**SOILS AND FOUNDATIONS**
**REPORT NO. 07-07**

**PROJECT PRA-FLP 10(1)**
**ACCESS BRIDGE TO REFUGE ROAD**

**FLORIDA PANTHER NATIONAL WILDLIFE REFUGE**
**COLLIER COUNTY, FLORIDA**

U.S. Department of Transportation
Federal Highway Administration
**Eastern Federal Lands Highway Division**
**21400 Ridgetop Circle**
**Sterling, VA 20166**


***October 2007***

Form FHWA-201
(Rev. 11-67)

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
MEMORANDUM: FWS-FLP 10(1)

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## ***SUBJECT:*** ***FWS-FLP 10(1) – Addendum to Soils and Foundation Report No. 07-07***

| TO | MESSAGE/COMMENT | FROM/DATE |
|---|---|---|
| A. Feleke<br>Project<br>Engineer<br><br>Through:<br>C. Sanders<br>Project<br>Manager<br><br>Through:<br>A. Teikari<br>Project<br>Development<br>Engineer | This memorandum is provided as an addendum to recommendations presented in Soils and Foundation Report No. 07-07, that was officially distributed on December 13, 2007. This memorandum amends the recommendations presented in the Special Contract Requirements in Appendix H of that report. This memorandum is to be inserted after the title page of Soils and Foundations Report No. 07-07 prior to project advertisement.<br><br>The following sections of the Special Contract Requirements in Appendix H are to be revised as presented herein.<br><br>**Section 207.03** Delete provided text and substitute the following:<br><br>Excavate the limestone caprock and overburden soils to the length, width and depth required for construction of the proposed foundation system and at the direction of the CO. The excavation subgrade shall be of uniform density throughout its length and width. When excavation is complete, request approval as to the character and suitability of the excavation subgrade prior to placement of geotextile and backfill.<br><br>**Section 207.04** Delete the provided text and substitute the following:<br><br>Lightweight compaction equipment should be used to compact material within 3 feet of the excavation subgrade. Examples of acceptable lightweight equipment include small single or double drum, walk behind vibratory rollers or vibratory plate compactors. | A. Anderson<br>Geotechnical<br>Engineer<br><br>Through:<br>K. Mohamed<br>Division<br>Geotechnical<br>Engineer<br><br>Through:<br>L. Lineman<br>Technical<br>Services<br>Engineer<br><br>04/29/2008 |

cc: Geotech, TS Reading, Bridge (Q.N., T.Q.), Hydraulics (B.B., A.G.)

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***Note:*** ***Design changes made subsequent to distribution of this report and prior to project advertisement will be detailed in a memo inserted after the title.***

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**REPORT NO. 07-07**

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**COLLIER COUNTY, FLORIDA**

## INTRODUCTION

### General

This report summarizes the findings of our site visits, subsurface field investigation, laboratory testing, design analyses; and provides foundation recommendations for Project FWS-FLP 10(1). The project is located along Interstate 75 (I-75) and within the boundaries of the Florida Panther National Wildlife Refuge, in Collier County, Florida. The general site location is shown on Figure 1, "Site Location and Vicinity Map," in Appendix A.

### Project Description

Project FWS-FLP 10(1) consists of the design and construction of a new access bridge to the Florida Panther National Wildlife Refuge (NWR) from westbound Interstate 75 (I-75). The proposed bridge is located at the site of the since-abandoned Florida State Road 84 Rest Stop; and is located approximately 0.6 miles west of the current Interstate 75 (I-75) refuge entrance. The new access is being constructed to address unsafe conditions resulting from substandard vertical and horizontal alignments at the current I-75 access. Work associated with this project consists of construction of new gravel entrance road, a gravel parking area and a new one-lane, single-span bridge over the existing canal; as well as, approximately 0.6 miles of acceleration and deceleration lanes along I-75.

### Regional Geology

The site of the proposed bridge is located at the southwestern end of Florida's Gulf Coast and is part of a large sedimentary basin, previously referred to as the Okeechobee Basin. Recently the designation of the underlying basin in Collier County was re-designated as the Big Cypress Basin by the South Florida Water Management District. The Big Cypress Basin is dominated by nonclastic sediments, which are primarily carbonates and anhydrites, chemically or biologically produced. Surficial geology in the vicinity of the project site is composed primarily of Pliocene-Pleistocene strata of the Cenozoic Era. The Pliocene-Pleistocene strata are composed of marine terraces and sands, namely of the Tamiami Formation and occasionally the Fort Thompson Formation and the Tampa Formation.

According to the United States Geological Survey (USGS), *"Geological Map of Florida," (2001)* and accompanying text, lithologies of the Tamiami Formation include: 1) light gray to tan, unconsolidated to poorly consolidated, very fine to coarse grained, calcareous, fossiliferous sandy clay, clayey sand and sand; and 2) white to light gray, poorly consolidated, moderately to well indurated, sandy fossiliferous limestone. Exposed limestone rock of the Tamiami Formation, appears as irregular, undulating surfaces perforated with solution features with a sandy and/or marl soil matrix. The exposed lime rock substrate comprises approximately 6.5% of the surface relief and is typically within 50 inches of the surface throughout Collier County.

The appearance of bare rock at ground surface is typically the result of erosion, dissolution, and reprecipitation; and ranges from absent to 50 feet in thickness in the southwest Florida area.

The sand strata of the Tamiami varies from a well-sorted, clean sand with abundant well-preserved shells and traces of silt-sized phosphate; to a clayey sand with sand-sized phosphate, and clay-sized carbonate in the matrix and abundant well-preserved mollusk shells. Refer to Figure 2 of Appendix A, for a geologic map of the project area.

Surficial soils in Collier County are poorly drained sandy and loamy soils with varying and intermittent layers of fractured and processed limestone. These soils typically range in thickness from 6 inches to 3 feet.

## PROCEDURES AND RESULTS

### General

The Eastern Federal Lands Highway Division's (EFLHD) Subsurface Exploration Team conducted a subsurface investigation program at the project site between March 6 and 13, 2007. The subsurface investigation program consisted of drilling a total of four (4) boreholes, designated B-1 through B-4, at the approximate location of the proposed bridge abutments. Additionally, two (2) probe holes, designated PH-1 and PH-2, were drilled in the vicinity of the boreholes in order to verify the consistency of subsurface conditions. One additional probe hole, designated PH-3 was drilled in the approximate center of the proposed parking area. All borings were advanced to depth using a CME 850 rotary, track-mounted drill rig. A Boring Location Plan and a generalized Subsurface Profile are provided in Appendix B.

### Sampling

The boreholes were drilled to depths ranging from 32.0 to 72.0 ft below the existing ground surface. Borings were advanced to depth using 3¾-in. (inside diameter) hollow stem augers. Standard Penetration Tests (SPT) were performed using a 2¼-in. (outside diameter) split-spoon sampler in accordance with AASHTO T200-87 and AASHTO T206-87. SPT soil samples were typically recovered at 5.0 ft intervals by driving the split-spoon sampler a distance of 24-in., or until refusal, into the undisturbed soil under the impact of a 140 lb. automatic hammer free-falling 30 inches. The number of hammer blows required to advance the split-spoon sampler the middle foot of the 24-in. sample interval (final 1 ft of an 18-in. sample interval) is designated as the "Standard Penetration Resistance" or N-Value. Auger refusal is defined by 50 blows per 1-inch of penetration of the split-spoon sampler. The number of blows required to advance the sampler through each 6-in. interval was recorded on field boring logs. Representative portions of split-spoon samples were preserved in glass jars for laboratory testing.

The sampling sequence and associated jar samples for each boring are presented on its appropriate Boring Log in Appendix C.

## Field Tests and Measurements

The EFLHD Subsurface Investigation Team performed the following field tests and measurements during the course of the subsurface exploration. The results of field tests and measurements were recorded on the driller's logs and appropriate data sheets in the field. These data sheets and logs contain information concerning the boring methods; samples attempted and recovered; indications of the presence of various material such as gravel, pebbles, organic matter, etc.; and observations of groundwater. They also contain interpretations by the exploration foreman of the subsurface conditions based on the performance of the equipment and cuttings brought to the surface by the drilling tools. Therefore, the field data represents both factual and interpretative information.

Boring locations were determined from features present on-site and by referencing the existing roadway. Boring elevations were determined by extrapolation of topographic lines from site maps provided by EFLHD's Survey Section. A field description by color and texture was made for each recovered soil sample. The boring logs in Appendix C represent a compilation of field laboratory data and description of the soil samples by a geotechnical engineer. These records occasionally do not include all data recorded on driller's logs and field data sheets, but do include all information considered relevant to the design and preparation of this report.

Groundwater level readings were made in the boreholes at the times and under the conditions stated on the boring logs. The groundwater table was not encountered during our subsurface investigation. However, fluctuations in groundwater level due to seasonal variations, rainfall, temperature, and other factors not evident at the time measurements were made should be expected.

## Laboratory Testing

A laboratory testing program was conducted on representative soil samples recovered during the subsurface explorations. The primary purpose of the testing program was to aid in classification and evaluation of the engineering properties of the soil present at the site. Laboratory tests included natural moisture content (AASHTO T-265), Atterberg Limits (AASHTO T-89 & T-90), particle size analysis (AASHTO T-88), and classification (AASHTO M-145). All tests were conducted in accordance with applicable ASTM/AASHTO standard test methods.

Laboratory test results are summarized below in Table 1, and are presented in Appendix D.

***Table 1 – Laboratory Test Results Summary***

| Boring No. | Sample No. | Sample Depth (ft) | Natural Water Content (%) | Liquid Limit[1] (%) | Plastic Limit[2] (%) | PI[3] (%) | Fines (%) | Soil Classification AASHTO |
|---|---|---|---|---|---|---|---|---|
| B-1 | J-3 | 10.0-12.0 | 21.8 | NP | NV | NP | 11.7 | A-1-b |
| B-1 | J-4 | 15.0-17.0 | 23.8 | NP | NV | NP | 10.9 | A-1-b |
| B-1 | J-14 | 65.0-67.0 | 17.7 | NP | NV | NP | 10.3 | A-1-b |
| B-2 | J-2 | 5.0-7.0 | 15.5 | NP | NV | NP | 4.5 | A-1-b |
| B-2 | J-5 | 20.0-22.0 | 25.4 | NP | NV | NP | 11.4 | A-1-b |
| B-3 | J-5 | 25.0-27.0 | 40.6 | NP | NV | NP | 11.3 | A-1-b |
| B-3 | J-7 | 35.0-37.0 | 32.7 | NP | NV | NP | 13.2 | A-1-b |
| B-4 | J-6 | 30.0-32.0 | 30.9 | NP | NV | NP | 10.2 | A-1-b |
| B-4 | J-9 | 45.0-47.0 | 18.0 | NP | NV | NP | 11.9 | A-1-b |

*[1]ND = No determined* *[2] NV = No value* *[3] NP = Non-plastic*

**Findings**

The soil stratigraphy on either side of the canal in the vicinity of the proposed bridge is fairly consistent and has been divided into three distinct strata, of similar characteristics, within the termination depths of the borings. Descriptions of soil strata encountered during our subsurface investigation are provided below in order of increasing depth below the ground surface.

*TOPSOIL* – A thin topsoil layer, comprised of brown silty fine sand with little amounts of gravel was encountered at the ground surface at all borehole locations. The topsoil layer was observed to vary in thickness between 6.0 and 9.0 inches.

*STRATUM 1: LIMESTONE "CAPROCK"* – Underlying the topsoil layer across the entire site, there is a solution-riddled calcareous limestone layer referred to as "caprock." The caprock is generally defined as moderately hard, brown to tan, moderately weathered to highly weathered, well-indurated, sandy fossiliferous limestone. Based on soil borings the caprock layer varies in thickness from 3.8 to 7.5 ft. SPT refusal was encountered within this material. However, this material is augerable, offering little to moderate resistance under the action of an auger bit. This limestone caprock is consistent with descriptions of the Fort Thompson Formation.

*STRATUM 2: SILTY SAND* – Underlying the limestone caprock is a stratum of gray-brown to white, fine to coarse sand, with varying amounts of gravel, trace amounts of clay and frequent pockets of shells and shell fragments [A-1-b]. This stratum was encountered immediately below the caprock layer in all borings at depths varying between 4.5 and 7.5 ft below ground surface (bgs). Occasionally, as in Boring B-1, the silty sand stratum is

overlain by a layer of sandy gravel [A-1-a]. N-values recorded within this stratum ranged from 0 blows per foot (bpf) to greater than 50 bpf, indicating very loose to very dense soil conditions.

Generally, the density of the silty sand stratum increases with depth. Very loose to medium dense soil conditions were recorded to a depth of approximately 35 ft. Dense to very dense soil conditions were typically encountered at a depth of 35 ft and were observed, in Borings B-1, B-3 and B-4, to extend to the borehole termination depth. All borings and probe holes were terminated within this stratum.

A probe hole, designated PH-3, was drilled within the limits of the proposed parking lot, in order to confirm the findings of Borings B-1 through B-4. This subsurface stratigraphy at the location of the probe was consistent with the findings detailed above.

The groundwater table was generally encountered at the caprock/silty sand interface or within the silty sand stratum at depths varying between 6.5 and 8.0 ft. However, seasonal fluctuations in the level of the groundwater should be expected.

## DESIGN ANALYSIS AND CONCLUSIONS

Both shallow and deep foundation alternatives were considered for support of the proposed bridge. The alternatives considered included a conventional spread footing foundation, and deep foundations systems that included driven piles and drilled shafts. The alternatives were evaluated on the basis of cost, constructability and potential environmental impact in order to determine the most suitable alternative. A shallow spread footing foundation was selected as the preferred foundation system for this project. This determination was driven largely by project budget constraints. It was also determined that equipment and methods necessary for the installation of a deep foundation system would impose an undesirable amount of environmental impact.

Based on the results of our subsurface investigation and proposed bridge loads, it was determined that supporting the bridge on conventional spread footings would result in excessive settlement. Consequently, it is proposed to support the bridge with spread footings bearing on a geosynthetic-reinforced soil (GRS) embankment. The GRS embankment will consist of alternating layers of geotextile reinforcement and structural backfill. Primary function of the GRS embankment is to transfer and distribute loads from the spread footings over a wider area, whereby reducing the load imposed on subgrade soils and in-turn reducing settlements. Additionally, due to the relative flexibility of the GRS foundation, settlements will be more uniform than those from a conventional rigid foundation system.

Bearing capacity and stability analyses were performed to satisfy the following failure criteria:

***Table 2 – Design Stability Criteria***

| Failure Mode | Min. FS |
|---|---|
| Sliding | 1.5 |
| Global Stability | 1.3 |
| Bearing Capacity | 3.0 |

The soils parameters listed in Table 3 were used in all design analyses. These parameters were determined based on empirical correlations based on the field SPT N-values.

***Table 3 – Design Parameters for Analysis***

| Layer No. | Material | Unit Weight, γ (pcf) | Friction Angle, φ (deg.) | Cohesion, c (psf) |
|---|---|---|---|---|
| 1 | Revet Mattress Fill | 125 | 38 | -- |
| 2 | Reinforced Fill | 125 | 34 | -- |
| 3 | Granular Backfill | 140 | 38 | -- |
| 4 | V. loose to loose silty SAND | 112 | 32 | -- |
| 5 | M. dense to dense silty SAND | 118 | 33 | -- |

**Bearing Capacity**

Bearing capacity analyses were performed in accordance with the procedures set forth in AASHTO (1996), *"Standard Specifications for Highway Bridges," 6th Edition.* As stated above, a layer of limestone caprock was typically encountered at the ground surface in all borings and was observed to be an average of 6.5 ft thick. This limestone caprock is experiencing ongoing dissolution at the base of the stratum. It is anticipated that this stratum will completely weather over the design life of the structure. As a result of the anticipated dissolution of the limestone caprock, we modeled this material in our analyses as a stratum of very loose to loose silty sand, having the same properties as the underlying silty sand stratum.

During our analyses we determined that a minimum footing area of 211 square feet was required to maintain a minimum factor of safety of 3 against bearing capacity failure. Example design computations are provided in Appendix E.

**Settlement**

Settlement analyses were performed for the embankment using a generalized subsurface profile and material properties as listed in Table 1. Total settlement of the embankment was analyzed

using the computer program FoSSA(2.0). Foundation soils were all assumed to be in a normally consolidated stress state. Additionally, the embankment was analyzed with a uniform surcharge load of 250 pounds per square foot at the crest, along the full width of the roadway. The dead loads and live loads imposed on the GRS embankment were evaluated as an equivalent volume of soil.

The result of the computer-aided computations indicates that placement of embankment material for the proposed GRS embankment will result in elastic compression of the loose sandy soils. We estimate settlement of the proposed embankment to be on the order of 1.1-inches along the center of the embankment and 0.375-inches along the edge, depending on the thickness and sequence of the soil strata, as well as the height of embankment material needed for construction of the abutments. Based on the nature of soils observed during our subsurface investigation it is expected that the majority of settlement will likely occur during construction as dead loads are placed on the foundations.

Output results of the computer-aided analysis may be referenced in Appendix E.

**Slope Stability**

Slope stability analyses were performed for a 4.0 feet high GRS foundation with a lateral dimension of 22.0 feet. Side slopes were presumed to be constructed on 2H:1V. Slope stability analyses evaluated the stability of the proposed foundation system and side slopes of the canal. Stability analyses were performed using the computer program ReSSA(2.0), and employing the Bishop Modified method of analysis. Material properties used in the stability analyses are as listed in Table 1 above.

The results of the stability computations indicate that the proposed foundation system satisfies all stability criteria. A factor of safety of 1.29 against deep-seated static failure was calculated for the foundation and side slopes of the canal; and a factor of safety of 1.95 was calculated against translational movement of the GRS embankment. Output files from our analysis are provided in Appendix E. These output files provide the geometry of the section analyzed, reinforcement spacing, type, strength and interaction parameters, and the calculated factors of safeties for the stability criteria provided

**Aggregate Surface Roadway**

Pavement design analyses were performed for a low-volume, aggregate-surfaced roadway in accordance with AASHTO (1993), *AASHTO Guide for Design of Pavement Structures"*, and using the design nomograph in Appendix E. The design analysis to determine the 18-kip Equivalent Single Axle Loads (ESALs) for the roadway was performed using the Simple ESAL Calculation in the computer program DARWin (3.01) and based on an assumed average daily traffic (ADT) value of 30 and an annual growth rate of two percent. The effective Resilient Modulus of Roadbed Material ($M_R$) was determined based on seasonal subgrade conditions for Region I, and a "good" quality of roadbed material. Design analyses were performed in order to determine total damage based on serviceability and rutting criterions; with the design aggregate thickness chosen as the minimum thickness that satisfies both criterion. Other parameters specified in our design analyses include an Elastic Modulus of

Roadbed Material ($E_{BS}$) of 30,000 pounds per square inch (psi), an allowable rut depth of 2.0 inches, and an annual aggregate loss of 1.0 inch.

Design analyses were performed for 5 and 10 year performance periods. Analysis results indicate that the 1.0 inch per year aggregate loss criteria controls the design.

The results of our analyses are presented in Appendix E.

## RECOMMENDATIONS

Due to ongoing dissolution of the limestone caprock, it is recommended that the caprock be removed down to the underlying silty sand subgrade within the footprint of the proposed GRS embankment. Above the exposed saturated silty sand subgrade a geotextile is to be installed and the excavation backfilled as follows:

1. It is anticipated that it may not be possible to compact backfill material at the bottom of the footing excavation due to presence of ground water. We recommend placing a minimum of 36-in. of granular backfill to bridge over the saturated silty sand subgrade.

2. Construct the GRS foundation beginning from the top of the granular backfill as presented below.

### GRS Foundation

Based on the loading conditions imposed by the bridge on the foundation, and due to the compressible nature of the underlying Stratum 2 soils, we recommend that the proposed abutments be supported on shallow spread footings founded on a Geosynthetic Reinforced Soil (GRS) foundation. The GRS foundation is to consist of alternating layers of Type III-A geotextile and structural backfill, conforming to Sections 714 and 704 of the FP-03 specifications, respectively. The GRS foundation should extend to a minimum depth of 3.0 feet below the existing ground surface and extend a minimum of 2.0 feet laterally beyond the limits of the spread footing foundation. The reinforcement geotextile is to be placed as follows:

1. Proportion the GRS foundation with a least lateral dimension of 12.0 ft or greater, and a minimum footing area of 211 square feet.

