Soil Mechanics Report

Plum Creek Watershed FRS No. 2 Rehabilitation Design
Hays County, Texas

Project reference: TSSWCB IDIQ-AECOM-2018-79017
Work Order Number: 12FPC219F0063
Project number: 60615067

July 2021

Texas State Soil and Water Conservation Board
1497 Country View Lane
Temple, Texas 76504

Quality information

Prepared by	Checked by	Verified by
Mariana Conceição de Sá, EIT Geotechnical Engineer	Lance Finnefrock, P.E., G.E. Geotechnical Engineer	Ananth Bukkapatnam, P.E. Geotechnical Engineer

Revision History

Revision	Revision date	Details	Authorized	Name	Position
0	November 2020	Initial 90% Draft	November 2020	MJL	PM
1	July 2, 2021	Final	July 9, 2021	LEA	PM

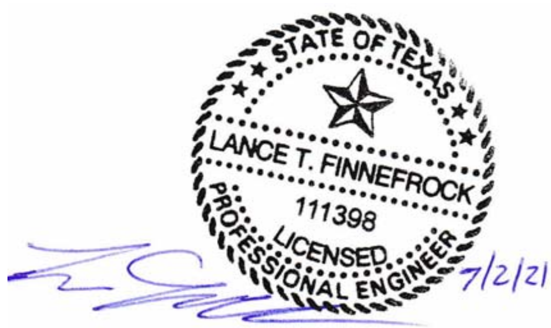
Distribution List

# Hard Copies	PDF Required	Association / Company Name
	X	Steve Bednarz, P.E. / TSSWCB
	X	Ronnie Skala, P.E., CFM / TSSWCB
	X	Luis Alday, P.E. / AECOM
	X	Manfred Daut, P.E. / AECOM

Prepared for:

Mr. Steve Bednarz, P.E.
Statewide Programs Engineer
Texas State Soil and Water Conservation Board
1497 Country View Lane
Temple, Texas 76504

Prepared by:



6/8/2021
Mariana Conceição de Sá, EIT
Geotechnical Engineer
M: 703.474.6778
E: mariana.sa@aecom.com

Lance Finnefrock, PE, GE
Geotechnical Engineer
M: 512.413.7269
E: lance.finnefrock@aecom.com

AECOM
9400 Amberglen Boulevard
Austin, TX 78729
aecom.com

Table of Contents

Tables

Figures

Appendices

1. Introduction

1.1 Project Overview

The Plum Creek Watershed Floodwater Retarding Structure (FRS) No. 2 is currently sponsored by Caldwell-Travis Soil and Water Conservation District (SWCD), Hays County Soil and Water Conservation District (SWCD), and Plum Creek Conservation District. The Texas State Soil and Water Conservation Board (TSSWCB) is assisting the sponsors with rehabilitation of the dam.

Since construction of the Plum Creek Floodwater Retarding Structure (FRS) No. 2 (Plum Creek 2) in 1968, residential and commercial structures, major highways, and utilities have been constructed downstream of and in the immediate vicinity of the dam. As a result, a catastrophic failure of the dam would result in property and infrastructure damages and potential loss of life. As such, the dam has been reclassified by NRCS as a high hazard dam. The existing dam does not meet current safety criteria and performance standards for high hazard dams.

The Texas State Soil and Water Conservation Board (TSSWCB) has contracted AECOM Technical Services, Inc. (AECOM) to design proposed improvements that will rehabilitate the dam to meet high-hazard criteria. AECOM's scope of work for this project is to conduct engineering analyses, permitting, and preliminary and final design services to develop the dam rehabilitation construction documents.

1.2 Proposed Improvements

The proposed rehabilitation of Plum Creek FRS No. 2 is intended to mitigate identified dam safety deficiencies associated with the dam's reclassification as a high hazard dam. The proposed modifications include the following major components:

- Raising the existing vegetated auxiliary spillway crest by 1.15 feet to Elevation (El.) 659.8;
- Widening the existing vegetated auxiliary spillway from 150 feet to 250 feet;
- Constructing a new 200-foot-wide overtopping roller-compacted concrete (RCC) spillway with crest at El. 658.6;
- Abandoning the existing principal spillway inlet and 24-inch diameter conduit;
- Replacing the existing principal spillway with a new 48-inch diameter conduit, inlet riser with crest at El. 645.4, and impact basin at the outlet;
- Installing rock riprap wave protection on the upstream embankment slope; and
- Maintaining the embankment crest at El. 662.8 (top of compacted earthfill which excludes additional height of topsoil) with nominal raise in areas that have experienced settling.

1.3 Objective and Scope of Work

As part of the dam rehabilitation design, AECOM's scope of work included geological investigation and geotechnical engineering evaluation of the dam and proposed improvements. Specifically, this scope of work included a site-specific field Geologic Investigation (GI), preparation of a Geologic Investigation Report (GIR), and preparation of a Soil Mechanics Report (SMR).

The primary objective of the GI was to collect geotechnical information about the existing earthen embankment, foundation materials, groundwater conditions, subgrade conditions for proposed structures (new overtopping RCC spillway and new PSW), and potential borrow sources for use in rehabilitation planning and design. The GIR was prepared by AECOM and is provided under separate cover (AECOM, 2021).

The objectives of this SMR are to present the findings of the geotechnical laboratory testing program and geotechnical engineering analyses, and to provide geotechnical recommendations for design and construction of the proposed improvements. Tasks associated with the SMR included the following:

1. Development of a laboratory testing program for soil and rock samples collected during the field GI;
2. Analysis and interpretation of laboratory data;
3. Geotechnical characterization of the embankment and foundation materials;
4. Seepage and slope stability analyses for the existing embankment and proposed modifications;
5. Seismic site characterization and analysis of the site;
6. Geotechnical recommendations for the proposed principal spillway modification including new conduit pipe and foundation support;
7. Geotechnical engineering analyses and recommendations for the proposed structures (i.e., principal spillway and RCC spillway), including bearing capacity, lateral earth pressures, sliding friction, swell/heave, and settlement analyses;
8. Recommendations for internal drainage and filter compatibility analyses for proposed aggregate drains/filters;
9. Geotechnical recommendations for design and construction including groundwater management, temporary excavations, subgrade preparation; fill material specifications, and fill placement and compaction criteria;.and
10. Preparation of this SMR.

Specific objectives of the laboratory investigation described in this SMR were characterization of the index properties, dispersion potential, shear strength, hydraulic conductivity, and volume-change potential for existing embankment and foundation materials. Additionally, materials in proposed excavations and designated borrow areas were evaluated to determine the suitability of on-site soils as a borrow source for the proposed embankment raise.

1.4 Authorization

The work herein was completed by AECOM for the TSSWCB in accordance with the Statement of Work described in Work Order No. 79017-1 and executed under the terms and conditions of the existing Contract No. IDIQ-AECOM-2018-79017.

2. Site Description

2.1 Dam Structure

The Plum Creek FRS No. 2 is located in Hays County, Texas about 1.5 mile east of downtown Kyle. The site is located approximately 0.75 miles east of the intersection of IH-35 and Center Street and 1.75 miles south of the intersection of IH-35 and Bunton Rd. The dam is situated on Plum Creek, within the Plum Creek Watershed. Access to the site is through the main entrance of Lake Kyle Park, on 700 Lehman Rd., Kyle, TX. Within the site, access to some areas is via pastures with non to marginal unimproved roads. A vicinity map of the site is provided in **Figure 1**.

The dam was originally constructed in 1968 as a low hazard (class "a"), zoned earthen embankment for the purposes of watershed protection and flood prevention. The FRS No. 2 has a maximum height of 38 feet, length of 2,588 feet, maximum storage capacity of 1,034 acre-feet, and is comprised of about 128,030 cubic yards of earth and rock fill.

The dam is a zoned earthen embankment with a 14-foot wide crest. The as-built drawings show the upstream and downstream slopes of the dam were constructed at an inclination of 2.5H:1V (horizontal:vertical). Topographic survey performed in late 2019 by AECOM's subcontracted surveyor (CP&Y) indicate the existing embankment slopes are flatter than shown on the as-builts, with an upstream slope inclination of about 3H:1V and downstream slope ranging from about 2.7H:1V to 3H:1V. The as-builts indicate two material zones were used in the embankment, designated as Zone 1 and Zone 2 as described as follows:

- Zone 1 materials were designated for the embankment core and cutoff trench and were prescribed to consist of non-calcareous, silty clays (CH) obtained from the on-site borrow area located in the present-day reservoir.
- Zone 2 materials were designated the upstream and downstream embankment slopes (shell zones). These materials were described as either silty fat clays (CH) from the designated borrow area, or non-calcareous, silty, clayey sand (SC) obtained from required excavations for the ASW channel.

A 12-foot-wide local berm is present on the upstream slope at El. 647.1 feet and a 20-foot-wide crossing berm with crest at El. 635.0 is present at the downstream toe over the PSW conduit. A minimum 12-ft wide cutoff trench, up to about 7 feet deep, was constructed under the crest of the dam. The as-built embankment crest elevation (top of dam including topsoil) is reported as El. 663.8[1]. Topographic survey conducted by CP&Y in late 2019 indicates the embankment crest varies from approximately El. 661.2 feet to El. 662.4 feet.

A vegetated earthen auxiliary spillway (ASW) is present at the left abutment and is 150 feet wide with a designed discharge of 658.5 cubic feet per second (cfs). The principal spillway (PSW) consists of an approximately 13-feet tall concrete inlet structure and 210 feet of 24-inch inner diameter (ID) prestressed, concrete lined, steel conduit pipe discharging to a stilling basin. The PSW pipe is furnished with a series of five concrete anti-seep collars spaced at 200 feet center-to-center. The as-built existing principal spillway has a crest elevation of 649.1 feet and a lower port elevation of 640.4 feet (normal pool), while the auxiliary spillway crest elevation is reported as El. 658.9 feet.

[1] The original as-built vertical datum was assumed to be the National Geodetic Vertical Datum of 1929 (NGVD29). The difference in elevation between NGVD29 and NAVD88 in the vicinity of FRS No. 2 is approximately 0.388 foot. Elevations reported herein have been converted from NGVD29 to NAVD88 by adding +0.388 foot.

The proposed dam improvements will increase the effective embankment crest elevation to El. 662.8 feet, requiring less than 1 foot of new embankment fill over much of the embankment. An additional proposed 12 inches of topsoil will result in an overall top of embankment at El. 663.8. Additionally, the vegetated ASW crest will be raised 0.9 feet to El. 659.8 feet, and the new RCC spillway will have crest at El. 658.6 feet. The existing PSW conduit will be abandoned in place by grouting, with demolition of the existing inlet tower. The crest elevation of the proposed rehab PSW inlet tower will be El. 645.4, with a low-flow port inlet at El. 640.4 and sluice gate at El. 633.2.

2.2 Geology

Detailed description of site geology is contained in the 2021 GIR. In summary, the project site is located within the Blackland Prairies of the Gulf Coastal Plains physiographic region of Texas. The region features low, rolling terrain with beds tilted south and east. The Upper Cretaceous bedrock of chalk and marls weather to a deep clay soil in this region (Wermund, 1996).

Published geologic mapping indicates the site is primarily underlain by Cretaceous-age Pecan Gap Chalk, termed “Kpg”. Cretaceous-age Austin Chalk (Kau) and Leona high gravel terrace deposits of Quaternary age are also mapped within a few miles of the project site.

The Pecan Gap Chalk is described as a medium gray, chalky, or marly formation with calcium carbonate content ranging from about 25 to over 75 percent (Young, 1977). The formation is composed of chalk in its lower part and chalky marl in its upper portion. Bedrock of this formation weathers to light gray and white, have thicknesses of approximately 200 feet (Proctor et al., 1974) in the vicinity of this site, and grades laterally in select locations to marl. Near the surface, due to weathering, the Pecan Gap becomes a highly plastic, fat clay with significant potential for vertical movement as a result of changes in moisture content.

The project site is located within the proximity of two surface expression faults, the Kyle fault and the San Marcos Springs fault mapped approximately 0.8 miles west and approximately 1.5 miles east of the site, respectively. While faults are generally not considered to be active in Central Texas, they are known transmit groundwater and can contain fault gouge. Although no faulting is mapped or identified during current or previous geologic investigations the project site, inactive bedrock faults could potentially be concealed by alluvium and other younger river terrace deposits. It should also be noted that the geologic contact between the Pecan Gap Chalk and the Austin Chalk is marked by the Kyle fault (DeCook, 1963) just west of the project site.

2.3 Previous Geological and Geotechnical Studies

The findings from previous site investigations conducted at the project site are described in the GIR (AECOM 2021), and listed below:

- Geologic Investigation Report (SCS, 1967a)
- Soil Mechanics Report (SCS, 1967b)
- Dam Assessment Report (NRCS, 2010)

3. Geologic Investigation

3.1 Field Explorations

The project-specific field GI was conducted by AECOM between December 2019 and January 2020. Supplemental investigations associated with the proposed RCC spillway and outlet channel took place in September and October 2020. Details of the field investigation and results are provided in the GIR (AECOM 2021). Locations of the borings are shown in **Figure 2**. The general scope of the field GI Phase I is summarized as follows:

- Embankment Crest: Six (6) borings designated as 8-19 through 12-19 and 15-19 were drilled on the top of the dam. Stand-pipe piezometers were installed at borings 9-19 and 11-19 for the purposes of monitoring the phreatic surface through the dam. Two (2) additional borings, designated 13-20 and 14-20, were drilled during the supplemental investigation in the proposed location of the proposed RCC spillway. These borings were intended to further characterize foundation conditions under the RCC spillway slab and walls, assess material variability, and obtain samples for additional laboratory testing.
- Embankment Slopes: Two (2) hand auger borings designated as 1301-19 and 1302-19 were drilled near the existing PSW alignment on the relatively steep embankment slope faces where drill rig access was not feasible. Five (5) additional borings, designated 1701-20 through 1705-20, were drilled on the upstream and downstream embankment slopes near the proposed location of the new RCC spillway.
- Downstream Toe: Five (5) borings designated as 601-19 through 605-19 were drilled along the downstream toe of the dam. Two (2) additional borings, designated 702-20 and 703-20, were drilled during the supplemental investigation in the proposed location of the new RCC spillway.
- Upstream Toe: One (1) test boring, designated as 701-20, was drilled near the upstream toe of the dam. The purpose of this boring was to characterize upstream foundation conditions for embankment slope stability evaluation at the proposed RCC spillway location.
- Principal Spillway: Two (2) test borings (304-19 and 305-19) were drilled alongside the existing PSW alignment near the proposed PSW alignment. Boring 304-19 was located on the local berm on the upstream embankment slope, while 305-19 was drilled at the downstream toe.
- Borrow Area: Six (6) test borings designated as 101-19 through 106-19 were completed in a potential on-site borrow area located on the left bank of the reservoir upstream of the dam embankment.
- Proposed Outlet Channel: Two (2) borings designated 401-20 and 402-20 were drilled within the proposed outlet channel alignment downstream of the dam between the end of the proposed stilling basin for the new RCC spillway and the existing creek. The borings were intended to characterize channel erodibility, and suitability of materials in the required excavation for use as embankment fill borrow source.
- Existing Auxiliary Spillway: Ten (10) hollow-stem auger borings designated as 201-19 through 210-19 were drilled within the limits of the existing auxiliary spillway. The purpose of these borings was to allow for characterization of the subsurface at the present location of the auxiliary spillway with the intent of developing estimates of headcut erodibility indices for SITES analysis. To develop estimates of the SITES analysis input parameters, representative samples of each geologic stratum were subjected to index testing,

dispersion testing, natural density, and unconfined compression testing on relatively undisturbed field extruded push tubes and laboratory extruded Shelby tube samples.

3.2 Surface Conditions

Findings of a limited geologic visual reconnaissance of the site in March 2020 are provided in the GIR (AECOM 2021). The dam appeared to be in relatively good condition, with no visual evidence of slope instability or seepage. However, grass was relatively high over most of the site, and it was difficult to observe ground surface on the embankment slopes. Additionally, there was some apparent wave erosion causing over-steepening of the upstream slope near the waterline, and some erosion under the cradle of the PSW conduit.

3.3 Generalized Subsurface Conditions

A detailed discussion of the various soil and rock units encountered during the field investigation is provided in the 2021 GIR. In general, the findings were consistent with those of previous investigations at the site. The GIR noted that it was difficult to discern between natural and man-made fill deposits in some cases due to the general similarity in appearance and physical properties. There was also some uncertainty on the depositional origin of the “Alluvium” layer due to conflicting interpretations provided in the literature.

A brief overview of the generalized site stratigraphy characterized in the GIR is summarized in the following sections. Further discussion of the physical and engineering characteristics of these materials, including results of laboratory index and engineering properties testing, are provided in later sections of this report.

3.3.1 Embankment Fill

Compacted Embankment Fill materials ranging from 8 to 40 feet thick were encountered in each of the borings drilled along the dam crest centerline and on the upstream and downstream slopes of the embankment. The color and materials characteristics of the Embankment Fill varied considerably, which was likely associated with the geologic origin of borrow sources used as fill material (i.e., residual or alluvial).

The intervals of Embankment Fill classified in the field as fat clay (CH) were typically described as dark brown, black, or dark gray in color, with occasional tan to gray mottling. These intervals were typically moist to slightly moist, and generally stiff to hard in consistency. The material was observed to contain trace to some organics, trace fine subangular to rounded gravel typically about ¼ to ½ inch in diameter, and trace calcareous nodules and shell fragments.

The intervals of Embankment Fill identified as medium-plastic clay (CL-CH), silty lean clay (CL), or clayey silt (ML) were typically light gray, light brown, tan, and/or orange in color with occasional iron oxidation staining. These intervals were typically dry to moist, very stiff to hard in consistency, and in some cases chalky and/or friable. The materials contained trace to some fine to coarse gravel, trace to abundant calcareous nodules and calcite crystals, and typically had a strong reaction to hydrochloric acid (HCl).

Embankment Fill encountered in the upstream and downstream slopes of the embankment was largely similar to that encountered along the centerline, indicating that similar materials were used to construct both the core and shell zones of the dam.

3.3.2 Downstream Fill

Suspected Downstream Fill materials up to about 8 feet thick were encountered in boring 305-19, which was drilled on the PSW crossing berm at the downstream toe. According to the GIR, the left-most extent of fill likely extends left of 305-19 to at least the designated “waste area” limits shown on the as-built drawings, which are located in the old channel alignment near Sta. 23+00 and corresponds to the left-most extent of the crossing berm. The right-most extent of the Downstream Fill likely occurs near Sta. 28+00 at the right-most extent of the crossing berm. While boring 603-19 was drilled within these station limits, it appears to have been drilled just downstream of the fill area based on visual characteristics of the material and examination of topographic data.

The Downstream Fill was classified in the field as a fat clay (CH) and medium-plastic clay (CL-CH). It was described as very stiff to hard, moist to dry, with trace to some subangular fine to coarse gravel up to 1.5 inches in diameter. Trace to some organic matter was also present.

3.3.3 Alluvium

The Alluvium at this site was identified as a relatively thin, dark brown clayey layer present across much of the project area ranging from about 2 to 8 feet in thickness (where present). Alluvium appeared to have been encountered in borings at the proposed borrow area, the ASW channel, the upstream and downstream toe, and proposed outlet channel borings for the RCC spillway. As indicated in the as-built drawings, the Alluvium appears to have been removed from under the embankment centerline to construct the cutoff trench.

The Alluvium was classified in the field as a high-plasticity fat clay (CH). It was described as dark brown, brown, and/or black in color, and typically moist, and stiff to very hard. The Alluvium contained trace to abundant organics, trace to some fine to coarse subrounded to subangular gravel, calcareous nodules and inclusions, iron oxidation staining, and trace shell fragments.

3.3.4 Residuum

Residuum of the parent Pecan Gap Chalk formation was encountered in each boring drilled for the project, except most of the embankment slope borings. Based on visual appearance and physical characteristics, the Residuum was subdivided into two general types for convenience: the Low Plasticity Residuum (LPR), and the Medium to High Plasticity Residuum (MPR).

The LPR was classified in the field as a low-plasticity, silty to sandy lean clay (CL) and clayey silt (CL-ML), with some instances of non-plastic silty sand (SM) in the ASW borings. It was typically described as light gray, gray, light brown, or tan in color with fine to coarse sand and gravel. The LPR was dry to moist, hard, and friable with abundant calcareous material and had a strong reaction to HCl. The LPR was primarily encountered in the upper elevations of ASW borings between about EL. 645 and 655 with a maximum thickness of about 10 feet. Near the dam embankment, the LPR was encountered in both upstream borings and upstream borrow area borings, and downstream toe borings located near the left abutment and the right abutment. The thickness ranged from about 4 feet in the borrow area to nearly 20 feet at the abutments.

The MPR was classified in the field primarily as medium- to highly plastic, lean to fat clay (CL-CH) and fat clay (CH). It was typically described as tan and/or light gray in color, and became increasingly more gray with depth in the less-weathered intervals. The MPR was moist and very stiff to hard in consistency, and became increasingly dry and hard with depth. The weathered upper zones contained trace fine gravel, iron oxidation staining, calcareous inclusions, gypsum crystals, occasional shell fossil imprints, and trace black specks interpreted as manganese oxide. Reaction with hydrochloric acid ranged from slight to strong, indicating appreciable calcareous content of the clays consistent with published information of the Pecan Gap Chalk formation. With depth, the Residuum became increasingly blocky in structure, with instances of very narrow to closed near-vertical fissures that were in some cases oriented in multiple directions (i.e., similar to orthogonal joint sets in rock).

3.3.5 Shale

Bedrock consisting of moderately- to highly-weathered, calcareous shale with occasional chalky marl layers and partings was encountered below the Residuum. The shale was described as light gray to white in color, dry, extremely weak to weak, fine grained, fissile, and friable with strong reaction to HCl. Occasional pyrite and gypsum crystals were noted. Based on published data and sample appearance, the bedrock was judged to be part of the Pecan Gap Chalk formation because of the presence of abundant calcite in the clay matrix and the light gray to white color, both characteristic weathering features of this formation (Barnes, 1979).

3.3.6 Groundwater Observations

Groundwater observations are discussed in detail in the 2021 GIR. In general, most borings were dry at the time of drilling and 24 hours after drilling.

Groundwater was encountered at the time of drilling in two (2) of the borings drilled on the embankment crest centerline (8-19 and 11-19) at elevations ranging from El. 643.7 to El. 633.7. Borings 9-19 and 11-19 were completed as piezometers, and a series of groundwater readings were collected between January and October 2020. Both piezometers were screened across the Embankment Fill / Residuum interface, with 9-19 completed in Residuum and 11-19 completed in shale. While 9-19 was dry during and after drilling, piezometer readings have varied considerably with each subsequent piezometer measurement, ranging from 14.9 feet bgs in August (El. 647.5) to 32.8 feet in March (El. 629.6). The source of the high variability is unclear. Readings in piezometer 11-19 dropped nearly 20 feet lower than the groundwater measurement at the time of drilling, but has steadily risen from 46.1 feet bgs (El. 615.1) to 21.0 feet bgs (El. 630.3) which is within a few feet of the initial reading. The results of the 11-19 piezometer suggest a relatively low hydraulic conductivity.

Groundwater was not encountered at the time of drilling in any of the downstream toe borings. Delayed readings in boring 601-19 encountered static groundwater at a depth of 11.3 feet bgs (El. 638.4), which was similar to the adjacent embankment piezometer 9-19 readings which had ranged from about El. 630 to 647. While delayed readings in the other open boreholes were dry, sidewall caving was encountered in most of the open boreholes at depths ranging from 13.8 to 22 feet bgs (about El. 613 to 642). Boring 702-20 was completed as a piezometer in October 2020. While the boring was dry during drilling, the water level in the piezometer 3 days after drilling was measured at a depth of 27.5 feet bgs (El. 620.3).

The groundwater table was not encountered at the time of drilling the ASW borings, but groundwater was encountered at the end of drilling activities in boring 209-19 at 21.4 feet bgs (El. 626.9). Delayed groundwater readings in open boreholes detected groundwater in several borings at elevations ranging from about El. 622 (8.9 feet bgs) at the downstream end of the ASW channel to El. 646.7 (23.1 feet bgs) at the outside edge of the ASW channel just downstream of the control section. Sidewall caving was noted during delayed readings in a number of the open holes at depths ranging from 12.2 to 22 feet bgs.

4. Laboratory Investigation

4.1 General Approach

Soil samples recovered from the borings were labeled, packaged, and transported by AECOM to the geotechnical laboratory of TRI Environmental, Inc. (TRI) in Austin, Texas for storage and testing. Following review of the draft boring logs prepared by the AECOM field representative, laboratory testing assignments on selected samples were developed by AECOM and provided to TRI to begin testing.

Laboratory testing was conducted on selected soil samples obtained from the borings primarily to characterize existing embankment and foundation materials, and included both index testing and engineering properties testing. In general, engineering properties testing was reserved for relatively undisturbed ST samples which were sealed in the field and extruded in the laboratory. Due to concerns of possible samples disturbance, the field-extruded PT samples were generally subjected to index testing only. However, in cases where a limited number of ST samples were available in a particular stratum or boring location, some of the PT samples were subjected for unit weight, simple strength testing (i.e. unconfined compression), and/or swell testing (i.e. swell pressure only).

Laboratory testing was conducted on remolded bulk samples from potential borrow sources to evaluate suitability as embankment fill, and to obtain estimates of engineering properties. Composite bulk samples were also produced from samples of embankment in the location of required excavation for the proposed RCC spillway. Further discussion of borrow source testing, and the overall testing program, is provided in the following sections.

4.2 Borrow Source Testing

4.2.1 On-Site Borrow Area

A potential borrow area located on the left bank of the reservoir upstream of the embankment was investigated for suitability as a source for earthfill. The borings encountered 2 to 4 feet of Alluvium described as fat clay (CH). The underlying Residuum consisted of 3 to 5 feet of LPR described as calcareous silty clay (CL-ML), underlain by MPR described as medium-plasticity clay (CL-CH).

Index testing was performed on natural samples obtained through the planned excavation depth interval in borings 101-19 through 106-19 to confirm field classifications and measure index properties. Bulk samples were collected from auger cuttings from various depth intervals within the proposed excavation. In order to evaluate engineering properties of this potential borrow source, composite samples were produced from the bulk samples to represent the uppermost two strata as follows:

- COMP-100A:
  - Boring 101-19: Bulk-1: 0 to 5 feet bgs (Alluvium)
  - Boring 103-19: Bulk-1: 0 to 5 feet bgs (Alluvium)
  - Boring 104-19: Bulk-1: 0 to 6 feet bgs (Alluvium)
  - Boring 105-19: Bulk-1: 0 to 5 feet bgs (Alluvium)
  - Boring 106-19: Bulk-1: 0 to 2.5 feet bgs (Alluvium)
- COMP-100B:

- Boring 101-19: Bulk-2: 5 to 10 feet bgs (LPR)
- Boring 104-19: Bulk-2: 6 to 7.5 feet bgs (LPR)

4.2.2 Excavation for Proposed Outlet Channel and RCC Stilling Basin

Required excavations for the proposed outlet channel and RCC spillway stilling basin located downstream of the dam are being considered as potential borrow source for earthfill. The depth of excavation for the outlet channel varies from about 3 to 4 feet bgs. The bottom of the proposed stilling basin slab and underdrain is approximately 11 to 12 feet bgs at the downstream toe.

Within the proposed excavation depth interval, about 4 to 6 feet of Alluvium was encountered overlying Residuum. The Alluvium was described in the field as dark brown, moist, very stiff to hard fat clay with gravel (CH) and gravelly fat clay (CH). The underlying Residuum was consistent with the MPR characterization and was described as orange, brown, and/or gray medium-plasticity clay (CL-CH).

Index testing was performed on natural samples obtained through the planned excavation depth interval in borings 401-20, 402-20, 601-19, 702-20, and 703-20 to confirm field classifications and measure index properties. Bulk samples were collected from auger cuttings from various depth intervals within the proposed excavation. In order to evaluate engineering properties of this potential borrow source, a composite sample were produced from the bulk samples to represent the uppermost two strata as follows:

- COMP-400A
  - Boring 401-20: Bulk-1 and Bulk-2: 0 to 5 feet bgs (Alluvium)
  - Boring 402-20: Bulk-1 and Bulk-2: 0 to 5 feet bgs (Alluvium)

4.2.3 Excavation for Proposed RCC Crest and Chute Structures

Required excavations for the proposed RCC crest structure and upper portions of the RCC chute structure (on the embankment slope) are being considered as potential borrow source for earthfill. The depth of excavation for the RCC crest structure and underdrain ranges from about 3 to 9 feet bgs, and approximately 6 to 8 feet bgs for the RCC chute structure and underdrain.

Required excavations for the RCC crest structure and PSW replacement will encounter the Zone 1 (core) and Zone 2 (shell) Embankment Fill as shown on the as-builts. As discussed previously, visual classification of samples recovered from the borings indicated no appreciable difference in physical characteristics or soil types between the two embankment zones. Within the proposed excavation depth interval, these materials were largely described in the field as fat clay (CH) and medium plasticity clay (CL-CH), with minor amount of lean clay (CL) and silt (ML).

Excavations for the portion of the RCC chute structure on the downstream slope will encounter Embankment Fill (Zone 2), which was described in the field as fat clay (CH) and medium-plasticity clay (CL-CH) with some lean clay (CL). For the portion located downstream of the existing toe, below-grade excavation for the RCC chute structure will encounter natural foundation soils (Alluvium and Residuum) which were described in the field as fat clay (CH), lean clay (CL), and silty clay (CL-ML).

For the RCC crest structure and upper portion of the RCC chute structure, index testing was performed on natural samples obtained in the planned excavation depth interval from borings 9-19, 13-20, 14-20, and 1701-20 through 1705-20 to confirm field classifications and measure index properties. In order to evaluate engineering properties of this potential borrow source, a bulk sample was composited from auger cuttings collected from various depth intervals within the proposed excavation as follows:

- COMP-1700A:
  - Boring 1701-20: 0 to 4.5 feet bgs (Embankment Zone 2)
  - Boring 1702-20: 0 to 4 feet bgs (Embankment Zone 2)
  - Boring 1703-20: 0 to 6 feet bgs (Embankment Zone 2)
  - Boring 1704-20: 0 to 8 feet bgs (Embankment Zone 2)

For the lower portion of the RCC chute structure (to be excavated downstream of the embankment toe), sampling and testing described performed within the excavation interval described in **Section 4.2.2** is applicable.

4.2.4 Excavations for Proposed PSW Replacement

Required excavations for abandonment of the existing PSW and installation of the new PSW are being considered as potential sources of earthfill. The depth of required excavation for abandonment of the PSW is a maximum of about 9 feet bgs on the upstream and downstream sides of the embankment. The required excavation to construct the new PSW is a maximum of about 32 feet below the embankment crest and will require a full temporary breach of the dam.

Required excavations for installation of the new PSW will primarily encounter the Zone 1 (core) and Zone 2 (shell) Embankment Fill as shown on the as-builts. There was no appreciable differences in these materials based on borings drilled for this project, and were largely described in the field as fat clay (CH) and medium plasticity clay (CL-CH), with minor amount of lean clay (CL) and silt (ML). Required excavations for abandonment of the existing PSW will primarily encounter Zone 2 (shell) Embankment materials. Below about El. 635± at both locations, required excavations may encounter Downstream Fill and native foundation materials (Alluvium and Residuum) which were described in the field as fat clay (CH) and lean to fat clay (CL-CH).

Index testing was performed on natural samples obtained in the planned excavation depth intervals from nearby borings 11-19, 304-19, 305-19, 603-19, 1301-19, and 1302-19 to confirm field classifications and measure index properties.

4.2.5 Excavation for ASW Widening

Proposed widening of the ASW channel will include required excavation of the existing right training dike and the left end of the dam embankment. Based on boring 8-19 drilled through the embankment centerline, it is anticipated that existing fill materials comprising the training dike and embankment consist of fat clay (CH).

The ASW widening will also include excavation of about 3 to 5 feet of the native overburden soils located to the right of the existing channel limits. Based on nearby borings drilled as part of the original design investigation (borehole nos. 51, 52, 252, 254, and 256) and for the current rehabilitation project (601-19 and 208-19 through 210-19), the planned excavations are expected to encounter predominantly Alluvium consisting of fat clay (CH) with lesser amounts of underlying Residuum consisting of lean to fat clay (CL, CL-CH).

Index testing was performed on natural samples obtained in the planned excavation depth intervals from borings cited above to confirm field classifications and measure index properties.

4.3 Summary of Testing and Results

Testing performed for this project included index properties (moisture, unit weight, gradation, plasticity, and specific gravity), dispersion (crumb, standard and double hydrometers), chemical/corrosion properties, and engineering properties. Engineering properties testing included volume change (consolidation and/or swell), shear strength, and hydraulic conductivity. Strength testing included unconfined compression (UC), unconsolidated-undrained triaxial compression (UU), isotropically consolidated-undrained triaxial compression (CIU') with pore pressure measurement, and consolidated-drained direct shear (CDDS). A summary of tests performed for each stratum is provided in the Table **4-1**. Discussion of test methods and specific tests results is included in the following sections.

Table 4-1 Summary of Tests Performed by Stratum

Stratum or Location (1)	Index	Dispersion	Corrosion	Lime Treat	Swell	Consol.	Strength	Perm.	Proctor
Embankment Fill	X	X	X		X	X	UC, UU, CIU', CDDS	X	
Downstream Fill	X	X	X				UU		
Alluvium	X	X	X		X		UU, CDDS		
Residuum	X	X			X	X	UC, UU, CIU'	X	
Shale	X	X					UC		
Borrow Area	X	X	X	X	X	X	CIU', UU, UC	X	X
Excavation for Outlet Channel & RCC Stilling Basin	X	X	X	X	X				X
Excavation for RCC Crest & Chute Structure	X	X	X	X	X		UC		X
Excavation for ASW Widening	X								

4.4 Index Testing

Index properties testing was conducted to measure physical properties of the materials and to confirm field soil classifications. Index tests include the following:

- Natural moisture content (ASTM D2216)
- Natural unit weight (ASTM D7263)
- Specific gravity (ASTM D854)
- Atterberg limits (ASTM D4318)
- #200 wash (ASTM D1140)
- Sieve analysis (ASTM D422 / D6913)
- Sieve analysis with hydrometer (ASTM D422 / D7928)

A tabulated summary of index test results is provided as **Table A.1** of **Appendix A**. Individual laboratory test data sheets are included in **Appendix A**. The results of index testing are also included on the boring logs in the GIR; however, it is noted that the soil classifications on the borings logs are based on field classifications consistent with NRCS standard practice, and were not modified by the laboratory-based classifications. A comparison of the field classifications and lab classifications is provided in **Table A.1**.

