PART H

TECHNICAL PROVISIONS

TP 101 - Mobilization

MOBILIZATION

Mobilization shall include all items detailed in Article 101 of the Standard Specifications, the Special Provisions and on the plans, except as directed by the Engineer.

Preservation of Property Corners including all items detailed in Section 7-11 of the Standard Specifications shall be included in the contract price for mobilization.

Basis of Payment

The work and incidental costs covered under Mobilization will be paid for at the contract lump sum price and will be paid in partial payments in accordance with the following:

Percent of Original Contract Amount Earned	Allowable Percent of the Lump Sum Price for the Items*
5	25
10	50
25	75
50	100

*Partial payments as detailed above will be limited to 10% of the original Contract amount for the roadway pay items. Any amount of mobilization in excess of 10% of the roadway pay items will be paid upon completion of all work.

Payment shall be made under:

Pay Item:

101-1	Mobilization	Lump Sum

PART H

TECHNICAL PROVISIONS

TP 102 – Maintenance of Traffic

MAINTENANCE OF TRAFFIC

All Maintenance of Traffic work shall conform to the requirements of Section 102 of the Standard Specifications, Index 600 of the FDOT Design Standards, the plans, and/or as herein modified, except as directed by the Engineer.

The road shall be kept open to two-way traffic on a paved surface during construction except when full closures are allowed by the plans or by the Engineer. The Contractor shall not be permitted to isolate residences or places of business. Access shall be provided to all residences and all places of business whenever construction interferes with the existing means of access.

The Contractor shall furnish, erect and maintain all necessary traffic control devices, including flagmen and pilot cars, in accordance with the *Manual of Uniform Traffic Control Devices for Streets and Highways,* published by the U.S. Department of Transportation, Federal Highway Administration. The Contractor shall provide and maintain in a safe condition the entire project limits included, but not limited to pre-existing conditions, driving lanes, temporary approaches, crossings, and intersections with trails, roads, streets, business parking lots, residences, garages and completed work. The Contractor shall take all necessary precautions for the protection of the work and the safety of the public in accordance with Section 102.

The Contractor shall present his signed and sealed Maintenance of Traffic Plan that is approved by Orange County Traffic Engineering to the Engineer at the preconstruction conference, and shall be fully and solely responsible for the adequacy of the Maintenance of Traffic plan regardless of the source. The plan shall be signed and sealed by a professional engineer licensed in the State of Florida.

The Contractor shall be responsible for installation of signs for all business along the project corridor. Signs should be manufactured and installed in accordance with FDOT design standards. No special compensation will be made to the contractor to defray costs of any of the work or delays for complying with the requirements of installing business signs, but such costs shall be considered as having been included in the price stipulated for the Maintenance of Traffic pay item.

Basis of Payment

All materials, work and incidental costs related to Maintenance of Traffic will be paid for at the contract lump sum price. All material, labor and equipment necessary for the construction and maintenance of the entire project limits included, but not limited to pre-existing conditions, driving lanes, temporary approaches, crossings, intersections with trails, roads, streets, business parking lots, residences, garages, temporary driving lanes, side streets, driveway connections, and completed work, as may be directed by the Engineer shall be included in the contract price.

Payment shall be made under:

Pay Item:

102-1 Maintenance of Traffic - Lump Sum

TECHNICAL PROVISIONS

TP 104 - Prevention, Control and Abatement of Erosion and Water Pollution

PREVENTION, CONTROL and ABATEMENT of EROSION and WATER POLLUTION

Prevention, control and abatement of erosion and water pollution shall conform to the requirements of Section 104 of the Standard Specifications, National Pollution Discharge Elimination System (NPDES) requirements, except as modified by these Technical Provisions or as directed by the Engineer.

The Contractor shall present at the Preconstruction Conference its Storm Water Pollution Prevention Plan (SWPPP) and a separate schedule to manage erosion and water pollution. This schedule shall include a complete outline of the proposed construction of all erosion and pollution control and abatement items required.

The Contractor shall be responsible for the preparation and submittal of the Notice of Intent (NOI) and Notice of Termination (NOT) to the Florida Department of Environmental Protection (FDEP) and shall obtain the FDEP Generic Permit for Stormwater Discharge from Large and Small Construction Activities.

Basis of Payment

All work and incidental costs required to comply with the articles of this specification will be paid at the contract lump sum price for Prevention, Control and Abatement of Erosion and Water Pollution.

Payment will be made under:

Pay Item:

104-1	Prevention, Control and Abatement of Erosion and Water Pollution	Lump Sum

TECHNICAL PROVISIONS

TP 104a-1

DEWATERING / FLOW DIVERSION

Due to the potential for ground water contamination, dewatering shall be performed in accordance with the National Pollutant Discharge Elimination System (NPDES) General Permit No. FLG830000.

Dewatering shall be allowed for construction of drainage structures and storm sewer after acceptance by the Engineer and Orange County Environmental Protection Department.

BASIS OF PAYMENT

The quantity to be paid for under this section shall be lump sum, which will include but is not limited to containment of contamination, treatment, monitoring, discharge, etc, all in accordance with EPA General Permit No. FLG830000.

Payment to dewater, contain, treat, monitor and discharge of surface water and groundwater shall be made in accordance with the Bid Item Schedule under:

Pay Item:

104a-1	Dewatering / Flow Diversion	Lump Sum

PART H
TECHNICAL PROVISIONS

TP 110 – Clearing and Grubbing

CLEARING AND GRUBBING

All clearing and grubbing shall be performed in accordance with the requirements of Section 110 of the Standard Specifications, except as directed by the Engineer.

Scope of work to include but not be limited to, the removal of all rigid, asphalt pavement, Portland cement concrete pavement, curb, curb and gutter, ditch pavement, sidewalk, driveway aprons, concrete slabs, concrete structures, brick, fences, gravity walls, retaining walls, pipes, etc.

Clearing and Grubbing shall also include the removal of existing pavement and base course and backfilling with suitable material, as shown in the construction plans. Removal of the existing roadway shall also include the proper disposal of the removed materials as specified above.

Basis of Payment

All work and incidental costs required to perform clearing and grubbing as herein specified will be paid for at the contract lump sum price.

Payment shall be made under:

Pay Item:

110-1-1	Clearing and Grubbing	Lump Sum

PART H

TECHNICAL PROVISIONS

TP 120

EXCAVATION, EMBANKMENT AND GRADING

All excavation and embankment work shall conform to the requirements of Section 120 of the "Standard Specifications", and the provisions of this section, except as directed by the Engineer.

Basis of Payment

Payment shall constitute full compensation for all work described herein and in the Special Provisions and shall include the excavation and disposal of muck, clay, rock, or any other material that is unsuitable in its original position and that is excavated below the finished grading template. Work under this pay item shall also include the excavation of all suitable material within the specified limits as necessary to excavate the unsuitable material. The bottom of the finished grading template shall be considered to be the top of the channel slope and maintenance berm. Payment shall also include the provision, placement, shaping, and compaction of suitable backfill material to replace the removed unsuitable material up to the original grade line.

Excavation, Embankment and Grading will be paid for at the contract lump sum price.

Payment shall constitute full compensation for all work described herein and in the Special Provisions and shall include grading of slopes and berms, compaction, final dressing, subsoil excavation, replacement material and all work required for completing the project that is not paid for under the other pay items. Also included are removals and off-site disposal or on-site utilization of all materials, structures, abandoned utilities and obstructions as directed by the Engineer.

Payment shall be made under:

Item 120-9 Excavation Embankment and Grading	Lump Sum (LS)

PART H

TECHNICAL PROVISIONS

TP 430 – Pipe Culverts and Storm Sewers

PIPE CULVERTS AND STORM SEWERS

Construction of Pipe Culverts, Storm Sewers and Mitered End Sections shall conform to the requirements of Section 430 of the Standard Specifications, except as modified herein or as directed by the Engineer.

Final pipe inspection requirements shall conform to Section 430-4.8 of the Standard Specifications.

The only acceptable repair method shall be remove and relay / replace, or as otherwise directed by the Engineer. The repair cost shall be borne solely and completely by the Contractor.

Method of Measurement

For mitered end sections the quantity measured for payment shall be the number completed and accepted.

Basis of Payment

Mitered End Sections will be paid for at the contract unit price completed and accepted. The unit price shall include connection of existing pipes to proposed structures and the replacement of the backfill. Payment shall be full compensation for all work and materials described herein, including excavation (in whatever material is encountered), dewatering, removing unsuitable material and replacing with select bedding material, backfilling, compaction, furnishing and installing all pipe, disposing of surplus materials, and other work as may be required for an acceptable installation.

Payment shall be made under:

Item No		
430- 984-129	Mitered End Section (24”)	EA

PART H
TECHNICAL PROVISIONS

TP 455 SHEET PILE

MATERIAL SPECIFICATION

METHOD OF MEASUREMENT

Quantities measured for payment under this Section shall be the area in square feet of sheet pile wall installed in place, completed and accepted. Measurements shall be from the end of sheet pile wall to end of sheet pile wall.

BASIS OF PAYMENT

Sheet Pile will be paid for at the contract unit price, completed and accepted. The unit price shall include all hardware and appurtenances necessary for installation. Payments shall be full compensation for all work and materials described herein, including (in whatever material is encountered), dewatering, removing subsurface obstacles encountered during the driving process, backfilling with select material, any necessary compacting around the sheet pile wall, disposing of surplus materials, and other works as may be required for an acceptable installation.

Payment shall be made under:

Item No. 455-1	Sheet Piling- Per Square Foot

TECHNICAL PROVISIONS

TP 530 - Riprap (Rubble)

RIPRAP (RUBBLE)

Constructing Riprap (Rubble) shall conform to the requirements of Section 530 of the Standard Specifications, except as directed by the Engineer.

Method of Measurement

Quantities measured for payment under this Section shall be the in place tons of riprap (rubble). This price shall include the filter fabric and bedding stone placed under the riprap.

Basis of Payment

Rubble riprap will be paid for at the contract unit price, completed and accepted. Payment shall be full compensation for all work described herein and shall include all materials, bedding stone, filter fabric, hauling, excavation and backfill.

Payment shall be made under:

Pay Item:

530-3-4	Riprap-Rubble (Ditch Lining)	Per Ton

PART H

TECHNICAL PROVISIONS

TP 570 - Performance Turf

PERFORMANCE TURF

The Contractor shall establish a stand of grass in all areas designated on the plans and disturbed by construction in accordance with Chapter 15, Environmental Control, Article XVII, Fertilizer Management Ordinance of the Orange County Code; Sections 162 and 570 of the Standard Specifications, except as directed by the Engineer.

Work under this Section shall include all seeding, mulching, sodding, fertilizing and watering necessary to provide routine maintenance of the grassed area until the work is accepted by the Engineer.

There must be at least 90% coverage of healthy grass prior to acceptance by the Engineer. The Engineer, at any time, may require replanting of any areas in which the establishment of the grass stand does not appear to be developing satisfactorily.

The Contractor shall mow grassed areas twice monthly, or as required by the Engineer, until final acceptance of the work.

Seeding and Mulching

Grass seed shall be common Bermuda and Bahia. In addition, brown top-millet will be included during summer months and annual rye in the winter months. All seed shall meet the requirements of the State Department of Agriculture.

Sodding

Sodding shall be Bahia. It may be placed in rolls or as individual pieces. In established areas, replacement sod shall be of the same type as the existing sod, unless otherwise approved by the Engineer.

Fertilizers

Fertilize as necessary based on soil testing performed in accordance with Section 162. For fertilizer rates and application times follow Chapter 15 Environmental Control, Article XVII Fertilizer Management Ordinance of the Orange County Code.

Method of Measurement

Payment shall be calculated based on the quantity in square yards as specified in the completed and accepted plans. The cost of establishing grass in other areas disturbed by construction activities shall be borne by the Contractor.

PART H
TECHNICAL PROVISIONS

TP 570 - Performance Turf

Basis of Payment

Payment shall be paid for at the contract unit price per square yard. Payment shall constitute full compensation for furnishing all materials and completing all the work specified herein, including ground preparation, fertilizing, seeding, mulching, sodding, watering, mowing and complete maintenance of the grassed area until final completion and acceptance by the Engineer.

Payment shall be made under:

Pay Item:

570-1	Performance Turf	Per Square Yard

PART H

TECHNICAL PROVISIONS

TP 571 – Plastic Erosion Mat

Plastic Erosion Mat

Installing Plastic Erosion Mat shall conform to the requirements of Section 571 of the Standard Specifications, except as directed by the Engineer.

Method of Measurement

Quantities measured for payment under this Section will be the surface area of plastic erosion mat installed and accepted in square yards with no allowance for overlaps.

Basis of Payment

Payment shall be paid for at the contract unit price per square yard. Payment shall constitute full compensation for furnishing, handling, placement of plastic erosion mat, all labor, equipment and miscellaneous materials necessary for a complete and accepted installation.

Payment shall be made under:

Pay Item:

571-1-13	Plastic Erosion Mat, TRM, Type 3	Per Square Yard

PART H

TECHNICAL PROVISIONS

TP 900-1- As Built Plans

AS-BUILT PLANS

The As-Built Plans shall incorporate all the changes made to the red line As-Built plans. They shall show locations and elevations of paving, swales, ditches, pipe inverts and structures constructed and all relocated or reset property corners, section corners and 1/4 section corners.

Upon the completion of the project, the Contractor shall submit to the County one (1) set of 11"x17" paper Full Size Drawings with Statement of Certifications, certifying that the project was constructed according to the Construction Plans and Specifications, and that the AS BUILT PLANS are correct representation of what was constructed. The plans shall delineate all red line information contained on the As-Built Plans.

The Contractor shall include the Statement of Certification on either the cover sheet certifying all of the sheets or certify each individual sheet. The Statement of Certifications shall be signed and sealed by a Professional Engineer and/or a Professional Surveyor and Mapper, both registered in the State of Florida.

Basis of Payment

As-Built Plans will be paid for at the contract lump sum price, completed and accepted.

Payment shall be made under:

<u>Pay Item:</u>

900-1	As-Built Plans	Lump Sum

TP 900-2 Indemnification

INDEMNIFICATION

The Contractor shall indemnify, defend, and hold harmless the COUNTY and all its officers, agents, and employees, from all claims, losses, damages, costs, charges, or expenses arising out of any acts, action, neglect, or omission by the Contractor during the performance of the Contract, whether direct or indirect, and whether to any person or property to which the COUNTY or said parties may be subject, except that neither the Contractor nor any of its subcontractors are liable under this Section for damages arising out of the injury or damage to persons or property directly caused or resulting from the sole negligence of the COUNTY or any of its officers, agents, or employees.

Payment shall be made under:

Pay Item:		
900-2	Indemnification	Lump Sum

PART H
TECHNICAL PROVISIONS

For

SKYLAKE CANAL
B-01-L IMPROVEMENTS
ORANGE COUNTY, FLORIDA

Geotechnical Reports

Geotechnical Investigation Report
Skylake Canal Improvements
Orange County, Florida
performed by:
Antillian Engineering Associates, Inc.
March 15th, 2016
Amended:
May 2, 2016
November 7, 2016
July 27, 2017

GEOTECHNICAL INVESTIGATION REPORT
SKYLAKE CANAL IMPROVEMENTS
ORANGE COUNTY, FLORIDA

AEA PROJECT No. 201504-4

Antillian Engineering Associates, Inc.
3331 Bartlett Boulevard
Orlando, Florida 32811
(407) 422-1441

ANTILLIAN
ENGINEERING ASSOCIATES, INC.

March 15, 2016

CDM Smith
2301 Maitland Center Parkway, Suite 300
Maitland, Florida 32751

Attention: Alyson Byrne, P.E.

Reference: Geotechnical Investigation Report
Skylake Canal Improvements
Orange County, Florida
AEA Project No. 201504-4

Dear Ms. Byrne:

Antillian Engineering Associates, Inc. has completed a geotechnical engineering investigation for planned improvements to portions of the Skylake Canal between West Taft Vineland Road and West Landstreet Road in Orlando, Orange County, Florida. The work was authorized under Orange County Continuing Contract Y15-900-B and was done in general accordance with the scope of services presented in our proposal dated August 4, 2015. This report presents the results of the investigation, assessments of the encountered subsurface conditions as they relate to planned channel improvements, and other concerns as appropriate.

It has been our pleasure to serve CDM Smith and Orange County on this project. Please call if you have any questions or if you need additional information.

ANTILLIAN ENGINEERING ASSOCIATES, INC.
State of Florida Authorization No. EB 6685

PETER GREGORY SUAH
LICENSE
No. 46910
03.16.2016
STATE OF FLORIDA
PROFESSIONAL ENGINEER

Peter G. Suah, P.E.
Principal Engineer
Florida Registration No. 46910

Attachments: Figures
Appendix A: Field and Laboratory Investigations
Appendix B: Important Information About This Geotechnical Engineering Report
Appendix C: Constraints and Restrictions

PROJECT DESCRIPTION

Orange County Public Works Department is planning to repair the distressed slopes along three sections of the Skylake Canal between West Taft Vineland Road and West Landstreet Road. These sections of open channel were designated from south to north as "B-01-N", "B-01-K" and "B-01-L". Section B-01-N was on the eastern side of the channel between West Taft Vineland Road and Thorpe Road. This section began about 1,000 feet north of West Taft Vineland Road. Its length was about 175 feet. Section B-01-K was on the eastern side of the channel between Thorpe Road and West Landstreet Road. This section began about 400 feet north of Thorpe Road. Its length was about 725 feet. Section B-01-L was on the western side of the channel, also between Thorpe Road and West Landstreet Road. This section began about 1,600 feet north of Thorpe Road. Its length was about 500 feet.

It is our understanding that the slopes along these sections have been eroded in places. The purposes of the improvements were to reduce the potential for future erosion and maintenance problems, and to minimize the potential for transport of sediments downstream.

Overall project design is by CDM Smith of Maitland, Florida. CDM Smith's scope of work was to provide Orange County with an analysis for alternative channel improvements. CDM Smith retained Antillian Engineering Associates, Inc. to conduct a geotechnical engineering investigation and provide information to support the alternatives analysis, and to provide evaluations and recommendations for the design of the preferred alternative.

AVAILABLE INFORMATION

The United States Geological Survey ("USGS") quadrangle topographic map of the area and the United States Department of Agriculture ("USDA") Natural Resources Conservation Service ("NRCS") Soil Survey of Orange County, Florida were reviewed to obtain general information about the project vicinity. CDM Smith also furnished a preliminary survey by Southeastern Surveying (not dated) and preliminary project information that was examined for additional information.

The USGS map (reproduced as Figure 1) showed the project area on a broad, level plain with ground surface elevation mapped near the Elevation 95 feet NGVD (El. 95) contour. The existing channel, West Taft Vineland Road, Thorpe Road and West Landstreet Road were shown. The channel was shown bisecting an elongated marsh that extended from near West Taft Vineland Road to north of Thorpe Road. The ground surface elevation within the marsh was mapped below the El. 95 contour.

The SCS Soil Survey map (reproduced as Figure 2) showed several soil units in the project area. St. Johns fine sand was shown as the predominant soil unit near Section B-01-N. This soil unit was reported to be nearly level and poorly drained with a seasonal high groundwater level within a foot of the natural, undisturbed ground surface. Basinger fine sand depressional was mapped in the marsh area shown on the USGS map, and near Section B-01-K and Section B-01-L. This soil unit was reported to be very poorly drained and submerged for most of the year.

The preliminary survey showed that Section B-01-N was oriented south to north between West Vineland Road and Thorpe Road. Section B-01-K and Section B-01-L were oriented southwest to northeast between Thorpe Road and West Landstreet Road. Spot elevations and ground surface contours along Section B-01-N indicated that the eastern channel bank and top of slope were near Elevation 92 feet NAVD88 (El. 92) and that the toe of slope was near El. 81. Similarly, spot elevations and ground surface contours along Section B-01-K indicated that the eastern channel bank and top of slope were near El. 94 and that the toe of slope was near El. 81. Elevations along the western channel bank and top of slope along Section B-01-L were shown to be near El. 93. The toe of slope were shown near El. 80.

Information furnished by CDM Smith indicated that the two channel improvement alternatives being considered were to reshape and re-grade the channel cross-section or to stabilize the channel side slopes while maintaining the current channel cross section.

[END OF SECTION]

FIELD INVESTIGATION

A site visit was conducted to prepare for the field investigation program and to observe existing field conditions. Test boring locations were established by this firm at selected locations along the channel banks near the tops of slope that were accessible to the drill rig. Auger boring locations were established at selected locations along the channel slopes between test boring locations that were accessible to the field crews. Survey stakes and paint marks, along with readily-available aerial imagery, were used to establish the boring locations, which were staked for underground utility location and marking as required by Florida Statutes and to facilitate identification by the field crews. Approximate boring locations are shown on Figure 3.

The field investigations consisted of test borings with split-spoon soil sampling and auger borings. Eight test borings, designated “B-1” through “B-8”, and eight shallow auger borings, designated “HAB-1” through “HAB-8”, were drilled to investigate subsurface conditions.

Test borings were drilled on the channel banks near the top of slope. Each borehole was advanced to a depth of 20 feet by continuous split-spoon soil sampling and mud rotary drilling methods. The Standard Penetration Test (“SPT”) was conducted with the split-spoon soil sampling in general accordance with ASTM D 1586. Testing and sampling were conducted continuously to a depth of ten feet, and at five-foot intervals from ten feet to the indicated completion depth.

Auger borings were drilled on the channel side slopes between the test boring locations. Auger boreholes were advanced to a depth of five feet using a hand-held bucket auger. Drilling and sampling of the auger borings was done in general accordance with ASTM D 1452.

Soils recovered in each sampler and from the auger, sampler penetration resistance expressed in hammer blows per foot (the “SPT N-value”) and other notable conditions were logged by the field crew. Depth to groundwater in each borehole was measured where encountered and recorded on the field logs. Representative soil samples were sealed in clean, airtight containers and transported to our Orlando office for further examination and testing. At the completion of drilling and testing, each borehole was backfilled with soil cuttings.

LABORATORY TESTING

Recovered soil samples were examined in our office by a geotechnical engineer who confirmed the descriptions on the field logs, classified the soils visually in accordance with the Unified Soil Classification System (ASTM D 2488) and developed a representation of the soil stratigraphy at each boring location. Representative soil samples were selected for laboratory testing, which consisted of 17 percent fines tests, two organic content tests and two natural moisture content tests. The test results are presented on the boring logs and on the Summary of Laboratory Test Results sheets in Appendix A.

SURFACE CONDITIONS

As mentioned, these three sections of the Skylake Canal were between West Taft Vineland Road and West Landstreet Road, and were designated from south to north as B-01-N, B-01-K and B-01-L. The cross section of the channel was trapezoidal, and its depth appeared to range from about ten feet to 12 feet. The water surface in the channel was about ten feet to twelve feet below the banks. Water in the channel appeared to be about a foot deep. Commercial and industrial facilities bordered the channel right-of-way.

Along each of the project sections, the channel banks were broad, flat and well-defined. Channel side slopes appeared to be inclined near 1 Horizontal to 1 Vertical (1H:1V). Areas of localized, surficial sloughing were observed on the side slopes of each section. Ground cover on the banks and side slopes was well-maintained turf and low weeds. The channel bottom was estimated to be between eight feet and about ten feet wide.

SUBSURFACE CONDITIONS

The stratigraphy, soil types and groundwater levels described below are based on the results of the field and laboratory testing programs. SPT N-values were used as empirical indications of soil condition. Unified Soil Classification System group names and group symbols were used for soil classification. The descriptions below are general and describe the major soil types that were encountered. Detailed subsurface characteristics at each boring location are shown on the boring logs and on the Summary of Laboratory Test Results sheet and chart in Appendix A.

Section B-01-N (Borings B-1 through B-3 and HAB-1 through HAB-3)
The uppermost soils encountered in test borings B-1 through B-3 were mixed brown and light brown, very dark brown and mixed brown and dark brown fine sand that contained silt and occasionally a trace amount of organic matter. Encountered thicknesses were about three feet and four feet. SPT N-values were between 4 blows per foot (bpf) and 11 bpf with most values lower than 10 bpf, indicating that these soils were loose to medium dense but mostly loose. Percent fines testing of one sample indicated a fines content (fraction by dry weight passing the U.S. Standard No. 200 sieve) of 14 percent. Additional laboratory testing of a sample from B-2 indicated an organic content of 4 percent and a moisture content of 12 percent. Based on visual examination and laboratory testing, these soils were classified as silty sand (SM), and were also characterized as "possible fill" based on their variations in color.

Beneath the possible fill was a zone of fine sand that contained a trace amount of silt. Its colors were white, light gray and gray, and its encountered thickness was about a foot. SPT N-values recorded in this zone were 14 bpf and 25 bpf, indicating that this soil was medium dense. This soil was classified visually as poorly graded sand (SP).

Beneath the medium dense fine sand was yellowish brown, dark yellowish brown, brown and dark grayish brown fine sand that contained more silt. Encountered thicknesses were about 14 feet and

15 feet. SPT N-values ranged from 8 bpf to 16 bpf, indicating that these soils were loose to medium dense. Percent fines testing of three samples indicated fines contents between 7 percent and 11 percent. Based on visual examination and laboratory testing, this soil was classified as sand with silt (SP-SM).