2. Provide Type III-B geotextile fabric with minimum long-term design strength (LTDS) of 2,000 pounds per foot.

3. Place fill lifts with a maximum vertical spacing of 8-inches. Compact all fill lifts in accordance with Section 204 of the FP-03.

4. Handle and place all geotextile in accordance with Section 207 of the FP-03.

We anticipate total settlement of the GRS foundation under static loading conditions, will not exceed 1.25-inches, with differential settlements between the center and edge of the foundation

not exceeding 0.75-inches. Most of the settlement should occur during construction, shortly after structure dead loads are placed on the foundation.

**Spread Footings**

We recommend supporting the proposed structure with reinforced concrete spread footings design to bear on a GRS foundation. Design footings as follows:

1. Design spread footings for a maximum allowable bearing pressure of 2,500 pounds per square foot (1.25 tsf).

2. Footings are to be designed with a least lateral dimension of 6.0 feet or greater.

3. At the recommended allowable bearing pressures, we anticipate that settlement of the individual footings under static loading conditions, will not exceed 0.75-inches. It is expected that the majority of settlement will likely occur during construction as dead loads are placed on the foundations.

These recommendations are based on structure loads provided to us by Bridge of 71.5 tons dead load, and 45 tons live load, respectively. Any changes in the applied loads will require reevaluation of the recommendations presented herein, by the Geotechnical section.

**Slope/Embankment Protection**

We recommend placing a revet mattress along the face of the embankment to protect both the GRS foundation system and the spread footing foundation from erosion and scour during high water events. The revet mattress is to be comprised of galvanized and PVC coated wire, and is to be a minimum of 6-inches thick. The revet mattresses are to be constructed at a maximum slope of 2(h):1(v), and is to extend a minimum of 10 feet beyond the limits of the bridge on either side.

**Aggregate Surfaced Roadway**

It is recommended to construct the roadway surface in accordance with the minimum requirements presented in Table 4.

***Table 4 – Minimum Pavement Requirements***

| Performance Period (yrs) | Layer | Minimum Thickness (in.) | Comments |
|---|---|---|---|
| 5 | Aggregate Surface Course | 6 | Base Aggregate, Grading C or D, as per Subsection 703.05(c) of the FP-03 Specifications |
| 10 | Aggregate Surface Course | 10 | Base Aggregate, Grading C or D, as per Subsection 703.05(c) of the FP-03 Specifications |

The project site is to be stripped of all vegetation, topsoil, or otherwise deleterious material prior to placement of the aggregate surface course. Routine maintenance of the roadway is recommended to regrade the roadway in order to maintain cross-slopes and prevent the accumulation of settlement, debris and vegetation within ditches.

## CONSTRUCTION CONSIDERATIONS

### Excavation and Sub-excavation

Due to the ongoing dissolution of the limestone caprock, it is recommended that the caprock be removed down to the underlying silty sand subgrade within the footprint of the proposed GRS abutment. The limestone material was observed, during our field investigation, to be rippable. The contractor should have all appropriate equipment necessary for the excavating and breaking rock and boulders available and onsite during structural excavation. All excavations are to be performed in accordance with applicable OSHA standards and in accordance with Section 204 of the FP-03 Specifications. Blasting of the limestone caprock is not permitted under any circumstances.

Subexcavated areas should be filled with a minimum of 36-in. of granular backfill, placed over a geotextile reinforcement, as indicated above in the Recommendations section of this report.

### Ground and Surface Water Management

Cofferdams, designed and constructed in accordance with Section 208 of the FP-03 Specifications, should be employed at all structural excavation and removal locations to keep water from the canal out of the working areas and to keep construction debris out of the canal. The GRS foundation will be founded near the observed ground water level. Excavations for footings will encounter groundwater seepage; and temporary dewatering techniques, such as sumps and pumps will be required to maintain dry conditions during construction. Seal concrete backfill (where required) at the base of excavation will fill crevices in the bedrock, limit water infiltration, provide a working platform, and add lateral support to the temporary sheeting system where applied.

All dewatering must be conducted in a manner that avoids undermining foundation subgrades and which limits the pumping of fines.

### Aggregate Surfaced Roadway

The aggregate surface course should be mixed, spread and compacted in accordance with Subsection 301 of the FP-03 Specifications. It is critical that the subgrade is stable prior to placement to ensure that compaction of the surface course can be achieved. Vibratory compaction may result in damage to the limestone caprock and liquefaction of the near-surface saturated silty sand soils. Consequently, vibratory compaction is not to be allowed.

## DISCLAIMER/LIMITATIONS CLAUSE

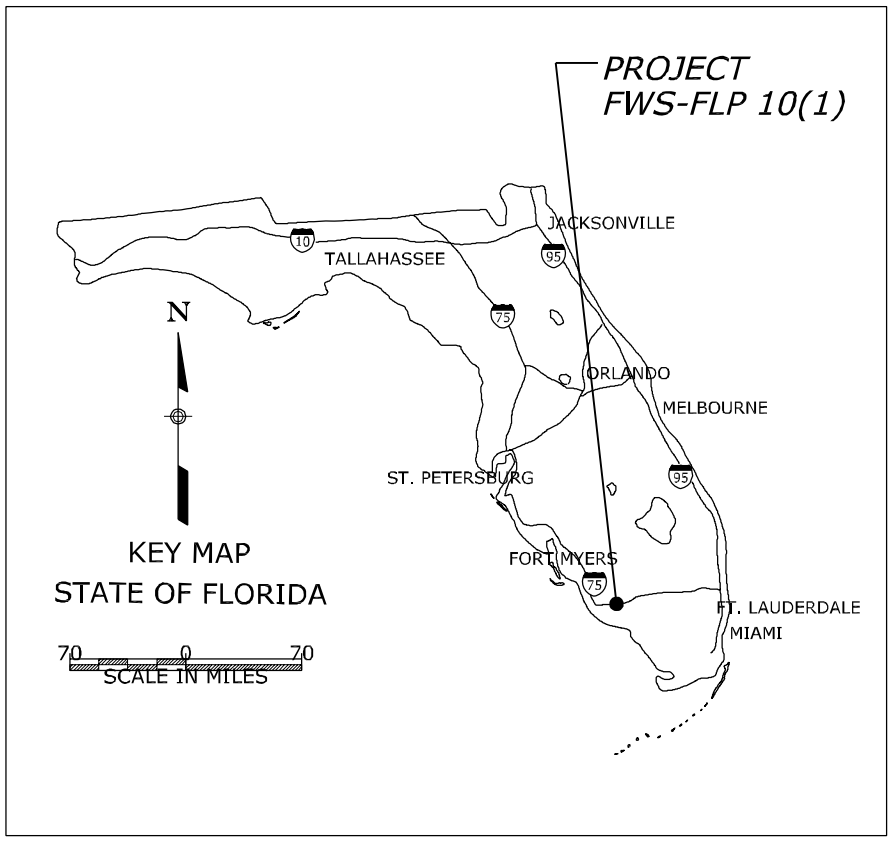
The subsurface explorations and tests described in the section on Procedures and Results have been conducted in accordance with standard practices and procedures (except as specifically noted). The results of these explorations and tests represent conditions at the specific locations indicated. Subsurface conditions between these locations may vary. The Analysis and Conclusions section and the Recommendations section in this report include interpretations and recommendations developed by the Government in the process of preparing the design. These interpretations are not intended as a substitute for the personal investigation, independent interpretation, and judgment of the Contractor.

Prepared by:
André O. Anderson
Geotechnical Engineer

Reviewed by:
Khalid T. Mohamed, P.E.
Division Geotechnical Engineer

# APPENDIX A

## Figures




**COLLIER COUNTY, FLORDIA**

PROJECT FWS-FLP 10(1)

| U.S. DEPARTMENT OF TRANSPORTATION<br>FEDERAL HIGHWAY ADMINISTRATION<br>EASTERN FEDERAL LANDS HIGHWAY DIVISION<br>STERLING, VIRGINIA | FLORIDA PANTHER NA<br>NATIONAL WILDLIFE REFUGE<br>SITE LOCATION AND VICINITY MAP<br>FIGURE 1 | REG | STATE | PROJECT | SHEET NO. | TOTAL SHEETS |
|---|---|---|---|---|---|---|
| | | SE | FL | FWS-FLP 10(1) | 1 | 2 |

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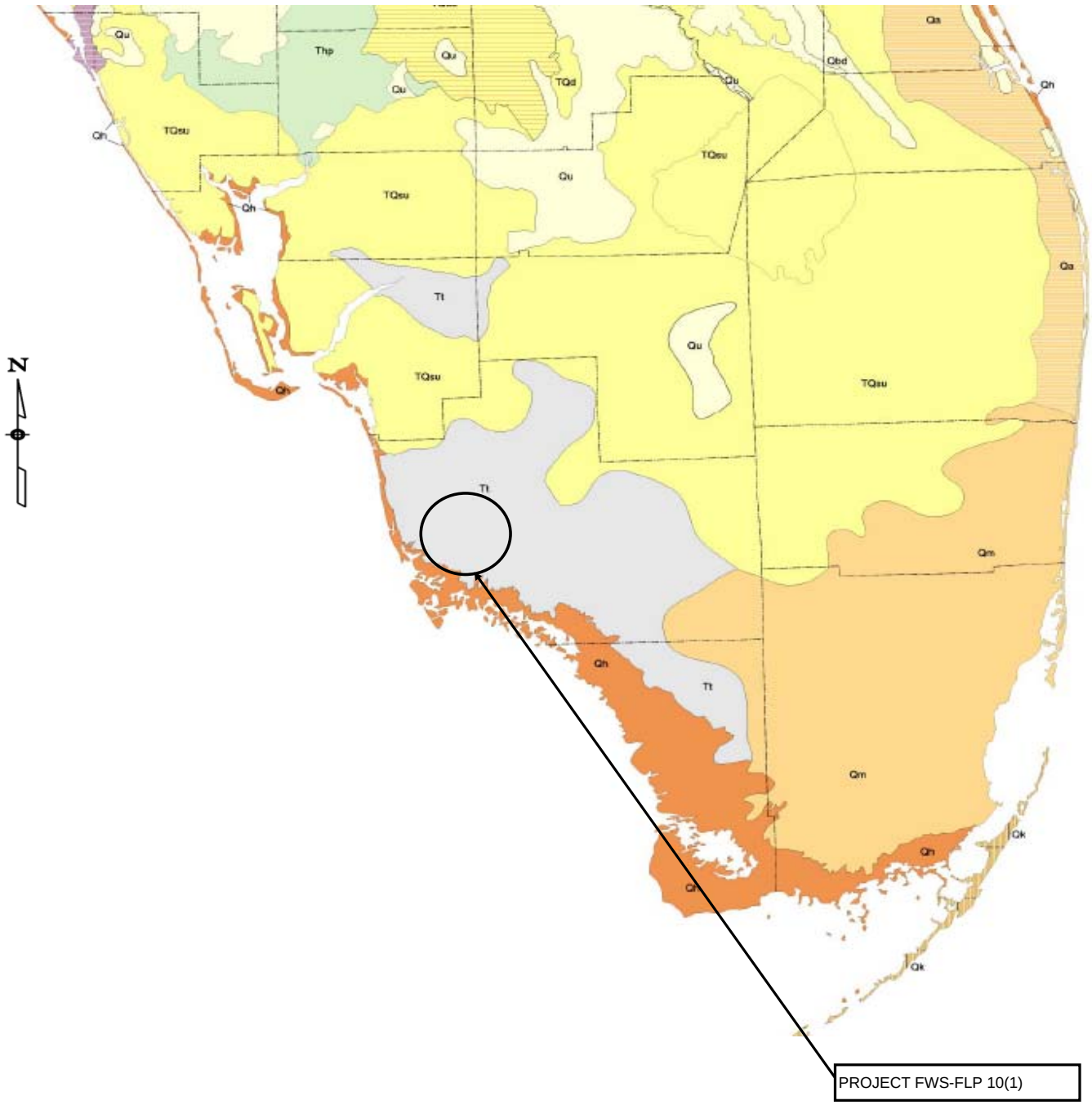



Tt

**Tamiami Formation -** light gray to gray, unconsolidated to poorly consiolidated, very fien to coarse grained, calcareous, fossiliferous sandy clay, clayey sand and sand; also white to light gray, poorly consolidated, moderately to well indurared, sandy fossiliferous limestone

Geologic Map
of the
State of Florida

by

Thomas M. Scott, P.G.#99, Kenneth M. Campbell, Frank R. Rupert
Jonathan D. Arthur, Thomas M. Missimer
Jacqueline M. Lloyd, J. William Yon, and Joel G. Duncan

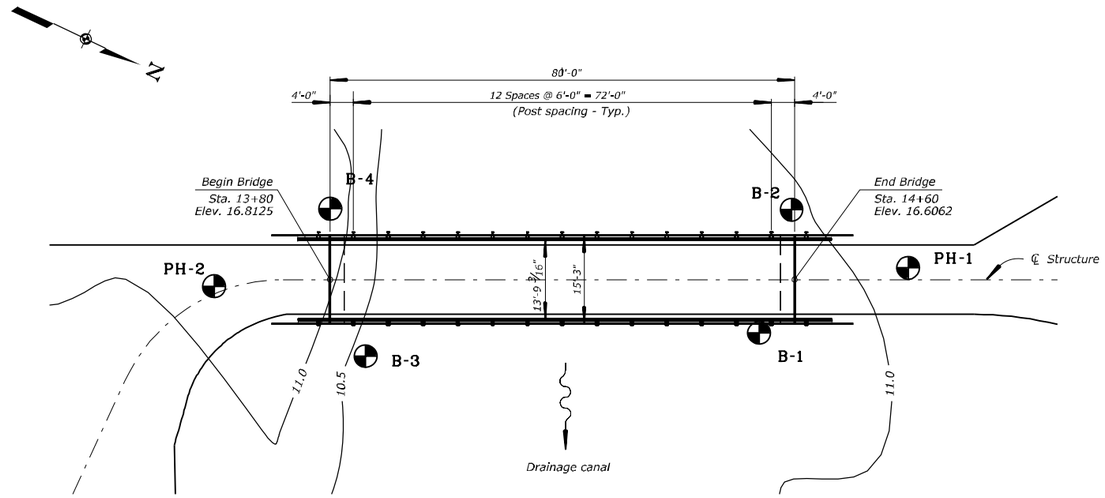
| U.S. DEPARTMENT OF TRANSPORTATION<br>FEDERAL LANDS HIGHWAY DIVISION<br>EASTERN FEDERAL LANDS HIGHWAY DIVISION<br>STERLING, VIRGINIA | **FIGURE 2**<br>GEOLOGIC MAP | REG | STATE | PROJECT | SHEET NO. | TOTAL SHEETS |
|---|---|---|---|---|---|---|
| | | SE | FL | FWS-FLP 10(1) | 2 | 2 |

# APPENDIX B

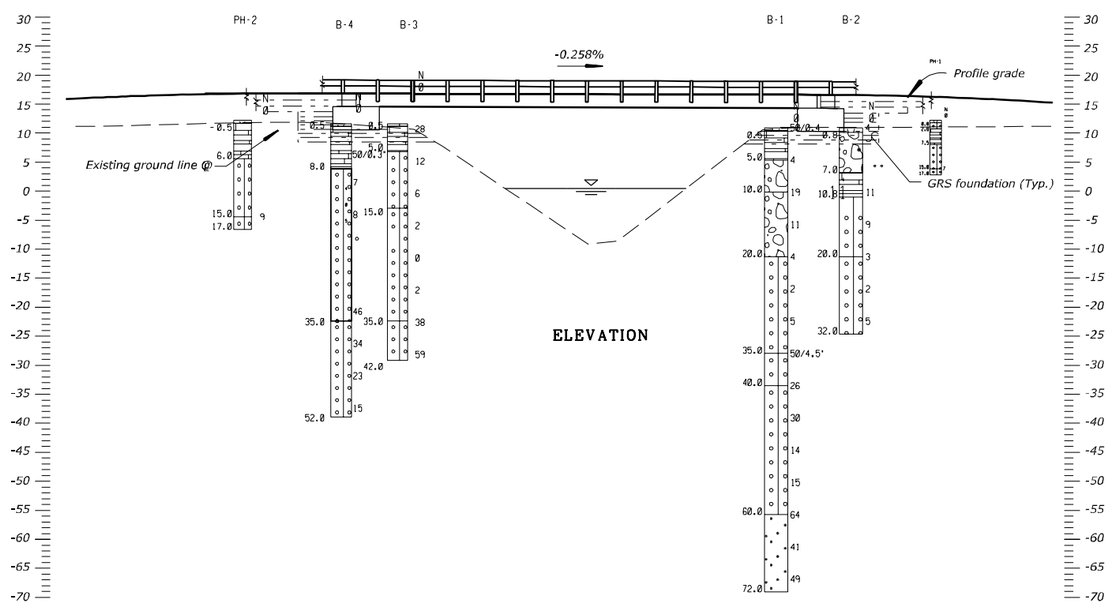
## Boring Logs and Subsurface Profile

LENGTH OF BRIDGE = 80'-0"

| REG | STATE | PROJECT | SHEET NO. | TOTAL SHEETS |
|---|---|---|---|---|
| SE | FL | FLP 10(1) | 1 | 1 |




PLAN




THE BORING LOGS ON THIS SHEET REPRESENT THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE BORING LOCATIONS SHOWN. SUBSURFACE CONDITIONS MAY VERY BETWEEN THESE LOCATIONS.

| SYMBOL | TYPE OF MATERIAL | SYMBOL | TYPE OF MATERIAL |
|---|---|---|---|
| | LIMESTONE | | |
| | GRAVEL | | |
| | SILTY SAND | | |
| | SAND | | |
| | | | |
| | | | |
| | | | |

TEST BORING

BORING NUMBER B-N

N BLOWS/12" (SPT)

J-N JAR SAMPLE NO.

WATER LEVEL (WL) (24 HOURS)

WATER LEVEL (WL) (TIME OF DRILLING)

CR% ROD

DEPTH MARKS

BHT OR BHR

MISCELLANEOUS

1. SPT - STANDARD PENETRATION TEST - AASHTO T206-74
2. R - REFUSAL, SPT 100 BLOWS/12"
3. CR% - PERCENT OF RECOVERY
4. RQD - ROCK QUALITY DESIGNATION
5. BHT - BORE HOLE TERMINATED
6. BHR - BORE HOLE REFUSAL
7. GEOPHYSICAL TEST SITE: SEISMIC S RESISTIVITY R

SCALE 0 10 20 SCALE IN FEET

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION
STERLING, VIRGINIA

# BORING LOCATION PLAN AND SUBSURFACE PROFILE

BRIDGE #
TO LUCKY LAKE ROAD
OVER DRAINAGE CANAL

PROJECT FLP 10(1)
GEOTECHNICAL REPORT NO. 07-07

8/9/2007 9:01:15 AM M:\Projects\refuge\f\fp10\techserv\geotech\CADD\Boring Location Plan & Subsurface Profile.dgn

# APPENDIX C

## Boring Logs

# SOIL BORING GENERAL NOTES

Drilling and Sampling Symbols

SS: Split Spoon - 1 3/8" I.D., 2" O.D., except where noted
ST: Shelby Tube - 2" O.D., except where noted
PA: Power Auger Sample

Water levels indicated on the boring logs are the levels measured in the boring at the times indicated. In pervious soils, the indicated elevations are considered reliable ground water levels. In impervious soils, the accurate determination of ground water elevations is not possible, even after several days, and additional evidence on ground water elevations must be sought.

---

## VISUAL METHODS FOR SOILS CLASSIFICATION

| Component | Distinguishing Features |
|---|---|
| Boulders | Larger than 12" (300 mm) |
| Cobbles | 3" to 12" (75 mm to 12 mm) |
| Gravel | Larger than No. 4 sieve and smaller than a 3" sieve, described with any of the following terms (or any combination): |
| Coarse | 3" to 3/4" (75 mm to 19 mm) sieve |
| Medium | 3/4" to 3/8" (19 mm to 9.5 mm) sieve |
| Fine | 3/8" to No. 4 (9.5 mm to 4.75 mm) sieve |
| Sand | The finest sand grains are just visible to the naked eye, while the largest would pass a No. 4 (4.75mm) sieve (pinhead size). Described with any of the following terms (or any combination): |
| Coarse | No. 4 to No. 10 (4.75 mm to 2.0 mm) sieve |
| Medium | No. 10 to No. 40 (2.0 mm to 0.42 mm) sieve |
| Fine | No. 40 to No. 200 (0.42 mm to 0.075 mm) sieve |
| Silt | 1. Lumps are easily crumbled when are-dried.<br>2. Feels gritty between the teeth.<br>3. A moist pat when shaken in the palm of the hand will appear shiny and wet. When squeezed it will appear dry and dull. |
| Clay | 1. Lumps are comparatively hard when air-dried.<br>2. Threads (1/8" diameter) of considerable length will support their own weight when held by one end.<br>3. A moist pat will appear the same whether shaken in the palm of the hand or squeezed. |

**Order of Description**

1. Soil Density (or consistency) – see table below
2. Color
3. Major Grain Size – Composes more than 50% of the sample
4. Modifying Term – "and" : 40% to 50% of the minor grain size
   "some" : 30% to 40%
   "little" : 10% to 30%
   "trace" : 10% or less
5. Minor Grain Size(s)
6. Other (plasticity, etc.)