4.5 Dispersion Testing

4.5.1 Crumb

To evaluate the potential dispersive characteristics of site soils, crumb dispersion tests (ASTM D6572) on fragments of discrete soil samples obtained from the borings. The test is performed by immersing a small fragment (crumb) of soil, at the natural moisture content, into about 150 ml of distilled water. After a few minutes, the sample is viewed and graded based on the colloidal suspension. Grades are summarized and interpreted as follows:

- Grade 1: No Reaction (Nondispersive)
- Grade 2: Slight Reaction (Intermediate)
- Grade 3: Moderate Reaction (Dispersive)
- Grade 4: Severe Reaction Highly Dispersive (Highly Dispersive)

It is noted that the crumb test is generally used a screening test to identify potentially dispersive soils, and is generally not relied upon exclusively for evaluating dispersion potential. Results are supplemented with more reliable test methods such as double-hydrometer or pinhole testing.

The results from 13 of 17 crumb tests performed in the existing ASW channel were Grade 1 classification. The remaining results were Grade 2 (three samples), with one case of Grade 3 (sample depth 22.5 to 24.5 in boring 203-19). Each of the 12 crumb tests on samples of foundation soils downstream of the dam were Grade 1. The results from 16 of 17 crumb tests on Embankment Fill were Grade 1, with one Grade 2 results on the upstream slope. Each of the seven (7) crumb tests in the borrow area were Grade 1. These results suggest the soils at this site are likely to be non-dispersive to intermediate. Results are provided in **Appendix A**.

4.5.2 Double-Hydrometer

The double-hydrometer test (ASTM D4221 and ASTM D7928) was performed to further evaluate the dispersive characteristics of the soil. The test is performed on both a natural soil specimen and a specimen artificially dispersed by sodium hexametaphospate and thorough agitation. The result is reported as a percent dispersion, defined as the percent finer than 0.002 mm without dispersant to that with dispersant. The interpretation of the results is as follows:

- < 30% Dispersion: Nondispersive
- 30 – 60 % Dispersion: Intermediate, more testing required
- > 60% Dispersion: Dispersive

Results of three double-hydrometer tests performed on Embankment Fill with crumb Grade 1 and 2 each measured 0% dispersion. Results of four double-hydrometer tests in the ASW samples were 10% (crumb test Grade 1), 14% (crumb test Grade 1), 15% (crumb test Grade 2), and 48% (crumb test Grade 2) dispersion. Results of one double-hydrometer test performed on MPR at the RCC spillway was 23% dispersion (crumb test Grade 1). The results of three double-hydrometer tests at the downstream toe near the principal spillway were 7%, 11% and 23% dispersion (each with crumb test Grade 1). Testing from the original SMR (SCS 1984b) indicated similar results, with three tests each yielding less than 21% dispersion. These results suggest the materials are largely non-dispersive with occasional layers that may exhibit slightly dispersive characteristics. Test results are provided in **Appendix A**.

4.6 Moisture-Density Relationship (Proctor Compaction)

Standard Proctor compaction testing (ASTM D698, Method A) was performed to evaluate moisture-density relationships for the potential borrow sources. Specific gravity testing (ASTM D854) was also performed on each sample tested for moisture-density. Results are provided in **Table 4-2**.

Table 4-2 Summary of Moisture-Density Relationship Test Results

Boring ID	Top Depth (ft)	Bottom Depth (ft)	Stratum	USCS	Fines Content (%)	LL	PI	Specific Gravity, Gs	Maximum Dry Unit Weight, MDD (pcf) (1)	Optimum Moisture Content, OMC (%) (1)
COMP-100A	0	2.5 to 6	Borrow (Borrow Area Upper Zone A)	CH	89.3	58	37	2.62	99.0	22.0
COMP-100B	5 to 6	7.5 to 10	Borrow (Borrow Area Mid Zone B)	CL	75.2	43	26	2.77	115.1	14.4
COMP-400A	0	5	Borrow (Excavation for RCC Outlet Channel)	CH	85.8	59	33	2.60	93.9	22.3
COMP-1700A	0	4 to 8	Excavation for RCC Crest / Chute	CH	94.1	64	43	2.60	95.1	24.4

Notes:
(1) Standard Proctor compaction energy (ASTM D698).

4.7 One Dimensional Consolidation

One-dimensional consolidation tests (ASTM D2435) were performed on relatively undisturbed ST samples to assess stress history and consolidation characteristics of site soils. During the test, soil specimens are laterally restrained and axially drained while subjected to applied vertical loadings. In preparation for testing, soil specimens are trimmed to approximately 2 inches in diameter and 0.75 inches in height. A vertical seating load of about 100 psf is applied, and the sample is inundated with water. The applied vertical load is progressively adjusted to prevent sample swelling upon inundation until reaching the “swell pressure” (i.e., the confining pressure at which no soil swelling occurs). The load is then incrementally increased in doubling increments to measure changes in void ratio with applied loading (i.e., compression), allowing time for load-settlement equilibration at each load increment. A plot of void ratio versus the log of applied stress is then prepared, which can be used to graphically estimate the preconsolidation pressure (P’c), which is defined as the maximum stress to which the soil has previously been subjected over a geologic timeframe. The slope of the void ratio-stress curve at applied loads less than P’c is termed the recompression index (Cr), and the slope at applied loads greater than the P’c is termed the compression index (Cc). Settlements at applied loads greater the P’c are significantly greater than loads less than P’c.

Consolidation tests performed for this project also included an unload-reload cycle to obtain an improved estimate of the soil recompression curve. This included initially loading the sample to 16,000 psf, unloading incrementally to 4,000 psf, and then reloading to the maximum 64,000 psf load. The sample was then incrementally unloaded back to the initial seating load and the test completed. Stresses selected for the unload-reload cycle were based on initial loading beyond the estimated P'c, and then unloading to a value above the estimated swell pressure.

Consolidation test data were analyzed by TRI using the Casagrande graphical method to estimate the values of P'c, Cc, and Cr. The overconsolidation ratio (OCR) was estimated by AECOM based on estimated in-situ effective stress at the sample depth. Test results are summarized in **Table 4-3**. Test results on undisturbed samples indicate the fill and natural materials are moderately to highly overconsolidated and are not susceptible to significant settlement for the anticipated structure loading. Settlement analyses for proposed structures are included in later sections of this report (see Sections 8.1 and 8.2.2).

Table 4-3 Summary of Consolidation Test Results

Boring ID	Top Depth (ft)	Bottom Depth (ft)	Stratum	USCS	LL	PI	Cc	Cr	σ'v (psf) (2)	P'c (psf)	OCR	e_0
9-19	8	10	Embankment Core	CH	74	50	0.083	0.027	1,125	13,700	12.2	0.588
9-19	23	25	MPR	CH	50	29	0.122	0.036	2,500	8,700	3.5	0.658
13-20	6	8	Embankment Core	CH	61	41	0.145	0.027	875	11,400	13.0	0.601
601-19	3.5	5.5	LPR	CH	64	35	0.163	0.011	540	19,700	36	0.633
601-19	13	15	LPR	CH	67	44	0.124	0.025	1,536	17,900	11.7	0.670
603-19	8	10	MPR	CL/CH	62	40	0.129	0.036	1,125	16,200	14.4	0.624

Notes:

1) Abbreviations:
   a) Cc – Compression index (void ratio basis)
   b) Cr – Recompression index (void ratio basis)
   c) σ'v – Estimated in-situ effective overburden pressures at mid-layer depth based on estimated long-term groundwater levels
   d) P'c – Estimated preconsolidation pressure
   e) CG – Casagrande method
   f) OCR – Estimated overconsolidation ratio
   g) e0 – Initial void ratio
   h) LL – Liquid Limt
   i) PI – Plasticity Index
2) Calculated at average sample depth assuming static groundwater at 15.4, 11.0, 11.7, and 14.9 feet bgs in borings 9-19, 13-20, 601-19, and 603-19, respectively, with average unit weight of 125 pcf.

4.8 Swell / Collapse Testing

Testing of relatively undisturbed thin-walled tube samples and remolded bulk samples was performed to evaluate the swell or collapse potential of select soil samples. The tests were conducted as constant-volume swell tests to obtain the swell pressure (ASTM D4546 Method B). Specifically, the procedure included loading test specimens to the initial confining pressure (nominal 120 psf) and inundating with water. The load was progressively increased as required to prevent swelling from occurring.

For some tests, an additional unloading cycle was included to evaluate percent swell at various confining pressures less than the swell pressure (ASTM D2435). Upon reaching the swell pressure (i.e. confining pressure at which zero swell occurs), the load was incrementally reduced and the corresponding percent swell was measured at each step load. Results of the test are reported as maximum percent swell at the lowest confining pressure, and swell pressure at the highest confining pressure.

Swelling behavior was observed in each of the test samples. The test results on relatively undisturbed samples indicate widely variable swell results, with measured swell pressures ranging from moderate (674 psf) to high (6,388 psf). Most tests yielded swell pressures between 1,000 and 3,000 psf. No trend was evident between soil index properties and swell pressure or swelling strain index. The estimated degree of saturation of tested samples ranged from about 69 to 99%.

Remolded bulk samples were compacted to 95% of maximum dry density (MDD) at varying moisture contents of 0, +2, or +4% relative to optimum moisture content (OMC) as determined by ASTM D698. Results indicate swell pressure decreases with increasing compaction moisture content. Measured swell pressures ranged from low (184 psf) to moderate (1,294 psf), with the lowest swell pressure measured on the CL sample compacted at the highest moisture content, and highest swell pressure measured on the CH sample compacted at the lowest moisture content.

Swell test results indicate that most site soils are moderately to highly expansive. The measured swell pressures in many cases exceed the design bearing pressure of various proposed structures, which indicate that foundation heave and settlement may occur in response to wetting and drying cycles of the subgrade. Expansive soil backfills may also exert large swelling pressures on walls and other buried structures. Therefore, expansive soil mitigation measures will need to be included in the design of foundations, retaining walls, and buried conduits for this project. Results and associated index properties of tested samples are summarized below in **Table 4-4**.

Table 4-4 Summary of Swell/Collapse Test Results

Boring ID	Top Depth (ft)	Bott. Depth (ft)	Stratum	Test Type (1)	USCS	LL	PI	CF (%)	Swell Pressure (psf) (2)	%Swell at σmin psf (3)	Swelling Strain Index, $C_{s\varepsilon}$ (4)	Est. Free Swell (%) (5)
9-19	0	2	Embank. Core	SP	CH	65	41	58.1	1,354	---	---	---
9-19	4	6	Embank. Core	SP	CH	68	43	46.4	2,762	---	---	---
9-19	8	10	Embank. Core	SPU	CH	74	50	---	2,517	3.67	0.037	7.83
"	"	"	"	IC	"	"	"	---	6,338	---	0.035	---
9-19	13	15	Embank. Core	SP	CH	60	34	48.5	841	---	---	---
9-19	23	25	MPR	IC	CH	50	29	---	2,521	---	0.034	---
9-19	28	30	MPR	SP	CH	73	48	48.5	2,955	---	---	---
13-20	2	4	Embank. Core	SP	CH	64	37	--	2,262	---	---	---
13-20	6	8	Embank. Core	SPU	CH	61	41	---	1,637	1.02	0.013	2.44
13-20	"	"	"	IC	"	"	"	---	2,666	---	0.034	
13-20	18	20	MPR	SP	CH	52	34	---	1,154	---	---	---
14-20	18	20	Embank. Core	SP	CH	58	38	---	1,040	---	---	---
601-19	0	2	Alluvium	SP	CH	79	46	64.3	2,175	---	---	---
601-19	4	6	LPR	SPU	CH	64	35	---	5,121	3.87	0.029	7.02
601-19	"	"	"	IC	"	"	"	"	3,364	---	---	---
601-19	6	8	LPR	SP	CL	31	15	38.1	674	---	---	---
601-19	13	15	LPR	SPU	CH	67	44	---	1,578	1.82	0.023	4.30
601-19	"	"	"	IC	"	"	"	"	3,373	---	---	---
601-19	18	20	LPR	SP	CH	77	54	66.2	3,282	---	---	---
603-19	8	10	MPR	IC	CH	62	40	---	5,200	---	0.045	---

603-19	13	15	MPR	SP	CL	29	14	68.1	2,826	---	---	---
702-20	13	15	MPR	SP	CH	73	40	47.4	1,163	---	---	---
702-20	23	25	MPR	SP	CH	66	44	---	810	---	---	---
703-20	18	20	MPR	SP	CH	61	39	---	1,530	---	---	---
COMP-100A	0	2.5 to 6	Borrow-Upper (+0.2% OMC)	SP	CH	58	37	61.3	875	---	---	---
"	"	"	Borrow-Upper (+4.3% OMC)	SP	"	"	"	"	346	---	---	---
COMP-100B	5 to 6	7.5 to 10	Borrow-Middle (+0.0% OMC)	SP	CL	43	26	43.0	532	---	---	---
"	"	"	Borrow-Middle (+2.0% OMC)	SP	"	"	"	"	327	---	---	---
"	"	"	Borrow-Middle (+4.0% OMC)	SP	"	"	"	"	184	---	---	---
COMP-400A	0	5	RCC Outlet (+0.0% OMC)	SP	CH	59	33	61.5	1,294	---	---	---
"	"	"	RCC Outlet (+4.0% OMC)	SP	"	"	"	"	614	---	---	---
COMP-1700A	0	4 to 8	Embank. Shell (+0.0% OMC)	SPU	CH	64	43	42.9	746	0.99	0.011	3.16

Notes:

1) Test Type: "IC" = Incremental Consolidation; "SP" = Swell Pressure only; "SPU" = Swell pressure with staged unloading
2) Constant-volume procedure.
3) Maximum swell at test minimum vertical confining pressure (typ. 80 to 100 psf) following incremental unloading from the swell pressure.
4) Swelling strain index is the slope of the unloading curve, $C_{s\varepsilon} = (\varepsilon_2 - \varepsilon_1) / \log(p_2/p_1)$
5) Estimated swell at 20 psf vertical confining pressure based on $C_{s\varepsilon}$.

4.9 Shear Strength Testing

4.9.1 Undrained Shear Strength

Unconsolidated-Undrained (UU) Triaxial Compression (ASTM D2850) or Unconfined Compression (UC) (ASTM D2166) tests were performed to obtain estimates of undrained shear strength (Su). In the UU test, the sample is loaded into a triaxial test chamber, the drainage lines are closed, a confining pressure is applied, and the sample is sheared to failure in compression. In the UC test, the sample is loaded into a simple load frame with no confining pressure or controls on drainage, and then sheared to failure in compression. The reported values of Su are taken as one-half of the unconfined compressive strength in unconfined compression tests, or one-half the maximum deviator stress for UU tests.

The UU and UC testing was performed on relatively undisturbed ST samples of existing fill and natural foundation soils. The effective confining pressure applied to UU test samples was generally equal to the estimated in-situ effective overburden pressure based on estimated static groundwater levels. Tests were performed on samples of most of the various geologic strata encountered.

The UU and UC test results on relatively undisturbed samples indicate very stiff to hard cohesive materials, confirming the results of field pocket penetrometer and SPT testing. For natural samples tested in the existing ASW channel, the results of 17 UC tests had peak Su values ranging from about 3,100 to more than 7,800 psf, with typical values between about 3,000 and 5,000 psf. The results of 4 UU/UC tests performed on existing embankment fill produced Su values ranging from 3,300 to 8,500 psf. The results of 14 UU/UC tests performed on natural foundation soils near the dam embankment (i.e., downstream fill, residuum, alluvium, and shale) produced Su values ranging from about 4,800 to 13,800 psf.

UU and UC testing was also performed on remolded bulk samples from potential borrow sources compacted to about 95% of maximum dry density (MDD) at varying moisture contents of either 0% or +4% above optimum moisture content (OMC) per ASTM D698. The value of Su decreased substantially with increasing moisture; the lean clay sample COMP-100B decreased from 2,160 to 1,123 psf and fat clay sample COMP-1700A decreased from 1,771 to 634 psf at compaction moisture of 0% and +4%, respectively. Results are provided in **Appendix A**.

Table 4-5 Summary of Undrained Shear Strength Test Results

Boring ID	Top Depth (ft)	Bott. Depth (ft)	Stratum	Lab USCS	LL	PI	Pass #200 (%)	Test Type (1)	Confining Pressure (psf)	Strain at Failure (%)	Su (psf)	Su/p Ratio
9-19	8	10.0	Embank. Core	CH	74	50	97.5	UC	0	4.9	8,554	---
9-19	23	25.0	MPR	CH	50	29	86.4	UC	0	9.5	4,824	---
13-20	6	8.0	Embank. Core	CH	61	41	89.5	UU	432	15.0	3,312	7.7
13-20	18	20.0	MPR	CH	52	34	99.2	UU	1,440	15.0	3,168	2.2
14-20	2	4.0	Embank. Core	CH	53	33	---	UC	0	5.9	5,789	---
14-20	18	20.0	Embank. Core	CH	58	38	80.9	UU	1,440	10.2	3,384	2.4
304-19	28	30.0	LPR	CH	60	39	96.1	UU	1,872	5.6	6,998	3.7
305-19	4	6.0	D.S. Fill	CL	48	27	89.4	UU	432	9.0	13,824	32.0
601-19	3.5	5.5	LPR	CH	64	35	96.2	UC	0	5.2	6,869	---
601-19	13	15.0	LPR	CH	67	44	97.1	UC	0	8.6	4,666	---
603-19	8	10.0	MPR	CH	62	40	95.0	UU	1,008	5.6	10,858	10.8
701-20	2	4.0	LPR	CH	51	31	---	UC	0	15.0	7,992	---
701-20	23	25.0	Shale	CH	66	44	---	UC	0	8.2	4,104	---
702-20	2	4.0	Alluvium	CH	66	44	---	UC	0	4.5	13,478	---
702-20	13	15.0	MPR	CH	73	40	98.3	UU	720	15.0	3,341	4.6
703-20	3.5	5.5	LPR	CL	44	26	---	UC	0	12.4	12,586	---
703-20	18	20.0	MPR	CH	61	39	---	UU	1,008	7.8	5,789	5.74
703-20	27.5	29.5	Shale	CH	65	42	---	UC	0	9.2	12,298	---
COMP-100B	5 to 6	7.5 to 10	Borrow-Layer B (+0.0% OMC) (2)	CL	43	26	75.2	UU	288	12.5	2,160	7.50
"	"	"	Borrow-Layer B (+4.0% OMC) (2)	"	"	"	"	UU	288	15.0	1,123	3.90
COMP-1700A	0	4 to 8	Embank. Shell (+0.0% OMC) (2)	CH	64	43	94.1	UC	0	13.0	1,771	---
"	"	"	Embank. Shell (+4.0% OMC) (2)	"	"	"	"	UC	0	15.0	634	---
201-19	2.0	4.0	LPR	CL	41	26	79.9	UC	0	7.6	4,378	---
201-19	13.0	15.0	MPR	CH	60	31	98	UC	0	15.0	3,269	---
202-19	2.0	4.0	LPR	CL	24	9	81.3	UC	0	5.2	6,437	---
202-19	8.0	10.0	LPR	ML	48	20	67	UC	0	10.7	3,211	---
204-19	2.0	4.0	LPR	CL	25	8	69.2	UC	0	3.0	4,378	---
204-19	13.0	15.0	MPR	CH	50	28	97.8	UC	0	8.4	3,917	---
205-19	8.0	10.0	MPR	CH	54	30	98.1	UC	0	15.0	4,550	---
206-19	8.0	10.0	MPR	CH	67	43	97.9	UC	0	6.7	3,802	---
206-19	18.0	20.0	MPR	CH	57	34	99.1	UC	0	11.7	3,643	---
207-19	2.0	4.0	Alluvium	SC	33	16	46.2	UC	0	7.0	5,270	---

207-19	18.0	20.0	MPR	CH	55	29	98.9	UC	0	8.0	4,766	---
208-19	2.0	4.0	LPR	CL	29	16	80.7	UC	0	3.8	3,125	---
208-19	13.0	15.0	MPR	CH	59	36	87.8	UC	0	7.2	5,544	---
209-19	6.0	8.0	MPR	CH	61	39	98.9	UC	0	9.0	4,248	---
209-19	18.0	20.0	MPR	CH	62	40	96.7	UC	0	6.9	5,990	---
210-19	8.0	10.0	MPR	CH	60	38	96.9	UC	0	13.6	7,819	---
210-19	18.0	20.0	MPR	MH	52	23	98.1	UC	0	5.4	4,781	---

Notes:

1) Test Type: “UC” = Unconfined Compression, “UU” = Unconsolidated-Undrained Triaxial
2) Remolded moisture content relative to Optimum Moisture Content (OMC). Samples remolded to 95% of maximum dry density per ASTM D698.

4.9.2 Consolidated-Undrained Triaxial Compression

In the isotopically consolidated-undrained (CIU’) triaxial compression test (ASTM D4767), a 2.8-inch diameter by 5.5-inch long specimen is loaded into a triaxial test chamber, seated, and backpressure saturated. Pore water pressure measurements are made until the sample is saturated (zero air voids). Following backpressure saturation, the sample is subjected to a selected confining pressure and allowed to consolidate. Once adequate consolidation is attained, the sample is sheared and pore water pressures are measured. The load applied (stress) and the sample deformation (strain) are measured.

For a conventional multi-specimen shear test, individual specimens are sheared to failure for each applied confining pressure. From the resulting stress, strain, and pore water measurements at three different confining pressures, the following strength parameters can be deduced: total stress friction angle (ϕ_u), effective stress friction angle (ϕ’), total stress cohesion intercept (cu), and effective stress cohesion intercept (c’). Estimates of these parameters were developed by TRI based on various failure criteria including maximum principal stress difference $(\sigma1\text{-}\sigma3)_{max}$ and maximum principal stress ratio $(\sigma1/\sigma3)_{max}$ considering both Mohr-Coulomb and modified Mohr-Coulomb (“p-q”) diagrams as shown in the **Appendix A** data sheets.

The CIU’ testing was performed on relatively undisturbed ST samples of existing embankment fill and natural foundation soils.

The testing was also performed on remolded bulk samples from potential borrow sources compacted to about 95% of maximum dry density at a moisture content about +4% of optimum (ASTM D698).

The CIU’ triaxial test results are included in **Appendix A** and summarized in Table **4-6**.

4.9.3 Consolidated-Drained Direct Shear

Consolidated-drained direct shear (CDDS) testing (ASTM D3080) was performed on relatively undisturbed samples. Test samples are trimmed to 2.5-inch diameter and 1.0-inch in height and consolidated to a specified effective normal stress. Following consolidation, the sample is sheared in a horizontal direction to a maximum displacement of 0.25 inches. The shear strain rate is based on the consolidation rate and is assumed to be slow enough to inhibit the development of excess pore water pressure within the specimen being tested. Drainage is allowed through both the top and bottom of the sample.

For each test, three (3) individual samples were tested at different effective normal stresses to obtain a strength envelope. The Mohr-Coulomb slope intercept data reduction techniques was used to fit an effective stress (drained) shear strength envelope to data points for both the peak shear stress and the post-peak shear stress at 0.25 inches of horizontal displacement. The interpreted effective friction angle and cohesion intercept (ϕ’, c’) for both the peak and post-peak envelopes are provided in **Table 4-7**.

The CDDS testing was performed on relatively undisturbed ST samples, and was generally reserved for samples in which too little sample was recovered in the Shelby tube to allow CIU’ testing with 3 test specimens from the same tube. Detailed laboratory results, including data sheets and displacement curves, are included in **Appendix A.**

Table 4-6 Summary of CIU' Triaxial Shear Test Results from Current Study

Boring ID	Depth (ft)		Stratum	Test Type (1)	USCS	Avg. WC (%)	Avg. DD (pcf)	LL	PI	FC (%)	CF (%)	Total Stress (CU-Envelope)(2)		Effective Stress (CD-Envelope) (2)	
	Top	Bottom										C_u (psf)	ϕ_u (deg)	C' (psf)	ϕ' (deg)
11-19	18	20	Embankment Core (Zone 1)	U,C	CH	18.2	116.8	55	36	82.8	---	1,166	12.5	821	16.9
305-19	18	20	MPR	U,C	CH	19.8	105.6	60	35	95.5	---	778	30.2	0 (3)	40 (3)
COMP-100B	5 to 6	7.5 to 10	Borrow-Layer B (LPR)	R,C	CL	17.4	109.0	43	26	75.2	43.0	835	16.7	432	24.4

Notes:

1) Test type:
    a. U – Relatively undisturbed sample (Shelby tube) at natural density and moisture content.
    b. N – Remolded to natural density at natural moisture content.
    c. R – Remolded to 95% maximum dry density at moisture content +3% of optimum per ASTM D698.
    d. C – Conventional multi-specimen shear test. Each specimen sheared to failure at one confining stress value.
    e. MS – Multi-stage shear testing on single specimen. Shearing at lower normal stresses limited to ~3% strain. Sheared to failure at highest tested normal stress.
2) Failure defined with respect to Peak Principal Stress Difference $(\sigma_1-\sigma_3)_{max}$. Refer to Appendix A data sheets for failure according to Peak Principal Stress Ratio $(\sigma_1/\sigma_3)_{max}$.
3) Secant friction angle reported for each of the 3 test specimens for this sample due to variable shear behavior and poor fit for linear regression of of Mohr-Coulomb envelope.

Table 4-7 Summary of CDDS Test Results from Current Study

Boring ID	Depth (ft)		Stratum	Test Type (1)	USCS	Avg. WC (%)	Avg. DD (pcf)	LL	PI	FC (%)	CF (%)	Peak Envelope		Post-Peak Envelope (2)	
	Top	Bottom										Cohesion, C (psf)	Friction Angle, ϕ (deg)	Cohesion, C (psf)	Friction Angle, ϕ (deg)
304-19	6	8	Embankment (Zone 1)	U	CH	24.3	98.9	76	55	91.0	-	662	16.8	619	15.2
304-19	18	20	Alluvium	U	CH	20	101.3	80	59	97.5	-	374	23.0	173	22.3

Notes:

1) Test type:
   a. U – Relatively undisturbed sample (shelby tube) at natural density and moisture content.
   b. N – Undisturbed samples molded to natural density at natural moisture content.
   c. R – Remolded to 95% maximum dry density at moisture content +3% of optimum per ASTM D698.
   d. C – Multi-specimen shear test. Each specimen sheared to failure at one confining stress value.
   e. MS – Multi-stage shear testing on single specimen. Shearing at lower normal stresses limited to ~3% strain. Sheared to failure at highest tested normal stress.
2) Post-peak envelope corresponds to 0.25" shear displacement.

4.9.4 Hydraulic Conductivity

Hydraulic conductivity testing (ASTM D5084) was performed on relatively undisturbed ST samples and remolded bulk samples from the on-site borrow area. In order to achieve a specified saturation, back pressure is applied to the sample at a low effective confining stress. Subsequently, the specimen is isotropically consolidated to an assigned stress and a gradient is applied from the bottom to the top drainage boundary. Volume of flow is recorded for the duration of the test and the hydraulic conductivity is then calculated.

Results of the hydraulic conductivity tests completed are presented in **Appendix A** and are summarized in Table **4-8**.

Table 4-8. Hydraulic Conductivity Test Results

Boring ID	Top Depth (ft)	Bottom Depth (ft)	Stratum	USCS	LL	PI	FC (%)	Test Type [(1)]	Effective Confining Pressure (psf)	Hydraulic Conductivity (cm/s)
11-19	38	40	MPR	CH	73	48	94.3	U	720	7.8E-09
701-20	6	8	LPR	CH	57	38	---	U	432	1.2E-06
304-19	28	30	LPR	CH	60	39	96.1	U	1,872	1.9E-09
COMP-100B	5 to 6	7.5 to 10	Borrow-Layer B (LPR)	CL	43	26	75.2	R	720	6.6E-06

Notes:

1) Test type:
   a. U – Relatively undisturbed sample (shelby tube) at natural density and moisture content.
   b. N – Undisturbed samples molded to natural density at natural moisture content.
   c. R – Remolded to 95% maximum dry density at moisture content +0% of optimum per ASTM D698.

4.10 Chemical Compatibility

4.10.1 Corrosivity Testing

Chemical compatibility testing was performed to assess soil corrosion hazard to buried metal and concrete. Chemical compatibility testing included the following:

- Organic content (ASTM D2974)
- pH analysis (ASTM D4972)
- Electrical resistivity (ASTM G57)
- Soluble Sulfates (ASTM C1580/D516)
- Soluble Chlorides (ASTM D512)

Results of the corrosivity testing are provided in Table **4-9.**

Soluble chloride content greater than about 500 ppm are generally considered to be corrosive to buried metal, but test results measured chloride contents between 180 and 300 ppm and should not be of concern. With respect to electrical resistivity, soils are considered to be “corrosive” to buried metal in the range of 700 to 2,000 ohm-cm, although there are several intermediate grades

(Elias et al., 2001). The measured resistivity values range from 370 to 1,210 ohm-cm, and suggest that buried metal will be subject to corrosive conditions.

The presence of high soluble sulfate content (greater than about 200 ppm) may be corrosive to buried metal and concrete (FHWA, 2010). The results of 41 sulfate tests on various soil units yielded sulfate contents ranging from 300 to 17,700 ppm, with 8 results greater than 7,000 ppm. Results are variable across the soil units encountered at the site, with the highest measured results obtained on samples of the existing Embankment Shell and MPR. For each soil unit tested, at least one test yielded sulfate content greater than 1,500 ppm, and all but the Embankment Core material had had one test with sulfate content 7,000 ppm or more .

Based on the sulfate test results, the sulfate exposure is classified as “moderate” (150-1,500 ppm) to “very severe” (>10,000 ppm) according to ACI 350 Table 4.3.1. The ACI 350 recommends Type II cement for “moderate”, Type V cement for “severe”, and Type V cement plus pozzolan for “very severe” sulfate exposure. Considering the high measured sulfates contents and variable distribution in site soils, the use of sulfate-resistant cement (e.g. Type V) is recommended for concrete and RCC to mitigate sulfate degradation, and consideration should be given to the addition of pozzolan.

The sulfate contents may also be problematic if chemical amendment of expansive soils is considered at this site. The presence of soluble sulfate salts in soils treated with calcium-based additives (e.g., lime or Portland cement) can be problematic. In excessive concentrations, the sulfate reacts adversely with calcium, water, and alumina in the clay to form the mineral ettringite. The formation of ettringite causes substantial volume increase (swelling) of 2 to 2.5 times its initial volume and can cause significant heaving and distress to adjacent structures, a process commonly referred to as “sulfate-induced heave”. Soluble sulfates are generally not problematic at concentrations less than 3,000 ppm. At concentrations between 3,000 and 5,000 ppm, special precautions are needed to reduce the risk of sulfate-induced heave (extended mellowing time, additional water, etc.). Sulfate concentrations greater than 5,000 ppm are considered high risk for sulfate-induced heave, and multiple applications of lime and extended mellowing periods are typically required (NLA, 2004). The Texas Department of Transportation (TxDOT) does not permit lime treatment of soils with sulfate concentration exceeding 7,000 ppm (TxDOT, 2014).

High organic contents may be associated with increased compressibility and lower shear strength. Measured organic contents range from 2.6 to 6.7% in the surficial Alluvium, and 1.1 to 5.2% in the Residuum. According to the organic classification system proposed by Huang et al. (2009), neither of these units would be considered an “organic” soil: the Residuum would be generally classified as “mineral soil” (0 to 3% organics) and the Alluvium would generally be classified “mineral soil with organic matter” (3 to 15% organics). Thus, the measured organic contents are not expected to significantly affect engineering properties (e.g. compressibility or shear strength) compared to similar clay soils free of organics. However, high organic contents (more than about 1 to 2 percent) can be problematic for lime treatment of high plasticity clays. Soils with high organic content may require additional lime and/or special construction procedures to obtain a stable treated soil mass, and typically have less strength gain than non-organic soils (NLA, 2004).

Further discussion of sulfates and organic content test results as they related to lime treatability is provided in the next section.