Within the loose to medium dense sand with silt in B-2 and B-3 were zones of black and very dark brown fine sand that contained more silt and a trace amount of organic matter. Encountered thicknesses were about three feet an five feet. SPT N-values recorded in these zones were 3 bpf and 8 bpf, indicating that this soil was very loose to loose. Percent fines testing of one sample indicated a fines content of 17 percent. Additional laboratory testing indicated an organic content of 4 percent and a moisture content of 23 percent. Based on visual examination and laboratory testing, this soil was classified as silty sand (SM).

Soils encountered in HAB-1 through HAB-3 were similar to soils encountered uppermost in the test borings. These soils were yellowish brown, dark brown, gray and grayish brown fine sands that contained silt. Encountered thicknesses were five feet. Actual thicknesses could not be confirmed because these borings were terminated in these soils without penetrating them completely. These soils were classified visually as poorly graded sand (SP) and sand with silt (SP-SM).

Groundwater was encountered in the boreholes of B-1 through B-3 at depths between eight feet and nine feet below the existing ground surface on the channel banks. Groundwater was not in encountered in the boreholes of HAB-1 through HAB-3.

Section B-01-K (Borings B-4 through B-6 and HAB-4 through HAB-6)

The uppermost soils encountered in test borings B-4 through B-6 were mixed brown and dark brown, mixed gray and brown and mixed pale brown and brown fine sands that contained silt. Encountered thicknesses were about two feet and three feet. SPT N-values were between 6 bpf and 12 bpf, indicating that these soils were loose to medium dense. Percent fines testing of two samples indicated fines contents of 6 percent and 14 percent. Based on visual examination and laboratory testing, these soils were classified as sand with silt (SP-SM) and silty sand (SM), and were also characterized as “possible fill” based on their variations in color.

Beneath the possible fill in B-2 and B-3 was white, very pale brown, pale yellow, gray and light gray fine sand that contained a trace amount of silt. Encountered thicknesses were about three feet and ten feet. SPT N-values were between 14 bpf and 25 bpf, indicating that this soil was medium dense. Percent fines testing of two samples indicated fines content of 2 percent and 5 percent. Based on visual examination and laboratory testing, this soil was classified as poorly graded sand (SP).

Beneath the possible fill in B-1 and the medium dense fine sand in B-2 was yellowish brown fine sand that contained more silt. Encountered thicknesses were about six feet and eight feet. SPT N-values ranged from 4 bpf to 17 bpf with most values lower than 10 bpf, indicating that this soil was very loose to medium dense but mostly loose. Percent fines testing of two samples indicated fines contents of 6 percent and 7 percent. Based on visual examination and laboratory testing, this soil was classified as sand with silt (SP-SM).

Grayish brown, brown and dark grayish brown fine sands that contained more silt were encountered lowermost in B-4 through B-6. Encountered thickness was about eight feet. SPT N-values ranged from 10 bpf to 59 bpf with most values between 10 bpf and 30 bpf, indicating that these soils were was medium dense to very dense but mostly medium dense. Percent fines testing of two samples indicated fines contents of 9 percent and 12 percent. Based on visual examination and laboratory testing, these soils were classified as sand with silt (SP-SM) and silty sand (SM).

Soils encountered in HAB-4 through HAB-6 were similar to soils encountered uppermost in test borings B-4 through B-6. These soils were yellowish brown, dark brown, pale brown and white fine sands that contained silt. Encountered thicknesses were five feet. Actual thicknesses could not be confirmed because these borings were terminated in these soils without penetrating them completely. These soils were classified visually as poorly graded sand (SP) and sand with silt (SP-SM).

Groundwater was encountered in the boreholes of B-4 through B-6 at depths between eight feet and ten feet below the existing ground surface on the channel banks. Groundwater was not in encountered in the boreholes of HAB-4 through HAB-6.

Section B-01-L (Borings B-7 and B-8 and HAB-7 and HAB-8)

The uppermost soils encountered in test borings B-7 and B-8 were mixed gray and dark gray fine sand that contained silt. Its encountered thickness was about two feet. SPT N-values were 6 bpf and 8 bpf, indicating that this soil was loose. This soil was classified visually as sand with silt (SP-SM), and was also characterized as “possible fill” based on the observed variations in color.

Beneath the possible fill was pale brown, yellowish brown and light gray fine sand that contained a trace amount of silt. Encountered thickness was about ten feet. SPT N-values ranged from 12 bpf to 55 bpf with most values between 10 bpf and 30 bpf, indicating that this soil was medium dense to very dense but mostly medium dense. Percent fines testing of two samples indicated a fines content of 4 percent for both samples. Based on visual examination and laboratory testing, this soil was classified as fine sand (SP).

Within the medium dense to dense fine sand in B-8 was a zone of brown fine sand that contained more silt. Its encountered thickness was about two feet. The two SPT N-values recorded in this zone were 6 bpf and 17 bpf, indicating that this soil was loose to medium dense. Percent fines testing of one sample indicated a fines contents of 14 percent. Based on visual examination and laboratory testing, this soil was classified as silty sand (SM).

Dark grayish brown, brown and grayish brown fine sands that contained silt were encountered lowermost in B-7 and B-8. Encountered thickness was about eight feet. SPT N-values ranged from 9 bpf to 31 bpf, indicating that these soils were loose to dense. Percent fines testing of one sample indicated a fines contents of 21 percent. Based on visual examination and laboratory testing, these soils were classified as sand with silt (SP-SM) and silty sand (SM).

Soils encountered in HAB-7 and HAB-8 were similar to soils encountered uppermost in test borings B-7 and B-8. These soils were brown, dark brown, light gray to gray and yellow fine sands that contained silt. Encountered thicknesses were five feet. Actual thicknesses could not be confirmed because these borings were terminated in these soils without penetrating them completely. These soils were classified visually as poorly graded sand (SP) and sand with silt (SP-SM).

Groundwater was encountered in the boreholes of B-7 and B-8 at depths of about five feet and eight feet below the existing ground surface on the channel banks. Groundwater was not in encountered in the boreholes of HAB-7 and HAB-8.

[END OF SECTION]

GENERAL COMMENTS ON RECOMMENDATIONS

The following recommendations are based on a review of the available information, the field and laboratory test results and our experience with similar projects and subsurface conditions. Soils are natural materials, so variations in composition and other physical characteristics are normal and should be expected. Because of natural variations in depth, composition and consistency of soils and the spacing between the borings drilled for this investigation, unsuitable materials and other soils not encountered by the borings (such as cemented soils) may exist between boring locations, and should be anticipated. If subsurface conditions encountered during construction differ significantly from those encountered in the borings, those conditions should be reported to us for our observation and comment.

If plans for the proposed improvements change from those discussed in this report, we request the opportunity to review our preliminary recommendations and amend them as needed to accommodate those changes. We recommend a review of the project plans and specifications by this office to ensure that the geotechnical engineering recommendations contained in this report are properly interpreted and presented in these documents.

It was our understanding from CDM Smith that two channel improvement alternatives are being considered; to reshape and re-grade the channel cross-section, or to stabilize the channel side slopes while maintaining the current channel cross-section.

The preliminary recommendations presented in the following sections of this report are based on our understanding that typical earthwork techniques will be used to reshape and regrade the channel.

GENERAL ASSESSMENT OF ENCOUNTERED SOILS

As discussed in the SUBSURFACE CONDITIONS section of this report, the predominant soil types encountered in the borings were poorly graded sand, sand with silt and silty sand that occasionally contained a trace amount of organic matter. Most of these soils exhibited low to moderate resistance to penetration testing, but zones of dense to very dense sands were encountered in B-5 and B-8. Groundwater was encountered in the boreholes at depths between five feet and ten feet below the existing ground surface on the channel banks, but more typically about eight feet below the channel banks. These depths tended to coincide with the water level in the channel.

As mentioned, the two channel improvement alternatives were to reshape and re-grade the channel cross-section or to stabilize the channel side slopes while maintaining the current channel cross section. Based on the encountered subsurface conditions, either of these alternatives appears feasible from a geotechnical engineering perspective. The soils encountered in the borings are suitable for construction of either alternative. Preliminary geotechnical engineering recommendations for each alternative are presented in the following report sections. Geotechnical engineering recommendations for the preferred alternative will be provided once Orange County selects that alternative.

Typical site preparation should include removing vegetation, trees, roots, stumps, topsoil, soft sediments and debris from the channel banks and channel bottom to expose clean, undisturbed soils. Any organic materials that are encountered should be completely removed, and should be replaced with suitable, compacted fill. Existing channel slopes should be benched to facilitate the placement and compaction of backfill. Soils along the channel banks, as well as all fill and backfill, would need to be densified. In order to accomplish the earthwork in the dry, the water in the channel will have to diverted around the various work area by bypass pumping. In addition, the groundwater level in the channel side-slopes would have to be lowered.

Reshape and Regrade Channel Cross-Section

Flattening of steep slopes is a widely applied and economical method of improving their stability. Based on the results of the borings, it is anticipated that conventional construction equipment would be able to excavate, grade and shape the sandy soils. Depending on the planned depth of excavation, some dense to very dense sands may be encountered. These soils will likely reduce the efficiency of typical excavating equipment. The contractor should anticipate occasionally difficult excavation and should select equipment that can continue to operate effectively when such conditions are encountered during construction. The contractor should also expect large roots in areas where trees were present.

Stabilize Channel Slopes

Information furnished by CDM Smith indicated that the channel side slopes have a history of scour and erosion. Since most maintenance problems in channels are related to erosion and sloughing, the open-channel design should consider the need for some form of channel lining. The two main classifications of open-channel linings are flexible (grasses, natural vegetation, rip-rap, gabions, articulated concrete-block mats, or turf-reinforcement mats) and rigid (concrete, asphalt, soil-cement, grouted rip-rap). The choice of the appropriate lining is dependent upon channel geometry and flow, as well as the velocity and shear stress limitations of the soils.

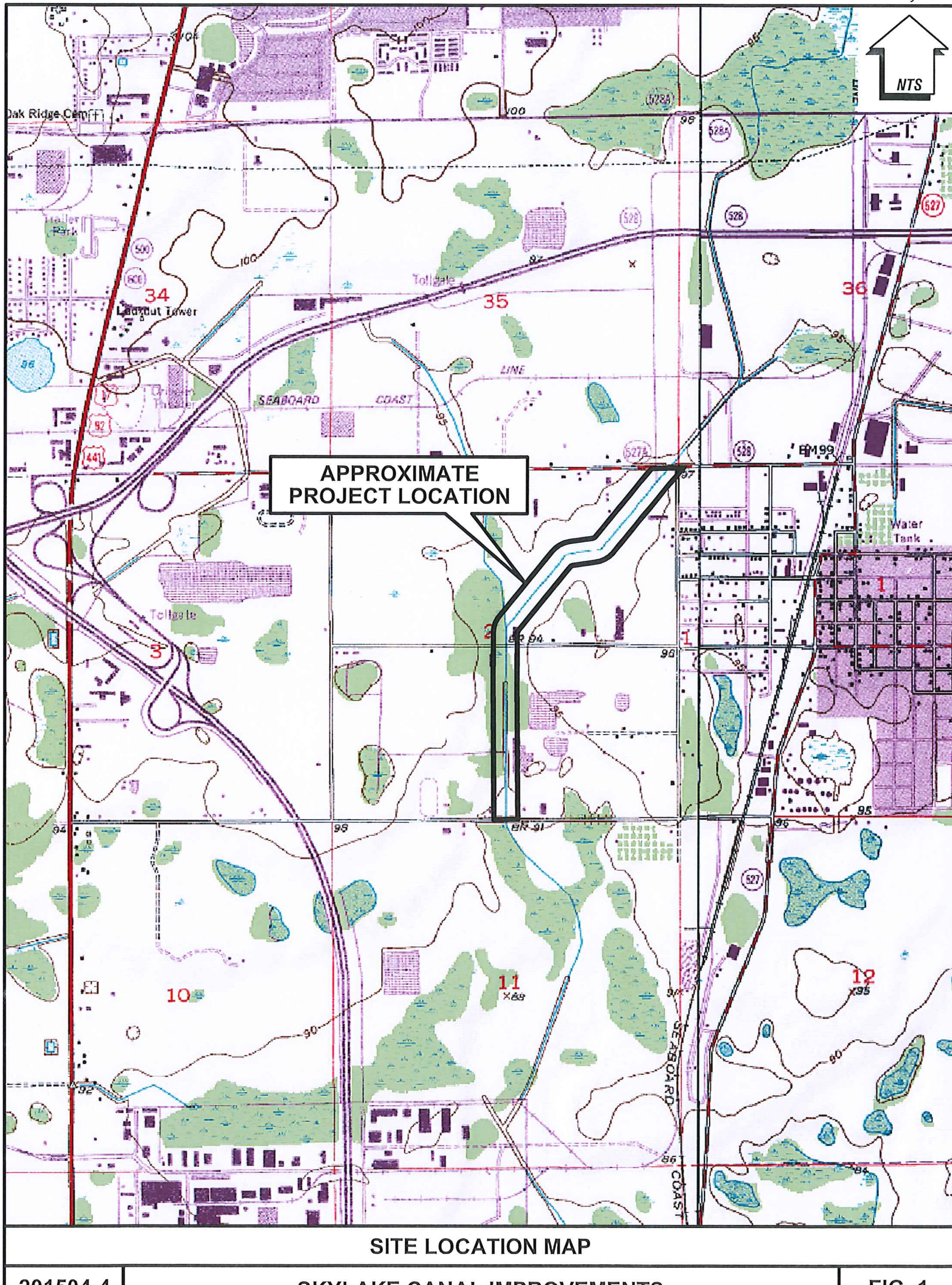
[END OF SECTION]

LIMITATIONS

This report presents a preliminary evaluation of the subsurface conditions on the basis of accepted geotechnical procedures for site characterization. The recovered soil samples were not examined or tested in any way for chemical composition or environmental hazards. The investigation was confined to the zone of soil which is likely to be affected by the proposed construction, and did not address the potential of surface expression of deep geologic activity such as sinkholes. This type of evaluation requires a more extensive range of services than those performed for this study.

Because of the natural limitations inherent in working with the subsurface, a geotechnical engineer cannot predict and address all possible problems. During construction, geotechnical issues not addressed in this report may arise. The bulletin "Important Information About This Geotechnical Engineering Report" published by the Geoprofessional Business Association (GBA) is presented in Appendix B to help explain the nature of geotechnical issues. Additional information is presented in Appendix C to discuss the potential concerns and the basic limitations of a typical geotechnical investigation report.

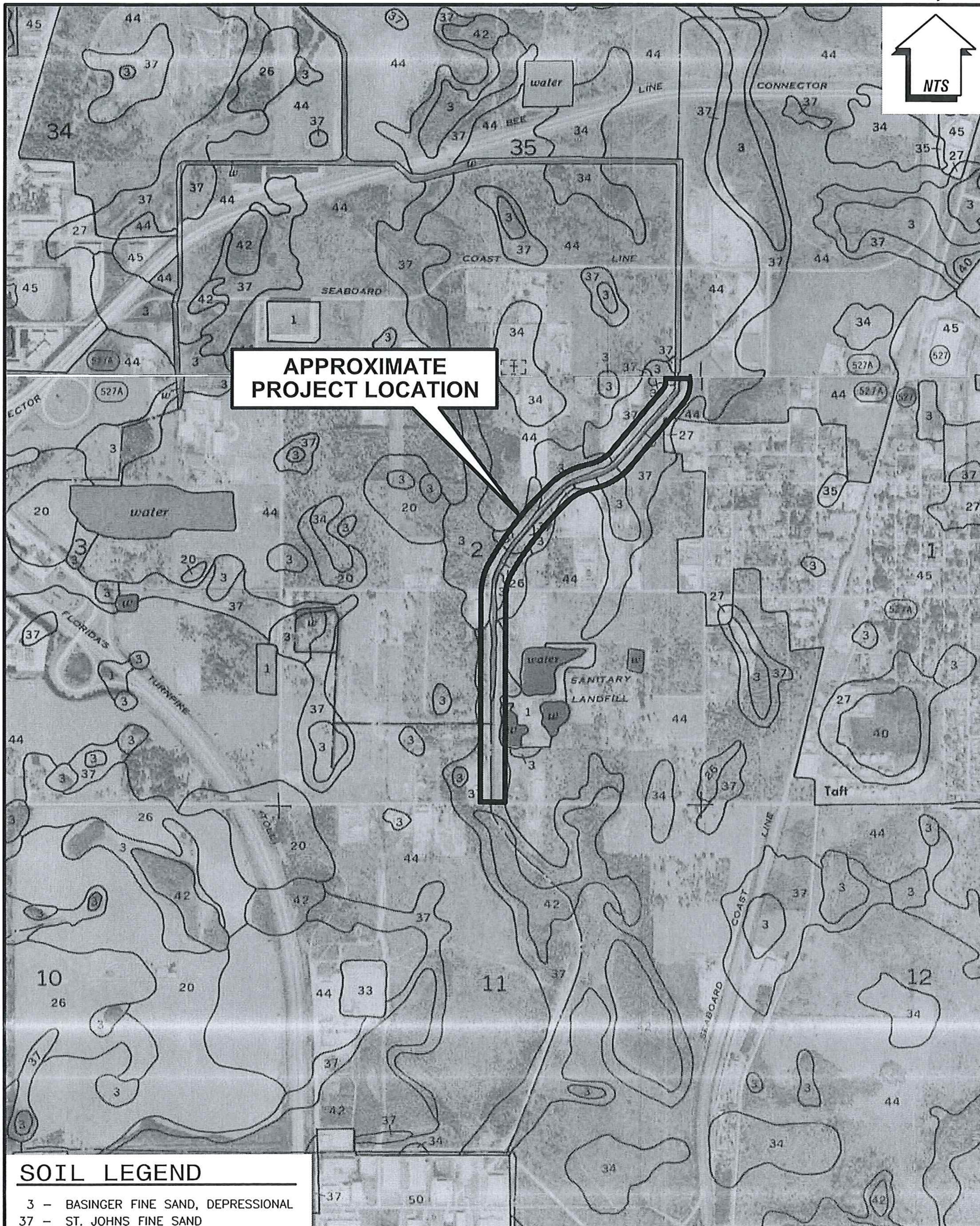
FIGURES



SITE LOCATION MAP

201504-4	SKYLAKE CANAL IMPROVEMENTS	FIG. 1

ANTILLIAN ENGINEERING ASSOCIATES, INC.



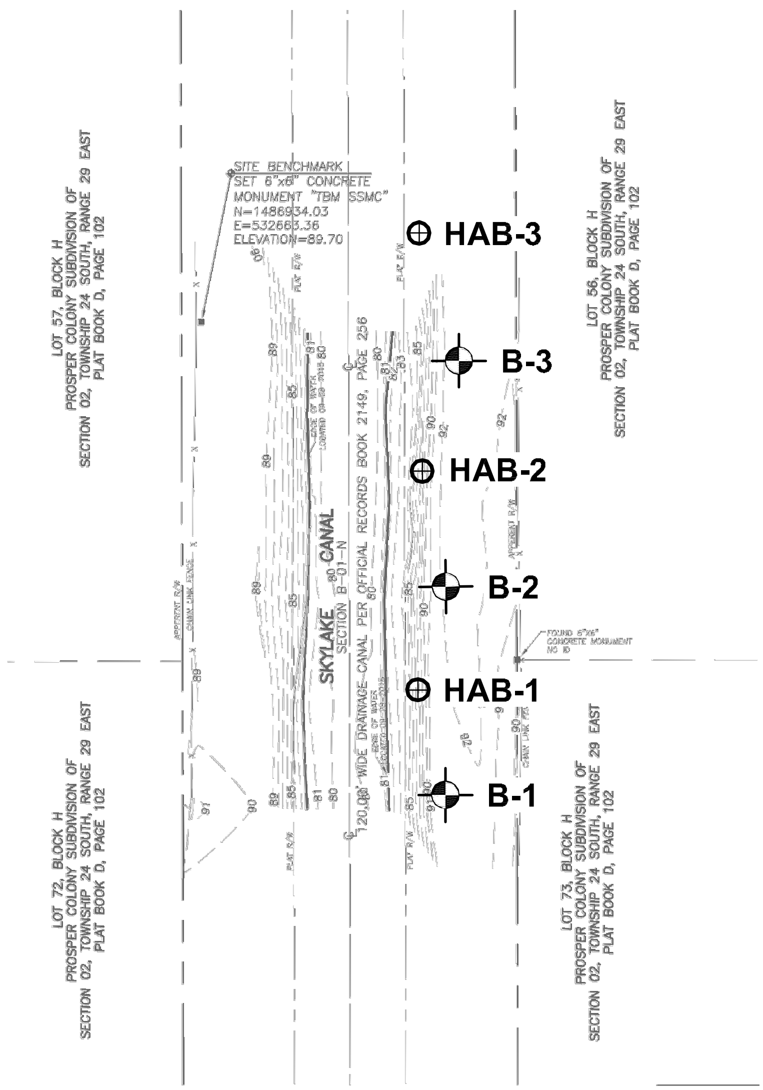
SOIL LEGEND

3 – BASINGER FINE SAND, DEPRESSIONAL
37 – ST. JOHNS FINE SAND

Figure developed from UDSA SCS Soil Survey of Orange County, Florida, issued August, 1989

