 805 of the Standard Specifications, current edition, except that the maximum size is 4 inches. Use material that is classified as non-erodible, as defined in Section 805 of the Standard Specifications, current edition. Place Type IV fabric in accordance with Sections 214 and 843 of the Standard Specifications, current edition, as shown below.

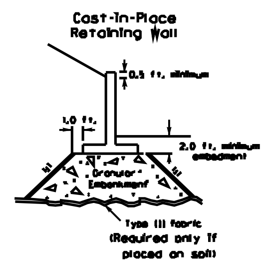
Where external granular backfill is required, place granular material as shown below. Use granular material meeting the requirements of "granular embankment" in Section 805 of the Standard Specifications, current edition, except that the maximum size is 4 inches. Use material that is classified as non-erodible, as defined in Section 805 of the Standard Specifications, current edition. Place Type IV fabric in accordance with Sections 214 and 843 of the Standard Specifications, current edition, as shown below.

EXTERNAL EXCAVATION AND BACKFILL REPLACEMENT





EXCAVATION AND GRANULAR FOUNDATION REPLACEMENT



S-005-04

REVISION	DATE
DATE: 25-SEPTEMBER-2004	CHECKED BY
DESIGNED BY:	
DETAILED BY: D.CONWAY	J. WOLEN

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY: SPRINGFIELD
ROUTE: US 555 CROSSING:

ITEM NUMBER
13-765.00

PREPARED BY
Division of Materials
Geotechnical Branch

SHEET NO.
DRAWING NO. 00000

SHEET LOCATION: FILE NAME: ssssdesignsfilesspecificationssss ssss[redacted]ssssplottedbyssss DATE: ssssDATEssss

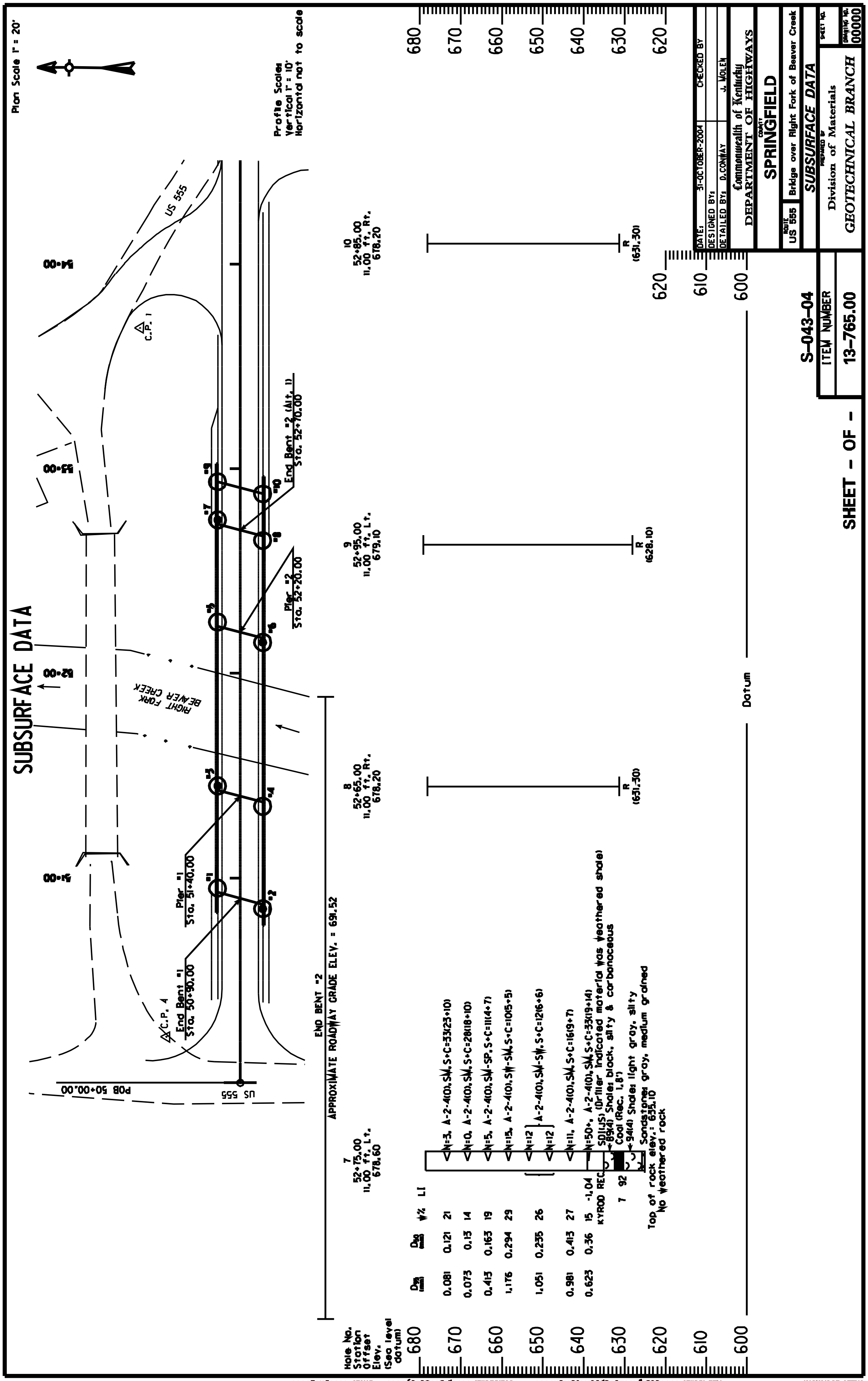
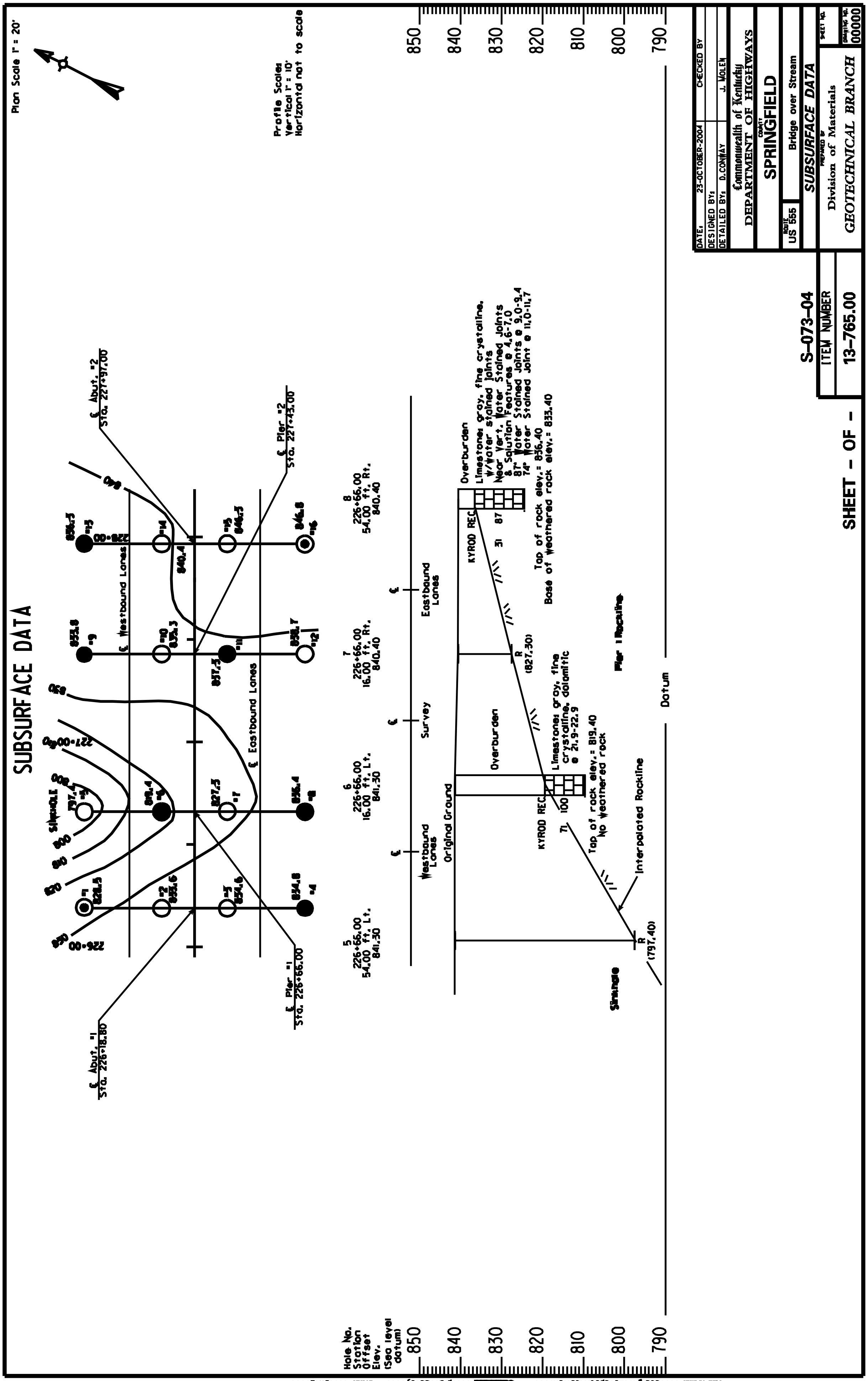

SUBSURFACE DATA
Plan Scale 1" = 20'
Profile Scale: Vertical 1" = 10' Horizontal not to scale
US 555
POB 50+00.00
51+00
52+00
53+00
54+00
C.P. 4
C.P. 1
RIGHT FORK BEAVER CREEK
End Bent #1 Sta. 50+90.00
Pier #1 Sta. 51+40.00
Pier #2 Sta. 52+20.00
End Bent #2 (Alt. 1) Sta. 52+70.00
END BENT #2
APPROXIMATE ROADWAY GRADE ELEV. = 691.52
Hole No. Station Offset Elev. (Sea level datum)
7 52+75.00 11.00 ft. Lt. 678.60
8 52+65.00 11.00 ft. Rt. 678.20
9 52+95.00 11.00 ft. Lt. 679.10
10 52+85.00 11.00 ft. Rt. 678.20
R (631.30)
R (628.10)
R (631.30)
Dm mm | D60 mm | W% | LI
0.081 0.121 21
0.073 0.15 14
0.415 0.165 19
1.176 0.294 29
1.051 0.235 26
0.981 0.413 27
0.623 0.36 15 -1.04
N=3, A-2-4(0), SM, S+C=33(23+10)
N=0, A-2-4(0), SM, S+C=28(18+10)
N=5, A-2-4(0), SM-SP, S+C=11(4+7)
N=15, A-2-4(0), SM-SM, S+C=10(5+5)
N=12 A-2-4(0), SM-SM, S+C=12(6+6)
N=12
N=11, A-2-4(0), SM, S+C=16(9+7)
N=50+, A-2-4(0), SM, S+C=33(19+14)
SD(US): (Driller indicated material was weathered shale)
89(4) Shale: black, silty & carbonaceous
Coal (Rec. 1.8')
94(4) Shale: light gray, silty
Sandstone: gray, medium grained
KYROD REC
7 92
Top of rock elev.: 635.10
No weathered rock
Datum
680 670 660 650 640 630 620 610 600
DATE: 31-OCTOBER-2004
DESIGNED BY:
DETAILED BY: D.CONWAY
CHECKED BY: J. WOLEN
Commonwealth of Kentucky DEPARTMENT OF HIGHWAYS
COUNTY SPRINGFIELD
ROUTE US 555 Bridge over Right Fork of Beaver Creek
SUBSURFACE DATA
Division of Materials
GEOTECHNICAL BRANCH
SHEET NO.
DRAWING NO. 00000
S-043-04
ITEM NUMBER 13-765.00
SHEET - OF -

Exhibit 40



01 / 01 / 05

COORDINATE DATA SUBMISSION FORM
KYTC DIVISION OF MATERIALS -- GEOTECHNICAL BRANCH

County ____________________ Date ____________________

Road Number ____________________

Survey Crew / Consultant ____________________

Contact Person ____________________

Item # ____________________

MARS # ____________________

Project # ____________________

Notes:

(circle one)

Elevation Datum   Sea Level   Assumed

HOLE NUMBER	STATION	OFFSET	ELEVATION (ft)	LATITUDE	LONGITUDE
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HOLE NUMBER	STATION	OFFSET	ELEVATION (ft)	LATITUDE	LONGITUDE
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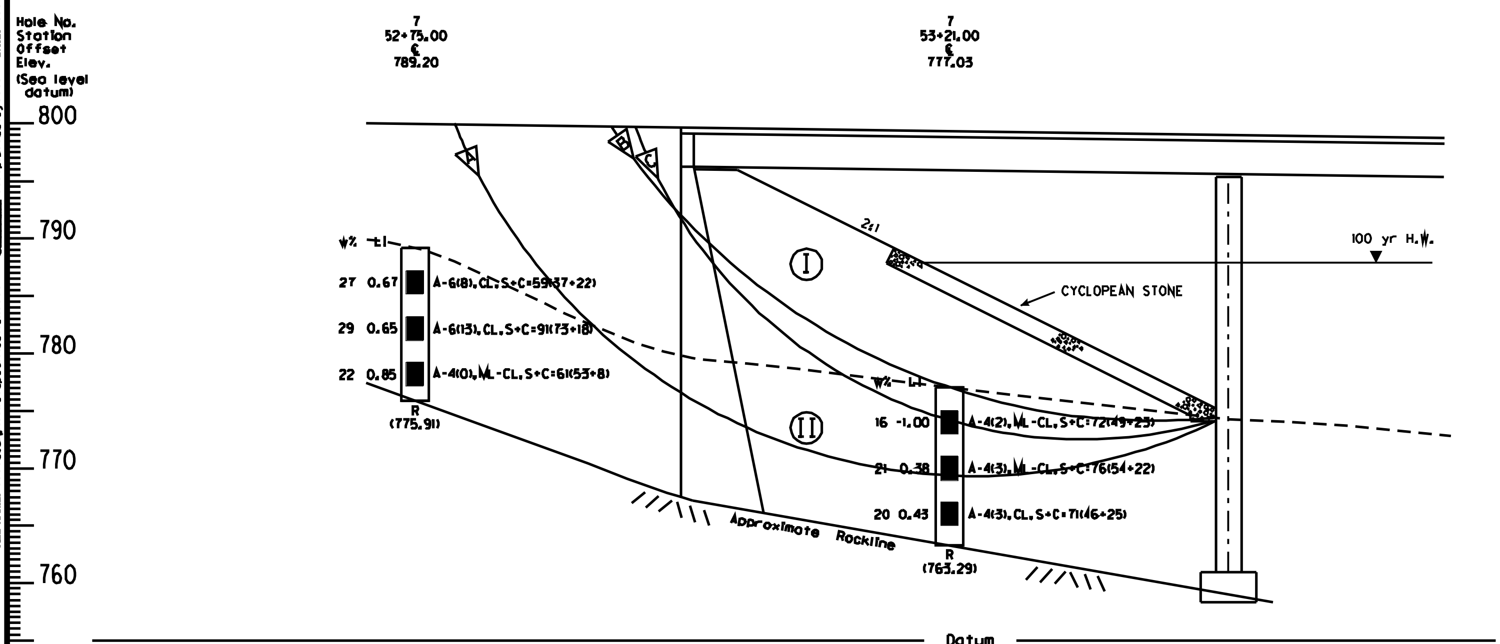
SUBSURFACE DATA

ASSUMED SOIL STRENGTH PARAMETERS			
SOIL		I	II
SHORT TERM	γ : c : φ :	125 pcf 1500 psf 0°	125 pcf 1500 psf 0°
LONG TERM	γ : c : φ :	125 pcf 250 psf 28°	125 pcf 220 psf 28°
RAPID DRAWDOWN	γ : c : φ :	125 pcf 250 psf 28°	125 pcf 220 psf 28°

FACTORS OF SAFETY		
SHORT TERM	A	2.4
LONG TERM	B	1.9
RAPID DRAWDOWN	C	1.4



S-133-97

DATE:	07-DECEMBER-1997	CHECKED BY
DESIGNED BY:		
DETAILED BY:	D. CONWAY	J. WOLEN

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY SPRINGFIELD

ROUTE US 555 — Bridge over Gladie Creek

SUBSURFACE DATA

PREPARED BY Division of Materials
GEOTECHNICAL BRANCH

ITEM NUMBER 13-765.00

SHEET NO.

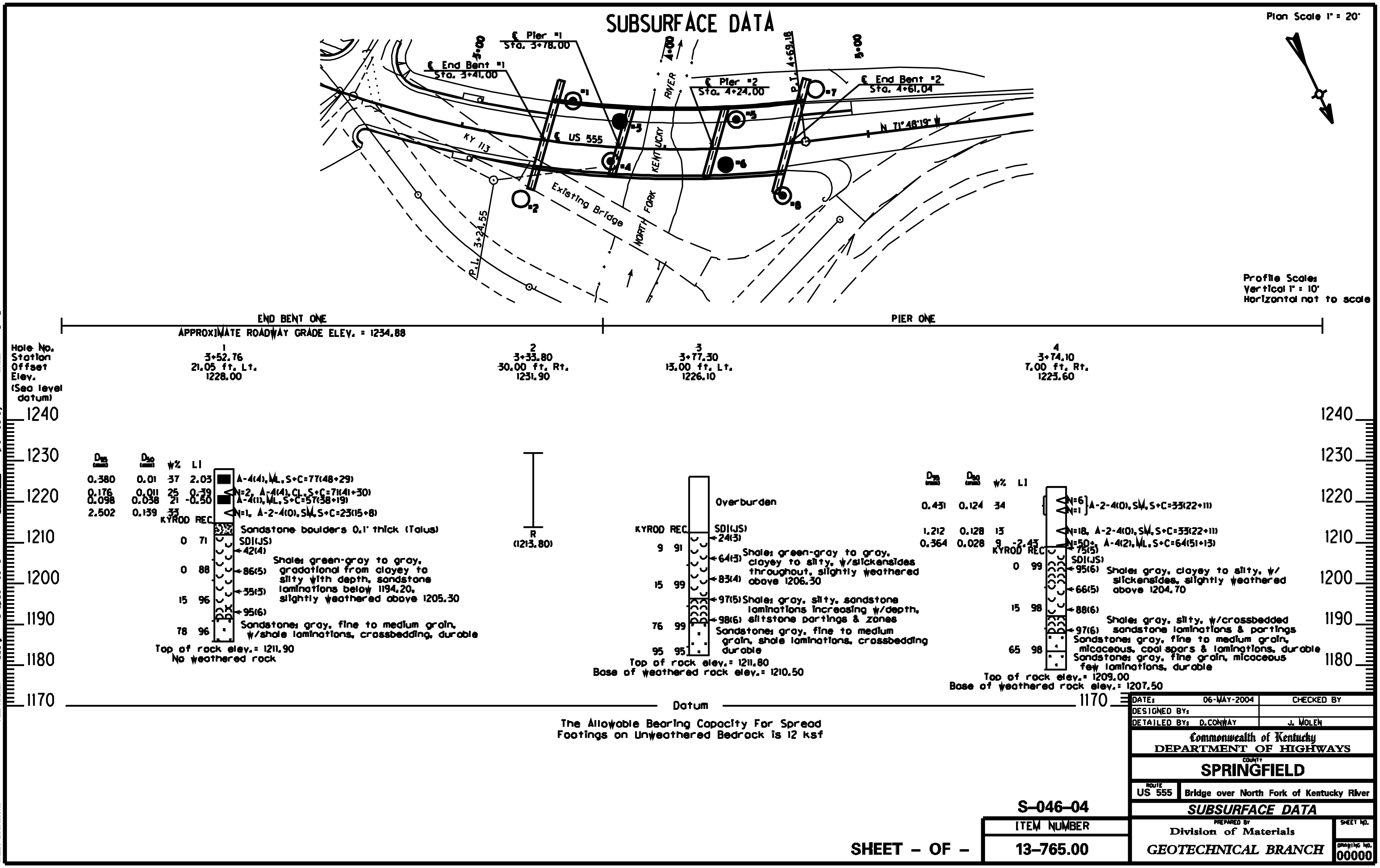
DRAWING NO. 00000

SHEET - OF -

FILE NAME: $$$$designfile$specification$$$$ [redacted] $$$$plotted$by$$$$ DATE: $$$$DATE$$$$