Table 4-9 Summary of Chemical Compatibility Testing

Boring ID	Top Depth (ft)	Bottom Depth (ft)	Stratum	USCS	Organic Content (%)	pH (1)	Electrical Resistivity (ohm-cm)	Soluble Chlorides (ppm) (2)	Soluble Sulfates (ppm) (2)
9-19	0	2	Embankment Core	CH	---	8.03	---	---	300
9-19	4	6	Embankment Core	CH	---	7.68	---	---	400
9-19	13	15	Embankment Core	CH	---	7.92	---	---	1,300
9-19	28	30	MPR	CH	---	7.90	---	---	600
101-19	2	3.5	Alluvium	CH	4.0	---	---	---	1,500
101-19	4	4.3	Alluvium	CH	---	---	---	---	700
102-19	0	2	Alluvium	CH	4.3	---	---	---	500
102-19	4	6	LPR	SC	---	---	---	---	900
102-19	8	10	MPR	CH	---	---	---	---	1,400
103-19	0	2	Alluvium	CH	---	---	---	---	4,300
103-19	6	7.5	LPR	CL	---	---	---	---	2,000
104-19	0	2	Alluvium	CH	6.7	---	---	---	5,900
104-19	4	6	LPR	CH	---	---	---	---	7,900
104-19	8	8.3	LPR	CH	---	---	---	---	10,600
105-19	0	2	Alluvium	CH	3.2	---	---	---	800
105-19	2	3.5	Alluvium	CH*	2.6	---	---	---	---
105-19	6	7.5	LPR	CH	---	---	---	---	8,900
106-19	0	2	Alluvium	CL	---	---	---	---	1,400
106-19	4	4.3	LPR	CH	5.2	---	---	---	700
401-20	0	2	Alluvium	CH	---	---	---	---	500
401-20	6	8	MPR	CH	---	---	---	---	6,700
401-20	13	15	MPR	CH	---	---	---	---	600
402-20	0	2	Alluvium	CH	3.9	---	---	---	---
402-20	2	4	Alluvium	CH	---	---	---	---	600
402-20	6	8	MPR	CH	---	---	---	---	17,700
402-20	8	10	MPR	CH	---	---	---	---	900
601-19	0	2	Alluvium	CH	4.7	8.08	---	---	500
601-19	6	8	LPR	CL	1.4	8.29	---	---	700
601-19	8	9.5	LPR	CL-ML	1.1	---	---	---	---
601-19	18	20	LPR	CH	---	7.92	---	---	800
603-19	0	2	Alluvium	CH	---	---	---	---	500
603-19	4	6	LPR	CH	---	---	---	---	600
603-19	13	15	MPR	CL	---	---	---	---	10,900
1701-20	0	1.5	Embank. Shell	CL	---	---	---	---	900
1701-20	6	8	Embank. Shell	CH	---	---	---	---	8,000
1702-20	0	2	Embank. Shell	CH	---	---	---	---	500
1703-20	2	4	Embank. Shell	CH	---	---	---	---	900
1704-20	0	2.5	Embank. Shell	CH	---	---	---	---	700
1704-20	4	5	Embank. Shell	CH	---	---	---	---	8,200

1704-20	9	10	Alluvium	CH	---	---	---	---	2,300
COMP-100A	0	2.5 to 6	Borrow-Layer A (Alluvium)	CH	5.2	8.02	370	300	7,000
COMP-100B	5 to 6	7.5 to 10	Borrow-Layer B (LPR)	CL	3.8	8.27	660	300	2,000
COMP-400A	0	5	Borrow-RCC Outlet	CH	5.0	8.04	1,210	180	2,700
COMP-1700A	0	4 to 8	Embank. Shell	CH	---	7.80	500	300	4,200

Notes:

(1) Results reported with respect to H_2O method. For results from $CaCl_2$ method, see lab data sheets.
(2) Converted from % to parts-per-million (ppm) using conversion factor of 10,000.
(3) USCS with '*' indicates field classification.

4.10.2 Lime Series Testing

Lime treatability testing was performed on samples of high plasticity clay materials located in potential on-site borrow sources to evaluate the feasibility of lime treatment to reduce the plasticity and expansive characteristics of these materials to allow for use as embankment fill and structure backfill.

Lime series testing according to the Eades and Grimm method (ASTM D4972) was conducted on bulk composite samples collected from the existing embankment slopes, proposed on-site borrow area, and required excavation for the RCC spillway outlet channel. The testing included mixing natural bulk soil samples with lime at different percentages by weight (1%, 2%, 3%, 4%, 5%, 6%, 7%, and 8%), and measuring the change in pH. The change in Atterberg Limits (LL, PL, PI) of the lime-treated soil was also measured according to Texas Department of Transportation (TXDOT) Test Method Tex-112-E, *Admixing Lime to Reduce Plasticity Index of Soils* at 2%, 4%, 6%, and 8% lime application rates by weight. A mellowing time of 24 hours following lime introduction to the soil is specified in the Tex-112-E method. The purpose of the testing is to identify the lime application rate required to reduce the shrink/swell properties of expansive soils below an established threshold (e.g., typically PI less than 15 to 20 or other performance criteria), and to produce a stable pH of typically at least 12.4 for durability. Lime treatment can also used to reduce the dispersion potential of dispersive clay soils.

Lime series test results on a composite sample of the existing Embankment Fill mixed from the downstream and upstream slopes of the dam (COMP-1700A) found that lime-treated samples achieved a stable pH≥12.4 at lime application rates of about 4% and greater. Lime application of greater than 2% was able to reduce the PI<15, and the lime-treated mixture retained plastic soil behavior at lime application rates up to 8% (PI=11).

Lime treatability testing was performed on two composite samples of Alluvium, one obtained from the borrow area (COMP-100A) and one from the proposed RCC spillway outlet channel excavation (COMP-400A). Despite the modest plasticity of these soils, lime series testing indicated relatively high lime application rates of 8% were required to obtain a stable pH≥12.4, presumably due to the high organic content. While lime application of only 2% was adequate to reduce PI<15, the soils became non-plastic (NP) at the 8% application rate. Non-plastic soil behavior is not desirable in dam applications, and using reduced lime application rates to maintain plastic soil behavior may not produce the desired irreversible lime reaction.

Based on variable and high sulfate content test results discussed in the previous section, lime treatment of existing Embankment Fill is considered too risky for implementation at this site. Similarly, lime treatment of the Residuum (MPR and LPR) is judged too risky based on variable and high sulfate content test results. While the Alluvium was initially considered as a better candidate for lime treatment based on initial test results indicating relatively low sulfate contents, the combination of a few elevated sulfate contents based on additional testing, the elevated organic content and related demand for high lime application rate to obtain chemically stable mixture, and the non-plastic behavior obtained at required lime application rates, the Alluvium is ultimately judged as too risky for lime treatment. Therefore, lime treatment of the on-site soils is not recommended. Specific reasons for excluding these materials from consideration for lime treatment are as follows:

1. Visual distinction between high-sulfate and low-sulfate soils was not possible.
2. Eight (8) of the 41 sulfates tests (20%) indicated sulfate content of 7,000 to 17,000 ppm, which exceed the upper threshold of 7,000 ppm for lime treatment according to TXDOT. While some roadway stabilization cases studies in Texas have demonstrated successful lime treatment of soils with sulfates > 30,000 ppm using special procedures and testing, the higher consequences of failure for a dam project warrant a higher degree of caution with lime treatment (particularly near structures).
3. Most sulfate test results were in the "intermediate" range (3,000 – 8,000 ppm), and lime treatment of such materials requires special procedures according to TxDOT. Proper treatment of such materials typically requires two or more applications of lime, extending mellowing times, and periodic testing of sulfate content over time during the mellowing period to ensure the lime/sulfate reaction proceeds to completion before placement/compaction. Such activities would be conducted in the mixing area prior to placement in proposed fill areas.
4. The additional time, materials, testing, and QA/QC oversight required for successful lime treatment adds significant complexity and cost to the project.
5. As discussed in Section 4.10.1, potential sulfate-induced heave resulting from inadequate QA/QC, inadequate construction methods, and/or material variability for lime-treated soils in contact with the proposed RCC spillway could produce serious adverse structural performance (e.g., cracking, differential movement) which can lead to other potential dam failure mechanisms (e.g., internal erosion, scour, structural instability). Thus, the risk of sulfate-induced heave in lime-treated on-site soils under/adjacent to proposed structures was considered unacceptable, and alternative methods of expansive soil mitigation should be considered (see discussion in Section 8.2.1).

Results obtained to date are summarized in Table **4-10**.

Table 4-10 Summary of Lime Series Testing

Boring / Sample ID	Top Depth (ft)	Bottom Depth (ft)	Stratum	USCS	Organics (%)	Sulfates (ppm)	Soil Properties at specified Lime Application Percentage by Weight								
							Property	Natural	2%	3%	4%	5%	6%	7%	8%
COMP-100A	0	5	Borrow (Upper Borrow Zone)	CH	5.2	7,000	LL	58	44	---	41	---	42	---	**41**
							PI	37	11	---	8	---	8	---	**NP**
							pH	8.02	11.69	12.00	12.22	12.32	12.31	12.33	**12.45**
COMP-400A	0	5	Borrow (RCC Spillway Outlet Channel)	CH	5.0	2,700	LL	59	46	---	46	---	45	---	**47**
							PI	33	8	---	7	---	7	---	**NP**
							pH	8.04	11.95	12.06	12.17	12.29	12.32	12.37	**12.44**
COMP-1700A	0	4, to 8	Embankment Fill (Zone 2)	CH	---	4,200	LL	64	46	---	**44**	---	47	---	46
							PI	43	14	---	**11**	---	12	---	11
							pH	7.80	11.99	12.25	**12.41**	12.50	12.59	12.60	12.62

Notes:
(1) Bolded values indicate properties at the minimum lime percentage to produce a stable pH≥12.4 per Eades & Grimm method (ASTM D4972).
(2) NP = Non-plastic

5. Material Characterization

The following sections pertain to characterization of in-situ embankment and foundation materials present near the dam embankment, and characterization of potential borrow source materials. Characterization of in-situ materials in the ASW channel for the purposes of erodibility and SITES parameters is included under separate cover in the GIR (AECOM 2021).

5.1 Embankment Fill

The Embankment Fill was classified in the field as predominantly fat clay (CH) and medium-plasticity lean to fat clay (CL-CH), with some intervals of lean clay (CL) and occasional clayey silt (ML). Laboratory-based USCS classifications from the current investigation generally confirm the field classifications described in the GIR. Field pocket penetrometer test results ranged from 1.0 to 4.5+ tsf (average 3.9 tsf) in the Embankment Core (Zone 1), and 1.5 to 4.5+ (average 2.8 tsf) in the Embankment Shell (Zone 2). Based on the SPT hammer calibration report in the GIR, the field SPT N-values corrected to 60% hammer efficiency (N_{60}) ranged from 11 to 33 blows-per-foot (bpf) with an average of 21 bpf in the Zone 1 core, and two values in the upstream Zone 2 shell were 11 and 13 bpf.

The laboratory test results from the original SMR (SCS 1967b) were considered for analysis purposes in conjunction with the available data from the current investigation. Based on review of the original SMR for the project (SCS 1967b), laboratory classifications of the proposed borrow sources for embankment fill were as follows:

- Emergency Spillway Excavations (designated for the Zone 2 shell): Clayey Sand (SC) to Sandy Lean Clay (CL) with LL= 28, PI = 13, and fines content = 48 to 64%.
- Borrow Area (designated for the Zone 1 core and/or Zone 2 shell): Fat Clay (CH) with LL= 52 to 56, PI = 32 to 34, and fines content = 77 to 90%.

While the original SMR and as-built drawings specified lower-plasticity sandy clays / clayey sands (CL, SC) be placed in the Zone 2 shell and higher-plasticity clays (CH) be reserved for the Zone 1 core/cutoff trench, samples collected during the current investigation indicate that the shell and core zones consist of largely similar materials. The current GIR considered it likely that insufficient CL/SC borrow material was available to construct the recommended zoning, and much of the Zone 2 shell was constructed from medium to high plasticity clays (CL-CH, CH).

Laboratory index testing on samples of the Zone 1 core from the embankment centerline borings yielded classifications of primarily CH with some CL intervals. The range of test results were LL = 34 to 74 (average 58), PI = 20 to 50 (average 36), fines content = 68 to 98% (average 86%), and clay fraction = 29 to 58% (average 45%). The gravel content ranged from 0 to 4% (average 3%), and sand content ranged from 6 to 28 (average 15%).

Laboratory index testing on samples of the Zone 2 shell from the embankment slope borings yielded classifications of CH and one sample with CL. The range of test results were LL = 34 to 76 (average 58), PI =19 to 55 (average 38), fines content = 89 to 98% (average 93%), and clay fraction = 43 to 66% (average 56%). The gravel content ranged from 0 to 1%, and sand content ranged from 3 to 11 (average 6%).

Based on the foregoing, the properties of the Zone 1 core and Zone 2 shell are expected to be similar. The results of other laboratory testing, and opinions regarding anticipated material behavior, are summarized below:

- Dispersion Potential: Based on the results of most crumb and double-hydrometer tests performed on the embankment fill material and natural soils in other areas of the site, the Embankment Fill is judged to be non-dispersive.
- Corrosivity: Laboratory test results indicate the presence of elevated soluble sulfate contents which will require sulfate-resistant cement for proposed concrete and RCC structures. Corrosivity to buried metal is also expected to be high based on limited resistivity testing.
- Hydraulic Conductivity: Based on the observed groundwater levels at the site, intact portions of the embankment core and cutoff trench are expected to be relatively impervious. However, as noted previously, highly variable piezometer readings at 9-19 indicates some localized pervious zones and/or defects could be present near the interface between the existing embankment slope and the underlying natural foundation soils.
- Compressibility: The results of field testing and laboratory strength tests (SPT, pocket penetrometer, UU, UC) and laboratory consolidation tests suggest the embankment is well compacted with low to moderate compressibility. These materials are expected to exhibit minor long-term consolidation (recompression) in response to loading associated with new fill and structure foundations based on the clayey nature of the materials and results of 2 consolidation tests which indicate P'c > 11,000 psf (OCR > 12).
- Expansive Shrink/Swell: Based on the relatively high PI values and results of laboratory swell testing (swell pressures = 746 to 2,762 psf), moderate to highly expansive soil shrink/swell behavior may be expected for structures constructed in the existing Embankment Fill.
- Shear Strength: The results of field testing (SPT, pocket penetrometer) and laboratory strength testing (UU, UC) indicate stiff to hard cohesive soil with relatively high Su values. The clayey composition of the embankment fill and the results of laboratory shear testing (UU, UC, CDDS, and CIU') indicate the embankment fill will exhibit distinct drained and undrained shear behavior in response to loading, and unique shear strength envelopes for UU, CD, and CU loading conditions are appropriate.

5.2 Downstream Fill

Suspected Downstream Fill materials up to about 8 feet thick were encountered in boring 305-19 at the downstream toe in the vicinity of the existing PSW outlet and original creek alignment. The Downstream Fill was classified in the field as fat clay (CH) to medium-plasticity clay (CL-CH) with gravel and organics that was dark brown to tan and light gray in color. Field pocket penetrometer testing gave two values of 4.5+ tsf, and a single N_{60} value was 45 bpf.

Laboratory index testing on two samples of the Downstream Fill yielded USCS classifications of CH and CL. The range of test results were LL = 48 and 71, PI = 27 and 48, fines content = 89 and 93, and clay fraction = 57%. Based on a single sieve analysis, the gravel content was 1% and sand content was 6%.

Based on the index test results and limited engineering properties testing, the properties of this material are similar to the Embankment Fill. The visual descriptions of the Downstream Fill suggest a likely alluvial source, based on similarity in appearance to Alluvium.

The results of other laboratory testing, and opinions regarding anticipated material behavior, are summarized below:

- Dispersion Potential: Based on a single crumb test on this material (Grade 1) and the results of most crumb and double-hydrometer tests performed in other areas of the site, the Downstream Fill material is judged to be non-dispersive, similar to the Embankment Fill.
- Corrosivity: No testing corrosivity testing was performed on this material, but instances of observed gypsum in the residual materials and corrosivity test results on other materials suggest the Downstream Fill is likely corrosive to buried metal and concrete.
- Hydraulic Conductivity: Based on the clayey nature of this material, it is expected to have relatively low permeability. However, the combination of its relatively high plasticity and proximity to the ground surface suggests this material may be susceptible to shrink/swell behavior and associated shrinkage cracks, potentially increasing the hydraulic conductivity through such secondary features.
- Compressibility: The results of field testing (SPT, pocket penetrometer) and a single laboratory UU test suggest this material is well compacted with low to moderate compressibility. Minor long-term consolidation (recompression) in response to fill and/or structure loading is expected based on the clayey nature of the materials and results of consolidation tests on other materials.
- Expansive Shrink/Swell: Based on the relatively high PI values and swell tests performed on other materials at the site, moderate expansive soil shrink/swell behavior may be expected for structures constructed on the Downstream Fill.
- Shear Strength: The results of field testing (SPT, pocket penetrometer) and a single UU test (Su > 13,000 psf) indicate stiff to hard cohesive soil with relatively high Su values. The Downstream Fill is expected to exhibit distinct drained and undrained shear behavior in response to loading, and shear strengths are expected to be similar to Embankment Fill.

5.3 Alluvium

Natural Alluvium foundation soils generally described as dark brown fat clay (CH) and measuring approximately 4 to 8 feet thick were encountered at the downstream toe and upstream toe of the dam. Alluvium was also encountered in borrow areas and in the ASW, but the descriptions in this section focus on the properties of Alluvium near the dam embankment. Field pocket penetrometer test results on samples of Alluvium at the upstream and downstream toe of the dam ranged from 3.0 to 4.5+ tsf (average 3.9 tsf). The N_{60} values ranged from 16 to 35 bpf (average 25 bpf).

Results of laboratory index testing on 7 samples of Alluvium near the upstream/downstream toe of the dam each yielded USCS classification of CH. The measured ranges were LL = 52 to 82 (average 70), PI = 35 to 62 (average 48), fines content = 76 to 98% (average 90%), and clay fraction = 53 to 64% (average 57%). The gravel content ranged from 0 to 20% (average 4%), and sand content ranged from 4 to 12% (average 8%).

The results of other laboratory testing, and opinions regarding anticipated material behavior, is summarized below:

- Dispersion Potential: Based on the results of 7 crumb tests on this material (all Grade 1), this material is judged to be non-dispersive.
- Corrosivity: Laboratory test results indicate the presence of elevated soluble sulfate contents which will require sulfate-resistant cement for proposed concrete and RCC

structures in contact with Alluvium. Corrosivity to buried metal is also expected to be high based on test results in other materials at the site.

- Hydraulic Conductivity: Based on the clayey nature of this material, it is expected to have relatively low permeability. However, the combination of its relatively high plasticity and proximity to the ground surface suggests this material may be susceptible to shrink/swell behavior and associated shrinkage cracks, potentially increasing the hydraulic conductivity through such secondary features.
- Compressibility: The results of field testing (SPT, pocket penetrometer) suggest this material is relatively stiff with low to moderate compressibility. The Alluvium is expected to exhibit minor long-term consolidation (recompression) based on the clayey nature of the materials and results of consolidation tests on other materials with similar strength values.
- Expansive Shrink/Swell: Based on the relatively high PI values and results of one laboratory swell test (swell pressure = 2,175 psf), highly expansive soil shrink/swell behavior may be expected for structures constructed on the Alluvium.
- Shear Strength: The results of field testing (SPT, pocket penetrometer) and a single UU test (Su > 13,000 psf) indicate generally stiff to hard cohesive soil with relatively high Su values. The clayey composition of the Alluvium and the results of laboratory shear testing (UU and CDDS) indicate this material will exhibit distinct drained and undrained shear behavior in response to loading, and unique shear strength envelopes for UU, CD, and CU loading conditions are appropriate.

5.4 Residuum

Residuum of the Pecan Gap Formation was encountered in each boring drilled for this project underlying either Alluvium (where not removed by previous grading) or various fill materials, except in most of the embankment slope borings which did not extend deep enough to reach this interface. The Residuum was subdivided into an upper calcareous and friable LPR described as mostly lean clay (CL) and silty clay (CL-ML), and a lower MPR described as fat clay (CH) and medium-plasticity clay (CL-CH). The extent of the LPR and MPR was laterally discontinuous, and vertical depth interval varied substantially between borings. The LPR was generally encountered in the higher-elevation areas of the alluvial valley near the right abutment, near the left half of the dam embankment, and in the ASW at the left abutment.

Total thickness of Residuum ranged from about 14 to 22 feet, but was as little as 11 feet in the vicinity of the original creek alignment. Field pocket penetrometer tests results ranged from 2.5 to 4.5+ tsf (average 4.3 tsf), and the N_{60} values ranged from 19 to 93 bpf (average 33 bpf), with no appreciable difference in the range of values measured for the LPR and MPR.

Results of laboratory index testing on 9 samples of LPR obtained from under and adjacent to the dam embankment yielded USCS classifications of primarily CH with some CL intervals. Measured ranges were LL = 31 to 77 (average 57), PI = 15 to 54 (average 36), and fines content = 80% to 99% (average 93%). Two sieve/hydrometer tests yielded clay fraction = 38 to 62%, gravel content = 0%, and sand content = 1.5 and 20%. The difference in field classifications (low-plasticity clay and silty clay) versus the laboratory classifications (medium- to high-plasticity clay) for the LPR near the dam suggests that variations in moisture, silt, sand, and calcareous content in this material can make it difficult to estimate the plasticity based on visual-manual methods alone, and that more highly-plastic layers may be present within the lower-plasticity unit overall. For comparison, laboratory-based classifications of LPR samples in the ASW channel included lean clay (CL), silt (ML), and silty sand (SM), and laboratory-based classifications of LPR in the on-site borrow area included lean clay (CL), clayey sand (SC), and fat clay (CH).

The laboratory classifications of the MPR included fat clay (CH) and one instance of lean clay (CL). The measured ranges were of LL = 29 to 75 (average 63), PI = 14 to 52 (average 41), and fines content = 69 to 99% (average 93%). Three sieve/hydrometers test yielded clay fraction = 47 to 68% (average 55%), gravel content = 0%, and sand content = 2 to 4% (average 3%).

The laboratory index test results on the LPR and MPR near the dam embankment were generally similar, and suggest that these materials can generally be considered as a single "residuum" unit for the purposes of engineering analysis. The results of other laboratory testing, and opinions regarding anticipated material behavior, are summarized below:

- Dispersion Potential: The results of 6 crumb tests on samples of Residuum from near the dam embankment were each Grade 1, suggesting this material is largely non-dispersive. Results of 16 crumb tests on Residuum in the ASW channel borings generally indicated similar results, but two samples in the upper 10 feet bgs recorded Grade 2 (with corresponding double-hydrometer results of 15 and 48% dispersion) and one sample at 22 feet bgs recorded Grade 3 (no double-hydrometer available). Therefore, while the Residuum may contain some isolated slightly dispersive layers, the material is judged to be primarily non-dispersive for engineering purposes.
- Corrosivity: Laboratory test results indicate the presence of elevated soluble sulfate contents which will require sulfate-resistant cement for proposed concrete and RCC structures in contact with Residuum. Corrosivity to buried metal is expected based on test results on other materials at the site. Visible calcareous material was noted in the LPR.
- Hydraulic Conductivity: Based on the high fines and clay content, intact zones of the Residuum not modified by faulting/fractures/shrinkage cracks would be expected to be relatively impervious. However, based on observed near-vertical fissures in Shelby tube samples and general blocky structure of the Residuum, this unit likely has secondary permeability along discontinuities that is somewhat greater than that of intact material. Results of three laboratory hydraulic conductivity tests were 1.9E-09, 7.8E-09, and 1.2E-06 cm/s, the highest value of which may be reflective of secondary permeability. In general, the LPR is expected to have slightly higher permeability than the MPR due to the typical low plasticity and occurrences of sandy layers within the generally clayey unit.
- Compressibility: The results of field testing (SPT, pocket penetrometer), laboratory strength tests (UU, UC), and laboratory consolidation tests suggest this material is relatively hard with low compressibility. The Residuum is expected to exhibit minor long-term consolidation (recompression) based on the clayey nature of the materials and results of 4 consolidation tests which indicate P'c > 8,700 psf (OCR = 3.5 to 36+).
- Expansive Shrink/Swell: Based on the moderate to high PI values and results of laboratory swell testing for the Residuum, the LPR is expected to have low to highly expansive soil shrink/swell behavior (swell pressure = 674 to 3,373 psf) and the MPR is expected to have moderate to highly expansive shrink/swell behavior (swell pressure = 910 to 5,200 psf) for structures constructed on these materials.
- Shear Strength: The results of field testing (SPT, pocket penetrometer) and 10 laboratory UU/UC tests (Su = 3,168 to 12,586 psf) on Residuum indicate stiff to hard cohesive soil with relatively high Su values. The clayey composition of the Residuum and the results of laboratory shear testing (UU/UC and CIU') indicate this material will exhibit distinct drained and undrained shear behavior in response to loading, and unique shear strength envelopes for UU, CD, and CU loading conditions are appropriate.

5.5 Shale

Moderately- to highly-weathered, extremely weak to weak calcareous shale was encountered in the deeper borings underlying Residuum throughout most of the site. The shale was generally described in the field as light gray to white, fissile, and friable. Field testing yielded several pocket penetrometer values of 4.5+ tsf, and the N_{60} values ranged from 43 to 100 bpf.

Results of laboratory index testing on 3 disaggregated samples of Shale obtained from under and adjacent to the dam embankment yielded USCS classifications of CH. The range of test results were LL = 65 to 96 (average 76), and PI = 42 to 69 (average 52). A single sieve analysis test yielded fines content = 69%, gravel content = 0.5%, and sand content = 30%. The results of other laboratory testing, and opinions regarding anticipated material behavior, are summarized below:

- Dispersion Potential: No test results have been performed on this material but given its depth below the dam and surrounding grade (more than 10 feet below the cutoff trench), dispersion in this material is not a concern.
- Corrosivity: No tests were performed on the shale, but instances of observed gypsum and high sulfate results in the residuum suggest elevated soluble sulfate contents may be present in the shale.
- Hydraulic Conductivity: Based on the hard, clayey consistency of the shale, intact zones not modified by faulting/fractures would be expected to be relatively impervious. However, based on the general fissile structure of the shale, the secondary permeability may be higher than laboratory test results may suggest.
- Compressibility: The results of field testing (SPT, pocket penetrometer) suggest this material is highly overconsolidated with very low compressibility. It is unlikely that significant settlements will be developed in this material in response to applied surface loading.
- Expansive Shrink/Swell: Based on the high PI of the shale, moderate to highly expansive soil shrink/swell behavior may be expected for structures constructed on the shale. However, given the depth of these materials below surface, expansive nature of the shale will not be a concern.
- Shear Strength: The results of field strength tests (pocket penetrometer, SPT) and 2 laboratory UC tests (Su = 4,100 to 12,300 psf) indicate hard cohesive soil / very weak rock. Based on the clayey composition of the shale, it may exhibit distinct drained and undrained shear behavior in response to loading. Based on the depth of this material and relatively higher strength, it is not expected to control stability.

5.6 Borrow Source Evaluation

5.6.1 Borrow Area

An on-site borrow area located on the left bank of the reservoir and upstream of the dam embankment is planned to serve as the primary source of borrow material for embankment construction. The GI encountered clayey materials which may be suitable for use as earthfill material, and the generalized stratigraphy includes:

- Upper Zone (Layer A): The upper 2 to 4 feet consisting of Alluvium field classified as CH;
- Middle Zone (Layer B): A 3 to 5 feet thick layer of calcareous LPR field classified as CL-ML encountered at depths of 2 to 4 feet bgs; and

- Lower Zone (Layer C): MPR field classified as CH and CL-CH was encountered at depths of about 8 feet bgs to borehole termination at 10 feet bgs (absent at boring 101-19).

Results of laboratory index testing on 8 samples of Layer A yielded lab classifications of CH. The range of test results were LL = 40 to 90 (average 64), PI = 21 to 63 (average 42), fines content = 78 to 95% (average 90%), and clay fraction = 37 to 61% (average 49%). Sieve analysis on two samples indicated gravel content of 1 to 2%, and sand content of 10 to 20%. Results of 5 crumb tests each indicated Grade 1. Results of 8 soluble sulfate tests ranged from 500 to 7,000 ppm (average 2,732 ppm).

Results of laboratory index testing on 8 samples of Layer B yielded lab classifications of CL, CH, and SC. The range of test results were LL = 32 to 69 (average 45 with most values <55), PI = 19 to 46 (average 29 with most values <33), and fines content = 19 to 96% (average 65%). Results of two sieve analysis tests were clay fraction = 43%, gravel content = 3 to 4%, and sand content = 21%. Results of 4 crumb tests each indicated Grade 1. Results of 7 soluble sulfate tests ranged from 700 to 10,600 ppm (average 4,714 ppm).

Results of laboratory index testing on 1 sample of Layer C yielded lab classification of CH. The measured values were LL = 65, PI = 45, and fines content = 99%. No dispersion testing was performed, but this material is expected to be non-dispersive based on tests on similar soils at the site. One soluble sulfate test yielded concentration of 1,400 ppm.

As discussed in Section 4, lime treatment is not recommended for Layers A, B, or C due to elevated soluble sulfate contents and/or organic contents in these materials.

Layers A and B were encountered generally above the normal reservoir level and should be accessible without the need for dewatering or extended drying times follow excavation. However, the relatively dry natural moisture contents (generally about 2 to 13% below the plastic limit) suggest that a significant amount of water will need to be added during construction to achieve recommended above-optimum compaction moisture content.

Based on the relatively high PI of Layers A and C, the Layer A and C materials should generally be used in less critical locations of required fill away from the dam embankment such as the ASW crest raise, ASW training dikes, and training dikes for the RCC spillway outlet channel. If necessary, these borrow materials may be reserved for interior portions of proposed embankment fills. This will help to protect from seasonal wetting and drying cycles that can cause shrink/swell movements and subsequent loss of strength, which can lead to potential shallow wet-weather slides. Additionally, these materials generally should not be placed under or adjacent to structures due to potential shrink/swell behavior, and risk of increased earth pressures due to swelling.

In general, the Layer B materials have low to moderate plasticity, and are not subject to significant strength loss resulting from seasonal wetting/drying. The typically low to moderate PI values and results of remolded swell tests indicate low to moderate risk of expansive behavior, but occasional layers of fat clay could be more expansive. Vertical mixing of the Layer B materials in the borrow area should serve to remove isolated layers of fat clays, sands, and silts and provide a homogeneous fill material. The Layer B materials should be suitable for selective placement in outer zones of the embankment (with appropriate topsoil/vegetative covering) to provide protective cover for more highly-plastic soils placed in interior zones of the embankment. Due to occasional layers of higher-plasticity material, Layer B should not be used as backfill for structures.

5.6.2 Excavation for Proposed Outlet Channel and RCC Stilling Basin

Required excavations for the proposed outlet channel and RCC stilling basin (as well as the lower portion of the RCC chute located downstream of the existing embankment toe) are expected to produce cohesive materials that may be suitable for earthfill. The upper 4 to 6 feet consists of Alluvium (gravelly CH) underlain by MPR (CH, CL-CH) to at least 20 feet bgs. Planned excavations will be entirely within Alluvium and are not anticipated to encountered underlying Residuum.

Results of laboratory index testing on 6 samples of Alluvium in the proposed excavations yielded lab classifications of CH. The range of test results were LL = 58 to 82 (average 69), PI = 33 to 62 (average 46), and fines content = 76 to 93% (average 88%). Results of four sieve analyses and two hydrometer tests gave clay fraction = 62 and 64%, gravel content = 1 to 20% (average 7%), and sand content = 4 to 10% (average 6%). Results of 5 crumb tests each indicated Grade 1. Results of 4 soluble sulfate tests ranged from 700 to 2,700 ppm (average 1,075 ppm).

Based on the relatively high PI of Layers A and C, the Layer A and C materials should generally be used in less critical locations of required fill away from the dam embankment such as the ASW crest raise, ASW training dikes, and training dikes for the RCC spillway outlet channel. If necessary, these borrow materials may be reserved for interior portions of proposed embankment fills. This will help to protect from seasonal wetting and drying cycles that can cause shrink/swell movements and subsequent loss of strength, which can lead to potential shallow wet-weather slides. Additionally, these materials generally should not be placed under of adjacent to structures due to potential shrink/swell behavior, and risk of increased earth pressures due to swelling. As discussed in Section 4, lime treatment is not recommended for this material due to elevated soluble sulfate contents and organic contents in these materials.

Proposed excavations in the channel area are well above the anticipated groundwater levels, but delayed groundwater was measured at El. 638 (about 11 feet bgs) in boring 601-19 near the proposed RCC stilling basin excavation. Consequently, temporary construction dewatering should be anticipated for the stilling basin excavation..

5.6.3 Excavation for Proposed RCC Crest and Chute Structures

Required excavations for the proposed RCC crest structure and upper portions of the RCC chute structure (on the embankment slope) may produce cohesive materials suitable for earthfill. Materials within the proposed excavation consist of existing Zones 1 and 2 Embankment Fill. No practical difference was identified between the Zone 1 and Zone 2 materials (consist of CH and CL-CH with minor CL and ML).

Based on the relatively high PI of the Embankment Fill, these borrow materials should generally be reserved for interior portions of embankment fills and away from proposed structures. The may also be used in less critical locations of required fill away from the dam embankment such as the ASW crest raise, ASW training dikes, and training dikes for the RCC spillway outlet channel.

Proposed excavations into the existing embankment are generally above the anticipated groundwater levels in this location, and temporary construction dewatering should not be necessary.

5.6.4 Excavations for PSW Replacement

Required excavations for abandonment of the existing PSW and installation of the new PSW will produce cohesive materials potentially suitable for earthfill. The planned excavations are expected to encounter primarily existing Embankment Fill, with anticipated Downstream Fill and native foundation materials (Alluvium and Residuum) below about El. 635±.

Based on the relatively high PI of the various fill and foundation materials in this area, these borrow materials were reserved for use in less critical areas of proposed earthfill such as the ASW channel, ASW training berms, and RCC spillway outlet channel berms.

Proposed excavations into the existing embankment are generally above the anticipated groundwater levels in this location. However, excavations below about El. 640± on the upstream side of the embankment will be below normal pool level, and groundwater levels as high as El. 630 have been measured in piezometer 11-19 located on the embankment crest. Therefore, drawdown of the reservoir and temporary dewatering during construction should be anticipated.

5.6.5 Excavation for Proposed ASW Widening

Required excavations for the proposed ASW widening may produce cohesive materials suitable for earthfill. Anticipated materials include existing Embankment Fill comprising the right training dike and the left end of the dam embankment, and native foundation materials (Alluvium and Residuum) located to the right of the existing channel limits.

Based on the wide range in PI of these potential borrow materials, they should generally be reserved for interior portions of embankment fills and away from proposed structures. These materials may also be used in less critical locations of required fill away from the dam embankment such as the the ASW crest raise, ASW training dikes, and training dikes for the RCC spillway outlet channel. Proposed excavations into the existing embankment are generally above the anticipated groundwater levels in this location, and dewatering should not be necessary. Proposed excavations into the existing embankment are above the anticipated groundwater levels in this location, and dewatering should not be necessary.

5.6.6 Imported Fill

Laboratory testing indicates the plasticity of the on-site materials is not reliably low enough to provide suitable non-expansive subgrade/backfill for proposed overtopping RCC spillway, and lime-treatment of the on-site fat clays is not practical due to elevated sulfate and organic contents. Consequently, the need for an off-site borrow source of imported non-expansive, low-plasticity clay or clayey sand with a minimum fines content (i.e., about 40%) should be anticipated for this project.

Additionally, imported granular fill will be required for filter/drainage materials because no on-site source is available. Discussion of proposed filter/drainage materials is provided in Section 8.4.