USDA SCS SOIL SURVEY MAP		
201504-4	SKYLAKE CANAL IMPROVEMENTS	FIG. 2

NTS



LEGEND

APPROXIMATE LOCATION OF SPT BORING

APPROXIMATE LOCATION OF AUGER BORING

Figure developed from plan furnished by Client

EXPLORATION LOCATION PLAN - SECTION B-01-N

201504-4	**SKYLAKE CANAL IMPROVEMENTS**	**FIG. 3**

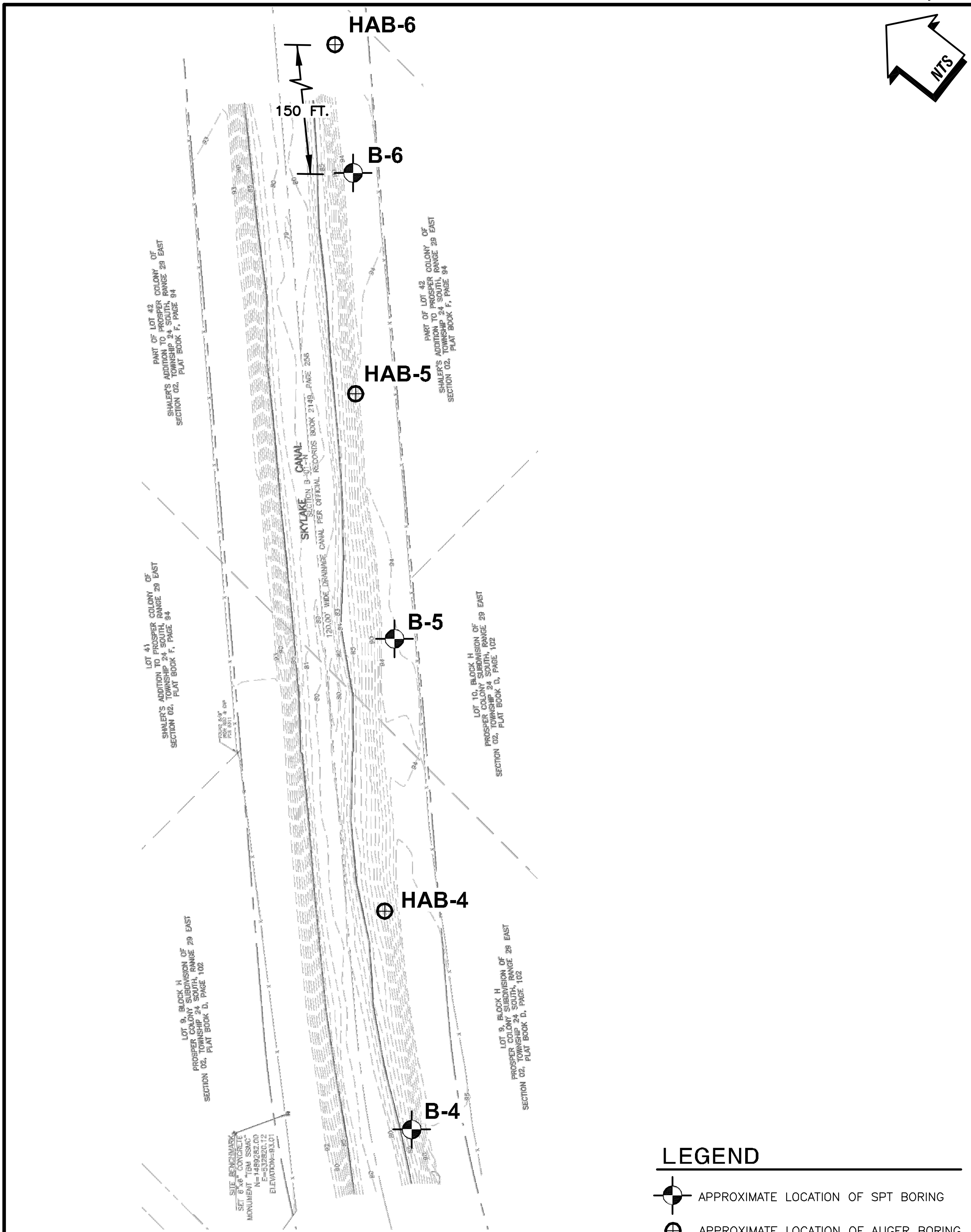


Figure developed from plan furnished by Client

EXPLORATION LOCATION PLAN - SECTION B-01-K

201504-4	SKYLAKE CANAL IMPROVEMENTS	FIG. 4

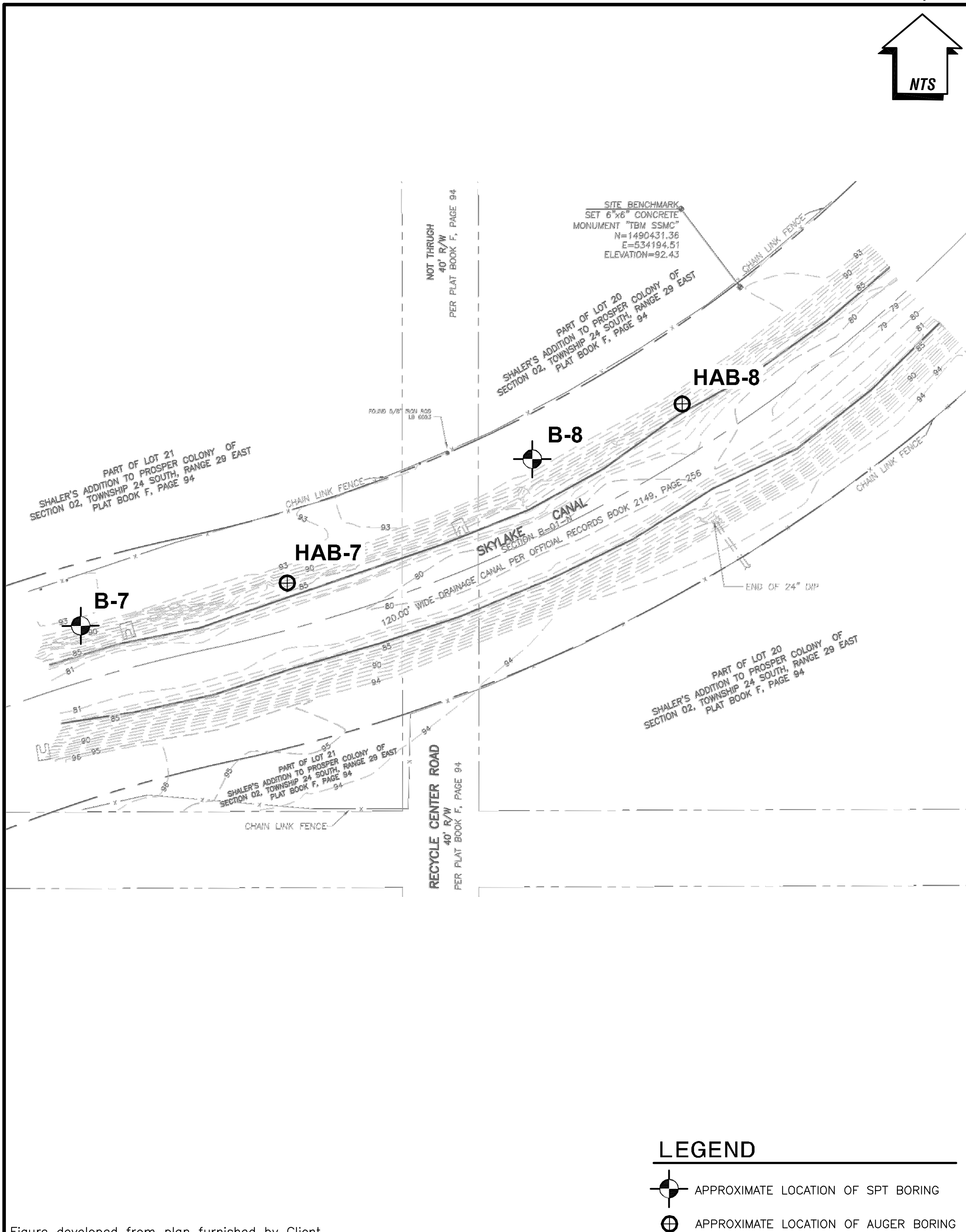


Figure developed from plan furnished by Client

EXPLORATION LOCATION PLAN - SECTION B-01-L

201504-4	SKYLAKE CANAL IMPROVEMENTS	FIG. 5

APPENDIX A

ANTILLIAN ENGINEERING ASSOCIATES, INC.
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Tel (407) 422-1441 Fax (407) 422-2226

KEY TO BORING LOGS

SYMBOLS

10	SPT N-Value (number of blows a 140-lb weight falling 30 inches required to drive a Standard Split-Spoon sampler one foot into otherwise undisturbed soil)
WR	Penetration of sampler under weight of drill rods
WH	Penetration of sampler under weight of drill rods and hammer
SS	Split Spoon sample
ST	Undisturbed thin-walled Shelby Tube sample
	Observed change in soil type
	Unobserved change in soil type
∇	Estimated seasonal high groundwater level
▼	Encountered groundwater level

SOIL CONSISTENCY

(Based on empirical correlation with SPT N-Value)

GRANULAR SOILS

Very Loose - Less Than 4 blows/ft.
Loose - 4 to 10 blows/ft.
Medium Dense - 10 to 30 blows/ft.
Dense - 30 to 50 blows/ft.
Very Dense - More Than 50 blows/ft.

FINE-GRAINED SOILS

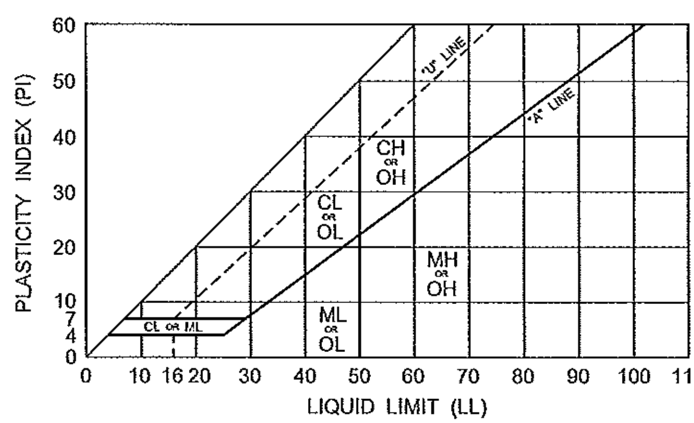
Very Soft - Less Than 2 blows/ft.
Soft - 2 to 4 blows/ft.
Firm - 4 to 8 blows/ft.
Stiff - 8 to 15 blows/ft.
Very Stiff - 15 to 30 blows/ft.
Hard - More Than 30 blows/ft.

UNIFIED SOILS CLASSIFICATION SYSTEM ASTM D 2487

(Based on material passing the 3-inch (75-mm) sieve)

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve	GRAVELS 50% or more of coarse fraction retained on No. 4 sieve	CLEAN GRAVELS	GW	Well-graded gravels and gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines
		GRAVELS WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand-clay mixtures
	SANDS More than 50% of coarse fraction passes No. 4 sieve	CLEAN SANDS	SW	Well-graded sands and gravelly sands, little or no fines
			SP	Poorly graded sands and gravelly sands, little or no fines
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS More than 50% passing No. 200 sieve	SILTS AND CLAYS Liquid limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	SILTS AND CLAYS Liquid limit greater than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts
			CH	Inorganic clays or high plasticity, fat clays
			OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS			Pt	Peat, muck and other highly organic soils

PLASTICITY CHART



LOG OF BORING B-1

ANTILLIAN ENGINEERING ASSOCIATES, INC.

SHEET 1 OF 1

PROJECT NO:	**201504-4**	SURFACE ELEVATION:	**92.1**
PROJECT:	**Skylake Canal Improvements**	GROUNDWATER DEPTH:	**8.0**
DATE:	**10/12/15**	COMPLETION DEPTH:	**20.0**
LOCATION:	**See Figure 3**	DRILLING METHOD:	**Mud Rotary**

DEPTH, ft.	SPT N-VALUE (bpf)	SAMPLE TYPE	DESCRIPTION	STRATUM EL / DEPTH	- 200	MC %	LL	PI	OC %
0	11	SS	Medium dense, mixed brown and light brown silty SAND (SM) (POSSIBLE FILL)	89.6 / 2.5	14				
	25	SS	Medium dense, gray fine SAND (SP)	88.1 / 4.0					
5	16	SS	Medium dense, yellowish brown fine SAND with silt (SP-SM)						
	11	SS	- dark yellowish brown		11				
	15	SS	- brown						
	15	SS	- pale brown						
10									
15	8	SS	- loose, brown						
20	12	SS	- medium dense	72.1 / 20.0					

ANTILLIAN ENGINEERING ASSOCIATES, INC.

LOG OF BORING B-2

SHEET 1 OF 1

PROJECT NO:	201504-4	SURFACE ELEVATION:	92.5
PROJECT:	Skylake Canal Improvements	GROUNDWATER DEPTH:	8.3
DATE:	10/12/15	COMPLETION DEPTH:	20.0
LOCATION:	See Figure 3	DRILLING METHOD:	Mud Rotary

DEPTH, ft.	SPT N-VALUE (bpf)	SAMPLE TYPE	DESCRIPTION	STRATUM EL / DEPTH	- 200	MC %	LL	PI	OC %
0									
	4	SS	Loose, very dark brown silty fine SAND with trace organic matter (SM)			12.2			3.5
	9	SS	(POSSIBLE FILL)	88.5 / 4.0					
	14	SS	Medium dense, light gray fine SAND (SP)	87.0 / 5.5					
5	10	SS	Loose, dark yellowish brown fine SAND with silt (SP-SM)	85.5 / 7.0					
	8	SS	Loose, black silty fine SAND (SM)	▼					
	8	SS	- trace organic matter		17	23.2			3.9
10				80.5 / 12.0					
	13	SS	Medium dense, dark grayish brown fine SAND with silt (SP-SM)		8				
15									
	13	SS	- grayish brown	72.5 / 20.0					
20									

ANTILLIAN ENGINEERING ASSOCIATES, INC.

LOG OF BORING B-3

SHEET 1 OF 1

PROJECT NO:	**201504-4**	SURFACE ELEVATION:	**92.9**
PROJECT:	**Skylake Canal Improvements**	GROUNDWATER DEPTH:	**9.0**
DATE:	**10/12/15**	COMPLETION DEPTH:	**20.0**
LOCATION:	**See Figure 3**	DRILLING METHOD:	**Mud Rotary**

DEPTH, ft.	SPT N-VALUE (bpf)	SAMPLE TYPE	DESCRIPTION	STRATUM EL / DEPTH	- 200	MC %	LL	PI	OC %
0									
	5	SS	Loose, mixed brown and dark brown silty SAND (SM)						
	8	SS	(POSSIBLE FILL)	88.9 / 4.0					
5	14	SS	Medium dense, white fine SAND (SP)	87.4 / 5.5					
	12	SS	Medium dense, dark yellowish brown fine SAND with silt (SP-SM)						
	12	SS		84.4 / 8.5 ▼					
	3	SS	Very loose, very dark brown silty fine SAND (SM)	80.9 / 12.0	7				
10									
15	12	SS	Medium dense, dark grayish brown fine SAND with silt (SP-SM)						
20	12	SS	- grayish brown	72.9 / 20.0					

ANTILLIAN ENGINEERING ASSOCIATES, INC.

LOG OF BORING B-4

SHEET 1 OF 1

PROJECT NO:	**201504-4**	SURFACE ELEVATION:	**95.6**
PROJECT:	**Skylake Canal Improvements**	GROUNDWATER DEPTH:	**9.0**
DATE:	**10/12/15**	COMPLETION DEPTH:	**20.0**
LOCATION:	**See Figure 4**	DRILLING METHOD:	**Mud Rotary**

DEPTH, ft.	SPT N-VALUE (bpf)	SAMPLE TYPE	DESCRIPTION	STRATUM EL / DEPTH	- 200	MC %	LL	PI	OC %
0									
	6	SS	Loose, mixed brown and dark brown silty fine SAND (SM)		14				
	12	SS	- medium dense (POSSIBLE FILL)	91.6					
	17	SS	Medium dense, yellowish brown fine SAND with silt (SP-SM)	4.0	6				
5	8	SS	- loose						
	7	SS							
	6	SS		▼					
10									
				83.6 12.0					
	11	SS	Medium dense, grayish brown silty fine SAND (SM)						
15									
	10	SS							
20				75.6 20.0					

LOG OF BORING B-5

ANTILLIAN ENGINEERING ASSOCIATES, INC.

SHEET 1 OF 1

PROJECT NO: **201504-4**
PROJECT: **Skylake Canal Improvements**
DATE: **10/12/15**
LOCATION: **See Figure 4**

SURFACE ELEVATION: **94.3**
GROUNDWATER DEPTH: **8.0**
COMPLETION DEPTH: **20.0**
DRILLING METHOD: **Mud Rotary**

DEPTH, ft.	SPT N-VALUE (bpf)	SAMPLE TYPE	DESCRIPTION	STRATUM EL / DEPTH	- 200	MC %	LL	PI	OC %
0	10	SS	Loose, mixed gray and brown fine SAND with silt (SP-SM) (POSSIBLE FILL)	91.8 / 2.5					
	24	SS	Medium dense, white fine SAND (SP)		2				
5	14	SS	- very pale brown	88.8 / 5.5					
	8	SS	Loose, yellowish brown fine SAND with silt (SP-SM)						
	4	SS	- very loose		7				
10	8	SS	- loose	82.3 / 12.0					
15	59	SS	Very dense, brown silty fine SAND (SM)		12				
20	29	SS	- medium dense	74.3 / 20.0					

ANTILLIAN ENGINEERING ASSOCIATES, INC.

LOG OF BORING B-6

PROJECT NO: **201504-4**
PROJECT: **Skylake Canal Improvements**
DATE: **10/12/15**
LOCATION: **See Figure 4**

SURFACE ELEVATION: **94.0**
GROUNDWATER DEPTH: **9.5**
COMPLETION DEPTH: **20.0**
DRILLING METHOD: **Mud Rotary**

DEPTH, ft.	SPT N-VALUE (bpf)	SAMPLE TYPE	DESCRIPTION	STRATUM EL / DEPTH	- 200	MC %	LL	PI	OC %
0									
	9	SS	Loose, mixed pale brown and brown fine SAND with silt (SP-SM) (POSSIBLE FILL)	91.5 / 2.5	6				
	25	SS	Medium dense, pale yellow fine SAND (SP)						
5	21	SS							
	24	SS	- gray						
	24	SS	- light gray						
	19	SS			5				
10									
				82.0 / 12.0					
	19	SS	Medium dense, dark grayish brown silty fine SAND (SM)						
15									
				77.0 / 17.0					
	21	SS	Medium dense, brown fine SAND with silt (SP-SM)		9				
20				74.0 / 20.0					

ANTILLIAN ENGINEERING ASSOCIATES, INC.

LOG OF BORING B-7

SHEET 1 OF 1

PROJECT NO:	**201504-4**	SURFACE ELEVATION:	**92.8**
PROJECT:	**Skylake Canal Improvements**	GROUNDWATER DEPTH:	**8.3**
DATE:	**10/12/15**	COMPLETION DEPTH:	**20.0**
LOCATION:	**See Figure 5**	DRILLING METHOD:	**Mud Rotary**

DEPTH, ft.	SPT N-VALUE (bpf)	SAMPLE TYPE	DESCRIPTION	STRATUM EL / DEPTH	- 200	MC %	LL	PI	OC %
0									
	8	SS	Loose, mixed gray and dark gray fine SAND with silt (SP-SM) (POSSIBLE FILL)	90.3 / 2.5					
	24	SS	Medium dense, very pale brown fine SAND (SP)						
	12	SS	- yellowish brown		4				
5	15	SS	- light gray						
	16	SS	- pale brown						
	12	SS							
10				80.8 / 12.0					
	9	SS	Loose, dark grayish brown silty fine SAND (SM)		21				
15				75.8 / 17.0					
	19	SS	Medium dense, brown fine SAND with silt (SP-SM)	72.8 / 20.0					
20									

LOG OF BORING B-8

ANTILLIAN ENGINEERING ASSOCIATES, INC.

SHEET 1 OF 1

PROJECT NO:	**201504-4**	SURFACE ELEVATION:	**93.0**
PROJECT:	**Skylake Canal Improvements**	GROUNDWATER DEPTH:	**5.3**
DATE:	**10/12/15**	COMPLETION DEPTH:	**20.0**
LOCATION:	**See Figure 5**	DRILLING METHOD:	**Mud Rotary**

DEPTH, ft.	SPT N-VALUE (bpf)	SAMPLE TYPE	DESCRIPTION	STRATUM EL / DEPTH	- 200	MC %	LL	PI	OC %
0	6	SS	Loose, mixed gray and dark gray fine SAND with silt (SP-SM) (POSSIBLE FILL)	90.5 / 2.5					
	12	SS	Medium dense, pale brown fine SAND (SP)	89.0 / 4.0					
5	6	SS	Loose, brown silty fine SAND (SM)		14				
	17	SS	- medium dense	86.0 / 7.0					
	48	SS	Dense, very pale brown fine SAND (SP)		4				
10	55	SS	- very dense, brown	81.0 / 12.0					
15	20	SS	Medium dense, dark grayish brown silty fine SAND (SM)	76.0 / 17.0					
20	31	SS	Dense, grayish brown fine SAND with silt (SP-SM)	73.0 / 20.0					

ANTILLIAN ENGINEERING ASSOCIATES, INC.

LOG OF BORING HAB-1

PROJECT NO:	**201504-4**	SURFACE ELEVATION:	**91 approx**
PROJECT:	**Skylake Canal Improvements**	GROUNDWATER DEPTH:	**GNE**
DATE:	**10/12/15**	COMPLETION DEPTH:	**5.0**
LOCATION:	**See Figure 3**	DRILLING METHOD:	**Hand Auger**

DEPTH, ft.	SAMPLES	SPT N-VALUE (bpf)	SAMPLE TYPE	DESCRIPTION	STRATUM EL / DEPTH	SYMBOL	- 200	MC %	LL	PI	OC %
0			HA	Yellowish brown fine SAND with silt (SP-SM)	0.0 3.5						
				Gray fine SAND (SP)	0.0 5.0						
5											

LOG OF BORING HAB-2

ANTILLIAN ENGINEERING ASSOCIATES, INC.

SHEET 1 OF 1

PROJECT NO:	201504-4	SURFACE ELEVATION:	91 approx
PROJECT:	Skylake Canal Improvements	GROUNDWATER DEPTH:	GNE
DATE:	10/12/15	COMPLETION DEPTH:	5.0
LOCATION:	See Figure 3	DRILLING METHOD:	Hand Auger

DEPTH, ft.	SAMPLES	SPT N-VALUE (bpf)	SAMPLE TYPE	DESCRIPTION	STRATUM EL / DEPTH	SYMBOL	- 200	MC %	LL	PI	OC %
0			HA	Yellowish brown fine SAND with silt (SP-SM)	0.0 3.5						
				Light gray fine SAND (SP)	0.0 5.0						
5											

ANTILLIAN ENGINEERING ASSOCIATES, INC.

LOG OF BORING HAB-3

PROJECT NO:	**201504-4**	SURFACE ELEVATION:	**Unknown**
PROJECT:	**Skylake Canal Improvements**	GROUNDWATER DEPTH:	**GNE**
DATE:	**10/12/15**	COMPLETION DEPTH:	**5.0**
LOCATION:	**See Figure 3**	DRILLING METHOD:	**Hand Auger**

DEPTH, ft.	SAMPLES	SPT N-VALUE (bpf)	SAMPLE TYPE	DESCRIPTION	STRATUM EL / DEPTH	SYMBOL	- 200	MC %	LL	PI	OC %
0			HA	Dark brown fine SAND with silt (SP-SM)	0.0 4.0						
				Grayish brown fine SAND (SP)	0.0 5.0						
5											

ANTILLIAN ENGINEERING ASSOCIATES, INC.

LOG OF BORING HAB-4

PROJECT NO:	**201504-4**	SURFACE ELEVATION:	**89 approx**
PROJECT:	**Skylake Canal Improvements**	GROUNDWATER DEPTH:	**GNE**
DATE:	**10/12/15**	COMPLETION DEPTH:	**5.0**
LOCATION:	**See Figure 4**	DRILLING METHOD:	**Hand Auger**

DEPTH, ft.	SAMPLES	SPT N-VALUE (bpf)	SAMPLE TYPE	DESCRIPTION	STRATUM EL / DEPTH	SYMBOL	- 200	MC %	LL	PI	OC %
0			HA	Yellowish brown fine SAND with silt (SP-SM)							
				- dark brown							
5					0.0 5.0						

ANTILLIAN ENGINEERING ASSOCIATES, INC.

LOG OF BORING HAB-5

SHEET 1 OF 1

PROJECT NO: **201504-4**
PROJECT: **Skylake Canal Improvements**
DATE: **10/12/15**
LOCATION: **See Figure 4**

SURFACE ELEVATION: **92 approx**
GROUNDWATER DEPTH: **GNE**
COMPLETION DEPTH: **5.0**
DRILLING METHOD: **Hand Auger**

DEPTH, ft.	SAMPLES	SPT N-VALUE (bpf)	SAMPLE TYPE	DESCRIPTION	STRATUM EL / DEPTH	SYMBOL	- 200	MC %	LL	PI	OC %
0			HA	Dark brown fine SAND with silt (SP-SM)							
5					0.0 5.0						

LOG OF BORING HAB-6

ANTILLIAN ENGINEERING ASSOCIATES, INC.

SHEET 1 OF 1

PROJECT NO:	**201504-4**	SURFACE ELEVATION:	**Unknown**
PROJECT:	**Skylake Canal Improvements**	GROUNDWATER DEPTH:	**GNE**
DATE:	**10/12/15**	COMPLETION DEPTH:	**5.0**
LOCATION:	**See Figure 4**	DRILLING METHOD:	**Hand Auger**

DEPTH, ft.	SAMPLES	SPT N-VALUE (bpf)	SAMPLE TYPE	DESCRIPTION	STRATUM EL / DEPTH	SYMBOL	- 200	MC %	LL	PI	OC %
0			HA	Dark brown fine SAND with silt (SP-SM)	0.0 2.0						
				Very pale brown fine SAND (SP) - white - pale brown							
5					0.0 5.0						

ANTILLIAN ENGINEERING ASSOCIATES, INC.

LOG OF BORING HAB-7

SHEET 1 OF 1

PROJECT NO:	201504-4	SURFACE ELEVATION:	89 approx
PROJECT:	Skylake Canal Improvements	GROUNDWATER DEPTH:	GNE
DATE:	10/12/15	COMPLETION DEPTH:	5.0
LOCATION:	See Figure 5	DRILLING METHOD:	Hand Auger

DEPTH, ft.	SAMPLES	SPT N-VALUE (bpf)	SAMPLE TYPE	DESCRIPTION	STRATUM EL / DEPTH	SYMBOL	- 200	MC %	LL	PI	OC %
0			HA	Brown fine SAND (SP) - light gray - gray - light gray							
5					0.0 5.0						

ANTILLIAN ENGINEERING ASSOCIATES, INC.

LOG OF BORING HAB-8

PROJECT NO:	**201504-4**	SURFACE ELEVATION:	**89 approx**
PROJECT:	**Skylake Canal Improvements**	GROUNDWATER DEPTH:	**GNE**
DATE:	**10/12/15**	COMPLETION DEPTH:	**5.0**
LOCATION:	**See Figure 5**	DRILLING METHOD:	**Hand Auger**

DEPTH, ft.	SAMPLES	SPT N-VALUE (bpf)	SAMPLE TYPE	DESCRIPTION	STRATUM EL / DEPTH	SYMBOL	- 200	MC %	LL	PI	OC %
0			HA	Dark brown fine SAND with silt (SP-SM)	0.0 2.5						
				Yellow fine SAND (SP)	0.0 5.0						
5											

Project: **Skylake Canal Improvements** Job Number: **201504-4** Sheet **1** of **1**

Manager:
Client:
Project Description:
Location:

Boring / Depth	Sample Description #4	#10	#40	#60	#100	Fines #200	Water Content	LL	PI	Organic Content	k (ft/day)	Stratum Number	AASHTO	USCS
B-1 1.0	Brown and light brown silty sand					13.6								SM
B-1 5.5	Dark yellowish brown sand with silt					11.2								SP-SM
B-2 1.0	Very dark brown silty sand						12			3.5				SM
B-2 8.5	Black silty sand					16.9	23			3.9				SM
B-2 13.5	Dark grayish brown sand with silt					7.6								SP-SM
B-3 8.5	Very dark brown sand with silt					6.8								SP-SM
B-4 1.0	Brown and dark brown silty sand					13.8								SM
B-4 4.0	Yellowish brown sand with silt					6.0								SP-SM
B-5 2.5	White sand					1.8								SP
B-5 7.0	Dark yellowish brown sand with silt					7.1								SP-SM
B-5 13.5	Brown silty sand					12.3								SM
B-6 1.0	Pale brown sand with silt					5.8								SP-SM
B-6 8.5	Brown sand					5.0								SP
B-6 18.5	Brown sand with silt					9.0								SP-SM
B-7 4.0	Yellowish brown sand					4.1								SP
B-7 13.5	Dark grayish brown silty sand					21.3								SM
B-8 4.0	Brown silty sand					13.5								SM
B-8 7.0	Very pale brown sand					4.1								SP

Summary Of Laboratory Test Results

ANTILLIAN ENGINEERING ASSOCIATES, INC.