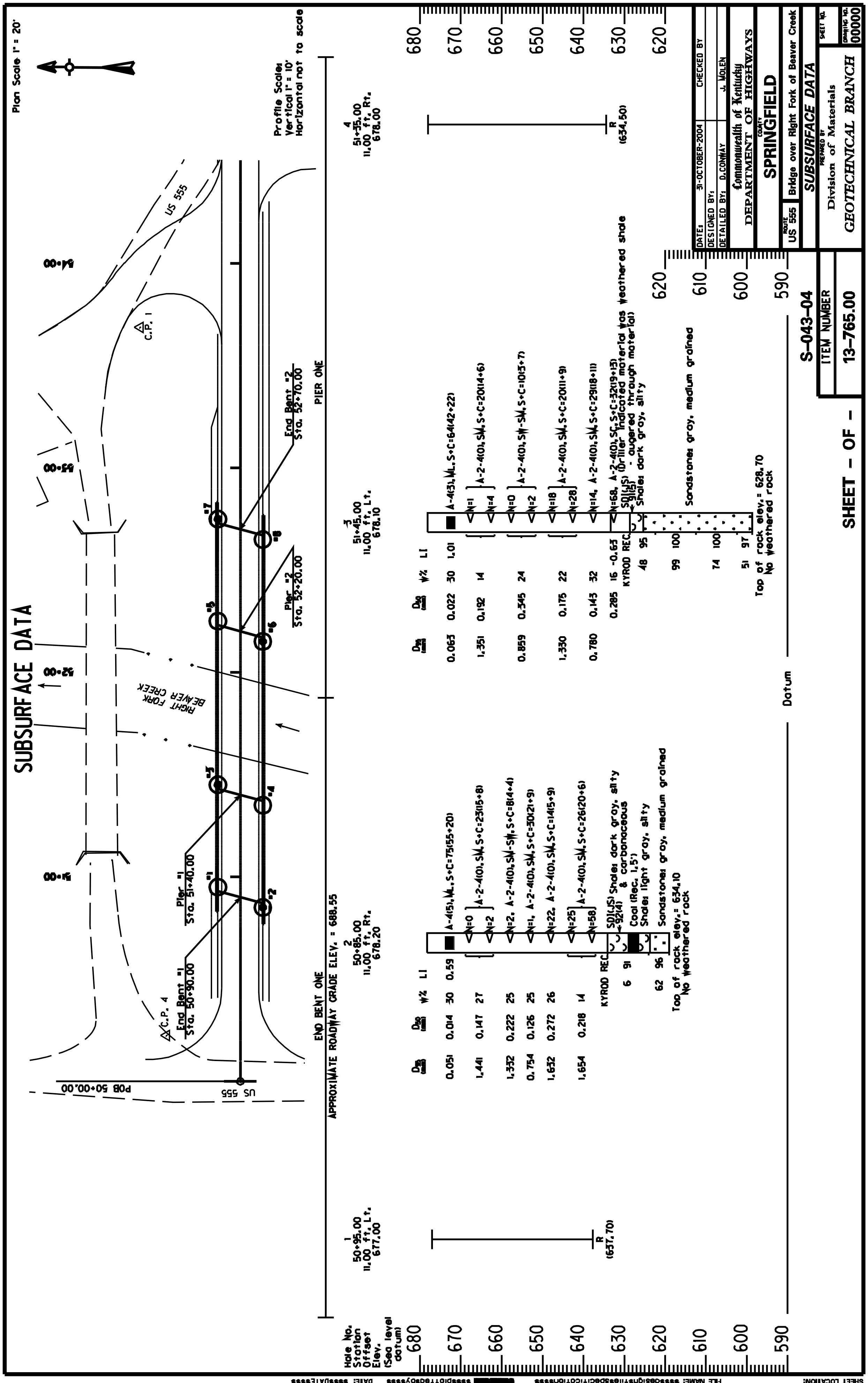
Sheet 1

Exhibit 43



01 / 01 / 05

Sheet 2 Exhibit 43



01 / 01 / 05

Sheet 3 Exhibit 43

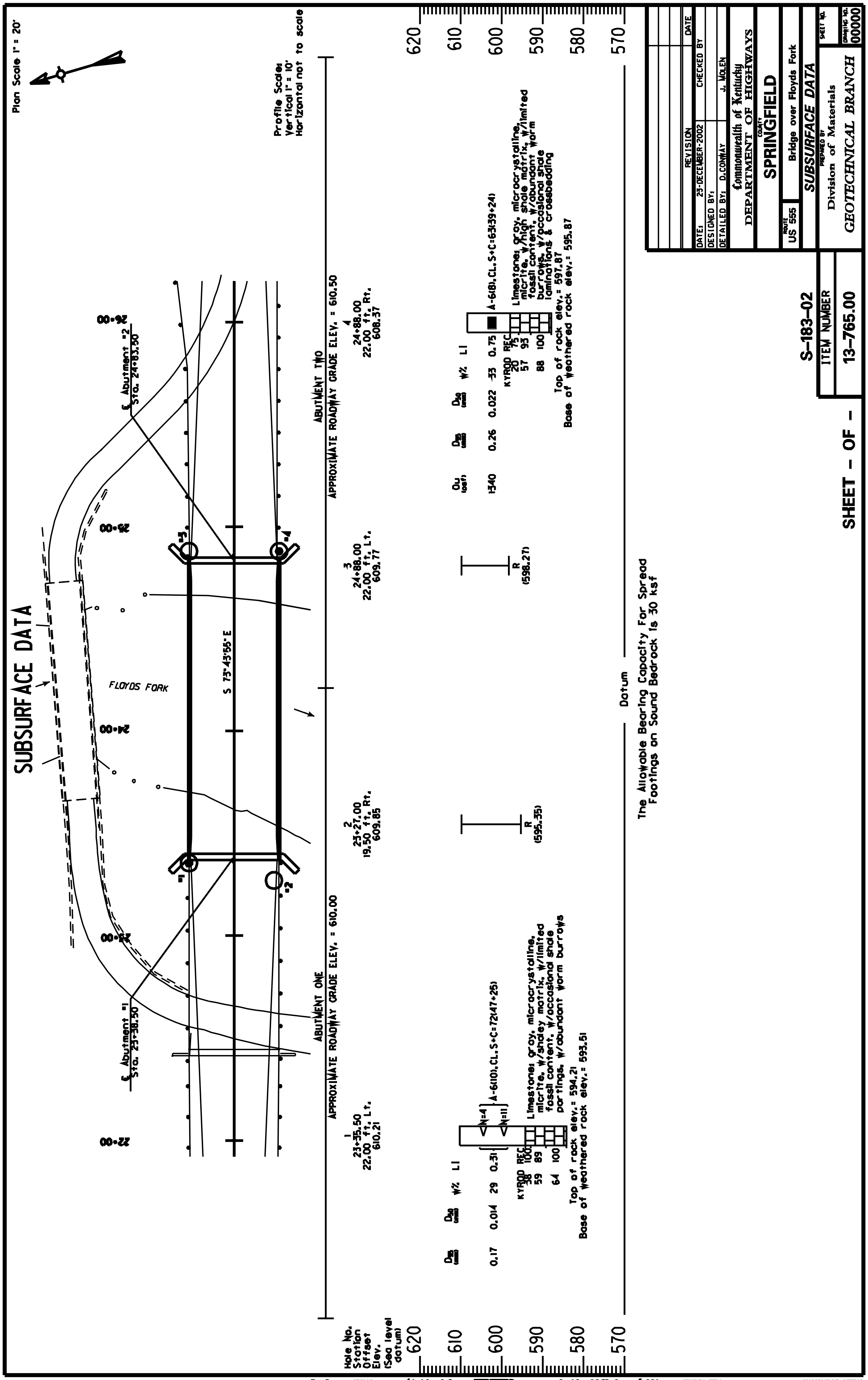
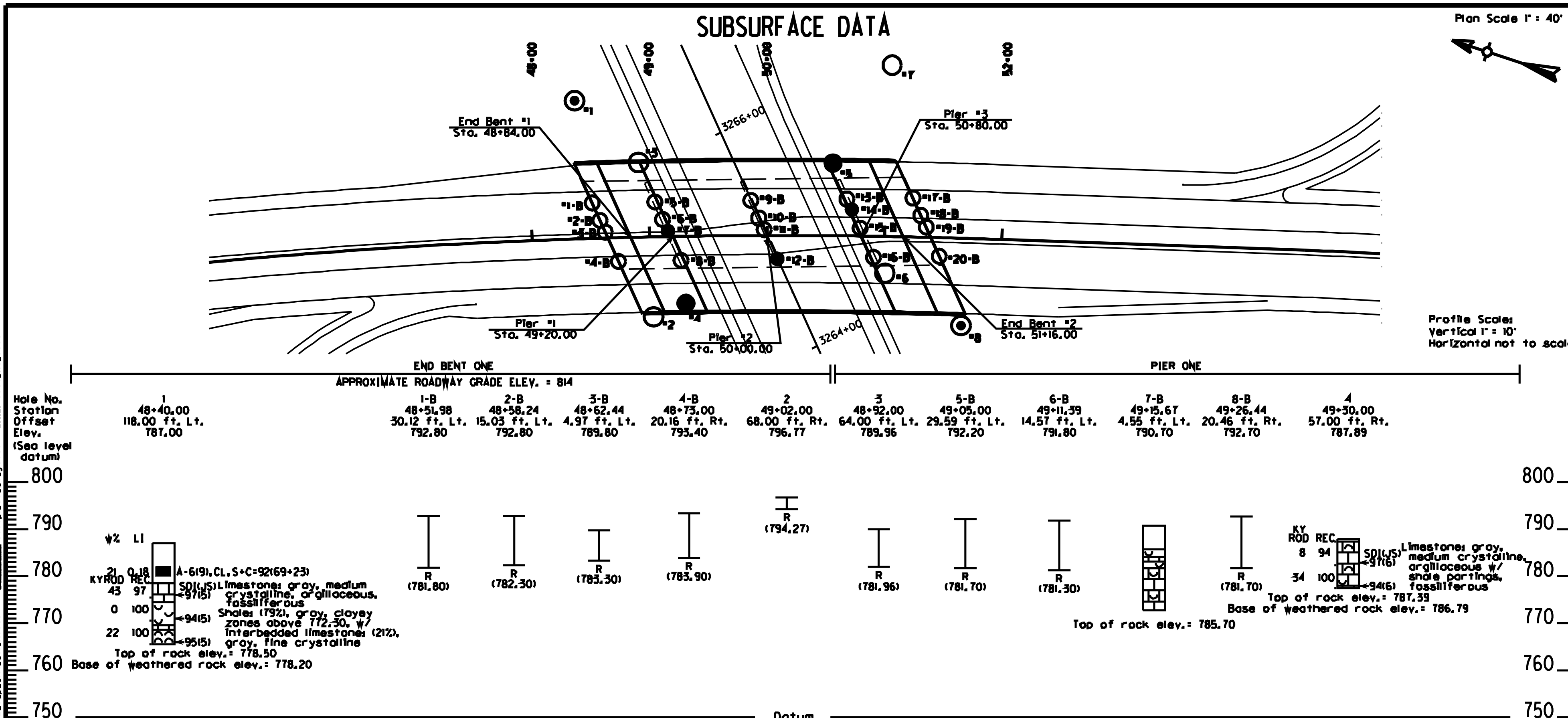


Exhibit 44



Holes with a "B" designation are borings from the original structure plans dated 1964.