6. Seismic Analysis

6.1 NRCS Seismic Screening Procedure

Seismic site characterization was performed according to the guidance in the most recent NRCS TR-210-60 (2019). The document specifies that conventional seismic analysis be evaluated for sites with PGA equal to or greater than 0.07g for the seismic event associated with the dam's consequence of seismic failure (conservatively taken as the dam's hazard potential classification herein). Since this dam has been upgraded to high hazard, the 0.5% in 50 year earthquake event (10,000-year return period) is appropriate for design-level evaluations. Based on a de-aggregation of seismic hazard using the online USGS National Seismic Hazards Mapping Tool, the PGA for this 10,000-year event is 0.055g for the top of competent rock. The PGA was adjusted for site class assuming Site Class D based on SPT N-values in the upper 100 feet of below the dam and corresponding site coefficient F_{PGA} of 1.6 (sites with top of rock PGA less than 0.1, per ASCE 7-10), which yields a design $PGA_{Design} = PGA \times F_{PGA} = 0.088g$.

Based on the relatively low seismicity of the site and distance from mapped faults and faults systems, and the relative stiffness and cohesive nature of site soils, the risks of seismic hazards such as liquefaction, cyclic strain softening, and fault-rupture are considered to be negligible. While the PGA_{Design} exceeds the referenced 0.07g cited in the TR-210-60, the document also has a provision which waives the requirement for seismic analysis of "well-built" embankment dams with limited potential loss of strength at sites with PGA_{Design} less than 0.2g. The TR-210- 60 defines "well-built" embankments as those constructed from well-compacted earth or rock fill, founded on rock or dense soil (particularly clay) foundations, with adequate static factors of safety, with seepage control and free-board, and constructed under controlled conditions.

Based on review of historical design information, the results of this field investigation, and the geotechnical analyses contained herein, AECOM believes that the dam meets the criteria for well-built embankment dams based on the following factors:

1. As-built drawings specify modern compaction criteria for the embankment, and results of field (SPT, pocket penetrometer) and laboratory strength tests (UC, UU, CIU') confirm relatively stiff cohesive soils indicative of well-compacted fill;
2. Embankment foundation consists of stiff to hard alluvium and residual clays which is not subject to significant strength loss during earthquake loading;
3. While no seepage control is currently provided in the dam, no observed seepage has been reported to date and the rehabilitation design will include seepage control in the form of filter diaphragms around the existing PSW conduit to be abandoned in-place and around the new PSW conduit;
4. The original design included embankment freeboard of 14.7 feet for normal pool (PSW crest) and 4.9 feet for flood pool (ASW crest) conditions, and there are no significant changes planned as part of the rehabilitation;
5. Calculated static slope stability factors of safety in the original design documents and the current rehab project are above minimum values, and there is no documented evidence of prior slope instability; and
6. The dam was designed by NRCS predecessor and presumably built under controlled conditions with appropriate oversight.

Therefore, further seismic evaluation is not required per NRCS criteria.

6.2 TCEQ Seismic Screening Procedure

Site seismicity was also evaluated with respect to guidelines provided by Texas Commission on Environmental Quality, *Design & Construction Guidelines for Dams in Texas* (2009). The guidance states that seismic evaluations of dam stability must be conducted for high- and significant-hazard dams near "seismically active" faults, which are defined as faults recognized by and included in the USGS Quaternary Fault and Fold Database. Based on AECOM's review of the USGS database, the nearest active fault zone is the Gulf-margin normal faults system located more than 45 miles east of the site. This system is considered as "latest Quaternary" (active within the last 15,000 years) and consists of a compilation of numerous individual unmapped faults. The faults are decoupled from the underlying crust and assigned as Class B structures due to their low seismicity (Wheeler, 1999). Based on this information and the discussion in **Section 6.1**, AECOM judges that seismic stability is not required per TCEQ screening guidelines.

6.3 Conclusions

Based on the relatively low seismicity of the site and distance from recently-active faults and faults systems, detailed investigation and evaluation of seismic hazard is not required for the project site. Based on this information, and the relative stiffness and cohesive nature of site soils, the risks of seismic hazards such as liquefaction, cyclic softening, and fault-rupture are considered to be negligible and no further analysis is needed.

7. Embankment Seepage and Stability Analysis

Seepage and slope stability analyses were performed to evaluate the proposed improvements for compliance with the current NRCS TR-210-60 requirements for earth embankment dams.

Two cross-sections were selected for analysis:

1. Dam centerline Station (Sta.) 18+50: this section represents the location of the proposed RCC spillway. Design geometries analyzed at this cross section included the existing conditions, the proposed RCC spillway section, and the proposed embankment crest modification.
2. Dam centerline Section Sta. 23+50: this section represents the maximum height of the dam located near the original creek centerline, and is relatively close to the existing PSW (STA. 24+30) and proposed new PSW (STA. 25+00). Design geometries analyzed at this cross section included the existing conditions, proposed embankment crest modification, and the adjacent proposed embankment reconstruction following open-cut construction of the new PSW conduit.

Embankment piezometers were available at both stations to aid in calibrating the analysis model phreatic surface to the measured groundwater levels. However, it is noted that the variability in readings for piezometer 9-19 near Sta. 18+50 did not allow for calibration.

Description of the analyses procedures, as well as presentation and discussion of results, are providing in the following sections.

7.1 Seepage Analysis

7.1.1 Design Criteria

The current version of NRCS TR-210-60 requires that the effects of seepage be evaluated for all dams. This evaluation must consider potential embankment and foundation seepage-related failure modes, includes the potential for internal erosion, erosive flow along defects, internal instability, and uplift pressures to damage the embankment, its foundation, and appurtenant structures. The TR-210-60 provides the following design criteria related to seepage:

1. Design seepage reduction measures to limit seepage and embankment saturation as necessary to address seepage failure modes, provide adequate static and dynamic stability, and limit water loss to the extent required by project function.
2. Minimum factor of safety (FOS) = 4.0 for vertical exit gradients at sites with cohesionless soils at the downstream toe;
3. Minimum FOS = 3.0 for a blanket-aquifer condition in soil using effective stress methods;
4. Include a filter diaphragm around any structure extending through the embankment to the downstream slope (e.g., conduit pipes);
5. Include filtration and drainage features for all significant and high hazard embankment dams unless the designers establish rationale for less filter and drain protection for rehabilitation of existing embankments; and
6. Provide seepage integrity for all reservoir stages up to the freeboard hydrograph water surface.

Criteria #2 and #3 do not only apply at this site because of the absence of pervious coarse-grained materials and/or thin impervious blanket materials. To satisfy Criteria #4 and #5, this project will require a filter diaphragm around the proposed PSW conduit and internal drainage layers, respectively. Criteria #1 and #6 are inherent to the seepage and stability evaluations described in the following sections of this report. Depending on structure complexity, the TR-210-60 allows the use of qualitative methods, analytical methods, graphical methods, and/or numerical methods to evaluate seepage effects.

7.1.2 Design Considerations

Seepage considerations are crucial in dam rehabilitation projects, particularly due to the risk of soil particle migration and internal erosion ("piping") which are inherent concerns in soil embankment dams. Un-mitigated piping can lead to dam failure.

No historic through-seepage or under-seepage has been reported at this site. The downstream areas of the dam were relatively dry at the time of AECOM's field investigation, with no observed instances of ponding water or probable seepage areas. Limited groundwater was encountered in the borings during drilling, and recharge of the piezometers installed was relatively slow. Measured groundwater levels are well below the ground surface elevation, and are not cause for concern.

Anomalous fluctuations in groundwater levels have been recorded in embankment centerline piezometer 9-19 near the proposed RCC spillway, with successive readings varying between about 14.9 to 32.8 feet bgs (El. 629.6 to El. 647.5). However, because the upstream toe of the dam near piezometer 9-19 has ground surface elevation significantly higher than the reservoir normal pool, it is unlikely that these anomalous readings are associated with fluctuation of the reservoir levels. As stated in the GIR (AECOM 2021), the fluctuations could be associated with cross-valley surface water flows and/or perched groundwater following storm events and originating from the higher ground near the left abutment. Continued readings in piezometer 9-19 and 702-20 (and possibly instrumenting both with automatic water level data loggers) may aid in further characterizing groundwater at this location. However, these observations are not cause for concern from a design perspective, since a full-height underdrain will be provided under the RCC spillway at this location.

Plum Creek 2 does not have any existing internal drainage measures. As stated in the GIR (AECOM 2021), installation of a new internal drainage system along the downstream slope/toe of the embankment (e.g. toe drain or chimney drain) does not seem to be a necessary part of the rehabilitation based on the following factors:

- No evidence of historic seepage or instability;
- The proposed rehabilitation will not include significant embankment crest raise or downstream slope flattening; fill on the dam will largely be restricted to re-shaping the crest with thin (<2 feet) fill added to low areas, and thus the embankment prism will largely remain unchanged;
- The normal pool is planned to be lowered slightly, and only a slight increase (1 to 2 feet) in the ASW crest elevation is planned.

Consequently, AECOM has assumed that no internal drainage (i.e., toe drain or chimney drain) will be included as part of the dam rehabilitation for Plum Creek 2. However, localized internal filter/drainage systems specific to the existing and proposed PSWs (i.e. filter diaphragm) and the proposed RCC spillway (i.e., underdrain) will be necessary to reduce risk of seepage problems, and should be included as part of the rehabilitation.

7.1.3 Methodology

Steady-state seepage analyses were performed using numerical methods to estimate the phreatic conditions within the embankment and internal pore water pressures for use in slope stability computations. Additionally, the seepage analyses were conducted to estimate seepage flow volumes for the sizing of the internal drainage system(s). Potential for through-seepage was examined based on position of the calculated phreatic surface.

Detailed discussion of the seepage analysis procedures and results are provided in **Appendix B**. A summary of the general analysis conditions that were considered are described as follows:

- Existing conditions: A steady-state seepage analysis was performed for existing conditions to calibrate the material parameters using known reservoir elevation and limited piezometer readings at various points in time.. The material parameters were iteratively adjusted until the phreatic surface through the embankment centerline approximated by the model was similar to the groundwater levels measured in piezometer.
- Proposed Normal Pool: A steady-state seepage analysis was performed for the proposed embankment raise section, with the reservoir at the proposed PSW crest elevation. This analysis was used to establish the design phreatic surface for steady-state slope stability analyses and post-drawdown surface for rapid drawdown analyses (see Section 7.2).
- Proposed Flood Pool: A steady-state seepage analysis was performed for the proposed embankment raise section, with the reservoir at the proposed ASW crest elevation. This conservative case was analyzed primarily for drain sizing, and to evaluate potential for seepage issues during an extended flood pool condition. This resulting phreatic surface was also considered in rapid drawdown slope stability analyses (see discussion in Section 7.2).
- Proposed 75% PMH Pool: A steady-state seepage analysis was performed for the proposed embankment raise section, with the reservoir at the proposed TCEQ 75% Probable Maximum Flood (PMF) pool level. For the purposes of geotechnical analysis, the 75% PMF was considered to be equivalent to the proposed Freeboard Hydrograph (FBH) pool level cited in NRCS TR-210-60 which must be evaluated for the flood surcharge stability condition. This very conservative case was used primarily for drain sizing, and the resulting hypothetical phreatic surface was also considered as a simulated uplift pressure applied to saturated material zones for the flood surcharge slope stability analyses (see discussion in Section 7.2)

7.1.4 Model Setup and Boundary Conditions

The computer program SEEP/W by Geo-Slope International (GeoStudio 2020, Version 10.2.2.20559) was used to perform the steady-state seepage analyses. SEEP/W utilizes a two-dimensional finite element method to compute seepage flow and piezometric head.

A finite element mesh was generated for the proposed embankment and existing foundation materials. In order to limit boundary effects, the modelled foundation materials were extended horizontally approximately 1,000 feet from the upstream and downstream dam toe.

On the upstream ground surface of the model, a total head boundary condition equal to the elevation of the corresponding reservoir level was applied. Similarly, a total head boundary condition was applied to the downstream vertical edge of the model equal to the assumed far-field groundwater level. A no-flow boundary was applied to the upstream vertical edge and bottom of the model. A potential seepage face was applied to the downstream slope of the embankment and ground surface. In the analyses for the proposed overtopping RCC spillway, the drain pipe for the spillway underdrain was modeled as a point at the location of the pipe outlet with a zero-pressure-head boundary condition.

7.1.5 Selected Seepage Parameters

Material parameters for the seepage analysis were developed based on the results of laboratory hydraulic conductivity testing, and published correlations with soil type. Selected material properties include the saturated vertical hydraulic conductivity (k_v) and the anisotropy ratio (k_h/k_v) which is used to calculate the saturated horizontal hydraulic conductivity (k_h). Detailed description of selection of design seepage parameters is provided in **Appendix B**. These parameters are provided in **Table 7-1**. Note that due to similarities between the Alluvium and the Downstream Fill, the Downstream Fill was not modeled separately.

Material input parameters for the SEEP/W model are provided in **Table 7-2**. For materials that are partially saturated and/or will not remain saturated, the "saturated / unsaturated" model was used for seepage modelling. The "saturated only" model was used only for soils that will always remain below the phreatic surface. The saturated/unsaturated model require 2 functions: hydraulic conductivity function (HCF) and volumetric water content function (VWC). The hydraulic conductivity function describes how the hydraulic conductivity varies with changes in suction (i.e. negative pore-water pressure) present in unsaturated soils. The volumetric water content function describes how the suction varies with changes in water content in the soil. Unsaturated functions for hydraulic conductivity and volumetric water content were based on SEEP/W default relationships.

Table 7-1 Selected Design Material Properties

Material	USCS	Kv (cm/sec)	Ratio Kh/Kv	Kh (cm/sec)
Embankment Fill - Zone 1	CL, CH	2.01E-08	5	1.01E-07
Embankment Fill – Zone 2	CL, CH	2.01E-07	5	1.01E-06
Proposed Embankment Fill	CL, CH	1.38E-07	4	5.53E-07
Alluvium/Downstream Fill	CH	5.03E-06	2	1.01E-05
Residuum	CL, CH	1.51E-06	3.33	5.03E-06
Shale	---	2.01E-07	5	1.01E-06
Riprap	----	1.11E+00	1	1.11E+00
Filter Drain	SP,GP	1.00E-03	2	5.03E-03
RCC	n/a	1.00E-01	1	1.01E-07

Table 7-2 Selected Design SEEP/W Input Parameters

Material	Model Type	Ksat = Kh (feet/sec)	Ratio Kv/Kh	Mv (psf/psf)[2]	Θw-sat [1]	HCF-Function	VWC-Function
Embankment Fill - Zone 1	Sat. / Unsat.	3.30E-09	0.2	1.00E-06	0.50	Clay	Clay
Embankment Fill – Zone 2	Sat. / Unsat.	3.30E-08	0.2	1.00E-06	0.50	Clay	Clay
Proposed Embankment Fill	Sat. / Unsat.	1.815E-08	0.25	1.00E-06	0.50	Clay	Clay
Alluvium / Downstream Fill	Sat. / Unsat.	3.30E-07	0.5	1.00E-06	0.50	Clay	Clay
Residuum	Sat. / Unsat.	1.65E-07	0.3	1.00E-06	0.50	Clay	Clay
Shale	Sat. Only	3.30E-08	0.2	1.00E-06	0.50	---	---
Riprap	Sat. / Unsat.	3.65E-02	1	1.00E-03	0.25	Gravel	Gravel
Filter Drain	Sat. / Unsat.	1.65E-04	0.5	5.00E-06	0.35	Sand	Sand
RCC	Sat. / Unsat.	3.3E-09	1	1.00E-06	0.10	Sand	Sand

Notes:
1. θw = Saturated Volumetric Water Content = Porosity x Degree of Saturation
2. M_v = Coefficient of Volume Compressibility = I / Modulus of Elasticity
3. Unsaturated functions for volumetric water content and hydraulic conductivity based on default SEEP/W relationships.

7.1.6 Results and Discussion

Steady-state seepage analysis results indicate acceptable seepage performance for proposed conditions. Examination of the predicted phreatic surface and associated exit gradients do not indicate seepage problems for existing or proposed conditions. Specifically, the phreatic surfaces do not daylight above the embankment toe and/or on the embankment slope, calculated factors of safety for exit gradients are well above 3.0 (even for the conservative 75% PMF case), and calculated slope stability factors of safety (discussed in **Section 7.2**) are not adversely affected by the phreatic surface. Graphical output for the seepage analyses are included in **Appendix C**.

Estimated inflow rates into the various internal drainage elements, based on the seepage analysis, are summarized below in **Table 7-3**. In general, the estimated inflow rates are relatively low for the RCC underdrain (less than 0.1 gpm), even for the conservative assumption of a steady-state reservoir level at the 75% PMF flood pool. Calculations indicate conventional 6-inch diameter perforated drain pipes surrounded by a two-stage aggregate filter are expected to be sufficient to adequately convey seepage inflows with a factor of safety greater than 10. Drain capacity sizing calculations are provided in **Appendix C**.

Table 7-3 Estimated Seepage Flow Rates for Drain Sizing

Cross-Section	Phreatic Surface	Proposed RCC Underdrain (Overtopping Spillway Section) [1]	
		Unit Flux per LF of Dam Length (ft^3/day/LF)	Total Toe Drain Flow Rate (gpm) [2]
STA. 18+50	Normal Pool (PSW crest)	---	n/a
	Flood Pool (ASW crest)	0.0472	0.0525
	Flood Pool (75% PMF)	0.0511	0.0567

Notes:
1) Length of proposed RCC underdrain is 214 LF along dam axis.
2) Conversion: 7.48 gal = 1 CF. Conversion from 1 gpm = 192.5134 CF/day.

7.2 Slope Stability Analysis

7.2.1 Design Criteria

Design criteria for slope stability is provided in the current version of the NRCS TR-210-60. The criteria require analysis of the following loading conditions for the proposed dam modification:

- End of Construction;
- Steady-State Seepage;
- Flood Surcharge;
- Rapid Drawdown; and
- Dynamic stability (if applicable).

The required factors of safety for each condition are provided later in this section (see **Section 7.2**).

7.2.2 Model Development

AECOM performed slope stability analyses using the software SLOPE/W by Geo-Slope International (GeoStudio 2020, Version 10.2.2.20559). The limit-equilibrium program allows use of Spencer's method of slices, a method that satisfies all conditions of equilibrium.

Analyses were conducted for the same three cross-sections evaluated in the seepage analysis. Slope stability analyses were conducted for existing conditions to calibrate the models, and for the proposed embankment raise conditions to estimate the Factor of Safety (FOS) for the various loading conditions required by the current version of the NRCS TR-210-60.

7.2.3 Analysis Cases

7.2.3.1 End of Construction

For the end-of-construction conditions (EOC), stability of the proposed final dam section was calculated conservatively assuming no dewatering of the reservoir. The phreatic surface was estimated based on the steady-state seepage phreatic surface developed at the existing normal pool level. Unconsolidated-undrained (UU) strengths were used to model slow-draining new earthfill and existing materials in accordance with TR-210-60 guidance. Free-draining materials were modeled using consolidated-drained (CD) strengths.

7.2.3.2 Steady-State Seepage

For steady-state seepage conditions, the phreatic surface corresponding to the proposed highest normal pool elevation (i.e., proposed PSW crest) was used. Per current TR-210-60 guidance, effective stress CD shear strength envelopes were assigned to modeled materials. For the proposed RCC Spillway Section, an external uniform vertical surcharge pressure was applied to the top of the embankment to simulate static loading associated with the proposed RCC crest structure. The surcharge pressure was iteratively adjusted until the minimum FOS of 1.5 was achieved (see discussion in Section 7.2.5).

7.2.3.3 Flood Surcharge

For flood surcharge conditions, the embankment and foundation materials were divided into saturated and unsaturated embankment zones based on an estimated steady-state phreatic surface corresponding to the proposed normal pool level. While the current TR-210-60 does not provide specific analytical guidance for this case, AECOM adopted an approach similar to the steady-state seepage case in the prior (2005) version of the TR-210-60 modified for the flood surcharge condition. In this modified approach, saturated materials were subjected to pore pressures associated with a hypothetical steady-state phreatic surface developed at the proposed 75% PMF pool level to simulate uplift pressures associated with the highest possible flood pool level. The 75% PMF phreatic surface was not applied to unsaturated material zones (i.e. above the normal pool phreatic surface), due to the unlikelihood that an elevated phreatic surface could develop over the relatively short duration of a flood event. This approach is conservative, because while desiccated near-surface soils on the upstream slope may become saturated during such an event, the limited duration of elevated pool level is unlikely to produce a wetting front that penetrates a significant distance into the embankment section. This is particularly likely given that this homogenous embankment dam consists of well-compacted, moderate- to high-plasticity clay with modest slopes (about 2.7H:1V to 3H:1V based on 2020 topographic survey) and no history of through-seepage or evident embankment cracking. Consequently, there is expected to be no appreciable effect on embankment saturation associated with the 75% PMF flood pool.

Slow-draining material zones were assigned a bi-linear strength envelope corresponding to the lower of the CD and consolidated-undrained (CU) strength envelopes. Free-draining soil zones were modeled with CD strengths. For the RCC Spillway Section, the uniform vertical surcharge pressure obtained from the steady state analysis was applied to the top of the embankment.

7.2.3.4 Rapid Drawdown

The current NRCS TR-210-60 requires rapid drawdown be assessed from the highest normal pool level to the lowest gated or ungated outlet. For this site, the highest normal pool will be the proposed PSW inlet riser crest elevation (El. 645.5), and the lowest outlet is the proposed PSW conduit with invert El. 632.2 at the inlet riser. Given the limited amount of drawdown (e.g. 13.1 feet), a more conservative case was also analyzed to check rapid drawdown conditions associated with a reservoir drawdown from the proposed ASW pool level (El. 659.8) to the normal pool level (El. 645.5).

For the proposed RCC Spillway Section only, the analysis incorporated an external uniform vertical surcharge pressure equal to the maximum value calculated from the steady-state analysis.

Rapid drawdown analyses were conducted according to the NRCS procedure using a 1-stage analysis. In that analysis, slow-draining saturated material zones are assigned a bi-linear strength envelope corresponding to the lower of the CU and CD strength envelopes per TR-210-60 guidance. Free-draining materials, and materials above the phreatic surface, are assigned CD strength parameters. The phreatic surface used in the rapid drawdown stability analysis was developed considering a reservoir drawdown as described above: the ASW pool phreatic surface was used within the embankment, but the phreatic surface was lowered to be coincident with the ground surface of the upstream embankment slope above the PSW crest level. As a check, rapid drawdown evaluation was also conducted according to the 3-stage method as presented by Duncan, Wright, and Wong (1990). Two steady-state seepage phreatic surfaces are incorporated into the analysis: pre-drawdown and post-drawdown. Both the CU and CD envelopes are evaluated in the 3-stage analysis. The method has been shown to reasonably predict instability conditions for several case histories, and has indicated that other methods tend to over-predict the occurrence of slope instability.

7.2.3.5 Dynamic Stabilty

Based on the discussion provided in **Section 6**, no further consideration of dynamic stability (i.e., seismic loading) is required. Therefore, dynamic stability calculations were not performed as part of this study.

7.2.4 Material Parameters

Design unit weights and selected total stress and effective stress strength envelopes were conservatively developed from correlations with in-situ tests and index properties, results of shear tests on similar soils from other nearby projects, and/or engineering judgment based on experience with similar materials. Details regarding the selection of material parameters are provided in **Appendix B**. The slope stability material parameters selected by AECOM for design are provided in Table 7-4.

The resulting NRCS bilinear composite strength envelopes required for analysis of rapid drawdown and flood surcharge are provided in **Table 7-5**.

Table 7-4. Selected Material Parameters

Material	USCS	Total Unit Weight (pcf)	UU Strength	Effective Stress (CD Envelope)		Total Stress (CU Envelope)	
			Su (psf)	c' (psf)	ϕ ' (deg)	c_u (psf)	ϕ_u (deg)
Embankment Fill – Zone 1	CL, CH	125	1,200	100	23	400	15
Embankment Fill – Zone 2	CL, CH	125	1,200	100	23	400	15
Proposed Embankment	CL, CH	125	1,200	100	23	400	15
Alluvium / Downstream Fill	CH	123	1,500	100	23	400	15
Residuum	CL, CH	126	1,500	100	23	400	15
Shale	CH	130	3,000	300	23	400	15
Filter Drain	---	120	---	0	33	---	---
Rock Riprap	---	110	---	0	35	---	---
RCC		145	---	100	45		

Table 7-5. NRCS Bilinear Strength Envelopes for Flood Surcharge and Rapid Drawdown

Material	USCS	Initial Envelope		Bi-Linear Envelope for Flood Surcharge		Bi-Linear Envelope for Rapid Drawdown	
		c (psf)	ϕ_1 (deg)	σ_n (psf)	$\phi_{2\text{-FBH}}$ (deg)	σ_n (psf)	$\phi_{2\text{-RDD}}$ (deg)
Embankment Fill – Zone 1	CL, CH	100	23	1,917	15	1,917	15
Embankment Fill – Zone 2	CL, CH	100	23	1,917	15	1,917	15
Proposed Embankment	CL, CH	100	23	1,917	15	1,917	15
Alluvium / Downstream Fill	CH	100	23	1,917	15	1,917	15
Residuum	CL, CH	100	23	1,917	15	1,917	15
Shale	CH	300	23	639	15	639	15
Filter Drain	SP, GP	0	33	---	---	---	---
Rock Riprap	---	0	35	---	---	---	---
RCC	CL, CH	100	45	---	---	---	---

7.2.5 Analysis Results

A summary of calculated slope stability factor of safety (FOS) relative to minimum required FOS values are provided in the series of tables below. Detailed discussion of results and graphical model output is provided in **Appendix D**.

Based on the existing and proposed embankment geometry, the calculated FOS generally meet or exceed the NRCS criteria at each analyzed cross-section, with the noted exception of the rapid drawdown case at Sta. 23+50 according to the conservative NRCS single-stage method. However, when using the more common 3-stage rapid drawdown procedure, the calculated FOS values are well in excess of the minimum 1.2. Additionally, the actual inclination of the upstream slope based on 2020 topographic survey (3H:1V) is flatter than modeled in the stability analysis (2.5H:1V), so the stability analysis results are conservative. Therefore, acceptable embankment performance is anticipated during rapid drawdown conditions and no mitigation measures are recommended.

It is noted that the RCC spillway analysis section FOS values are reported for an applied uniform bearing pressure of 1,530 psf to represent the RCC crest structure. This value is well in excess of the average bearing pressure across the 200-foot wide crest structure, and adequate performance is expected.

Table 7-6. Slope Stability Results – STA. 18+50 – Embankment Crest Modification

Loading Condition	Calculated FOS		Minimum FOS
	Downstream Slope	Upstream Slope	
End of Construction (Shallow)	5.3	5.6	1.3
End of Construction (Deep)	4.2	4.3	1.4
Steady-State Seepage	1.7	---	1.5
Rapid Drawdown – ASW to PSW (NRCS Method)	---	1.2	1.2
Rapid Drawdown – ASW to PSW (3-stage Method)	---	1.9	1.2
Rapid Drawdown – PSW to Lowest Outlet (NRCS Method)	---	1.9	1.2
Rapid Drawdown – PSW to Lowest Outlet (3-stage Method)	---	1.9	1.2
Flood Surcharge (75% PMF / FBH)	1.7	---	1.4

Table 7-7. Slope Stability Results – STA. 18+50 – RCC Spillway Section

Loading Condition	Calculated FOS (1)		Minimum FOS
	Downstream Slope	Upstream Slope	
End of Construction (Shallow)	1.9	3.7	1.3
End of Construction (Deep)	2.5	3.2	1.4
Steady-State Seepage	1.5	---	1.5
Rapid Drawdown – ASW to PSW (NRCS Method)	---	1.2	1.2
Rapid Drawdown – ASW to PSW (3-stage Method)	---	1.6	1.2
Rapid Drawdown – PSW to Lowest Outlet (NRCS Method)	---	1.7	1.2
Rapid Drawdown – PSW to Lowest Outlet (3-stage Method)	---	1.7	1.2
Flood Surcharge (75% PMF / FBH)	1.5	---	1.4

Notes:
(1) Calculated based on 1,530 psf uniform bearing pressure over footprint of RCC crest structure.

Table 7-8. Slope Stability Results – STA. 23+50 – Embankment Crest Modification

Loading Condition	Calculated FOS		Minimum FOS
	Downstream Slope	Upstream Slope	
End of Construction (Shallow)	3.2	3.1	1.3
End of Construction (Deep)	2.5	3.0	1.4
Steady-State Seepage	1.5	---	1.5
Rapid Drawdown – ASW to PSW (NRCS Method)	---	1.1*	1.2
Rapid Drawdown – ASW to PSW (3-stage Method)	---	1.5	1.2
Rapid Drawdown – PSW to Lowest Outlet (NRCS Method)	---	1.1*	1.2
Rapid Drawdown – PSW to Lowest Outlet (3-stage Method)	---	1.4	1.2
Flood Surcharge (75% PMF / FBH)	1.4	---	1.4

Notes:
* - See discussion in text Section 7.2.5.

Table 7-9. Slope Stability Results – STA. 23+50 – Embankment Reconstruction at New PSW

Loading Condition	Calculated FOS		Minimum FOS
	Downstream Slope	Upstream Slope	
End of Construction (Shallow)	3.2	2.9	1.3
End of Construction (Deep)	2.6	2.8	1.4
Steady-State Seepage	1.6	---	1.5
Rapid Drawdown – ASW to PSW (NRCS Method)	---	1.1*	1.2
Rapid Drawdown – ASW to PSW (3-stage Method)	---	1.4	1.2
Rapid Drawdown – PSW to Lowest Outlet (NRCS Method)	---	1.1*	1.2
Rapid Drawdown – PSW to Lowest Outlet (3-stage Method)	---	1.3	1.2
Flood Surcharge (75% PMF / FBH)	1.4	---	1.4
Notes: * - See discussion in text Section 7.2.5.			

8. Embankment and Foundation Design

8.1 Embankment Settlement

8.1.1 Dam Embankment

The Plum Creek 2 rehabilitation will not include a raise of the embankment crest or flattening of either the upstream or downstream slopes, and thus the embankment prism will remain largely unchanged by the rehabilitation. Except for the areas of the new PSW and RCC spillway, modification of the existing embankment will be limited to minor amounts of new fill to level the embankment crest, and possibly some minor cut/fill grading to smooth the embankment slopes. Consequently, anticipated settlement of the embankment is minor to negligible.

Construction of the proposed new PSW structures will require a full breach excavation of the dam embankment. Preliminary design grades indicate the excavation will extend to a minimum El. 631, which is approximately 31 feet below the existing embankment crest. Following installation of the PSW, the embankment will be reconstructed back to current grade using embankment fill. While negligible settlement is expected in the underlying foundation soils, self-weight consolidation of the new 31-foot thick clay fill needs to be considered to evaluate the need for overbuild at the crest. Assuming self-weight consolidation of the new compacted fill is about 1% of the fill height, total settlement at the re-constructed crest is estimated to be about 4 inches. It is expected that a fraction of this settlement will occur during construction, possibly 25 to 50 percent due to the unsaturated condition of the material. Based on uncertainty regarding construction duration and the time rate of settlement, an embankment crest overbuild of 6 inches is recommended at the proposed PSW installation.

8.1.2 Training Dikes

Preliminary design drawings indicate that construction of training dikes (berms) will be required to contain flows on both sides of the proposed ASW channel widening and right side of the proposed outlet channel for the RCC spillway. Training dikes are expected to be on the order of 5 to 8 feet in height with crest width of about 12 feet and 3H:1V sideslopes. Estimates of settlement associated with the proposed training dikes were developed to evaluate need for potential overbuild. Selected consolidation parameters for analysis are provided in **Table 8-1**.

Settlement analyses were conducted according to Terzaghi's one-dimensional theory of consolidation using a spreadsheet developed by AECOM. The analysis modeled the proposed dike geometry as a non-uniform distributed load of infinite length to estimate consolidation settlement in the underlying foundations soils. The distribution of surface stresses with depth was estimated according to Boussinesq's equations which incorporate the theory of elasticity.

Results of the settlement analysis indicate that the estimated maximum fill-induced consolidation settlement in foundation soils under the training dikes for the ASW and RCC spillway is about 1.8 and 1.5 inches, respectively. Given the relatively minor amount of estimated settlement, overbuild of the training dikes is likely not required.

Analysis input parameters, calculations, and results are provided in **Appendix G**.

Settlement estimates for each of the proposed PSW and RCC spillway structures are discussed later in **Section 8.2**.

Table 8-1. Selected Consolidation Parameters for Embankment Settlement Analysis

Material	γ (pcf)	e_0	Min. OCR	Minimum P'_c (psf)	C_c	C_r	E_s (ksf)	Cv (ft^2/day)
Exist. Embankment Fill	125	0.60	2.0	4,000	0.20	0.030	---	1E-03
Alluvium/DS Fill	123	0.65	2.0	4,000	0.20	0.030	---	1E-02
Residuum	126	0.60	2.0	4,000	0.20	0.030	---	1E-02
Shale	130	0.50	---	4,000	---	---	---	---
New Embankment Fill	125	0.65	2.0	3,000	0.20	0.020	---	1E-03

Notes:

1. Abbreviations legend:
   1) γ – Total Moist Unit Weight
   2) e_0 – Initial Void Ratio;
   3) OCR – Overconsolidation Ratio (applies to zones where the P'c is greater than minimum value);
   4) P'_c – Maximum Past Pressure (minimum value accounts for near-surface desiccated "crust");
   5) C_c – Compression Index from e-log(p) curve;
   6) C_r – Recompression Index from e-log(p) curve
   7) E_s – Elastic Modulus
   8) Cv – Coefficient of consolidation

8.2 Foundation Design Analyses

Geotechnical analyses and recommendations for proposed spillway structure foundations are provided in the following sections. Specifically, these include the proposed PSW structures (Inlet Tower, Impact Basin, and Conduit pipe) and the proposed RCC spillway structures (Crest Structure, Chute Structure, and Stilling Basin). The recommended parameters for foundation design assume that foundation subgrade preparation will be consistent with requirements presented in the **Section 8.3**.