APPENDIX B

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a civil engineer may not fulfill the needs of a constructor — a construction contractor — or even another civil engineer. Because each geotechnical- engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. No one except you should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply this report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical-engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

Geotechnical Engineers Base Each Report on a Unique Set of Project-Specific Factors

Geotechnical engineers consider many unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk-management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical-engineering report that was:

- not prepared for you;
- not prepared for your project;
- not prepared for the specific site explored; or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical-engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical-engineering report is based on conditions that existed at the time the geotechnical engineer performed the study. *Do not rely on a geotechnical-engineering report whose adequacy may have been affected by*: the passage of time; man-made events, such as construction on or adjacent to the site; or natural events, such as floods, droughts, earthquakes, or groundwater fluctuations. *Contact the geotechnical engineer before applying this report to determine if it is still reliable.* A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ — sometimes significantly — from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide geotechnical-construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are Not Final

Do not overrely on the confirmation-dependent recommendations included in your report. *Confirmation-dependent recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's confirmation-dependent recommendations if that engineer does not perform the geotechnical-construction observation required to confirm the recommendations' applicability.*

A Geotechnical-Engineering Report Is Subject to Misinterpretation

Other design-team members' misinterpretation of geotechnical-engineering reports has resulted in costly

problems. Confront that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Constructors can also misinterpret a geotechnical-engineering report. Confront that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing geotechnical construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical-engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make constructors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give constructors the complete geotechnical-engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise constructors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure constructors have sufficient time* to perform additional study. Only then might you be in a position to give constructors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and constructors fail to recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Environmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform an *environmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold-prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold- prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical- engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; *none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.*

Rely, on Your GBC-Member Geotechnical Engineer for Additional Assistance

Membership in the Geotechnical Business Council of the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you GBC-Member geotechnical engineer for more information.

GBC GEOTECHNICAL BUSINESS COUNCIL of the Geoprofessional Business Association

8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@geoprofessional.org www.geoprofessional.org

APPENDIX C

ANTILLIAN ENGINEERING ASSOCIATES, INC.
CONSTRAINTS AND RESTRICTIONS

WARRANTY

Antillian Engineering Associates, Inc. has prepared this report for our client for his exclusive use, in accordance with generally accepted soil and foundation engineering practices, and makes no other warranty either expressed or implied as to the professional advice provided in the report.

UNANTICIPATED SOIL CONDITIONS

The analysis and recommendations submitted in this report are based upon the data obtained from soil borings performed at the locations indicated on the Boring Location Plan. This report does not reflect any variations which may occur between these borings.

CHANGED CONDITIONS

We recommend that the specifications for the project require that the contractor immediately notify Antillian Engineering Associates, Inc., as well as the owner, when subsurface conditions are encountered that are different from those present in this report.

No claim by the contractor for any conditions differing from those anticipated in the plans, specifications, and those found in this report, should be allowed unless the contractor notifies the owner and Antillian Engineering Associates, Inc. of such changed conditions. Further, we recommend that all foundation work and site improvements be observed by a representative of Antillian Engineering Associates, Inc. to monitor field conditions and changes, to verify design assumptions and to evaluate and recommend any appropriate modifications to this report.

MISINTERPRETATION OF SOIL ENGINEERING REPORT

Antillian Engineering Associates, Inc. is responsible for the conclusions and opinions contained within this report based upon the data relating only to the specific project and location discussed herein. If the conclusions or recommendations based upon the data presented are made by others, those conclusions or recommendations are not the responsibility of Antillian Engineering Associates, Inc..

CHANGED STRUCTURE OR LOCATION

This report was prepared in order to aid in the evaluation of this project and to assist the architect or engineer in the design of this project. If any changes in the design or location of the structure as outlined in this report are planned, or if any structures are included or added that are not discussed in the report, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and the conclusions modified or approved by Antillian Engineering Associates, Inc..

USE OF REPORT BY BIDDERS

Bidders who are examining the report prior to submission of a bid are cautioned that this report was prepared as an aid to the designers of the project and it may affect actual construction operations.

Bidders are urged to make their own soil borings, test pits, test caissons or other investigations to determine those conditions that may affect construction operations. Antillian Engineering Associates, Inc. cannot be responsible for any interpretations made from this report or the attached boring logs with regard to their adequacy in reflecting subsurface conditions which will affect construction operations.

STRATA CHANGES

Strata changes are indicated by a definite line on the boring logs which accompany this report. However, the actual change in the ground may be more gradual. Where changes occur between soil samples, the location of the change must necessarily be estimated using all available information and may not be shown at the exact depth.

OBSERVATIONS DURING DRILLING

Attempts are made to detect and/or identify occurrences during drilling and sampling, such as: water level, boulders, zones of lost circulation, relative ease or resistance to drilling progress, unusual sample recovery, variation of driving resistance, obstructions, etc.; however, lack of mention does not preclude their presence.

WATER LEVELS

Water level readings have been made in the drill holes during drilling and they indicate normally occurring conditions. Water levels may not have been stabilized at the last reading. This data has been reviewed and interpretations made in this report. However, it must be noted that fluctuations in the level of the groundwater may occur due to variations in rainfall, temperature, tides, and other factors not evident at the time measurements were made and reported. Since the probability of such variations is anticipated, design drawings and specifications should accommodate such possibilities and construction planning should be based upon such assumptions of variations.

LOCATION OF BURIED OBJECTS

All users of this report are cautioned that there was no requirement for Antillian Engineering Associates, Inc. to attempt to locate any man-made buried objects during the course of this exploration and that no attempt was made by Antillian Engineering Associates, Inc. to locate any such buried objects. Antillian Engineering Associates, Inc. cannot be responsible for any buried man-made objects which are subsequently encountered during construction that are not discussed within the text of this report.

TIME

This report reflects the soil conditions at the time of investigation. If the report is not used in a reasonable amount of time, significant changes to the site may occur and additional reviews may be required.

ANTILLIAN
ENGINEERING ASSOCIATES, INC.

May 2, 2016

CDM Smith
2301 Maitland Center Parkway, Suite 300
Maitland, Florida 32751

Attention: Alyson Byrne, P.E.

Reference: Slope Stability Technical Memorandum
Skylake Canal Improvements
Orange County, Florida
AEA Project No. 201504-4

Dear Ms. Byrne:

I have completed a preliminary slope stability analysis of the Skylake Canal bank, as discussed in our design team conference call on April 22, 2016. The purpose of the analysis was to investigate other possible options for stabilizing the channel slopes, and present a possible option to the design team for consideration.

I analyzed a section of the channel side slope in Section B-01K where signs of rotational failure were apparent. We drilled test boring B-4 at that location during our geotechnical engineering investigation. This is also the area that we examined during our joint site visit with Orange County staff, and where we surmised that seepage from the stormwater pond on the adjacent, private property may have caused the apparent bank slope failure.

I estimated soil properties for the analyses using accepted empirical correlations between the encountered soil types and SPT N-values, and developed slope geometry using topographical survey information on Sheet 3 of 6 in the 30 Percent plans prepared by Pegasus Engineering. The analyses were conducted using STABL5M, a widely accepted microcomputer application operated through STEDwin, a shareware user-interface.

As you know, a factor of safety of 1.5 is the generally accepted minimum for long-term stability against rotational failure in soil slopes. Intuitively, a factor of safety of 1.0 would represent a condition with no reserve stability, i.e., where a failure is about to occur or has occurred. However, research conducted by back-calculating actual failures has shown that the factor of safety at failure can range from 0.8 to 1.2. That finding has been attributed (in part) to natural variations in the subsurface conditions, the simplifying assumptions that are necessary for conducting these analyses, and practical limitations of the limit-state equilibrium theories on which slope stability analyses are based.

3331 Bartlett Boulevard • Orlando, FL 32811 • (407) 422-1441 • Fax (407) 422-2226

My analyses revealed the following results, which are presented graphically in Appendix A.

1. The factor of safety against rotational failure was 1.1 in the channel bank where instability had been observed. This analysis was conducted with the water surface in the channel at Elevation 84 approximately, and higher groundwater levels in the channel bank to model seepage from the stormwater pond on the adjacent, private property.

2. The factor of safety was 1.2 at the same location with water in the channel at Elevation +82 approximately and no seepage from the stormwater pond (the "steady-state" condition).

3. The factor of safety was only 3 percent higher with the water surface lowered to the bottom of the channel, i.e., to Elevation +80 approximately.

Those results were consistent with the observed bank instability. More important, they indicated that this section of the channel bank did not meet current design criteria, as would any section of the channel bank with similar configuration and subsurface conditions.

Based on our earlier discussions, I understood that any repair should maintain the volume flow capacity of the channel, not change the configuration of the channel cross-section (which might cause eddies and unintended erosion upstream or downstream of the repair), not reduce the existing maintenance berm width, and be durable, low-maintenance, and economical.

I conducted a literature review and found that bank stability may be enhanced using a buried barrier, which would force potential failure surfaces deeper below the surface. The method was documented in a research study funded by the Federal Highway Administration. I conducted a preliminary trial by adding a buried barrier to the worst-case analysis (with the seepage in the slope) and obtained a factor of safety of 2.0. The results of that preliminary trial are presented in Appendix B.

Based on those preliminary results, I believe this method merits further evaluation to select an appropriate factor of safety for design (since post-failure soil properties generally have lower ("residual") values than the peak values), and select a barrier type, depth, spacing, and position beneath in the slope. I would be pleased to discuss this option further with the team.

ANTILLIAN ENGINEERING ASSOCIATES, INC.

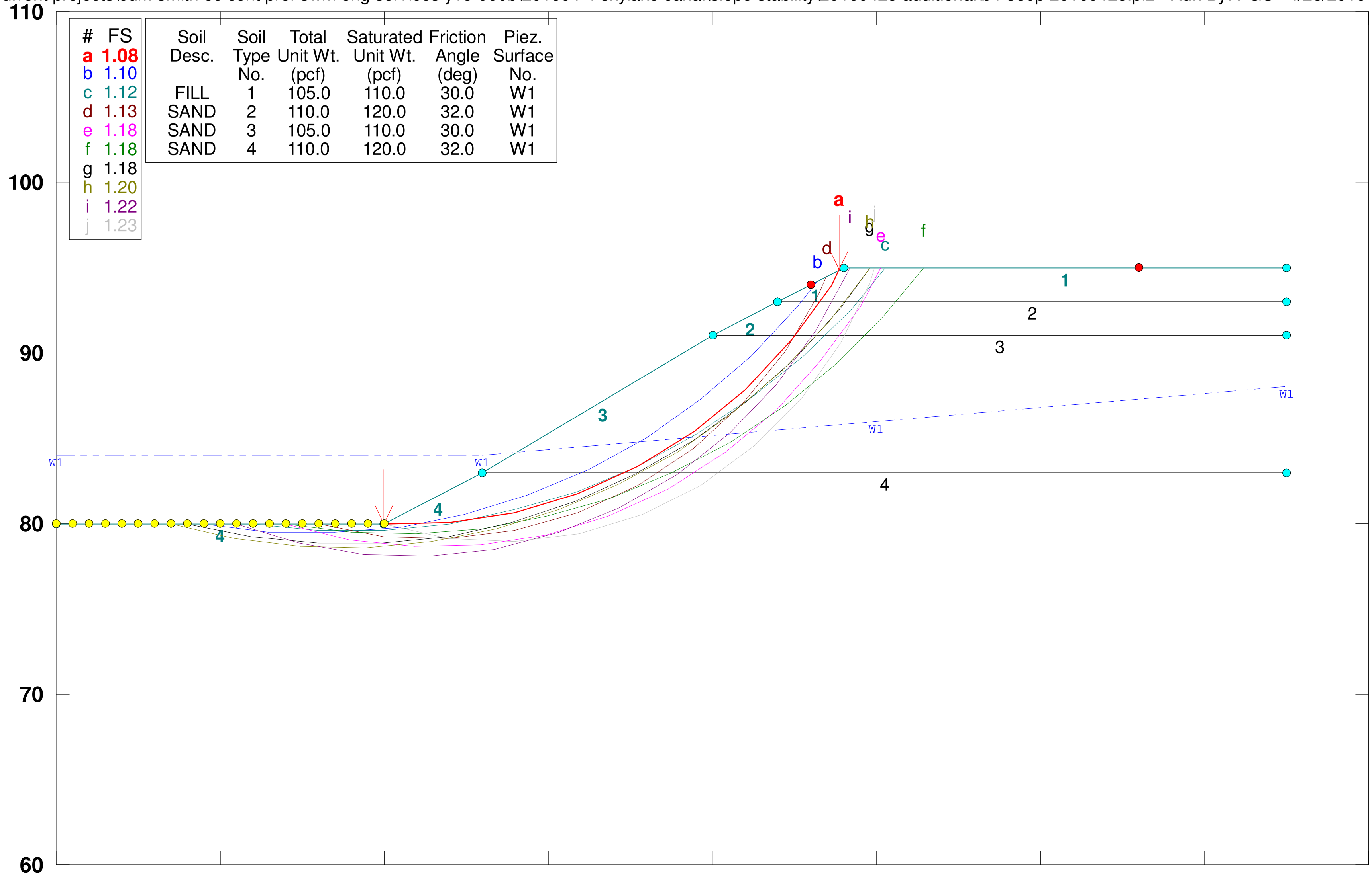
Peter G. Suah, P.E.
Principal Engineer
Florida Registration No. 46910

Attachments: Appendix A - Rotational Stability Analyses of Existing Slope
Appendix B - Preliminary Rotational Stability Analysis with Slope Enhancement

APPENDIX A

Skylake Canal B-01-K Existing Slope B-4 with Seepage in Slope

s:\current projects\cdm smith oc cont prof swm eng services y15-900b\201504-4 skylake canal\slope stability\20160428 additional\b4-seep 20160428.pl2 Run By: PGS 4/28/2016 02:33PM



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Safety Factors Are Calculated By The Modified Bishop Method

STED

Skylake Canal B-01-K Existing Slope B-4 Stage El. 82

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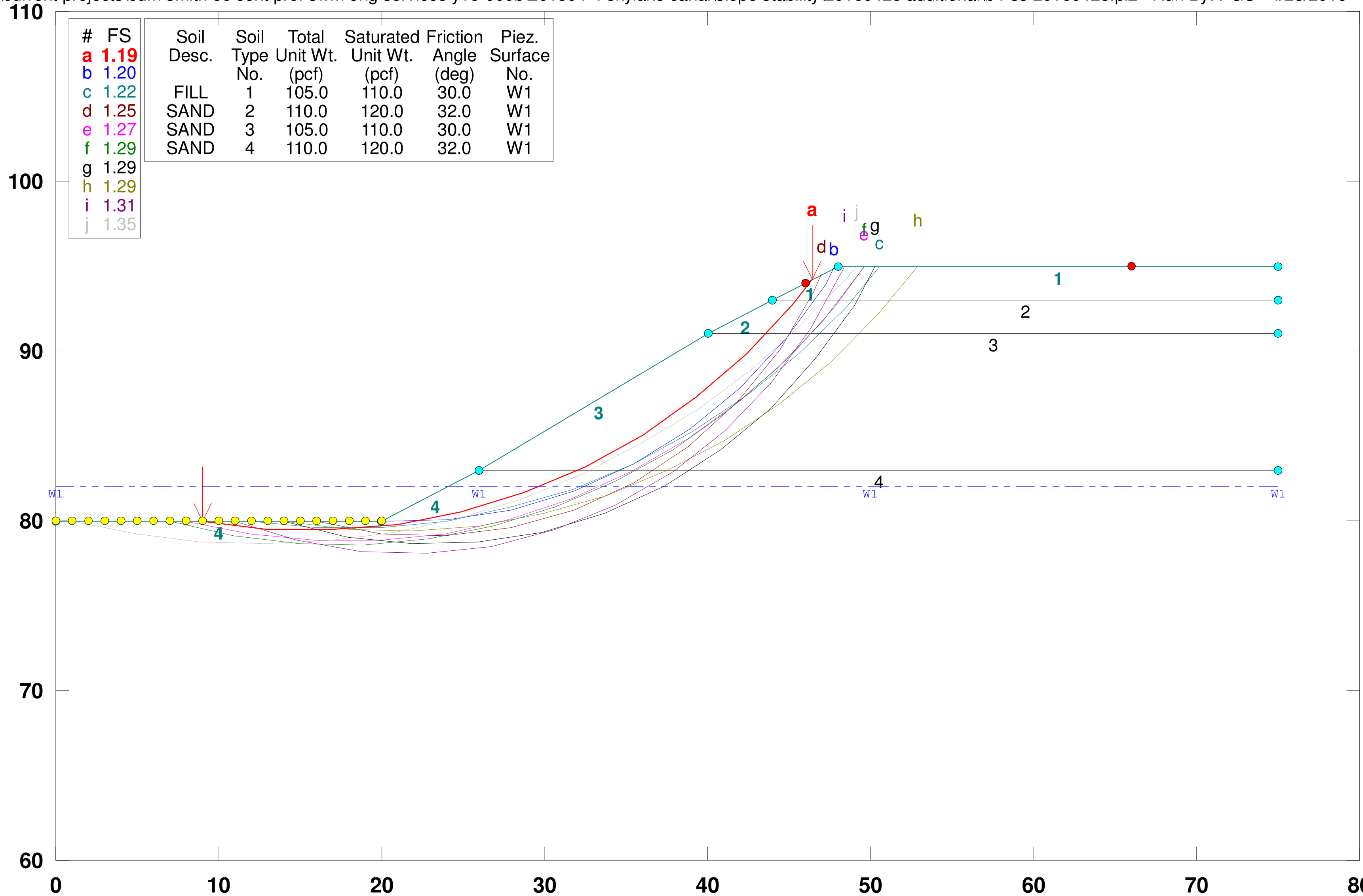

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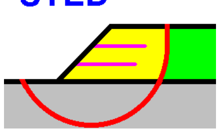
Safety Factors Are Calculated By The Modified Bishop Method



Skylake Canal B-01-K Existing Slope B-4 Stage El. 80

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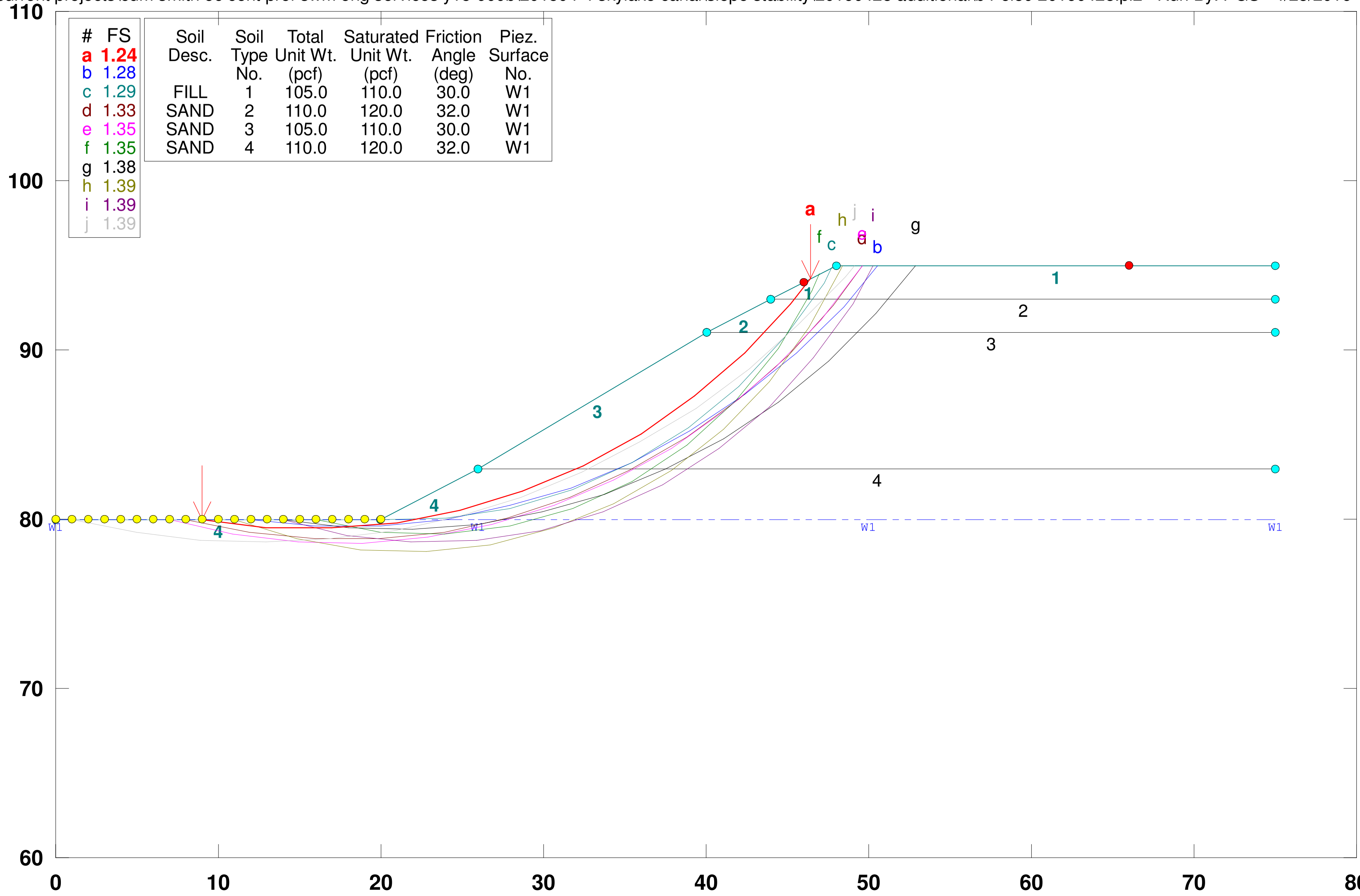

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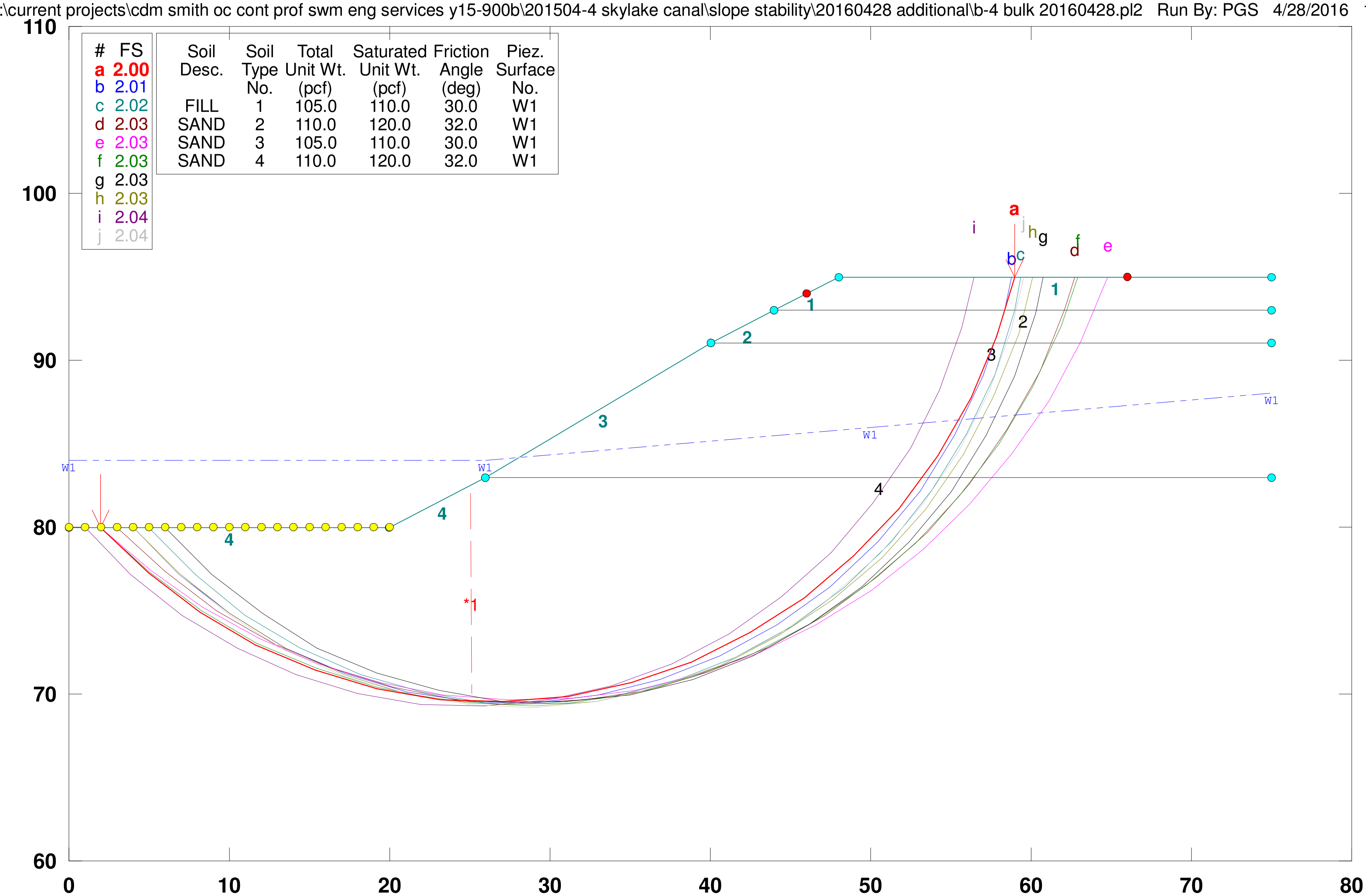
Safety Factors Are Calculated By The Modified Bishop Method

STED

APPENDIX B

Skylake Canal B-01-K Ex Slope Boring B-4 Sheet Pile Bulwark

s:\current projects\cdm smith oc cont prof swm eng services y15-900b\201504-4 skylake canal\slope stability\20160428 additional\b-4 bulk 20160428.pl2 Run By: PGS 4/28/2016 10:35AM



PCSTABL5M/si FSmin=2.00

Safety Factors Are Calculated By The Modified Bishop Method

STED

November 7, 2016

CDM Smith
2301 Maitland Center Parkway, Suite 300
Maitland, Florida 32751

Attention: Jane Williams, P.E.