The Allowable Bearing Capacity For Spread Footings on Sound Bedrock is 20 ksf

REVISION	DATE
DATE: 25-JULY-2000	CHECKED BY
DESIGNED BY:	
DETAILED BY: D.CONWAY	J. WOLEN

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY: SPRINGFIELD

ROUTE: US 555 — Bridge over Bluegrass Parkway

SUBSURFACE DATA

PREPARED BY: Division of Materials
GEOTECHNICAL BRANCH

SHEET NO.
DRAWING NO. 00000

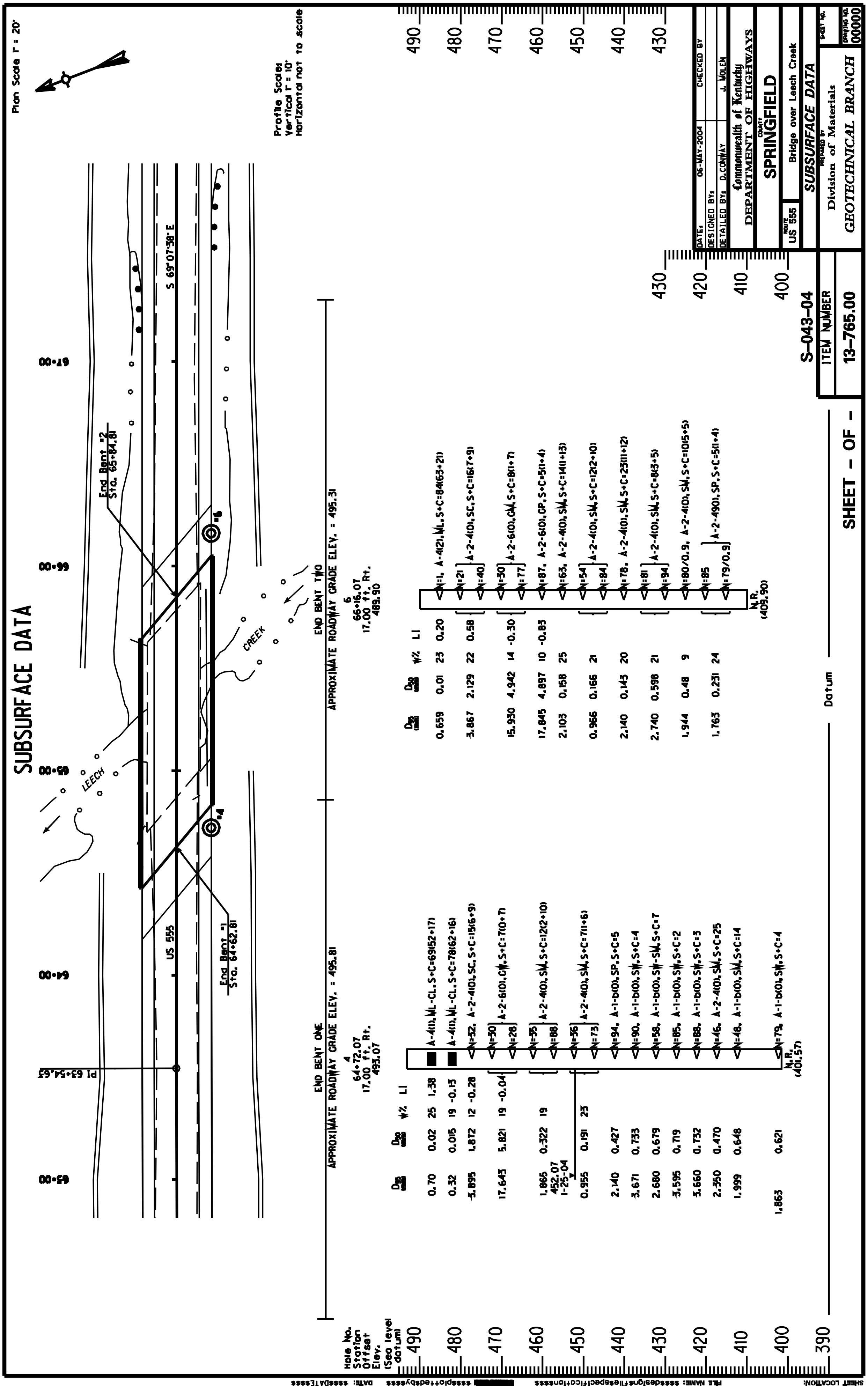
S-099-00

ITEM NUMBER
13-765.00

SHEET - OF -

01 / 01 / 05

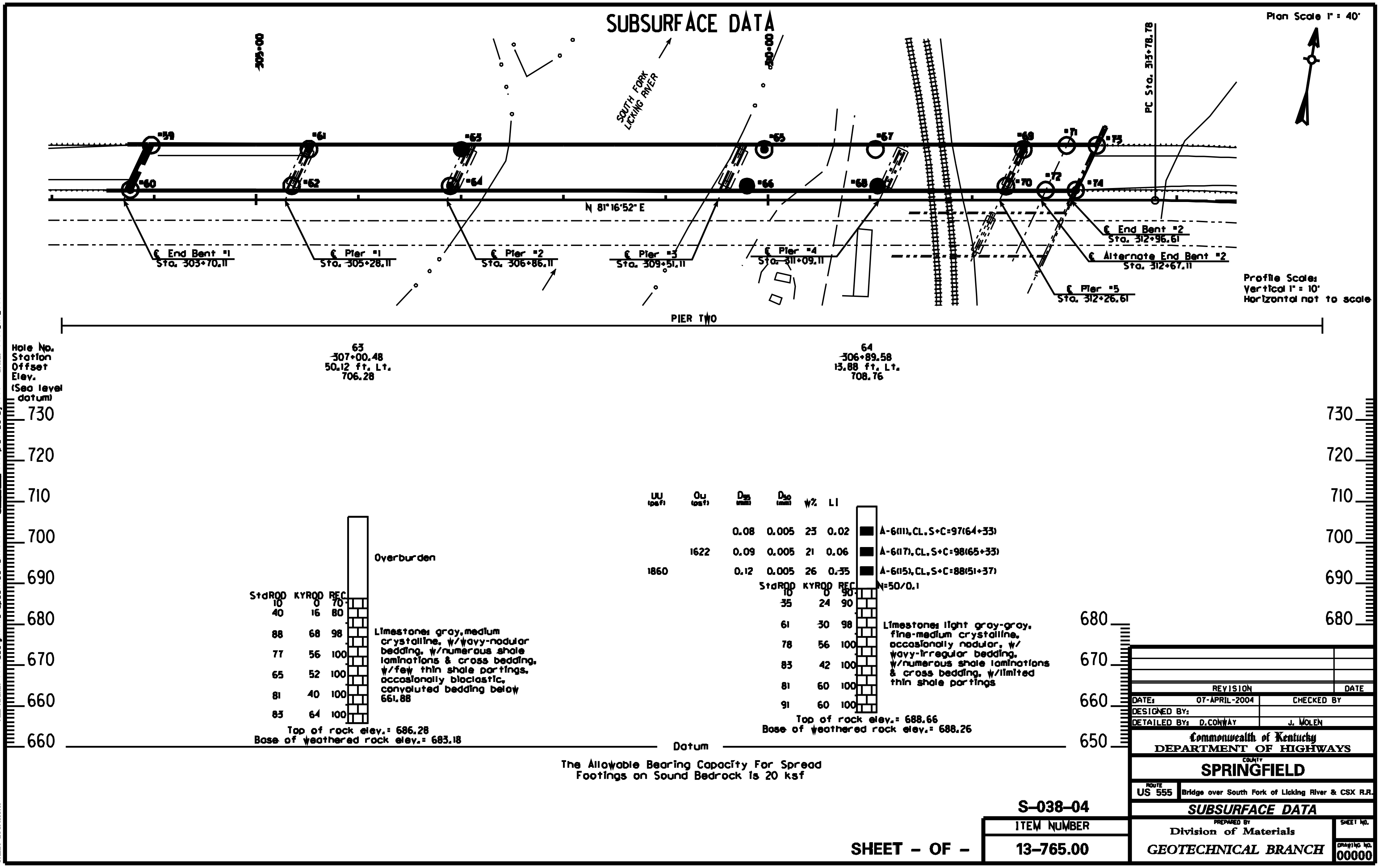
Exhibit 45

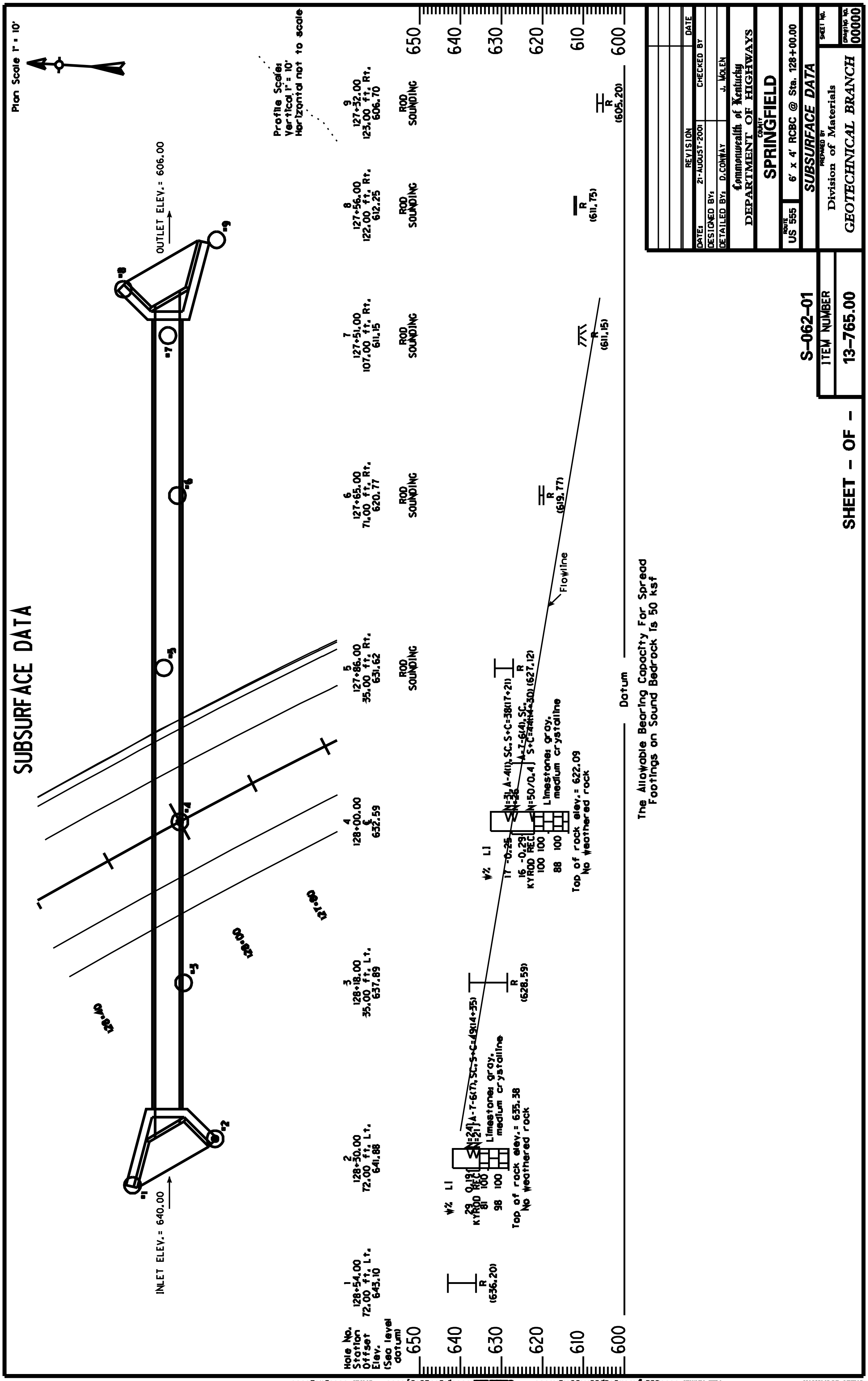


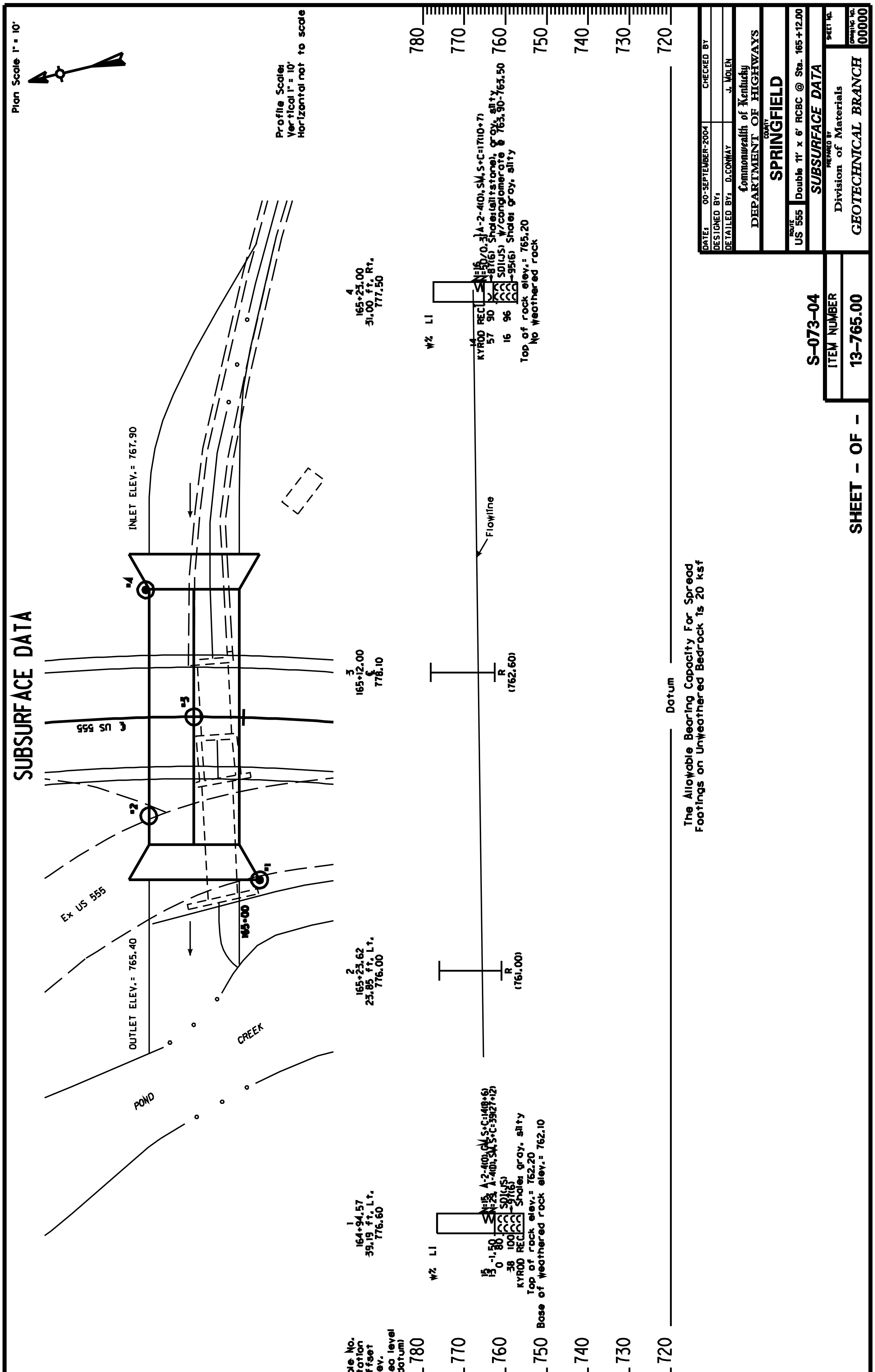
01 / 01 / 05

Sheet 3

Exhibit 46




SUBSURFACE DATA
Plan Scale 1" = 10'
Profile Scales Vertical 1" = 10' Horizontal not to scale
INLET ELEV.= 640.00
OUTLET ELEV.= 606.00
Hole No. Station Offset Elev. (Sea level datum)
1 128+54.00 72.00 ft. Lt. 643.10
2 128+30.00 72.00 ft. Lt. 641.88
3 128+18.00 35.00 ft. Lt. 637.89
4 128+00.00 ℄ 632.59
5 127+86.00 35.00 ft. Rt. 631.62
6 127+65.00 71.00 ft. Rt. 620.77
7 127+51.00 107.00 ft. Rt. 611.15
8 127+56.00 122.00 ft. Rt. 612.25
9 127+32.00 123.00 ft. Rt. 606.70
ROD SOUNDING
R (636.20)
R (628.59)
R (627.12)
R (619.77)
R (611.15)
R (611.75)
R (605.20)
Limestone: gray, medium crystalline
Top of rock elev.= 635.38 No weathered rock
Top of rock elev.= 622.09 No weathered rock
Flowline
Datum
The Allowable Bearing Capacity For Spread Footings on Sound Bedrock is 50 ksf
Commonwealth of Kentucky DEPARTMENT OF HIGHWAYS
SPRINGFIELD
US 555
6' x 4' RCBC @ Sta. 128+00.00
SUBSURFACE DATA
Division of Materials
GEOTECHNICAL BRANCH
DATE: 21-AUGUST-2001
DESIGNED BY:
DETAILED BY: D.CONWAY
CHECKED BY: J. WOLEN
S-062-01
ITEM NUMBER 13-765.00
SHEET - OF -
650 640 630 620 610 600


SUBSURFACE DATA
Plan Scale 1" = 10'
Profile Scale: Vertical 1" = 10' Horizontal not to scale
INLET ELEV.= 767.90
OUTLET ELEV.= 765.40
℄ US 555
Ex US 555
CREEK
POND
Flowline
Datum
The Allowable Bearing Capacity For Spread Footings on Unweathered Bedrock is 20 ksf
Top of rock elev.= 765.20
No Weathered rock
Top of rock elev.= 762.20
Base of weathered rock elev.= 762.10
Hole No. Station Offset Elev. (Sea level datum)
Commonwealth of Kentucky DEPARTMENT OF HIGHWAYS
SPRINGFIELD
US 555
Double 11' x 6' RCBC @ Sta. 165+12.00
SUBSURFACE DATA
Division of Materials
GEOTECHNICAL BRANCH
S-073-04
ITEM NUMBER
13-765.00
SHEET - OF -

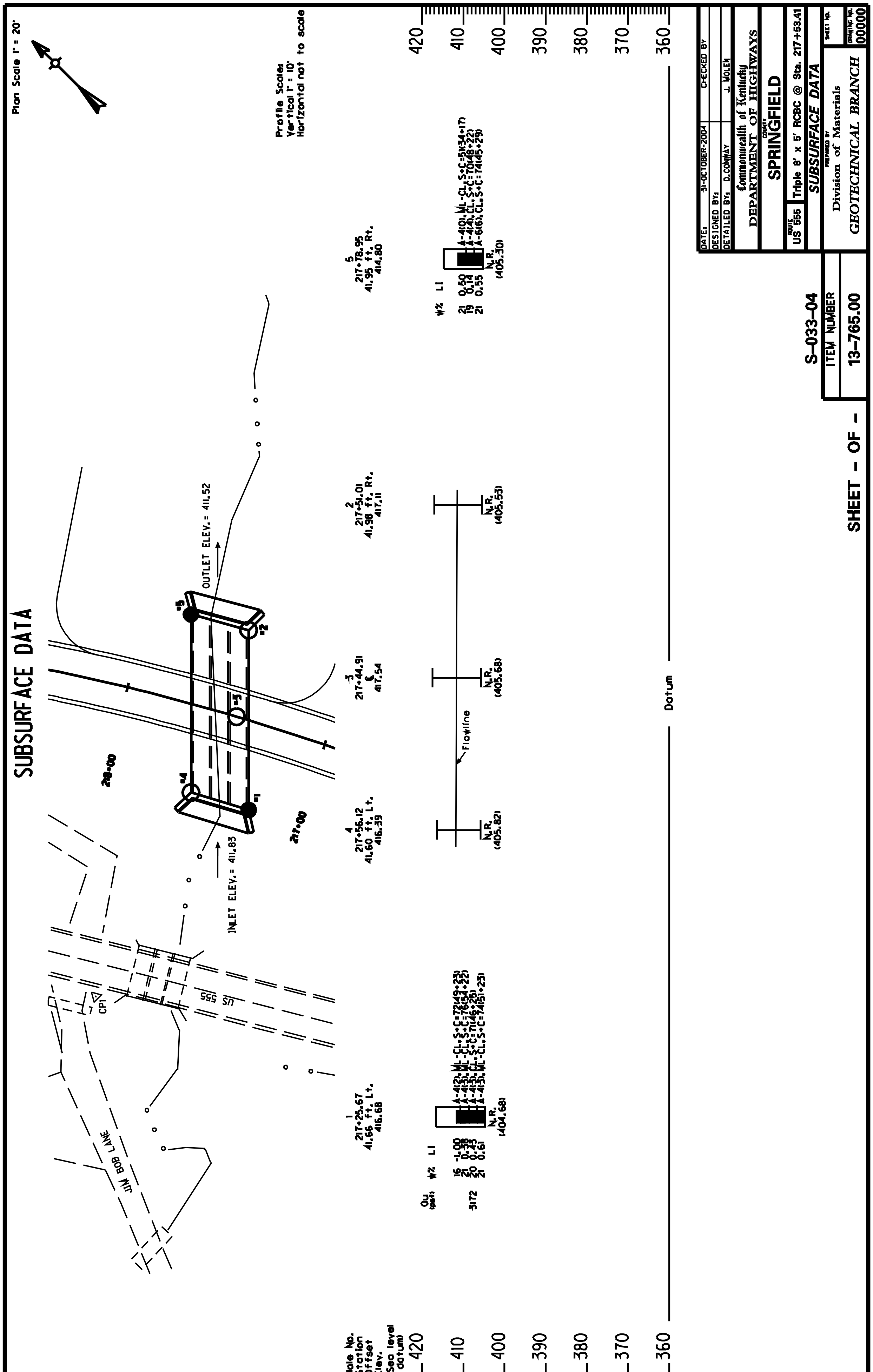
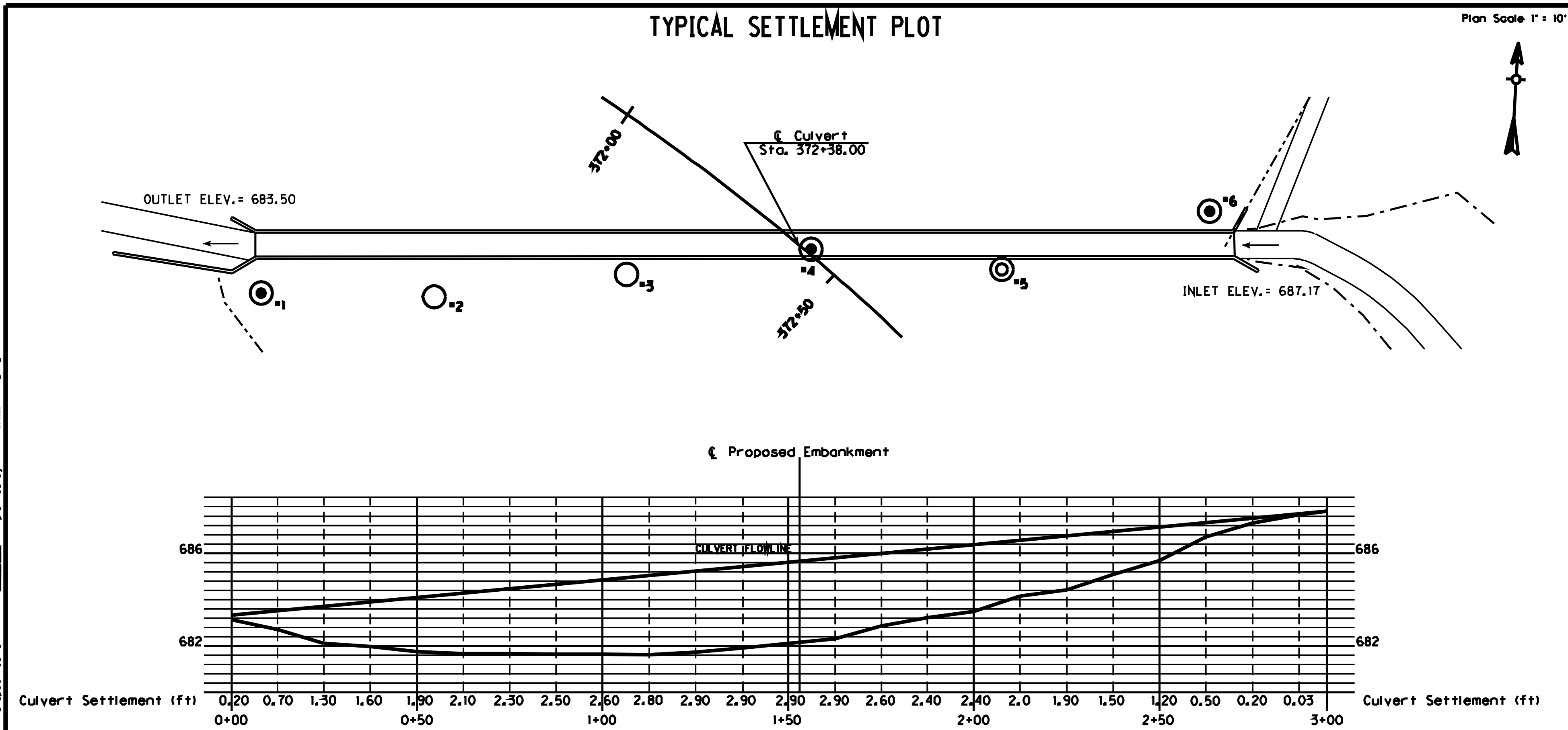

SUBSURFACE DATA
Plan Scale 1" = 20'
Profile Scales
Vertical 1" = 10'
Horizontal not to scale
OUTLET ELEV.= 411.52
INLET ELEV.= 411.83
US 555
JIM BOB LANE
CP1
217+00
218+00
Flowline
Datum
Hole No.
Station
Offset
Elev.
(Sea level datum)
1
217+25.67
41.66 ft. Lt.
416.68
N.R.
(404.68)
4
217+56.12
41.60 ft. Lt.
416.39
N.R.
(405.82)
-3
217+44.91
℄
417.54
N.R.
(405.68)
2
217+51.01
41.98 ft. Rt.
417.11
N.R.
(405.53)
5
217+78.95
41.95 ft. Rt.
414.80
N.R.
(405.30)
DATE: 31-OCTOBER-2004
DESIGNED BY:
DETAILED BY: D.CONWAY
CHECKED BY
J. WOLEN
Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS
COUNTY
SPRINGFIELD
ROUTE
US 555
Triple 8' x 5' RCBC @ Sta. 217+53.41
SUBSURFACE DATA
PREPARED BY
Division of Materials
GEOTECHNICAL BRANCH
S-033-04
ITEM NUMBER
13-765.00
SHEET - OF -

Exhibit 48

TYPICAL SETTLEMENT PLOT



DATE: 06-MAY-1998		CHECKED BY
DESIGNED BY:		
DETAILED BY: D.CONWAY		J. WOLEN

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY SPRINGFIELD

ROUTE US 555 | 11' x 8' RCBC @ Sta. 372+38.00

SETTLEMENT PLOT

PREPARED BY Division of Materials
GEOTECHNICAL BRANCH

SHEET NO.