8.2.1 Expansive Soils

8.2.1.1 Risk and Mitigation Options

Based on the results of laboratory testing discussed previously and AECOM's experience with similar structures at other sites in similar geology, the existing embankment fill and foundation materials range from slightly to highly expansive. Expansive soils experience shrink/swell movements in response to seasonal wetting and drying cycles. When restrained from movement, expansive soils can exert high swelling pressure on adjacent structures. In cases where the weight of the structure is less than the swell pressure of the soil, excessive total/differential movement may occur. Excessive movement and/or increased loading associated with swelling (e.g. walls) may lead to structure distress.

The site soils are expected to range from slightly expansive to highly expansive. The LPR materials and zones of Embankment Fill constructed from LPR, with USCS classification such as CL-ML, CL, ML, and SC and with PI < 20, are expected to have low to moderate swell potential. Moderate to high swell potential is expected for the Embankment Fill, Downstream Fill, Alluvium, and MPR with USCS classifications such as CH, CL-CH, and SC with PI > 20. Consequently, proposed structures (particularly the lightly-loaded slab for the overtopping RCC spillway) founded on these materials may be susceptible to excessive shrink/swell movements and related distress. In general, mitigation options may include one or more of the following:

- Overexcavation of expansive soils to a specified depth below the foundation grade, and replacement with non-expansive materials. The intent of such an approach is to reduce the thickness of expansive soils, and to use the non-expansive material's self-weight to counteract swelling. Typical low-permeability replacement materials include imported non-expansive cohesive borrow material, additional RCC thickness, lime-treated high-plasticity soils from on-site borrow sources, and/or moisture-conditioned low-plasticity soils from on-site soils. In areas where underlying soils are not required to serve as a low-permeability hydraulic barrier (e.g., below the PSW inlet tower, PSW impact basin, and RCC spillway stilling basin), engineered structural fill consisting of well-graded crushed aggregate such as flexbase may be suitable replacement material.
- Anchored slabs designed to resist swelling pressures and related uplift. This type of system would include grouted soil or rock anchors connected to the slab at uniform pattern spacing and bonded in materials below the zone of seasonal moisture fluctuation. The slab would be designed to span between anchors and resist shear and flexural loads resulting from the swelling pressure. A composite slab with reinforced concrete and RCC would likely be required to provide adequate flexural and shear resistance.

For this project, it has been assumed that overexcavation/replacement is preferable mitigation approach for its relative simplicity. This is also based on the anticipated low anchor bond strength of site soils and significant depth to strata with higher bond strength, increased complexity and specialty construction associated with anchored systems, and additional quality assurance and quality control (QA/QC) measures required during construction. Accordingly, preliminary subgrade preparation recommendations utilizing this approach are provided specific to each proposed structure in the following sections. If an anchored slab is preferred for one or more proposed structures, supplemental designed recommendations can be provided in a subsequent revision of this report.

Expansive soils should also not be used as backfill against retaining walls, as the expansive soils can generate significant additional lateral pressures when restrained from swelling. Additionally, special attention is needed to internal drains/underdrain design to minimize the amount of excess moisture accessible to expansive soils that could exacerbate swelling (see discussion in **Section 8.4**).

8.2.1.2 Expansive Soil Heave Analysis Procedure

The clayey, moderately- to highly-plastic soils at the site have been identified as potentially expansive. In general, soil swell cannot occur when the effective vertical confining pressure is equal to or greater than the swell pressure of the soil. However, at vertical confining pressures less than the swell pressure, the soils can be expected to shrink/swell in response to moisture content changes, resulting in cycles of vertical heave (i.e., swell from wetting) and settlement (i.e., shrinkage from drying) at the ground surface. The shrink/swell movement can be problematic for overlying structures supported on shallow foundations.

Heave analyses were conducted to develop estimates of potential vertical heave (in inches) for proposed structures supported on shallow foundations (i.e., RCC spillway and PSW structures). As presented earlier in this report, results of laboratory swell tests were used to estimate swell pressure, and constant-volume swell tests with an unloading phase were used to estimate the percent swell at confining stresses less than the swell pressure.

The heave analyses were performed analogous to a “reverse-consolidation” process, whereby the foundation soils are sub-divided into layers and volume change (swelling) is assumed to occur in layers where the effective stress is less than the measured swell pressure. The effective stress is a function of the soil self-weight, pore water pressure from groundwater, and the sustained foundation load (the simplified 2:1 load dissipation with depth was assumed). Swelling in each soil layer is calculated based on the swelling strain index, $C_{s\varepsilon}$ which is defined as the linear slope of the strain vs. log-pressure curve from each swell test. The total heave is the summation of calculated swell in each layer below the foundation base.

Heave is assumed to only occur within the “active zone” (i.e., zone of seasonal moisture fluctuation), which is generally assumed to be the upper 15 feet below lowest surrounding finished grade, which is common practice in Central Texas. In order to capture the variability of the swell test results, each structure was evaluated based on individual swell test results applied to the entire subgrade separately (as opposed to assigning swell properties from each test to specific depth intervals in a single analysis). The analyses for the RCC spillway assumed a minimum 2-foot overexcavation / replacement with non-expansive soils under the base of each structure foundation to account for the proposed underdrain system.

For several structures, a reduced active zone thickness was considered appropriate based on estimated minimum groundwater elevation. Heave calculations for the PSW inlet tower, which will be founded on subgrade materials that are currently saturated by the reservoir pool and will remain below the proposed permanent pool, considered a reduced active zone thickness of 8 feet to account for temporary reservoir drawdown and potential short-term subgrade drying associated with the construction phase followed by a restoration of the reservoir pool.

Where the calculated heave was judged to be excessive, the analyses were repeated assuming additional overexcavation / replacement with non-expansive soils under the base of each structure foundation. The analyses were performed to obtain estimates of the thickness of overexcavation / replacement required to limit total heave to 1 inch or less and 1.5 inches or less.

8.2.1.3 Heave Analysis Results and Recommendations

The results of the heave analysis using site-specific laboratory swell data, as well as options for potential non-expansive fill materials to be used in the overexcavation / replacement zones, are summarized in **Table 8-2**. Calculations are provided in **Appendix H**.

The results of the analyses indicate that the estimated heave for each structure varies considerably depending on which swell test results were considered. For the RCC spillway walls and 3-foot thick RCC slab, estimated heave ranges from negligible to nearly 3 inches without expansive soil mitigation (typically 1 to 2 inches for walls and about 2 inches for the slab). Estimated heave for the PSW structures ranged from about 2 to 3 inches without expansive soil mitigation, but the results are based on a single swell test. The results suggest that there is significant risk that expansive soil heave will exceed the tolerable limits for a number of the structures analyzed, and confirm the need for overexcavation/replacement to limit heave to tolerable levels.

In order to limit total heave to tolerable levels (considered to be about 1.5 inches or less based on discussions with structural engineers), a uniform overexcavation / replacement depth of about 7 feet below the bottom-of-slab elevation is suggested for the RCC crest structure, chute structure, and stilling basin. Additionally, overexcavation / replacement depths of 2 feet and 6 feet below the proposed bottom-of-slab elevation are recommended for the PSW inlet tower and PSW impact basin foundations, respectively. The shallower depth recommended for the inlet tower is because the footing will be permanently submerged, limiting the long-term potential for changes in subgrade moisture content (and thus shrink/swell behavior).

The magnitude of differential heave is more difficult to estimate, but is commonly assumed to be approximately one-half (1/2) the total heave over a distance of about 30 to 50 feet. Larger values of differential movement are possible at abutting structures, particularly where a lightly-loaded structure is expected to heave and a heavily-loaded structure is expected to settle (i.e., at the RCC wall / slab interface). Structures with relatively higher sustained design bearing pressures aid to counteract expansive swelling forces from subgrade soils.

Most of the proposed PSW conduit will be buried under a significant thickness of embankment fill, which will provide resistance to counteract subgrade shrink/swell movements. However, near the ends of the pipe, cover soil thickness may not be adequate to counteract expansive soil swelling. Where final grading design provides less than 10 feet of soil cover on the conduit, a minimum overexcavation of 2 feet below the cradle and replacement with non-expansive compacted fill should be performed.

Recommendations based on the analysis results are summarized in **Table 8-3**.

Table 8-2. Summary of Heave Analyses

Proposed Structure	Foundation	Assumed Active Zone Depth (feet below finish grade)	Range of Calculated Total Heave (inches) with No Mitigation	Range of Calculated Remove / Replace Depths (feet) required to Limit Total Heave to Specified Amount		Potential Non-Expansive Replacement Material
				1.5 inch	1 inch	
RCC Crest Structure	RCC Walls	15	0.1 to 2.0	2 to 3	2 to 3	Import Embankment Fill, Filter Material, or RCC
	RCC Slab	15	0.5 to 2.2	2 to 7	2 to 6	
RCC Chute Structure	RCC Walls	15	0 to 0.9	2	2	Import Embankment Fill, Filter Material, or RCC
	RCC Slab	15	0 to 2.2	2 to 7	2 to 6	
RCC Stilling Basin Structure	RCC Walls	15	0 to 1.7	2 to 7	2 to 4	Import Embankment Fill, Filter Material, or RCC
	RCC Slab	15	0.8 to 2.9	2 to 9	2 to 7	
PSW Structure	Inlet Tower	8	2.8	4	2	Flexbase
	Impact Basin	15	2.4	8	6	Flexbase
	Conduit	15	(see text)	(see text)	(see text)	Flexbase(2), Import Embankment fill

Notes:
(1) Minimum 2 feet is recommended for all structures regardless of estimated and tolerable heave.
(2) Flexbase only permitted in downstream and upstream 20 feet of conduit; continuous flexbase placement under conduit would produce undesirable preferential seepage path through the embankment foundation and should not be performed.

8.2.2 Settlement

Foundation settlement for each of the proposed structures was estimated according to Terzaghi's theory of one-dimensional consolidation. Settlement calculations were based on the net increase in stress above the existing in-situ effective stress associated with design maximum gross bearing pressure at the proposed footing depth. Stress distribution with depth into the subsurface layers was calculated according to Boussinesq's equations based on the design footing dimensions and net stress increase at the base of the foundations.

Analyses were performed using estimated consolidation parameters (**Table 8-1**) based on results of consolidation tests, correlations with field and laboratory test data, and results of consolidation tests from other projects sites in Central Texas with similar geology.

Estimated settlement for each of the proposed structures analyzed is less than 1.5 inches, which is generally within tolerable limits for shallow foundations. Note that for the Inlet Tower and Impact Basin, settlement analyses assume a minimum of 2 feet of overexcavation below the footing bearing elevation and replacement with compacted, well-graded, crushed aggregate flexible base (flexbase) material to limit settlement to tolerable levels.

The results are summarized in **Table 8-3**. Calculations are provided in **Appendix G**.

8.2.3 Bearing Capacity

Allowable bearing capacity was calculated for each of the proposed structures according to the equations for general bearing capacity theory considering both undrained (short-term) and drained (long-term) strength parameters of the various subgrade materials. Allowable bearing capacity was based on a factor of safety of 3.0 against general shear.

Actual design bearing pressures for the structures are not finalized at this time, but based on experience with similar projects, the calculated allowable bearing pressures likely meet or exceed the design maximum bearing pressures. The results are summarized in Table **8-3**. Calculations are provided in **Appendix H**.

8.2.4 Hydrostatic Uplift

The foundations for several structures will bear near or below the estimated groundwater table. Consequently, these foundations will be subject to hydrostatic uplift forces. In the event that the factor of safety against uplift for the foundation (i.e., the ratio of sustained downward forces to hydrostatic uplift force) is less than 1.5 for normal conditions, uplift mitigation will be required. Uplift mitigation may include extending the slab laterally to provide additional downward forces from soil overburden, thickening the slab to increase downward forces, and/or using grouted soil or rock anchors to restrain the slab from uplift (similar to option for expansive soils).

Recommended groundwater levels to be used in hydrostatic uplift calculations are provided in **Table 8-3**. The table provides recommended "typical" groundwater values during normal operation of the dam, as well as "maximum" values during ASW activation flows. A slightly lower factor of safety may be acceptable during extreme operating conditions.

8.2.5 Lateral Earth Pressures

The proposed PSW structures (inlet tower, impact basin, and conduit pipe) and training walls of the RCC spillway structures (crest structure, chute structure, and stilling basin) will be subjected to lateral earth pressures.

Due to the need to provide a hydraulic barrier around the outside of the overtopping RCC spillway, low-permeability embankment fill materials will be required as wall backfill for sections of the RCC spillway training walls located upstream of the existing embankment crest. Inclusion of an underdrain system upstream of the crest is not recommended due to the risk of developing a hydraulic connection between the reservoir and the wall drainage system, which could otherwise lead to excessive hydraulic gradient and seepage pressures via shortened seepage path through the dam. Accordingly, the recommended embankment fill material specifications should be consistent with those specified in **Section 11.2**. Because wall underdrains cannot be provided in these areas, design lateral earth pressures will need to account for hydrostatic pressures. Further, the back side of the training walls should be battered slightly to allow proper compaction of the fine-grained backfill materials to reduce the risk of a preferential seepage path alongside the wall.

For portions of the RCC spillway training walls located downstream of the existing embankment crest (i.e., including the training walls for the chute structure and stilling basin), a fine aggregate chimney drain is permissible to provide wall drainage. Recommendations for the wall drainage is provided in **Section 8.4**.

For design, compacted embankment fill (assuming imported low-plasticity soil with USCS designation CL or SC) should consider a moist total unit weight of 126 pcf, and saturated total unit weight of 128 pcf. A drained friction angle of 25 degrees is recommended for embankment fill materials based on results of shear strength tests, and published correlations with Atterberg limits and clay fraction. Calculations for lateral earth pressures are provided in **Appendix I**. The resulting earth pressure coefficients are summarized as follows:

- Active earth pressure coefficient, $K_A = 0.41$ (horizontal backfill)
- Active earth pressure coefficient, $K_A = 0.55$ (3H:1V sloping backfill)
- At-rest earth pressure coefficient, $K_0 = 0.58$ (horizontal backfill)
- At-rest earth pressure coefficient, $K_0 = 0.76$ (3H:1V sloping backfill)
- Passive earth pressure coefficient, $K_P = 2.46$ (horizontal backfill)

In cases where the design groundwater level is above the bottom of the wall, hydrostatic pressures should be included in lateral pressure calculations. Design groundwater levels are provided for each structure in Table **8-3**.

8.2.6 Sliding Resistance

Resistance to lateral loads is provided by the frictional resistance between the base of the concrete/RCC foundation and underlying soil subgrade, and is represented as the ultimate coefficient of sliding friction (μ). Recommended values of μ specific to each structure is provided in Table **8-3**.

The recommended values assume that the interface friction between the soil and concrete (or soil and RCC) is 75% of the internal shear strength of the soil, i.e., 0.75*tan(ϕ’). The coefficient of sliding friction can be increased to that of the soil’s internal strength if shear keys are provided to preclude a slip plane from forming between the foundation and underlying soil. However, the value of μ at the concrete/soil interface should be compared against the interface friction between any improved soil and weaker natural subgrade below the foundation, and the smaller of the two values should be used. Calculations for sliding resistance parameters are provided in **Appendix I**.

A minimum factor of safety of 1.5 should be applied to the calculated ultimate sliding resistance based on buoyant unit weights.

8.2.7 Foundation Design Recommendations Summary

A summary of the geotechnical design parameters and calculation results discussed in this section is provided in the table below.

Table 8-3. Summary of Foundation Design Analysis Results and Recommendations

Location	Structure	Foundation Bearing Level		Footing Dimension, B x L (feet)	Bearing Stratum	Min. Overex / Replace Depth Below Footing (feet)	Proposed Fill Materials [1]		Friction Angle, ϕ' (deg)		Subgrade Ultimate Coeff. of Sliding Friction, μ [3]			Backfill Unit Weight (pcf)		Design Bearing Pressure (psf) [4]	Allowable Bearing Capacity (psf) [5]	Calc'd. Max. Total Settlement (inch) [6]	Calc'd. Expansive Soil Heave (inch) [7]	Design GW for Buoyancy and Earth Pressures (ft NAVD88) [8]
		Elev. (ft NAVD88)	Depth Below Existing (ft)				Under Structure	Retained Zone	Sub-grade [2]	Retain. Fill	No Shear Key	With Shear Key (Case 1)	With Shear Key (Case 2)	Moist	Sat.					
Proposed RCC Spillway – Crest Structure	RCC Walls	El. 655.5	3 to 7	11.33 x 30	Embankment Zone 1 and Zone 2	8	Import	Import	25	25	0.35	0.47	0.47	126	128	1,500	1,500	< 1.5	< 1.5	El. 640 (typ.) El. 658.6 (max.)
	RCC Chute Slab	El. 655.5	3 to 7	30 x 190		8	Import	Import	25	---	0.35	0.47	0.47	---	---	500	OK	< 1.5	< 1.5	El. 640 (typ.) El. 658.6 (max.)
Proposed RCC Spillway – Chute Structure	RCC Walls	Varies; El. 655.5 to 638.7	5 to 6.5	11.33 x 48	Embankment Zone 2, Alluvium, Residuum	8	Drainfill	Import	33	25	0.49	0.65	0.47	126	128	1,800	2,000	< 1.5	< 1.5	Varies; El. 647-638 (typ.) El. 647-644 (max.)
	RCC Chute Slab	Varies; El. 655.5 to 638.7	5 to 6.5	48 x 190		8	Drainfill	Import	33	---	0.49	0.65	0.47	---	---	500	OK	< 1.5	< 1.5	Varies; El. 647-638 (typ.) El. 647-644 (max.)
Proposed RCC Spillway – Stilling Basin	RCC Walls	El. 638.7	10	11.33 x 24	Residuum	8	Import	Import	25	25	0.35	0.47	0.47	126	128	2,000	2,000	< 1.5	< 1.5	El. 638 (typ.) El. 644 (max.)
	RCC Chute Slab	El. 638.7	10	24 x 190		8	Import	Import	25	---	0.35	0.47	0.47	---	---	500	OK	< 1.5	< 1.5	El. 638 (typ.) El. 644 (max.)
Proposed PSW Structures	Impact Basin	El. 626.5	8.5 to 6.6	19.6 x 24.75	Residuum	5	Flexbase	Import	32	25	0.47	0.62	0.42	126	128	2,000	2,500	< 1.5	< 1.5	El. 620 (typ.) El. 630 (max.)
	Inlet Tower	El. 630	3 to 10	13.5 x 20.5	Residuum	3	Flexbase	Import	32	25	0.47	0.62	0.42	126	128	1,500	2,000	< 1.5	< 1.5	El. 640 (typ.) El. 660 (max.)
	Conduit Pipe	Varies; El. 631.5 to 630	5.7 to 33.8	5.8 x 166.0	Residuum	See Note 9	See Note 9	Import	23	25	0.32	0.42	0.42	126	128	n/a	OK	< 1.5	< 1.5	Varies; El. 640-620 (typ.) El. 660-630 (max.)

Notes:

1) Description of fill materials:
   a) Import: Imported non-expansive, low plasticity clayey earth fill material meeting requirements of **Table 8-5**.
   b) Drainfill: ASTM C-33 No. 8 or 89 aggregates placed and compacted according to the requirements of **Section 8.4**.
   c) Borrow: Non-expansive, low plasticity clayey earth fill material obtained from on-site borrow area and/or required excavations and meeting requirements of **Table 8-5**.
   d) Subgrade: Existing in-situ subgrade materials prepared according to the requirements of **Section 9.4**.
   e) Flexbase: Well-graded crushed aggregate material meeting requirements of **Section 8.5**.
2) Subgrade material in direct contact with bottom of structure footing.
3) Friction between cast-in-place concrete and prepared subgrade considering 75% of the internal friction angle of soil (i.e., 0.75*tanϕ'). If shear keys are provided on foundations, the full soil friction of native subgrade may be used (i.e., 1.0*tanϕ'), shown as Case 1. Sliding friction along interface of underlying weaker subgrade layer controls when shear keys fully-penetrate high quality fill layer under slab (shown as Case 2).
4) Values not available at this time from project structural engineer; estimated from experience with similar projects.
5) Based on FOS=3 for against general shear failure for static loading. Reported as the lower of drained vs. undrained strengths. Values limited by settlement and/or slope stability considerations in some cases.
6) Analyzed for the larger of design bearing pressure or allowable bearing pressure.
7) Analyzed for the lower of design bearing pressure or allowable bearing pressure. Estimated value with specified minimum overexcavation/replacement; larger values expected otherwise. Estimate based on analysis of each individual swell test result applied to various structures' loading and geometry.
8) Recommend groundwater level for buoyancy and earth pressures may vary from that used in geotechnical design calculations (e.g., bearing capacity, settlement, heave, slope stability). Reported as PSW crest elevation for PSW Inlet Tower.
9) Where final grading specifies the conduit is buried under less than 10 feet of cover soil, overexcavate 2 feet below the pipe cradle and replace with non-expansive Imported Embankment Fill or Flexbase.

8.3 Foundation Subgrade Preparation and Inspection

8.3.1 RCC Spillway – Crest Structure

Recommendations for subgrade preparation for the RCC chute and walls on the crest of the embankment includes over-excavating 8 feet below the proposed bottom-of-slab elevation and replacing with non-expansive fill. The required depth of overexcavation is based on removing expansive soils to limit the estimated potential vertical heave to tolerable levels (estimated to be 1.5 inches). Excavated materials may be stockpiled and tested to confirm they will be suitable for re-use as compacted earth fill. Materials found to be unsuitable due to high plasticity could possibly be lime treated to meet embankment fill specifications, or be used elsewhere as shown on the drawings.

The subgrade should be inspected by a qualified professional as specified in **Section 9.4**. Prior to receiving fill material, the subgrade should be scarified, moisture conditioned, and recompacted as specified in **Section 9.4**. Fill placement and compaction should be in accordance with recommendations in **Section 8.5**.

Continuous reinforced concrete turn-down keys should be cast into the RCC slab on both the upstream and downstream ends of the crest structure to provide under-seepage cutoff. The turn-down keys should be constructed in an excavated trench that extends at least 1 foot deeper than the surrounding excavation limits. The turn-down keys may require steel reinforcement to prevent crack development, and waterstops may be needed at joints.

If extension of the turn-down key into undisturbed material below the overecavation / replacement zone is not feasible, an embankment key trench can be constructed to penetrate 2 feet below the surrounding subgrade elevation to provide seepage cutoff along the subgrade/fill interface.

8.3.2 RCC Spillway – Chute Structure

Recommendations for subgrade preparation for the RCC chute and walls on the crest of the embankment includes over-excavating 8 feet below the proposed bottom-of-slab elevation and replacing with non-expansive fill. The required depth of overexcavation is based on removing expansive soils to limit the estimated potential vertical heave to tolerable levels (estimated to be 1.5 inches). Excavated materials may be stockpiled and tested to confirm they will be suitable for re-use as compacted earth fill. Materials found to be unsuitable due to high plasticity could possibly be lime treated to meet embankment fill specifications, or be used elsewhere as shown on the drawings.

In locations where earth fill (embankment fill) will be placed directly onto the prepared sloping subgrade surface, horizontal benched excavations each less than 1 feet in height and at least 2 feet in width should be cut into the downstream slope face to preclude development of preferential slip planes at the materials interface. Benched excavations are not required where aggregate drain fill will be placed directly onto the prepared subgrade.

The subgrade should be inspected by a qualified professional as specified in **Section 9.4**. Prior to receiving fill material, the subgrade should be scarified, moisture conditioned, and recompacted as specified in **Section 9.4**. Fill placement and compaction should be in accordance with recommendations in **Section 8.5**.

8.3.3 RCC Spillway – Stilling Basin

Recommendations for subgrade preparation for the RCC stilling basin at the downstream toe of the embankment includes over-excavating 8 feet below the proposed bottom-of-slab elevation and replacing with non-expansive fill. The required depth of overexcavation is based on removing expansive soils to limit the estimated potential vertical heave to tolerable levels (estimated to be 1.5 inches). Excavated materials may be stockpiled and tested to confirm they will be suitable for re-use as compacted earth fill. Materials found to be unsuitable due to high plasticity could possibly be lime treated to meet embankment fill specifications, or be used elsewhere as shown on the drawings.

In order to counteract hydrostatic pressures and reduce the magnitude to swelling and potential for structure heave, mitigation measures may be required for the foundation of this structure. Options to address hydrostatic pressure may include over-excavating the subgrade materials and increasing the thickness of the RCC. Grouted soil/rock anchors may also be considered to provide uplift resistance on the RCC slab. These measures would also be effective in reducing expansive soil-related heave. For this project, it has been assumed that only overexcavation / replacement is preferable for the stilling basin structures.

The subgrade should be inspected by a qualified professional as specified in **Section 9.4**. Prior to receiving fill material, the subgrade should be scarified, moisture conditioned, and recompacted as specified in **Section 9.4**. Fill placement and compaction should be in accordance with recommendations in **Section 8.5**.

Groundwater seepage may be encountered in the excavation. Dewatering should be employed by the Contractor to maintain dry excavation as recommended in **Section 9.3**.

8.3.4 PSW Inlet Tower

The location for the proposed PSW inlet tower is currently submerged by the reservoir pool, and borings could not be drilled in close proximity to this planned structure. Consequently, inspection of the subgrade by a qualified geotechnical engineer or engineering geologist will be critical to assure a suitable foundation bearing stratum.

Subgrade preparation for the PSW inlet tower will include over-excavating a minimum depth of 2 feet below the proposed footing level and replacement with compacted flexbase material. to mitigate risk of expansive soil-related swelling and heave (see **Section 10.1.3**). The purpose is to remove soft surficial soils to reduce settlement, mitigate risk of expansive soil-related swelling and heave, and increase friction along the subgrade/footing interface. This overexcavation depth may need to be extended based on field observations during construction to remove soft/compressible materials that could not be identified during the field GI. Excavated materials may be stockpiled and tested for re-use suitability.

The subgrade should be excavated to planned subgrade elevation and be inspected by a qualified professional as specified in **Section 9.4**. Prior to receiving fill material, the subgrade should be scarified, moisture conditioned, and recompacted as specified in **Section 9.4**.

Groundwater seepage may be encountered in the excavation, even after reservoir drawdown. Dewatering should be employed by the Contractor to maintain dry excavation as recommended in **Section 9.3**.

8.3.5 PSW Conduit Pipe

New sections of PSW conduit pipe should be placed onto an unreinforced concrete pipe cradle, cast up to the spring line of the pipe. The pipe cradle addresses the difficulty of compacting fill under the haunches of the pipe, which could otherwise lead to loosened soil zones or voids creating preferential seepage paths and presenting risk for internal piping erosion. A filter diaphragm is required around the conduit pipe (see **Section 8.4**). Design of the PSW conduit connections should account for potential consolidation settlements discussed in **Section 8.1** and **Section 8.2**.

The subgrade should be excavated to the planned elevation, and be inspected by a qualified professional as specified in **Section 9.4**. Prior to receiving fill material, the subgrade should be scarified, moisture conditioned, and recompacted as specified in **Section 9.3**. Where final grading indicates less the 10 feet of cover soil (i.e. near both ends of the pipe), overexcavation / replacement with non-expansive fill to a depth of at least 2 feet below the bottom of the pipe cradle should be performed.

Groundwater seepage may be encountered in the excavation. Dewatering should be employed by the Contractor to maintain dry excavation as recommended in **Section 9.3**.

8.3.6 PSW Impact Basin

Recommendations for subgrade preparation for the PSW impact basin includes over-excavating below the proposed bottom-of-slab elevation at least 2 feet and replacing with flexbase fill. Excavated materials may be stockpiled and tested to confirm they will be suitable for re-use as compacted earth fill.

The subgrade should be inspected by a qualified professional as specified in **Section 9.4**. Prior to receiving fill material, the subgrade should be scarified, moisture conditioned, and recompacted as specified in **Section 9.4**. Fill placement should be in accordance with recommendations in **Section 8.5**.

Groundwater seepage may be encountered in the excavation. Dewatering should be employed by the Contractor to maintain dry excavation as recommended in **Section 19.3**.

8.4 Internal Drainage Design

Internal drainage material are intended to intercept potential seepage along preferential pathways (e.g., lift boundaries, more pervious layers, cracks/fissures) within the embankment and/or foundation materials. Properly designed internal drainage materials filter seepage without restricting seepage flows and prevent particle migration. Internal drainage measures may also serve to improve slope stability in earthen embankment sections by lowering the phreatic surface. Additionally, internal drainage will reduce hydrostatic lateral pressures and uplift forces acting on proposed structures. Internal drainage elements included in the design are discussed below.

8.4.1 Filter Compatibility

Filter compatibility analyses were conducted to estimate the necessary gradations for internal drainage/filter materials associated with the proposed construction. Filter compatibility between drainage layers and surrounding materials is essential to reduce the risk of particle migration (piping), maintain particle segregation, and to not restrict seepage flows.

Filter compatibility for the existing embankment and foundation materials was checked according to *NEH Part 633, Chapter 26 Gradation Design of Sand and Gravel Filters* (NRCS 2017). Base soil materials were considered as non-dispersive based on the vast majority of laboratory crumb and double-hydrometer testing. The detailed filter compatibility analysis calculations and results are provided in **Appendix J**.

Results of the filter compatibility analysis indicate ASTM C-33 Fine Aggregate (a standardized commercial gradation commonly available) is not suitable as Fine Filter material based on the gradations of the existing soil materials near the dam and proposed on-site borrow sources. While the fine gradation band of the ASTM C-33 Fine Aggregate falls within the design filter limits, the coarse gradation band is coarser than the design filter limits for each of the base soil materials considered. This is primarily attributed to the relatively small d_{85} particle sizes of the clayey on-site materials. Therefore, a non-standard gradation is recommended for design of the Fine Filter materials is shown in **Table 8-3**.

Filter compatibility analyses indicate that non-standard gradation is also required for Coarse Filter materials. The non-standard gradation is recommended for design of the Coarse Filter materials is shown in **Table 8-4**..

The filter compatibility analysis results indicate the slotted/perforated drainpipes installed in an envelope of Coarse Filter materials should have a maximum slot/perforation size of 1 mm (0.04 inches). Slotted/perforated drainpipes should not be installed in contact with Fine Filter, embankment fill, or other materials.

Table 8-4. Recommended Fine Filter Gradation

Sieve Size	Particle Size (mm)	Recommended Gradation of Fine Filter – Percent Finer by Weight	
		Coarse Band	Fine Band
3/8"	9.5	100	---
#4	4.75	100	---
#8	2.36	90	100
#16	1.18	65	100
#30	0.6	45	90
#50	0.3	45	93
#100	0.15	7	40
#200	0.074	0	3

Table 8-5. Recommended Coarse Filter Gradation

Sieve Size	Particle Size (mm)	Recommended Gradation of Coarse Filter for Design – Percent Finer	
		Coarse Band	Fine Band
2 in.	50	100	---
1 in.	25	90	100
½ in.	12.7	75	100
3/8"	9.5	65	100
#4	4.75	45	90
#10	2	20	65
#18	1	3	50
#40	0.425	0	25
#100	0.15	0	8
#200	0.074	0	5

8.4.2 Embankment Toe Drain

The existing embankment does not have a toe drain. Based on lack of historic seepage problems, and the fact that the geometry of the embankment prism will not be modified as part of the dam rehabilitation, AECOM believes that installation of a new toe drain is not required.

8.4.3 Proposed Filter Diaphragm – Existing and Proposed PSWs

A filter diaphragm is required around the new PSW conduit to control seepage flow and prevent a piping condition from developing.

Additionally, it is recommended that the abandonment of the existing PSW also included a new filter diaphragm. This recommendation is based on the fact that the current abandonment strategy is to leave the existing conduit pipe in place under the dam, and that the conduit was constructed with problematic concrete anti-seep collars and no existing filter diaphragm.

The following is recommended for filter diaphragm design:

1. Design of filter diaphragms should be in accordance with the latest version of the *NEH Part 628, Chapter 45, Filter Diaphragms* (NRCS, 2007).
2. Filter diaphragm materials should consist of Fine Filter (see **Table 8-3**).

3. Filter diaphragm should be located downstream of the embankment crest centerline, and maintain a minimum cover of 2 feet of embankment fill material in all directions.
4. Top of filter diaphragm should extend to the normal pool elevation, or to a height of 3 times the diameter of the principal spillway conduit above the top of the principal spillway conduit, whichever is higher. Minimum 2-foot cover of embankment fill material should be maintained in all directions.
5. Foundation soils are expected to exhibit low compressibility due to presence of generally stiff to hard clays. Accordingly, the bottom of the filter diaphragm should extend at least 2 feet below the bottom of the principal spillway conduit's installation trench.
6. The filter diaphragm should extend laterally from the outer edges of the principal spillway conduit by at least 3 times the diameter of the principal spillway conduit.
7. The thickness of the filter diaphragm should be a minimum of 3 feet in all directions.

Strip drains should be provided to drain off seepage that collects in the filter diaphragm. Strip drains should extend from the filter diaphragm and discharge into the proposed PSW stilling basin. The following is recommended for strip drain design:

1. Strip drain materials should consist of Fine Filter (see **Table 8-3**).
2. Strip drains should be a minimum of 2-foot width in all directions.
3. Strip drains should be graded to drain by gravity towards stilling basin structure (minimum 1% grade).
4. If required to provide sufficient flow capacity, minimum 6-inch diameter, slotted Schedule 80 PVC piping should be provided in each strip drain surrounded by a layer of Coarse Filter (see **Section 8.4.1**) on all sides. Pipes with slotted perforations should have a minimum of two (2) rows of slots along the bottom half of the pipe separated by an arc of between 60 and 125 degrees (i.e., one row between roughly the 4 and 5 o'clock positions and one row roughly between the 6 and 7 o'clock positions). Pipes with round perforations should have at least 4 rows of perforations, with the two lowest rows separated by an arc of between 60 and 125 degrees. The bottom of PVC piping should extend at least 6 inches above the bottom of the strip drain aggregate. Piping should outlet through the headwall or sidewalls of the principal spillway outlet structure at locations where flow volumes can be easily monitored.
5. Ductile iron pipe should be used at the end section of the strip drains to protect against damage in the riprap lined stilling basin. The ductile iron pipe should protrude slightly from face of the riprap slopes such that flows can be measured and monitored.