Reference: Side-Slope Stabilization Technical Memorandum
Skylake Canal Improvements
Orange County, Florida
AEA Project No. 201504-4

Dear Ms. Wiliams:

Antillian Engineering Associates, Inc. has completed an initial stabilization analysis for a failed side-slope in Section B-01K of the Skylake Canal. The work was done in accordance with the scope of services presented in our proposal dated June 22, 2016. The proposed stabilization method consists of installing a row of vertical, structural elements parallel to the channel beneath the channel side-slope near the toe. These vertical elements would

a. supplement the shear resistance of the channel side slopes to shallow rotational failures like those observed in Section B-01K of the channel, and
b. connect shallow soils that are more prone to rotational failure to deeper, more stable soils

Buried vertical elements satisfy criteria established earlier by the CDM Smith design team, i.e., that any channel side-slope repair or stabilization procedure should;

a. maintain the volume flow capacity of the channel by not reducing its cross-sectional area
b. match the adjacent the channel cross-sections, to avoid the formation of eddies that might cause unintended channel erosion upstream or downstream of the repaired side-slope,
c. not reduce the existing maintenance berm width at the top of the side-slope, and
d. be economical, durable, and low-maintenance.

SYNOPSIS OF PRELIMINARY STUDY

Our May 2, 2016 technical memorandum presented the results of a preliminary study we conducted in a segment of Section B-01K, where the side-slope had undergone a shallow, rotational failure. Topographical survey information revealed that the side-slopes in this segment had been excavated at an inclination of about 1.5 Horizontal to 1 Vertical (“1.5H:1V”). By comparison, side slopes in ponds are typically excavated at 3H:1V, or half as steep as the channel, so we anticipated that the factor of safety against rotational failure would be lower than accepted by current design standards.

The first analysis we conducted in the preliminary study was of the existing slope as constructed. That analysis yielded a factor of safety against rotational failure of 1.1, which was significantly lower than the generally accepted minimum value of 1.5 for long-term stability in soil slope design. The results showed that the B-01K side-slope as constructed had very little, if any, reserve stability, probably because of its steep inclination.

The final analysis in the preliminary study showed that placing a vertical boundary to represent an idealized, barrier or wall buried beneath the side-slope near the toe increased the factor of safety against rotational failure from 1.1 to 2.0. When we compared the summary output plots for those two analyses, we observed that the worst-case potential failure surfaces with the barrier were deeper below the slope, as expected.

The results of the preliminary study indicated that channel side-slope stability against rotational failure could be improved by placing a rigid, vertical boundary beneath the slope near the toe. The vertical boundary acted like an idealized barrier or wall to counteract the formation of shallow potential-failure surfaces. Those results also suggested that a vertical barrier or wall could have prevented the failure in the B-01K side-slope. However, because the scope of that study was limited, we were unable to examine the type of barrier or wall, nor possible positions or depth within the slope. We were also unable to examine the possible effects of soil shear resistance reduction associated with the observed failure. Reduced ("residual") shear resistance is caused by large soil displacements during rotational failure and is lower than the peak shear resistance typically used for soil slope design. Accounting for post-failure, residual shear properties could enable the development of a repair procedure for failed slopes. Orange County commissioned this additional study to examine the potential benefits of vertical barriers in more detail. This memorandum presents the results of the additional study.

INTRODUCTION TO ADDITIONAL STUDY

We began this study with the results of the analyses in the preliminary study, including those analyses with the vertical boundary representing an idealized barrier or wall. The results of the STABL5M analyses included x-y coordinates representing points on the B-01K channel side-slope, the subsurface soil profiles developed from boring B-4, the surface-water and estimated groundwater surfaces used in the analyses, the ten most likely ("least stable") rotational-failure surfaces for each case, and the vertical barrier. STABL5M uses that information to generate plots of the results. We used excerpts of that same information to develop a plot of the channel side-slope to illustrate its geometry, the soil profile, the idealized vertical barrier, and the most likely rotational-failure surfaces with and without that barrier. That plot is presented in Appendix A. The STABL5M outputs, including summary plots and printed outputs, are presented in Appendix B.

BARRIER PLACEMENT AND CONFIGURATION

Typical rotational-stability analyses are two-dimensional. They assume infinitely long failures in infinitely long slopes, to avoid the complication of calculating loads and soil resistance values along the ends of actual, finite, "real-world" failures. The result is that stability analyses can be conducted using manageable, one-foot-wide ("unit-width") segments of the slope. Loads, resistance values, and moments are expressed in applicable units per unit width. Factors of safety are dimensionless ratios. In keeping with that approach, we assumed that the vertical barrier was also infinitely long. In reality, the barrier would be at least as long as the width of the actual section of slope to be stabilized.

The vertical barrier was placed in the slope almost directly below the indicated center of rotation of the shallow, rotational-failure surface. We did this so that the barrier would be loaded in a horizontal, or near-horizontal direction, enabling numerical results of the rotational-failure ("slope stability") analyses to be used for conventional lateral earth pressure ("retaining wall") analyses without having to resolve forces into horizontal and vertical components. We discovered that this location placed the vertical barrier below the steady-state water surface in the channel, where it is not likely to be disturbed mowing operations on the slope.

The upper end of the vertical barrier was initially positioned to engage the full depth of the soil mass above the shallow rotational-failure surface (the "failure mass"). We then lowered it about a foot below the slope surface so that it would not be exposed, resulting in a vertical barrier height above the shallow failure surface of about two feet. We arbitrarily selected an initial, minimum, vertical-barrier penetration of ten feet into the undisturbed soils below the failure surface, with the expectation that we could increase it as needed to enhance stability. Based on those dimensions, the overall height of the vertical barrier was about 12 feet. The configuration of the vertical barrier is shown in Appendix A.

GEOTECHNICAL STABILITY ANALYSES

We examined the ability of the vertical barrier to support the soil mass above the shallow failure surface (the "failure mass"). From a geotechnical-engineering perspective, the vertical barrier would function like an idealized retaining wall, resisting the force from the soils in the failure mass (and limiting their displacement) by mobilizing the passive resistance of the soils below that surface.

Although the vertical barrier was modeled as an idealized retaining wall, we did not calculate the lateral load conventionally using active earth pressure theory because that approach uses peak shear properties that may no longer exist as the soil in the slope approaches the failure condition. Instead, we used the tabulated output from the initial analysis to obtain more detailed information about the anticipated load from the soil failure mass.

To analyze stability against rotational failure, the Bishop method divides the failure mass into vertical slices. STABL5M divided the failure mass on the shallow rotational-failure surface into 16 slices. The STABL5M output provided numerical information about those slices, which we used to calculate the force exerted in the direction of failure by the portion of the failure mass behind the vertical barrier. The force we obtained (which we designated the "down-slope" force) was about 4.1 kips per foot width (klf) of channel side-slope. By comparison, the lateral load calculated conventionally using active earth pressure theory was less than 1 klf.

The STABL5M output also provided shear resistance along the base of each vertical slice in the failure mass. We calculated the total shear resistance in the direction of failure for the portion of the failure mass above and behind the vertical barrier, and obtained a shear resistance of 4.8 klf. Since the side slope in Section B-01K had already failed, we decided not to use the shear resistance we calculated because it was based on the peak shear resistance properties that are typically used for design. Residual shear strength values (which are lower than peak shear strength values) would have been more appropriate, but we did not have enough information to estimate them. Instead, we made the simplifying assumption that the shallow failure surface would offer no shear resistance. Under those conditions, the vertical barrier would have to resist the force from the portion of the failure mass above and behind it by mobilizing only the passive earth pressure of the portion below the failure surface against the underlying, undisturbed soil.

We calculated the passive pressure mobilized against the ten-foot-deep section of vertical barrier below the shallow failure surface using conventional, lateral-earth-pressure methods. We obtained a total passive resistance force of 16.8 klf, or more than four times the down-slope force. Based on those results, we concluded that the ten-foot portion of vertical barrier below the shallow failure surface could mobilize sufficient passive soil resistance to resist the down-slope force imposed by the failure mass. In other words, the vertical barrier, modeled as an idealized wall, enabled adequate stability in a slope that had little, if any, reserve stability against shallow rotational failure. The tabulated STABL5M output, the down-slope force calculation, and shear resistance calculation are attached as Appendix C.

We also checked the structural capability of an assumed vertical barrier by calculating its resistance to bending as a vertical cantilever under the down-slope load. For this analysis, we assumed a PZ-22, steel, sheet-pile, one of the smaller, structural steel, sheet-pile shapes available. That shape was reported to be 22 inches wide (about two feet), so we multiplied the total down-slope force of 4.1 klf by two to account for the increased width, applied that load to a moment arm equal to the two-foot-long upper portion of the vertical barrier to yield an estimated bending moment of 16.4 foot-kips on each section of sheet pile. Using the published section modulus of 18.1 inches cubed per foot (in^3/ft) for the PZ-22 section , we calculated a bending stress of 10.9 kips per square inch (ksi), which was about 28 percent of the 39 ksi yield stress for ASTM A 328 mild steel. Using the converse approach, any A 328 mild steel structural shape with a section modulus higher than 5.1 in^3/ft for a unit width of one foot should resist the total down-slope force without exceeding 50 percent of its 39 ksi yield strength in bending. These results indicated that a typical steel sheet-pile section can be used as a vertical barrier. Smaller sections may be used if higher bending stresses are acceptable.

Based on these results, it is our professional opinion that channel side slopes can be stabilized by driving readily available, structural-steel shapes into those slopes to form vertical barriers that can resist lateral loads and supplement overall slope resistance to shallow rotational failure. Placing these structural shapes near the toe of the slope reduces the length within potential failure masses while keeping bending moments and bending stresses within reasonable limits for A 328 steel shapes. Even with an overall length of just 12 feet, vertical barriers can mobilize adequate passive soil resistance to resist down-slope force associated with a failed soil mass, and transfer that force to deeper soils that offer more resistance to rotational failure.

VERTICAL BARRIER TYPES

It is our professional opinion that vertical barriers should be made from low-displacement structural-steel shapes, such as sheet piles, H-piles or pipe piles. Structural steel shapes less than 15 feet long should be readily available because they are rarely usable for any other structural purpose. As a result, they should be available for little more than the purchase price of recycled steel. Installation of short sections should be less expensive than conventional steel shapes, because the heavier, hydraulic, vibratory hammers that are typically used may not be needed. Lighter driving equipment, including small, impact hammers running on compressed air, may be able to drive these shapes.

We also considered other readily-available, economical, vertical elements such as timber piles and precast concrete pile cut-offs. Those shapes require more effort to set up for installation, require higher driving energies and typically generate more vibration and soil disturbance during installation than the low-displacement, steel, structural shapes listed above. Auger-cast concrete piles may be needed in cases where slopes are very unstable because their installation methods have very low associated disturbance. However, these piles usually have high mobilization costs and usually are not economical in the small quantities that would be needed for a typical, slope-stabilization project.

SOIL RESIDUAL SHEAR PROPERTIES

As discussed earlier in this memorandum, soil properties in and near the failure mass and potential rotational-failure surfaces were probably closer to the residual shear condition. We avoided the problem of estimating values for those properties in this study by using the simplifying assumption of zero shear resistance along the failure surface. Though convenient, that assumption is unrealistic because some shear resistance is always available, in which case the net down-slope force imposed by the retained portion of the failure mass is probably lower than the value obtained in the analysis. Since the resulting analyses would be more conservative, it would appear at this point that estimating residual shear properties is probably unnecessary.

SEEPAGE IN SIDE SLOPES

We did not consider the effect of seepage forces acting on the vertical barrier in the analyses because vertical barriers are likely to be less than 60 feet wide, based on the failures we observed. That is probably not wide enough to restrict seepage in the slope to the point that significant seepage forces would be generated. However, if seepage forces in a particular channel side-slope are a concern, the sections of vertical barrier material should be perforated before being installed.

STABILIZATION OF FAILED SLOPES

A failed soil slope is usually repaired by removing the entire failure mass and all the disturbed soils within the rotational-failure zone until undisturbed soils are exposed. Terraces or "benches" are then excavated into the exposed soils in the slope to provide near-level surfaces for receiving the fill for the slope repair. We recommend installing the row of vertical barriers before placing the repair fil, so that barrier location and depth can be verified. Barrier location, length and penetration should be developed using the results of a rotational-stability analysis of the existing slope, if it has not failed, or the slope that existed before the failure occurred.

Repair fill should be placed uniformly on both sides of the barrier, beginning on the lowest terrace, and compacted in accordance with specifications selected by Orange County. In the absence of suitable specifications from Orange County, we recommend compacting the repair fill to achieve an in-place dry density not less than 95 percent of the maximum obtained by the Modified Proctor method, ASTM D 1557. Repair fill should be placed and graded as needed to restore the original channel side-slope configuration, before being stabilized with sod, erosion matting or rip-rap.

Slopes repaired in the manner described above can be analyzed using peak soil shear properties.

LIMITATIONS

This report presents an evaluation of the subsurface conditions on the basis of accepted geotechnical procedures for slope stabilty analysis. The analyses were confined to the zone of soil which is likely to be affected by the proposed construction, and did not address the potential of surface expression of deep geologic activity such as sinkholes. This type of evaluation requires a more extensive range of services than those performed for this study.

Because of the natural limitations inherent in working with the subsurface, a geotechnical engineer cannot predict and address all possible problems. During construction, geotechnical issues not addressed in this report may arise. The bulletin "Important Information About Your Geotechnical-Engineering Report" published by the Geoprofessional Business Association (GBA) is presented in Appendix C to help explain the nature of geotechnical issues. Additional information is presented in Appendix D to discuss the potential concerns and the basic limitations of a typical geotechnical investigation report.

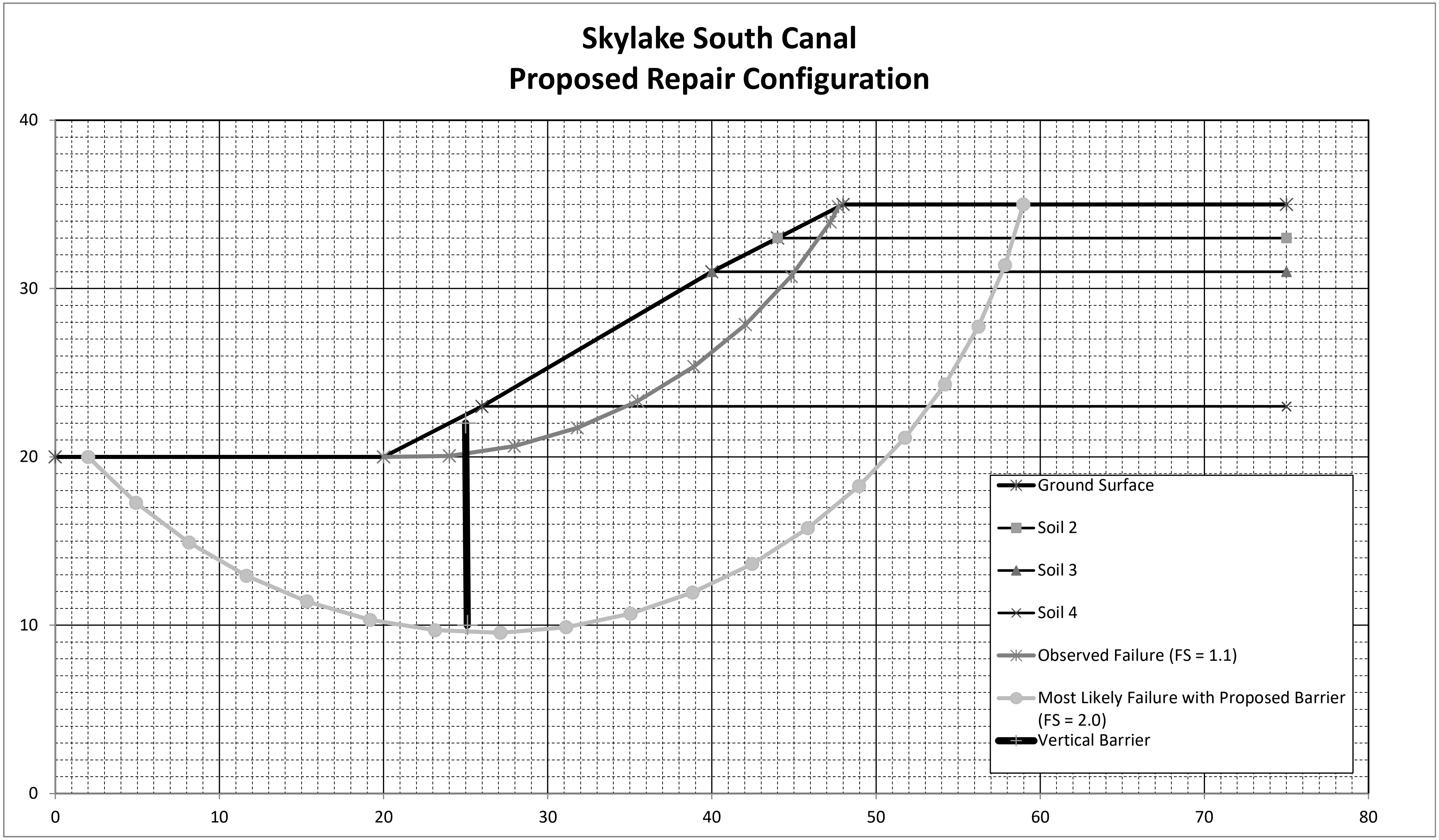
It has been our pleasure to continue serving CDM Smith and Orange County Stormwater Department on this project. Please contact our office if you have any questions or if you need additional information.

ANTILLIAN ENGINEERING ASSOCIATES, INC.

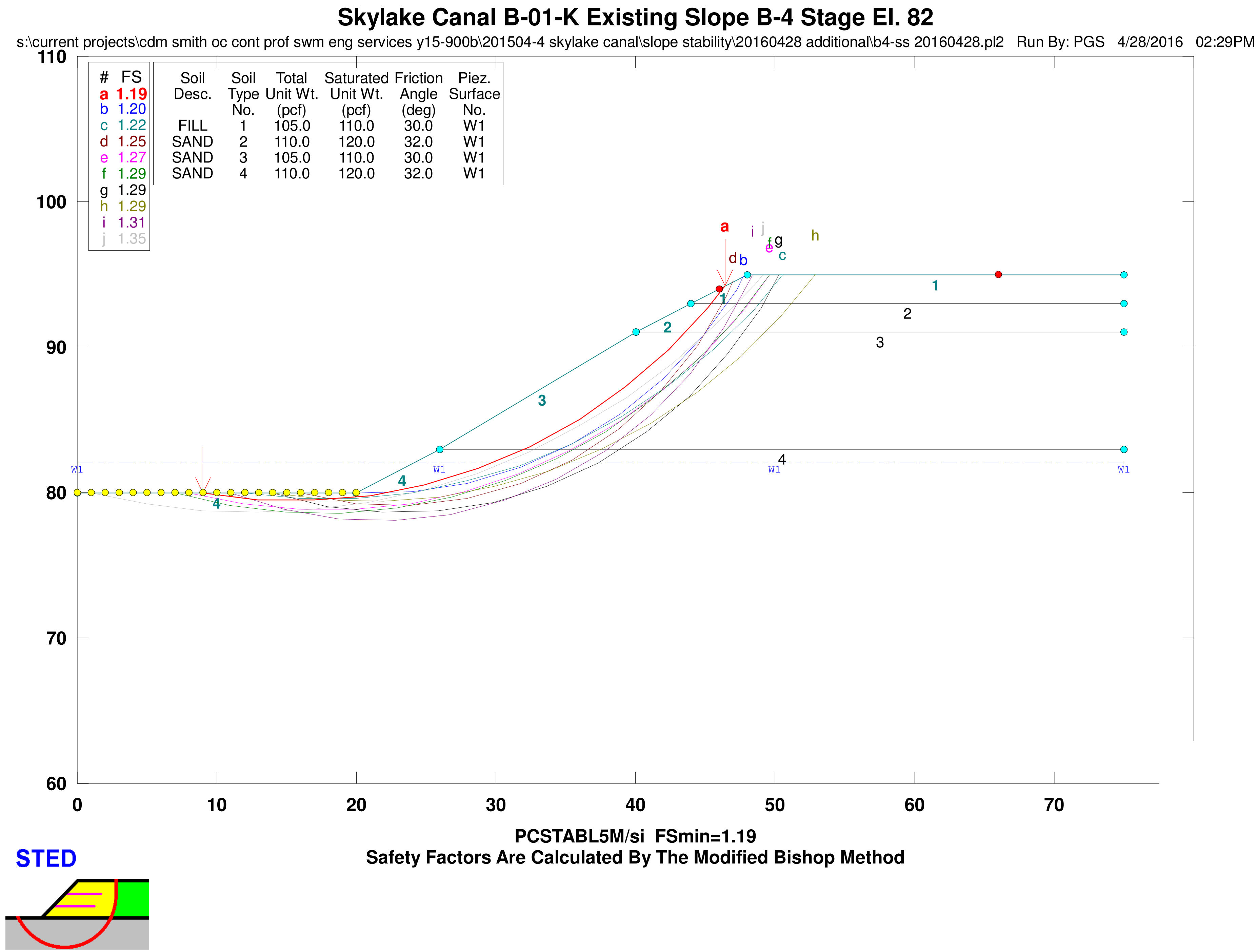
Peter G. Suah, P.E.
Principal Engineer
Florida Registration No. 46910

Attachments: Appendix A - Plot of B-01K Side Slope
Appendix B - Rotational Stability Analyses of Slope with and without Vertical Barrier
Appendix C: Important Information About This Geotechnical-Engineering Report
Appendix D: Constraints and Restrictions

APPENDIX A


Skylake South Canal
Proposed Repair Configuration
Ground Surface
Soil 2
Soil 3
Soil 4
Observed Failure (FS = 1.1)
Most Likely Failure with Proposed Barrier (FS = 2.0)
Vertical Barrier
0
10
20
30
40
50
60
70
80

APPENDIX B



Skylake Canal B-01-K Existing Slope B-4 Stage El. 82
s:\current projects\cdm smith oc cont prof swm eng services y15-900b\201504-4 skylake canal\slope stability\20160428 additional\b4-ss 20160428.pl2 Run By: PGS 4/28/2016 02:29PM
FS
a 1.19
b 1.20
c 1.22
d 1.25
e 1.27
f 1.29
g 1.29
h 1.29
i 1.31
j 1.35
Soil Desc. | Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Friction Angle (deg) | Piez. Surface No.
FILL 1 105.0 110.0 30.0 W1
SAND 2 110.0 120.0 32.0 W1
SAND 3 105.0 110.0 30.0 W1
SAND 4 110.0 120.0 32.0 W1
110
100
90
80
70
60
0
10
20
30
40
50
60
70
W1
PCSTABL5M/si FSmin=1.19
Safety Factors Are Calculated By The Modified Bishop Method
STED

** PCSTABL5M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 4/28/2016
Time of Run: 10:31AM
Run By: PGS
Input Data Filename: S:B-4 20160428.in
Output Filename: S:B-4 20160428.OUT
Unit: ENGLISH
Plotted Output Filename: S:B-4 20160428.PLT

PROBLEM DESCRIPTION Skylake Canal B-01-K
Existing Slope at Boring B-4

BOUNDARY COORDINATES

6 Top Boundaries
9 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	20.00	20.00	20.00	4
2	20.00	20.00	26.00	23.00	4
3	26.00	23.00	40.00	31.00	3
4	40.00	31.00	44.00	33.00	2
5	44.00	33.00	48.00	35.00	1
6	48.00	35.00	75.00	35.00	1
7	44.00	33.00	75.00	33.00	2
8	40.00	31.00	75.00	31.00	3
9	26.00	23.00	75.00	23.00	4

1

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	105.0	110.0	0.0	30.0	0.00	0.0	1
2	110.0	120.0	0.0	32.0	0.00	0.0	1
3	105.0	110.0	0.0	30.0	0.00	0.0	1
4	110.0	120.0	0.0	32.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	24.00
2	26.00	24.00
3	50.00	26.00
4	75.00	28.00

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

168 Trial Surfaces Have Been Generated.

8 Surfaces Initiate From Each Of 21 Points Equally Spaced Along The Ground Surface Between X = 0.00 ft.
and X = 20.00 ft.

Each Surface Terminates Between X = 46.00 ft.
and X = 66.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 0.00 ft.