DRAWING NO. 00000

S-082-98

ITEM NUMBER 13-765.00

SHEET - OF -

FILE NAME: sssdesignsfilesspecificationssss [redacted] ssssplottedbyssss DATE: ssssDATEssss

SHEET LOCATION:

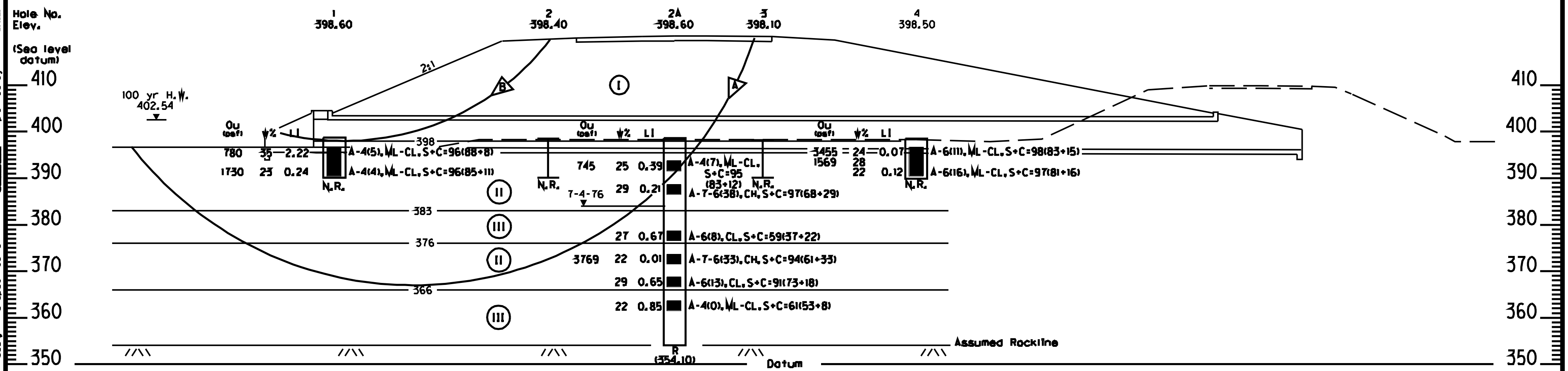
01 / 01 / 05

SUBSURFACE DATA

FACTORS of SAFETY		
A	Short Term	2.8
B	Long Term	2.2

ASSUMED SOIL STRENGTH PARAMETERS				
Soil		I	II	III
Unit Weight	γ (pcf)	125	120	120
Short Term	c (psf) φ (deg.)	c = 1500 φ = 0°	c = 1200 φ = 0°	c = 1800 φ = 0°
Long Term	c̄ (psf) φ̄ (deg.)	c̄ = 200 φ̄ = 28°	c̄ = 400 φ̄ = 28°	c̄ = 200 φ̄ = 32°

Profile Scale:
Vertical 1" = 10'
Horizontal not to scale



SUMMARY OF CONSOLIDATED UNDRAINED TRIAXIAL TEST		
Hole	2A	4
Depth	5'-7' 10'-12' 25'-27'	2'-4' 4'-6' 6'-8'
c̄	407	0
φ̄	27.8°	35.3°

S-028-04

ITEM NUMBER
13-765.00

SHEET - OF -

DATE: 31-OCTOBER-2004	CHECKED BY
DESIGNED BY:	
DETAILED BY: D.CONWAY	J. WOLEN

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS
COUNTY SPRINGFIELD
ROUTE US 555 — 8' x 6' RCBC @ Sta. 69+96.41
SUBSURFACE DATA
PREPARED BY Division of Materials
GEOTECHNICAL BRANCH
SHEET NO.
DRAWING NO. 00000

DATE: ssssDATEssss sssspiottedbyssss [redacted] FILE NAME: ssssdesignsfilesspecificationssss SHEET LOCATION:

Exhibit 49

01 / 01 / 05

KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch

TC 64-522
Rev. 5/05

PERFORMANCE EVALUATION FOR GEOTECHNICAL SERVICES

County ____________ Roadway Name ____________________ Mars No. __________

Project No. ______________________________________ Item No. __________

Drilling Company __________________________ Geotechnical Engr. Consultant __________________

Contract Completion Date ____________________

Actual Completion Date ____________________

INSTRUCTIONS: Check one of the three boxes. Unless the "not applicable" box is checked, circle one of the relative performance numbers, where 5 is the best performance and 1 is the worst.

	Satisfactory	Relative Performance Scale	Unsatisfactory	Not Applicable
Drilling and Sampling	☐	5 4 3 2 1	☐	☐
Laboratory Testing	☐	5 4 3 2 1	☐	☐
Engineering Analysis	☐	5 4 3 2 1	☐	☐
Engineering Report	☐	5 4 3 2 1	☐	☐
Time of Completion	☐	5 4 3 2 1	☐	☐
Amount of State Supervision Required	☐	5 4 3 2 1	☐	☐

WORK CRITIQUE: **(Explain any reasons for rating below 3)**

Evaluated By (Please Print)

Name ____________________

Title ____________________

____________________ Signature

__________ Date

CC: Geotech (Project File)
Geotech (Consultant File)

KENTUCKY TRANSPORTATION CABINET
Divison of Materials
Geotechnical Branch

TC 64-540
Rev. 5/05
Page 1 of 4

PREQUALIFICATION REQUIREMENTS FOR GEOTECHNICAL DRILLING SERVICES

I. Experience

The vendor must provide evidence of experience in the last 5 years performing drilling services for highway projects (roadways and bridges). The evidence shall include projects illustrating this type of experience, with references (agency, project engineer, or consultant) with addresses and phone numbers.

II. Equipment

The vendor must provide a list of available equipment (drill rigs and accessories) for soil sampling and rock coring. The vendor must have at least one drill rig equipped with an automatic hammer in order to be prequalified.

III. Personnel

Drill crew supervisors must be experienced in obtaining rock cores for rock cut slope and bridge foundation design, performing rock line soundings, performing standard penetration tests, obtaining thin-walled tube samples, obtaining disturbed soil samples, and installing cased observation wells. Evidence must be provided that the drill crew supervisors have a minimum of 3 years experience in the above-mentioned operations for highway projects (roadways and bridges). A drill crew supervisor is defined as the person on the drill crew field party who is responsible for the drilling operations mentioned above.

IV. Insurance

Worker's Compensation and Liability Insurance as required by the Division of Professional Services.

Notes:

1. Complete Pages 2 - 4 of this form. Pages 3 and 4 should reflect equipment and personnel that will be used on Kentucky highway projects. Provide personal history statements for drill crew supervisors included on Page 4.

2. Attach proof of the above-referenced insurances.

KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch

SUMMARY OF HIGHWAY PROJECTS COMPLETED IN THE LAST 5 YEARS FOR WHICH THE FIRM PROVIDED GEOTECHNICAL DRILLING SERVICES

Project Name	Project Location (County & State)	Type of Project (Roadway or Bridge)	Dates Performed	Estimated Drilling Units		Client (Include Address & Phone)
				Rock Coring (feet)	Soil Profile (miles)	

KENTUCKY TRANSPORTATION CABINET
Division of Materials
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SUMMARY OF DRILLING EQUIPMENT

1. Drill Rigs

Type (truck, skid, or track) Make Model Year

Type (truck, skid, or track) Make Model Year

Type (truck, skid, or track) Make Model Year

Type (truck, skid, or track) Make Model Year

2. Core Barrels

Type (wireline or conventional) Diameter Length

Type (wireline or conventional) Diameter Length

Type (wireline or conventional) Diameter Length

Type (wireline or conventional) Diameter Length

3. Standard Penetration Hammers

Type (standard, safety, or automatic)

Type (standard, safety, or automatic)

Type (standard, safety, or automatic)

Type (standard, safety, or automatic)

4. Split Barrel Samplers

Diameter Length Type of Shoe

Diameter Length Type of Shoe

Diameter Length Type of Shoe

Diameter Length Type of Shoe

5. Thin-Walled Tube Samplers

Diameter Length

Diameter Length

Diameter Length

Diameter Length

6. List other equipment such as pumps, augers (hollow or solid), casing, floating equipment (barge), etc. Please use additional sheets as necessary.

KENTUCKY TRANSPORTATION CABINET

Division of Materials

Geotechnical Branch

SUMMARY OF DRILLING PERSONNEL EXPERIENCE

		AREAS OF EXPERIENCE (Indicate all that apply):						
Name	**Years of Drilling Experience**	Drill Supervisor	Drill Helper	Rock Coring	Soil Profile Drilling and Sampling	Performing Standard Penetration Tests	Obtaining Thin Walled Samples	Installing Cased Observation Wells

Provide personal history statements for Drill Crew Supervisors.

KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch

TC 64-541
Rev. 5/05
Page 1 of 3

PREQUALIFICATION REQUIREMENTS
FOR GEOTECHNICAL ENGINEERING SERVICES

I. Firm Requirements

A. A firm permit issued by the Kentucky Board of Licensure for Professional Engineers and Land Surveyors.

B. Sufficient geotechnical engineering experience by the firm, as demonstrated by having performed geotechnical engineering on a minimum of 3 transportation projects (or other projects where related engineering tasks were performed) in the last 5 years.

C. MicroStation CADD Software.

II. Personnel Requirements

A. At least one Professional Engineer licensed in Kentucky with a minimum of 3 years of geotechnical engineering experience applicable to the design and/or construction of highway facilities (demonstrated by performing tasks included on Page 3 of this form). The firm will be required to assign at least one person meeting these requirements to actively participate in KYTC geotechnical projects in the capacity of Project Manager, Project Engineer, etc.

B. At least one Professional Geologist licensed in Kentucky with a minimum of 3 years of engineering geology experience applicable to the design and/or construction of highway facilities (demonstrated by performing tasks included on Page 3 of this form).

C. Staff with sufficient experience to perform geotechnical engineering tasks for KYTC, as demonstrated by experience in a minimum of 9 of the 12 areas of "conventional" experience included on Page 3 of this form. (Seismic experience is not required.)

D. A minimum of one CADD operator proficient with Microstation.

Notes:

1. Complete Page 2 of this form and provide detailed project descriptions for a minimum of 3 of the projects completed by the firm included in the summary.

2. Complete Page 3 of this form and provide resumes of personnel needed to meet the personnel requirements above. All personnel experience need not be with the current employer.

3. A firm may subcontract laboratory testing and/or field drilling operations to firms prequalified in the applicable area(s). A firm may also subcontract speciality work in areas not covered by prequalification. All subcontracting is subject to the prior approval of the Division of Professional Services and the Geotechnical Branch.

4. For details regarding Licensure and Firm Permits, refer to:
   KY Board of Licensure for Professional Engineers and Land Surveyors http://kyboels.ky.gov/
   KY Board of Registration for Professional Geologists http://finance.ky.gov/ourcabinet/caboff/OAS/op/progeo/

KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch

SUMMARY OF TRANSPORTATION (OR RELATED) PROJECTS COMPLETED IN THE LAST 5 YEARS FOR WHICH THE FIRM PROVIDED GEOTECHNICAL ENGINEERING SERVICES

Project Name	Project Location (County & State)	Description of Work Performed	Dates Performed	Key Personnel	Client (Include Address & Phone)	Approximate Fee

Provide detailed project descriptions for a minimum of 3 project

KENTUCKY TRANSPORTATION CABINET

Division of Materials

Geotechnical Branch

SUMMARY OF PROFESSIONAL PERSONNEL EXPERIENCE

PERSONNEL					AREAS OF EXPERIENCE (Indicate all that apply):																
						CONVENTIONAL												SEISMIC			
Name	PE License No. & State	PG License No. & State	Other Professional Staff (Include Classification)	Years of Geotechnical Experience	MicroStation	Slope Stability Analysis	Settlement Analysis	Deep Foundation Analysis	Wave Equation/ Driveability Analysis	Negative Skin Friction Analysis	Bearing Capacity Analysis	Retaining Wall Analysis	Rock Cut Slope Design	Preparing Geologist Rock Core Logs	Developing Subsurface Exploration Plans	Developing Geotechnical Laboratory Testing Plans	Writing Geotechnical Reports	Equivalent Linear 1-D Site Response Analysis	Liquefaction Analysis	Seismic Settlement Analysis	Pseudo-Static Slope Stability Analysis

Provide resumes of personnel needed to meet the experience requirement

KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch

TC 64-542
Rev. 5/05

PREQUALIFICATION REQUIREMENTS
FOR GEOTECHNICAL LABORATORY TESTING SERVICES

A. Accreditation by the AASHTO Materials Reference Laboratory (AMRL) for the following AASHTO Test Methods: T87, T88, T89, T90, T99, T100, T193, T208, and T265. The Geotechnical Branch will verify accreditation on the AMRL website during the prequalification review.

B. Management and staff meeting the requirements for AASHTO R18 accreditation and with experience performing all the above-referenced tests.

C. A loading device with a movable head or base such that it is capable of applying a compressive load up to 60,000 lb. (267 kN), as required for the compaction portion of KM 64-501 (the Kentucky Method for performing the California Bearing Ratio Test).

NOTES:

1. Complete Page 2 of this form and provide resumes of key personnel identified in the laboratory's Quality Manual (e.g. Technical Manager, Supervising Laboratory Technician, and Quality Manager).

2. Identify the location(s) of lab(s) to be used on KYTC projects.

3. Provide a description and laboratory location of the above-referenced loading device. Include the make, model, load capacity, etc., and a statement that it meets the requirements above. This device must be located at a laboratory that is accredited for AASHTO T193.

4. In addition to the above-referenced test methods, the Geotechnical Branch considers AMRL accreditation for T216, T296, and T297, and the capability to perform the Unconfined Compressive Strength of Rock, Slake Durability, and Jar Slake tests to be highly desirable. Although these tests are not required for prequalification, the Geotechnical Branch strongly recommends that labs be accredited for and/or have the ability to perform these tests.

5. Although not generally required to be submitted for prequalification, the Geotechnical Branch may request accreditation documents such as the Quality Manual, On-Site Assessment Reports, Proficiency Sample Test Results, etc. Please be prepared to provide such documents upon request.

6. For details regarding laboratory accreditation, refer to:
   AASHTO Materials Reference Laboratory http://www.amrl.net/

KENTUCKY TRANSPORTATION CABINET

Division of Materials

Geotechnical Branch

SUMMARY OF GEOTECHNICAL LABORATORY PERSONNEL EXPERIENCE

		AREAS OF EXPERIENCE (Indicate all that apply):														
Name	**Years of Geotech and/or Construction Materials Testing Experience**	Supervising Lab Technician	Lab Technician	AASHTO T87 Dry Preparation of Samples	AASHTO T88 Particle Size Analysis	AASHTO T89, T90 Liquid and Plastic Limits	AASHTO T99 Moisture-Density	AASHTO T100 Specific Gravity	AASHTO T193 California Bearing Ratio	AASHTO T208 UC Strength of Soil	AASHTO T265 Moisture Content	AASHTO T216 1-D Consolidation	AASHTO T296 UU Triaxial	AASHTO T297 CU Trx w/ PP Measurements	UC Strength of Rock	Slake Durability & Jar Slake

Include only personnel in lab(s) to be used on KYTC projects

Provide the resumes of key personnel identified in the lab's Quality Manua

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KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch

UNIT COST ITEMS FOR GEOTECHNICAL SERVICES

COUNTY ____________ **ITEM #** ____________ **MARS #** ____________
REGION # ______ **RANK** ______ **CONTRACT #** ____________ **ESTIMATE #** ____________

	UNIT PRICE			UNITS		TOTAL
1. Rock Coring	$	per foot	x		=	$
2. Rock Coring on Floating Eq.	$	per foot	x		=	$
3. Rock Sounding	$	per foot	x		=	$
4. Rock Sounding on Floating Eq.	$	per foot	x		=	$
5. Visual Inspection & Logging Rock Exposure	$	per foot	x		=	$
6. Disturbed Soil Boring	$	per foot	x		=	$
7. Bag Sample	$	per sample	x		=	$
8. Standard Penetration Test	$	per test	x		=	$
9. Standard Penetration Test on Floating Eq.	$	per test	x		=	$
10. Thin-Walled Tube Sample	$	per tube	x		=	$
11. Thin-Walled Tube Sample on Floating Eq.	$	per tube	x		=	$
12. Field Vane Shear Test	$	per test	x		=	$
13. Field Vane Shear Test on Floating Eq.	$	per test	x		=	$
14. Cased Observation Well	$	per well	x		=	$
15. Drill Hole for Slope Inclinometer Casing	$	per foot	x		=	$
16. Pavement Cores	$	per foot	x		=	$
17. Grouting Intervals, 6 Inch Auger	$	per foot	x		=	$
18. Grouting Intervals, 4 Inch Auger	$	per foot	x		=	$
19. Grouting Intervals, Rock Core	$	per foot	x		=	$
20. Moisture Content Sample	$	per sample	x		=	$
21. Moisture Content Test	$	per test	x		=	$
22. Logging Rock Core	$	per foot	x		=	$
23. Soil Classifications	$	per sample	x		=	$

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KENTUCKY TRANSPORTATION CABINET

Division of Materials
Geotechnical Branch

UNIT COST ITEMS FOR GEOTECHNICAL SERVICES

COUNTY ______________________ **ITEM #** ____________

24. Wash and Sieve Gradations	**$**	**per test**	**x**		**=**	**$**
25. Moisture/Density/CBR/Soil Classification	**$**	**per sample**	**x**		**=**	**$**
26. Moisture/Density Test	**$**	**per sample**	**x**		**=**	**$**
27. Slake Durability Index & Jar Slake Test	**$**	**per test**	**x**		**=**	**$**
28. Unconfined Compression Tests on Soil	**$**	**per test**	**x**		**=**	**$**
29. Unconfined Compression Tests on Rock	**$**	**per test**	**x**		**=**	**$**
30. One-Dimensional Consolidation Tests	**$**	**per test**	**x**		**=**	**$**
31. Consolidated-Undrained Triaxial Test with Pore Pressure Measurements	**$**	**per test**	**x**		**=**	**$**
32. Unconsolidated-Undrained Triaxial Test Total Stress Method	**$**	**per test**	**x**		**=**	**$**
33. Slope Stability Analyses	**$**	**per analysis**	**x**		**=**	**$**
34. Settlement Analyses	**$**	**per analysis**	**x**		**=**	**$**
35. Deep Foundation Analyses	**$**	**per analysis**	**x**		**=**	**$**
36. Wave Equation Driveability Analyses	**$**	**per analysis**	**x**		**=**	**$**
37. Negative Skin Friction Analyses	**$**	**per analysis**	**x**		**=**	**$**
38. Bearing Capacity Analyses	**$**	**per analysis**	**x**		**=**	**$**
39. Retaining Wall Analyses	**$**	**per section**	**x**		**=**	**$**
40. Drafting	**$**	**per sheet**	**x**		**=**	**$**
41. Dozer Working Time	**$**	**per hour**	**x**		**=**	**$**
42. Track Hoe Working Time	**$**	**per hour**	**x**		**=**	**$**
43. Mobilization/Demobilization of Drill Eq.	**$**	**per mile**	**x**		**=**	**$**
			+	**(FIXED FEE)**	**+**	**$**
44. Mobilization/Demobilization of Subcontracted Dozer or Track Hoe	**$**	**per hour**	**x**	**2**	**=**	**$**
45. Mobilization/Demobilization of Company Owned Dozer or Track Hoe		**per mile**	**x**		**=**	**$**
			+	**(FIXED FEE)**	**+**	**$**

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KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch

UNIT COST ITEMS FOR GEOTECHNICAL SERVICES

COUNTY ______________ **ITEM #** ______________

46. Mobilization/Demobilization of Company Owned Floating Equipment	**$**	**lump sum**	**x**		**=**	**$**
47. Towboat and /or Barge & its crew (Subcontracted)	**$**	**per invoice**	**x**		**=**	**$**
			+	**(FIXED FEE)**	**+**	**$**
48. Towboat and /or Barge & its crew (In-House)	**$**	**per day**	**x**		**=**	**$**
			+	**(FIXED FEE)**	**+**	**$**
49. Reclamation : Activity	**$**	**per day**	**x**		**=**	**$**
50. Reclamation : Material Cost	**$**	**per invoice**	**+**	10%	**=**	**$**
51. Traffic Control (In-House)	**$**	**per day**	**x**		**=**	**$**
52. Subcontracted Traffic Control	**$**	**per invoice**	**+**	10%	**=**	**$**
53. Preliminary Plans	**$**	**lump sum**	**x**		**=**	**$**
54. Preliminary Meetings	**$**	**lump sum**	**x**		**=**	**$**
55. Rock Core Meetings	**$**	**lump sum**	**x**		**=**	**$**
56. Interim Meetings	**$**	**lump sum**	**x**		**=**	**$**
57. Final Meetings	**$**	**lump sum**	**x**		**=**	**$**
58. Report Writing	**$**	**lump sum**	**x**		**=**	**$**
59. Publication of Reports	**$**	**lump sum**	**x**		**=**	**$**
		TOTAL THIS ESTIMATE			**=**	**$**
ACCUMULATED TOTAL ESTIMATES		**THROUGH**			**=**	**$**

FIRM NAME ______________

SIGNED ______________
DATE ______________

TC 64-525
REV 5/05

KENTUCKY TRANSPORTATION CABINET

Division of Materials
Geotechnical Branch

TABULATION OF QUANTITIES FOR INVOICES

County ____________ Federal Project # ________ State Project # ____________ Page ____ of ____

Region # ______ Rank # ______ Agreement # ________ Estimate # ________ Item # ________ MARS # ________

HOLE NO.	STATION	OFFSET	1 ROCK CORING	2 ROCK CORING ON FLOATING EQUIPMENT	3 ROCK SOUNDING	4 ROCK SOUNDING ON FLOATING EQUIPMENT	5 VISUAL INSPECTION AND LOGGING ROCK EXPOSURES	6 DISTURBED SOIL BORING	7 BAG SAMPLE	8 STANDARD PENETRATION TEST	9 STANDARD PENETRATION TEST ON FLOATING EQUIPMENT	10 THIN-WALLED TUBE SAMPLE	11 THIN-WALLED TUBE SAMPLE ON FLOATING EQUIPMENT	12 FIELD VANE SHEAR TEST	13 FIELD VANE SHEAR TEST ON FLOATING EQUIPMENT	14 CASED OBSERVATION WELL	15 DRILL HOLE FOR SLOPE INCLINOMETER CASING	16 PAVEMENT CORES	17 GROUTING INTERVALS 6" AUGER
Sheet																			
This Estimate																			
All Estimates																			

KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch

TC 64-525
REV 5/05

TABULATION OF QUANTITIES FOR INVOICES

County ____________ Item # ____________ Page _____ of _____

HOLE NO.	STATION	OFFSET	18 GROUTING INTERVALS 4" AUGER	19 GROUTING INTERVALS ROCK CORE	20 MOISTURE CONTENT SAMPLE	21 MOISTURE CONTENT TEST	22 LOGGING ROCK CORE	23 SOIL CLASSIFICATION	24 WASH AND SIEVE GRADATIONS	25 MOISTURE / DENSITY, CBR, SOIL CLASSIFICATION	26 MOISTURE / DENSITY TEST	27 SLAKE DURABILITY AND JAR SLAKE TEST	28 UNCONFINED COMPRESSION TEST ON SOIL	29 UNCONFINED COMPRESSION TEST ON ROCK	30 ONE-DIMENSIONAL CONSOLIDATION TEST	31 CONSOLIDATED-UNDRAINED TRIAXIAL TEST	32 UNCONSOLIDATED-UNDRAINED TRIAXIAL TEST	33 SLOPE STABILITY ANALYSES	34 SETTLEMENT ANALYSES
Sheet																			
This Estimate																			
All Estimates																			

TC 64-525
REV 5/05

KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch

TABULATION OF QUANTITIES FOR INVOICES

County ______________ Item # ______________ Page ______ of ______

HOLE NO.	STATION	OFFSET	35 DEEP FOUNDATION ANALYSES	36 WAVE EQUATION DRIVEABILITY ANALYSES	37 NEGATIVE SKIN FRICTION ANALYSES	38 BEARING CAPACITY ANALYSES	39 RETAINING WALL ANALYSES	40 DRAFTING	41 DOZER WORKING TIME	42 TRACKHOE WORKING TIME
Sheet										
This Estimate										
All Estimates										

OTHER QUANTITES (include invoice where applicable)

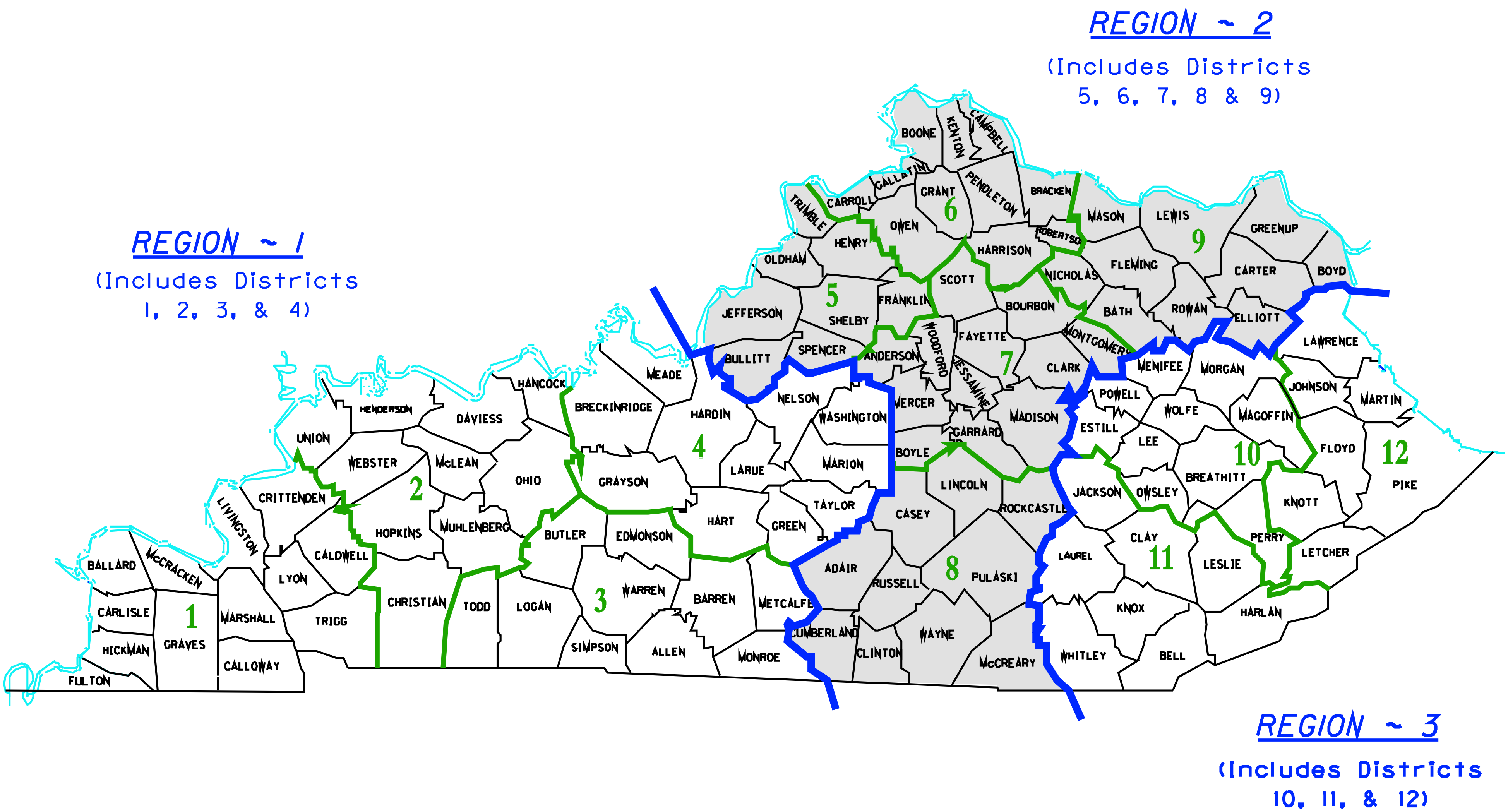
43 MOB & DEMOB OF DRILL EQUIPMENT (MILES X PRICE) + (FIXED FEE) = ______.
44 MOB & DEMOB OF SUBCONTRACTED DOZER/TRACKHOE $_____/hr x 2 hrs $_____.
45 MOB & DEMOB OF COMPANY OWNED DOZER (MILES X PRICE) + (FIXED FEE) = _____.
46 MOB & DEMOB OF COMPANY OWNED BARGE(LUMP SUM) $________.
47 SUBCONTRACTED TOWBOAT/BARGE (INVOICE) + (FIXED FEE) $_________.
48 COMPANY OWNED TOWBOAT/BARGE/CREW (PER DAY) + (FIXED FEE) $_________ .
49 RECLAMATION ACTIVITY___________ DAYS (8 HOURS EACH FOR 2 MEN).
50 MATERIAL COST (INVOICE PLUS 10%) $____________ .
51 TRAFFIC CONTROL (IN HOUSE)$___________ . PER DAY (8 HOURS EACH FOR 2 MEN)
52 TRAFFIC CONTROL (SUBCONTRACTED) $___________(LUMP SUM - INVOICE PLUS 10%)
53 PRELIMINARY PLANS $___________ (LUMP SUM)
54 PRELIMINARY MEETINGS $_____________ (LUMP SUM).
55 ROCK CORE MEETINGS $___________ (LUMP SUM).
56 INTERIM MEETINGS $_______________ (LUMP SUM).
57 FINAL MEETINGS $_______________ (LUMP SUM).
58 REPORT WRITING $__________ (LUMP SUM)
59 PUBLICATION OF REPORTS $_____________ (LUMP SUM).

Firm Name ______________________

Signed ______________________

Date ______________________

REGIONS FOR GEOTECHNICAL DRILLING SERVICES



KENTUCKY TRANSPORTATION CABINET
Division of Materials
Geotechnical Branch

TC 64-523

NOTIFICATION FOR DRILLING SERVICES

VENDOR:

SUBJECT: **Drilling Services**

Region #
Agreement #
Contract Rank:

COUNTY:

PROJECT #: **MARS #:** **ITEM #:**

ROAD NAME:

Type of Drilling Services:

DATE OF NOTIFICATION:

DATE TO COMPLETE: ____________

TIME TO COMPLETE: ____________ **Calendar Days from Date of Notification**

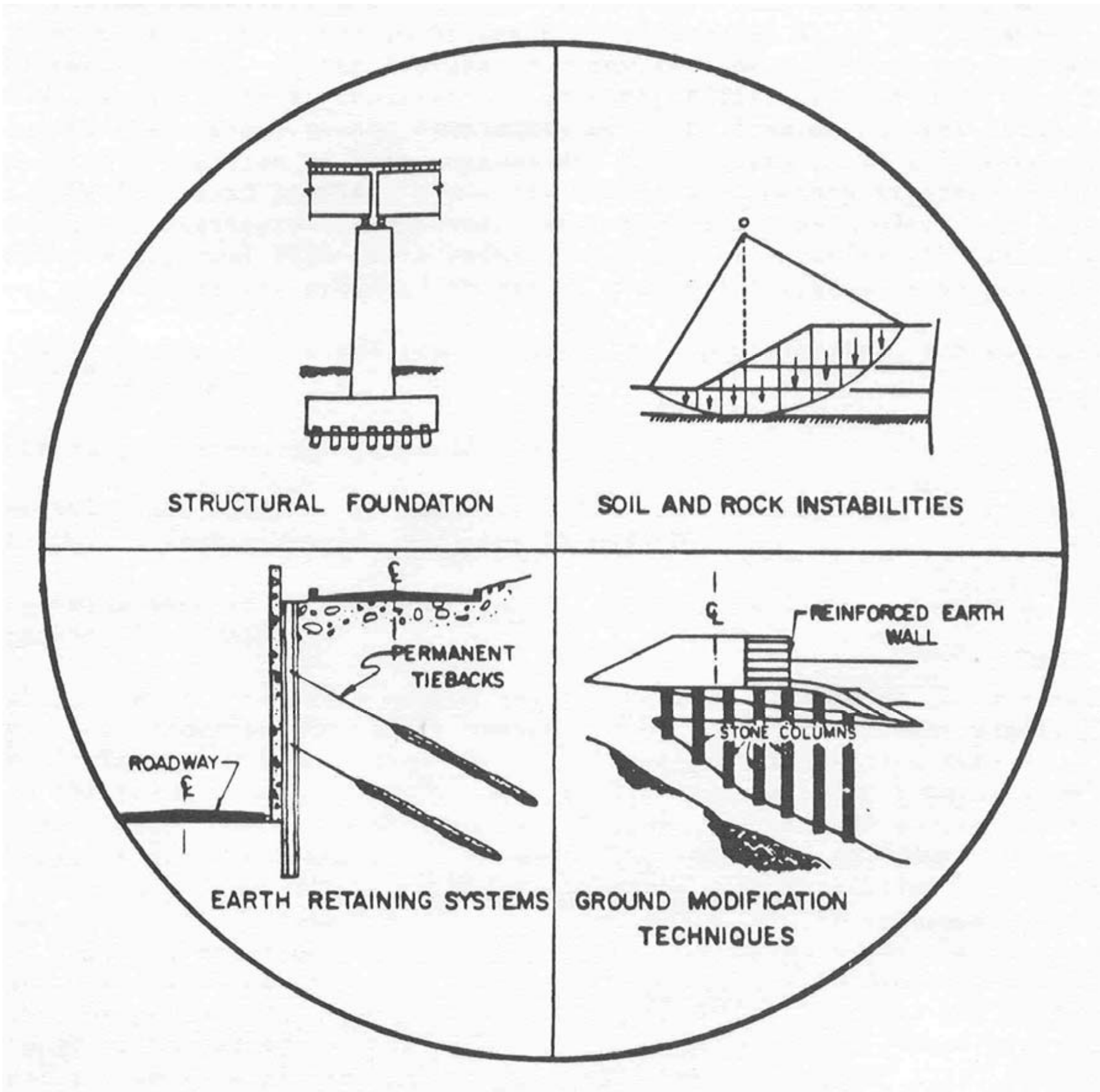
Signed: ______________________________ ____________
Department Representative *Date*

Project Accepted: ☐ **Yes** ☐ **No**

Signed: ______________________________ ____________
Vendor Representative *Date*

U.S. Department
of Transportation
**Federal Highway
Administration**

Publication No. FHWA ED-88-053
August 1988
Revised February 2003



CHECKLIST AND GUIDELINES FOR REVIEW OF GEOTECHNICAL REPORTS AND PRELIMINARY PLANS AND SPECIFICATIONS

PREFACE

A set of review checklists and technical guidelines has been developed to aid engineers in their review of projects containing major and unusual geotechnical features. These features may involve any earthwork or foundation related activities such as construction of cuts, fills, or retaining structures, which due to their size, scope, complexity or cost, deserve special attention. A more specific definition of both unusual and major features is presented in Table 1. Table 1 also provides a description of a voluntary program by which FHWA generalists engineers determine what type and size projects may warrant a review by a FHWA geotechnical specialist. The review checklists and technical guidelines are provided to assist generalist highway engineers in:

- Reviewing both geotechnical reports and plan, specification, and estimate (PS&E)* packages;

- Recognizing cost-saving opportunities

- Identifying deficiencies or potential claim problems due to inadequate geotechnical investigation, analysis or design;

- Recognizing when to request additional technical assistance from a geotechnical specialist.

At first glance, the enclosed review checklists will seem to be inordinately lengthy, however, this should not cause great concern. First, approximately 50 percent of the review checklists deal with structural foundation topics, normally the primary responsibility of a bridge engineer; the remaining 50 percent deal with roadway design topics. Second, the general portion of the PS&E checklist is only one page in length. The remaining portions of the PS&E checklist apply to specific geotechnical features – such as pile foundations, embankments, landslide corrections, etc., and would only be completed when those specific features exist on the project. Third, the largest portion of the checklists deals with the review of geotechnical reports, with a separate checklist for each of eight geotechnical features. The checklist for each geotechnical feature is only one to two pages in length. Therefore, on most projects, reviewers will find that only a small portion of the total enclosed checklist needs to be completed.

* For purposes of this document, PS&E refers to a plan and specification review at any time during a project's development. Hence, the review may be at a preliminary or partial stage of plan development.

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LIST OF TABLES

GEOTECHNICAL REVIEW CHECKLISTS AND TECHNCIAL GUIDLINES

Introduction

The following review checklists and technical guidelines have been developed to aid engineers with review of geotechnical reports, plans and special provisions on projects containing major and unusual geotechnical features. These may involve any earthwork or foundation related activities such as construction of cuts, fills, or retaining structures, which due to their size, scope, complexity or cost, deserve special attention. A more specific definition of both major and unusual features is presented in Table 1. The checklists and review guidelines are intended to serve four primary purposes.

First, for projects that are submitted to a FHWA geotechnical specialist, the checklists and technical guidelines are provided to aid FHWA generalist engineers in making a quick review of the geotechnical report and accompanying support data provided by the State, to insure that the information provided by the State is complete enough to allow adequate technical review by the FHWA geotechnical specialist.

Second, for projects which will not be submitted to a FHWA geotechnical specialist for formal review (which will be the majority of projects handled by the FHWA division office) the checklists and technical guidelines are provided to assist generalist engineers in (1) reviewing geotechnical reports and preliminary plan and specification packages; (2) recognizing cost-saving opportunities; (3) spotting deficiencies or potential claim problems due to inadequate geotechnical investigations, analysis, or design; (4) recognizing when to request technical assistance for a FHWA geotechnical specialist.

Third, it should be noted that the checklists and technical guidelines also include coverage of structure foundations. These review checklists and technical guidelines have been developed to fill an existing need in this area.

Fourth, this document sets forth minimum geotechnical standards or criteria to show transportation agencies and consultants the basic geotechnical information which FHWA recommends be provided in geotechnical reports and PS&E packages.

TABLE 1
PROJECT REVIEW GUIDELINES

The following project review guidelines are given to assist FHWA generalist engineers in determining what type and size projects may warrant review by a FHWA geotechnical specialist.

A FHWA geotechnical specialist should review Geotechnical reports and supporting data for major or unusual geotechnical features, described below. The FHWA division office should also request FHWA geotechnical specialist review for any project that is considered to involve geotechnical risk or excessive expense in its design or construction. Supporting data for these reviews include preliminary plans, specifications, and cost estimates (if available at the time of geotechnical report submittal). Emphasis will be placed on review of these projects in the preliminary stage in order to optimize cost savings through early identification of potential problems or more innovative designs. To be of maximum benefit geotechnical reports and supporting data should be forwarded for review as soon as available, and at least 60 days prior to the scheduled project advertisement date. The review by the FHWA geotechnical specialist should be completed within 10 working days.