8.4.4 Underdrain for RCC Spillway

A continuous underdrain blanket providing both filtering and drainage functions will be included under the RCC spillway. The underdrain will be constructed over the full height of the exposed slope face. The underdrain will consist of a continuous aggregate blanket with transverse perforated collection pipes at regular vertical intervals (no greater than 10 feet). The collection pipes will connect to near-horizontal weep-holes consisting of solid PVC pipe laterals discharging through the RCC surface. The laterals will be constructed at regular horizontal spacing to drain seepage that could accumulate within the underdrain and collection pipes.

The RCC chute underdrain should consist of Fine Filter material placed onto the prepared subgrade, and overlain by a Coarse Filter layer extending to the base of the RCC. The inclusion of a layer of coarse filter directly under the RCC slab is recommended to provide filter protection against subgrade piping and/or scour through cracks which may develop through the unreinforced

RCC slab. A cover of Coarse Filter material should be provided around all PVC piping. The underdrain should be designed to satisfy filter compatibility requirements and sized for estimated seepage flows. Gradation design for fine and coarse aggregates is provided in **Section 8.4.1**.

The underdrain should not be located upstream of the proposed embankment crest centerline in order to preclude development of a shortened seepage path from the reservoir into the underdrain. Thus, the underdrain should begin near the downstream end of the proposed RCC crest structure, and continue downstream under the RCC chute structure. To provide uniform bearing surface, the full underdrain thickness should be provided below the entire plan footprint of both the RCC slab and RCC walls. The outside edges of the underdrain fill should slope downward from the back of the wall footings at a 1H:1V slope or flatter away from the footing as needed for constructability in order to allow for suitable stress distribution of footing pressures.

The selected termination point of the underdrain at the downstream end of the chute structure should be carefully considered. If the underdrain extends under the below-grade RCC stilling basin slab, it may allow seepage/infiltration to accumulate (i.e., “bath tub” effect) and access the expansive clay soils below the RCC stilling basin which may cause soil swelling and related heave. As discussed previously, the recommended 8-foot thickness of overexcavation / replacement below the stilling basin slab (which includes the approximately 3-foot thick aggregate underdrain), will provide a proposed 5-foot thick layer of non-expansive clayey soil between the underdrain and the potentially-expansive subgrade soils. This 5-foot thick clayey layer should provide an adequate low-permeability hydraulic barrier between the underdrain and the underlying expansive soils so as to limit seepage into the subgrade, thereby reducing the risk of moisture-induced swelling. On this basis, installing the underdrain below the RCC stilling basin slab may be an appropriate means for reducing hydrostatic uplift on the stilling basin slab due to spillway flows and/or fluctuating shallow groundwater.

However, if higher-permeability soils are used in the overexcavation / replacement fill, or if the thickness of the overexcavation / replacement is reduced to less than 8 feet, risk of seepage/infiltration to the underlying expansive soils is significantly increased. In such case, consideration should be given to terminating the underdrain at the invert of the stilling basin to allow free drainage and prevent accumulation of water below the stilling basin to minimize effect of expansive soils. If this option is selected, the lack of an underdrain system will increase hydrostatic uplift on the stilling basin slab. Hydrostatic uplift will need to be counteracted by either adding additional thickness (i.e., weight) to the RCC slab, or by providing soil/rock anchors in the stilling basin slab.

8.4.5 Wall Drain – RCC Spillway

Similar to the underdrain for the RCC spillway, it is recommended that no wall drainage system be provided for the sections of the RCC spillway walls which are located upstream of the proposed embankment crest centerline. This is intended to limit the potential for a hydraulic connection between the reservoir and the RCC wall underdrains, which could otherwise lead to excessive hydraulic gradient and seepage pressures via shortened seepage path through the dam.

For RCC walls located downstream of the proposed crest centerline (i.e., the chute structure and stilling basin), an aggregate chimney drain may be provided behind the exterior training walls to provide wall drainage. The chimney drain will serve to drain off accumulated infiltration behind the walls to reduce lateral hydrostatic pressures, and will be easier to properly compact with lightweight equipment behind the wall. The chimney drain should be at least 2 feet thick in any direction, and should consist of a vertical layer of Coarse Filter material against the back of the wall surrounded by Fine Filter material to prevent direct contact with embankment fill. A minimum 2-foot thick cap of compacted embankment fill should be placed above the chimney drain to minimize surface water infiltration into the chimney drain. Gradation design of the Fine and Coarse Filter materials is provided in **Section 8.4.1**. A slotted or perforated underdrain pipe within the Coarse Filter layer may be included to discharge seepage to the stilling basin.

8.4.6 Seepage Design Considerations for RCC Spillway Walls

The upstream portions of the RCC spillway crest structure will be in direct contact with the reservoir pool during spillway flow events. Because the RCC training walls extend through the full cross-section of the embankment, the walls should be designed to minimize the risk of developing preferential seepage path(s) at the interface with adjacent embankment fill. Preferential seepages paths can develop in zones of poorly-compacted backfill adjacent to the walls. Shrinkage of backfill away from the wall following compaction can also result in the development of preferential seepage paths.

One method to reduce the risk of seepage at the wall/backfill interface is to batter the back side of the RCC walls for the crest structure. This allows each lift of embankment fill to be compacted directly above and across the RCC-soil interface of the prior lift, assuring good compaction against the back of the wall. This also reduces the risk of shrinkage of the backfill away from the wall, which is more likely to develop for non-battered walls. However, battered RCC walls generally require formwork, and can be more difficult to construct. From a seepage control standpoint, battered walls would not be necessary for downstream sections of the RCC spillway (i.e., chute structure and stilling basin).

If vertical (non-battered) RCC walls are preferred for the spillway, a filter diaphragm is recommended due to the higher degree of difficulty in compacting backfill against a vertical interface, and the greater likelihood of backfill shrinkage away from the wall. The filter diaphragm is intended to intercept and filter potential preferential seepage paths that may develop along the RCC-backfill interface. Similar to the design of filter diaphragms for PSW conduits, the filter diaphragm for the RCC spillway walls should be oriented parallel to the embankment crest with a minimum thickness of 3 feet, and located downstream of the proposed embankment crest centerline. The filter diaphragm should be installed in an excavated trench extending below and laterally beyond the limits of mass-grading excavations and backfill according to the guidance in *NEH Part 628, Chapter 45, Filter Diaphragms* (NRCS, 2007). A minimum 2-foot thick “cap” of low permeability embankment fill should be placed above the top of the filter diaphragm to limit surface water infiltration and erosion.

8.5 Borrow Material Specification and Embankment Zoning

8.5.1 Embankment Material Specifications

Based on the results of field borrow investigation, suitable on-site materials for embankment fill will consist of USCS designations CL, SC, CL-ML, or CH with at least 40% fines (i.e., material passing the No. 200 sieve by weight) and less than 20% gravel (i.e., material retained on the No. 4 sieve by weight). The fill should be free of debris, vegetation, or other deleterious materials, and particles larger than 3 inches in diameter. All fill materials should be non-dispersive. Non-dispersive soils are considered to be those which have a percent dispersion less than 40% in the double-hydrometer test (ASTM D4221), and ND1 or ND2 per pinhole test (ASTM D4647). Crumb testing (ASTM D6572) should be performed to screen for potentially dispersive soils.

Fill materials placed under or adjacent to structures should also be non-expansive. Non-expansive soils are considered to be those which experience less than 1% swell at a confining pressure of 250 psf according to ASTM D4546, Method B (One-Dimensional Swell/Collapse) when remolded to at least 95% maximum dry density (MDD) at optimum moisture content (OMC) according to ASTM D698.

8.5.2 Embankment Zoning

In general, lower-plasticity materials should be reserved for the exterior zones of the embankment. Higher plasticity materials should be reserved for interior zones of the embankment to be protected from the effect of seasonal wetting and drying cycles, which can cause the development of shrinkage cracking and subsequent softening and strength loss. Recommended zoning and materials properties for interior and exterior fill zones are provided below in **Table** 8-**5**.

Lower-plasticity materials are required for embankment fill placed under and adjacent to proposed structures (i.e. RCC spillway and PSW structures). A higher degree of compaction is also required under structure foundations to provide adequate bearing capacity. Placement moisture contents should be above optimum to limit the potential for wetting-induced swell near structures, and to provide low-permeability characteristics of the fill. Engineering analyses contained herein assume the material requirements for proposed embankment fill will meet those provided in **Table** 8-**5**.

8.5.3 Embankment Placement Criteria

The fill should be placed in loose lifts not exceeding 9 inches thick, and moisture conditioned and compacted with reference to ASTM D698 (Standard Proctor) to meet the requirements of **Table 8-5**. The surface of each lift should be roughened prior to placement of subsequent lifts to promote inter-lift bonding and preclude development of preferential seepage paths or planes of weakness.

Fill materials placed within a horizontal distance of 3 feet from structures, or the first 3 feet placed on top of buried structures, should be compacted with lightweight equipment to avoid damage to structures.

The finished surface for foundation construction should be maintained throughout construction prior to RCC placement, and should be periodically moistened during dry periods and protected from erosion and ponding during wet periods to maintain the target compaction moisture content.

For the RCC crest structure, an alternative to continued moisture maintenance of the finished embankment surface could be construction of a lean concrete seal slab (mud mat), which would serve to maintain soil moisture and reduce rutting. The seal slab would also provide a uniform working surface for construction of the crest structure foundation. If used, the seal slab should be placed shortly after completing the embankment surface (i.e., 1 to 2 days). This approach would likely require inclusion of a construction joint at the interface between the RCC crest weir and RCC chute to accommodate differing foundation support. Additionally, the foundation slab should be provided with a cutoff extending through the mud mat to interrupt the relatively smooth material interface and risk of preferential seepage path.

8.5.4 Flexbase Specifications and Placement Criteria

Overexcavation and replacement with compacted flexbase materials is recommended below the foundations for the PSW Inlet Tower and Impact Basin. Flexbase should consist of a well-graded, crushed aggregate material meeting the requirements of TxDOT Item 247, Type A, Grade 1-2. The flexbase should be placed in maximum 9 inch loose lifts and compacted to a minimum of 100% of maximum dry density at a moisture content ±2% of optimum moisture according to Standard Proctor energy (ASTM D698). Flexbase should be sourced from a commercial aggregate supplier approved by TxDOT.

Where the final embankment cover on the new PSW conduit pipe is less than 10 feet, a minimum of 2 feet of overexcavation and replacement is required. Flexbase is permissible as replacement below the conduit pipe in these zones but should be isolated to the upstream toe and downstream toe of the dam (i.e. within about 20 feet). Flexbase should <u>not</u> be used as bedding under the conduit pipe because it would serve as a preferential seepage path. Alternatively, non-expansive embankment fill may also be used in the overexcavation/replacement zone under the PSW conduit pipe.

Flexbase should be isolated from adjacent filter materials using non-woven geotextile to preclude issues with filter incompatibility between these materials (e.g., potential clogging of filter layers). Additionally, a non-woven geotextile separation layer should be provided between the flexbase and clayey embankment/foundation soils at the PSW Impact Basin to preclude filter incompatibility issues (e.g., fines migration) associated with planned drain outlets and potential seepage path outlets into the creek channel at this location.

8.5.5 Filter Material Specifications and Placement Criteria

Fine and coarse filter materials should meet the gradations specified in **Section 8.4.1** and the requirements of ASTM C-33. Fine and coarse filter materials should be sourced from an approved commercial supplier.

Fine filter materials should be compacted to 65 to 70% relative density, or a minimum of 98% of maximum dry density from one-point Standard Proctor testing (ASTM D698) on an oven-dried sample. To ensure repeatability, the reference maximum density should be based on the average of three (3) one-point Proctor tests. In order to prevent bulking, fine filter materials will require near saturation (water applied immediately in front of a vibratory roller) during field compaction. The fine filter materials should not be contaminated by fines from the surrounding embankment fill or foundation materials.

Coarse filter materials should be compacted to 65 to 70% relative density. Given the difficulty in compaction testing clean coarse aggregate materials, suitable compaction may be achieved by specifying a minimum number of passes by the compaction equipment. At minimum, compaction should consist of no less than four (4) overlapping passes by a vibratory roller or more until no further densification is observed. A field test section is recommended to confirm whether additional passes should be required during compaction.

Table 8-6. Recommended Material Specifications and Placement Requirements for Earth Fill

Proposed Earthfill Types		Borrow Source Information									Recommended Specifications for Earthfill Materials						
Material Type	Placement Location	Material Source	Referenced Borings	Typical Depths (feet bgs)		Measured Range of Atterberg Limits		Description and USCS	Estimated Fill Volumes (CY) (5)		USCS (5)	LL	PI	Percent Passing No. 200 Sieve	Compaction Reference (6)	Required Relative Compaction (% of MDD)	Compaction Moisture Limits (%)
				Top	Bottom	LL	PI		Available	Required							
A	Adjacent to Structures (1)	Off-Site Borrow Area (Import)	---	---	---	---	---	---	---	1,200	CL, SC, CL-ML	< 45	7 - 20	40 min.	ASTM D698, Method A	95 – 100	Opt. + 4
B	Under RCC Spillway (2)	Off-Site Borrow Area (Import)	---	---	---	---	---	---	---	7,700	CL, SC, CL-ML	< 45	7 - 20	40 min.	ASTM D698, Method A	98 min.	Opt. + 4
C	Interior Zone of Embankment (3)	Borrow Area (Layer B)	101-19 thru 106-19	4	8	35 – 51*	22 – 32*	LPR (CL, SC, CL-ML, CH)	54,800	3,500	CL, SC, CH	< 60	10 - 35	40 min.	ASTM D698, Method A	95 – 100	Opt. + 4
		Supplemental Off-Site Borrow Area	---	---	---	---	---	---	----								
D	Outer Zone of Embankment (3,4)	Borrow Area (Layer B)	101-19 thru 106-19	4	8	35 – 51*	22 - 32*	LPR (CL, SC, CL-ML, CH)	(see Material C)	20,100	CL, SC	< 50	10 - 30	40 min.	ASTM D698, Method A	95 – 100	Opt. + 4
		Supplemental Off-Site Borrow Area	---	---	---	---	---	---	---								
E	Auxiliary Spillway Channel and Berms, RCC Spillway Outlet Channel	Borrow Area (Layer C)	101-19 thru 106-19	8	10	51 – 65	33 – 45	MPR (CH)	27,400	6,800	CH, CL	30 - 75	10 - 55	40 min.	ASTM D698, Method A	95 – 100	Opt. + 4
		ASW Excavation	8-19, 201-19 thru 209-19	0	5	29 – 53	16 – 32	Alluvium, LPR, and Embankment (CL, CH)	8,900								
		PSW Embankment Excavation	11-19, 12-19, 304-19, 1301-19, 1302-19	0	32	34 – 76	20 – 55	Embankment (CL, CH)	14,000								
		PSW Downstream Toe Excavation	305-19, 603-19	0	11	48 – 71	27 – 48	Fill, Alluvium, and MPR (CH, CL)	2,000								
		RCC Spillway Embankment Excavation	9-19, 13-20, 14-20, 1701-20 thru 1705-20	0	15	34 – 74	19 – 50	Embankment (CL, CH)	9,700								
		RCC Downstream Toe Excavation	601-19, 702-20, 703-20	4	18	31 – 77	15 – 54	LPR and MPR (CL, CH)	7,500								
		RCC Outlet Channel Excavation	401-20, 402-20	1	4	58 – 82	37 – 62	Alluvium (CH)	5,000								

Notes:

1) Applies to earthfill zones located within a horizontal distance of 5 feet or the wall height (1H), whichever is larger, and 5 feet above and below structures. Refer to section **8.5.4** for exceptions.
2) Applies to earthfill zones within the footprint of the RCC crest foundation, RCC chute, impact basin, inlet tower, conduit pipe, and within 5-foot horizontal distance beyond the footprint. Within a 20 foot horizontal distance from the final upstream slope face, only natural CL/SC soils should be permitted in this zone (no lime-treated soils) to reduce risk of brittle soil behavior / cracking.
3) Applies to earthfills located a distance greater than 5 feet or the wall height (1H), whichever is greater, beyond structures.
4) Applies to earthfill placed in the outer 5-ft (vertical) of the embankment. Minimum placement width of 10-ft (horizontal) for embankment reconstruction at the new principal spillway.
5) Approximate volumes provided by AECOM civil design team (6/30/2021).
6) All materials shall have no greater than 20% gravel (i.e., percent coarser than the us no. 4 sieve by weight). Maximum particle size is 2 inches.
7) Earthfills and backfills near structures to be compacted by hand tamping or with manually-directed power tampers or plate vibrators shall be placed in layers not exceeding 4 inches in thickness before compaction. Maximum allowable particle size for such material shall be 2 inches.
8) * – Excludes one outlier sample test results with LL=69 and PI=46 which is not considered to be representative.

8.6 Geotechnical Instrumentation

8.6.1 Piezometers

Installation of four (4) new open-well (stand-pipe) piezometers will be included in the design drawings to permit future measurement of piezometric levels within the embankment and near the toe of the dam. The purposes of the piezometers are to: 1) confirm design assumptions for phreatic surface and stability analysis; 2) monitor uplift pressures on the new spillway structure; and 3) monitor fluctuations in phreatic surface over time that could be indicative of possible adverse dam performance.

Each piezometer will be furnished as a nested piezometer with two screened intervals tipped in Embankment Fill and/or Alluvium/Residuum depending on location. One (1) piezometer will be installed at the crest of the embankment on the outside edge of the RCC overtopping spillway to the right of the RCC chute. Two (2) additional piezometers will be installed at the toe of the dam immediately adjacent to the outside edge of the right and left walls of the RCC stilling basin. One (1) piezometer will be installed on the downstream toe of the dam and will be located adjacent to the proposed PSW impact basin. Proposed piezometer screen intervals and tip depths will be specified as part of the design package. Piezometers should be constructed and monitored daily for at least 3 weeks prior to raising the reservoir normal pool above existing conditions.

Additionally, the existing piezometer at borings 9-19 and 11-19 should be modified (or replaced) as part of the construction contract to accommodate the embankment crest modification and allow continued readings. The piezometer in boring 702-20 will be abandoned as part of construction of the proposed RCC spillway chute.

8.6.2 Reservoir Staff Gauge

AECOM understands the existing electronic reservoir stage recorder and rainfall gauge station is no longer functional, and had been difficult to operate and maintain in the past.

AECOM recommends the proposed dam rehabilitation include installation of a manual-read reservoir staff gauge(s) to permit accurate measurements of reservoir level. This will allow future comparison of reservoir level versus piezometric levels surface to better understand the response of the phreatic surface to changes in reservoir level. If feasible, the reservoir stage recorder and rainfall gauge could be repaired to provide supplemental data in between manual readings that may be valuable in evaluating hydraulic performance of the dam.

8.6.3 Survey Monitoring Points

AECOM recommends the installation of fifteen (15) survey monitoring points on the RCC spillway structures, and an additional five (5) survey monitoring points on the PSW spillway structures. Proposed location of proposed monitoring points will be included in the design drawings. The survey monitoring points will be established on the walls and slab of the RCC spillway structures (crest, chute, and stilling basin) and the PSW structures (inlet tower, impact basin) to monitor potential settlement and/or heave. Monitoring points should be established, and initial readings taken, within 7 days of structure installation and at least 2 weeks prior to backfilling against the training walls and reservoir filling. Monitoring points should be surveyed weekly until the substantial completion of construction and initial filling of the reservoir, after which point readings should continue for at least 2 months. Frequency of readings may be reduced if no significant movement is observed.

Follow-up readings conducted at 6 and 12 months following substantial completion are suggested. Subsequent readings should be conducted are part of routine dam safety inspections, typically every 1 to 2 years.

9. Construction Considerations

9.1 Clearing and Grubbing

Before site grading and excavating, existing vegetation, topsoil, and any debris should be cleared and disposed of outside the construction limits. The clearing and grubbing depths are generally 6 inches unless organic soils or tree roots are encountered. Where concentrations of organic soils and tree roots are found, deeper clearing may be required. The geotechnical engineer may be consulted to provide additional recommendations for removal of deeper organics, if encountered. Topsoil and debris should not be incorporated into any engineered fill.

9.2 Excavations

9.2.1 Excavation Potential

Planned excavations should proceed without difficulty using modern earth-moving equipment, and can be classified as "common" excavation for bidding purposes per NRCS Construction Specification 21. Within the planned depths of excavation, common excavation classification also applies to the residuum of the Pecan Gap Chalk.

9.2.2 Temporary Excavation Slopes

Temporary excavations are the sole responsibility of the Contractor. All temporary excavations should comply with OSHA guidelines. Excavations into the dam embankment deeper than 4 feet should not exceed an inclination of 2H:1V. Excavations that cannot be sloped to a stable configuration will require shoring. All shoring designs, and any excavations deeper than 20 feet, should be designed by a Professional Civil Engineer licensed in the State of Texas. The Contractor's submittals related to temporary excavation should be formally reviewed and approved by the Engineer of Record prior to the start of construction.

As noted in previous sections, temporary excavation at the downstream toe is required to install PSW and RCC spillway structures and may encountered shallow groundwater. Maximum permissible slope angles flatter than those dictated by OSHA guidelines may be required as part of the project design. The contract documents may also set additional requirements for the contractor's design related to temporary excavations (e.g., reservoir operations and flood routing, construction sequence, duration for open excavation, weather considerations, backfill tie-in, etc.).

9.3 Groundwater Control and Dewatering

Groundwater was encountered in several of the borings completed and will may be encountered in subgrade excavations planned for the construction of the proposed ASW and PSW structures at the downstream toe. Temporary dewatering is an important consideration for construction of the proposed RCC stilling basin, which will be founded near the groundwater levels measured during the field investigation in boring 601-19.

The reservoir level should be lowered to the greatest extent possible prior to construction to reduce the magnitude of dewatering at the downstream toe. Groundwater controls will be necessary for the entire duration of the earthwork operation until constructed internal drains have proper outlets. Groundwater levels should be maintained at least 2 feet below the proposed excavation bottom for trafficability and stability. Temporary dewatering is the responsibility of the contractor.

Groundwater levels can fluctuate depending on rainfall, runoff conditions, and other factors. The proposed filter blanket grades will extend below the static groundwater levels measured in the boring at the time of drilling. The contractor should verify groundwater conditions before construction. The contractor should prepare and submit a dewatering plan for review as part of the contract documents.

9.4 RCC Construction Considerations

The RCC should be constructed in horizontal lifts, including the steps of the chute structure. Consideration may be given to including contraction joints in the RCC slab to control crack development. Each contraction joint should include an underlayment of geosynthetic filter fabric with apparent opening size (AOS) compatible with the granular underdrain materials.

9.5 Construction Quality Assurance and Quality Control

9.5.1 Subgrade Inspections

A qualified geotechnical engineer or engineering geologist (Field Representative) should inspect foundation subgrades to confirm bearing strata are consistent with the design assumptions stated herein. This includes subgrades associated with the foundations for the proposed RCC auxiliary spillway (crest weir, stepped chute, stilling basin); proposed principal spillway (inlet tower, conduit pipe, impact basin); and downstream toe of the earth fill embankment raise.

The Field Representative should observe the excavated subgrade for these areas to verify potentially compressible soils are not present. Before the start of construction of structures or placement of fill, the subgrade should be proof-rolled with a minimum of six complete passes of a minimum of 10-ton (static) vibratory roller or equivalent. If pockets of unsuitable materials encountered in this process cannot be satisfactorily compacted at the subgrade, these soils should be removed and replaced with embankment fill or other material approved by the geotechnical engineer and compacted as recommended in **Section 8**. The contractor should be prepared to provide a small excavator for shallow test pits. The finished subgrade should be clean and free of unsuitable materials (trash, organics, wood, and other degradable or deleterious materials).

Particular attention should be paid to identifying and removing gravelly strata if exposed in excavations to minimize seepage conveyance under the dam which may adversely affect planned structures.

9.5.2 Subgrade Compaction

Following excavation to the lowest subgrade elevation and inspection/proof-rolling activities are completed, the subgrade should be compacted prior to placement of fill or structure foundations. The cut subgrade surface should be graded level, scarified to a minimum depth of 6 inches, and moisture conditioned to between optimum and +4% of optimum moisture according to ASTM D698 (Standard Proctor).

Subgrades underlying the footprint of proposed structures and within 5 feet horizontal distance of foundations should be recompacted to at least 98% of maximum dry density in accordance with ASTM D698. Subgrades outside these areas (e.g., proposed embankment raise section) should be recompacted to at least 95% of maximum dry density in accordance with ASTM D698.

The moisture content of the prepared subgrade should be regularly maintained by the Contractor until subsequent placement of directly overlying fill material or structures.

For subgrades to receive fill which are steeper than 5H:1V inclination, benched excavations into the subgrade will be required prior to fill placement in order to preclude the development of a preferential weak plane at the subgrade-fill interface.

9.5.3 Instrumentation Installation

A qualified engineer or geologist should be present full-time during the installation of piezometers to log soils encountered, record groundwater observations, and document well materials and depths. Piezometer installation should be conducted under the direction of a licensed Professional Engineer.

Survey monitoring points should be installed and surveyed by a licensed Professional Land Surveyor. The data should be periodically reviewed and interpreted by a licensed Professional Engineer.

9.5.4 Fill Placement and Testing

Each lift of compacted fill should be tested to confirm it has the specified moisture and compaction. One moisture/density verification test should be performed for every compacted lift at a rate of 1 per 10,000 SF of compacted area or every 500 LF per lift of dam embankment, whichever requires the most testing. For smaller areas, a minimum of three moisture/density verification tests should be provided for every lift. Subsequent lifts should not be placed until the exposed lift has the specified moisture and density. Lifts failing to meet the moisture and density requirements should be reworked to meet the required specifications.

Ongoing sampling from the borrow area and/or the as-placed fill material should be performed periodically to confirm the consistency of material from borrow sources meets the range of acceptable index properties provided in **Section 8**. Sampling and testing should occur at the following minimum frequencies:

- LL, PI, and Minus #200: 1 test per 2,500 CY;
- Crumb test: 1 test per 2,500 CY;
- Standard Proctor: 1 test per 10,000 CY; and
- Pinhole test: 1 test per 10,000 CY

10. Limitations

This report was prepared by AECOM using the degree of care and skill ordinarily exercised under similar circumstances by responsible engineers and geologists practicing in the same general location. No other warranty or representation, either expressed or implied, is made as to the findings and professional advice in this report.

The opinions, conclusions, and recommendations contained in this report are based on the field observations and subsurface explorations, laboratory tests, and present understanding of the proposed improvements. The findings in this report are believed to describe site conditions to the extent practical given the scope of the investigation. However, this investigation, like all such investigations, can directly explore subsurface conditions only at the boring locations within the site. Soil and geologic conditions can vary greatly between or beyond the exploration sites, and different conditions may be found during subsequent investigations or project construction.

The conclusions and recommendations contained herein are based in part upon information provided by others (including our subcontractors) and upon the assumption that all relevant information has been provided by those parties from whom it has been requested and that such information is accurate. Information provided to AECOM has not been independently verified by AECOM, unless otherwise stated.

There is no intention that this report addresses any environmental issues (for example, environmentally-affected soil or groundwater, or historic site uses) related to this site. Such evaluations are outside the scope of this work and should be addressed in separate studies. In the event that changes are made to the nature, design, or location of the proposed construction layout or design criteria, the conclusions and recommendations presented herein should not be considered valid, unless AECOM has reviewed the changes and addresses their impact to the recommendations provided.

11. References

AECOM. 2018. *Field Investigation Plan, Plum Creek FRS No. 21 Rehabilitation Design.* Prepared for TSSWCB. November.

ASTM. *D2113-08, Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation*;

ASTM. *D5434-12, Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock;*

Bureau of Economic Geology (BEG). 1996. *Physiographic Map of Texas.* University of Texas at Austin.

Balcones Geotechnical. 2019. *Final Geologic Investigation and Data Report, Plum Creek FRS No. 21, Caldwell County, Texas.* Prepared for AECOM. September 15.

Barnes, V.E. 1979. *Geologic Atlas of Texas, Seguin Sheet*. The University of Texas at Austin, map and explanatory bulletin.

DeCook, K. J. 1963. *Geology and ground-water resources of Hays County, Texas* (pp. 45-50, Geological Survey Water-Supply Paper 1612). Washington, DC: U.S. Government Printing Office. doi:10.3133/wsp1612

Duncan, J.M.,Wright S.G. and Wong, K.S. 1990. *Slope Stability during Rapid Drawdown.* Proceedings of H. Bolton Seed Memorial Symposium. Vol. 2.

Elias, V., Christopher, B., and Berg, R. (2001). *Mechanically Stabilized Earth Walls and Reinforced Soil Slopes, Design and Construction Guidelines.* FHWA NHI-00-043. Report to the National Highway Institute, Federal Highway Administration, Washington, DC, by Ryan R. Berg & Associates, Woodbury, MN. March.

M&E Consultants (M&E), 2010, *Dam Assessment Report*, *Plum Creek Watershed Floodwater Retarding Structure No. 2, Hays County, Texas.* October.

National Lime Association (NLA). 2004. *Lime-Treated Soil Construction Manual, Lime Stabilization & Lime Modification.* Bulletin 326, January.

NRCS. 2007. *National Engineering Handbook (NEH) Part 628, Chapter 45, Filter Diaphragms.* January.

NRCS. 2009. *NEH Part 642, Specifications for Construction Contracts.* January.NRCS. 2017a. *Title 210 – National Engineering Manual (NEM), Part 531 – Geology, Subpart A – Geologic Investigations.* June.

NRCS. 2017b. *NEH Part 633, Chapter 26, Gradation Design of Sand and Gravel Filters.* August.

NRCS. 2012a. *NEH Part 631 – Geology, Chapter 2 Engineering Geologic Investigations*. January.

NRCS. 2012b. *NEH Part 631 – Geology, Chapter 3, Engineering Classification of Earth Materials.* January.

NRCS. 2012c. *NEH Part 631 – Geology, Chapter 4, Engineering Classification of Rock Materials.* January.

NRCS. 2012d. *NEH Part 631 – Geology, Chapter 5, Engineering Geology Logging, Sampling, and Testing.* January.

NRCS. 2012e. *NEH Part 631 – Geology, Chapter 12, Rock Material Field Classification System.* January.

NRCS. 2019. *Technical Release 210-60 (TR-210-60), Earth Dams and Reservoirs.* March.

Proctor, C. V., Jr., Brown, T. E., Waechter, N. B., Aronow, S., Pieper, M. K., and Barnes, V. E., 1974, Geologic Atlas of Texas, Seguin Sheet: The University of Texas at Austin, Bureau of Economic Geology, Geologic Atlas of Texas, map scale 1:250,000.

Soil Conservation Service (SCS). 1967a. *Geological Report, Texas, Plum Creek Site 2*, Hays County. June 12.

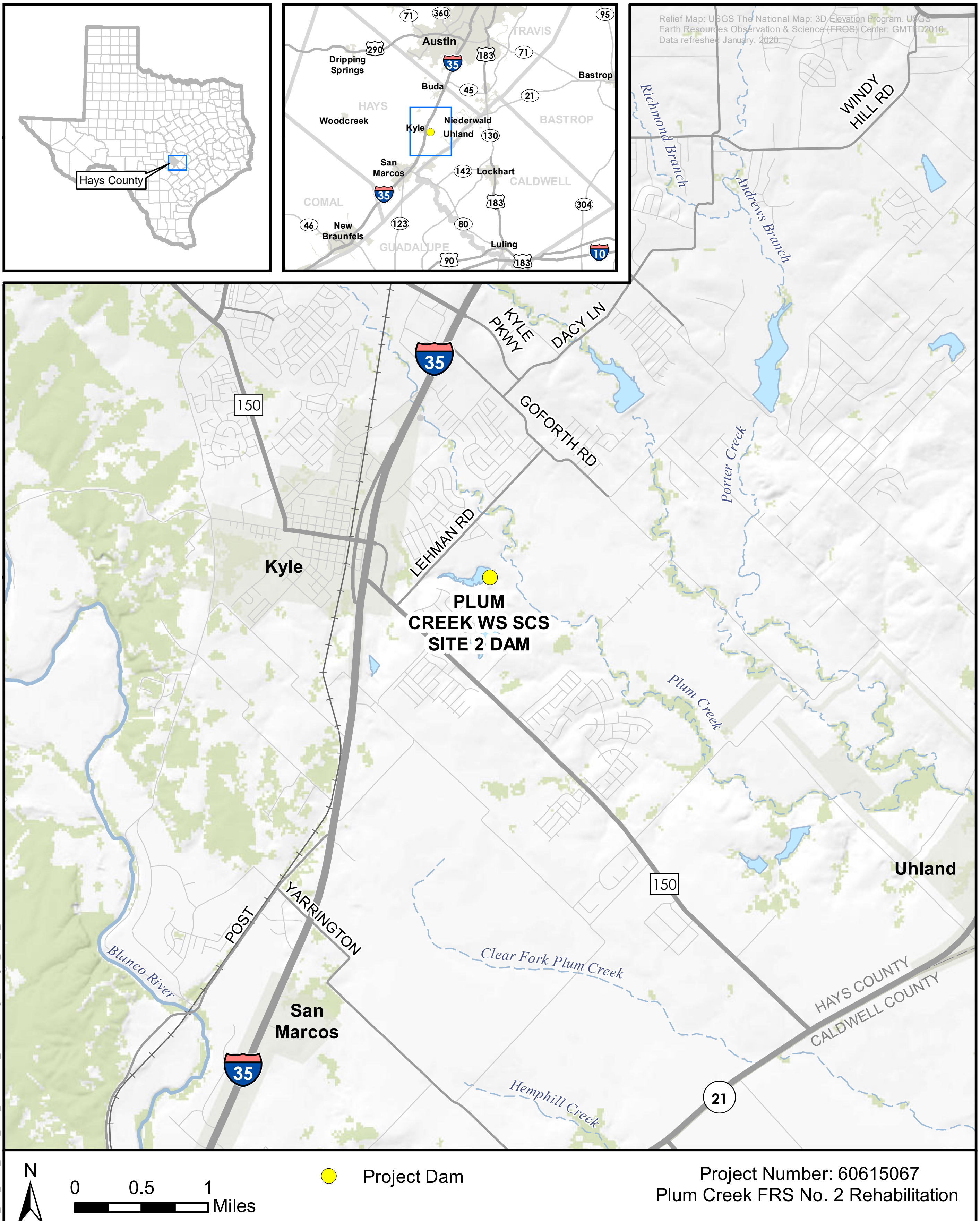
Soil Conservation Service (SCS). 1967b. *Soil Mechanics Report, Texas, Plum Creek Site 2*, Hays County. July 18.