7. Moisture Content (by field test) – "dry" : Absence of moisture, dusty, dry to the touch
"moist" : Damp but no visible water
"wet" : Visible free water, usually soil is below water table
8. General Classification – Fill, Residual Soil, Weathered Rock

| SOIL DENSITY (OR CONSISTENCY) TABLE | | | |
|---|---|---|---|
| **Coarse-Grained Soil (Gravel, Sand)** | | **Fine-Grained Soil (Clay, Silt)** | |
| Apparent Density | SPT (# blows / ft) | Consistency | SPT (# blows / ft) |
| Very loose | 0-4 | Very soft | 0-2 |
| Loose | 5-10 | Soft | 3-4 |
| Medium dense | 11-30 | Medium stiff | 5-8 |
| Dense | 31-50 | Stiff | 9-15 |
| Very dense | >50 | Very stiff | 16-30 |
| | | Hard | >30 |

*Examples:*

1. Dense to very dense, brown to light brown, **SILTY SAND**, some gravel [A-7-6(10)] (Moist)

**-FILL-**

**Criteria for Describing Soil Structure**

| Description | Criteria |
|---|---|
| Bed | A sedimentary layer bounded by depositional surfaces. |
| Blocky | A characteristic in which cohesive soil can be broken down into small angular lumps which resist further breakdown. |
| Bonded | Attached or adhering. |
| Fissured | Broken along definite planes of fracture. |
| Foliated | Planar arrangement of textural or structural features. |
| Frequent | More than one per foot of thickness. |
| Homogeneous | Same color and appearance throughout. |
| Interbedded | Alternating soil layers of different composition. |
| Laminae | A very thin cohesive layer. |
| Layer | A general term for material lying essentially parallel to the surfaces against which it was formed. |
| Lens | A lenticular deposit, larger than a pocket. |
| Occasional | One or less per foot of thickness. |
| Parting | A very thin granular layer. |
| Pocket | Small erratic deposits less than 12" in thickness. |
| Seam | A thin layer separating two distinctive layers of different composition or greater magnitude. |
| Stratified | Alternating layers of varying material or color. |
| Stratum | A stratigraphic unit. |
| Varve | A cyclic sedimentary couplet consisting of a coarser and a finer layer representing the variation in depositional energy resulting from the annual freeze-thaw cycle typically found in glaciolacustrine environments. |

# ROCK CORING GENERAL NOTES

Depth and Elevation: Use large marks as 1' (300mm) increments. Record proper elevations.

Core: Draw sketch of core breaks as it is oriented in the core box (align all core breaks so they fit together properly before drawing sketch). Starting at the top of core, measure each piece of core down its centerline to 1/100 of a foot. Record this measurement along the left side of the core sketch at the break.

---

## VISUAL METHODS FOR ROCK IDENTIFICATION

Description:

1. Draw a heavy line through description at depth to which core run penetrated.
2. Describe the rock type.
3. Note the condition of the core break on the right side of the core sketch
   Mud seam (MS); Sand seam (SS); Weathered surface (WS); Fresh break (FB)
4. Record coring time in minutes.
5. Record to nearest 1/100 foot the core recovered (after alignment in core box). Discard any debris at top of core, which obviously fill into the core hole.
6. Calculate per cent core recovery and record: $CR = \frac{\text{feet of core recovered}}{\text{feet cored}}$
7. Rock Quality Designation (RQD)

$$(RQD) = \frac{\Sigma[\text{Lengths of all pieces of the core} \geq 4'' \ (100mm)]}{\text{Total length of core run}} \times 100$$

---

**Hardness**:

| | |
|---|---|
| Very Soft (VS) | Can be deformed or crumbled by hand; |
| Soft (S) | Can be scratched with a fingernail |
| Moderately Hard (MH) | Can be scratched easily with a knife; |
| Hard (H) | Can be scratched with difficulty with a knife; |
| Very hard (VH) | Cannot be scratched with a knife |

**Color**: Wet the rock with water and describe the color including the color of any unusual or reoccurring markings on the core (i.e. light green with dark green bands, foliation lines).

**Soundness**: Use the proper number 1 through 4

| | | |
|---|---|---|
| 1. | Weathered | RQD = 0% to 25% |
| 2. | Highly jointed to Jointed | RQD = 25% to 50% |
| 3. | Jointed to Relatively sound | RQD = 50% to 75% |
| 4. | Relatively sound to Sound | RQD = 75% to 100% |

**Main Rock Formation Name**

**Texture**

Very Fine (VF),
Fine (F),
Medium (M),
Course (C)

**Modifying Term**

| | |
|---|---|
| "and" | 40% to 50% of the core run |
| "some" | 30% to 40% |
| "little" | 10% to 30% |
| "trace" | 10% or less |

**Minor Rock Type(s)**

**Other**

***Foliation***: Foliation planes are parallel planes of different minerals forming a banded appearance on the rock. The foliation planes are usually of a different color than the surrounding rock. Also the rock shears along the foliation planes if struck with a hammer. Record the following:

Close spaced (CS) – 1/8" (3mm) or closer; Medium spaced (MS) – 1/8" to 1/4" (3mm to 6mm); Open spaced (OS) – 1/4" (6mm) or larger

The angle to the horizontal should be measured (with a protractor) and recorded for the rock core. (Several different angles can be found in each 5' to 10' core.)

***Weathering***: Use the proper number 1 through 5.

1. Unweathered: No evidence of any mechanical or chemical alteration along discoloration evidenced.
2. Slightly weathered: Discoloration is evident, on surface, slight alteration no discontinuities, less than 10% of the volume is altered, strength is substantially unaffected.
3. Moderately weathered: Discoloring is evident, surface is pitted and altered with alteration penetrating will below rock surfaces, weathering "halos" evident, 10% to 50% of the rock is altered, strength is noticeably less than fresh rock.
4. Highly weathered: Entire mass is discolored; alteration pervades nearly all of the rock with some pockets of slightly weathered rock noticeable, some minerals leached away, retains only a fraction of original strength (with wet strength usually lower than dry strength).
5. Decomposed: Rock is reduced to a soil with relict rock structure (saprolite), can be generally molded and crumbled by hand.

***Recovery*** Core Recovery

***Rock Quality***: Use the proper number 1 through 5

| | | |
|---|---|---|
| 1. | Very Poor | RQD = 0% to 25% |
| 2. | Poor | RQD = 25% to 50% |
| 3. | Fair | RQD = 50% to 75% |
| 4. | Good | RQD = 75% to 90% |
| 5. | Excellent | RQD = 90% to 100% |

---

*Examples:*

1. Moderately hard, blue-gray to gray, weathered **BIOTITE GNEISS BOULDER**, medium texture

   Recovery = 24%
   RQD = 17%

2. Very hard, gray and white, relatively sound to sound **BIOTITE GNEISS**, medium to fine texture, some quartz veins, foliation angle = 20 degrees

   Recovery = 100%
   RQD = 100%

   -Fresh break @ approximately 47'

# BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

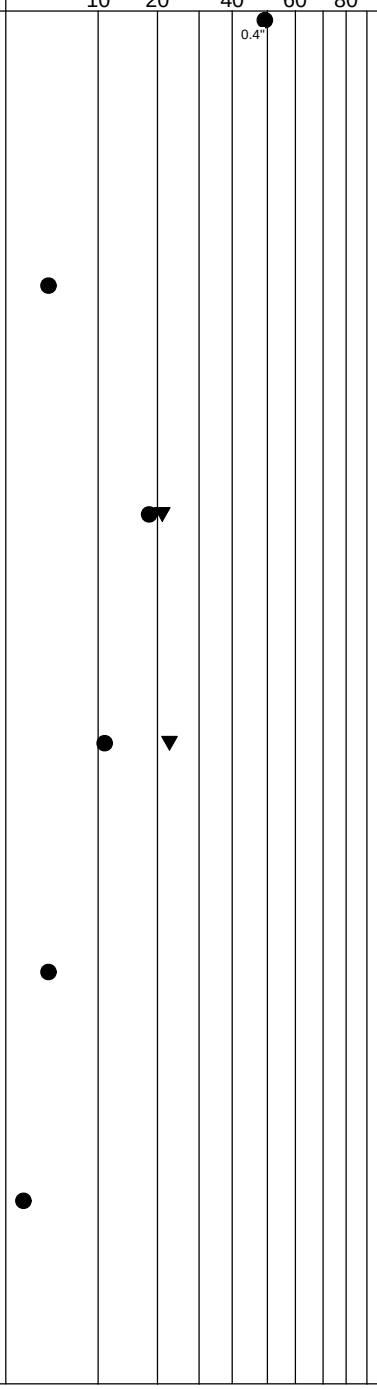
Project Name: FLP 10(1) | Boring No.: B-1 | Sheet: 1 of 3

Project Location: Florida Panther National Wildlife Refuge - Collier County, FL | Boring Location: North abutment at the left of the centerline

| | | | | | |
|---|---|---|---|---|---|
| Groundwater Depth: | | Surface Elevation: | 11.0 ft | Boring Began: | 3/7/07 |
| Encountered at: | 6.5 ft | Caved at: | | Boring Method: | HSA |
| At Completion: | | Hammer Wt. & Type: | 140 lbs/Automatic | Hole Diameter: | 8.0 in. |
| After ___ hrs | | Hammer Drop: | 30 in. | Rock Core Diam: | N/A |

| | |
|---|---|
| Completed: | 3/7/07 |
| Inspector: | A. Anderson |
| Operator: | R. Kingsley/D. Hutchins |
| Weather: | Sunny 70-75 ºF |

| Elevation (feet) | Layer Depth (ft) | MATERIAL DESCRIPTION (Density, Color, Plasticity, Size, Proportions, Moisture) | Depth Scale (ft) | Sample Type | No. | Rec. | Blows per 6 in. |
|---|---|---|---|---|---|---|---|
| 10.5 | 0.5 | Brown, **TOPSOIL**, little of coarse gravel (pulverized limestone) (Dry) | | | J-1 | 0.5 | 50/0.4 |
| | | Moderately hard, brown to tan, moderately weathered **LIMESTONE**, coarse to medium textured | | | | | |
| 6.0 | 5.0 | - augered thru rock w/moderate difficulty | 5 | | | | |
| | | Very loose, gray-brown to white, **GRAVEL**, some fine to coarse sand, little of silt, [A-1-b] (Moist to wet) | | | J-2 | 0.9 | 6-2-2-3 |
| 1.0 | 10.0 | | 10 | | | | |
| | | Medium dense, gray-brown to white, **GRAVEL**, some fine to coarse sand, little of silt (Wet) | | | J-3 | 1.2 | 11-13-6-7 |
| | | | 15 | | J-4 | 1.0 | 3-5-6-6 |
| -9.0 | 20.0 | | 20 | | | | |
| | | Very loose to loose, gray-brown to white, fine to medium **SILTY SAND**, trace of clay, trace of shell fragments (Wet) | | | J-5 | 1.8 | 2-2-2-2 |
| | | | 25 | | J-6 | 2.0 | 0-1-1-2 |
| | | | 30 | | | | |




Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
1. Groundwater was encountered at 6.5 ft.

# BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: FLP 10(1) Boring No.: B-1 Sheet: 2 of 3

Project Location: Florida Panther National Wildlife Refuge - Collier County, FL Boring Location: North abutment at the left of the centerline

| | | | | | |
|---|---|---|---|---|---|
| Groundwater Depth: | | Surface Elevation: | 11.0 ft | Boring Began: | 3/7/07 |
| Encountered at: | 6.5 ft | Caved at: | | Boring Method: | HSA |
| At Completion: | | Hammer Wt. & Type: | 140 lbs/Automatic | Hole Diameter: | 8.0 in. |
| After ___ hrs | | Hammer Drop: | 30 in. | Rock Core Diam: | N/A |

| | |
|---|---|
| Completed: | 3/7/07 |
| Inspector: | A. Anderson |
| Operator: | R. Kingsley/D. Hutchins |
| Weather: | Sunny 70-75 ºF |

| Elevation (feet) | Layer Depth (ft) | MATERIAL DESCRIPTION<br>Density, Color, Plasticity, Size, Proportions, Moisture | Depth Scale (ft) | SAMPLE Type | No. | Rec. | Blows per 6 in. | ▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80 |
|---|---|---|---|---|---|---|---|---|
| | | Very loose to loose, gray-brown to white, fine to medium **SILTY SAND**, trace of clay, trace of shell fragments (Wet) *(Continued)* | | | J-7 | 0.8 | 1-2-3-3 | |
| -24.0 | 35.0 | | 35 | | | | | |
| | | Very dense, gray-brown to white, medium to coarse **SILTY SAND**, trace of cemented shell fragments (Wet) | | | J-8 | 1.7 | 13-37-50/4.5" | 10.5" |
| -29.0 | 40.0 | | 40 | | | | | |
| | | Medium dense, gray to gray-brown to white, medium to coarse **SILTY SAND**, trace of cemented shell fragments (Wet) | | | J-9 | 1.2 | 12-13-13-43 | |
| | | | 45 | | J-10 | 1.8 | 12-16-14-9 | |
| | | | 50 | | J-11 | 1.5 | 5-6-8-9 | |
| | | | 55 | | J-12 | 1.0 | 5-5-10-13 | |
| -49.0 | 60.0 | | 60 | | | | | |

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
1. Groundwater was encountered at 6.5 ft.

# BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: FLP 10(1) | Boring No.: B-1 | Sheet: 3 of 3

Project Location: Florida Panther National Wildlife Refuge - Collier County, FL | Boring Location: North abutment at the left of the centerline

| | | | | | |
|---|---|---|---|---|---|
| Groundwater Depth: | | Surface Elevation: | 11.0 ft | Boring Began: | 3/7/07 |
| Encountered at: | 6.5 ft ▽ | Caved at: | | Boring Method: | HSA |
| At Completion: | ▼ | Hammer Wt. & Type: | 140 lbs/Automatic | Hole Diameter: | 8.0 in. |
| After ____ hrs | ▼ | Hammer Drop: | 30 in. | Rock Core Diam: | N/A |

| | | | |
|---|---|---|---|
| Completed: | 3/7/07 |
| Inspector: | A. Anderson |
| Operator: | R. Kingsley/D. Hutchins |
| Weather: | Sunny 70-75 ºF |

| Elevation (feet) | Graphic Log | Layer Depth (ft) | MATERIAL DESCRIPTION<br>Density, Color, Plasticity, Size, Proportions, Moisture | Depth Scale (ft) | SAMPLE Type | No. | Rec. | Blows per 6 in. | ▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80 |
|---|---|---|---|---|---|---|---|---|---|
| | | | Very dense to dense, gray to gray-brown to white, coarse **SAND**, some cemented shell fragments, little of silt [A-1-b]<br>(Wet) | | | J-13 | 1.3 | 20-37-27-38 | |
| | | | | 65 | | J-14 | 1.4 | 11-19-22-24 | |
| | | | | 70 | | J-15 | 1.4 | 13-22-27-42 | |
| -61.0 | | 72.0 | - Borehole Terminated @ 72.0 ft | | | | | | |
| | | | | 75 | | | | | |
| | | | | 80 | | | | | |
| | | | | 85 | | | | | |
| | | | | 90 | | | | | |

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
1. Groundwater was encountered at 6.5 ft.

# BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: FLP 10(1) Boring No.: B-2 Sheet: 1 of 2

Project Location: Florida Panther National Wildlife Refuge - Collier County, FL Boring Location: North abutment at right of the centerline

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Groundwater Depth: | | Surface Elevation: | 11.0 ft | Boring Began: | 3/8/07 | Completed: | 3/8/07 |
| Encountered at: | 6.5 ft ▽ | Caved at: | | Boring Method: | HSA | Inspector: | A. Anderson |
| At Completion: | ▼ | Hammer Wt. & Type: | 140 lbs/Automatic | Hole Diameter: | 8.0 in. | Operator: | R. Kingsley/D. Hutchins |
| After ____ hrs | ▼ | Hammer Drop: | 30 in. | Rock Core Diam: | N/A | Weather: | Sunny 70-75 ºF |

| Elevation (feet) | Layer Depth (ft) | MATERIAL DESCRIPTION (Density, Color, Plasticity, Size, Proportions, Moisture) | Depth Scale (ft) | Type | No. | Rec. | Blows per 6 in. |
|---|---|---|---|---|---|---|---|
| 10.3 | 0.8 | Brown, **TOPSOIL**, little of coarse gravel (pulverized limestone) (Dry) | | | J-1 | 1.3 | 1-2-2-3 |
| | | Medium dense, tan to yellow, **GRAVEL**, some fine to coarse sand [A-1-a] (Wet) | 5 | | J-2 | 1.3 | 9-8-3-4 |
| 4.0 | 7.0 | Highly weathered to moderately hard, brown to tan, moderately weathered **LIMESTONE**, coarse to medium textured | | | | | |
| | | - augered thru rock w/little to moderate difficulty | 10 | | J-3 | 1.6 | 10-7-4-5 |
| 0.3 | 10.8 | Medium dense, gray-brown to white, fine **SILTY SAND**, trace of gravel (Wet) | 15 | | J-4 | | 3-4-5-3 |
| -9.0 | 20.0 | Very loose to loose, gray-brown to white, fine to medium **SILTY SAND**, little of cemented shell fragments [A-1-b] (Wet) | 20 | | J-5 | 1.0 | 2-1-2-1 |
| | | | 25 | | J-6 | | 1-1-1-2 |
| | | | 30 | | | | |

SAMPLE

▼ Water Content %
Plastic Limit ├──┤ Liquid Limit
● Standard Penetration Test Data (Blows / ft)
10 20 40 60 80

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
1. Groundwater was encountered at 6.5 ft.

# BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: FLP 10(1) Boring No.: B-2 Sheet: 2 of 2

Project Location: Florida Panther National Wildlife Refuge - Collier County, FL Boring Location: North abutment at right of the centerline

| | | | | | |
|---|---|---|---|---|---|
| Groundwater Depth: | | Surface Elevation: | 11.0 ft | Boring Began: | 3/8/07 |
| Encountered at: | 6.5 ft ▽ | Caved at: | | Boring Method: | HSA |
| At Completion: | ▼ | Hammer Wt. & Type: | 140 lbs/Automatic | Hole Diameter: | 8.0 in. |
| After ____ hrs | ▼ | Hammer Drop: | 30 in. | Rock Core Diam: | N/A |

| | | | |
|---|---|---|---|
| Completed: | 3/8/07 | | |
| Inspector: | A. Anderson | | |
| Operator: | R. Kingsley/D. Hutchins | | |
| Weather: | Sunny 70-75 ºF | | |

| Elevation (feet) | Graphic Log | Layer Depth (ft) | MATERIAL DESCRIPTION<br>Density, Color, Plasticity, Size, Proportions, Moisture | Depth Scale (ft) | SAMPLE Type | No. | Rec. | Blows per 6 in. | ▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80 |
|---|---|---|---|---|---|---|---|---|---|
| -21.0 | | 32.0 | | | SPT | J-7 | | 2-2-3-2 | ● |
| | | | -Borehole Terminated @ 32.0 ft | | | | | | |
| | | | | 35 | | | | | |
| | | | | 40 | | | | | |
| | | | | 45 | | | | | |
| | | | | 50 | | | | | |
| | | | | 55 | | | | | |
| | | | | 60 | | | | | |

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
1. Groundwater was encountered at 6.5 ft.

# BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: FLP 10(1) | Boring No.: B-3 | Sheet: 1 of 2

Project Location: Florida Panther National Wildlife Refuge - Collier County, FL | Boring Location: South abutment at left of the centerline

| | | | | | |
|---|---|---|---|---|---|
| Groundwater Depth: | | Surface Elevation: | 11.0 ft | Boring Began: | 3/9/07 |
| Encountered at: | 6.5 ft ▽ | Caved at: | | Boring Method: | HSA |
| At Completion: | ▼ | Hammer Wt. & Type: | 140 lbs/Automatic | Hole Diameter: | 8.0 in. |
| After ___ hrs | ▼ | Hammer Drop: | 30 in. | Rock Core Diam: | N/A |

| | |
|---|---|
| Completed: | 3/9/07 |
| Inspector: | A. Anderson |
| Operator: | R. Kingsley/D. Hutchins |
| Weather: | Partly Cloudy 60-70 ºF |

| Elevation (feet) | Layer Depth (ft) | MATERIAL DESCRIPTION (Density, Color, Plasticity, Size, Proportions, Moisture) | Depth Scale (ft) | Type | No. | Rec. | Blows per 6 in. |
|---|---|---|---|---|---|---|---|
| 10.5 | 0.5 | Brown, **TOPSOIL**, little of coarse gravel (pulverized limestone) (Dry) | | | | | |
| | | Moderately hard, brown to tan, moderately weathered **LIMESTONE**, coarse to medium textured | | | | | |
| 6.0 | 5.0 | - augered thru rock w/moderate difficulty | 5 | | | | |
| | | Medium dense, gray-brown to white, fine **SILTY SAND**, some pulverized limestone fragments, little of shell fragments (Wet) ▽ | | SPT | J-1 | 0.9 | 18-21-7-1 |
| | | | 10 | SPT | J-2 | 1.1 | 5-8-4-3 |
| -4.0 | 15.0 | Loose to very loose, gray-brown to white, fine to medium **SILTY SAND**, little of shell fragments, trace of clay [A-1-b] (Wet) | 15 | SPT | J-3 | | 3-3-3-5 |
| | | | 20 | SPT | J-4 | 1.6 | 1-1-1-1 |
| | | | 25 | SPT | J-5 | 1.8 | 0-0-0-1 |
| | | | 30 | | | | |

▼ Water Content %
Plastic Limit ├──┤ Liquid Limit
● Standard Penetration Test Data (Blows / ft)
10 20 40 60 80

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
1. Groundwater was encountered at 6.5 ft.

# BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: FLP 10(1) Boring No.: B-3 Sheet: 2 of 2

Project Location: Florida Panther National Wildlife Refuge - Collier County, FL Boring Location: South abutment at left of the centerline

| | | | | | |
|---|---|---|---|---|---|
| Groundwater Depth: | | Surface Elevation: | 11.0 ft | Boring Began: | 3/9/07 |
| Encountered at: | 6.5 ft ▽ | Caved at: | | Boring Method: | HSA |
| At Completion: | ▼ | Hammer Wt. & Type: | 140 lbs/Automatic | Hole Diameter: | 8.0 in. |
| After ____ hrs | ▼ | Hammer Drop: | 30 in. | Rock Core Diam: | N/A |

| | | | |
|---|---|---|---|
| Completed: | 3/9/07 | Inspector: | A. Anderson |
| Operator: | R. Kingsley/D. Hutchins | Weather: | Partly Cloudy 60-70 ºF |

| Elevation (feet) | Graphic Log | Layer Depth (ft) | MATERIAL DESCRIPTION<br>Density, Color, Plasticity, Size, Proportions, Moisture | Depth Scale (ft) | SAMPLE Type | No. | Rec. | Blows per 6 in. | ▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80 |
|---|---|---|---|---|---|---|---|---|---|
| | | | Loose to very loose, gray-brown to white, fine to medium **SILTY SAND**, little of shell fragments, trace of clay [A-1-b] (Wet) *(Continued)* | | SPT | J-6 | | 1-1-1-1 | ● |
| -24.0 | | 35.0 | | 35 | | | | | |
| | | | Very dense to dense, gray-brown to white, medium to coarse**SILTY SAND**, litlle of cemented shell fragments [A-1-b] (Wet) | | SPT | J-7 | 2.0 | 19-20-18-45 | ▼● |
| | | | | 40 | | | | | |
| | | | | | SPT | J-8 | 1.2 | 8-23-36-40 | ● |
| -31.0 | | 42.0 | | | | | | | |
| | | | Borehole Terminated @ 42.0 ft | | | | | | |
| | | | | 45 | | | | | |
| | | | | 50 | | | | | |
| | | | | 55 | | | | | |
| | | | | 60 | | | | | |

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
1. Groundwater was encountered at 6.5 ft.

# BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: FLP 10(1) | Boring No.: B-4 | Sheet: 1 of 2

Project Location: Florida Panther National Wildlife Refuge - Collier County, FL | Boring Location: South abutment at the right of the center line

| | | | | | |
|---|---|---|---|---|---|
| Groundwater Depth: | | Surface Elevation: | 11.0 ft | Boring Began: | 3/9/07 |
| Encountered at: | 8.0 ft ▽ | Caved at: | | Boring Method: | HSA |
| At Completion: | ▼ | Hammer Wt. & Type: | 140 lbs/Automatic | Hole Diameter: | 8.0 in. |
| After ___ hrs | ▼ | Hammer Drop: | 30 in. | Rock Core Diam: | N/A |

| | |
|---|---|
| Completed: | 3/9/07 |
| Inspector: | A. Anderson |
| Operator: | R. Kingsley/D. Hutchins |
| Weather: | Sunny 60-75 ºF |

| Elevation (feet) | Layer Depth (ft) | MATERIAL DESCRIPTION (Density, Color, Plasticity, Size, Proportions, Moisture) | Depth Scale (ft) | Type | No. | Rec. | Blows per 6 in. | Water Content % / Standard Penetration Test Data (Blows / ft) |
|---|---|---|---|---|---|---|---|---|
| 10.5 | 0.5 | Brown, **TOPSOIL**, little of coarse gravel (pulverized limestone) (Dry) | | | | | | |
| | | Moderately hard, brown to tan, moderately weathered **LIMESTONE**, coarse to medium textured | | | | | | |
| | | - augered thru rock w/moderate difficulty | 5 | SPT | J-1 | 0.3 | 50/0.3" | 0.3" |
| 3.0 | 8.0 | Loose, gray-brown to white, fine to coarse **SILTY SAND**, little of cemented shell fragments [A-1-b] (Wet) | | | | | | |
| | | | 10 | SPT | J-2 | 0.8 | 3-4-3-4 | |
| | | - loose silty sand statum encountered from 25-30 ft | | | | | | |
| | | | 15 | SPT | J-3 | 1.3 | 4-4-4-6 | |
| | | | 20 | SPT | J-4 | 1.6 | 3-3-1-1 | |
| | | | 25 | SPT | J-5 | 2.0 | 0-0-0-1 | << |
| | | | 30 | | | | | |

Plastic Limit ⊢——⊣ Liquid Limit
● Standard Penetration Test Data (Blows / ft)
10 20 40 60 80

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
1. Groundwater was encountered at 8.0 ft.

# BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: FLP 10(1) | Boring No.: B-4 | Sheet: 2 of 2

Project Location: Florida Panther National Wildlife Refuge - Collier County, FL | Boring Location: South abutment at the right of the center line

| | | | | | |
|---|---|---|---|---|---|
| Groundwater Depth: | | Surface Elevation: | 11.0 ft | Boring Began: | 3/9/07 |
| Encountered at: | 8.0 ft | Caved at: | | Boring Method: | HSA |
| At Completion: | | Hammer Wt. & Type: | 140 lbs/Automatic | Hole Diameter: | 8.0 in. |
| After ____ hrs | | Hammer Drop: | 30 in. | Rock Core Diam: | N/A |

| | |
|---|---|
| Completed: | 3/9/07 |
| Inspector: | A. Anderson |
| Operator: | R. Kingsley/D. Hutchins |
| Weather: | Sunny 60-75 ºF |

| Elevation (feet) | Layer Depth (ft) | MATERIAL DESCRIPTION<br>Density, Color, Plasticity, Size, Proportions, Moisture | Depth Scale (ft) | SAMPLE Type | No. | Rec. | Blows per 6 in. | ▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80 |
|---|---|---|---|---|---|---|---|---|
| | | | | SPT | J-6 | 1.7 | 1-2-3-3 | |
| -24.0 | 35.0 | | 35 | | | | | |
| | | Dense to medium dense, gray-brown to white, medium to coarse **SILTY SAND**, trace of cemented shell fragments [A-1-b]<br>(wet) | | SPT | J-7 | 1.5 | 8-22-24-20 | |
| | | | 40 | SPT | J-8 | 1.2 | 11-15-19-29 | |
| | | | 45 | SPT | J-9 | 1.0 | 10-8-15-50 | |
| | | | 50 | SPT | J-10 | | 3-7-8-18 | |
| -41.0 | 52.0 | | | | | | | |
| | | -Borehole Terminated @ 52.0 ft | 55 | | | | | |
| | | | 60 | | | | | |

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
1. Groundwater was encountered at 8.0 ft.

# BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: FLP 10(1) | Boring No.: PH-1 | Sheet: 1 of 1

Project Location: Florida Panther National Wildlife Refuge - Collier County, FL | Boring Location: North abutment at 20.0 ft offset along centerline

| | | | | | |
|---|---|---|---|---|---|
| Groundwater Depth: | | Surface Elevation: | 9.5 ft | Boring Began: | 3/8/07 |
| Encountered at: | 7.5 ft ▽ | Caved at: | | Boring Method: | HSA |
| At Completion: | ▼ | Hammer Wt. & Type: | 140 lbs/Automatic | Hole Diameter: | 8.0 in. |
| After ____ hrs | ▼ | Hammer Drop: | 30 in. | Rock Core Diam: | N/A |

| | |
|---|---|
| Completed: | 3/8/07 |
| Inspector: | A. Anderson |
| Operator: | R. Kingsley/D. Hutchins |
| Weather: | Sunny 65-75 ºF |

| Elevation (feet) | Layer Depth (ft) | MATERIAL DESCRIPTION (Density, Color, Plasticity, Size, Proportions, Moisture) | Depth Scale (ft) | Sample Type | Sample No. | Rec. | Blows per 6 in. | ▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80 |
|---|---|---|---|---|---|---|---|---|
| 8.8 | 0.8 | Brown, **TOPSOIL**, little of coarse gravel (pulverized limestone) (Dry) | | | | | | |
| 6.8 | 2.8 | Light brown to tan, fine **SILTY SAND**, some rock fragments, trace of organics (Moist to wet) | | | | | | |
| | | Moderately hard, brown to tan, moderately weathered **LIMESTONE**, coarse to medium textured | 5 | | | | | |
| | | - augered thru rock w/moderate difficulty | | | | | | |
| 2.0 | 7.5 | Gray-brown, **SILTY SAND**, some gravel, trace of shell fragments (Wet) | 10 | | | | | |
| -5.5 | 15.0 | | 15 | | | | | |
| | | Loose, gray-brown to white, fine to medium **SILTY SAND**, some gravel, trace of shell fragments (Wet) | | | J-1 | | 3-3-4-4 | ● |
| -7.5 | 17.0 | Borehole Terminated @ 17.0 ft | | | | | | |
| | | | 20 | | | | | |
| | | | 25 | | | | | |
| | | | 30 | | | | | |

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
1. Probehole to determine if subsurface conditions are consistent with bridge borings.
2. Groundwater was encountered at 7.5 ft.

# BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: FLP 10(1) | Boring No.: PH-2 | Sheet: 1 of 1

Project Location: Florida Panther National Wildlife Refuge - Collier County, FL | Boring Location: South abutment at 20.0 ft offset along centerline

| | | | | | |
|---|---|---|---|---|---|
| Groundwater Depth: | | Surface Elevation: | 12.3 ft | Boring Began: | 3/9/07 |
| Encountered at: | 7.5 ft ▽ | Caved at: | | Boring Method: | HSA |
| At Completion: | ▼ | Hammer Wt. & Type: | 140 lbs/Automatic | Hole Diameter: | 8.0 in. |
| After ___ hrs | ▼ | Hammer Drop: | 30 in. | Rock Core Diam: | N/A |

| | |
|---|---|
| Completed: | 3/9/07 |
| Inspector: | A. Anderson |
| Operator: | R. Kingsley/D. Hutchins |
| Weather: | Sunny 60-75 ºF |

| Elevation (feet) | Layer Depth (ft) | MATERIAL DESCRIPTION (Density, Color, Plasticity, Size, Proportions, Moisture) | Depth Scale (ft) | Sample Type | No. | Rec. | Blows per 6 in. |
|---|---|---|---|---|---|---|---|
| 11.8 | 0.5 | Brown, **TOPSOIL**, little of coarse gravel (pulverized limestone) (Dry) | | | | | |
| | | Moderately hard, brown to tan, moderately weathered **LIMESTONE**, coarse to medium textured | | | | | |
| | | - augered thru rock w/moderate difficulty | 5 | | | | |
| 6.3 | 6.0 | Gray-brown, fine to medium **SILTY SAND**, some gravel, trace of shell fragments (Wet) ▽ | | | | | |
| | | | 10 | | | | |
| -2.8 | 15.0 | | 15 | | | | |
| | | Loose, gray-brown to white, fine to medium **SILTY SAND**, trace of gravel, trace of shell fragments (Wet) | | | J-1 | 1.7 | 4-5-4-4 |
| -4.8 | 17.0 | Borehole Terminated @ 17.0 ft | | | | | |
| | | | 20 | | | | |
| | | | 25 | | | | |
| | | | 30 | | | | |

▼ Water Content %
Plastic Limit ├──┤ Liquid Limit
● Standard Penetration Test Data (Blows / ft)
10 20 40 60 80

Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
1. Probehole to determine if subsurface conditions are consistent with bridge borings.
2. Groundwater was encountered at 7.5 ft.

# BORING LOG

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

Project Name: FLP 10(1) | Boring No.: PH-3 | Sheet: 1 of 1

Project Location: Florida Panther National Wildlife Refuge - Collier County, FL | Boring Location: Proposed parking area

| | | | | | |
|---|---|---|---|---|---|
| Groundwater Depth: | | Surface Elevation: | | Boring Began: 3/9/07 | Completed: 3/9/07 |
| Encountered at: | 7.5 ft ▽ | Caved at: | | Boring Method: HSA | Inspector: A. Anderson |
| At Completion: | ▼ | Hammer Wt. & Type: | 140 lbs/Automatic | Hole Diameter: 8.0 in. | Operator: R. Kingsley/D. Hutchins |
| After ____ hrs | ▼ | Hammer Drop: | 30 in. | Rock Core Diam: N/A | Weather: Sunny 65-75 ºF |

| Elevation (feet) | Graphic Log | Layer Depth (ft) | MATERIAL DESCRIPTION<br>Density, Color, Plasticity, Size, Proportions, Moisture | Depth Scale (ft) | SAMPLE Type | No. | Rec. | Blows per 6 in. | ▼ Water Content % / Plastic Limit ⊢—⊣ Liquid Limit / ● Standard Penetration Test Data (Blows / ft) 10 20 40 60 80 |
|---|---|---|---|---|---|---|---|---|---|
| | | 0.5 | Brown, **TOPSOIL**, little of coarse gravel (pulverized limestone) | | | | | | |
| | | 1.5 | (Dry) | | | | | | |
| | | | Brown to tan, fine **SILTY SAND**, trace of organics (Dry) | | | | | | |
| | | | Moderately hard, brown to tan, moderately weathered **LIMESTONE**, coarse to medium textured | 5 | | | | | |
| | | | - augered thru rock w/moderate difficulty | | | | | | |
| | | 7.5 | | | | | | | |
| | | | Gray- brown to tan, fine to medium **SILTY SAND**, little of gravel (Moist to wet) | 10 | | | | | |
| | | 15.0 | | 15 | | | | | |
| | | | Loose, gray-brown to white, fine to medium **SILTY SAND**, trace of shell fragments (wet) | | | J-1 | 1.3 | 5-4-4-5 | ● |
| | | 17.0 | | | | | | | |
| | | | Borehole Terminated @ 17.0 ft | 20 | | | | | |
| | | | | 25 | | | | | |
| | | | | 30 | | | | | |

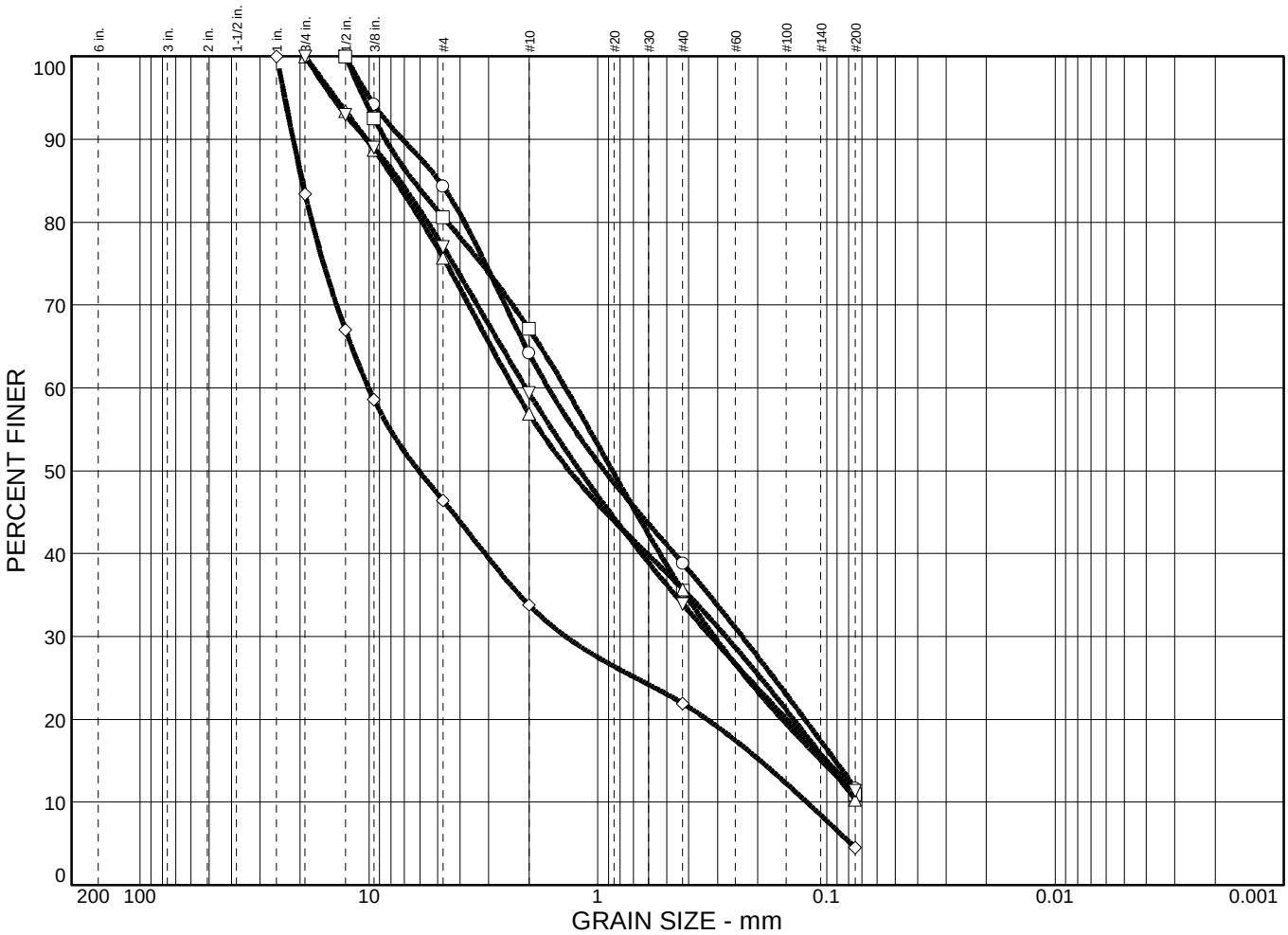
Sample Types:
- Auger Cuttings
- Vane Shear
- SPT
- UD
- Penetrometer
- Rock Core

Remarks:
1. Probehole to determine if subsurface conditions are consistent with bridge borings.
2. Groundwater was encountered at 7.5 ft.