4.00 ft. Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	20.00	20.00
2	24.00	20.06
3	27.96	20.64
4	31.81	21.73
5	35.48	23.32
6	38.91	25.37
7	42.04	27.85
8	44.83	30.73
9	47.21	33.94
10	47.71	34.86

Circle Center At X = 21.6 ; Y = 50.3 and Radius, 30.3

*** 1.076 ***

Individual data on the 16 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	4.0	466.4	837.1	991.3	0.0	0.0	0.0	0.0	0.0
2	2.0	551.3	209.3	478.9	0.0	0.0	0.0	0.0	0.0
3	2.0	709.6	71.7	441.6	0.0	0.0	0.0	0.0	0.0
4	3.8	1761.0	0.0	781.4	0.0	0.0	0.0	0.0	0.0
5	2.9	1533.0	0.0	447.0	0.0	0.0	0.0	0.0	0.0
6	0.7	392.4	0.0	79.1	0.0	0.0	0.0	0.0	0.0
7	2.9	1532.4	0.0	153.0	0.0	0.0	0.0	0.0	0.0
8	0.6	299.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	1.1	559.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	2.0	963.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0

11	2.0	763.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.8	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.2	56.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	1.5	300.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.7	70.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.5	17.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	9.00	20.00
2	12.97	19.54
3	16.97	19.48
4	20.96	19.82
5	24.89	20.56
6	28.73	21.69
7	32.43	23.20
8	35.96	25.07
9	39.29	27.29
10	42.38	29.83
11	45.20	32.67
12	46.45	34.23

Circle Center At X = 15.6 ; Y = 59.0 and Radius, 39.6

*** 1.098 ***

1

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	12.00	20.00
2	15.98	19.63
3	19.98	19.63
4	23.96	20.01
5	27.89	20.77
6	31.73	21.89
7	35.45	23.37
8	39.01	25.20
9	42.38	27.35
10	45.53	29.81
11	48.43	32.56
12	50.56	35.00

Circle Center At X =   18.0 ; Y =   61.8 and Radius,   42.2

***   1.119   ***

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	16.00	20.00
2	19.93	19.26
3	23.93	19.11
4	27.90	19.57
5	31.76	20.62
6	35.42	22.23
7	38.80	24.38
8	41.81	27.01
9	44.40	30.06
10	46.50	33.46
11	46.92	34.46

Circle Center At X =   22.9 ; Y =   45.7 and Radius,   26.6

***   1.132   ***

1

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	14.00	20.00
2	17.89	19.06
3	21.86	18.63
4	25.86	18.72
5	29.82	19.33
6	33.66	20.46
7	37.32	22.07
8	40.74	24.14
9	43.86	26.64
10	46.63	29.53
11	49.00	32.75
12	50.24	35.00

Circle Center At X = 23.2 ; Y = 49.2 and Radius, 30.6

*** 1.175 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	14.00	20.00
2	17.97	19.51
3	21.97	19.42
4	25.96	19.72
5	29.90	20.41
6	33.75	21.49
7	37.48	22.94
8	41.05	24.74
9	44.42	26.89
10	47.57	29.36
11	50.45	32.13
12	52.91	35.00

Circle Center At X = 20.9 ; Y = 60.0 and Radius, 40.6

*** 1.175 ***

1

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.00	20.00
2	11.92	19.21
3	15.90	18.81
4	19.90	18.82
5	23.88	19.24
6	27.79	20.06
7	31.61	21.27
8	35.28	22.87
9	38.77	24.82
10	42.04	27.12
11	45.06	29.74
12	47.80	32.65

13	49.60	35.00

Circle Center At X = 17.8 ; Y = 58.2 and Radius, 39.4

*** 1.181 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	7.00	20.00
2	10.90	19.12
3	14.87	18.65
4	18.87	18.57
5	22.86	18.91
6	26.79	19.65
7	30.63	20.78
8	34.33	22.29
9	37.86	24.17
10	41.18	26.40
11	44.26	28.96
12	47.06	31.81
13	49.56	34.94
14	49.60	35.00

Circle Center At X = 17.6 ; Y = 57.9 and Radius, 39.4

*** 1.202 ***

1

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	11.00	20.00
2	14.82	18.83
3	18.77	18.18
4	22.77	18.07
5	26.75	18.50
6	30.63	19.47
7	34.35	20.94
8	37.83	22.91

9	41.02	25.32
10	43.85	28.15
11	46.28	31.32
12	48.26	34.80
13	48.34	35.00

Circle Center At X = 21.6 ; Y = 47.7 and Radius, 29.6

*** 1.215 ***

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	20.00	20.00
2	23.91	19.14
3	27.90	18.94
4	31.88	19.39
5	35.72	20.50
6	39.33	22.23
7	42.60	24.52
8	45.45	27.33
9	47.80	30.57
10	49.58	34.15
11	49.84	35.00

Circle Center At X = 27.1 ; Y = 43.1 and Radius, 24.2

*** 1.230 ***

1

```
              Y            A     X     I     S           F     T

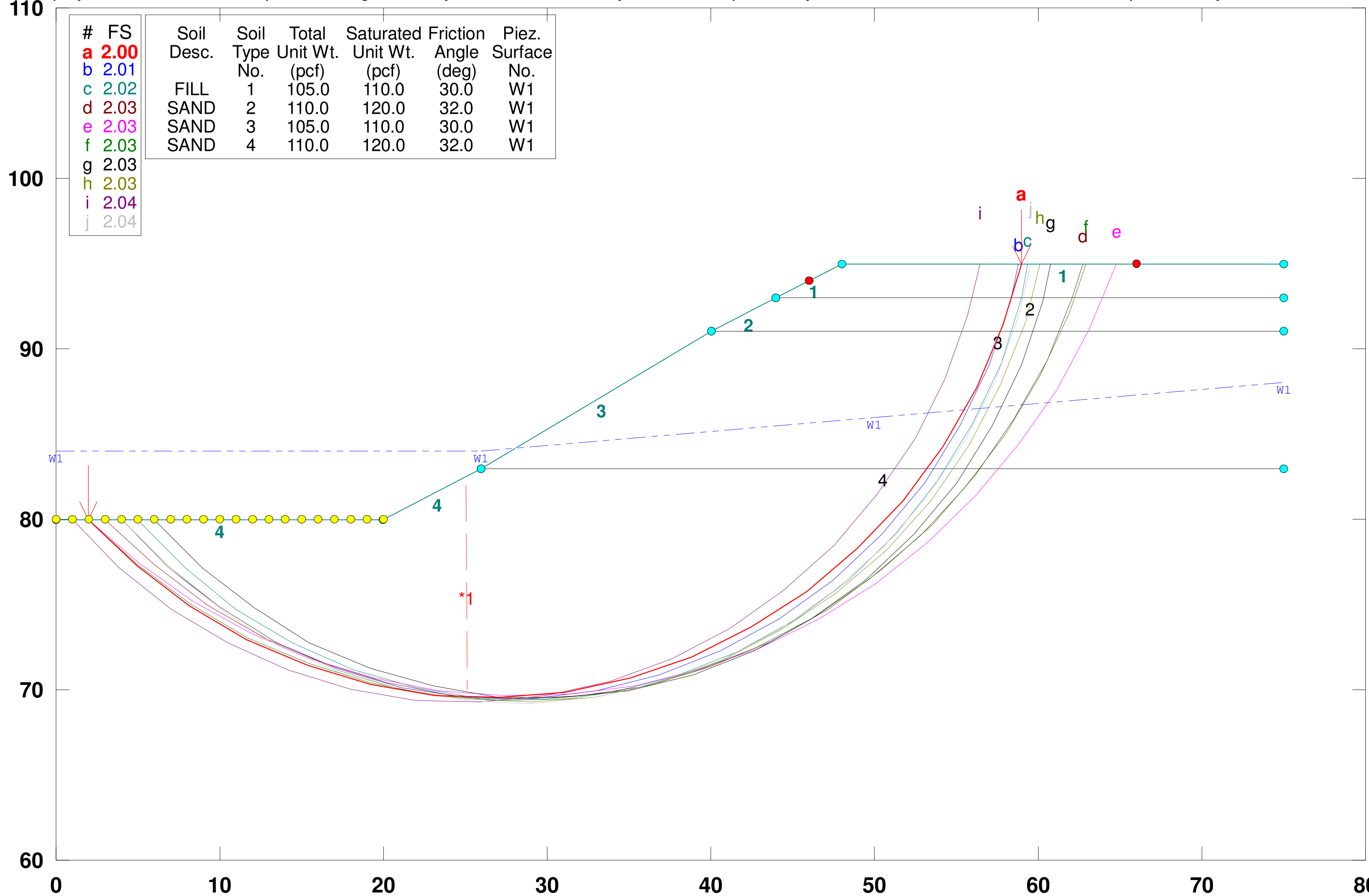
              0.00      9.38     18.75     28.13     37.50     46.88

X       0.00 +---------+---------+*----W---+---------+---------+
             -                    .
             -                 ....
             -                 ....
             -               . ...8
             -               .....7
        9.38 +            .. .....2
             -            .......89
```

```
             -            . ......72
             -            ........95
             -            ........73
             -          ..........52
A     18.75  +           ........986
             -         ... .......7*
             -         ...........56
             -          .........941
             -         ...........  2
             -         ...........56   *W
X     28.13  +        ............0412
             -         ............56
             -         ............941.
             -         ............  .2
             -         .............568
             -         .............0.41.2
I     37.50  +          ..............5 8
             -          ..............0 41.2
             -          ................598    *
             -           ..............0. 31.2
             -           .................56984  *
             -            .................0..31.2
S     46.88  +             ....... ..........5.98.12
             -             ....................0.3.*
             -              ......... ....W.....6.03
             -              ......................
             -               ................ ....6
             -                ....................
      56.25  +                  .... ..............
             -                   ................ ..
             -                     ................
             -                       ..............
             -                          ............
             -                              ........
F     65.63  +                                  ....
             -
             -
             -
             -
             -
T     75.00  +                        *    W  * * *
```

Skylake Canal B-01-K Ex Slope Boring B-4 Sheet Pile Bulwark

s:\current projects\cdm smith oc cont prof swm eng services y15-900b\201504-4 skylake canal\slope stability\20160428 additional\b-4 bulk 20160428.pl2 Run By: PGS 4/28/2016 10:35AM



PCSTABL5M/si FSmin=2.00

Safety Factors Are Calculated By The Modified Bishop Method

STED

** PCSTABL5M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:	4/28/2016
Time of Run:	10:35AM
Run By:	PGS
Input Data Filename:	S:B-4 BULK 20160428.in
Output Filename:	S:B-4 BULK 20160428.OUT
Unit:	ENGLISH
Plotted Output Filename:	S:B-4 BULK 20160428.PLT

PROBLEM DESCRIPTION   Skylake Canal B-01-K
Ex Slope Boring B-4 Sheet Pile Bulwark

BOUNDARY COORDINATES

6 Top   Boundaries
9 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	20.00	20.00	20.00	4
2	20.00	20.00	26.00	23.00	4
3	26.00	23.00	40.00	31.00	3
4	40.00	31.00	44.00	33.00	2
5	44.00	33.00	48.00	35.00	1
6	48.00	35.00	75.00	35.00	1
7	44.00	33.00	75.00	33.00	2
8	40.00	31.00	75.00	31.00	3
9	26.00	23.00	75.00	23.00	4

1

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	105.0	110.0	0.0	30.0	0.00	0.0	1
2	110.0	120.0	0.0	32.0	0.00	0.0	1
3	105.0	110.0	0.0	30.0	0.00	0.0	1
4	110.0	120.0	0.0	32.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	24.00
2	26.00	24.00
3	50.00	26.00
4	75.00	28.00

1

Searching Routine Will Be Limited To An Area Defined By 1 Boundaries
Of Which The First 0 Boundaries Will Deflect Surfaces Upward

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)
1	25.00	22.00	25.10	10.00

1

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

168 Trial Surfaces Have Been Generated.

8 Surfaces Initiate From Each Of 21 Points Equally Spaced
Along The Ground Surface Between X = 0.00 ft.
and X = 20.00 ft.

Each Surface Terminates Between X = 46.00 ft.
and X = 66.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 0.00 ft.

4.00 ft. Line Segments Define Each Trial Failure Surface.

**** ERROR - RC11 ****

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	2.00	20.00
2	4.92	17.27
3	8.15	14.91
4	11.64	12.94
5	15.33	11.41
6	19.18	10.32
7	23.13	9.70
8	27.13	9.55
9	31.12	9.88
10	35.04	10.68
11	38.83	11.94
12	42.45	13.64
13	45.85	15.76
14	48.96	18.27
15	51.76	21.13
16	54.20	24.30
17	56.24	27.74
18	57.86	31.39
19	58.97	35.00

Circle Center At X = 26.4 ; Y = 43.2 and Radius, 33.6

*** 1.997 ***

Individual data on the 28 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	2.9	478.9	729.8	1339.0	0.0	0.0	0.0	0.0	0.0
2	3.2	1514.7	805.6	1974.6	0.0	0.0	0.0	0.0	0.0
3	3.5	2540.3	869.9	2514.5	0.0	0.0	0.0	0.0	0.0
4	3.7	3467.5	921.9	2951.0	0.0	0.0	0.0	0.0	0.0
5	3.8	4219.5	960.9	3278.2	0.0	0.0	0.0	0.0	0.0
6	0.8	957.8	204.5	711.2	0.0	0.0	0.0	0.0	0.0
7	3.1	4072.2	702.9	2780.0	0.0	0.0	0.0	0.0	0.0
8	2.9	4347.8	343.5	2569.9	0.0	0.0	0.0	0.0	0.0
9	1.1	1859.4	54.7	1017.0	0.0	0.0	0.0	0.0	0.0
10	4.0	7124.4	0.0	3617.0	0.0	0.0	0.0	0.0	0.0
11	3.9	7675.3	0.0	3558.7	0.0	0.0	0.0	0.0	0.0
12	3.8	7851.3	0.0	3382.7	0.0	0.0	0.0	0.0	0.0
13	1.2	2464.0	0.0	1035.5	0.0	0.0	0.0	0.0	0.0
14	2.5	5175.9	0.0	2056.0	0.0	0.0	0.0	0.0	0.0
15	1.5	3241.5	0.0	1283.3	0.0	0.0	0.0	0.0	0.0
16	1.8	3798.9	0.0	1405.7	0.0	0.0	0.0	0.0	0.0
17	2.2	4292.0	0.0	1567.6	0.0	0.0	0.0	0.0	0.0
18	1.0	1826.9	0.0	613.7	0.0	0.0	0.0	0.0	0.0
19	1.0	1856.4	0.0	660.6	0.0	0.0	0.0	0.0	0.0
20	1.8	2847.3	0.0	914.5	0.0	0.0	0.0	0.0	0.0
21	1.4	2014.4	0.0	607.9	0.0	0.0	0.0	0.0	0.0
22	1.0	1212.2	0.0	269.5	0.0	0.0	0.0	0.0	0.0
23	1.3	1306.4	0.0	157.9	0.0	0.0	0.0	0.0	0.0
24	0.8	649.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	1.4	870.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.2	71.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.5	147.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.6	64.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	4.00	20.00
2	6.86	17.20
3	10.05	14.79
4	13.51	12.79
5	17.20	11.24
6	21.06	10.17

7	25.01	9.59
8	29.01	9.51
9	32.99	9.93
10	36.88	10.85
11	40.63	12.25
12	44.17	14.11
13	47.45	16.40
14	50.42	19.08
15	53.03	22.12
16	55.23	25.45
17	57.00	29.04
18	58.31	32.82
19	58.77	35.00

Circle Center At X = 27.6 ; Y = 41.3 and Radius, 31.8

*** 2.009 ***

1

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.00	20.00
2	7.84	17.18
3	11.01	14.74
4	14.46	12.72
5	18.14	11.16
6	21.99	10.08
7	25.95	9.50
8	29.95	9.42
9	33.93	9.86
10	37.82	10.79
11	41.55	12.21
12	45.08	14.10
13	48.34	16.42
14	51.28	19.13
15	53.85	22.19
16	56.01	25.56
17	57.73	29.17
18	58.97	32.98
19	59.35	35.00

Circle Center At X = 28.5 ; Y = 40.8 and Radius, 31.4

*** 2.023 ***

Failure Surface Specified By 20 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	3.00	20.00
2	5.97	17.32
3	9.23	15.00
4	12.72	13.05
5	16.41	11.50
6	20.24	10.37
7	24.18	9.67
8	28.18	9.42
9	32.17	9.62
10	36.12	10.26
11	39.97	11.33
12	43.68	12.83
13	47.20	14.73
14	50.48	17.02
15	53.49	19.65
16	56.19	22.60
17	58.54	25.84
18	60.52	29.32
19	62.10	32.99
20	62.70	35.00

Circle Center At X = 28.4 ; Y = 45.2 and Radius, 35.8

*** 2.027 ***

1

Failure Surface Specified By 21 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	2.00	20.00
2	5.06	17.43
3	8.37	15.18
4	11.90	13.29
5	15.60	11.78
6	19.44	10.65
7	23.37	9.93
8	27.36	9.61
9	31.36	9.71

10	35.33	10.22
11	39.22	11.14
12	43.00	12.45
13	46.62	14.15
14	50.05	16.21
15	53.25	18.61
16	56.18	21.33
17	58.82	24.34
18	61.13	27.60
19	63.09	31.09
20	64.68	34.76
21	64.76	35.00

Circle Center At X = 28.4 ; Y = 48.3 and Radius, 38.7

*** 2.027 ***

Failure Surface Specified By 20 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	2.00	20.00
2	4.99	17.34
3	8.25	15.02
4	11.74	13.08
5	15.43	11.52
6	19.26	10.37
7	23.19	9.64
8	27.18	9.35
9	31.18	9.49
10	35.14	10.06
11	39.01	11.06
12	42.75	12.48
13	46.32	14.29
14	49.66	16.48
15	52.75	19.03
16	55.55	21.89
17	58.01	25.04
18	60.12	28.43
19	61.85	32.04
20	62.89	35.00

Circle Center At X = 27.9 ; Y = 46.1 and Radius, 36.7

*** 2.030 ***

1

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	6.00	20.00
2	8.86	17.20
3	12.05	14.79
4	15.51	12.79
5	19.20	11.24
6	23.06	10.17
7	27.02	9.60
8	31.01	9.52
9	34.99	9.94
10	38.88	10.87
11	42.63	12.27
12	46.17	14.13
13	49.45	16.42
14	52.41	19.11
15	55.02	22.15
16	57.22	25.48
17	58.99	29.07
18	60.29	32.86
19	60.73	35.00

Circle Center At X = 29.6 ; Y = 41.3 and Radius, 31.8

*** 2.031 ***

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	4.00	20.00
2	6.86	17.21
3	10.05	14.78
4	13.50	12.77
5	17.17	11.19
6	21.02	10.07
7	24.96	9.43
8	28.96	9.27
9	32.95	9.61
10	36.86	10.43
11	40.65	11.72

12	44.25	13.47
13	47.61	15.64
14	50.67	18.20
15	53.41	21.13
16	55.76	24.36
17	57.70	27.86
18	59.20	31.56
19	60.12	35.00

Circle Center At X = 28.2 ; Y = 41.9 and Radius, 32.7

*** 2.032 ***

1

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.00	20.00
2	3.84	17.18
3	7.01	14.74
4	10.46	12.71
5	14.13	11.13
6	17.97	10.02
7	21.92	9.39
8	25.92	9.25
9	29.90	9.62
10	33.81	10.47
11	37.58	11.81
12	41.16	13.61
13	44.48	15.83
14	47.50	18.45
15	50.17	21.43
16	52.46	24.71
17	54.31	28.26
18	55.71	32.00
19	56.43	35.00

Circle Center At X = 25.0 ; Y = 41.4 and Radius, 32.1

*** 2.036 ***

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	4.00	20.00
2	6.84	17.18
3	10.00	14.73
4	13.45	12.70
5	17.12	11.11
6	20.96	9.99
7	24.90	9.35
8	28.90	9.21
9	32.89	9.56
10	36.80	10.41
11	40.57	11.74
12	44.15	13.53
13	47.48	15.74
14	50.51	18.35
15	53.19	21.32
16	55.48	24.60
17	57.34	28.14
18	58.76	31.88
19	59.51	35.00