Texas Department of Transportation (TXDOT). 2014. *Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges.* November 1.

US Bureau of Reclamation (BOR). *Engineering Geology Field Manual, 2nd Ed. Volumes 1 and 2.*

Wermund, E.G.. *Physiographic Map of Texas* (scanned). 1:6,336,000. State Maps, SM0005. Austin, TX: University of Texas at Austin, Bureau of Economic Geology, 1996.

Figures

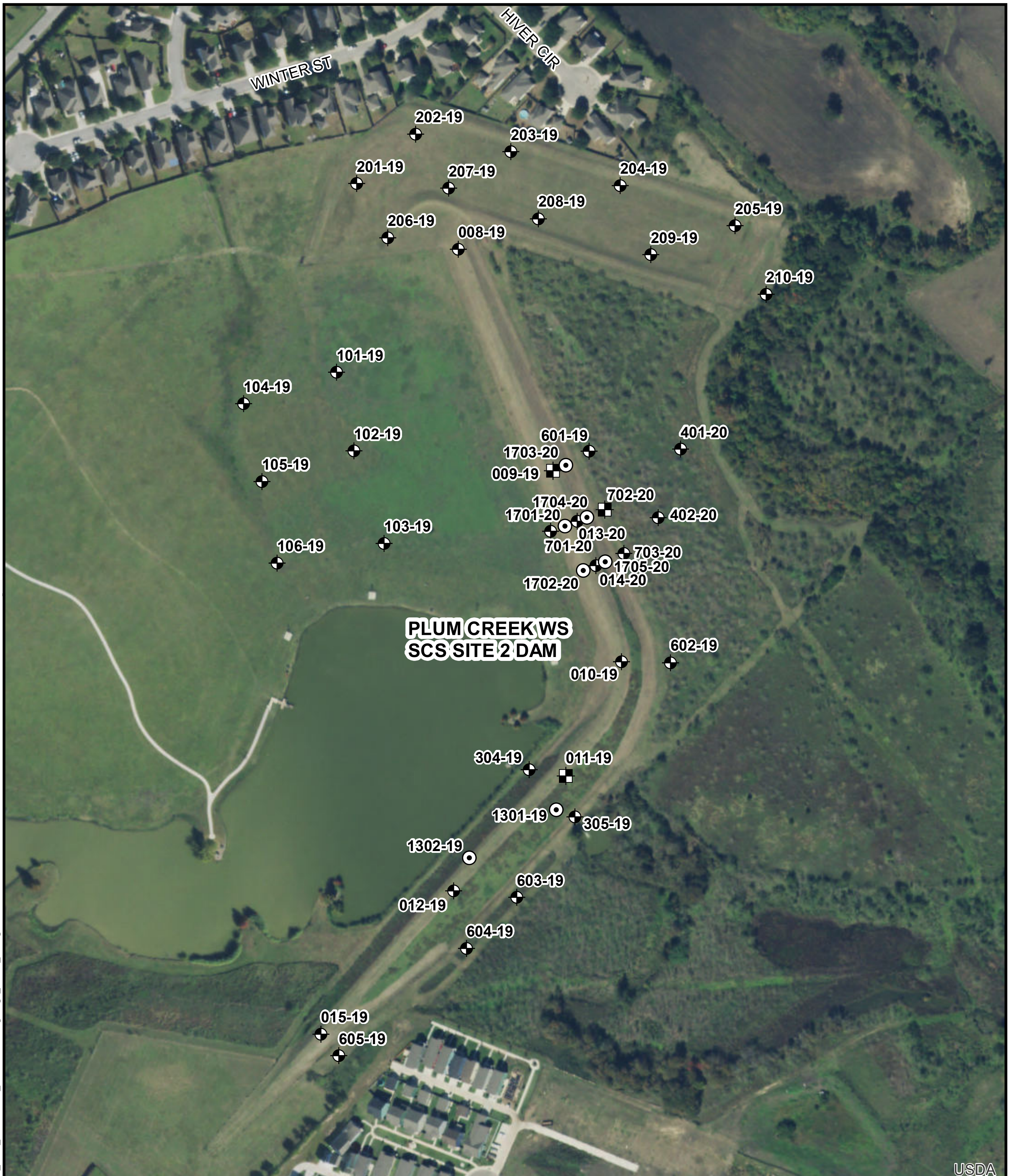


Project Dam

Project Number: 60615067
Plum Creek FRS No. 2 Rehabilitation

AECOM

Figure 1
Location Map



Boring Completed as Piezometer

Hand Auger Boring

Soil Boring

Project Number: 60615067
Plum Creek FRS No. 2 Rehabilitation

Figure 2.

Boring Location Map

AECOM

L:\DCS\Projects\INFR\TSSWCB\Elm_and_Plum_Creek_Dam_Rehabs\900_GIS\MXD\Borings\Fig7_Plum2_Borings.mxd

Appendix A Laboratory Test Results

Laboratory Summary Table

Sample Information									Field Tests		Laboratory Index								Sieve/Hydrometer				Atterberg Limits				Dispersion			Proctor		Analytical						
Boring Number	Top Depth	Bottom Depth	GS Elev.	Top Elev.	Bottom Elev.	Sample ID	Stratum	Field USCS	Field SPT N-value	Pocket Pen.	Lab USCS	Wc	γd	γt	Est. e0	Est. Deg. of Sat	Assumed Gs	G_s	Gravel	Sand	Pass #200	Pass 2μm	LL	PL	PI	LI	Crumb	Double Hydro	Pinhole	MDD	OMC	Organic Content	pH (H_20)	pH ($CaCL_2$)	Resist.	Chlorides	Sulfates	Other Tests Performed
	feet	feet	NAVD88	NAVD88	NAVD88				(bpf)	(tsf)		(%)	(pcf)	(pcf)		(%)			(%)	(%)	(%)	(%)					(Gr)	(%)	(-)	(pcf)	(%)	(%)	(-)	(-)	(ohm-cm)	(mg/kg)	(mg/kg)	
8-19	0	2.0	662.2	662.2	660.2	P-1	Embank. Core	CH		4.50		17.5																										
8-19	2.5	4.0	662.2	659.7	658.2	SS-2	Embank. Core	CH	20			13.6																										
8-19	4	6.0	662.2	658.2	656.2	P-3	Embank. Core	CH,CL/CH		4.50		17.6																										
8-19	6.5	8.0	662.2	655.7	654.2	SS-4	Embank. Core	CL/CH		4.50		11.5																										
8-19	8	10.0	662.2	654.2	652.2	P-5	MPR	CL/CH		4.50		17.4																										
8-19	13	15.0	662.2	649.2	647.2	ST-6	MPR	CL/CH		4.50		9.8																										
8-19	18.5	20.0	662.2	643.7	642.2	SS-7	MPR	CL/CH	22			18.7																										
8-19	23.5	25.0	662.2	638.7	637.2	SS-8	MPR	CL/CH	20			22.1																										
8-19	28.5	30.0	662.2	633.7	632.2	SS-9	MPR	CL/CH	24			22.2																										
9-19	0	2.0	662.4	662.4	660.4	P-1	Embank. Core	CH		4.00	CH	18.3	98.1	116.1	0.72	68.9	2.7		0	6	94	58.1	65	24	41	-0.14	1						8.03				300	SP
9-19	2	3.5	662.4	660.4	658.9	SS-2	Embank. Core	ML	22		CL	9.7									89.8		40	20	20	-0.52												
9-19	4	6.0	662.4	658.4	656.4	P-3	Embank. Core	CL/CH		4.50	CH	16.7	104.9	122.4	0.61	74.4	2.7		2.3	11.8	85.9	46.4	68	25	43	-0.19	1						7.68				400	SP
9-19	6	7.5	662.4	656.4	654.9	SS-4	Embank. Core	CL/CH	20			14.2																										
9-19	8	10.0	662.4	654.4	652.4	ST-5	Embank. Core	CH		4.50	CH	20.1	106.8	128.3	0.58	94.0	2.7				97.5		74	24	50	-0.08												UC, Consol.
9-19	13	15.0	662.4	649.4	647.4	P-6	Embank. Core	CL/CH		4.25	CH	20.5	97.9	118.0	0.72	76.8	2.7		3.2	16.2	80.6	48.5	60	26	34	-0.16	1						7.92				1,300	SP
9-19	18.5	20.0	662.4	643.9	642.4	SS-7	MPR	CH	18			12.9																										
9-19	23	25.0	662.4	639.4	637.4	ST-8	MPR	CH		4.50	CH	23	104.6	128.7	0.61	101.7	2.7				86.4		50	21	29	0.07												UC, Consol
9-19	28	30.0	662.4	634.4	632.4	P-9	MPR	CH		4.50	CH	19.7	101.9	122.0	0.65	81.4	2.7		0	2.1	97.9	48.5	73	25	48	-0.11	1						7.9				600	SP
9-19	33.5	35.0	662.4	628.9	627.4	SS-10	MPR	CH	28			21																										
10-19	0	2.0	662.2	662.2	660.2	P-1	Embank. Core	CH		4.50		19.9																										
10-19	2	3.5	662.2	660.2	658.7	SS-2	Embank. Core	ML	21			8.3																										
10-19	4	5.0	662.2	658.2	657.2	P-3A	Embank. Core	CH		4.50		12.6																										
10-19	5	6.0	662.2	657.2	656.2	P-3B	Embank. Core	CH				2.9																										
10-19	6	8.0	662.2	656.2	654.2	ST-4	Embank. Core	CL		4.00		12.5																										
10-19	8	9.0	662.2	654.2	653.2	SS-5A	Embank. Core	CH	16			14.3																										
10-19	9	9.5	662.2	653.2	652.7	SS-5B	Embank. Core	CH				11																										
10-19	13	15.0	662.2	649.2	647.2	P-6	Embank. Core	CH		4.00		25.3																										
10-19	18.5	20.0	662.2	643.7	642.2	SS-7	Embank. Core	CH	12			11.7																										
10-19	23	25.0	662.2	639.2	637.2	ST-8	Embank. Core	CH		4.00		14.4																										
10-19	28	30.0	662.2	634.2	632.2	P-9	MPR	CH		4.50		23.7																										
10-19	33	35.0	662.2	629.2	627.2	ST-10	MPR	CH		4.50		24.7																										
10-19	38.5	40.0	662.2	623.7	622.2	SS-11	MPR	CH	17			21.5																										
10-19	43	45.0	662.2	619.2	617.2	P-12	MPR	CL/CH		4.50		17.8																										
11-19	0	2	661.2	661.2	659.2	P-1	Embank. Core	CH		4.00		16.8																										
11-19	2	3.5	661.2	659.2	657.7	SS-2	Embank. Core	CH,CH/CL	10			8.5																										
11-19	4	6	661.2	657.2	655.2	ST-3	Embank. Core	CH/CL		4.50	CL	10.0	117.3	129.0	0.44	61.9	2.7		4.3	27.6	68.1	29	34	14	20	-0.20	1	0										
11-19	6	8	661.2	655.2	653.2	P-4	Embank. Core	CH/CL,CH		4.50		14.7																										
11-19	8.5	10	661.2	652.7	651.2	SS-5	Embank. Core	CH/CL,CH	10			13.3																										
11-19	13	15	661.2	648.2	646.2	P-6	Embank. Core	CH		3.00		20.5																										
11-19	18	20	661.2	643.2	641.2	ST-7	Embank. Core	CH		3.75	CH	9.2	116.8	127.5	0.44	56.1	2.7				82.8		55	19	36	-0.27												CIU'
11-19	23.5	25	661.2	637.7	636.2	SS-8	Embank. Core	CH	12			19.8																										
11-19	28	30	661.2	633.2	631.2	P-9	Embank. Core	CH/CL,CH		2.25		19.4																										
11-19	33.5	35	661.2	627.7	626.2	SS-10	Embank. Core	CH/CL	12			17.3																										
11-19	38	40	661.2	623.2	621.2	ST-11	MPR	CH/CL		4.50	CH	22.3	101.3	123.9	0.66	90.8	2.7				94.3		73	25	48	-0.06												HC
11-19	43	45	661.2	618.2	616.2	P-12	MPR	CH/CL		4.50		16.6																										
11-19	48.5	50	661.2	612.7	611.2	SS-13	MPR	CH/CL	34			16.3																										
11-19	53	53.5	661.2	608.2	607.7	ST-14	Shale	Shale				5.6	140.1	147.9	0.20	74.6	2.7																					
11-19	53.5	55	661.2	607.7	606.2	SS-15	Shale	Shale	100			2																										
11-19	58.5	60	661.2	602.7	601.2	SS-16	Shale	Shale	100			1.1																										
12-19	0	2.0	662.4	662.4	660.4	P-1	Embank. Core	CH		4.50		18.9																										
12-19	2	3.5	662.4	660.4	658.9	SS-2	Embank. Core	CL/CH	25			12.7																										
12-19	4	6.0	662.4	658.4	656.4	P-3	Embank. Core	CH		4.50		2.3																										
12-19	6	7.5	662.4	656.4	654.9	SS-4	Embank. Core	CL/CH	18			10.5																										
12-19	8	10.0	662.4	654.4	652.4	ST-5	Embank. Core	CL/CH		4.50		19.3																										
12-19	13	15.0	662.4	649.4	647.4	P-6	Embank. Core	CL/CH		3.25		17																										
12-19	18.5	20.0	662.4	643.9	642.4	SS-7	Embank. Core	CL/CH	8			19.9																										
12-19	23	25.0	662.4	639.4	637.4	ST-8	Embank. Core	CL/CH		4.50		23.1																										
12-19	28	30.0	662.4	634.4	632.4	P-9	Embank. Core	CL/CH		3.00		21.2																										
12-19	33	34.5	662.4	629.4	627.9	SS-10	Embank. Core	CL/CH	20			21.1																										
12-19	38	40.0	662.4	624.4	622.4	ST-11	MPR	CL/CH		4.50		23.9																										
12-19	43	45.0	662.4	619.4	617.4	P-12	MPR	CL		4.50		18.2																										
12-19	48	50.0	662.4	614.4	612.4	ST-13	MPR	CL		4.50		18.5																										
12-19	53	54.5	662.4	609.4	607.9	SS-14	Shale	Shale	100			4.1																										
12-19	58.5	60.0	662.4	603.9	602.4	SS-15	Shale	Shale	100			4.3																										
13-20	0	2.0	662.3	662.3	660.3	P-1	Embank. Core	CH		4.50		17.3																										
13-20	2	4.0	662.3	660.3	658.3	ST-2	Embank. Core	CH		4.00	CH	16.8	107.4	125.4	0.57	79.8	2.7						64	27	37	-0.28												SP
13-20	4	6.0	662.3	658.3	656.3	P-3	Embank. Core	CH		4.00		19.9																										
13-20	6	8.0	662.3	656.3	654.3	ST-4	Embank. Core	CH		2.00	CH	19.1	108.4	129.1	0.55	93.0	2.7				89.5		61	20	41	-0.02												UU, Consol.
13-20	8	9.5	662.3	654.3	652.8	SS-5	Embank. Core	CH	11			23.3																										
13-20	13	15.0	662.3	649.3	647.3	P-6	Embank. Core	CH		3.50		23.4																										
13-20	18	20.0	662.3	644.3	642.3	ST-7	MPR	CH		3.00	CH	23.1	103.3	127.2	0.63	98.8	2.7				99.2		52	18	34	0.15												UU, SP
13-20	23.5	25.0	662.3	638.8	637.3	SS-x	MPR	CH	21																													
13-20	28	29.5	662.3	634.3	632.8	SS-8	MPR	CH	28			23.7																										
13-20	33	35.0	662.3	629.3	627.3	ST-9	MPR	CH		3.50		24.1																										
13-20	38	39.5	662.3	624.3	622.8	SS-10	MPR	CH	32			20.2																										

Sample Information									Field Tests		Laboratory Index								Sieve/Hydrometer				Atterberg Limits				Dispersion			Proctor		Analytical						
Boring Number	Top Depth	Bottom Depth	GS Elev.	Top Elev.	Bottom Elev.	Sample ID	Stratum	Field USCS	Field SPT N-value	Pocket Pen.	Lab USCS	Wc	γd	γt	Est. e0	Est. Deg. of Sat	Assumed Gs	G_s	Gravel	Sand	Pass #200	Pass 2μm	LL	PL	PI	LI	Crumb	Double Hydro	Pinhole	MDD	OMC	Organic Content	pH (H_20)	pH ($CaCL_2$)	Resist.	Chlorides	Sulfates	Other Tests Performed
	feet	feet	NAVD88	NAVD88	NAVD88				(bpf)	(tsf)		(%)	(pcf)	(pcf)		(%)			(%)	(%)	(%)	(%)					(Gr)	(%)	(-)	(pcf)	(%)	(%)	(-)	(-)	(ohm-cm)	(mg/kg)	(mg/kg)	
14-20	0	0.83	662.2	662.2	661.3	P-1A	Embank. Core	CH		4.50		16.3																										
14-20	0.83	2.0	662.2	661.3	660.2	P-1B	Embank. Core	CL																														
14-20	2	4.0	662.2	660.2	658.2	ST-2	Embank. Core	CL		4.50	CH	15.3	108.4	125.0	0.55	74.5	2.7						53	20	33	-0.14												UC
14-20	4	6.0	662.2	658.2	656.2	P-3	Embank. Core	CL		4.50		14.4																										
14-20	6	8.0	662.2	656.2	654.2	P-4	Embank. Core	CL		4.00		12.3																										
14-20	8	9.5	662.2	654.2	652.7	SS-5	Embank. Core	CH	17			22.1																										
14-20	13	13.8	662.2	649.2	648.3	P-6A	Embank. Core	CH		1.00		21.3																										
14-20	13.83	15.0	662.2	648.3	647.2	P-6B	Embank. Core	CH		2.00																												
14-20	18	20.0	662.2	644.2	642.2	ST-7	Embank. Core	CH		1.50	CH	21	107.3	129.8	0.57	99.4	2.7				80.9		58	20	38	0.03												UC, SP
14-20	23	24.5	662.2	639.2	637.7	SS-8	MPR	CH	23			14.7																										
14-20	28	30.0	662.2	634.2	632.2	ST-9	MPR	CH		4.00		24.8																										
14-20	33	35.0	662.2	629.2	627.2	P-10	MPR	CH		2.50		23.3																										
14-20	38	40.0	662.2	624.2	622.2	ST-11	MPR	CH		2.50		24																										
15-19	0	1.5	662.4	662.4	660.9	P-1a	Embank. Core	CH		4.50		16.6																										
15-19	1.5	2.0	662.4	660.9	660.4	P-1b	Embank. Core	CL/CH																														
15-19	2	3.5	662.4	660.4	658.9	SS-2	Embank. Core	CL/CH	16			9.1																										
15-19	4	6.0	662.4	658.4	656.4	P-3	Embank. Core	CH,CL/CH		4.50		15.3																										
15-19	6	8.0	662.4	656.4	654.4	ST-4	Embank. Core	CL/CH		4.50		14																										
15-19	8.5	10.0	662.4	653.9	652.4	SS-5	Embank. Core	CL/CH	16			11.5																										
15-19	13	15.0	662.4	649.4	647.4	ST-6	Embank. Core	CL/CH		4.50		19.3																										
15-19	18	20.0	662.4	644.4	642.4	P-7	Embank. Core	CL/CH				18.6																										
15-19	23.5	25.0	662.4	638.9	637.4	SS-8	MPR	CL/CH	22			17																										
15-19	28	30.0	662.4	634.4	632.4	ST-9	MPR	CL/CH		4.50		19.2																										
15-19	33	35.0	662.4	629.4	627.4	P-10	MPR	CL/CH				18.5																										
15-19	38	40.0	662.4	624.4	622.4	P-11	MPR	CL/CH				12.3																										
15-19	43.5	45.0	662.4	618.9	617.4	SS-12	MPR	CL/CH	70			20.6																										
101-19	0	2.0	652.0	652.0	650.0	P-1	Alluvium	CH		3.25		22.1																										
101-19	2	3.5	652.0	650.0	648.5	SS-2	Alluvium	CH	11		CH	14.6									90.6		69	21	48	-0.13	1					4.0					1,500	
101-19	4	4.3	652.0	648.0	647.8	P-3a	Alluvium	CH			CH	25.6									91.8		90	27	63	-0.02	1										700	
101-19	4.29	6.0	652.0	647.8	646.0	P-3b	LPR	CL-ML				11.5																										
101-19	6	7.5	652.0	646.0	644.5	SS-4	LPR	CL-ML	21		SC	6.2									33.3		39	19	20	-0.64	1											
101-19	8	10.0	652.0	644.0	642.0	P-5	LPR	CL-ML		4.25		12.4																										
101-19	0	5.0	652.0	652.0	647.0	B-1	Alluvium	CH																														
101-19	5	10.0	652.0	647.0	642.0	B-2	LPR	CL-ML																														
102-19	0	2.0	650.1	650.1	648.1	P-1	Alluvium	CH		3	CH	18.4									89.9		59	22	37	-0.10						4.3					500	
102-19	2	3.5	650.1	648.1	646.6	SS-2	LPR	CL-ML	17			7.7																										
102-19	4	6.0	650.1	646.1	644.1	ST-3	LPR	CL-ML		4.5	SC	7.1	128	137.1	0.32	60.6	2.7				47.5		35	13	22	-0.27											900	
102-19	6	7.5	650.1	644.1	642.6	SS-4	LPR	CL-ML	13			5																										
102-19	8	10.0	650.1	642.1	640.1	P-5	MPR	CL/CH		3.75	CH	21.5									98.7		65	20	45	0.03											1,400	
102-19	0	3.5	650.1	650.1	646.6	B-1	Alluvium	CH,CL-ML																														
102-19	3.5	7.5	650.1	646.6	642.6	B-2	LPR	CL-ML,CL/CH																														
103-19	0	2.0	647.1	647.1	645.1	P-1	Alluvium	CH		3.25	CH	21.5									90.8		77	25	52	-0.07	1										4,300	
103-19	2	3.5	647.1	645.1	643.6	SS-2	Alluvium	CH	10			14.2																										
103-19	4	6.0	647.1	643.1	641.1	P-3	LPR	CL-ML		4.5		15.9																										
103-19	6	7.5	647.1	641.1	639.6	SS-4	LPR	CL-ML	24		CL	6.3									58.5		32	13	19	-0.35	1										2,000	
103-19	8	10.0	647.1	639.1	637.1	P-5	MPR	CL/CH		4.5		14																										
103-19	0	5.0	647.1	647.1	642.1	B-1	Alluvium	CH																														
103-19	5	10.0	647.1	642.1	637.1	B-2	LPR/MPR	CL-ML,CL/CH																														
104-19	0	2.0	651.3	651.3	649.3	P-1	Alluvium	CH		3.25	CH	29.7									94.7		62	17	45	0.28						6.7					5,900	
104-19	2	3.5	651.3	649.3	647.8	SS-2	Alluvium	CH	31			14.9																										
104-19	4	6.0	651.3	647.3	645.3	P-3	LPR	CL-ML		4.5	CH	14.9									95.7		51	19	32	-0.13											7,900	
104-19	6	7.5	651.3	645.3	643.8	SS-4	LPR	CL-ML	16			14.9																										
104-19	8	8.3	651.3	643.3	643.0	P-5a	LPR	CL/CH		4.25	CH	16.5									92.5		51	18	33	-0.05											10,600	
104-19	8.25	10.0	651.3	643.0	641.3	P-5b	MPR	"																														
104-19	0	6.0	651.3	651.3	645.3	B-1	Alluvium	CH																														
104-19	6	7.5	651.3	645.3	643.8	B-2	LPR	CL-ML																														
104-19	7.5	10.0	651.3	643.8	641.3	B-3	MPR	CL/CH																														
105-19	0	2.0	649.6	649.6	647.6	P-1	Alluvium	CH		3	CH	16.5									92.1		59	23	36	-0.18						3.2					800	
105-19	2	3.5	649.6	647.6	646.1	SS-2	Alluvium	CH	16			9.5																				2.6						
105-19	4	6.0	649.6	645.6	643.6	P-3	LPR	CL-ML		4.5		16.8																										
105-19	6	7.5	649.6	643.6	642.1	SS-4	LPR	CL-ML	12		CH	12									91.2		52	19	33	-0.21											8,900	
105-19	8	10.0	649.6	641.6	639.6	P-5	MPR	CL/CH		4.25		21.9																										
105-19	0	5.0	649.6	649.6	644.6	B-1	Alluvium	CH																														
105-19	5	10.0	649.6	644.6	639.6	B-2	LPR/MPR	CL-ML,CL/CH																														
106-19	0	2.0	647.8	647.8	645.8	P-1	Alluvium	CH		4.5	CL	11.4							2	20.3	77.7	36.6	40	19	21	-0.36	1										1,400	
106-19	2	2.4	647.8	645.8	645.4	SS-2a	LPR	CL-ML	41			5.4																										
106-19	2.4	3.5	647.8	645.4	644.3	SS-2b	LPR	CL-ML																														
106-19	4	4.3	647.8	643.8	643.5	P-3a	LPR	CL-ML			CH	21							3.4	21.1	75.5	42.6	69	23	46	-0.04	1					5.2					700	
106-19	4.33	6.0	647.8	643.5	641.8	P-3b	LPR	CL-ML																														
106-19	6	7.5	647.8	641.8	640.3	SS-4	LPR	CL-ML	29			2.9									18.7																	
106-19	8	10.0	647.8	639.8	637.8	P-5	MPR	CL/CH		4.25		24.7																										
106-19	0	2.5	647.8	647.8	645.3	B-1	Alluvium	CH																														
106-19	2.5	10.0	647.8	645.3	637.8	B-2	LPR/MPR	CL-ML,CL/CH																														

Sample Information									Field Tests		Laboratory Index								Sieve/Hydrometer				Atterberg Limits				Dispersion			Proctor		Analytical						
Boring Number	Top Depth	Bottom Depth	GS Elev.	Top Elev.	Bottom Elev.	Sample ID	Stratum	Field USCS	Field SPT N-value	Pocket Pen.	Lab USCS	Wc	γ_d	γ_t	Est. e_0	Est. Deg. of Sat	Assumed Gs	G_s	Gravel	Sand	Pass #200	Pass 2μm	LL	PL	PI	LI	Crumb	Double Hydro	Pinhole	MDD	OMC	Organic Content	pH (H_2O)	pH ($CaCL_2$)	Resist.	Chlorides	Sulfates	Other Tests Performed
	feet	feet	NAVD88	NAVD88	NAVD88				(bpf)	(tsf)		(%)	(pcf)	(pcf)		(%)			(%)	(%)	(%)	(%)					(Gr)	(%)	(-)	(pcf)	(%)	(%)	(-)	(-)	(ohm-cm)	(mg/kg)	(mg/kg)	
1301-19	0	2	648.5	648.5	646.5	G-1	Embank. Shell	CH		1.75	CH	23.1									90.8		63	23	44	0.00	1											
1301-19	2	4	648.5	646.5	644.5	G-2	Embank. Shell	CH/CL		4.50		13.1									96.4						1											
1301-19	4	6	648.5	644.5	642.5	G-3	Embank. Shell	CH/CL		3.00	CH	14.9							0.2	2.9	96.9	66.2	51	17	34	-0.06		0										
1301-19	6	8	648.5	642.5	640.5	G-4	Embank. Shell	CH		1.75		20.6							0.5	6.8	93.0																	
1301-19	8	10	648.5	640.5	638.5	G-5	Embank. Shell	CH		1.75	CH	20.2									91.1		63	18	45	0.05	1											
1302-19	0	2	657.8	657.8	655.8	G-1	Embank. Shell	CH		1.75	CH	18.9							0	6.2	93.8	49.3	51	19	32	0.00	2	0										
1302-19	2	4	657.8	655.8	653.8	G-2	Embank. Shell	CH/CL		3.00	CH	18.1							0	7.9	92.1		55	17	38	0.03												
1302-19	4	6	657.8	653.8	651.8	G-3	Embank. Shell	CH		4.50	CH										90.3		56	22	34	-0.65	1											
1302-19	6	6.5	657.8	651.8	651.3	G-4	Embank. Shell	CH		3.50											98.0																	
1701-20	0	1.5	657.9	657.9	656.4	G-1	Embank. Shell	CH			CL	9.3											34	15	19	-0.30	1										1,100	
1701-20	1.5	2.5	657.9	656.4	655.4	G-2	Embank. Shell	CL				19.8																										
1701-20	3.5	4.5	657.9	654.4	653.4	G-3	Embank. Shell	CH				16.2																										
1701-20	6	8	657.9	651.9	649.9	G-4	Embank. Shell	CL/CH			CH	19.9											63	21	42	-0.03	1										8,000	
1701-20	8	9	657.9	649.9	648.9	G-5	Embank. Shell	CH				21.1																										
1701-20	9	10	657.9	648.9	647.9	G-6	Embank. Shell	CH				23.2																										
1702-20	0	2	657.7	657.7	655.7	G-1	Embank. Shell	CH			CH	15.3											57	22	35	-0.19	1										500	
1702-20	2	4	657.7	655.7	653.7	G-2	Embank. Shell	CL				17.3																										
1703-20	0	2	653.7	653.7	651.7	G-1	Embank. Shell	CH				18.3																										
1703-20	2	4	653.7	651.7	649.7	G-2	Embank. Shell	CL/CH			CH	19.1											56	20	36	-0.03	1										900	
1703-20	4	6	653.7	649.7	647.7	G-3	Embank. Shell	CL/CH				19																										
1704-20	0	2.5	653.6	653.6	651.1	G-1	Embank. Shell	CH			CH	17.9							0.4	10.5	89.1	59.1	51	18	33	0.00	1										700	
1704-20	2.5	3	653.6	651.1	650.6	G-2	Embank. Shell	CL/CH				18.8																										
1704-20	3	4	653.6	650.6	649.6	G-3	Embank. Shell	CH				19.1																										
1704-20	4	5	653.6	649.6	648.6	G-4	Embank. Shell	CH			CH	20.7											67	24	43	-0.08	1										8,200	
1704-20	5	6	653.6	648.6	647.6	G-5	Embank. Shell	CL/CH				19.8																										
1704-20	6	7	653.6	647.6	646.6	G-6	Embank. Shell	CL/CH				23.8																										
1704-20	7	8	653.6	646.6	645.6	G-7	Embank. Shell	CL/CH																														
1704-20	8	9	653.6	645.6	644.6	G-8	Alluvium	CL/CH				24.3																										
1704-20	9	10	653.6	644.6	643.6	G-9	Alluvium	CH			CH	18							0	11.5	88.5	56.4	52	17	35	0.03	1										2,300	
1705-20	0	1	654.1	654.1	653.1	G-1a	Embank. Shell	CH				13.9																										
1705-20	2	4	654.1	652.1	650.1	G-1b	Embank. Shell	CH				23.2																										
1705-20	4	5	654.1	650.1	649.1	G-2a	Embank. Shell	CH				22																										
1705-20	5	6	654.1	649.1	648.1	G-2b	Embank. Shell	CL/CH				20.4																										
1705-20	6	8	654.1	648.1	646.1	G-3	Embank. Shell	CL/CH				21.3																										
1705-20	8	10	654.1	646.1	644.1	G-4	Embank. Shell	CL/CH				23.8																										
304-19	0	1.0	646.4	646.4	645.4	P-1A	Embank. Shell	CH,CL/CH		1.50		23.8	93.9	116.2	0.79	80.9	2.7				93.9																	
304-19	1	2.0	646.4	645.4	644.4	P-1B	Embank. Shell	"				18.4																										
304-19	2.5	3.5	646.4	643.9	642.9	SS-2c	Embank. Shell	CL/CH,CH	10			13.7																										
304-19	3.5	4.0	646.4	642.9	642.4	SS-2d	Embank. Shell	"				14.9																										
304-19	4	6.0	646.4	642.4	640.4	P-3	Embank. Shell	CH,CL/CH		3.50		22.1	96.7	118.1	0.74	80.4	2.7		0.2	6.2	93.6	60.7																
304-19	6	8.0	646.4	640.4	638.4	ST-4	Embank. Shell	CL/CH		4.50	CH	16.8	105.2	122.9	0.60	75.3	2.7				91		76	21	55	-0.08												CDDS
304-19	8.5	10.0	646.4	637.9	636.4	SS-5	Embank. Shell	CL/CH	8			20.0																										
304-19	13	15.0	646.4	633.4	631.4	P-6	Embank. Shell	CL/CH		1.50		27.4	94.7	120.6	0.78	95.0	2.7		0.4	4.7	94.9	59.5																
304-19	18	20.0	646.4	628.4	626.4	ST-7	Alluvium	CH,CL/CH		3.00	CH	22.3	99.5	121.6	0.69	86.6	2.7				97.5		80	21	59	0.02												CDDS
304-19	23.5	25.0	646.4	622.9	621.4	SS-8	MPR	CL/CH	13			20.0																										
304-19	28	30.0	646.4	618.4	616.4	ST-9	LPR	CL-ML		4.50	CH	17.8	111.3	131.1	0.51	93.5	2.7				96.1		60	21	39	-0.08												UU, HC
304-19	33.5	35.0	646.4	612.9	611.4	SS-10	LPR	CL-ML	44			15.0																										
305-19	0	2.0	635.1	635.1	633.1	P-1	D.S. Fill	CH		4.50	CH	17.2	107.5	126.0	0.57	81.9	2.7		1.1	6.4	92.5	56.8	71	23	48	-0.12	1											
305-19	2.5	4.0	635.1	632.6	631.1	SS-2	D.S. Fill	CL/CH	34			5.1																										
305-19	4	6.0	635.1	631.1	629.1	ST-3	D.S. Fill	CL/CH		4.50	CL	15.9	114.2	132.4	0.48	90.3	2.7				89.4		48	21	27	-0.19												UU
305-19	6	8.0	635.1	629.1	627.1	P-4	Alluvium	CH		3.75		18.3																										
305-19	8.5	10.0	635.1	626.6	625.1	SS-5	Alluvium	CH	12			17.9							0.3	7.9	91.8	54.6					1											
305-19	13	15.0	635.1	622.1	620.1	P-6	MPR	CH,CL/CH		3.75		24.4																										
305-19	18	20.0	635.1	617.1	615.1	ST-7	MPR	CL/CH		4.50	CH	17.4	107.8	126.5	0.56	83.3	2.7				95.5		60	25	35	-0.22												CIU'
305-19	23.5	25.0	635.1	611.6	610.1	SS-8	Shale	CL/CH	50/3.5"			11.5																										
401-20	0	2.0	648.0	648.0	646.0	P-1	Alluvium	CH		3.50	CH	22.4	101.0	123.6	0.67	90.5	2.7		19.5	4.3	76.2		58	21	37	0.04	1										500	
401-20	2	4.0	648.0	646.0	644.0	P-2	Alluvium	CH		4.50		18.8							4.4	6.7	88.9																	
401-20	4	6.0	648.0	644.0	642.0	P-3	MPR	CL/CH		4.50		16.9									89.9																	
401-20	6	8.0	648.0	642.0	640.0	P-4	MPR	CL/CH		4.50	CH	16.8	115.5	134.9	0.46	98.9	2.7				92.1		73	23	50	-0.12											6,700	
401-20	8	10.0	648.0	640.0	638.0	P-5	MPR	CL/CH		4.50		20.4																										
401-20	13	15.0	648.0	635.0	633.0	P-6	MPR	CL/CH		4.50	CH	23.8									98.3		75	24	51	0.00											600	
401-20	18	20.0	648.0	630.0	628.0	P-7	MPR	CL/CH		4.50		23.8																										
401-20	0	5.0	648.0	648.0	643.0	B-1	Alluvium	CH																														
401-20	0	5.0	648.0	648.0	643.0	B-2	Alluvium	CH																														
401-20	5	10.0	648.0	643.0	638.0	B-3	MPR	CL/CH																														
401-20	5	10.0	648.0	643.0	638.0	B-4	MPR	CL/CH																														
401-20	10	15.0	648.0	638.0	633.0	B-5	MPR	CL/CH																														
401-20	10	15.0	648.0	638.0	633.0	B-6	MPR	CL/CH																														
401-20	15	20.0	648.0	633.0	628.0	B-7	MPR	CL/CH																														
401-20	15	20.0	648.0	633.0	628.0	B-8	MPR	CL/CH																														
402-20	0	2.0	646.6	646.6	644.6	P-1	Alluvium	CH		4.00		23.1									92.9		72	19	53	0.08	1					3.9						
402-20	2	4.0	646.6	644.6	642.6	P-2	Alluvium	CH		3.50	CH	20.3									93.4		82	20	62	0.00											600	