# APPENDIX D

## Laboratory Test Results

# Particle Size Distribution Report




| | % + 3" | % GRAVEL | % SAND | % SILT | % CLAY |
|---|---|---|---|---|---|
| ○ | 0.0 | 15.7 | 72.6 | 11.7 | |
| □ | 0.0 | 19.4 | 69.7 | 10.9 | |
| △ | 0.0 | 24.3 | 65.4 | 10.3 | |
| ◇ | 0.0 | 53.6 | 41.9 | 4.5 | |
| ▽ | 0.0 | 23.0 | 65.6 | 11.4 | |

## SOIL DATA

| SYMBOL | SOURCE | SAMPLE NO. | DEPTH (ft.) | DESCRIPTION | AASHTO |
|---|---|---|---|---|---|
| ○ | | B-1/J-3 | 10.0-12.0 | Poorly graded sand with silt and gravel | A-1-b |
| □ | | B-1/J-4 | 15.0-17.0 | Poorly graded sand with silt and gravel | A-1-b |
| △ | | B-1/J-14 | 65.0-67.0 | Poorly graded sand with silt and gravel | A-1-b |
| ◇ | | B-2/J-2 | 5.0-7.0 | Well-graded gravel with sand | A-1-a |
| ▽ | | B-2/J-5 | 20.0-22.0 | Poorly graded sand with silt and gravel | A-1-b |

Particle Size Distribution Report

**FEDERAL HIGHWAY ADMINISTRATION**

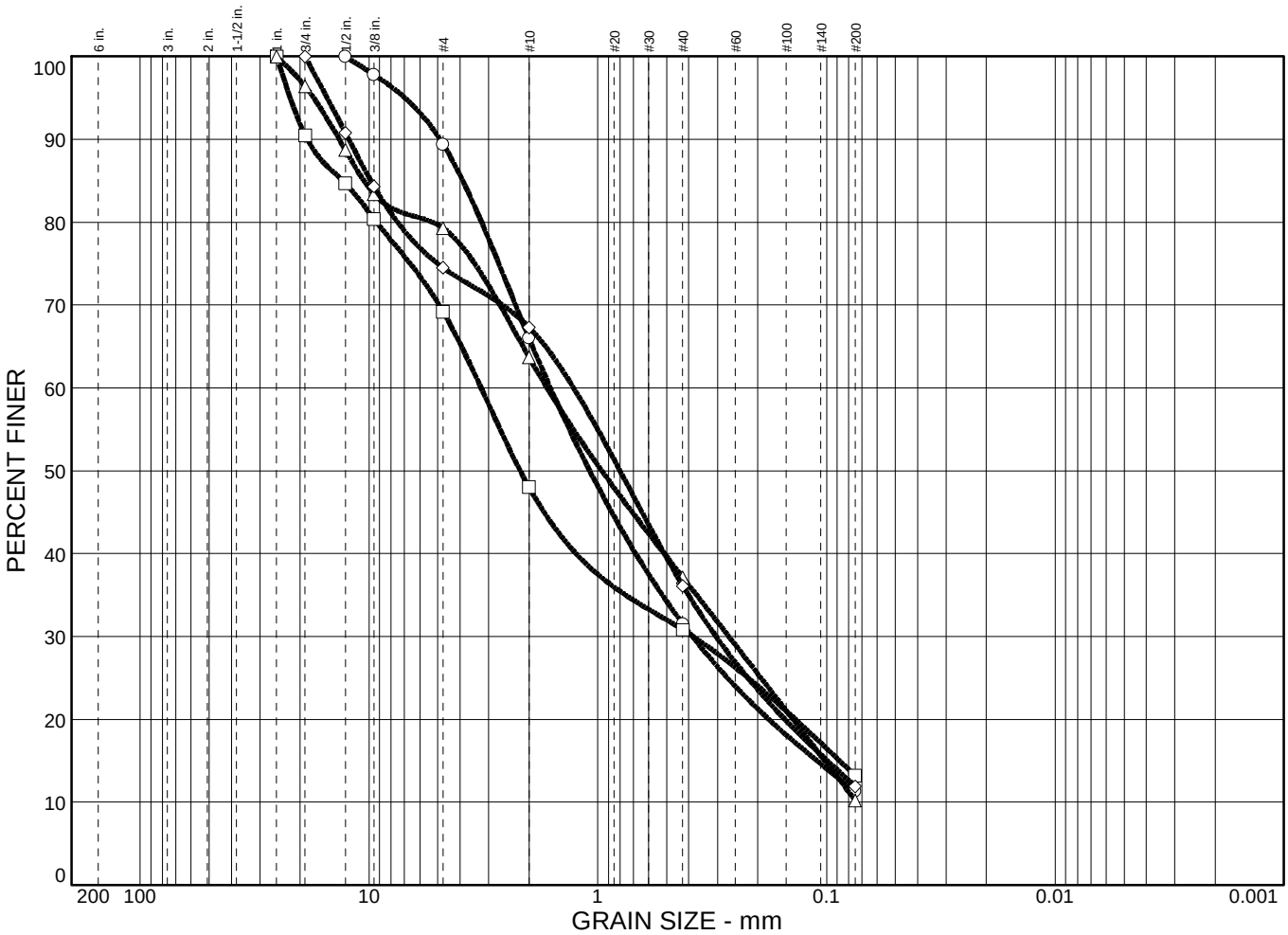
**EASTERN FEDERAL LANDS HIGHWAY DIVISION**

**Client:** FHWA/EFLHD

**Project:** Florida Panther National Wildlife Refuge

**Project No.:** FLP 10(1)

# Particle Size Distribution Report




| | % + 3" | % GRAVEL | % SAND | % SILT | % CLAY |
|---|---|---|---|---|---|
| ○ | 0.0 | 10.6 | 78.1 | 11.3 | |
| □ | 0.0 | 30.8 | 56.0 | 13.2 | |
| △ | 0.0 | 20.7 | 69.1 | 10.2 | |
| ◇ | 0.0 | 25.5 | 62.6 | 11.9 | |
| | | | | | |

## SOIL DATA

| SYMBOL | SOURCE | SAMPLE NO. | DEPTH (ft.) | DESCRIPTION | AASHTO |
|---|---|---|---|---|---|
| ○ | | B-3/J-5 | 25.0-27.0 | Poorly graded sand with silt | A-1-b |
| □ | | B-3/J-7 | 35.0-37.0 | Silty sand with gravel | A-1-b |
| △ | | B-4/J-6 | 30.0-32.0 | Poorly graded sand with silt and gravel | A-1-b |
| ◇ | | B-4/J-9 | 45.0-47.0 | Poorly graded sand with silt and gravel | A-1-b |
| | | | | | |

Particle Size Distribution Report

**FEDERAL HIGHWAY ADMINISTRATION**

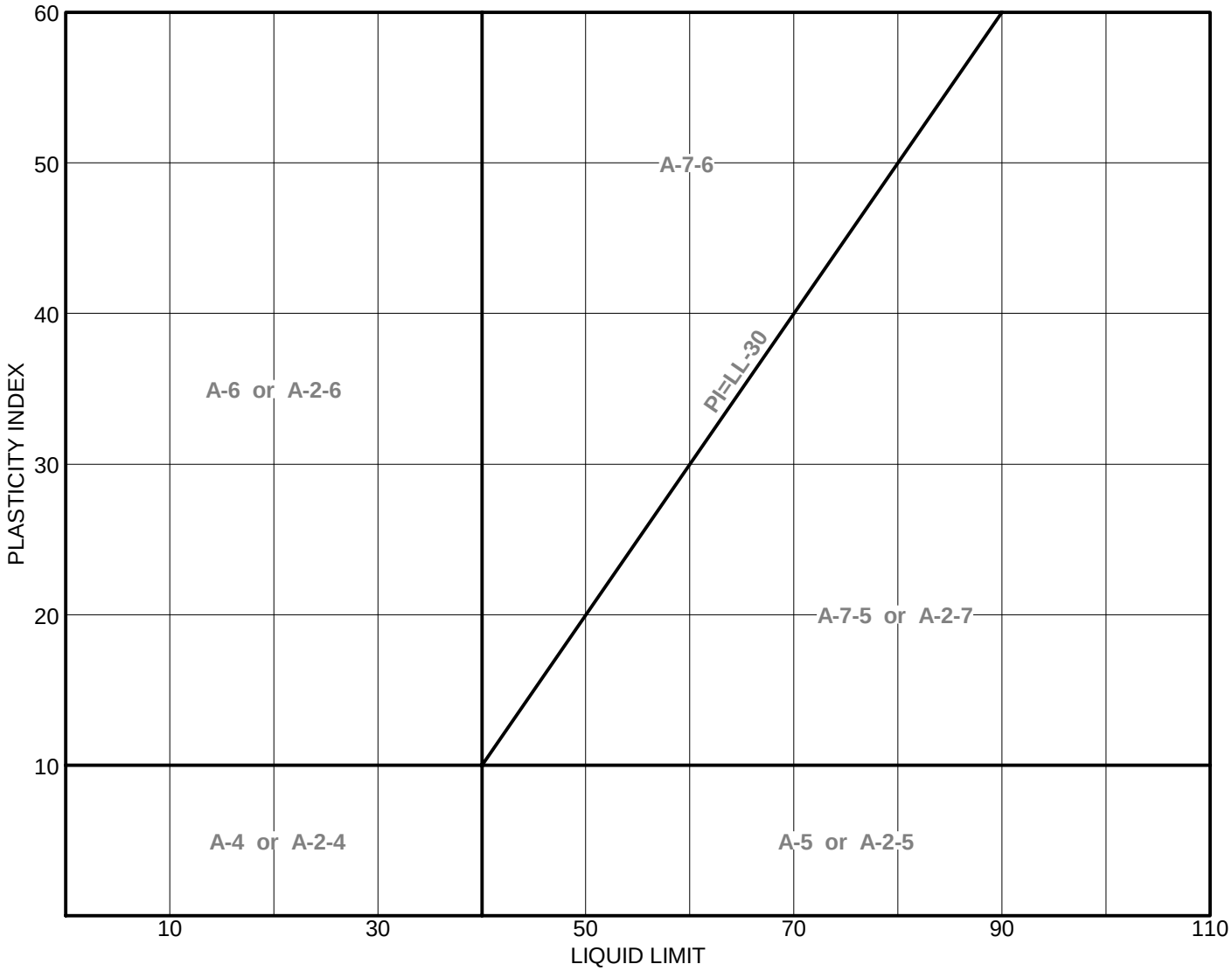
**EASTERN FEDERAL LANDS HIGHWAY DIVISION**

**Client:** FHWA/EFLHD

**Project:** Florida Panther National Wildlife Refuge

**Project No.:** FLP 10(1)

# LIQUID AND PLASTIC LIMITS TEST REPORT




**SOIL DATA**

| SYMBOL | SOURCE | SAMPLE NO. | DEPTH (ft.) | NATURAL WATER CONTENT (%) | PLASTIC LIMIT (%) | LIQUID LIMIT (%) | PLASTICITY INDEX (%) | AASHTO |
|---|---|---|---|---|---|---|---|---|
| ● | | B-1/J-3 | 10.0-12.0 | 21.8 | NP | NV | NP | A-1-b |
| ■ | | B-1/J-4 | 15.0-17.0 | 23.8 | NP | NV | NP | A-1-b |
| ▲ | | B-1/J-14 | 65.0-67.0 | 17.7 | NP | NV | NP | A-1-b |
| ◆ | | B-2/J-2 | 5.0-7.0 | 15.5 | NP | NV | NP | A-1-a |
| ▼ | | B-2/J-5 | 20.0-22.0 | 25.4 | NP | NV | NP | A-1-b |

LIQUID AND PLASTIC LIMITS TEST REPORT

**FEDERAL HIGHWAY ADMINISTRATION**

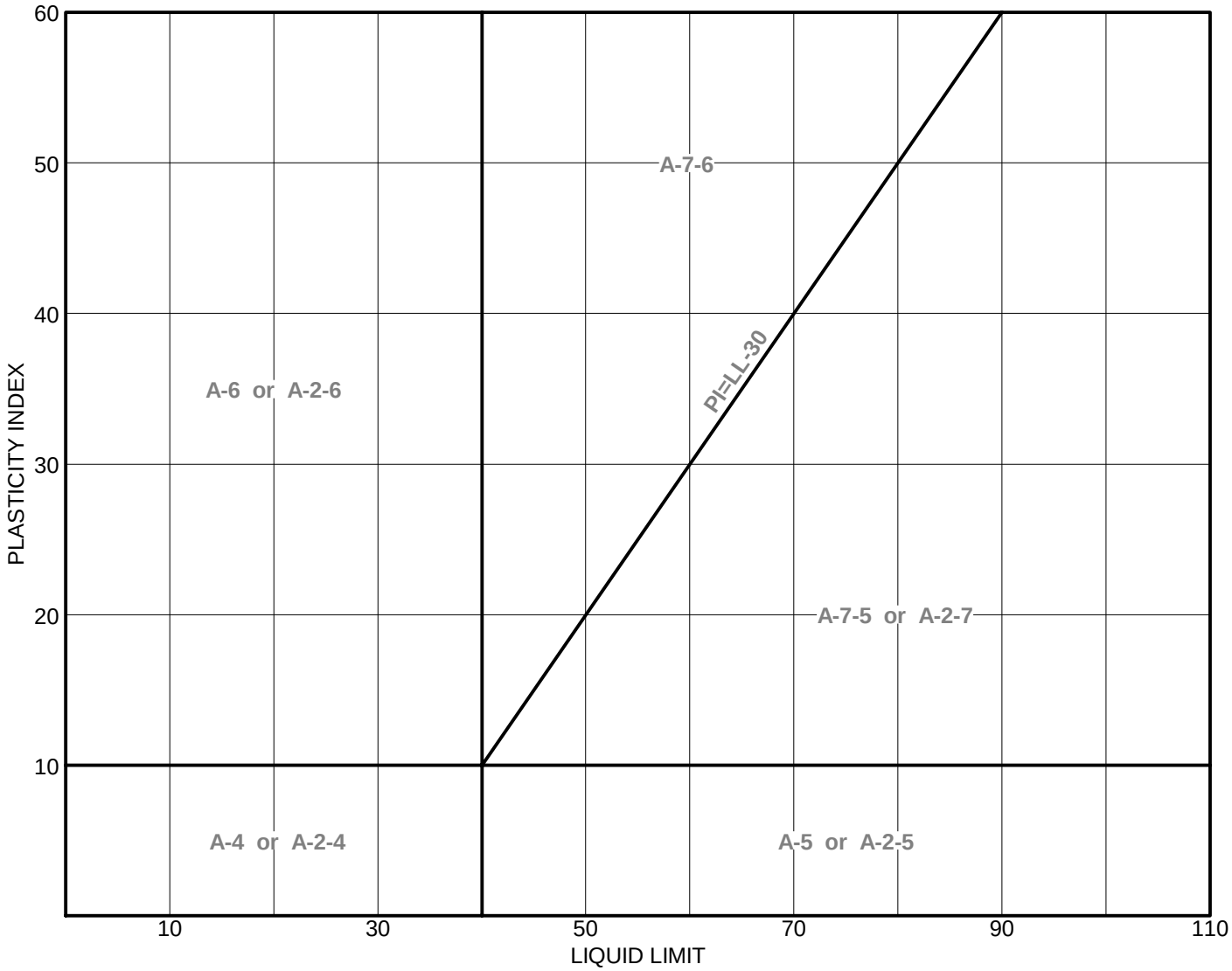
**EASTERN FEDERAL LANDS HIGHWAY DIVISION**

**Client:** FHWA/EFLHD

**Project:** Florida Panther National Wildlife Refuge

**Project No.:** FLP 10(1)

# LIQUID AND PLASTIC LIMITS TEST REPORT




**SOIL DATA**

| SYMBOL | SOURCE | SAMPLE NO. | DEPTH (ft.) | NATURAL WATER CONTENT (%) | PLASTIC LIMIT (%) | LIQUID LIMIT (%) | PLASTICITY INDEX (%) | AASHTO |
|---|---|---|---|---|---|---|---|---|
| ● | | B-3/J-5 | 25.0-27.0 | 40.6 | NP | NV | NP | A-1-b |
| ■ | | B-3/J-7 | 35.0-37.0 | 32.7 | NP | NV | NP | A-1-b |
| ▲ | | B-4/J-6 | 30.0-32.0 | 30.9 | NP | NV | NP | A-1-b |
| ◆ | | B-4/J-9 | 45.0-47.0 | 18.0 | NP | NV | NP | A-1-b |

LIQUID AND PLASTIC LIMITS TEST REPORT

**FEDERAL HIGHWAY ADMINISTRATION**

**EASTERN FEDERAL LANDS HIGHWAY DIVISION**

**Client:** FHWA/EFLHD

**Project:** Florida Panther National Wildlife Refuge

**Project No.:** FLP 10(1)

# APPENDIX E

## Design Analysis Computations

- **Foundation Design**
- **Slope Stability**
- **Pavement Design**

# Foundation Design

Form FHWA-1460
(Rev. 3-74)

# U.S. DEPARTMENT OF TRANSPORTATION
## FEDERAL HIGHWAY ADMINISTRATION

MADE BY AAA DATE 7/30/07 PROJECT FNS-FLS 10(1)
CHECKED BY ..... DATE ..... FLORIDA PANTHER NWR
CALCULATIONS FOR SETTLEMENT ANALYSIS - SPREAD FOOTINGS SHEET NO. 1

□ DETERMINE THE PLAN DIMENSIONS FOR A SPREAD FOOTING THAT SATISFIES AN ALLOWABLE SETTLEMENT OF:

- ALLOWABLE ANGULAR DISTORTION OF A SIMPLE SPAN BRIDGE

$$\delta/\ell = 0.005$$

$$\Delta_{max} = 0.005(15.25\,ft)(12''/ft) = 0.9 - \text{INCH}$$

- USE: MEYERHOF, DUNCAN & B. METHOD AS PRESENTED IN "AN ENGINEERING MANUAL FOR SETTLEMENT STUDIES (1986), PP 11-21

EQUATION (1): $$\rho_i = \frac{5P}{(N-1.5)C_B}$$

WHERE: $\rho_i$ = MAX. VALUE OF IMMEDIATE SETTLEMENT, INCHES

P = BEARING PRESSURE, TSF

N = MIN. AVERAGE SPT N-VALUE

$C_B$ = WIDTH CORRECTION

(1). DETERMINE MINIMUM AVERAGE SPT N-VALUE

| DEPTH (FT) | BORING No. 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 5 | 4 | 11 | 28 | - |
| 10 | 19 | 11 | 12 | 7 |
| 15 | 11 | 9 | 6 | 8 |
| 20 | 4 | 3 | 2 | 4 |
| 25 | 2 | 2 | 0 | 0 |
| 30 | 5 | 5 | 2 | 5 |
| $N_{AVG}$ = | 7.5 | 6.8 | 8.3 | 4.8 |

} USE $N_{AVG}$ = 5

(2) $$P = \frac{P_D + P_L}{B^2} = 143\,k + 90\,k = 233\,k = \frac{116.5\,T}{B^2}$$

(3) $C_B$ = 0.95 ⇒ ASSUMING B = 6 FT

Form FHWA-1460
(Rev. 3-74)

**U.S. DEPARTMENT OF TRANSPORTATION**
**FEDERAL HIGHWAY ADMINISTRATION**

MADE BY ADA DATE 7/30/09 PROJECT AKS-AP 101
CHECKED BY DATE FLORIDA PANTHER NWR
CALCULATIONS FOR SETTLEMENT ANALYSIS - SPREAD FOOTINGS SHEET NO. 2/

(4) $f_i$ = 0.9 - INCHES

5) $$B = \sqrt{\frac{5P}{f_i(N-1.5)C_B}}$$

$$= \left[\frac{5(1165T)}{0.9(5-1.5)(0.95)}\right]^{1/2} = 13.95 \text{ SAY } 14 \text{ FT}$$

** SIZE OF FOOTING IF LOWER TOLERABLE SETTLEMENT REQ'D

| $f_i$ (IN) | B (FT) | L (FT) | |
|---|---|---|---|
| 0.9 | 6 | 14 | |
| 0.75 | 6 | 15.5 | ← ASSUMED MAX LENGTH OF PROPOSED FOOTING |

*** ACTUAL SETTLEMENT OF THE SPREAD FOOTING IS ANTICIPATED TO BE LESS THAN 1/2-INCH. SETTLEMENT OF THE KIRS FOUNDATION WILL DEFINE TOTAL SETTLEMENT OF THE PROPOSED STRUCTURE NONETHELESS, DESIGN SPREAD FOOTING FOR A MAXIMUM ALLOWABLE BEARING PRESSURE OF 2,500 PSF

*** BASED ON 70% BRIDGE DESIGN

B = 8 FT ; THEREFORE FOR $f_i$ = 0.75", L = 16 FT
= 0.9", = 14.5 FT

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Form FHWA-1460
(Rev. 3-74)

# U.S. DEPARTMENT OF TRANSPORTATION
## FEDERAL HIGHWAY ADMINISTRATION

MADE BY AA DATE 05/02/07 PROJECT FNS - FLP 10(1) FLORIDA PANTHER NWR
CHECKED BY ..... DATE .....
CALCULATIONS FOR PROPOSED KIRS ABUTMENT/EMBANKMENT SHEET NO. 1

□ BEARING CAPACITY

BASIS OF DESIGN
- DETERMINE THE MINIMUM REQUIRED FOOTING SIZE TO MAINTAIN A FACTOR OF SAFETY OF 3 AGAINST BEARING CAPACITY FAILURE
- SUBSURFACE CONSISTS OF V. LOOSE TO LOOSE SILTY SAND, OVERLYING M. DENSE TO DENSE SILTY SAND.
- ASSUME GROUNDWATER TABLE IS AT BOTTOM-OF-FOOTING GRADE
- ANALYZE IN ACCORDANCE WITH AASHTO (1996), "STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 6TH ED., PP. 49-57.