Circle Center At X = 28.0 ; Y = 41.3 and Radius, 32.1

*** 2.038 ***

1

```
           Y            A     X     I     S            F     T

           0.00      9.38     18.75     28.13     37.50     28.13

X      0.00 +---------+---------+*----W---+---------+---------+
            -                    1
            -                 9. 4
            -                 15 2
            -               9 2  7
            -               1 3  .
       9.38 +            .. 2 7  .
            -            .1 3 .
            -           ..4 7 .
            -           9.2 .
            -           157 .
            -         ..2..
A     18.75 +         .13.
            -        ..2.        *
            -        .93.
            -        .15
```

```
               -       ..2L          L
               -        .1.            *W
X     28.13 +       ..4
               -       ..2
               -       ..51
               -        .42
               -        ..1
               -        ..4.
I     37.50 +        ..829
               -         ..51
               -         ..42.9                 *
               -          ..3 1
               -          ..542.9                 *
               -          ....3.1
S     46.88 +           ...542..9
               -            .....31                   *
               -             ...5482..9    W
               -              .....3. 1 .
               -                ...54.82 9  .
               -                .......7 12. 9  .
      56.25 +                  ....54.83. 12  9  9
               -                    ......64.83 1 2 .
               -                      ...5...67. 83.1
               -                       .....5.4...7.7
               -                          ......564.4
               -                              ......5
F     65.63 +                                   ...
               -
               -
               -
               -
               -
T     75.00 +                        *    W  * * *
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EXCERPT FROM DEEP ROTATIONAL STABILITY ANALYSIS
EXISTING CHANNEL SLOPE SECTION B-01K

Safety Factors Are Calculated By The Modified Bishop Method
Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)	ΔX (ft)	tanα	sinα	cosα
1	20	20		0.0150	0.0150	0.9999
2	24	20.06	4.0	0.1465	0.1449	0.9894
3	27.96	20.64	4.0	0.2831	0.2724	0.9622
4	31.81	21.73	3.9	0.4332	0.3975	0.9176
5	35.48	23.32	3.7	0.5977	0.5130	0.8584
6	38.91	25.37	3.4	0.7923	0.6210	0.7838
7	42.04	27.85	3.1	1.0323	0.7182	0.6958
8	44.83	30.73	2.8	1.3487	0.8033	0.5956
9	47.21	33.94	2.4	1.8400	0.8786	0.4775
10	47.71	34.86	0.5			

Circle Center at X = 21.6; Y = 50.3 and Radius, 30.3

*   **   1.076   ***

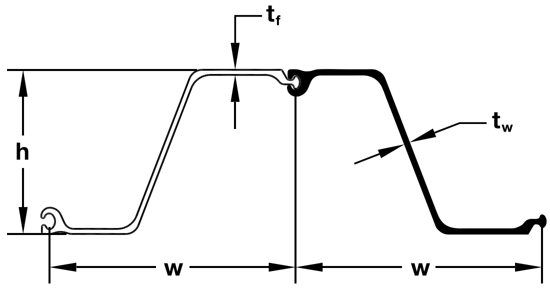
Soil No.	phi (degrees)	tanϕ
1	30	0.5774
2	32	0.6249
3	30	0.5774
4	32	0.6249

Individual data on the 16 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Failure Surface Segment	Driving Force Wsinα (lbs)	Resisting Force Wcosα.tanϕ (lbs)
1	4.0	4466.4	837.1	991.3	1	64.7	2489.4
2	2.0	2551.3	209.3	478.9	2	330.7	1303.4
3	2.0	2709.6	71.7	441.6	2	339.1	1336.6
4	3.8	1761.0	0.0	781.4	3	266.9	544.2
5	2.9	1533.0	0.0	447.0	4	431.7	575.3
6	0.7	392.4	0.0	79.1	4	124.5	166.0
7	2.9	1532.4	0.0	153.0	5	707.7	739.9
8	0.6	299.7	0.0	0.0	5	153.8	160.8
9	1.1	559.3	0.0	0.0	6	347.3	273.9
10	2.0	963.9	0.0	0.0	6	598.6	472.1
11	2.0	763.5	0.0	0.0	7	548.4	332.0
12	0.8	260.0	0.0	0.0	7	186.7	104.4
13	0.2	56.8	0.0	0.0	8	45.6	19.5
14	1.5	300.5	0.0	0.0	8	241.4	111.8
15	0.7	70.2	0.0	0.0	8	56.4	26.1
16	0.5	17.6	0.0	0.0	9	15.5	5.3
					∑W:	4063.5	4867.8

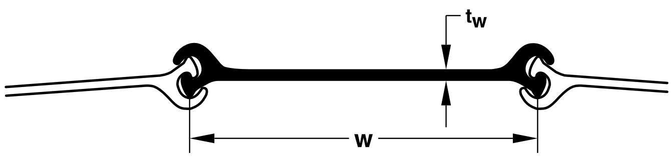
PZ/PS

PZ/PS Hot Rolled Steel Sheet Pile



PZ

SECTION	Width (w) in (mm)	Height (h) in (mm)	THICKNESS: Flange (t_f) in (mm)	THICKNESS: Wall (t_w) in (mm)	Cross Sectional Area in²/ft (cm²/m)	WEIGHT: Pile lb/ft (kg/m)	WEIGHT: Wall lb/ft² (kg/m²)	SECTION MODULUS: Elastic in³/ft (cm³/m)	SECTION MODULUS: Plastic in³/ft (cm³/m)	Moment of Inertia in⁴/ft (cm⁴/m)	COATING AREA: Both Sides ft²/ft of single (m²/m)	COATING AREA: Wall Surface ft²/ft² of wall (m²/m²)
PZ 22	22.0 559	9.0 229	0.375 9.50	0.375 9.50	6.47 136.9	40.3 60.0	22.0 107.4	18.1 973	21.79 1171.4	84.38 11500	4.48 1.37	1.22 1.22
PZ 27	18.0 457	12.0 305	0.375 9.50	0.375 9.50	7.94 168.1	40.5 60.3	27.0 131.8	30.2 1620	36.49 1961.9	184.20 25200	4.48 1.37	1.49 1.49
PZ 35	22.6 575	14.9 378	0.600 15.21	0.500 12.67	10.29 217.8	66.0 98.2	35.0 170.9	48.5 2608	57.17 3073.5	361.22 49300	5.37 1.64	1.42 1.42
PZ 40	19.7 500	16.1 409	0.600 15.21	0.500 12.67	11.77 249.1	65.6 97.6	40.0 195.3	60.7 3263	71.92 3866.7	490.85 67000	5.37 1.64	1.64 1.64



PS

SECTION	Width (w) in (mm)	Web (t_w) in (mm)	Maximum Interlock Strength k/in (kN/m)	Minimum Cell Diameter* ft (m)	Cross Sectional Area in²/ft (cm²/m)	WEIGHT: Pile lb/ft (kg/m)	WEIGHT: Wall lb/ft² (kg/m²)	Elastic Section Modulus in³/sheet (cm³/sheet)	Moment of Inertia in⁴/sheet (cm⁴/sheet)	COATING AREA: Both Sides ft²/ft of single (m²/m)	COATING AREA: Wall Surface ft²/ft² of wall (m²/m²)
PS 27.5	19.69 500	0.4 10.2	20 3500	30 9.14	8.09 171.2	45.1 67.1	27.5 134.3	3.3 54	5.3 221	3.65 1.11	1.11 1.11
PS 31	19.69 500	0.5 12.7	20 3500	30 9.14	9.12 193.0	50.9 75.7	31.0 151.4	3.3 54	5.3 221	3.65 1.11	1.11 1.11

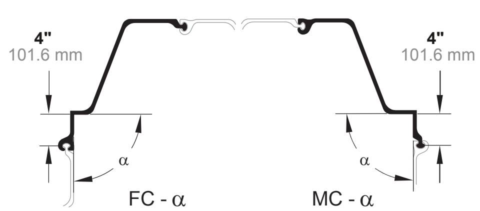
* Minimum cell diameter cannot be guaranteed for piles over 65 feet (19.81 m) in length, or if piles are spliced. 58 Piles are needed to make a 30 foot diameter cell.

PZ/PS

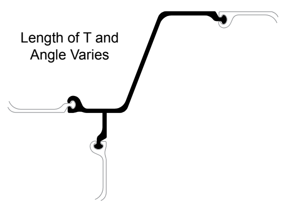
PZ/PS Hot Rolled Steel Sheet Pile

Available Steel Grades						
ASTM	PZ		PS			
	YIELD STRENGTH		YIELD STRENGTH		INTERLOCK STRENGTH	
	(ksi)	(MPa)	(ksi)	(MPa)	(k/in)	(kN/m)
A 328	39	270	39	270	16	2800
A 572 Grade 50	50	345	50	345	20	3500
A 572 Grade 60	60	415	-	-	-	-
A 588	50	345	50	345	20	3500
A 690	50	345	50	345	20	3500

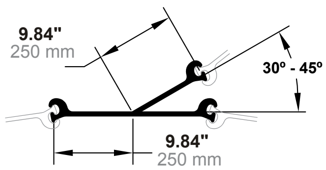
Corner and Junction Piles



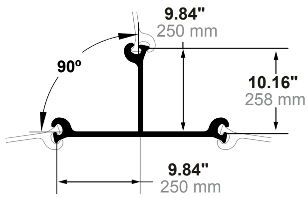
Female or Male Corner



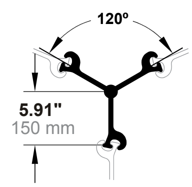
T Pile



30° Y Pile



90° T Pile



120° Y Pile

Delivery Conditions & Tolerances

	ASTM A 6	
Mass	± 2.5%	
Length	+ 5 inches	– 0 inches

Maximum Rolled Lengths*

PZ	105.0 ft	(32.0 m)
PS	90 ft	(27.4 m)

* Longer lengths may be possible upon request.

APPENDIX C

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a civil engineer may not fulfill the needs of a constructor — a construction contractor — or even another civil engineer. Because each geotechnical- engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. No one except you should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply this report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical-engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

Geotechnical Engineers Base Each Report on a Unique Set of Project-Specific Factors

Geotechnical engineers consider many unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk-management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical-engineering report that was:

- not prepared for you;
- not prepared for your project;
- not prepared for the specific site explored; or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical-engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical-engineering report is based on conditions that existed at the time the geotechnical engineer performed the study. *Do not rely on a geotechnical-engineering report whose adequacy may have been affected by*: the passage of time; man-made events, such as construction on or adjacent to the site; or natural events, such as floods, droughts, earthquakes, or groundwater fluctuations. *Contact the geotechnical engineer before applying this report to determine if it is still reliable.* A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ — sometimes significantly — from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide geotechnical-construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are Not Final

Do not overrely on the confirmation-dependent recommendations included in your report. *Confirmation-dependent recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's confirmation-dependent recommendations if that engineer does not perform the geotechnical-construction observation required to confirm the recommendations' applicability.*

A Geotechnical-Engineering Report Is Subject to Misinterpretation

Other design-team members' misinterpretation of geotechnical-engineering reports has resulted in costly

problems. Confront that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Constructors can also misinterpret a geotechnical-engineering report. Confront that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing geotechnical construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical-engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make constructors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give constructors the complete geotechnical-engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise constructors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure constructors have sufficient time* to perform additional study. Only then might you be in a position to give constructors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and constructors fail to recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Environmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform an *environmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold-prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold- prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical- engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; *none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.*

Rely, on Your GBC-Member Geotechnical Engineer for Additional Assistance

Membership in the Geotechnical Business Council of the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you GBC-Member geotechnical engineer for more information.

GBC GEOTECHNICAL BUSINESS COUNCIL
of the Geoprofessional Business Association

8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@geoprofessional.org www.geoprofessional.org

APPENDIX D

ANTILLIAN ENGINEERING ASSOCIATES, INC.
CONSTRAINTS AND RESTRICTIONS

WARRANTY

Antillian Engineering Associates, Inc. has prepared this report for our client for his exclusive use, in accordance with generally accepted soil and foundation engineering practices, and makes no other warranty either expressed or implied as to the professional advice provided in the report.

UNANTICIPATED SOIL CONDITIONS

The analysis and recommendations submitted in this report are based upon the data obtained from soil borings performed at the locations indicated on the Boring Location Plan. This report does not reflect any variations which may occur between these borings.

CHANGED CONDITIONS

We recommend that the specifications for the project require that the contractor immediately notify Antillian Engineering Associates, Inc., as well as the owner, when subsurface conditions are encountered that are different from those present in this report.

No claim by the contractor for any conditions differing from those anticipated in the plans, specifications, and those found in this report, should be allowed unless the contractor notifies the owner and Antillian Engineering Associates, Inc. of such changed conditions. Further, we recommend that all foundation work and site improvements be observed by a representative of Antillian Engineering Associates, Inc. to monitor field conditions and changes, to verify design assumptions and to evaluate and recommend any appropriate modifications to this report.

MISINTERPRETATION OF SOIL ENGINEERING REPORT

Antillian Engineering Associates, Inc. is responsible for the conclusions and opinions contained within this report based upon the data relating only to the specific project and location discussed herein. If the conclusions or recommendations based upon the data presented are made by others, those conclusions or recommendations are not the responsibility of Antillian Engineering Associates, Inc..

CHANGED STRUCTURE OR LOCATION

This report was prepared in order to aid in the evaluation of this project and to assist the architect or engineer in the design of this project. If any changes in the design or location of the structure as outlined in this report are planned, or if any structures are included or added that are not discussed in the report, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and the conclusions modified or approved by Antillian Engineering Associates, Inc..

USE OF REPORT BY BIDDERS

Bidders who are examining the report prior to submission of a bid are cautioned that this report was prepared as an aid to the designers of the project and it may affect actual construction operations.

Bidders are urged to make their own soil borings, test pits, test caissons or other investigations to determine those conditions that may affect construction operations. Antillian Engineering Associates, Inc. cannot be responsible for any interpretations made from this report or the attached boring logs with regard to their adequacy in reflecting subsurface conditions which will affect construction operations.

STRATA CHANGES

Strata changes are indicated by a definite line on the boring logs which accompany this report. However, the actual change in the ground may be more gradual. Where changes occur between soil samples, the location of the change must necessarily be estimated using all available information and may not be shown at the exact depth.

OBSERVATIONS DURING DRILLING

Attempts are made to detect and/or identify occurrences during drilling and sampling, such as: water level, boulders, zones of lost circulation, relative ease or resistance to drilling progress, unusual sample recovery, variation of driving resistance, obstructions, etc.; however, lack of mention does not preclude their presence.

WATER LEVELS

Water level readings have been made in the drill holes during drilling and they indicate normally occurring conditions. Water levels may not have been stabilized at the last reading. This data has been reviewed and interpretations made in this report. However, it must be noted that fluctuations in the level of the groundwater may occur due to variations in rainfall, temperature, tides, and other factors not evident at the time measurements were made and reported. Since the probability of such variations is anticipated, design drawings and specifications should accommodate such possibilities and construction planning should be based upon such assumptions of variations.

LOCATION OF BURIED OBJECTS

All users of this report are cautioned that there was no requirement for Antillian Engineering Associates, Inc. to attempt to locate any man-made buried objects during the course of this exploration and that no attempt was made by Antillian Engineering Associates, Inc. to locate any such buried objects. Antillian Engineering Associates, Inc. cannot be responsible for any buried man-made objects which are subsequently encountered during construction that are not discussed within the text of this report.

TIME

This report reflects the soil conditions at the time of investigation. If the report is not used in a reasonable amount of time, significant changes to the site may occur and additional reviews may be required.

ANTILLIAN
ENGINEERING ASSOCIATES, INC.

July 27, 2017

CDM Smith
101 Southall Lane, Suite 200n
Maitland, Florida 32751

Attention: Jane Williams, P.E.

Reference: Side-Slope Reconfiguration Technical Memorandum
Skylake Canal Improvements
Orange County, Florida
AEA Project No. 201504-4

Dear Ms. Wiliams:

During a telephone conference with the design team on January 5, 2017, we were asked to examine the possibility of reducing the inclination ("flattening") to improve the stability of side slopes that had failed along Skylake Canal. The design team had not considered that option before, because Orange County staff had advised during a site meeting in 2015 that flattening side-slopes could narrow the channel banks below the minimum width needed for maintenance-equipment access. Staff also mentioned at the time that acquiring right-of-way for that purpose could be cumbersome, but in December 2016 the design team was asked to consider side-slope flattening.