A. “Major” Geotechnical Features

Geotechnical reports and supporting data for major geotechnical project features should be submitted to the FHWA geotechnical specialist for review if the following project cost and complexity criteria exist:

	Cost Criteria
1. Earthwork – soil or rock cuts or fills where (a) the maximum height of cut or fill exceeds 15 m (50 ft), or (b) the cuts or fills are fills are located in topography and/or geological units with known stability problems.	Greater than $1,000,000
2. Soil and Rock Instability Corrections – cut, fill, or natural slopes which are presently or potentially unstable.	Greater than $ 500,000
3. Retaining Walls (geotechnical aspects) - maximum height at any point along the length exceeds 9 m (30 ft). Consideration of bidding cost-effective alternatives and geotechnical aspects (bearing capacity, settlement, overturning, sliding, etc.) are of prime concern. Structural design of and footings is beyond the scope of these reviews.	Greater than $ 250,000

B. “Unusual” Geotechnical Features

Geotechnical reports and supporting data for all projects containing unusual geotechnical features should be submitted to the FHWA geotechnical specialist for review.

An unusual geotechnical project feature is any geotechnical feature involving: (1) difficult or unusual problems, e.g. embankment construction on a weak and compressible foundation material (difficult) or fills constructed using degradable shale (unusual); (2) new or complex designs, e.g. geotextile soil reinforcement, permanent ground anchors, wick drains, ground improvement technologies; and (3) questionable design methods, e.g. experimental retaining wall systems, pile foundations where dense soils exists.

What is a Geotechnical Report?

The geotechnical report is the tool used to communicate the site conditions and design and construction recommendations to the roadway design, bridge design, and construction personnel. Site investigations for transportation projects have the objective of providing specific information on subsurface soil, rock, and water conditions. Interpretation of the site investigation information, by a geotechnical engineer, results in design and construction recommendations that should be presented in a project geotechnical report. The importance of preparing an adequate geotechnical report cannot be overstressed. The information contained in this report is referred to often during the design period, construction period, and frequently after completion of the project (resolving claims). Therefore, the report should be as clear, concise, and accurate. Both an adequate site investigation and a comprehensive geotechnical report are necessary to construct a safe, cost-effective project. Engineers need these reports to conduct an adequate review of geotechnical related features, e.g., earthwork and foundations.

The State or their consultant should prepare "Preliminary" geotechnical reports for submittal to the design team whenever this information will benefit the design process. Early submittal of geotechnical information and recommendations or engineering evaluation of preliminary data may be necessary to establish basic design concepts or design criteria. This is commonly the case on large projects or projects containing complex or difficult geotechnical problems where alignment and/or grade changes may be appropriate based on geotechnical recommendations. The development of a "Final" geotechnical report will not normally be completed until design has progressed to the point where specific recommendations can be made for all of the geotechnical aspects of the work. Final alignment, grade, and geometry will usually have been selected prior to issuance of the final geotechnical report.

While the geotechnical report content and format will vary by project size and highway agency, all geotechnical reports should contain certain basic essential information, including:

- Summary of all subsurface exploration data, including subsurface soil profile, exploration logs, laboratory or in situ test results, and ground water information;
- Interpretation and analysis of the subsurface data;
- Specific engineering recommendations for design;
- Discussion of conditions for solution of anticipated problems; and
- Recommended geotechnical special provisions.

It is suggested that the State routinely include this minimum information in the geotechnical report for Federal-Aid highway projects and that a copy of this report be supplied to the FHWA division office at the time when the report is internally distributed in the State.

For brevity in this document, the term geotechnical report will be used as a general term to cover all types of geotechnical reports, e.g., foundation report, centerline soils report, landslide study report, etc.

Use of Review Checklists and Technical Guidelines

Review checklists have been prepared for review of geotechnical reports and review of the geotechnical aspects of preliminary plans, specification and estimate (PS&E)* packages. To simplify their use, the checklists are set up in a question and answer format. The geotechnical report checklists (pages 11 through 27) cover the important information that should be presented in project geotechnical reports. The PS&E review checklists (pages 28 through 33) cover the geotechnical aspects, ranging from assuring continuity between the project geotechnical report and contract documents to avoiding common claim pitfalls. Items that are identified with an asterisk (*) are considered to be of major importance. A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

Groups of related questions and, in some cases, individual questions have been cross referenced to the "Soils and Foundations Workshop Manual"** so as to provide the generalist engineer user a reference on basic geotechnical items. Technical guidelines are presented in Tables 1 through 4. Since it is not possible to establish strict criteria for all geotechnical information that should be obtained or geotechnical analysis that should be performed for a particular project, only general or minimum guidelines can be established. Table 1 provides definitions of both major and unusual features and guidelines as to which projects may be appropriate for review by the FHWA geotechnical specialist. Table 2 presents guideline minimum boring, sampling, and testing criteria for subsurface investigations that should be conducted for major or unusual geotechnical features. Table 3 presents general guidelines on the major types of geotechnical engineering analyses that are normally required for embankments and cut slopes, structure foundations, and retaining structures. Guidance is given for all major soil types. Table 4 presents a list of technical support data that should be provided for correction of soil and rock instabilities (landslides). Due to the unique situation that landslides present in terms of a major expenditure of funds for rehabilitation, a concise and specific list of necessary support information is warranted.

The enclosed review checklists and technical guidelines cover the following geotechnical features:

- Centerline Cuts and Embankments
- Embankments Over Soft Ground
- Landslide Corrections
- Retaining Structures
- Structure Foundations (spread footings, piles, drilled shafts)
- Ground Improvement Techniques
- Material Sites

*For the purposes of this document, PS&E refers to a plan and specification review at anytime during a project's development. Hence, the review may occur at a preliminary or partial stage of plan development.

** "Soils and Foundations Workshop Manual", Publication # FHWA NHI-00-045

Reviews made during the preliminary stage of project development will commonly consist of reviewing the geotechnical report only, since detailed plans and specifications may not yet be prepared.

When reviewing the PS&E, the plans, special provisions, and final geotechnical report should be examined together. A major aspect of the PS&E review of project geotechnical features is to verify that the major design and construction recommendations given in the geotechnical report have been properly incorporated into the plans and specifications. The practice of most highway agencies is to prepare a single geotechnical report that includes subsurface information, interpretations, and design and construction recommendations. However, some agencies prepare two separate reports; one report that only presents the factual subsurface data (made available to bidders), and a separate report or design memorandum (not made available to bidders) which contains the interpretation of subsurface conditions and the design and construction recommendations. These reports not only form the basis of technical reviews but should also be the agency's basis for design and construction of earthwork and foundation features.

The review checklists should be used as the working document while the guidelines in Tables 1 through 4, and the indicated sections of the "Soils and Foundations Workshop Manual" should be used as references. The checklist questions should be completed by referring to the geotechnical report and contract documents, the appropriate sections of the tables, and by use of engineering judgement. For each question, the reviewer should indicate a yes, no, or unknown or non-application response. Upon completion of the checklists, the reviewer should summarize the negative responses and discuss these with the appropriate geotechnical engineers to determine if additional follow-up is appropriate.

Seismic design of geotechnical features has not been considered in this document. For guidance the reader is referred to "Geotechnical Engineering Circular No. 3, Design Guidance: Geotechnical Earthquake Engineering for Highways, Volume I – Design Principles", FHWA SA-97-076. Seismic loads represent an extreme loading condition therefore relatively low factors of safety are generally considered acceptable in a pseudo-static analysis. Factors of safety on the order of 1.1 to 1.15 are typically used in practice for both bearing capacity and sliding resistance. The choice of the factor of safety and of the seismic coefficient are intimately linked. For instance, of a seismic coefficient equal to the PGA (divided by g) has been used in the pseudo-static analysis because the foundation cannot tolerate large movements, a factor of safety of 1.0 may be used. Alternatively, if the seismic coefficient is one-half the PGA and the soil is susceptible to a post-peak strength decrease, a factor of safety of 1.1 to 1.15 should be used.

TABLE 2

GUIDELINE “MINIMUM” BORING, SAMPLING, AND TESTING CRITERIA

The most important step in geotechnical design is to conduct an adequate subsurface investigation. The number, depth, spacing and character of borings, sampling, and testing to be made in an individual exploration program are so dependent upon site conditions and the type of project and its requirements, that no “rigid” rules may be established. Usually the extent of work is established as the site investigation progresses in the field. However, the following are considered reasonable “guidelines” to follow to produce the minimum subsurface data needed to allow cost-effective geotechnical design and construction and to minimize claim problems. (Reference: “Subsurface Investigations” FHWA HI-97-021)

Geotechnical Feature	Minimum Number of Borings	Minimum Depth of Borings
Structure Foundation	1 per substructure unit under 30 m (100 ft) in width 2 per substructure unit over 30 m (100 ft) in width Additional borings in areas of erratic subsurface conditions	Spread footings: 2B where L< 2B, 4B where L > 2B and interpolate for L between 2B and 4B Deep foundations: 6m (20ft) below tip elevation or two times maximum pile group dimension, whichever is greater If bedrock is encountered: for piles core 3 m (10 ft) below tip elevation; for shafts core 3D or 2 times maximum shaft group dimension below tip elevation, whichever is greater.
Retaining Structures	Borings spaced every 30 to 60 m (100 to 200 ft). Some borings should be at the front of and some in back of the wall face.	Extend borings to depth of 0.75 to 1.5 times wall height When stratum indicates potential deep stability or settlement problem, extend borings to hard stratum
Bridge Approach Embankments over Soft Ground	When approach embankments are to be placed over soft ground, at least one boring should be made at each embankment to determine the problems associated with stability and settlement of the embankment. Typically, test borings taken for the approach embankments are located at the proposed abutment locations to serve a dual function.	Extend borings into competent material and to a depth where added stresses due to embankment load is less than 10% of existing effective overburden stress or 3 m (10 ft) into bedrock if encountered at a shallower depth Additional shallow explorations (hand auger holes) taken at approach embankment locations to determine depth and extent of unsuitable surface soils or topsoil.
Centerline Cuts and Embankments	Borings typically spaced every 60 m (200 ft) (erratic conditions) to 120 m (400 ft) (uniform conditions) with at least one boring taken in each separate landform. For high cuts and fills, should have a minimum of 3 borings along a line perpendicular to centerline or planned slope face to establish geologic cross-section for analysis.	Cuts: (1) in stable materials extend borings minimum 5 m (15 ft) below depth of cut at the ditch line and, (2) in weak soils extend borings below grade to firm materials or to twice the depth of cut whichever occurs first. Embankments: Extend borings to a hard stratum or to a depth of twice the embankment height.
Landslides	Minimum 3 borings along a line perpendicular to centerline or planned slope face to establish geologic cross-section for analysis. Number of sections depends on extent of stability problem. For active slide, place at least on boring each above and below sliding area	Extend borings to an elevation below active or potential failure surface and into hard stratum, or to a depth for which failure is unlikely because of geometry of cross-section. Slope inclinometers used to locate the depth of an active slide must extend below base of slide.
Ground Improvement Techniques	Varies widely depending in the ground improvement technique(s) being employed. For more information see “Ground Improvement Technical Summaries” FHWA SA-98-086R.	
Material Sites (Borrow sources, Quarries)	Borings spaced every 30 to 60 m (100 to 200 ft).	Extend exploration to base of deposit or to depth required to provide needed quantity.

TABLE 2 (Continued)

GUIDELINE “MINIMUM” BORING, SAMPLING, AND TESTING CRITERIA

<u>Sand or Gravel Soils</u> SPT (split-spoon) samples should be taken at 1.5 m (5 ft) intervals or at significant changes in soil strata. Continuous SPT samples are recommended in the top 4.5 m (15 ft) of borings made at locations where spread footings may be placed in natural soils. SPT jar or bag samples should be snt to lab for classification testing and verification of field visual soil identification.
<u>Silt or Clay Soils</u> SPT and “undisturbed” thin wall tube samples should be taken at 15 m (5 ft) intervals or at significant changes in strata. Take alternate SPT and tube samples in same boring or take tube samples in separate undisturbed boring. Tube samples should be sent to lab to allow consolidation testing(for settlement analysis) and strength testing (for slope stability and foundation bearing capacity Analysis). Field vane shear testing is also recommended to obtain in-place shear strength of soft clays, silts and well-rotted peat.
<u>Rock</u> Continuous cores should be obtained in rock or shales using double or triple tube core barrels. In structural foundation investigations, core a minimum of 3 m (10 ft) into rock to insure it is bedrock and not a boulder. Core samples should be sent to the lab for possible strength testing (unconfined compression) if for foundation investigation. Percent core recovery and RQD value should be determined in field or lab for each core run and recorded on borng log.
<u>Groundwater</u> Water level encountered during drilling, at completion of boring,and at 24 hours after completion of boring should be recorded on boring log. In low permeability soils such as silts and clays, a false indication of the waterlevel may be obtained when water is used for drilling fluid andadequate time is not permitted after boring completion for the water level to stabilize (more than one week maybe required). In such soils a plastic pipe water observaton well should be installed to allow monitoring of the water level over a period of time. Seasonal fuctuations of water table should be determined where fluctuaton will have significant impact on design or construction (e.g., borrow source, footing excavation, excavation at toe of landslide, etc.). Artesian pressure and seepage zones, if encountered, should also be noted on the boring log. In landslide investigations, slope inclinometer casings can also serve as water observations wells by using “leaky” couplings (either normal aluminum couplings or PVC couplings with small holes drilled through them) and pea gravel backfill. The top 0.3 m (1 ft) or so of the annular space between water observation well pipes and borehole wall should be backfilled with grout, bentonite, or sand-cement mixture to prevent surface water inflow which can cause erroneous groundwater level readings.
<u>Soil Borrow Sources</u> Exploration equipment that will allow direct observation and sampling of the subsurface soil layers is most desirable for material site investigations. Such equipment that can consist of backhoes, dozers, or large diameter augers, is preferred for exploration above the water table. Below thewater table, SPT borings can be used. SPT samples should be taken at 1.5 m (5 ft) intervals or at signifcant changes in strata. Samples should be sent to lab for classification testing to verify field visual identification. Groundwater level should be recorded. Observations wells should be installed to monitor water levels where significant seasonal fluctuation is anticipated.
<u>Quarry Sites</u> Rock coring should be used to explore new quarry sites. Use of double or triple tube core barrels is recommended to maximize ore recovery. For riprap source, spacing of fractures should be carefully measured to allow assessment of rock sizes that can be produced by blasting. For aggegate source, the amount and type of joint infilling should be carefully noted. If assessment is made on the basis of an existing quarry site face, it may be necessary to core or use geophysical techniques to verify that nature of rock does not change behind the face orat depth. Core samples should be sent to lab for quality tests to determine suitability for riprap or aggregate.

TABLE 3

REQUIRED GEOTECHNICAL ENGINEERING ANALYSIS

Soil Classification			Embankment and Cut Slopes	Structure Foundations (Bridges and Retaining Structures)			Retaining Structures (Conventional, Crib and MSE)	
Unified	AASHTO [1]	Soil Type	Slope Stability Analysis [2]	Settlement Analysis	Bearing Capacity Analysis	Settlement Analysis	Lateral Earth Pressure	Stability Analysis
GW GP GM GC SW SP SM SC	A-1-a A-1-a A-1-b A-2-6 A-2-7 A-1-b A-3 A-2-4 A-2-5 A-2-6 A-2-7	GRAVEL Well-graded GRAVEL Poorly-graded GRAVEL Silty GRAVEL Clayey SAND Well-graded SAND Poorly-graded SAND Silty SAND Clayey	Generally not required if cut or fill slope is 1.5H to 1V or flatter, and underdrains are used to draw down the water table in a cut slope. Erosion of slopes may be a problem for SW or SM soils.	Generally not required except possibly for SC soils.	Required for spread footings, pile or drilled shaft foundations. Spread footings generally adequate except possibly for SC soils	Generally not needed except for SC soils or for large, heavy structures. Empirical correlations with SPT values usually used to estimate settlement	GW, SP, SW & SP soils generally suitable for backfill behind or in retaining or reinforced soil walls. GM, GC, SM & SC soils generally suitable if have less than 15% fines. Lateral earth pressure analysis required using soil angle of internal friction.	All walls should be designed to provide minimum F.S. = 2 against overturning & F.S. = 1.5 against sliding along base. External slope stability considerations same as previously given for cut slopes & embankments.
ML	A-4	SILT Inorganic silt Sandy	Required unless non-plastic. Erosion of slopes may be a problem.	Required unless non-plastic.	Required. Spread footing generally adequate.	Required. Can use SPT values if non-plastic.	These soils are not recommended for use directly behind or in retaining or reinforced soil walls.	
CL	A-6	CLAY Inorganic Lean Clay	Required	Required				
OL	A-4	SILT Organic	Required	Required				

[1] This is an approximate correlation to Unified (Unified Soil Classification system is preferred for geotechnical engineering uage, AASHTO system was developed for rating pavement subgrades).

[2] These are general guidelines, detailed slope stability analysis my not be required where past experience in area is similar cr rock gives required slope angles.

TABLE 3 (Continued)

Soil Classification			Embankment and Cut Slopes		Structure Foundations (Bridges and Retaining Structures)		Retaining Structures (Conventional, Crib and MSE)	
Unified	AASHTO [1]	Soil Type	Slope Stability Analysis [2]	Settlement Analysis	Bearing Capacity Analysis	Settlement Analysis	Lateral Earth Pressure	Stability Analysis
MH	A-5	SILT Inorganic	Required. Erosion of slopes may be a problem.	Required.	Required. Deep foundation generally required unless soil has been preloaded.	Required. Consolidation test data needed to estimate settlement amount and time.	These soils are not recommended for use directly behind or in retaining walls.	All walls should be designed to provide minimum F.S. = 2 against overturning & F.S. = 1.5 against sliding along base. External slope stability considerations same as previously given for cut slopes & embankments
CH	A-7	CLAY Inorganic Fat Clay	Required.	Required.				
OH	A-7	CLAY Organic	Required.	Required.				
PT	----	PEAT Muck	Required.	Required. Long term settlement can be significant	Deep foundation required unless peat excavated and replaced.	Highly compressible and not suitable for foundation support		
Rock			Fills – not required for slopes 1.5H to 1V or flatter. Cuts – required but depends on spacing, orientation and strength of discontinuities and durability of rock		Required for spread footings or drilled shafts. Empirically related to RQD[3]	Required where rock is badly weathered or closely fractured (low RQD). May require in situ test such as pressuremeter.	Required. Use rock backfill angle of internal friction.	

REMARKS:

Soils – temporary ground water control may be needed for foundation excavations in GW through SM soils.

Backfill specifications for reinforced soil walls using metal reinforcements should meet the following requirements in insure use of non-corrosive backfill:
pH range = 5 to 10; Resistivity > 3000 ohm-cm; Chlorides < 100 ppm; Sulfates < 200 ppm; Organic content 1% maximum

Rock – Durability of shales (siltstone, claystone, mudstone, etc.) to be used in fills should be checked. Non-durable shales should be embanked as soils, i.e., placed in maximum 0.3 m (1 ft) loose lifts and compacted with heavy sheepsfoot or grid rollers.

[1] This is an approximate correlation to Unified (Unified Soil Classification system is preferred for geotechnical engineering usage, AASHTO system was developed for rating pavement subgrades).

[2] These are general guidelines, detailed slope stability analysis may not be required where past experience in area is similar or rock gives required slope angles.

[3] RQD (Rock Quality Designation) = sum of pieces of rock core 4' or greater in length divided by the total length of core run.

TABLE 4
CORRECTION OF SOIL AND ROCK-RELATED INSTABLIITIES

Each year hundreds of millions of dollars are spent to correct soil or rock-related instabilities on highways. The purpose of this technical note is to advise field engineers what technical support information is essential such that a complete evaluation can be performed. For the purpose of this technical note, soil and rock-related instabilities are defined as follows: “A condition that currently or threatens to affect the stability or performance the stability or performance of a highway facility and is the result of the inadequate performance of the soil or rock components.” This includes major instabilities resulting form or associated with: landslides, rockfalls, sinkholes, and degrading shales. Technical support data needed are:

1. Site plan and typical cross-section(s) representing ground surface conditions prior to failure, along with subsurface configuration after failure. Photographs, including aerials, if available, would also be beneficial.