LOADS

DEAD LOAD = 143 KIPS
LIVE LOAD = 90 KIPS
233 KIPS

SOIL PROPERTIES

1). V. LOOSE TO LOOSE SILTY SAND
$\gamma = 112$ PCF $t = 35'$
$\phi = 32°$
$c = 0$

2). M. DENSE TO DENSE SILTY SAND
$\gamma = 115$ PCF $t = 37'+$
$\phi = 32°$
$c = 0$

* USE EQUATION 4.4.7.1-1

$$Q_{ULT} = cN_c + 0.5\gamma B N_\gamma + q N_q$$

WHERE: $c$ = SOIL COHESION
$\gamma$ = UNIT WEIGHT OF SOIL OR ROCK
$B$ = WIDTH OF FOOTING
$q$ = EFFECTIVE OVERBURDEN PRESSURE AT BASE OF FOOTING
$N_c, N_\gamma, N_q$ = BEARING CAPACITY FACTORS

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Form FHWA-1460
(Rev. 3-74)

**U.S. DEPARTMENT OF TRANSPORTATION**
**FEDERAL HIGHWAY ADMINISTRATION**

MADE BY AJA DATE 05/22/07 PROJECT FNS-FLP 10(1)
CHECKED BY ..... DATE ..... FLORIDA PANTHER NWR
CALCULATIONS FOR PROPOSED NBS ABUTMENT/EMBANKMENT SHEET NO. 2/

BEARING CAPACITY CONT'D

* DETERMINE SIZE OF FOOTING

$$Q_{ult} = \cancel{cN_c}^{0} + 0.5\gamma B N_\gamma + \cancel{qN_q}^{0}$$

$$= 0.5\gamma B N_\gamma$$

* ASSUME B = 8 ft

$$= 0.5(112 - 62.4 \text{ pcf})(8 \text{ ft})(16.72) = 3,317 \text{ psf} = 3.32 \text{ ksf}$$

$$Q_{all} = \frac{Q_{ult}}{FS} = 3.32 \text{ ksf} / 3.0 = 1.10 \text{ ksf}$$

$Q_{applied}$ = 233 kips

$$\text{Area of footing req'd} = \frac{Q_{applied}}{Q_{all}} = \frac{233 \text{ kip}}{1.10 \text{ ksf}}$$

$$= 211 \text{ sf}$$

| B (ft) | L (ft) |
|---|---|
| 10 | 21.25 |
| 12 | 18 |
| 14.5 | 14.5 |
| 20 | 10.5 |
| 35 | 7.1 |

Form FHWA-1460
(Rev. 3-74)

**U.S. DEPARTMENT OF TRANSPORTATION**
**FEDERAL HIGHWAY ADMINISTRATION**

MADE BY Aob DATE 07/29/07 PROJECT FNS-FLP 10(1)
CHECKED BY ..... DATE ..... FLORIDA PANTHER NWR
CALCULATIONS FOR PROPOSED CRS ABUTMENT/EMBANKMENT SHEET NO. 3/

□ SETTLEMENT

* BASIS OF DESIGN

DETERMINE THE MAGNITUDE OF IMMEDIATE SETTLEMENT FOR THE PROPOSED ABUTMENT/EMBANKMENT GEOMETRIES

- ANALYZE IN ACCORDANCE WITH DUNCAN, J.M. AND BUCHIGNANI, A.L. (1987), "AN ENGINEERING MANUAL FOR SETTLEMENT STUDIES", PP 11-21

EQUATION (1) $\frac{5P}{(N-1.5)C_B} = \rho_i$

WHERE: $\rho_i$ = MAX. VALUE OF IMMEDIATE SETTLEMENT (IN.)

P = BEARING PRESSURE

N = MIN. AVG. SPT N-VALUE OVER 5B BELOW FOOTING

$C_B$ = WIDTH CORRECTION FACTOR, TABLE 4

$P = 316^k + W_f$

$W_f = 20'(15.5')(125\ pcf)(5\ ft)/1000\ \#/k = \frac{334.75/2}{(15.5)(20)}$

$= 0.54\ ksf$

1). $\rho_i = \frac{5(0.54\ ksf)}{(5-1.5)(6.0)} = 0.02\text{-INCHES}$ } * VALUE APPEARS LOW - WILL CHECK USING FOOSA (2.0)

U.S. GPO: 2005—314-798

Form FHWA-1460
(Rev. 3-74)

**U.S. DEPARTMENT OF TRANSPORTATION**
**FEDERAL HIGHWAY ADMINISTRATION**

MADE BY AoA DATE 7/30/07 PROJECT FLP 10(1)
CHECKED BY ..... DATE ..... FLORIDA PANTHER NWR
CALCULATIONS FOR SETTLEMENT OF GRS EMBANKMENT SHEET NO. 4/

ANALYZE SETTLEMENT OF THE PROPOSED GRS FOUNDATION

- BASED ON 70% BRIDGE TS&L, THE SPREAD FOOTING TO BEAR ON THE GRS HAS THE FOLLOWING DIMENSION

  B = 8'-0"
  L = 17'-3"

- DIMENSIONS OF PROPOSED EMBANKMENT

  L + 2ft (ON EITHER SIDE) = 17'-3" + 4'-0" = 21.25'

  - PER PREVIOUS CALCULATIONS A 211 SQFT FOOTING IS REQUIRED TO MAINTAIN A FACTOR OF SAFETY = 3.0 AGAINST BEARING CAPACITY FAILURE

  ∴ B = 211 SQFT / 21.25 = 9.9 ft, USE: 10.0'

  - USE STRUCTURAL FILL WITH UNIT WEIGHT = 125 PCF

  - BRIDGE LOAD = 233,000 #

    MODEL AS AN EQUIVALENT VOLUME OF FILL

    - ADDITIONAL FILL HEIGHT IS:

      $$\frac{233{,}000''}{125\ \text{pcf}\ (21.25')(16')} = 8.8'$$

- EVALUATE IMMEDIATE SETTLEMENT USING COMPUTER PROGRAM FOSSA(2.0). SEE ATTACHED.

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# Florida Panther National Wildlife Refuge

Report created by FoSSA(2.0): Copyright (c) 2003-2006, ADAMA Engineering, Inc.

PROJECT IDENTIFICATION

| | |
|---|---|
| Title: | Florida Panther National Wildlife Refuge |
| Project Number: | FWS - FLP 10(1) |
| Client: | U.S. Fish & Wildlife Service |
| Designer: | A.Anderson |
| Station Number: | 13+75.00 |

Description:

Company's information:

| | |
|---|---|
| Name: | FEDERAL HIGHWAY ADMINISTRATION |
| Street: | Eastern Federal Lands Highway Division<br>21400 Ridgetop Circle<br>Sterling, VA 22302 |
| Telephone #: | (703) 404-6352 |
| Fax #: | (703) 404-6217 |
| E-Mail: | Andre.Anderson@FHWA.DOT.GOV |

Original file path and name: M:\Project ..... eotech\Analysis\Embankment Settlement (FoSSA1).2ST
Original date and time of creating this file: Tue Aug 21 09:31:38 2007

GEOMETRY: Analysis of a 3D-Approximate geometry


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INPUT DATA -- FOUNDATION LAYERS -- 2 layers

| | Wet Unit Weight, γ [lb/ft³] | Poisson's Ratio μ | Description of Soil |
|---|---|---|---|
| 1 | 112.00 | 0.25 | V. loose to loose, silty SAND |
| 2 | 118.00 | 0.30 | M. dense to dense, silty SAND |

INPUT DATA -- EMBANKMENT LAYERS -- 2 layers

| | Wet Unit Weight, γ [lb/ft³] | Description of Soil |
|---|---|---|
| 1 | 125.00 | GRS Embankment Fill |
| 2 | 125.00 | Generalized Load |

INPUT DATA OF WATER

| Point # | Coordinates (X, Z) : (X) [ ft.] | (Z) [ ft.] |
|---|---|---|
| 1 | -30.00 | 6.50 |
| 2 | 0.00 | 6.50 |
| 3 | 62.00 | 6.50 |
| 4 | 125.00 | 6.50 |
| 5 | 150.00 | 6.50 |


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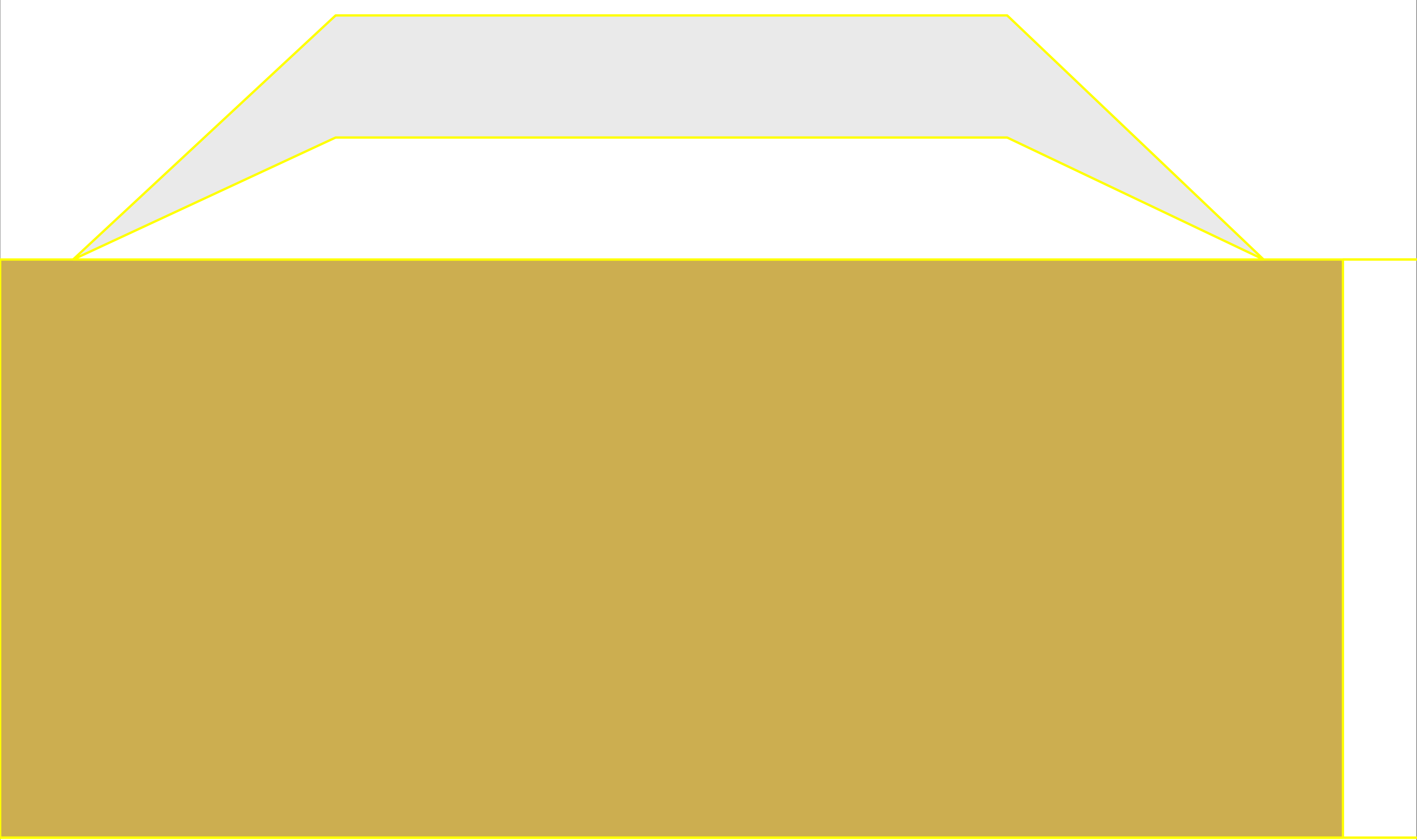
DRAWING OF SPECIFIED GEOMETRY

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IMMEDIATE SETTLEMENT, Si

| Node # | Settlement along section: X [ ft.] | Y [ ft.] | Layer (k) | Young's Modulus, E [lb/ft ²] | Poisson's Ratio, μ | Settlement of each layer, Si(k) [ ft.] | Initial Z [ ft.] | Final Z * [ ft.] | Total Settlement Sum of Si(k), [ ft.] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 30.00 | 0.00 | 1 | 350000 | 0.2500 | 0.0179 | 11.00 | 10.97 | 0.03 |
| | | | 2 | 104423 | 0.3000 | 0.0143 | | | |
| 2 | 40.25 | 0.00 | 1 | 350000 | 0.2500 | 0.0547 | 11.00 | 10.92 | 0.08 |
| | | | 2 | 104423 | 0.3000 | 0.0205 | | | |
| 3 | 50.50 | 0.00 | 1 | 350000 | 0.2500 | 0.0645 | 11.00 | 10.91 | 0.09 |
| | | | 2 | 104423 | 0.3000 | 0.0232 | | | |
| 4 | 60.75 | 0.00 | 1 | 350000 | 0.2500 | 0.0549 | 11.00 | 10.92 | 0.08 |
| | | | 2 | 104423 | 0.3000 | 0.0206 | | | |
| 5 | 71.00 | 0.00 | 1 | 350000 | 0.2500 | 0.0181 | 11.00 | 10.97 | 0.03 |
| | | | 2 | 104423 | 0.3000 | 0.0144 | | | |

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.


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## TABULATED GEOMETRY: INPUT OF FOUNDATION SOILS

| Found. Soil # | Point # | Coordinates (X, Z) : (X) [ ft.] | (Z) [ ft.] | DESCRIPTION |
|---|---|---|---|---|
| 1 | 1 | 0.00 | 11.00 | V. loose to loose, silty SAND |
| | 2 | 31.60 | 11.00 | |
| | 3 | 50.60 | 11.00 | |
| | 4 | 61.60 | 11.00 | |
| | 5 | 93.00 | 11.00 | |
| | 6 | 125.00 | 11.00 | |
| 2 | 1 | 0.00 | -24.00 | M. dense to dense, silty SAND |
| | 2 | 31.60 | -24.00 | |
| | 3 | 61.60 | -24.00 | |
| | 4 | 93.00 | -24.00 | |
| | 5 | 125.00 | -24.00 | |


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## TABULATED GEOMETRY: INPUT OF EMBANKMENT SOILS

| Embank. Soil # | | Point # | Coordinates (X, Z) : (X) [ ft.] | (Z) [ ft.] | D E S C R I P T I O N |
|---|---|---|---|---|---|
| 1 | X1 = 31.00 [ft] | 1 | 39.60 | 15.00 | GRS Embankment Fill |
| | X2 = 70.00 [ft] | 2 | 61.60 | 15.00 | |
| 2 | X1 = 31.00 [ft] | 1 | 39.60 | 19.00 | Generalized Load |
| | X2 = 70.00 [ft] | 2 | 61.60 | 19.00 | |


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# Slope Stability

# Florida Panther National Wildlife Refuge

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PROJECT IDENTIFICATION

| | |
|---|---|
| Title: | Florida Panther National Wildlife Refuge |
| Project Number: | FWS - FLP 10(1) |
| Client: | U.S. Fish & Wildlife Service |
| Designer: | A.Anderson |
| Station Number: | 13+75.00 |

Description:

Company's information:

| | |
|---|---|
| Name: | FEDERAL HIGHWAY ADMINISTRATION |
| Street: | Eastern Federal Lands Highway Division<br>21400 Ridgetop Circle<br>Sterling, VA 20166 |
| Telephone #: | (571) 404-6352 |
| Fax #: | (571) 404-6217 |
| E-Mail: | Andre.Anderson@fhwa.dot.gov |

Original file path and name: M:\Project ..... serv\geotech\Analysis\Slope Stability (ReSSA1).MSE
Original date and time of creating this file: Wed Aug 22 10:17:09 2007

PROGRAM MODE: ANALYSIS of a Complex Slope using GEOSYNTHETIC as reinforcing material.


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## INPUT DATA (EXCLUDING REINFORCEMENT LAYOUT)

### SOIL DATA

| ========== Soil Layer #: ========== | Unit weight, $\gamma$ [lb/ft ³] | Internal angle of friction, $\phi$ [deg.] | Cohesion, c [lb/ft ²] |
|---|---|---|---|
| ....1.....Revet Mattress..... | 125.0 | 38.0 | 0.0 |
| ....2.....GRS Foundation Fill..... | 125.0 | 34.0 | 0.0 |
| ....3.....Granular Backfill (Subex.)..... | 140.0 | 38.0 | 0.0 |
| ....4.....Limestone Caprock..... | 140.0 | 36.0 | 3500.0 |
| ....5.....V. loose to loose, silty SAND..... | 112.0 | 32.0 | 0.0 |

### REINFORCEMENT

| Reinforcement Type # | Geosynthetic Designated Name | Ultimate Strength, Tult [lb/ft] | Reduction Factor for Installation Damage, RFid | Reduction Factor for Durability, RFd | Reduction Factor for Creep, RFc | Coverage Ratio, Rc |
|---|---|---|---|---|---|---|
| 1 | Geosynthetic type #1 | 4000.00 | 1.20 | 1.10 | 1.67 | 1.00 |

| Interaction Parameters Type # | Geosynthetic Designated Name | == Direct Sliding == Cds-phi | Cds-c | ==== Pullout ==== Ci | Alpha |
|---|---|---|---|---|---|
| 1 | Geosynthetic type #1 | 0.80 | 0.00 | 0.80 | 0.80 |

Relative Orientation of Reinforcement Force, ROR = 1.00. Assigned Factor of Safety to resist pullout, Fs-po = 1.50

### WATER

Unit weight of water = 62.45 [lb/ft ³]
Water pressure is defined by phreatic surface in Effective Stress Analysis.