This technical memorandum presents the results of a series of analyses that we conducted in Section B-01K of Skylake Canal where a rotational failure had occurred. As documented in our geotechnical investigation report dated March 15, 2016, slopes had failed in three sections of Skylake Canal, i.e., B-01K, B-01L, and B-01N. We selected B-01-K because our assessment of the eight test borings we had drilled in the three failed sections indicated that the subsurface conditions in B-01K offered the least resistance to side-slope rotational failure. We also suspected seepage within the B-01K side slope from a retention pond on the neighboring property. In effect, B-01K represented the worst case of the three sections, which indicated that improvements obtained at that location could be applied elsewhere in B-01K, as well as in B-01L and B-01N, and possibly other channels in Orange County. Portions of this memorandum were refined through discussions with CDM Smith staff in July 2017.

INITIAL ANALYSIS

In April 2016, we analyzed a segment of the Section B-01K side-slope that had undergone a shallow, rotational failure. Like most unlined, open channels, B-01K had been formed by excavating into the natural soils. The resulting side-slopes and banks probably had been sodded to protect against erosion. Topographic survey information revealed that the failed side-slope was inclined at 1.9 Horizontal to 1 Vertical ("1.9H:1V"), indicating that the original side-slope probably had been excavated at 2H:1V. By comparison, stormwater-pond side-slopes are currently excavated at 3H:1V or even flatter. Based on side-slope inclination alone, we anticipated that the B-01K side-slope would be less stable against rotational failure than currently accepted for soil slopes. The results of our analysis confirmed that expectation. The generally accepted minimum factor of safety against rotational failure in a slope ("FS_{min}") is 1.5. As shown below in Table 1, our analysis at B-01K yielded 1.1. Our report dated May 2, 2016 contains the full results of the initial analyses. Based on those results, it is our professional opinion that the steep, initial inclination of the channel side-slopes had left little reserve stability against naturally loose to very loose soils, erosion of the toe of the slope with time, or other adverse effects such as seepage in the side-slopes from the ground surface.

REDUCING SIDE-SLOPE INCLINATION

We modified the initial analyses at B-01K by reducing the side-slope inclination from 1.9H:1V to 2.5H:1V, without changing the loose to medium dense soil conditions indicated by our test boring at that location. Side-slope stability improved, but the inclination had to be reduced to 3H:1V before FS_{min} exceeded 1.5. We extended the analysis of the 3H:1V slope further by adjusting the soil properties to simulate loose conditions and obtained FS_{min} of 1.4. The results of our analyses are summarized below in Table 1. Graphical plots are presented in Appendix A.

TABLE 1
SUMMARY OF SIDE-SLOPE RECONFIGURATION ANALYSES

SIDE-SLOPE INCLINATION	DESCRIPTION	FS_{min}	DESIGN CRITERIA MET?
1.9H:1V	Existing slope and existing soils	1.1	No
2.5H:1V	Reduced slope in existing soils	1.4	No
3H:1V	Reduced slope in existing soils	1.6	Yes
3H:1V	Reduced slope in loose soils	1.4	No

The results of the slope-reconfiguration analysis indicated that channel side-slope stability against rotational failure could be improved by flattening the slopes. Possible gains in stability appear to be limited by soil conditions, and require additional right-of-way but this approach offers a more stable substrate for placement of side-slope protection against erosion and forces induced by channel flow.

VERTICAL STRUCTURAL ELEMENTS

In our draft technical memorandum dated November 7, 2016, we discussed enhancing an existing, marginally-stable side-slope by installing short piles or similar, vertical, structural elements within the slope near the toe to provide additional resistance to lateral movement associated with rotational failure. Our analyses indicated that the existing slope at B-01K could be stabilized to meet current design criteria using vertical structural elements, as indicated by FS_{min} values that were consistently higher than 1.5. The results of those analyses are summarized in Table 2 on the following page. Graphical plots are presented in Appendix B.

TABLE 2
SUMMARY OF PILE-ENHANCED SLOPE ANALYSES

SIDE-SLOPE INCLINATION	DESCRIPTION	FS_{min}	DESIGN CRITERIA MET?
1.9H:1V	Pile-enhanced slope in existing soils	2.0	Yes
1.9H:1V	Pile-enhanced slope in loose soils	1.7	Yes
1.9H:1V	Pile-enhanced slope in very loose soils	1.6	Yes

The results of the pile-enhanced slope analysis indicated that channel side-slope stability against rotational failure could be improved by installing vertical structural elements. As expected, possible gains in stability were limited by the soil conditions, but current design criteria were satisfied.

RECOMMENDATIONS

The following recommendations are based on the results of our analyses and the condition that other factors that could decrease side-slope stability need to be considered when developing a final recommendation. Such factors include, but are not limited to, seepage in the side slopes from off-site sources, side-slope erosion, bottom scour, forces caused by channel flow, and the vulnerability of side-slope protection to sliding and erosion both during and after construction.

Our current understanding is that side-slope flattening is being considered because of familiarity with that method. As long as channel performance and resistance to erosion are not affected, the Skylake Canal banks in the failed areas may be flattened to achieve a factor of safety against deep rotational failure that is satisfactory to County staff and satisfies any economic constraints that may apply. The work should include any remedial earthwork that may be needed. Failed sections should be excavated to form level terraces in the underlying, undisturbed soil. Earth fill should be placed on the terraces in lifts and compacted to meet the specifications selected by the County for that purpose.

Our analyses indicated that vertical structural elements had improved the stability of the existing slope at B-01K more noticeably than flattening the slope, even in very loose soil conditions and with off-site seepage within the slope. If flattening the slopes is not feasible or cannot achieve stability against deep rotational failure that is satisfactory to the County, we recommend installing vertical, structural elements beneath the side-slope surface near the toe, as discussed above, to enhance the stability. Both methods may be combined to enhance stability even further.

The results of our analyses in steep slopes with very loose soils suggested that vertical, structural elements in the slope may be beneficial in other existing, unlined, open channels in Orange County. Advantages with this method include substantial gains in stability, little need for earthwork other than a possible repair, and stabilized slopes that would match the existing side-slopes upstream and downstream. Additional right-of-way also would not be needed.

The Skylake Canal project may serve as an opportunity for the County to conduct a trial stabilization using vertical, structural elements. Many bridge-widening projects in the I-4 Ultimate project currently under way in central Orange County are using steel H-pile foundations, so short, steel pile cutoffs may be available as surplus at little cost. In addition, the equipment needed to drive such short piles (typically 12 feet to 15 feet long) is not likely to be very heavy or expensive. We do not expect the duration of installation in a short section like B-01K to last for more than one or two days.

LIMITATIONS

This report presents an evaluation of the subsurface conditions on the basis of accepted geotechnical procedures for slope stabilty analysis. The analyses were confined to the zone of soil which is likely to be affected by the proposed construction, and did not address the potential of surface expression of deep geologic activity such as sinkholes.

Because of the natural limitations inherent in working below the ground surface, a geotechnical engineer cannot predict and address all possible problems. During construction, geotechnical issues not addressed in this memorandum may arise. The bulletin "Important Information About Your Geotechnical-Engineering Report" published by the Geoprofessional Business Association (GBA) is presented in Appendix C to help explain the nature of geotechnical-engineering issues.

It has been our pleasure to continue serving CDM Smith and Orange County Stormwater Department on this project. Please contact our office if you have questions or if you need additional information.

ANTILLIAN ENGINEERING ASSOCIATES, INC.

PETER GREGORY SUAH LICENSE No. 46910 STATE OF FLORIDA PROFESSIONAL ENGINEER
08.18.2017

Peter G. Suah, P.E.
Principal Engineer
Florida Registration No. 46910

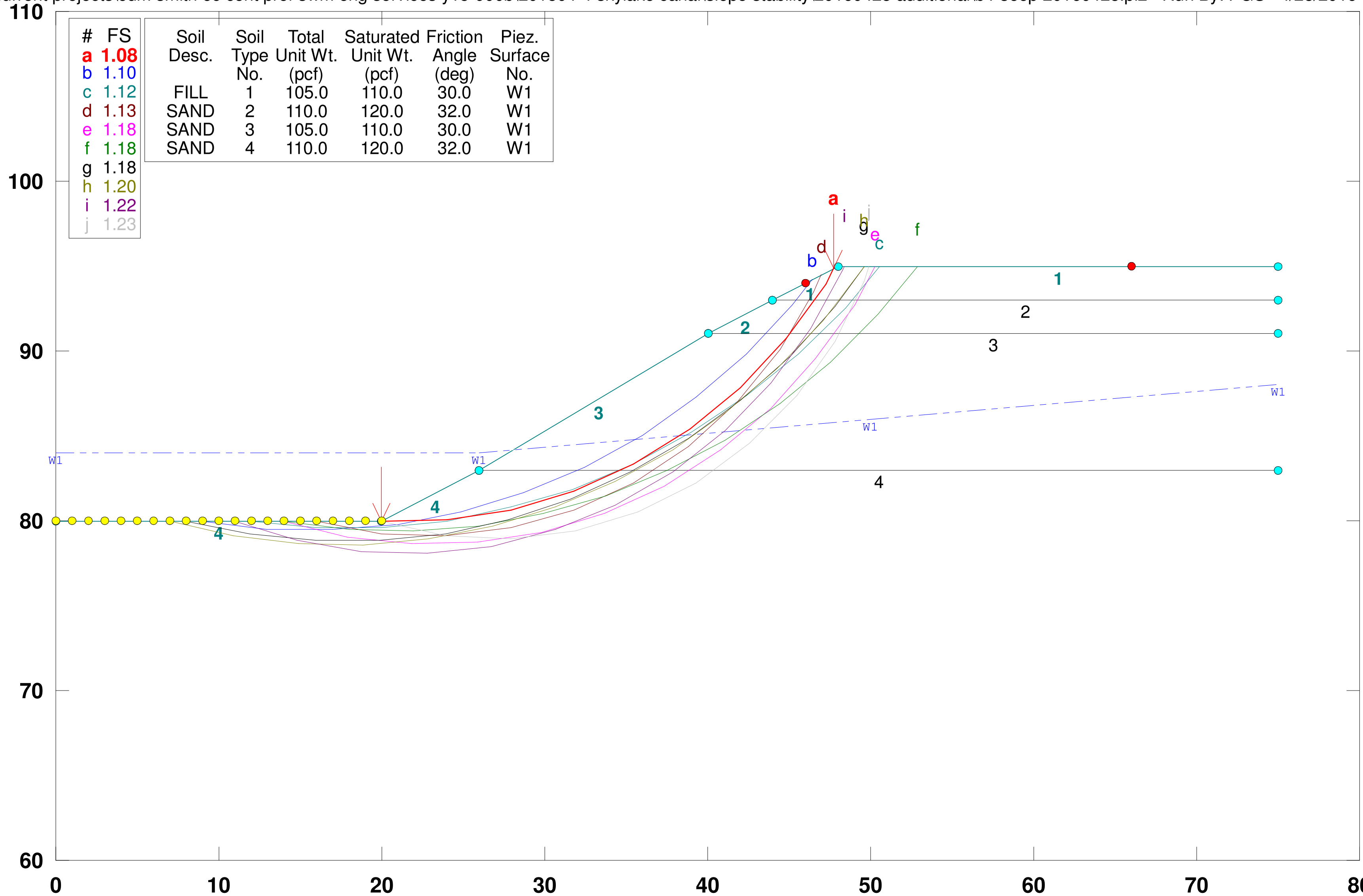
Attachments:

Appendix A: Rotational Stability Analyses of Reconfigured Slopes Without Pile Enhancement
Appendix B : Additional Rotational Stability Analyses of Slopes with Pile Enhancement
Appendix C: Important Information About This Geotechnical-Engineering Report

APPENDIX A

Skylake Canal B-01-K Existing Slope B-4 with Seepage in Slope

s:\current projects\cdm smith oc cont prof swm eng services y15-900b\201504-4 skylake canal\slope stability\20160428 additional\b4-seep 20160428.pl2   Run By: PGS   4/28/2016   02:33PM



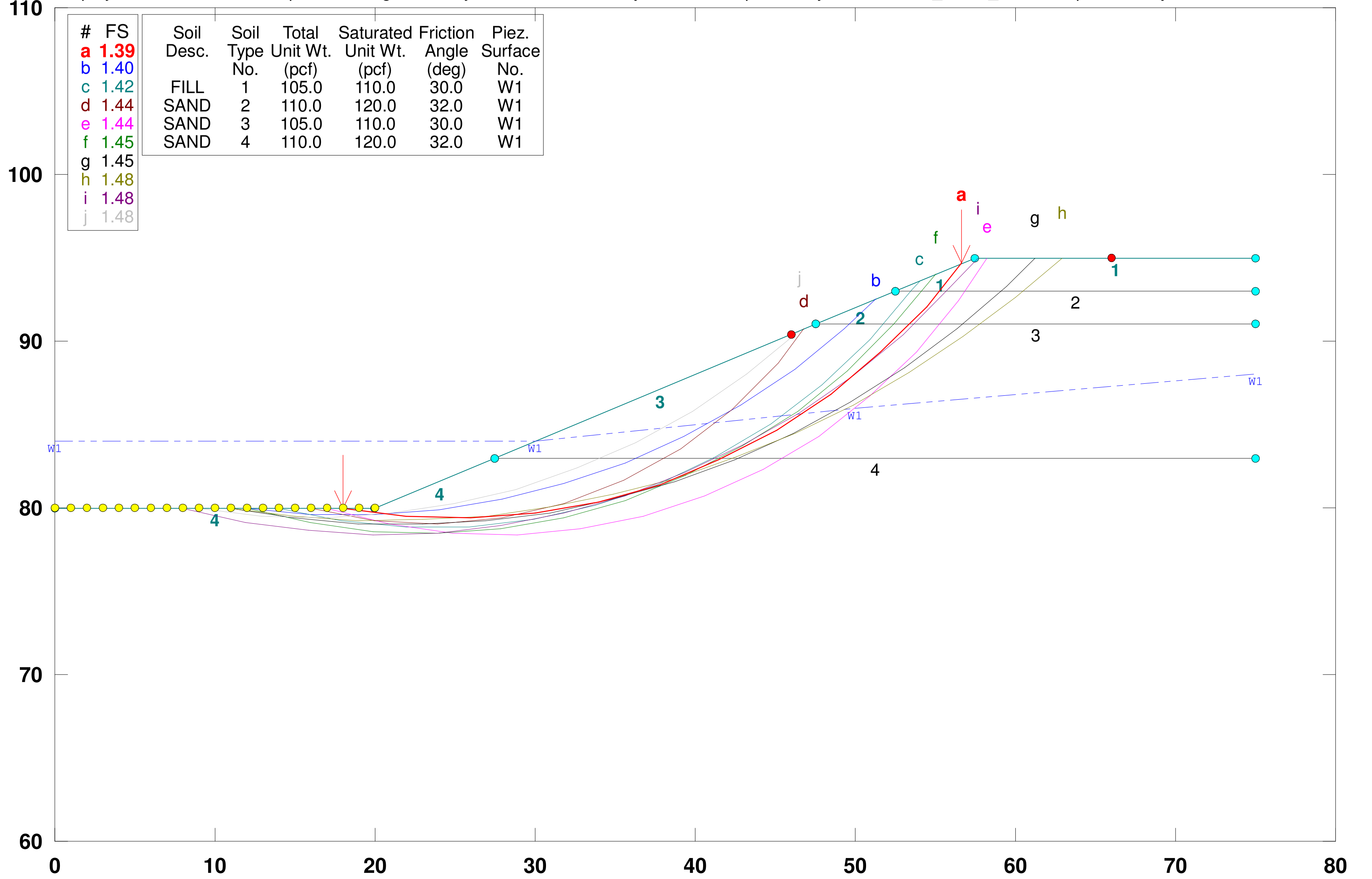
PCSTABL5M/si FSmin=1.08

Safety Factors Are Calculated By The Modified Bishop Method

STED

Skylake Canal B-01-K 2.5H:1V Slope at B-4 with Seepage

s:\current projects\cdm smith oc cont prof swm eng services y15-900b\201504-4 skylake canal\slope stability\20170111\b-4_25h1v_20170111.pl2   Run By: PGS   1/11/2017   06:36PM



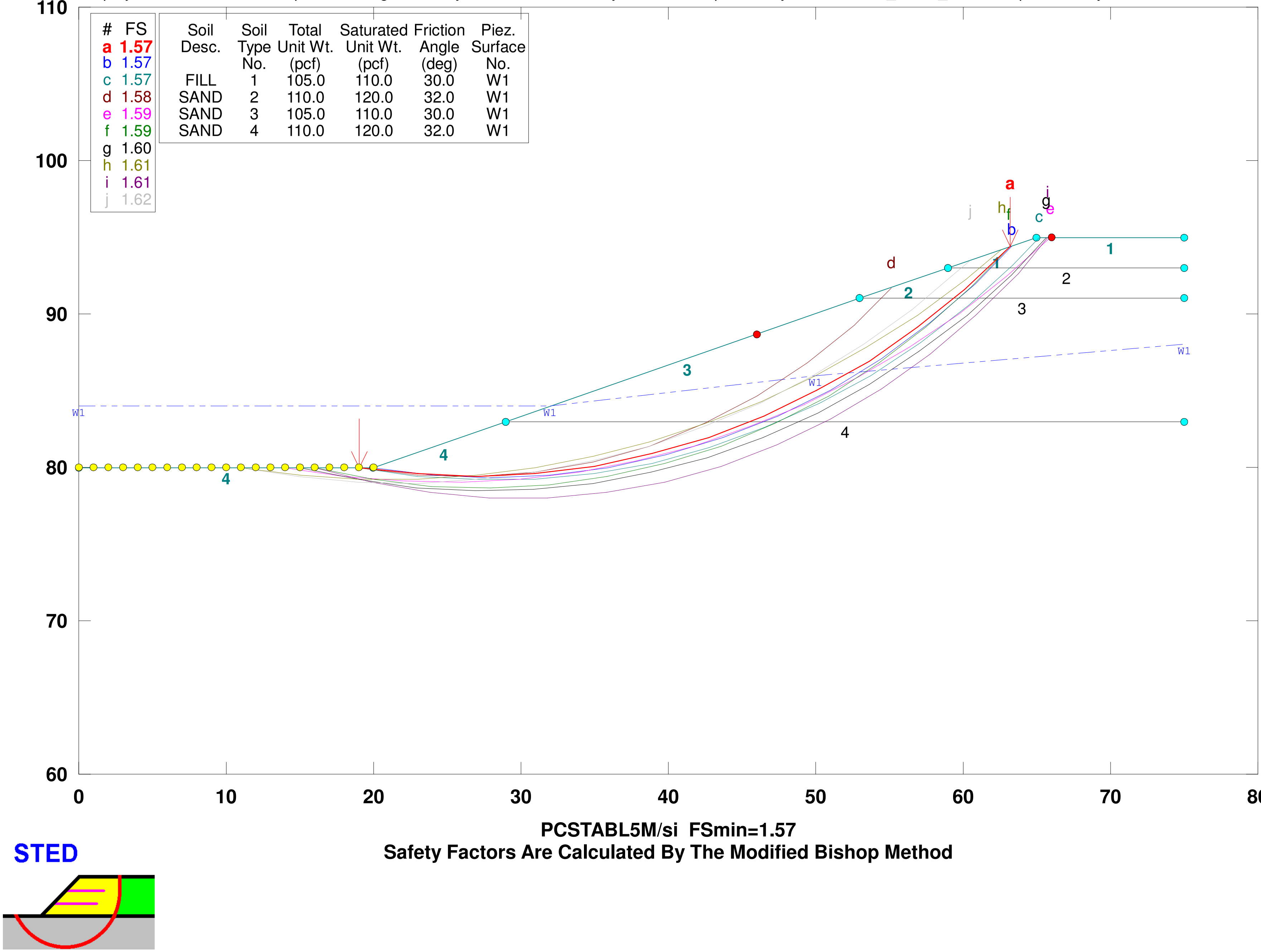
PCSTABL5M/si FSmin=1.39

Safety Factors Are Calculated By The Modified Bishop Method

STED

Skylake Canal B-01-K 3.0H:1V Slope at B-4 with Seepage

s:\current projects\cdm smith oc cont prof swm eng services y15-900b\201504-4 skylake canal\slope stability\20170111\b-4_30h1v_20170111.pl2 Run By: PGS 1/11/2017 06:40PM

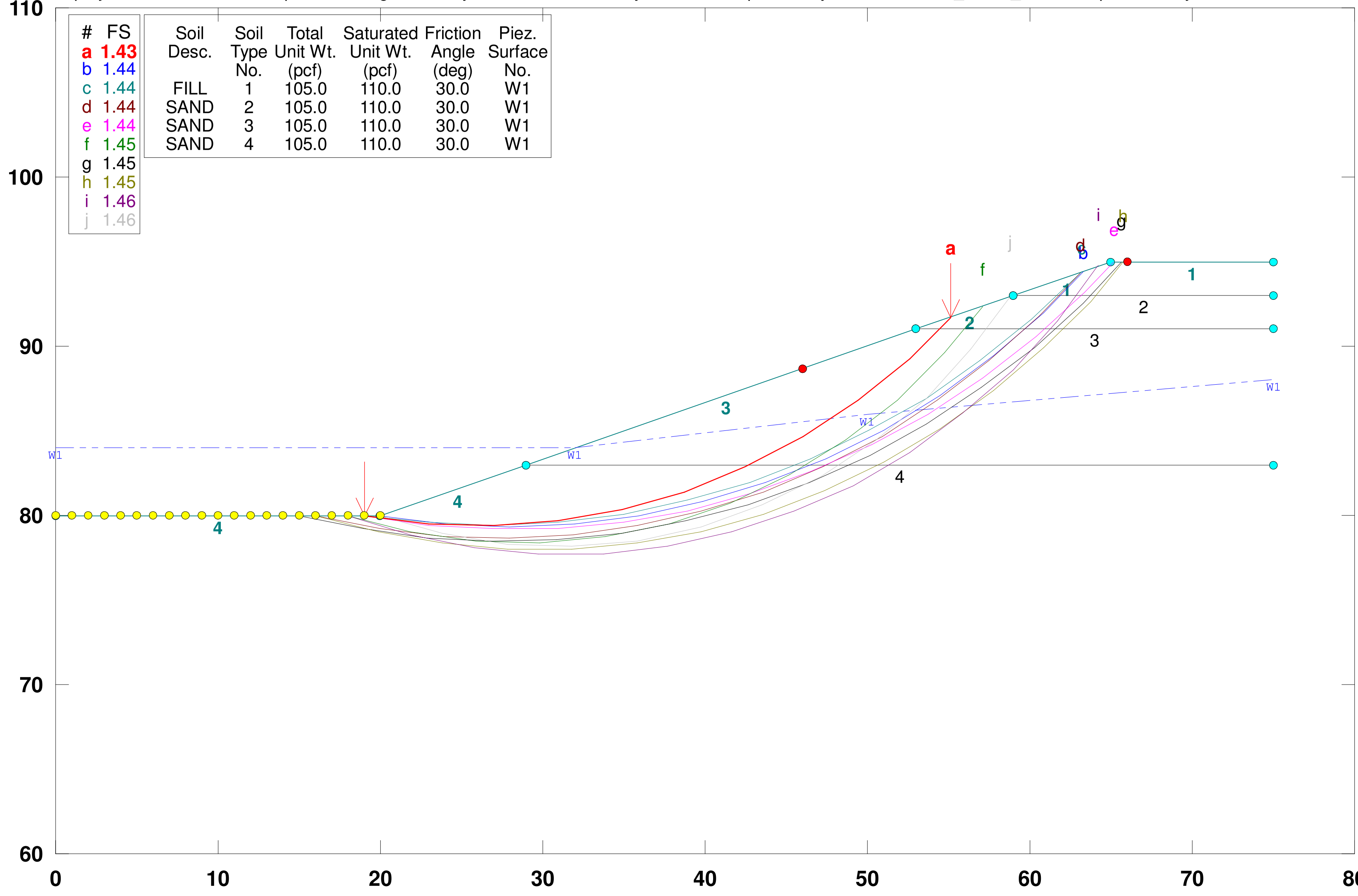


PCSTABL5M/si FSmin=1.57

Safety Factors Are Calculated By The Modified Bishop Method

Skylake Canal B-01-K Loose 3.0H:1V Slope with Seepage

s:\current projects\cdm smith oc cont prof swm eng services y15-900b\201504-4 skylake canal\slope stability\20170111\loose_30h1v_20170111.pl2 Run By: PGS 1/11/2017 06:45PM



PCSTABL5M/si FSmin=1.43

Safety Factors Are Calculated By The Modified Bishop Method

STED

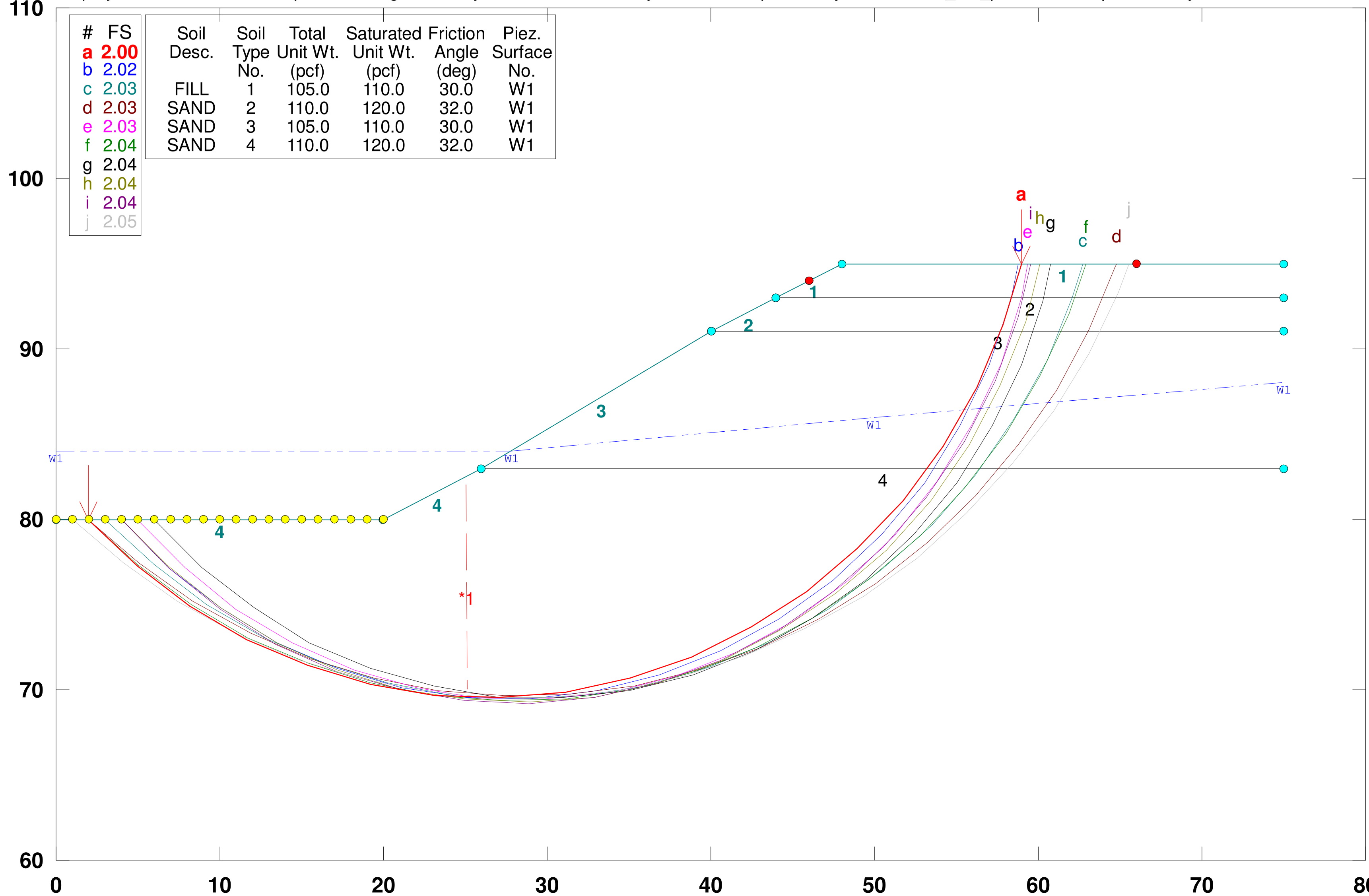
APPENDIX B

Skylake Canal B-01-K Ex Bank Boring B-4 Pile-Enhanced

s:\current projects\cdm smith oc cont prof swm eng services y15-900b\201504-4 skylake canal\slope stability\20170111\ex_b-4_pile 20170111.pl2 Run By: PGS 1/11/2017 07:08PM

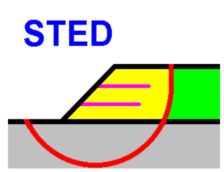
#	FS
a	2.00
b	2.02
c	2.03
d	2.03
e	2.03
f	2.04
g	2.04
h	2.04
i	2.04
j	2.05

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Friction Angle (deg)	Piez. Surface No.
FILL	1	105.0	110.0	30.0	W1
SAND	2	110.0	120.0	32.0	W1
SAND	3	105.0	110.0	30.0	W1
SAND	4	110.0	120.0	32.0	W1



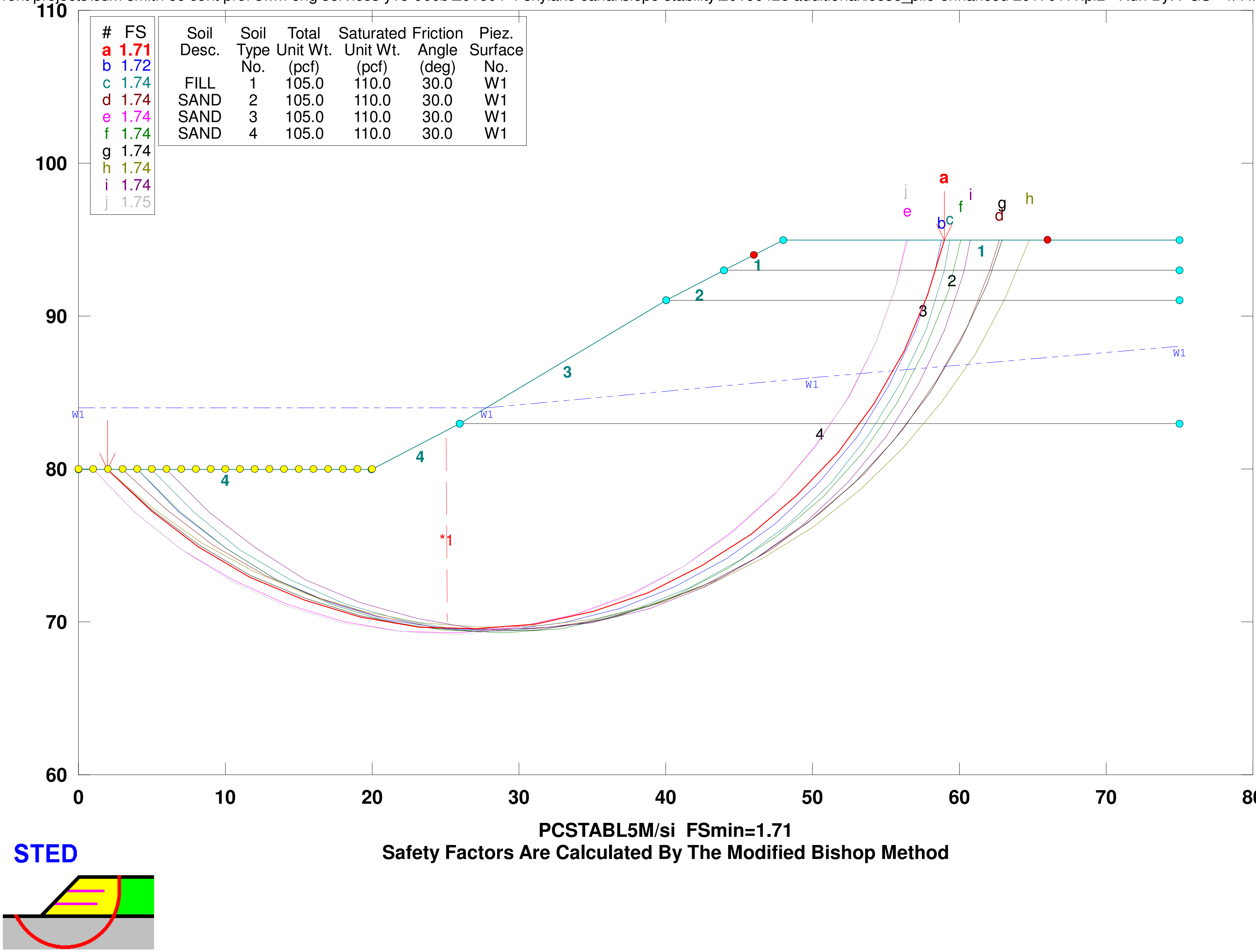
PCSTABL5M/si FSmin=2.00

Safety Factors Are Calculated By The Modified Bishop Method



Skylake Canal B-01-K Loose Existing Slope Pile-Enhanced

s:\current projects\cdm smith oc cont prof swm eng services y15-900b\201504-4 skylake canal\slope stability\20160428 additional\loose_pile-enhanced 20170111.pl2 Run By: PGS 1/11/2017 06:58PM



#	FS
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b	1.72
c	1.74
d	1.74
e	1.74
f	1.74
g	1.74
h	1.74
i	1.74
j	1.75

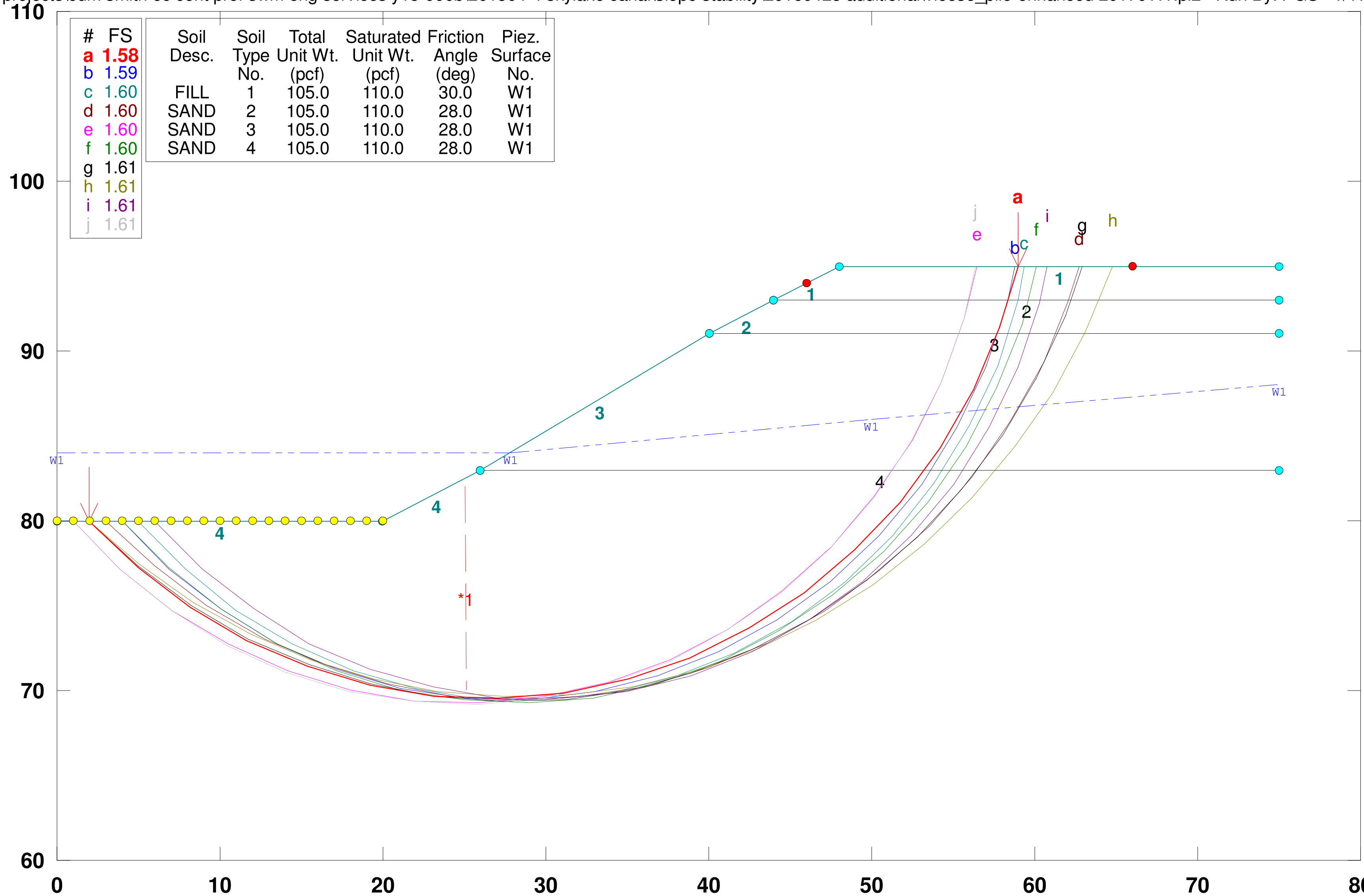
Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Friction Angle (deg)	Piez. Surface No.
FILL	1	105.0	110.0	30.0	W1
SAND	2	105.0	110.0	30.0	W1
SAND	3	105.0	110.0	30.0	W1
SAND	4	105.0	110.0	30.0	W1

PCSTABL5M/si FSmin=1.71

Safety Factors Are Calculated By The Modified Bishop Method

Skylake Canal B-01-K Very Loose Existing Slope Pile-Enhanced

s:\current projects\cdm smith oc cont prof swm eng services y15-900b\201504-4 skylake canal\slope stability\20160428 additional\vloose_pile-enhanced 20170111.pl2 Run By: PGS 1/11/2017 07:02PM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Friction Angle (deg)	Piez. Surface No.
FILL	1	105.0	110.0	30.0	W1
SAND	2	105.0	110.0	28.0	W1
SAND	3	105.0	110.0	28.0	W1
SAND	4	105.0	110.0	28.0	W1

PCSTABL5M/si FSmin=1.58

Safety Factors Are Calculated By The Modified Bishop Method

STED

APPENDIX C

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a civil engineer may not fulfill the needs of a constructor — a construction contractor — or even another civil engineer. Because each geotechnical- engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. No one except you should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply this report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical-engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

Geotechnical Engineers Base Each Report on a Unique Set of Project-Specific Factors

Geotechnical engineers consider many unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk-management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical-engineering report that was:

- not prepared for you;
- not prepared for your project;
- not prepared for the specific site explored; or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical-engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical-engineering report is based on conditions that existed at the time the geotechnical engineer performed the study. *Do not rely on a geotechnical-engineering report whose adequacy may have been affected by*: the passage of time; man-made events, such as construction on or adjacent to the site; or natural events, such as floods, droughts, earthquakes, or groundwater fluctuations. *Contact the geotechnical engineer before applying this report to determine if it is still reliable.* A minor amount of additional testing or analysis could prevent major problems.

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A Report's Recommendations Are Not Final

Do not overrely on the confirmation-dependent recommendations included in your report. *Confirmation-dependent recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's confirmation-dependent recommendations if that engineer does not perform the geotechnical-construction observation required to confirm the recommendations' applicability.*

A Geotechnical-Engineering Report Is Subject to Misinterpretation

Other design-team members' misinterpretation of geotechnical-engineering reports has resulted in costly

problems. Confront that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Constructors can also misinterpret a geotechnical-engineering report. Confront that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing geotechnical construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical-engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make constructors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give constructors the complete geotechnical-engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise constructors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure constructors have sufficient time* to perform additional study. Only then might you be in a position to give constructors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and constructors fail to recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Environmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform an *environmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold-prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold- prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical- engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; *none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.*

Rely, on Your GBC-Member Geotechnical Engineer for Additional Assistance

Membership in the Geotechnical Business Council of the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you GBC-Member geotechnical engineer for more information.

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