2. Cross-section(s) showing soil and/or rock conditions and water bearing strata as determined by drilling and possibly geophysical surveys.

3. Description of the latent state of the unstable mass, whether movement has stopped or is still occurring, and if so, at what rate.

4. Boring logs.

5. Instrumentation data and/or other information used to define the depth and location of the failure zone. The underground location of the failure zone should be shown on the cross-section(s).

6. Shear strength test data and a description of the testing method utilized on the materials, through which failure is occurring. Where average shear strength is calculated using an assumed failure surface and a factor of safety of 1.0, the complete analysis should be provided and location of assumed water table(s) shown.

7. Proposed corrective schemes including: estimated costs, final safety factors, and design analysis for each alternative solution.

8. Narrative report containing instability history; record of maintenance costs and activity, and preventative measures taken, if any; reasons for inadequacy of the original design; description and results of subsurface investigation performed; summary and results of stability analysis performed; and recommendations for correction.

GEOTECHNICAL REPORT REVIEW CHECKLISTS

The following checklists cover the major information and recommendations that should be addressed in project geotechnical reports.

Section A covers site investigation information that will be common to all geotechnical reports for any type of geotechnical feature.

Sections B through I cover the basic information and recommendations that should be presented in geotechnical reports for specific geotechnical features: centerline cuts and embankments, embankments over soft ground, landslides, retaining structures, structure foundations and material sites.

In most sections and subsections the user has been provided supplemental page references to the "Soils and Foundations Workshop Manual" FHWA NHI-00-045. These page numbers appear in parentheses ( ) immediately adjacent to the section or subsection topic. Generalist engineers are particularly encouraged to read these references. Additional reference information on these topics is available in the Geotechnical Engineering Notebook, a copy of which is kept in all FHWA Division offices by either the Bridge Engineer or the engineer with the geotechnical collateral duty.

Certain checklist items are of vital importance to have been included in the geotechnical report. These checklist items have been marked with an asterisk (*). A negative response to any of these asterisked items is cause to contact the geotechnical engineer for clarification of this omission.

GTR REVIEW CHECKLIST FOR SITE INVESTIGATION

A. Site Investigation Information

Since the most important step in the geotechnical design process is to conduct an adequate site investigation, presentation of the subsurface information in the geotechnical report and on the plans deserves careful attention.

Geotechnical Report Text (Introduction) (Pgs. 10-1 to 10-4)	Yes	No	Unknown or N/A
1. Is the general location of the investigation described and/or a vicinity map included?	___	___	_____
2. Is scope and purpose of the investigation summarized?	___	___	_____
3. Is concise description given of geologic setting and topography of area?	___	___	_____
4. Are the field explorations and laboratory tests on which the report is based listed?	___	___	_____
5. Is the general description of subsurface soil, rock, and groundwater conditions given?	___	___	_____
*6. Is the following information included with the geotechnical report (typically included in the report appendices):			
a. Test hole logs? (Pgs. 2-24 to 2-32)	___	___	_____
b. Field test data?	___	___	_____
c. Laboratory test data? (Pgs. 4-22 to 4-23)	___	___	_____
d. Photographs (if pertinent)?	___	___	_____
Plan and Subsurface Profile (Pgs. 2-19, 3-9 to 3-12, 10-13)			
*7. Is a plan and subsurface profile of the investigation site provided?	___	___	_____
8. Are the field explorations located on the plan view?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

		Yes	No	Unknown or N/A
A.	Site Investigation Information (Cont.)			
*9.	Does the conducted site investigation meet minimum criteria outlined in Table 2?	___	___	_____
10.	Are the explorations plotted and correctly numbered on the profile at their true elevation and location?	___	___	_____
11.	Does the subsurface profile contain a word description and/or graphic depiction of soil and rock types?	___	___	_____
12.	Are groundwater levels and date measured shown on the subsurface profile?	___	___	_____
	Subsurface Profile or Field Boring Log (Pgs. 2-14, 2-15, 2-24 to 2-31)			
13.	Are sample types and depths recorded?	___	___	_____
*14.	Are SPT blow count, percent core recovery, and RQD values shown?	___	___	_____
15.	If cone penetration tests were made, are plots of cone resistance and friction ratio shown with depth?			
	Laboratory Test Data (Pgs. 4-6, 4-22, 4-23)			
*16.	Were lab soil classification tests such as natural moisture content, gradation, Atterberg limits, performed on selected representative samples to verify field visual soil identification?	___	___	_____
17.	Are laboratory test results such as shear strength (Pg. 4-14), consolidation (Pg. 4-9), etc., included and/or summarized?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

GTR REVIEW CHECKLIST FOR CENTERLINE CUTS AND EMBANKMENTS

B. Centerline Cuts and Embankments (Pgs. 2-2 to 2-6)

In addition to the basic information listed in Section A, is the following information provided in the project geotechnical report.

Are station-to-station descriptions included for:	Yes	No	Unknown or N/A
1. Existing surface and subsurface drainage?	___	___	_____
2. Evidence of springs and excessively wet areas?	___	___	_____
3. Slides, slumps, and faults noted along the alignment?	___	___	_____

Are station-to-station recommendations included for the following?

General Soil Cut or Fill

4. Specific surface/subsurface drainage recommendations?	___	___	_____
5. Excavation limits of unsuitable materials?	___	___	_____
*6. Erosion protection measures for back slopes, side slopes, and ditches, including riprap recommendations or special slope treatment.	___	___	_____

Soil Cuts (Pgs. 5-23, 5-24)

*7. Recommended cut slope design?	___	___	_____
8. Are clay cut slopes designed for minimum F.S. = 1.50?	___	___	_____
9. Special usage of excavated soils?	___	___	_____
10. Estimated shrink-swell factors for excavated materials?	___	___	_____
11. If answer to 3 is yes, are recommendations provided for design treatment?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

B. Centerline Cuts and Embankments (Cont.)	Yes	No	Unknown or N/A
Fills (Pgs. 5-1 to 5-3)			
12. Recommended fill slope design?	___	___	_____
13. Will fill slope design provide minimum F.S. = 1.25?	___	___	_____
Rock Slopes			
*14. Are recommended slope designs and blasting specifications provided?	___	___	_____
*15. Is the need for special rock slope stabilization measures, e.g., rockfall catch ditch, wire mesh slope protection, shotcrete, rock bolts, addressed?	___	___	_____
16. Has the use of "template" designs been avoided (such as designing all rock slopes on 0.25:1 rather than designing based on orientation of major rock jointing)?	___	___	_____
*17. Have effects of blast induced vibrations on adjacent structures been evaluated?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

GTR REVIEW CHECKLIST FOR EMBANKMENTS OVER SOFT GROUND

C. Embankments Over Soft Ground

Where embankments must be built over soft ground (such as soft clays, organic silts, or peat), stability and settlement of the fill should be carefully evaluated. In addition to the basic information listed in Section A, is the following information provided in the project geotechnical report?

Embankment Stability (Pgs. 5-1 to 5-3, 5-20 to 5-22)	Yes	No	Unknown or N/A
*1. Has the stability of the embankment been evaluated for minimum F.S. = 1.25 for side slope and 1.30 for end slope of bridge approach embankments?	___	___	_____
*2. Has the shear strength of the foundation soil been determined from lab testing and/or field vane shear or cone penetrometer tests?	___	___	_____
*3. If the proposed embankment does not provide minimum factors of safety given above, are recommendations given or feasible treatment alternates, which will increase factor of safety to minimum acceptable (such as change alignment, lower grade, use stabilizing counterberms, excavate and replace weak subsoil, lightweight fill, geotextile fabric reinforcement, etc.)?	___	___	_____
*4. Are cost comparisons of treatment alternates given and a specific alternate recommended?	___	___	_____
Settlement of Subsoil (Pgs. 6-7 to 6-20)			
5. Have consolidation properties of fine-grained soils been determined from laboratory consolidation tests?	___	___	_____
*6. Have settlement amount and time been estimated?	___	___	_____
7. For bridge approach embankments, are recommendations made to get the settlement out before the bridge abutment is constructed (waiting period, surcharge, or wick drains)?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

C. Embankments Over Soft Ground (Cont.)	Yes	No	Unknown or N/A
8. If geotechnical instrumentation is proposed to monitor fill stability and settlement, are detailed recommendations provided on the number, type, and specific locations of the proposed instruments?	___	___	_____
Construction Considerations (Pgs. 10-8, 10-9)			
9. If excavation and replacement of unsuitable shallow surface deposits (peat, muck, top soil) is recommended, are vertical and lateral limits of recommended excavation provided?	___	___	_____
10. Where a surcharge treatment is recommended, are plan and cross-section of surcharge treatment provided in geotechnical report for benefit of the roadway designer?	___	___	_____
11. Are instructions or specifications provided concerning instrumentation, fill placement rates and estimated delay times for the contractor?	___	___	_____
12. Are recommendations provided for disposal of surcharge material after the settlement period is complete?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

GTR REVIEW CHECKLIST FOR LANDSLIDE CORRECTIONS

D. Landslide Corrections (Pgs. 5-1 to 5-4, 5-17 to 5-20)

In addition to the basic information listed in Section A, is the following information provided in the landslide study geotechnical report? (Refer to Table 4 for guidance on the necessary technical support data for correction of slope instabilities.)

		Yes	No	Unknown or N/A
*1.	Is a site plan and scaled cross-section provided showing ground surface conditions both before and after failure?	___	___	_____
*2.	Is the past history of the slide area summarized, including movement history, summary of maintenance work and costs, and previous corrective measures taken, if any?	___	___	_____
*3.	Is a summary given of results of site investigation, field and lab testing, and stability analysis, including cause(s) of the slide?	___	___	_____
Plan				
4.	Are detailed slide features, including location of ground surface cracks, head scarp, and toe bulge, shown on the site plan?	___	___	_____
Cross-section				
*5.	Are the cross-sections used for stability analysis included with the soil profile, water table, soil unit weights, soil shear strengths, and failure plane shown as it exists?	___	___	_____
6.	Is slide failure plane location determined from slope indicators?	___	___	_____
*7.	For an active slide, was soil strength along the slide failure plane back-calculated using a F.S. = 1.0 at the time of failure?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

D.	Landslide Corrections (Cont.)	Yes	No	Unknown or N/A
	Text			
*8.	Is the following information presented for each proposed correction alternative (typical correction methods include buttress, shear key, rebuild slope, surface drainage, subsurface drainage-interceptor, drain trenches or horizontal drains, etc.).			
	a. Cross-section of proposed alternative?	___	___	_____
	b. Estimated safety factor?	___	___	_____
	c. Estimated cost?	___	___	_____
	c. Advantages and disadvantages?	___	___	_____
9.	Is recommended correction alternative(s) given that provide a minimum F.S. = 1.25?	___	___	_____
10.	If horizontal drains are proposed as part of slide correction, has subsurface investigation located definite water bearing strata that can be tapped with horizontal drains?	___	___	_____
11.	If a toe counterberm is proposed to stabilize an active slide has field investigation confirmed that the toe of the existing slide does not extend beyond the toe of the proposed counterberm?	___	___	_____
	Construction considerations			
12.	Where proposed correction will require excavation into the toe of an active slide (such as for buttress or shear key) has the "during construction backslope F.S." with open excavation been determined?	___	___	_____
13.	If open excavation F.S. is near 1.0, has excavation stage stage construction been proposed?	___	___	_____
14.	Has seasonal fluctuations of groundwater table been considered?	___	___	_____
15.	Is stability of excavation backslope to be monitored?	___	___	_____
16.	Are special construction features, techniques and materials described and specified?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

GTR REVIEW CHECKLIST FOR RETAINING STRUCTURES

E. Retaining Structures (See "Earth Retaining Structures" FHWA NHI-99-025)

In addition to the basic information listed in Section A, is the following information provided in the project geotechnical report?

		Yes	No	Unknown or N/A
*1.	Recommended soil strength parameters and groundwater elevations for use in computing wall design lateral earth pressures and factor of safety for overturning, sliding, and external slope stability.	___	___	_____
2.	Is it proposed to bid alternate wall designs?	___	___	_____
*3.	Are acceptable reasons given for the choice and/or exclusion of certain wall types?	___	___	_____
*4.	Is an analysis of the wall stability included with minimum acceptable factors of safety against overturning (F.S. = 2.0), sliding (F.S. = 1.5), and external slope stability (F.S. = 1.5)?	___	___	_____
5.	If wall will be placed on compressible foundation soils, is estimated total, differential and time rate of settlement given?	___	___	_____
6.	Will wall types selected for compressible foundation soils allow differential movement without distress?	___	___	_____
7.	Are wall drainage details, including materials and compaction, provided?	___	___	_____

Construction Considerations

		Yes	No	Unknown or N/A
8.	Are excavation requirements covered including safe slopes for open excavations or need for sheeting or shoring?	___	___	_____
9.	Fluctuation of groundwater table?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

Top-down Construction Type Walls (See "Manual for Design & Construction Monitoring of Soil Nail Walls", FHWA SA-96-069R and "Ground Anchors and Anchored Systems", FHWA IF-99-015)

		Yes	No	Unknown or N/A
*10.	For soil nail and anchor walls are the following included in the geotechnical report?			
	a. Design soil parameters (ϕ, c, γ)	___	___	_____
	b. Minimum bore size (soil nails)?	___	___	_____
	c. Design pullout resistance (soil nails)?	___	___	_____
	d. Ultimate anchor capacity (anchors)?	___	___	_____
	e. Corrosion protection requirements?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

GTR REVIEW CHECKLIST FOR SPREAD FOOTINGS

F. Structure Foundations – Spread Footings (Pgs. 7-1 to 7-17)

In addition to the basic information listed in Section A, is the following information provided in the project foundation report?

		Yes	No	Unknown or N/A
*1.	Are spread footing recommended for foundation support? If not, are reasons for not using them discussed?	___	___	_____
	If spread footing supports are recommended, are conclusions and recommendations given for the following:			
*2.	Is recommended bottom of footing elevation and reason for recommendation (e.g., based on frost depth, estimated scour depth, or depth to competent bearing material) given?	___	___	_____
*3.	Is recommended allowable soil or rock bearing pressure given?	___	___	_____
*4.	Is estimated footing settlement and time given?	___	___	_____
*5.	Where spread footings are recommended to support abutments placed in the bridge end fill, are special gradation and compaction requirements provided for select end fill and backwall drainage material (Pgs. 6-1 to 6-4)	___	___	_____
Construction Considerations				
6.	Have the materials been adequately described on which the footing is to be placed so the project inspector can verify that material is as expected?	___	___	_____
7.	Have excavation requirements been included for safe slopes in open excavations, need for sheeting or shoring, etc.?	___	___	_____
8.	Has fluctuation of the groundwater table been addressed?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

GTR REVIEW CHECKLIST FOR DRIVEN PILES

G. Structure Foundations – Driven Piles (Pgs. 8-1 to 8-29, 9-1 to 9-35)

In addition to the basic information listed in Section A, if pile support is recommended or given as an alternative, conclusions/recommendations should be provided in the project geotechnical report for the following:

		Yes	No	Unknown or N/A
*1.	Is the recommended pile type given (displacement, non-displacement, steel pipe, concrete, H-pile, etc.) with valid reasons given for choice and/or exclusion? (Pgs. 8-1 to 8-3)	___	___	_____
2.	Do you consider the recommended pile type(s) to be the most suitable and economical?	___	___	_____
*3.	Are estimated pile lengths and estimated tip elevations given for the recommended allowable pile design loads?	___	___	_____
4.	Do you consider the recommended design loads to be reasonable?	___	___	_____
5.	Has pile group settlement been estimated (only of practical significance for friction pile groups ending in cohesive soil)? (Pgs. 8-20 to 8-22)	___	___	_____
6.	If a specified or minimum pile tip elevation is recommended, is a clear reason given for the required tip elevation, such as underlying soft layers, scour, downdrag, piles uneconomically long, etc.?	___	___	_____
*7.	Has design analysis (wave equation analysis) verified that the recommended pile section can be driven to the estimated or specified tip elevation without damage (especially applicable where dense gravel-cobble-boulder layers or other obstructions have to be penetrated)?	___	___	_____
8.	Where scour piles are required, have pile design and driving criteria been established based on mobilizing the full pile design capacity below the scour zone?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

G. Structure Foundations – Driven Piles (Cont.)	Yes	No	Unknown or N/A
9. Where lateral load capacity of large diameter piles is an important design consideration, are p-y curves (load vs. deflection) or soil parameters given in the geotechnical report to allow the structural engineer to evaluate lateral load capacity of all piles?	___	___	_____
*10. For pile supported bridge abutments over soft ground:			
a. Has abutment downdrag load been estimated and solutions such bitumen coating been considered in design? Not generally required if surcharging of the fill is being performed. (Pgs. 8-21, 8-23)	___	___	_____
b. Is bridge approach slab recommended to moderate differential settlement between bridge ends and fill?	___	___	_____
c. If the majority of subsoil settlement will not be removed prior to abutment construction (by surcharging), has estimate been made of abutment rotation that can occur due to lateral squeeze of soil subsoil? (Pgs. 5-25, 5-26)	___	___	_____
d. Does the geotechnical report specifically alert the structural designer to the estimated horizontal abutment movement?	___	___	_____
11. If bridge project is large, has pile load test program been recommended? (Pgs. 9-23 to 9-26)	___	___	_____
12. For major structure in high seismic risk area, has assessment been made of liquefaction potential of foundation soil during design earthquake (only loose saturated sands and silts are susceptible to liquefaction)? (See GEC No. 3, FHWA SA-97-076)	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

G. Structure Foundations – Driven Piles (Cont.)

Construction Considerations (Pgs. 9-4 to 9-35)	Yes	No	Unknown or N/A
13. Pile driving details such as: boulders or obstructions which may be encountered during driving; need for preaugering, jetting, spudding; need for pile tip reinforcement; driving shoes, etc.?	___	___	_____
14. Excavation requirements: safe slope for open excavations; need for sheeting or shoring; fluctuation of groundwater table?	___	___	_____
15. Have effects of pile driving operation on adjacent structures been evaluated such as protection against damage caused by footing excavation or pile driving vibrations?	___	___	_____
16. Is preconstruction condition survey to be made of adjacent structures to prevent unwarranted damage claims?	___	___	_____
17. On large pile driving projects, have other methods of pile driving control been considered such as dynamic testing or wave equation analysis?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

GTR REVIEW CHECKLIST FOR DRILLED SHAFTS

H. Structure Foundations – Drilled Shafts (Pgs. 8-23 to 8-29)

In addition to the basic information listed in Section A, if drilled shaft support is recommended or given as an alternative, are conclusion/recommendations provided in the project foundation report for the following:

		Yes	No	Unknown or N/A
*1.	Are recommended shaft diameter(s) and length(s) for allowable design loads based on an analysis using soil parameters for side friction and end bearing?	___	___	_____
*2.	Settlement estimated for recommended design loads?	___	___	_____
*3.	Where lateral load capacity of shaft is an important design consideration, are p-y (load vs. deflection) curves or soils data provided in geotechnical report that will allow structural engineer to evaluate lateral load capacity of shaft?	___	___	_____
4.	Is static load test (to plunging failure) recommended?	___	___	_____

Construction Considerations

		Yes	No	Unknown or N/A
5.	Have construction methods been evaluated, i.e., can less expensive dry method or slurry method be used or will casing be required?	___	___	_____
6.	If casing will be required, can casing be pulled as shaft is concreted (this can result in significant cost savings on very large diameter shafts)?	___	___	_____
7.	If artesian water was encountered in explorations, have design provisions been included to handle it (such as by requiring casing and a tremie seal)?	___	___	_____
8.	Will boulders be encountered? (If boulders will be encountered, then the use of shafts should be seriously questioned due to construction installation difficulties and resultant higher cost to boulders can cause.)	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

GTR REVIEW FOR GROUND IMPROVEMENT TECHNIQUES

I. Ground Improvement Techniques

In addition to the basic information listed in Section A, if ground improvement techniques are recommended or given as an alternative, are conclusion/recommendations provided in the project foundation report for the following:

	Yes	No	Unknown or N/A
1. For wick drains, do recommendations include the coefficient of consolidation for horizontal drainage, c_h, and the length and spacing of wick drains?	___	___	_____
2. For lightweight fill, do recommendations include the material properties (ϕ, c, γ), permeability, compressibility, and drainage requirements?	___	___	_____
3. For vibro-compaction, do the recommendations include required degree of densification (e.g., relative density, SPT blow count, etc.), settlement limitations, and quality control?	___	___	_____
4. For dynamic compaction, do the recommendations include required degree of densification (e.g., relative density, SPT blow count, etc.), settlement limitations, and quality control?	___	___	_____
5. For stone columns, do the recommendations include spacing and dimensions of columns, bearing capacity, settlement characteristics, and permeability (seismic applications)?	___	___	_____
6. For grouting, do the recommendations include the grouting method (permeation, compaction, etc.), material improvement criteria, settlement limitations, and quality control?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

GTR REVIEW CHECKLIST FOR MATERIAL SITES

J. Material Sites

In addition to the basic information listed in Section A, is the following information provided in the project Material Site Report.