### SEISMICITY

Not Applicable


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DRAWING OF SPECIFIED GEOMETRY - COMPLEX - Quick Input

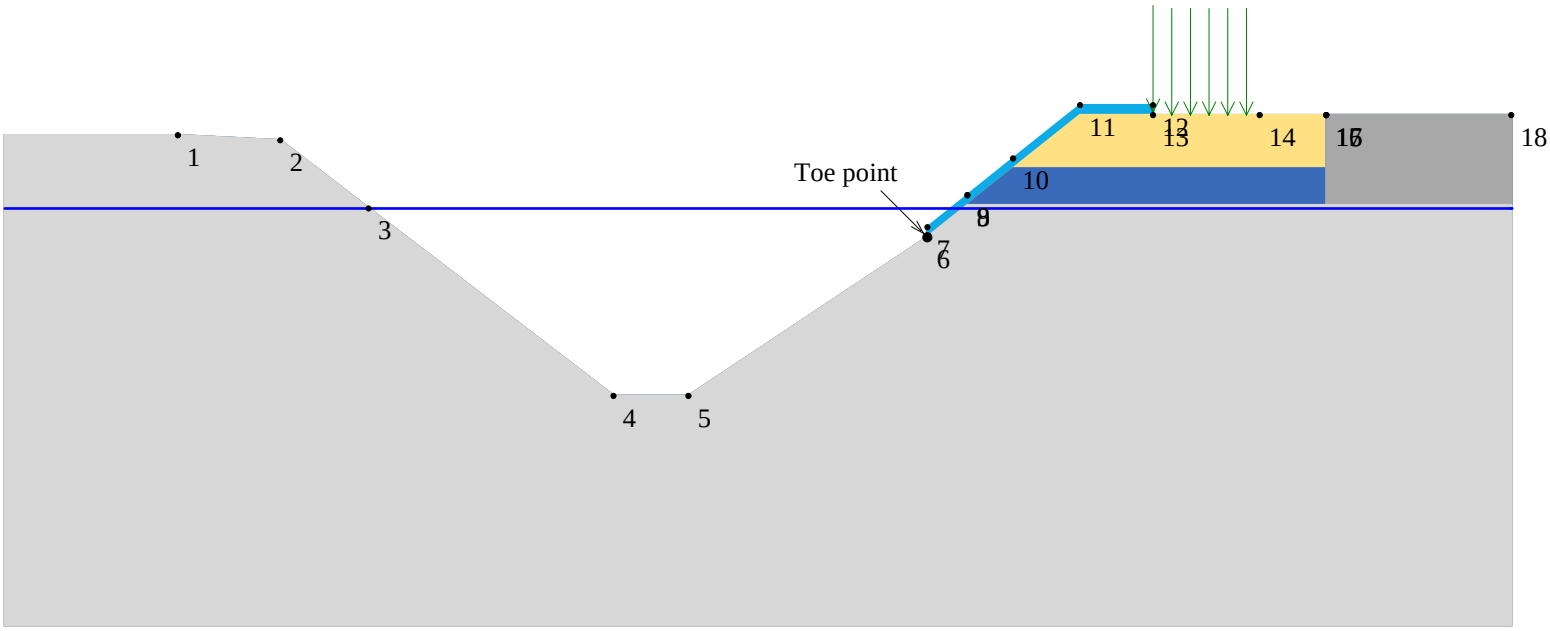
-- Problem geometry is defined along sections selected by user at x,y coordinates.
-- X1,Y1 represents the coordinates of soil surface. X2,Y2 represent the coordinates of the end of soil layer 1 and start of soil layer 2, and so on.
-- Xw,Yw represents the coordinates of phreatic surface.

GEOMETRY
Soil profile contains 5 layers (see details in next page)

WATER GEOMETRY
Phreatic line was specified.

UNIFORM SURCHARGE
Load Q1 = 1700.00 [lb/ft²] inclined from verical at 0.00 degrees, starts at X1s = 22.29 and ends at X1e = 24.73 [ft].
Surcharge load, Q2.....None
Surcharge load, Q3.....None

STRIP LOAD
.....None.....




SCALE:

0 2 4 6[ft]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TABULATED DETAILS OF QUICK SPECIFIED GEOMETRY

Soil profile contains 5 layers. Coordinates in [ft.]
Water was described by phreatic line.

| | # | Xi | Yi |
|---|---|---|---|
| Top of Layer 1 | 1 | 0.00 | 23.75 |
| | 2 | 7.67 | 23.37 |
| | 3 | 14.30 | 18.26 |
| | 4 | 32.67 | 4.20 |
| | 5 | 38.29 | 4.20 |
| | 6 | 56.21 | 16.10 |
| | 7 | 56.21 | 16.85 |
| | 8 | 67.66 | 26.01 |
| | 9 | 73.13 | 26.01 |
| | 10 | 73.13 | 25.26 |
| | 11 | 81.13 | 25.26 |
| | 12 | 86.13 | 25.26 |
| | 13 | 100.00 | 25.26 |
| Top of Layer 2 | 14 | 0.00 | 23.75 |
| | 15 | 7.67 | 23.37 |
| | 16 | 14.30 | 18.26 |
| | 17 | 32.67 | 4.20 |
| | 18 | 38.29 | 4.20 |
| | 19 | 56.21 | 16.10 |
| | 20 | 59.21 | 18.51 |
| | 21 | 62.65 | 21.26 |
| | 22 | 67.66 | 25.26 |
| | 23 | 73.13 | 25.26 |
| | 24 | 81.13 | 25.26 |
| | 25 | 100.00 | 25.26 |
| Top of Layer 3 | 26 | 0.00 | 23.75 |
| | 27 | 7.67 | 23.37 |
| | 28 | 14.30 | 18.26 |
| | 29 | 32.67 | 4.20 |
| | 30 | 38.29 | 4.20 |
| | 31 | 56.21 | 16.10 |
| | 32 | 59.21 | 18.51 |
| | 33 | 62.65 | 21.26 |
| | 34 | 86.13 | 21.26 |
| | 35 | 86.13 | 25.26 |
| | 36 | 100.00 | 25.26 |
| Top of Layer 4 | 37 | 0.00 | 23.75 |
| | 38 | 7.67 | 23.37 |
| | 39 | 14.30 | 18.26 |
| | 40 | 32.67 | 4.20 |
| | 41 | 38.29 | 4.20 |
| | 42 | 56.21 | 16.10 |
| | 43 | 59.21 | 18.51 |
| | 44 | 86.13 | 18.51 |
| | 45 | 86.13 | 21.26 |
| | 46 | 86.13 | 25.26 |
| | 47 | 100.00 | 25.26 |
| Top of Layer 5 | 48 | 0.00 | 23.75 |
| | 49 | 7.67 | 23.37 |
| | 50 | 14.30 | 18.26 |
| | 51 | 32.67 | 4.20 |
| | 52 | 38.29 | 4.20 |
| | 53 | 56.21 | 16.10 |
| | 54 | 59.21 | 18.51 |
| | 55 | 86.13 | 18.51 |
| | 56 | 100.00 | 18.51 |
| Top of Phreatic Line | 58 | 14.30 | 18.26 |
| | 59 | 59.21 | 18.26 |


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TABULATED DETAILS OF SPECIFIED GEOMETRY

Soil profile contains 5 layers. Coordinates in [ft.]
Water was described by phreatic line. Y values are tabulated in the right most column.

| # | X | Y1 | Y2 | Y3 | Y4 | Y5 | (phreatic) Yw |
|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 23.75 | 23.75 | 23.75 | 23.75 | 23.75 | 18.26 |
| 2 | 7.67 | 23.37 | 23.37 | 23.37 | 23.37 | 23.37 | 18.26 |
| 3 | 14.30 | 18.26 | 18.26 | 18.26 | 18.26 | 18.26 | 18.26 |
| 4 | 32.67 | 4.20 | 4.20 | 4.20 | 4.20 | 4.20 | 18.26 |
| 5 | 38.29 | 4.20 | 4.20 | 4.20 | 4.20 | 4.20 | 18.26 |
| 6 | 56.21 | 16.10 | 16.10 | 16.10 | 16.10 | 16.10 | 18.26 |
| 7 | 56.21 | 16.85 | 16.10 | 16.10 | 16.10 | 16.10 | 18.26 |
| 8 | 59.21 | 19.25 | 18.51 | 18.51 | 18.51 | 18.51 | 18.26 |
| 9 | 59.21 | 19.25 | 18.51 | 18.51 | 18.51 | 18.51 | 18.26 |
| 10 | 62.65 | 22.00 | 21.26 | 21.26 | 18.51 | 18.51 | 18.26 |
| 11 | 67.66 | 26.01 | 25.26 | 21.26 | 18.51 | 18.51 | 18.26 |
| 12 | 73.13 | 26.01 | 25.26 | 21.26 | 18.51 | 18.51 | 18.26 |
| 13 | 73.13 | 25.26 | 25.26 | 21.26 | 18.51 | 18.51 | 18.26 |
| 14 | 81.13 | 25.26 | 25.26 | 21.26 | 18.51 | 18.51 | 18.26 |
| 15 | 86.13 | 25.26 | 25.26 | 21.26 | 18.51 | 18.51 | 18.26 |
| 16 | 86.13 | 25.26 | 25.26 | 24.90 | 21.26 | 18.51 | 18.26 |
| 17 | 86.13 | 25.26 | 25.26 | 25.26 | 25.26 | 18.51 | 18.26 |
| 18 | 100.00 | 25.26 | 25.26 | 25.26 | 25.26 | 18.51 | 18.26 |


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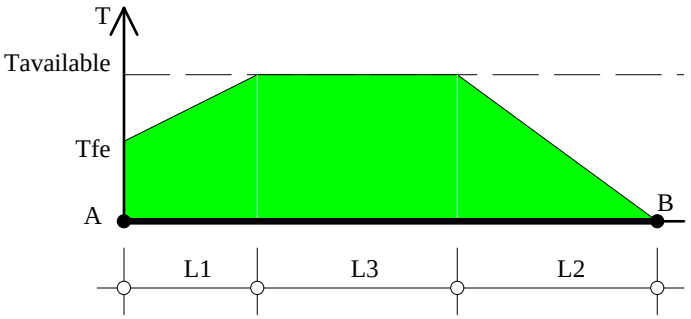
## DISTRIBUTION OF AVAILABLE STRENGTH ALONG EACH REINFORCEMENT LAYER




A = Front-end of reinforcement (at face of slope)
B = Rear-end of reinforcement
AB = L1 + L2 + L3 = Embedded length of reinforcement

Tavailable = Long-term strength of reinforcement
Tfe = Available front-end strength (e.g., connection to facing)

L1 = Front-end 'pullout' length
L2 = Rear-end pullout length
Tavailable prevails along L3

Factor of safety on resistance to pullout on either end of reinforcement, Fs-po = 1.50

| Reinforcement Layer # | Designated Name | Height Relative to Toe [ft] | L [ft] | L1 [ft] | L2 [ft] | L3 [ft] | Tfe [lb/ft] | Tavailable [lb/ft] |
|---|---|---|---|---|---|---|---|---|
| 1 | Geosynthetic type #1 | 2.16 | 27.50 | 0.00 | 3.74 | 23.76 | 1814.55 | 1814.55 |
| 2 | Geosynthetic type #1 | 5.11 | 24.00 | 0.00 | 5.38 | 18.62 | 1814.55 | 1814.55 |
| 3 | Geosynthetic type #1 | 5.77 | 23.15 | 0.00 | 7.45 | 15.70 | 1814.55 | 1814.55 |
| 4 | Geosynthetic type #1 | 6.44 | 22.35 | 0.00 | 9.28 | 13.07 | 1814.55 | 1814.55 |
| 5 | Geosynthetic type #1 | 7.11 | 21.50 | 0.00 | 12.30 | 9.20 | 1814.55 | 1814.55 |
| 6 | Geosynthetic type #1 | 7.77 | 20.75 | 0.00 | 16.21 | 4.54 | 1814.55 | 1814.55 |
| 7 | Geosynthetic type #1 | 8.44 | 20.00 | 0.00 | 20.00 | 0.00 | 1336.88 | 1336.88 (*) |

(*) This Tavailable is dictated by the pullout resistance capacity, which is smaller than the long-term strength of the reinforcement that is related to its specified ultimate strength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RESULTS OF ROTATIONAL STABILITY ANALYSIS

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each entry point (considering all specified exit points)

| Entry Point # | Entry Point (X , Y) [ft] | | Exit Point (X , Y) [ft] | | Critical Circle (Xc , Yc , R) [ft] | | | Fs | STATUS |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 72.60 | 26.01 | 34.78 | 4.28 | 44.36 | 31.38 | 28.75 | 2.13 | |
| 2 | 74.24 | 25.26 | 34.80 | 4.26 | 43.42 | 35.61 | 32.52 | 1.84 | |
| 3 | 75.88 | 25.26 | 34.83 | 4.24 | 43.00 | 38.87 | 35.58 | 1.61 | |
| 4 | 77.52 | 25.26 | 34.87 | 4.23 | 43.87 | 39.76 | 36.65 | 1.48 | |
| 5 | 79.16 | 25.26 | 34.91 | 4.22 | 44.31 | 41.52 | 38.46 | 1.38 | |
| 6 | 80.80 | 25.26 | 34.96 | 4.21 | 45.21 | 42.32 | 39.47 | 1.30 | |
| 7 | 82.44 | 25.26 | 35.00 | 4.20 | 45.69 | 44.09 | 41.30 | 1.30 | |
| 8 | 84.08 | 25.26 | 37.08 | 4.21 | 47.67 | 43.57 | 40.75 | 1.30 | |
| . 9 | 85.72 | 25.26 | 37.09 | 4.21 | 47.66 | 46.48 | 43.57 | 1.29 . | OK |
| 10 | 87.36 | 25.26 | 34.54 | 4.34 | 47.66 | 48.35 | 45.93 | 1.50 | |
| 11 | 89.00 | 25.26 | 34.57 | 4.31 | 47.13 | 52.86 | 50.14 | 1.81 | |

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-entry' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

**********

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each exit point (considering all specified entry points)

| Exit Point # | Exit Point (X , Y) [ft] | | Entry Point (X , Y) [ft] | | Critical Circle (Xc , Yc , R) [ft] | | | Fs | STATUS |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 34.51 | 4.34 | 85.72 | 25.26 | 47.15 | 46.56 | 44.06 | 1.29 | |
| . 2 | 37.09 | 4.21 | 85.72 | 25.26 | 47.66 | 46.48 | 43.57 | 1.29 . | OK |
| 3 | 39.09 | 4.87 | 85.72 | 25.26 | 49.28 | 45.09 | 41.49 | 1.31 | |
| 4 | 41.26 | 6.27 | 85.72 | 25.26 | 51.89 | 42.94 | 38.17 | 1.35 | |
| 5 | 43.35 | 7.69 | 80.80 | 25.26 | 51.75 | 38.48 | 31.92 | 1.39 | |
| 6 | 45.53 | 9.08 | 80.80 | 25.26 | 54.12 | 36.90 | 29.11 | 1.43 | |
| 7 | 47.60 | 10.51 | 80.80 | 25.26 | 55.78 | 36.82 | 27.56 | 1.48 | |
| 8 | 49.57 | 11.98 | 80.80 | 25.26 | 58.24 | 34.94 | 24.55 | 1.55 | |
| 9 | 51.84 | 13.33 | 80.80 | 25.26 | 60.09 | 34.43 | 22.66 | 1.64 | |
| 10 | 53.93 | 14.76 | 80.80 | 25.26 | 62.08 | 33.53 | 20.46 | 1.77 | |
| 11 | 56.21 | 16.10 | 80.80 | 25.26 | 63.99 | 32.79 | 18.42 | 1.94 | |

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-exit' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.


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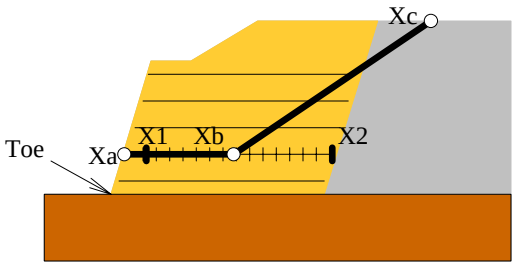
## RESULTS OF TRANSLATIONAL ANALYSIS




Results in the table below represent critical two-part wedges identified between specified starting (X1) and ending (X2) search points. Wedges along all reinforcement layers and at elevation zero are reported. The critical two-part wedge, one for each predetermined elevation, is defined by Xa, Xb and Xc where Xa is the front end of the passive wedge (slope face), Xb is where the passive wedge ends and the active one starts, and Xc is the X-ordinate at which the active wedge starts.

Critical two-part wedge along each interface:

| Interface | Height Relative to Toe [ft] | ( Xa, Ya ) [ft] | | ( Xb, Yb ) [ft] | | ( Xc, Yc ) [ft] | | Fs | STATUS |
|---|---|---|---|---|---|---|---|---|---|
| At toe elevation | 0.00 | 56.21 | 16.10 | 72.66 | 16.10 | 81.21 | 25.26 | 1.95 | OK |
| Reinf. Layer #1 | 2.16 | 57.97 | 18.26 | 74.73 | 18.26 | 81.04 | 25.26 | 2.34 | OK |
| Reinf. Layer #2 | 5.11 | 61.66 | 21.21 | 71.56 | 21.21 | 78.57 | 25.26 | 3.23 | OK |
| Reinf. Layer #3 | 5.77 | 62.49 | 21.87 | 72.00 | 21.87 | 77.42 | 25.26 | 3.11 | OK |
| Reinf. Layer #4 | 6.44 | 63.32 | 22.54 | 72.62 | 22.54 | 76.23 | 25.26 | 2.93 | OK |
| Reinf. Layer #5 | 7.11 | 64.16 | 23.21 | 73.06 | 23.21 | 75.18 | 25.26 | 2.66 | OK |
| Reinf. Layer #6 | 7.77 | 64.99 | 23.87 | 73.58 | 23.87 | 74.92 | 25.26 | 2.70 | OK |
| Reinf. Layer #7 | 8.44 | 65.82 | 24.54 | 74.16 | 24.54 | 74.90 | 25.26 | 3.33 | OK |

Note: In the 'Status' column, OK means the critical two part-wedge was identified within the specified search domain. 'Minimum on Edge' means the critical result corresponds to a minimum on the edge of the search domain; i.e., either on X1 or X2 or the internally preset limits on Xc.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CRITICAL RESULTS OF ROTATIONAL AND TRANSLATIONAL STABILITY ANALYSES

Rotational (Circular Arc; Bishop) Stability Analysis

Minimum Factor of Safety = 1.29

Critical Circle: Xc = 47.66[ft], Yc = 46.48[ft], R = 43.57[ft]. (Number of slices used = 59 )

Translational (2-Part Wedge; Spencer), Direct Sliding, Stability Analysis

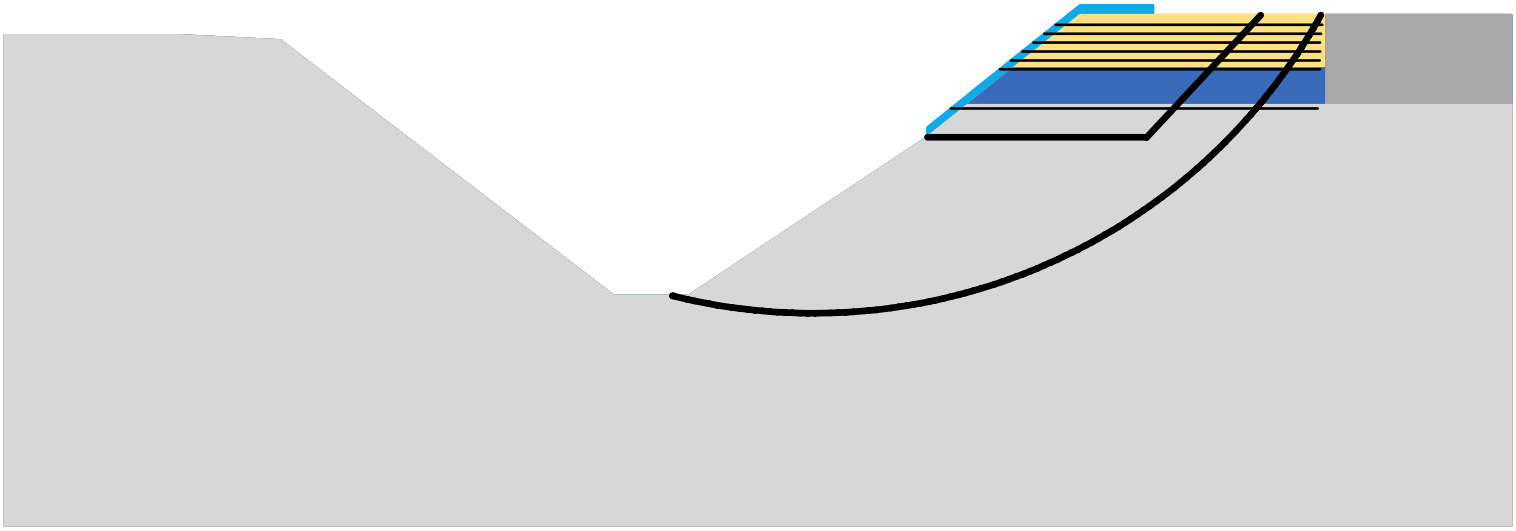
Minimum Factor of Safety = 1.95

Critical Two-Part Wedge: (Xa = 56.21, Ya = 16.10) [ft]
(Xb = 72.66, Yb = 16.10) [ft]
(Xc = 81.21, Yc = 25.26) [ft]
(Number of slices used = 30 )
Interslice resultant force inclination = 19.27 [degrees]

Three-Part Wedge Stability Analysis

N O T C O N D U C T E D

REINFORCEMENT LAYOUT: DRAWING



SCALE:

0 2 4 6[ft]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## REINFORCEMENT LAYOUT: TABULATED DATA & QUANTITIES

| Layer # | Reinf. Type # | Geosynthetic Designated Name | Height Relative to Toe [ft] | Embedded Length [ft] | Covergae Ratio, Rc | ( X, Y ) front [ft] | | ( X, Y ) rear [ft] | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Geosynthetic type #1 | 2.16 | 27.50 | 1.00 | 186.18 | 54.98 | 213.68 | 54.98 |
| 2 | 1 | Geosynthetic type #1 | 5.11 | 24.00 | 1.00 | 189.87 | 57.93 | 213.87 | 57.93 |
| 3 | 1 | Geosynthetic type #1 | 5.77 | 23.15 | 1.00 | 190.69 | 58.59 | 213.84 | 58.59 |
| 4 | 1 | Geosynthetic type #1 | 6.44 | 22.35 | 1.00 | 191.53 | 59.26 | 213.88 | 59.26 |
| 5 | 1 | Geosynthetic type #1 | 7.11 | 21.50 | 1.00 | 192.37 | 59.93 | 213.87 | 59.93 |
| 6 | 1 | Geosynthetic type #1 | 7.77 | 20.75 | 1.00 | 193.19 | 60.59 | 213.94 | 60.59 |
| 7 | 1 | Geosynthetic type #1 | 8.44 | 20.00 | 1.00 | 194.03 | 61.26 | 214.03 | 61.26 |

## QUANTITIES

| Reinf. Type # | Designated Name | Coverage Ratio | Area of reinforcemnt [ft²] / length of slope [ft] |
|---|---|---|---|
| 1 | Geosynthetic type #1 | 1.00 | 159.25 |


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# Pavement Design

1993 AASHTO Pavement Design

# DARWin Pavement Design and Analysis System

## A Proprietary AASHTOWare Computer Software Product

FHWA / Eastern Federal Lands Highway Division
21400 Ridgetop Circle
Sterling, VA
USA

## Flexible Structural Design Module

FWS-FLP 10(1)
Florida Panther NWR
Collier County, Forida

- 5 yr Performance Period -

## Flexible Structural Design

| | |
|---|---|
| 18-kip ESALs Over Initial Performance Period | 2,965 |
| Initial Serviceability | 4.2 |
| Terminal Serviceability | 2 |
| Reliability Level | 50 % |
| Overall Standard Deviation | 0.44 |
| Roadbed Soil Resilient Modulus | 7,211 psi |
| Stage Construction | 1 |
| | |
| Calculated Design Structural Number | 0.99 in |

## Effective Roadbed Soil Resilient Modulus

| Period | Description | Roadbed Resilient Modulus (psi) |
|---|---|---|
| 1 | Spring/Fall (Wet Roadbed) | 6,000 |
| 2 | Summer (Dry Roadbed) | 10,000 |

Calculated Effective Modulus 7,211 psi

## Simple ESAL Calculation

| | |
|---|---|
| Performance Period (years) | 5 |
| Two-Way Traffic (ADT) | 30 |
| Number of Lanes in Design Direction | 1 |
| Percent of All Trucks in Design Lane | 100 % |
| Percent Trucks in Design Direction | 100 % |
| Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater | 10 % |
| Average Initial Truck Factor (ESALs/truck) | 0.5 |
| Annual Truck Factor Growth Rate | 2 % |
| Annual Truck Volume Growth Rate | 2 % |
| Growth | Simple |
| | |
| Total Calculated Cumulative ESALs | 2,965 |

1993 AASHTO Pavement Design

# DARWin Pavement Design and Analysis System

## A Proprietary AASHTOWare Computer Software Product

FHWA / Eastern Federal Lands Highway Division
21400 Ridgetop Circle
Sterling, VA
USA

## Flexible Structural Design Module

FWS-FLP 10(1)
Florida Panther NWR
Collier County, Forida

- 10 yr Performance Period -

## Flexible Structural Design

| | |
|---|---|
| 18-kip ESALs Over Initial Performance Period | 6,590 |
| Initial Serviceability | 4.2 |
| Terminal Serviceability | 2 |
| Reliability Level | 50 % |
| Overall Standard Deviation | 0.44 |
| Roadbed Soil Resilient Modulus | 7,211 psi |
| Stage Construction | 1 |
| | |
| Calculated Design Structural Number | 1.17 in |

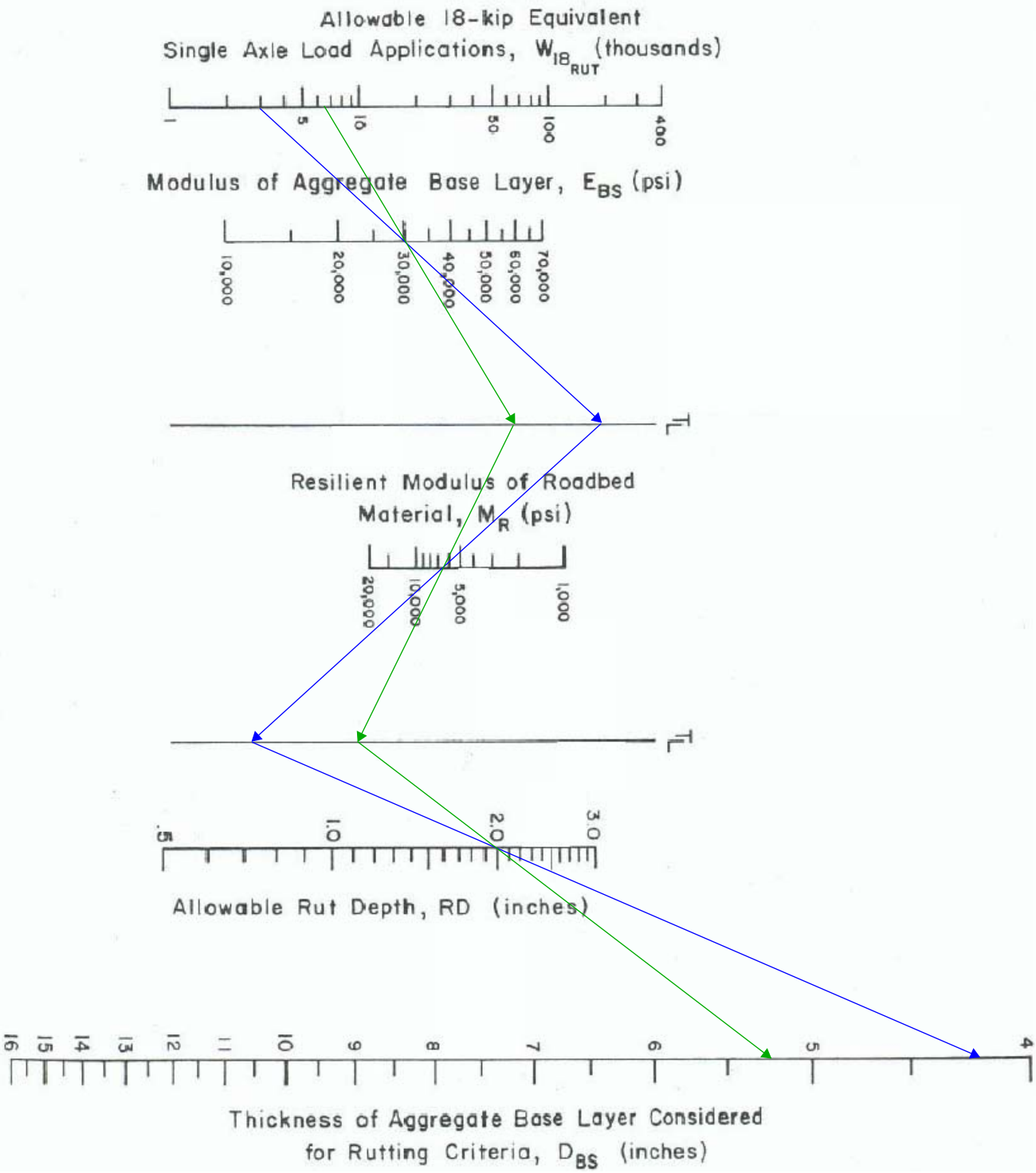
## Effective Roadbed Soil Resilient Modulus

| Period | Description | Roadbed Resilient Modulus (psi) |
|---|---|---|
| 1 | Spring/Fall (Wet Roadbed) | 6,000 |
| 2 | Summer (Dry Roadbed) | 10,000 |

Calculated Effective Modulus 7,211 psi

## Simple ESAL Calculation

| | |
|---|---|
| Performance Period (years) | 10 |
| Two-Way Traffic (ADT) | 30 |
| Number of Lanes in Design Direction | 1 |
| Percent of All Trucks in Design Lane | 100 % |
| Percent Trucks in Design Direction | 100 % |
| Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater | 10 % |
| Average Initial Truck Factor (ESALs/truck) | 0.5 |
| Annual Truck Factor Growth Rate | 2 % |
| Annual Truck Volume Growth Rate | 2 % |
| Growth | Compound |
| | |
| Total Calculated Cumulative ESALs | 6,590 |




| Design Period (years) | Allowable Rut Depth (in) | Design Mr (psi) | W18 | Aggregate Loss (in) | Dbs (in) |
|---|---|---|---|---|---|
| 5 | 2 | 7,200 psi | 3,000 | 5 | 4.25 |
| 10 | 2 | 7,200 psi | 6,600 | 10 | 5.25 |

PROJECT: FWS-FLP 10(1)
Florida Panther National Wildlife Refuge
Collier County, Florida

# APPENDIX F

## Typical Details

| REGION | STATE | PROJECT | SHEET NO. |
|---|---|---|---|
| | | | R02 |

Notes:

1.. Provide galvanized and PVC coated wire gabion and revet mattresses in accordance with subsection 720.02. Fill gabion and revet mattresses with rock in accordance with subsection 705.01. Construct slope face and lay mattresses to existing slope angles and no steeper than 2 horizontal to 1 vertical. Embed gabions a minimum of 2 ft at bottom of slopes. Extend mattresses along embankment fill slopes a minimum of 10 ft beyond end of bridge.

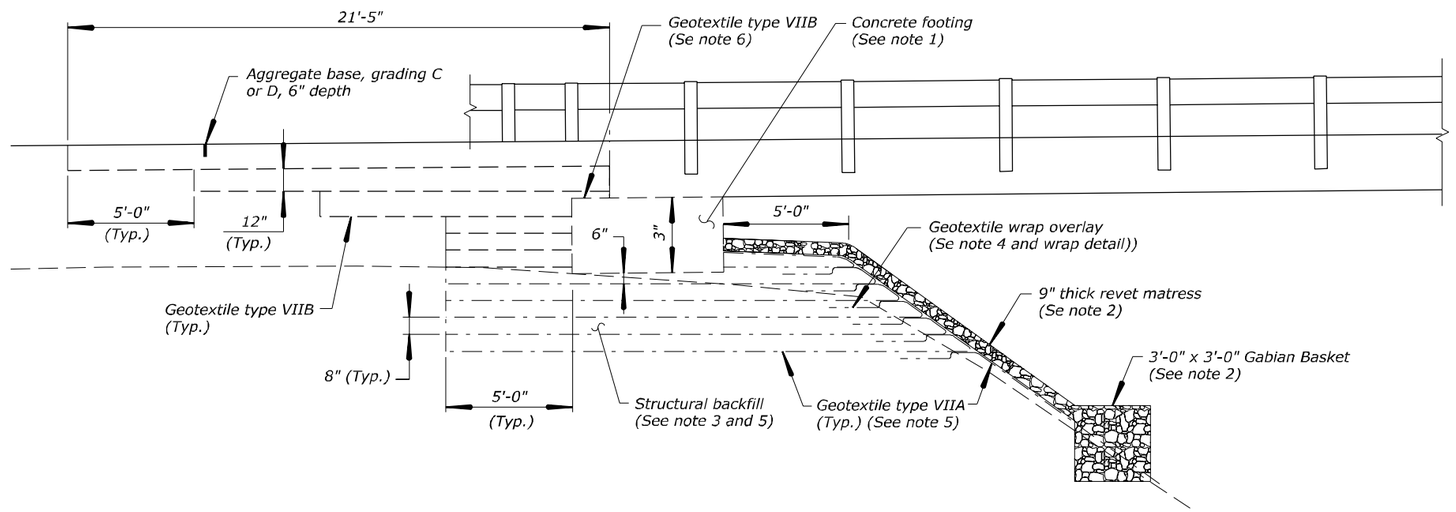
2. Place and compact structural backfill in accordance with Section 208.

3. Overlap geotextile wraps a minimum of 3 ft. Provide a minimum of 3 inches of aggregate between geotextile layers over the last 2 ft of wrap.

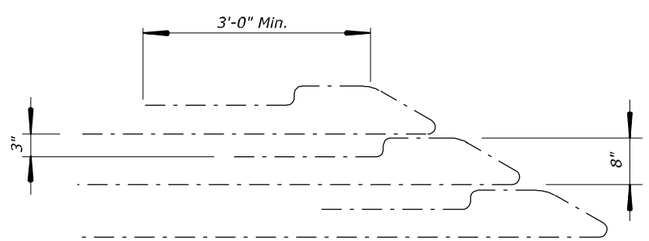
4. Extend geotextile reinforcement and structural backfill a minimum of 3 ft on both sides (perpedicular to centerline) of footings and embankment.

5. Wrap geotextile Type VIIB directly on top of the concrete footing and along ends of the box beams to provide separation from the structural backfill.

6. At the completion of the GRS embankment for the bridge over Cecil Creek at Big Lake 2, allow 7 working days for installation of instrumentation prior to construction of the abutment footing. Instrumentation will include slope inclinometers located adjacent to both sides of abutment footings and magnetic extensometers that extend through both abutment footings. Materials for instrumentation will be provided and installed by the Government. Provide access to the GRS embankment to facilitate iinstallation of instrumentation.




**TYPICAL SECTION**




**WRAP DETAIL**

PRELIMINARY
NOT FOR CONSTRUCTION

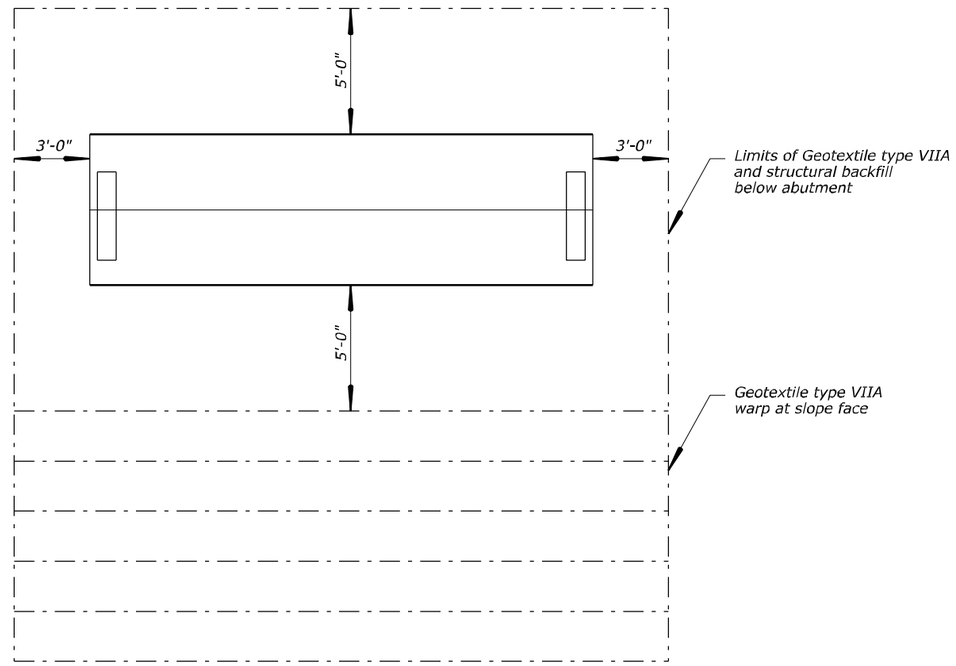
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

GEOSYNTHETIC REINFORCING SOIL (GR
FOUNDATION - 1

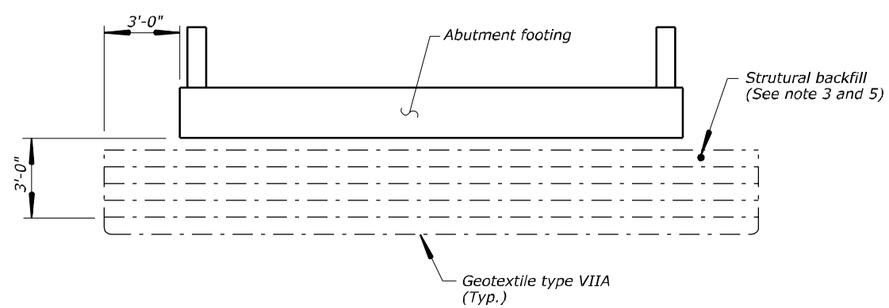
| NO. | DATE | BY | REVISIONS | NO. | DATE | BY | REVISIONS | DESIGNED BY | DRAWN BY | CHECKED BY | SCALE | PROJECT TEAM LEADER | BRIDGE DRAWING | DATE | DRAWING NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | 2 of | | |

8/20/2007 11:22:37 AM C:\Documents and Settings\aanderson\Local Settings\Temporary Internet Files\OLK34\GRS-ldgn.dgn ACTUAL FILE: XXXX .DGN

| REGION | STATE | PROJECT | SHEET NO. |
|---|---|---|---|
| | | | R03 |




**TYPICAL PLAN**




**TYPICAL ELEVATION**

PRELIMINARY
NOT FOR CONSTRUCTION

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION

GEOSYNTHETIC REINFORCING SOIL (GR
FOUNDATION - 2

| NO. | DATE | BY | REVISIONS | NO. | DATE | BY | REVISIONS | DESIGNED BY | DRAWN BY | CHECKED BY | SCALE | PROJECT TEAM LEADER | BRIDGE DRAWING | DATE | DRAWING NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | 3 of | | |

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# APPENDIX G

## Representative Photographs

*<u>Photo No. 1</u> – Looking west from I-75 towards existing entrance to FLP NWR*

*<u>Photo No. 2</u> – Looking south from Abutment 2 back towards Abutment 1*

*<u>Photo No. 3</u> – Looking north from approximately 20 ft south of the location of Abutment 1*

*<u>Photo No. 4</u> – Looking north towards Abutment 2, from approximate location of Abutment 1*

*<u>Photo No. 5</u> – Close-up of limestone caprock at approximate location of Abutment 2*

*Photo No. 6 – Very loose to loose silty, sand encountered below limestone caprock*

# APPENDIX H

## Special Contract Requirements

## Section 204. – EXCAVATION AND EMBANKMENT

204.11(a)(1) Delete the entire subsection and substitute the following:

Vibratory compaction is not permitted.

## Section 207. – EARTHWORK GEOTEXTILES

207.04 Delete the fourth sentence of the second paragraph and substitute the following:

Overlap adjacent sections of geotextile a minimum of 3 ft at the ends and sides, or sew the geotextile joints.

207.04 Delete the fourth sentence of the third paragraph and substitute the following:

Place subsequent lifts of geotextile, if required, and cover material in the same manner.

## Section 208. – STRUCTURE EXCAVATION AND BACKFILL FOR SELECTED MAJOR STRUCTURES

208.09 Add the following

**(f) Footings placed on GRS embankments.** Remove material to the bottom of GRS foundation. Do not disturb the bottom of the GRS foundation excavation. Place reinforcement geotextile and structural backfill according to Subsection 207.04 and 208.10.

208.10 Delete the first line of the first paragraph and substitute the following:

Place backfill in horizontal layers that do no exceed 8 inches in compacted thickness.

## Section 703. – AGGREGATE

703.05(a) Add the following:

Material shall have a minimum California Bearing Ratio of 70 percent as determined by AASHTO T 193 at 95 percent of maximum dry density in accordance with AASHTO T 180 (Method D).

## Section 704. – SOIL

704.04 Delete Item (a) and substitute the following:

(a) Gradation Table 704-6

704.04 Add the following:

**Table 704-6**
**Structural Backfill Gradation**

| Sieve Size | Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11) |
|---|---|
| 2 inch | 100 |
| No. 4 | 30-100 |
| No. 50 | 10-60 |
| No. 200 | 5-20 |

704.06(a) Delete the entire text and substitute the following:

(a) Maximum particle size 6 inches

## Section 714. – GEOTEXTILE AND GEOCOMPOSITE DRAIN MATERIAL

714.01 Add the following:

Use only woven polypropylene fabrics that are inert to biological degradation and resistance to commonly encountered chemicals, alkalis and acids for reinforcement geotextiles.