		Yes	No	Unknown or N/A
1.	Material site location, including description of existing or proposed access routes and bridge load limits, if any?	___	___	_____
*2.	Have soil samples representative of all materials encountered during pit investigation been submitted and tested?	___	___	_____
*3.	Are laboratory quality test results included in the report?	___	___	_____
4.	For aggregate sources, do the laboratory quality test results (such as L.A. abrasion, sodium sulfate, degradation, absorption, reactive aggregate, etc.) indicate if specification materials can be obtained from the deposit using normal processing methods?	___	___	_____
5.	If the lab quality test results indicate that specification material cannot be obtained from the pit materials as they exist naturally, has the source been rejected or are detailed recommendations provided for processing or controlling production so as to ensure a satisfactory product?	___	___	_____
*6.	For soil borrow sources, have possible difficulties been noted, such as above optimum moisture content for clay-silt soils, waste due to high PI, boulders, etc.?	___	___	_____
*7.	Where high moisture content clay-silt soils must be used, are recommendations provided on the need for aeration to allow the materials to dry out sufficiently to meet compaction requirements?	___	___	_____
8.	Are estimated shrink-swell factors provided.	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

I. Material Sites (Cont.)		Yes	No	Unknown or N/A
*9.	Do the proven material site quantities satisfy the estimated project quantity needs?	___	___	_____
10.	Where materials will be executed from below the water table, have seasonal fluctuations of the water table been determined?	___	___	_____
11.	Are special permit requirements been covered?	___	___	_____
12.	Have pit reclaimation requirements been covered adequately?			
13.	Has a material site sketch (plan and profile) been provided for inclusion in the plans, which contains:	___	___	_____
a.	Material site number?	___	___	_____
b.	North arrow and legal subdivision?	___	___	_____
c.	Test hole or test pit logs, locations, numbers and date?	___	___	_____
d.	Water table elevation and date?	___	___	_____
e.	Depth of unsuitable overburden, which will have to be stripped?	___	___	_____
f.	Suggested overburden disposal area?	___	___	_____
g.	Proposed mining area and previously mined areas?	___	___	_____
h.	Existing stockpile locations?	___	___	_____
i.	Existing or suggested access road?	___	___	_____
j.	Bridge load limits?	___	___	_____
k.	Reclaimation details?	___	___	_____
14.	Are recommended special provisions provided?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

PS&E REVIEW CHECKLISTS

Plans and specifications (PS&E)** reviews of projects with major or unusual geotechnical features[1] should preferably be made by examining the plans, special provisions, and geotechnical report together.***

Certain checklist items are of vital importance to have been included in the PS&E. These checklist items have been marked with an asterisk (*). A negative response to any of these asterisked items is cause to contact the geotechnical engineer for clarification of this omission.

The information covered in Section A, General will apply to all geotechnical features. The rest of the sections cover additional important PS&E review items that pertain to specific geotechnical features.

** For purposes of this document, PS&E refers to a plan and specification review at any time during a project's development. Hence, the review may be at a preliminary or partial stage of plan development.

***When plan reviews are conducted at a partial stage the final geotechnical report may not be available.

[1]Major and unusual geotechnical features are defined in Table 1.

PS&E REVIEW CHECKLIST – GENERAL

A. General	Yes	No	Unknown or N/A
*1. Has the appropriate geotechnical engineer reviewed the PS&E to ensure that the design and construction recommendations have been incorporated as intended and that the subsurface information has bee presented correctly? <u>This is absolutely necessary</u>.	___	___	_____
2. Are the finished profile exploration logs and locations included in the plans?	___	___	_____
*3. Have geotechnical designs prepared by region or district offices or consultants been reviewed and approved by the State Headquarters' geotechnical engineer?	___	___	_____
4. Do the contract documents contain the special provisions as provided in the project geotechnical report?	___	___	_____
5. Have the following common pitfalls been avoided:			
a. Has an adequate site investigation been conducted (reasonably meeting or exceeding the minimum criteria given in Table 2)?	___	___	_____
b. Has the use of "subjective" subsurface terminology (such as relatively soft rock or gravel with occasional boulders) been avoided?	___	___	_____
c. If alignment has been shifted, have additional subsurface explorations been conducted along the new alignment?	___	___	_____
d. Has a note been included in the contract indicating all subsurface information is available to bidders?	___	___	_____
e. Do you think the wording of the geotechnical special provisions are clear, specific and unambiguous?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

PS&E REVIEW CHECKLIST FOR SPECIFIC FEATURES

		Yes	No	Unknown or N/A
B.	**<u>Centerline Cuts and Embankments</u>**			
1.	Where excavation is required, are excavation limits and description of unsuitable organic soils shown on the plans?	___	___	_____
2.	Are plan details and special provisions provided for special drainage details, such as lined surface ditches, drainage blanket under sidehill fill, interceptor trench drains, etc.?	___	___	_____
3.	Are special provisions included for fill materials requiring special treatment, such as nondurable shales, lightweight fill, etc.?	___	___	_____
4.	Are special provisions provided for any special rock slope excavation and stabilization measures called for in plans, such as controlled blasting, wire mesh slope protection, rock bolts, shotcrete, etc.?	___	___	_____
C.	**<u>Embankments Over Soft Ground</u>**			
*1.	Where subexcavation is required, are excavation limits and description of unsuitable soils clearly shown on the plans?	___	___	_____
*2.	Where settlement waiting period will be required, has estimated settlement time been stated in the special provisions to allow bidders to fairly bid the project?	___	___	_____
*3.	If instrumentation will be used to control the rate of fill placement, do special provisions clearly spell out how this will be done and how the readings will be used to control the contractor's operation?	___	___	_____
4.	Do special provisions state that any instrumentation damage by contractor personnel will be repaired at the contractor's expense?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

PS&E REVIEW CHECKLIST FOR SPECIFIC FEATURES

		Yes	No	Unknown or N/A
D.	Landslide Corrections			
1.	Are plan details and special provisions provided for special drainage details, such as lined surface ditches, drainage blankets, horizontal drains, etc.?	___	___	_____
*2.	Where excavation is to be made into the toe of an active slide, such as for a buttress or shear key, and stage construction is required, do the special provisions clearly spell out the stage construction sequence to be followed?	___	___	_____
*3.	Where a toe buttress is to be constructed, do the special provisions clearly state gradation and compaction requirements for the buttress material?	___	___	_____
*4.	If the geotechnical report recommends that slide repair work not be allowed during the wet time of the year, is the proposed construction schedule in accord with this?	___	___	_____
E.	Retaining Structures			
*1.	Are select materials specified for wall backfill with gradation and compaction requirements covered in the specification?	___	___	_____
2.	Are limits of required select backfill zones clearly detailed on the plans?	___	___	_____
3.	Are excavation requirements specified, e.g., safe slopes for excavations, need for sheeting, etc.?	___	___	_____
*4.	Where alternative wall types will be allowed, are fully detailed plans included for all alternatives?	___	___	_____
5.	Were designs prepared by the wall supplier?	___	___	_____
6.	Were wall supplier's design calculations and specifications reviewed and approved by the structural and geotechnical engineers?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

PS&E REVIEW CHECKLIST FOR SPECIFIC FEATURES

E. Retaining Structures (Cont.)	Yes	No	Unknown or N/A
*7. Where proprietary retaining walls are bid as alternates, does bid schedule require bidders to designate which alternate their bid is for, to prevent bid shopping after contract award?	___	___	_____
8. Have FHWA guidelines for experimental designations for certain proprietary wall types been followed?	___	___	_____
9. Is ROW limit or easements shown on plans and mentioned in specifications where anchors are to be installed?	___	___	_____

Top-down Construction Type Walls (See "Manual for Design & Construction Monitoring of Soil Nail Walls", FHWA SA-96-069R and "Ground Anchors and Anchored Systems", FHWA IF-99-015)

	Yes	No	Unknown or N/A
*10. For soil nail and anchor walls are the following included in the provisions:			
a. Construction tolerances?	___	___	_____
b. Minimum drill-hole size?	___	___	_____
c. Material requirements?	___	___	_____
d. Load testing procedures and acceptance criteria?	___	___	_____
e. Construction monitoring requirements?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

PS&E REVIEW CHECKLIST FOR SPECIFIC FEATURES

F. Structure Foundations – Spread Footings	Yes	No	Unknown or N/A
*1. Where spread footings are to be placed on natural soil, is the specific bearing strata in which the footing is to be founded clearly described, e.g., placed on Br. Sandy GRAVEL deposit, etc.?	___	___	_____
*2. Where spread footings are to be placed in the bridge end fill, are gradation and compaction requirements, for the select fill and backfill drainage material, covered in the special provisions, standard specifications, or standard structure sheets?	___	___	_____

G. Structure Foundations – Driven Piles			
1. Do plan details adequately cover pile splices tip reinforcement, driving shoes, etc.?	___	___	_____
*2. Where friction piles are to be driven in silty or clayey soils, significant setup or soil freeze affecting long-term capacity may occur. Do specifications require retapping the piles after 24 to 48 hour waiting period when required bearing is not obtained at estimated length at the end of initial driving?	___	___	_____
3. Where friction piles are to be load tested, has a reaction load of four times design load been specified to allow load testing the pile to plunging failure so that the ultimate soil capacity can be determined?	___	___	_____
4. Where end bearing steel piles are to be load tested, has load test been designed to determine if higher than 62 MPa (9 ksi) allowable steel stress can be used, e.g., 83 to 103 MPa (12 – 15 ksi)?	___	___	_____
*5. Where cofferdam construction will be required, have soil gradation results been included in the plans or been made available to bidders to assist them in determining dewatering procedures?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

		Yes	No	Unknown or N/A
G.	Structure Foundations – Driven Piles (Cont.)			
*6.	If a wave equation analysis will be used to approve the contractor's pile driving hammer, has a minimum hammer energy or estimated soil resistance in kN (tons) to be overcome to drive the piles to the estimated length, been given in the special provisions?	___	___	_____
*7.	Has the appropriate safety factor, based on construction control method (static load test, dynamic load test, wave equation, etc.) been included? Have the specifications for the applicable construction control method been included?	___	___	_____
H.	Structure Foundations – Drilled Shafts			
*1.	Where drilled shafts are to be placed in soil, is the specified bearing stratum in which the drilled shaft is to be found clearly described, e.g., placed on Br. Sandy GRAVEL deposit, etc.?	___	___	_____
2.	Where end bearing drilled shafts are to be founded on rock, has the rock elevation at the shaft pier locations been determined form borings at the pier locations?	___	___	_____
3.	Where drilled shafts are to be socketed some depth into rock, have rock cores been extracted at depths to 3 m (10 ft) below proposed socket at location within 3 m (10 ft) of the shaft?	___	___	_____
*4.	Are shafts equipped with PVC access tubes to accommodate non-destructive testing (gamma/gamma logging, cross-hole sonic logging) of the shaft? Are provisions for the appropriate non-destructive testing methods included?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

PS&E REVIEW CHECKLIST FOR SPECIFIC FEATURES

I. Ground Improvement Techniques	Yes	No	Unknown or N/A
1. For wick drains, are contractor submittals required that include proposed equipment and materials, method(s) for addressing obstructions, and method(s) for splicing wick drains.	___	___	_____
2. For lightweight fill, are minimum/maximum densities, gradation, lift thickness, and method of compaction specified?	___	___	_____
3. For vibro-compaction, are contractor submittals required that include proposed equipment and materials? Are methods of measurement and acceptance criteria specified?	___	___	_____
4. For dynamic compaction:			
a. If method specification is used, are the following specified: tamper mass and size; drop height, grid spacing; applied energy; number of phases or passes; site preparation requirements; subsequent surface compaction procedures?	___	___	_____
b. If performance specification is used, are the following specified: minimum soil property value to be achieved and method of measurement; maximum permissible settlement?	___	___	_____
5. For stone columns, are the following specified: site preparation, backfill materials, minimum equipment requirements, acceptance criteria and quality assurance procedures?	___	___	_____
6. For grouting, are contractor submittals required that include proposed equipment and materials. Are methods of measurement and acceptance criteria specified?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

PS&E REVIEW CHECKLIST FOR SPECIFIC FEATURES

J. Material Sites	Yes	No	Unknown or N/A
*1. Is a material site sketch, containing the basic information listed on page 27, included in the plans?	___	___	_____
*2. Has the material site investigation established a proven quantity of material sufficient to satisfy the project estimated quantity needs?	___	___	_____
3. Where specification material cannot be obtained directly from the natural deposit, do the special provisions clearly spell out that processing will be required?	___	___	_____
4. Are contractor special permit requirements covered in the special provisions?	___	___	_____
5. Are pit reclaimation requirements clearly spelled out on the plans and in the special provisions?	___	___	_____

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate geotechnical engineer for a clarification and/or to discuss the project.

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KENTUCKY TRANSPORTATION CABINET

Division of Materials
Geotechnical Branch

SUMMARY OF COST ITEMS FOR STATEWIDE GEOTECHNICAL ENGINEERING SERVICES

County ________ **ITEM #** ________ **MARS #** ________
ROAD NAME ________ **CONTRACT #** ________ **ESTIMATE #** ________

	Hourly Rate		Units/Hours		No. of Test/Samples		TOTAL
1. Moisture Content Test	$	x		x		=	$
2. Logging Rock Core *	$	x		x		=	$
3. Soil Classifications	$	x		x		=	$
4. Wash and Sieve Gradations	$	x		x		=	$
5. Moisture/Density/CBR/Soil Classifications	$	x		x		=	$
6. Moisture/Density Test	$	x		x		=	$
7. Slake Durability Index & Jar Slake Tests	$	x		x		=	$
8. Unconfined Compression Tests on Soil	$	x		x		=	$
9. Unconfined Compression Tests on Rock	$	x		x		=	$
10. One-Dimensional Consolidation Tests	$	x		x		=	$
11. Consolidated-Undrained Triaxial Tests with Pore Pressure Measurements	$	x		x		=	$
12. Unconsolidated-Undrained Triaxial Tests, Total Stress Method	$	x		x		=	$
13. Slope Stability Analyses	$	x				=	$
	$	x				=	$
14. Settlement Analyses	$	x				=	$
	$	x				=	$
15. Deep Foundation Analyses	$	x				=	$
	$	x				=	$
16. Wave Equation Driveability Analyses	$	x				=	$
	$	x				=	$
17. Negative Skin Friction Analyses	$	x				=	$
	$	x				=	$
18. Bearing Capacity Analyses	$	x				=	$
	$	x				=	$
19. Retaining Wall Analyses	$	x				=	$
	$	x				=	$

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Division of Materials
Geotechnical Branch

SUMMARY OF COST ITEMS FOR STATEWIDE GEOTECHNICAL ENGINEERING SERVICES

COUNTY ____________________ **ITEM No.** ____________

20. Drafting	**$** ______	**x**	______	______	**=**	**$** ______
	$ ______	**x**	______	______	**=**	**$** ______
21. Preliminary Plans *	**$** ______	**x**	______	______	**=**	**$** ______
22. Preliminary Meetings *	**$** ______	**x**	______	______	**=**	**$** ______
23. Rock Core Meetings *	**$** ______	**x**	______	______	**=**	**$** ______
24. Interim Meetings *	**$** ______	**x**	______	______	**=**	**$** ______
25. Final Meetings *	**$** ______	**x**	______	______	**=**	**$** ______
26. Report Writing *	**$** ______	**x**	______	______	**=**	**$** ______
27. Publication of Reports *	**$** ______	**x**	______	______	**=**	**$** ______
		Subtotal			**=**	**$** ______
		Plus 10 percent			**=**	**$** ______
28. Direct Cost						**$** ______
TOTAL THIS ESTIMATE						**$** ______
ACCUMULATED TOTAL ESTIMATES	______	**THROUGH**		______	**=**	**$** ______

* Please provide additional justification for these items.

FIRM NAME ____________________

SIGNED ____________________

DATE ____________________

KENTUCKY TRANSPORTATION CABINET
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Geotechnical Branch

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COST ITEMS FOR STATEWIDE GEOTECHNICAL ENGINEERING SERVICES

Page ______ of ______

County ____________________ Federal Project # __________ State Project # ______________________

Road Name ____________________ Estimate # __________ Item # __________ Mars # __________

HOLE NO.	STATION	OFFSET	1 MOISTURE CONTENT TEST	2 LOGGING ROCK CORE	3 SOIL CLASSIFICATION	4 WASH AND SIEVE GRADATIONS	5 MOISTURE / DENSITY, CBR, SOIL CLASSIFICATION	6 MOISTURE / DENSITY TEST	7 SLAKE DURABILITY AND JAR SLAKE TEST	8 UNCONFINED COMPRESSION TEST ON SOIL	9 UNCONFINED COMPRESSION TEST ON ROCK	10 ONE-DIMENSIONAL CONSOLIDATION TEST	11 CONSOLIDATED-UNDRAINED TRIAXIAL TEST	12 UNCONSOLIDATED-UNDRAINED TRIAXIAL TEST	13 SLOPE STABILITY ANALYSES	14 SETTLEMENT ANALYSES	15 DEEP FOUNDATION ANALYSES	16 WAVE EQUATION DRIVEABILITY ANALYSES	17 NEGATIVE SKIN FRICTION ANALYSES
		Sheet																	
		This Estimate																	
		All Estimates																	

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KENTUCKY TRANSPORTATION CABINET

Division of Materials
Geotechnical Branch

COST ITEMS FOR STATEWIDE GEOTECHNICAL ENGINEERING SERVICES

County ____________ Item # ________ Mars # ________ Page ____ of ____

HOLE NO.	STATION	OFFSET	18 BEARING CAPACITY ANALYSES	19 RETAINING WALL ANALYSES	20 DRAFTING	21 PRELIMINARY PLANS	22 PRELIMINARY MEETINGS	23 ROCK CORE MEETINGS	24 INTERIM MEETINGS	25 FINAL MEETINGS	26 REPORT WRITING	27 PUBLICATION OF REPORTS
Sheet												
This Estimate												
All Estimates												

28 DIRECT COSTS

A. Personal Expenses

B. Materials

Mileage

Miscellaneous

Firm Name ____________ **Date** ________

Signed ____________