Sample Information									Field Tests		Laboratory Index								Sieve/Hydrometer				Atterberg Limits				Dispersion			Proctor		Analytical						
Boring Number	Top Depth	Bottom Depth	GS Elev.	Top Elev.	Bottom Elev.	Sample ID	Stratum	Field USCS	Field SPT N-value	Pocket Pen.	Lab USCS	Wc	γd	γt	Est. e0	Est. Deg. of Sat	Assumed Gs	G_s	Gravel	Sand	Pass #200	Pass 2µm	LL	PL	PI	LI	Crumb	Double Hydro	Pinhole	MDD	OMC	Organic Content	pH ($H_2$0)	pH ($CaCL_2$)	Resist.	Chlorides	Sulfates	Other Tests Performed
	feet	feet	NAVD88	NAVD88	NAVD88				(bpf)	(tsf)		(%)	(pcf)	(pcf)		(%)			(%)	(%)	(%)	(%)					(Gr)	(%)	(-)	(pcf)	(%)	(%)	(-)	(-)	(ohm-cm)	(mg/kg)	(mg/kg)	
402-20	4	5.0	646.6	642.6	641.6	P-3A	Alluvium	CH		4.50		15.7																										
402-20	5	6.0	646.6	641.6	640.6	P-3B	MPR	CL/CH		4.50		15.5																										
402-20	6	8.0	646.6	640.6	638.6	P-4	MPR	CL/CH		4.50	CH	17.2									95		67	19	48	-0.04											17,700	
402-20	8	10.0	646.6	638.6	636.6	P-5	MPR	CL/CH		4.50	CH	22.6									68.8		73	21	52	0.03											900	
402-20	13	15.0	646.6	633.6	631.6	P-6	MPR	CL/CH		4.50		24.2																										
402-20	18	20.0	646.6	628.6	626.6	P-7	MPR	CL/CH		4.50		25.3																										
402-20	0	5.0	646.6	646.6	641.6	B-1	Alluvium	CH																														
402-20	0	5.0	646.6	646.6	641.6	B-2	Alluvium	CH																														
402-20	5	10.0	646.6	641.6	636.6	B-3	MPR	CL/CH																														
402-20	5	10.0	646.6	641.6	636.6	B-4	MPR	CL/CH																														
402-20	10	15.0	646.6	636.6	631.6	B-5	MPR	CL/CH																														
402-20	10	15.0	646.6	636.6	631.6	B-6	MPR	CL/CH																														
402-20	15	20.0	646.6	631.6	626.6	B-7	MPR	CL/CH																														
402-20	15	20.0	646.6	631.6	626.6	B-8	MPR	CL/CH																														
601-19	0	2.0	649.7	649.7	647.7	P-1	Alluvium	CH		3.25	CH	17.6	96	112.9	0.76	62.9	2.7		0.9	5.7	93.4	64.3	79	33	46	-0.33	1					4.7	8.08				500	SP
601-19	2	3.5	649.7	647.7	646.2	SS-2	Alluvium	CH	18			14.7																										
601-19	3.5	5.5	649.7	646.2	644.2	ST-3	LPR	CL-ML		4.50	CH	20.7	102.4	123.6	0.65	86.6	2.7				96.2		64	29	35	-0.24												UC, Consol.
601-19	6	8.0	649.7	643.7	641.7	P-4	LPR	CH,CL-ML		4.50	CL	10.6	116.6	129.0	0.44	64.3	2.7		0	19.8	80.2	38.1	31	16	15	-0.36	1					1.4	8.29				700	SP
601-19	8	9.5	649.7	641.7	640.2	SS-5	LPR	CL-ML	16																							1.1						
601-19	13	15.0	649.7	636.7	634.7	ST-6	LPR	CL-ML		4.50	CH	15.3	114.6	132.1	0.47	87.9	2.7				97.1		67	23	44	-0.18												UC, Consol.
601-19	18	20.0	649.7	631.7	629.7	P-7	LPR	CL-ML		4.50	CH	17.6	106	124.7	0.59	80.6	2.7		0	1.5	98.5	66.2	77	23	54	-0.10	1						7.92				800	SP
601-19	23.5	25.0	649.7	626.2	624.7	SS-8	LPR	CL-ML	21			20.4																										
602-19	0	2.0	642.7	642.7	640.7	P-1	Alluvium	CH		4.50		15.8																										
602-19	2	3.5	642.7	640.7	639.2	SS-2	Alluvium	CL-ML	17			12.6																										
602-19	4	6.0	642.7	638.7	636.7	P-3	Alluvium	CH		4.50		18.9																										
602-19	6	8.0	642.7	636.7	634.7	ST-4	LPR	CL-ML		4.50		17.3																										
602-19	8	9.5	642.7	634.7	633.2	SS-5	LPR	CL-ML	22			17.5																										
602-19	13	15.0	642.7	629.7	627.7	ST-6	LPR	CL-ML		4.50		20.6																										
602-19	18	20.0	642.7	624.7	622.7	P-7	LPR	CL				19.4																										
602-19	23.5	25.0	642.7	619.2	617.7	SS-8	MPR	CL/CH	30			17.6																										
603-19	0	2.0	634.9	634.9	632.9	P-1	Alluvium	CH		4.50	CH	19	111.3	132.4	0.51	99.9	2.7		0	11.7	88.3	53.1	67	19	48	0.00	1										500	
603-19	2	3.5	634.9	632.9	631.4	SS-2	Alluvium	CH	26			12.9																										
603-19	4	6.0	634.9	630.9	628.9	P-3	LPR	CL-ML		4.50	CH	21.7	99	120.5	0.70	83.5	2.7				87.9		62	21	41	0.02	1										600	
603-19	6	7.5	634.9	628.9	627.4	SS-4	MPR	CL/CH	27			14.2																										
603-19	8	10.0	634.9	626.9	624.9	ST-5	MPR	CL/CH		4.50	CH	20.1	107.7	129.3	0.56	96.2	2.7				95		62	22	40	-0.05												UU, Consol.
603-19	13	15.0	634.9	621.9	619.9	P-6	MPR	CL/CH		4.50	CL	20.3	99.1	119.2	0.70	78.3	2.7		0	4.2	95.8	68.1	29	15	14	0.38	1										10,900	SP
603-19	18.5	20.0	634.9	616.4	614.9	SS-7	MPR	CL/CH	26			17.8																										
603-19	23.5	25.0	634.9	611.4	609.9	SS-8	Shale	Shale	100		CH	4.2							0.5	30.2	69.3		96	27	69	-0.33												
604-19	0	2	638.0	638.0	636.0	P-1	Alluvium	CH		4.50		19.1																										
604-19	2	3.5	638.0	636.0	634.5	SS-2	Alluvium	CH	17			8.4																										
604-19	4	6	638.0	634.0	632.0	ST-3	Alluvium	CH				11																										
604-19	6	8	638.0	632.0	630.0	P-4	Alluvium	CH				10.7																										
604-19	8.5	10	638.0	629.5	628.0	SS-5	MPR	CH/CL	18			12.5																										
604-19	13.5	15	638.0	624.5	623.0	P-6	MPR	CH/CL		4.50		19																										
604-19	18	20	638.0	620.0	618.0	P-7	MPR	CH/CL		4.50		20																										
604-19	23.5	25	638.0	614.5	613.0	SS-8	Shale	CH/CL	100			7.4																										
605-19	0	2.0	658.3	658.3	656.3	P-1	Alluvium	CH		3.50		18.3																										
605-19	2	3.5	658.3	656.3	654.8	SS-2	Alluvium	CH	18			11.7																										
605-19	4	6.0	658.3	654.3	652.3	ST-3	LPR	CL		4.50		14.1																										
605-19	6	8.0	658.3	652.3	650.3	P-4	LPR	CL		4.50		16.5																										
605-19	8	9.5	658.3	650.3	648.8	SS-5	LPR	CL	22			14.8																										
605-19	13	15.0	658.3	645.3	643.3	ST-6	LPR	CL		4.50		18.7																										
605-19	18	20.0	658.3	640.3	638.3	P-7	LPR	CL		4.50		17.3																										
605-19	23.5	25.0	658.3	634.8	633.3	SS-8	LPR	CL	28			18.4																										
701-20	0	2.0	648.7	648.7	646.7	P-1	Alluvium	CH		4.00		22.1																										
701-20	2	4.0	648.7	646.7	644.7	ST-2	LPR	ML/CL		4.50	CH	18.3	110.5	130.7	0.52	94.2	2.7						51	20	31	-0.05												UC
701-20	4	5.5	648.7	644.7	643.2	SS-3	LPR	ML/CL	15			10.3																										
701-20	6	8.0	648.7	642.7	640.7	ST-4	LPR	ML/CL		4.50	CH	11.2	124.8	138.8	0.35	86.4	2.7						57	19	38	-0.21												HC
701-20	8	10.0	648.7	640.7	638.7	P-5	LPR	ML/CL		4.50		11.6																										
701-20	13	15.0	648.7	635.7	633.7	ST-6	MPR	CH		4.00		25.4																										
701-20	18	19.5	648.7	630.7	629.2	SS-7	MPR	CH	20			24.1																										
701-20	23	25.0	648.7	625.7	623.7	ST-8	Shale	CH		4.50	CH	20.7	104.7	126.4	0.61	91.7	2.7						66	22	44	-0.03												UC
701-20	28	29.5	648.7	620.7	619.2	SS-9	Shale	CH	63			18.4																										
702-20	0	2.0	647.8	647.8	645.8	P-1	Alluvium	CH		3.50		22.5																										
702-20	2	4.0	647.8	645.8	643.8	ST-2	Alluvium	CH		3.50	CH	15.7	113.5	131.3	0.48	87.5	2.7						66	22	44	-0.14	1											UC
702-20	4	6.0	647.8	643.8	641.8	P-3	Alluvium	CL		4.00		18.8																										
702-20	6	8.0	647.8	641.8	639.8	ST-4	LPR	CL				12.2																										
702-20	8	9.5	647.8	639.8	638.3	SS-5	LPR	CL	20			16.6																										
702-20	13	15.0	647.8	634.8	632.8	ST-6	MPR	CH		4.00	CH	23.3	103.6	127.7	0.63	100.5	2.7		0	1.7	98.3	47.4	73	33	40	-0.24	1											UU, SP
702-20	18	20.0	647.8	629.8	627.8	P-7	MPR	CH		4.00		22.9																										
702-20	23	25.0	647.8	624.8	622.8	ST-8	MPR	CL		4.00	CH	19.9	103.9	124.6	0.62	86.4	2.7						66	22	44	-0.05												SP
702-20	28	29.5	647.8	619.8	618.3	SS-9	Shale	CH	36			18.7																										
703-20	0	2.0	646.3	646.3	644.3	P-1	Alluvium	CH		4.50		16.9																										

Sample Information									Field Tests		Laboratory Index								Sieve/Hydrometer				Atterberg Limits				Dispersion			Proctor		Analytical						
Boring Number	Top Depth	Bottom Depth	GS Elev.	Top Elev.	Bottom Elev.	Sample ID	Stratum	Field USCS	Field SPT N-value	Pocket Pen.	Lab USCS	Wc	γd	γt	Est. e0	Est. Deg. of Sat	Assumed Gs	G_s	Gravel	Sand	Pass #200	Pass 2µm	LL	PL	PI	LI	Crumb	Double Hydro	Pinhole	MDD	OMC	Organic Content	pH (H_20)	pH ($CaCL_2$)	Resist.	Chlorides	Sulfates	Other Tests Performed
	feet	feet	NAVD88	NAVD88	NAVD88				(bpf)	(tsf)		(%)	(pcf)	(pcf)		(%)			(%)	(%)	(%)	(%)					(Gr)	(%)	(-)	(pcf)	(%)	(%)	(-)	(-)	(ohm-cm)	(mg/kg)	(mg/kg)	
703-20	2	3.5	646.3	644.3	642.8	SS-2	Alluvium	CH	21			16.1																										
703-20	3.5	5.5	646.3	642.8	640.8	ST-3	LPR	ML/CL		4.50	CL	15.6	113.8	131.6	0.48	87.7	2.7						44	18	26	-0.09												UC
703-20	6	8.0	646.3	640.3	638.3	P-4	LPR	ML/CL		4.50		11.8																										
703-20	8	10.0	646.3	638.3	636.3	ST-5	MPR	CL/CH		3.50		14.3																										
703-20	13.5	15.0	646.3	632.8	631.3	SS-6	MPR	CH	14			22.6																										
703-20	18	20.0	646.3	628.3	626.3	ST-7	MPR	CH		4.50	CH	23.9	101.4	125.6	0.66	97.5	2.7						61	22	39	0.05												UU, SP
703-20	23	25.0	646.3	623.3	621.3	P-8	Shale	CL/CH		4.50		21.3																										
703-20	27.5	29.5	646.3	618.8	616.8	ST-9	Shale	CL/CH		4.50	CH	18.5	107.6	127.5	0.57	88.3	2.7						65	23	42	-0.11												UC
201-19	0.0	2.0	656.5	656.5	654.5	P-1	Alluvium	CH,CL/CH				26.4																										
201-19	2.0	4.0	656.5	654.5	652.5	ST-2	LPR	CL-ML		4.50	CL	11.8	122.5	136.9	0.38	84.9	2.7		0.5	19.6	79.9	37	41	15	26	-0.12	1	14										UC
201-19	4.5	6.0	656.5	652.0	650.5	SS-3	LPR	SM	13		CL	12									93		23	14	9	-0.22												
201-19	6.0	8.0	656.5	650.5	648.5	P-4	MPR	CL/CH		4.50		19.7																										
201-19	8.0	9.5	656.5	648.5	647.0	SS-5	MPR	CL/CH	13			23.5																										
201-19	13.0	15.0	656.5	643.5	641.5	ST-6	MPR	CL/CH		4.50	CH	17.8	108.7	128.1	0.55	87.4	2.7		0	2	98	47.8	60	29	31	-0.36	1	-										UC
201-19	18.0	20.0	656.5	638.5	636.5	P-7	MPR	CL/CH				23.4																										
201-19	23.5	25.0	656.5	633.0	631.5	SS-8	MPR	CH	22			21.7																										
202-19	0.0	2.0	656.9	656.9	654.9	P-1	Alluvium	CH		4.00		21.5																										
202-19	2.0	4.0	656.9	654.9	652.9	ST-2	LPR	CL		4.50	CL	11.4	120.8	134.6	0.39	78.0	2.7		0	18.7	81.3	27.2	24	15	9	-0.40	2	48										UC
202-19	4.5	6.0	656.9	652.4	650.9	SS-3	LPR	ML	22			4.8																										
202-19	6.0	8.0	656.9	650.9	648.9	P-4	LPR	ML			CL	10.5											30	12	18	-0.08												
202-19	8.0	10.0	656.9	648.9	646.9	ST-5	LPR	ML		4.50	ML	16	118.1	137.0	0.43	101.3	2.7		3.4	29.6	67	37.2	48	28	20	-0.60	2	-										UC
202-19	13.5	15.0	656.9	643.4	641.9	SS-6	MPR	CH	13			20.4																										
202-19	18.0	20.0	656.9	638.9	636.9	P-7	MPR	CH		4.50	CH	23.2											51	21	30	0.07												
202-19	23.5	25.0	656.9	633.4	631.9	SS-8	MPR	CH,CL	18			21.9																										
203-19	0.0	2.0	656.9	656.9	654.9	P-1	Alluvium	CH		4.25		23.5																										
203-19	2.0	3.5	656.9	654.9	653.4	SS-2A	LPR	CL/CH	28			18.9																										
203-19	2.0	3.5	656.9	654.9	653.4	SS-2B	LPR	CL	"			8.5																										
203-19	3.5	5.5	656.9	653.4	651.4	ST-3	LPR	SM		4.50	CL	10.4							0	18.6	81.4	35.1	32	14	18	-0.20	1	-										
203-19	6.0	8.0	656.9	650.9	648.9	P-4A	LPR	SM		1.50		7.1																										
203-19	6.0	8.0	656.9	650.9	648.9	P-4B	LPR	SM			SM	8.7	113.4	123.3	0.49	48.4	2.7				34.8		18	11	7	-0.33												
203-19	8.0	9.5	656.9	648.9	647.4	SS-5	LPR	SM	20		SM	11									46.8		NP	NP	NP													
203-19	13.0	15.0	656.9	643.9	641.9	P-6A	LPR	SM		4.50		10.8									66.9																	
203-19	13.0	15.0	656.9	643.9	641.9	P-6B	MPR	SM		4.50		21.1																										
203-19	18.5	20.0	656.9	638.4	636.9	SS-7	MPR	SM	17			21.6									98.6																	
203-19	22.5	24.5	656.9	634.4	632.4	ST-8	MPR	CH		4.50	CH	23.6							0	1.5	98.5	53	58	26	32	-0.08	3	-										
204-19	0.0	2.0	651.3	651.3	649.3	P-1A	Alluvium	CH		4.50		23.3																										
204-19	0.0	2.0	651.3	651.3	649.3	P-1B	LPR	CL/CH		4.50		10.9																										
204-19	2.0	4.0	651.3	649.3	647.3	ST-2	LPR	CL/CH		4.50	CL	8.1	116.3	125.7	0.45	48.7	2.7		1.5	29.3	69.2	36.3	25	17	8	-1.11		-										UC
204-19	4.0	4.5	651.3	647.3	646.8	SS-3A	MPR	CL/CH	28			20.0																										
204-19	4.5	6.0	651.3	646.8	645.3	SS-3B	MPR	CL/CH	"			6.8																										
204-19	6.0	8.0	651.3	645.3	643.3	P-4A	MPR	CL/CH		3.50	CH	22.4											68	22	46	0.01												
204-19	6.0	8.0	651.3	645.3	643.3	P-4B	MPR	CL/CH				14.7																										
204-19	8.0	9.5	651.3	643.3	641.8	SS-5A	MPR	CL/CH	13			9.2																										
204-19	8.0	9.5	651.3	643.3	641.8	SS-5B	MPR	CL/CH	"			19.5																										
204-19	13.0	15.0	651.3	638.3	636.3	ST-6	MPR	CL/CH		4.50	CH	18.3	110.8	131.1	0.52	94.9	2.7		0	2.2	97.8	61	50	22	28	-0.13	1	-										UC
204-19	18.0	20.0	651.3	633.3	631.3	P-7	MPR	CL/CH		4.50		20.8																										
204-19	23.5	25.0	651.3	627.8	626.3	SS-8	MPR	CL/CH	27																													
205-19	0.0	2.0	644.4	644.4	642.4	P-1	Alluvium	CH		4.50	CH	23.1											53	21	32	0.07												
205-19	2.0	3.5	644.4	642.4	640.9	SS-2	MPR	CL/CH	21			11.7																										
205-19	3.5	5.5	644.4	640.9	638.9	P-3A	MPR	CL/CH		4.50		19.3																										
205-19	3.5	5.5	644.4	640.9	638.9	P-3B	MPR	CL/CH				16.9																										
205-19	6.0	7.5	644.4	638.4	636.9	SS-4	MPR	CL/CH	17			19.2																										
205-19	8.0	10.0	644.4	636.4	634.4	ST-5	MPR	CL/CH		4.50	CH	20.6	104.1	125.5	0.62	89.9	2.7		0	1.9	98.1	66.3	54	24	30	-0.11	1	-										UC
205-19	13.5	15.5	644.4	630.9	628.9	P-6	MPR	CL/CH		4.50		21.7																										
205-19	18.5	20.0	644.4	625.9	624.4	SS-7	MPR	CL/CH	15			22.7																										
205-19	23.0	25.0	644.4	621.4	619.4	ST-8	MPR	CL/CH		4.50		21.6																										
206-19	0.0	2.0	656.6	656.6	654.6	P-1	Alluvium	CH		3.50		19.4																										
206-19	2.0	3.5	656.6	654.6	653.1	SS-2A	LPR	CL/CH	33			14.2																										
206-19	2.0	3.5	656.6	654.6	653.1	SS-2B	LPR	ML	"		CH	4.3											68	23	45	-0.42												
206-19	2.0	3.5	656.6	654.6	653.1	SS-2C	LPR	CH	"			5.2																										
206-19	4.0	6.0	656.6	652.6	650.6	P-3A	LPR	CH				19.7																										
206-19	4.0	6.0	656.6	652.6	650.6	P-3B	LPR	SM			SM	8.9	127.9	139.3	0.32	75.7	2.7				17.7		NP	NP	NP													
206-19	6.0	7.5	656.6	650.6	649.1	SS-4	LPR	SM	35			5.8									23.5																	
206-19	8.0	10.0	656.6	648.6	646.6	ST-5	MPR	CL/CH		4.50	CH	24.9	101.1	126.3	0.67	100.9	2.7		0	2.1	97.9	73.2	67	24	43	0.02	1	-										UC
206-19	13.0	15.0	656.6	643.6	641.6	P-6	MPR	CL/CH		4.50		23.5																										
206-19	18.0	20.0	656.6	638.6	636.6	ST-7	MPR	CL/CH			CH	22.5	103.1	126.3	0.63	95.8	2.7		0	0.9	99.1	65.6	57	23	34	-0.01		-										UC
206-19	23.5	25.0	656.6	633.1	631.6	SS-8	MPR	CL/CH	18			23.5																										
207-19	0.0	2.0	658.8	658.8	656.8	P-1	Alluvium	CH		3.50		13.5																										
207-19	2.0	4.0	658.8	656.8	654.8	ST-2	Alluvium	CH		4.50	SC	12.6	116.5	131.1	0.45	76.2	2.7		14.9	38.9	46.2	35.3	33	17	16	-0.28	2	15										UC
207-19	4.5	6.0	658.8	654.3	652.8	SS-3A	LPR	CH	26			21.3																										
207-19	4.5	6.0	658.8	654.3	652.8	SS-3B	LPR	ML	"			6																										
207-19	6.0	8.0	658.8	652.8	650.8	P-4	LPR	ML		4.50	CL	8.5	123.1	133.6	0.37	62.3	2.7						35	15	20	-0.33												
207-19	8.0	9.5	658.8	650.8	649.3	SS-5	LPR	CL-ML	17		CL	12.2											37	14	23	-0.08												
207-19	13.0	15.0	658.8	645.8	643.8	P-6	MPR	CL/CH		4.50		21																										

Sample Information									Field Tests		Laboratory Index								Sieve/Hydrometer				Atterberg Limits				Dispersion			Proctor		Analytical						
Boring Number	Top Depth	Bottom Depth	GS Elev.	Top Elev.	Bottom Elev.	Sample ID	Stratum	Field USCS	Field SPT N-value	Pocket Pen.	Lab USCS	Wc	γd	γt	Est. e0	Est. Deg. of Sat	Assumed Gs	G_s	Gravel	Sand	Pass #200	Pass 2μm	LL	PL	PI	LI	Crumb	Double Hydro	Pinhole	MDD	OMC	Organic Content	pH (H_2O)	pH ($CaCl_2$)	Resist.	Chlorides	Sulfates	Other Tests Performed
	feet	feet	NAVD88	NAVD88	NAVD88				(bpf)	(tsf)		(%)	(pcf)	(pcf)		(%)			(%)	(%)	(%)	(%)					(Gr)	(%)	(-)	(pcf)	(%)	(%)	(-)	(-)	(ohm-cm)	(mg/kg)	(mg/kg)	
207-19	18.0	20.0	658.8	640.8	638.8	ST-7	MPR	CL/CH		4.50	CH	22.1	104.9	128.0	0.61	98.4	2.7		0	1.1	98.9	64.8	55	26	29	-0.13	1	-										UC
207-19	23.5	25.0	658.8	635.3	633.8	SS-8	MPR	CH	20			21.2																										
207-19	28.0	30.0	658.8	630.8	628.8	P-9	MPR	CH		4.50		21.4																										
207-19	33.0	35.0	658.8	625.8	623.8	ST-10	MPR	CL/CH		4.50		20.3																										
208-19	0.0	2.0	654.8	654.8	652.8	P-1A	Alluvium	CH		4.00		22																										
208-19	0.0	2.0	654.8	654.8	652.8	P-1B	LPR	CL/CH		4.50		13.9																										
208-19	2.0	4.0	654.8	652.8	650.8	ST-2	LPR	CL/CH		4.50	CL	10.2	113.6	125.3	0.48	57.0	2.7		0.2	19.1	80.7	37.9	29	13	16	-0.18	1	-										UC
208-19	4.5	6.0	654.8	650.3	648.8	SS-3A	LPR	CH	25			15.4																										
208-19	4.5	6.0	654.8	650.3	648.8	SS-3B	LPR	CL/CH	"			8.3																										
208-19	6.0	8.0	654.8	648.8	646.8	P-4	LPR	s. CL		4.50	CL	13.8	117.2	133.4	0.44	85.2	2.7				75.8		39	15	24	-0.05												
208-19	8.0	9.5	654.8	646.8	645.3	SS-5	LPR	CL	20		CL	13.5											25	10	15	0.23												
208-19	13.0	15.0	654.8	641.8	639.8	ST-6	MPR	CL/CH		4.50	CH	21.1	103	124.8	0.64	89.6	2.7		1.6	10.6	87.8	42.4	59	23	36	-0.05	1	-										UC
208-19	18.0	20.0	654.8	636.8	634.8	P-7	MPR	CL/CH		4.50		20																										
208-19	23.5	24.0	654.8	631.3	630.8	SS-8A	MPR	CL/CH	23			19.2																										
208-19	24.0	25.0	654.8	630.8	629.8	SS-8B	MPR	CL/CH	"			20.3																										
209-19	0.0	2.0	648.3	648.3	646.3	P-1A	Alluvium	CL/CH		3.50		25.3																										
209-19	0.0	2.0	648.3	648.3	646.3	P-1B	LPR	CL/CH				15.8																										
209-19	2.0	3.5	648.3	646.3	644.8	SS-2	LPR	CL/CH	18			6.6																										
209-19	4.0	6.0	648.3	644.3	642.3	P-3A	LPR	CH		4.50		21.2																										
209-19	4.0	6.0	648.3	644.3	642.3	P-3B	LPR	CL/CH				17.5																										
209-19	6.0	8.0	648.3	642.3	640.3	ST-4	MPR	CL/CH		4.50	CH	22	104.6	127.6	0.61	97.3	2.7		0	1.1	98.9	72.1	61	22	39	0.00	1	10										UC
209-19	8.0	9.5	648.3	640.3	638.8	SS-5	MPR	CL/CH	14			20.2																										
209-19	13.0	15.0	648.3	635.3	633.3	P-6	MPR	CL/CH		4.50		21.5																										
209-19	18.0	20.0	648.3	630.3	628.3	ST-7	MPR	CL/CH		4.50	CH	21.7	106.1	129.1	0.59	99.7	2.7		0	3.3	96.7	60	62	22	40	-0.01	1	-										UC
209-19	23.5	25.0	648.3	624.8	623.3	SS-8	MPR	CL/CH	23			22.7																										
210-19	0.0	2.0	635.7	635.7	633.7	P-1	Alluvium	CH		2.50	CH	20.3	107.6	129.4	0.57	96.9	2.7				71.8		53	21	32	-0.02												
210-19	2.0	3.5	635.7	633.7	632.2	SS-2	Alluvium	CH	15	4.50		28.2																										
210-19	4.0	6.0	635.7	631.7	629.7	P-3	Alluvium	CH		4.50		15.2																										
210-19	6.0	8.0	635.7	629.7	627.7	P-4	MPR	CL/CH		4.50		19.1																										
210-19	8.0	10.0	635.7	627.7	625.7	ST-5	MPR	CL/CH		4.50	CH	17.8	112.4	132.4	0.50	96.3	2.7		0	3.1	96.9	65.2	60	22	38	-0.11	1	-										UC
210-19	13.5	15.0	635.7	622.2	620.7	SS-6	MPR	CL/CH	15	4.50		20.6																										
210-19	18.0	20.0	635.7	617.7	615.7	ST-7	MPR	CL/CH		4.50	MH	22.4	103.8	127.0	0.62	97.1	2.7		0	1.9	98.1	57	52	29	23	-0.29	1	-										UC
210-19	23.5	25.0	635.7	612.2	610.7	SS-8	MPR	CL/CH	39	4.50		18.5																										
COMP-100A	0.0	2.5 to 6	varies	varies	varies	Natural	Alluvium	CH	-	-	CH	0% OMC	95% MDD					2.62	1.1	9.6	89.3	61.3	58	21	37		1			99.0	22.0	5.2	8.02		370	300	7,000	SP
COMP-100A	"	"	"	"	"	Natural	"	"				+4% OMC	95% MDD																									SP
COMP-100A	"	"	"	"	"	2%lime	"	"															44	33	11								11.69					
COMP-100A	"	"	"	"	"	3%lime	"	"																									12.00					
COMP-100A	"	"	"	"	"	4%lime	"	"															41	33	8								12.22					
COMP-100A	"	"	"	"	"	5%lime	"	"																									12.32					
COMP-100A	"	"	"	"	"	6%lime	"	"															42	34	8								12.31					
COMP-100A	"	"	"	"	"	7%lime	"	"																									12.33					
COMP-100A	"	"	"	"	"	8%lime	"	"															41	34	NP								12.45					
COMP-100B	5 to 6	7.5 to 10	varies	varies	varies	Natural	LPR	CL-ML	-	-	CL	0% OMC	95% MDD					2.77	3.8	21.0	75.2	43	43	17	26		1			115.1	14.4	3.8	8.27		660	300	2,000	HC, SP
COMP-100B	"	"	"	"	"	Natural	"	"				+2% OMC	95% MDD																									UU, SP
COMP-100B	"	"	"	"	"	Natural	"	"				+3% OMC	95% MDD																									CIU'
COMP-100B	"	"	"	"	"	Natural	"	"				+4% OMC	95% MDD																									UU, SP
COMP-400A	0.0	5.0	varies	varies	varies	Natural	Alluvium	CH	-	-	CH	0% OMC	95% MDD					2.60	4.5	9.7	85.8	61.5	59	26	33		1			93.9	22.3	5.0	8.04		1,210	180	2,700	SP
COMP-400A	"	"	"	"	"	Natural	"	"				+4% OMC	95% MDD																									SP
COMP-400A	"	"	"	"	"	2%lime	"	"															46	38	8								11.95					
COMP-400A	"	"	"	"	"	3%lime	"	"																									12.06					
COMP-400A	"	"	"	"	"	4%lime	"	"															46	39	7								12.17					
COMP-400A	"	"	"	"	"	5%lime	"	"																									12.29					
COMP-400A	"	"	"	"	"	6%lime	"	"															45	38	7								12.32					
COMP-400A	"	"	"	"	"	7%lime	"	"																									12.37					
COMP-400A	"	"	"	"	"	8%lime	"	"															47	NP	NP								12.44					
COMP-1700A	0	4 to 8	varies	varies	varies	Natural	Embank. Shell	CL,CH	-	-	CH	0% OMC	95% MDD					2.60	0.8	5.1	94.1	42.9	64	21	43		1	0		95.1	24.4		7.80		500	300	4,200	UC, SP
COMP-1700A	"	"	"	"	"	Natural	"	"				+4% OMC	95% MDD																									UC
COMP-1700A	"	"	"	"	"	2%lime	"	"															46	32	14								11.99					
COMP-1700A	"	"	"	"	"	3%lime	"	"																									12.25					
COMP-1700A	"	"	"	"	"	4%lime	"	"															44	33	11								12.41					
COMP-1700A	"	"	"	"	"	5%lime	"	"																									12.50					
COMP-1700A	"	"	"	"	"	6%lime	"	"															47	35	12								12.59					
COMP-1700A	"	"	"	"	"	7%lime	"	"																									12.60					
COMP-1700A	"	"	"	"	"	8%lime	"	"															46	35	11								12.62					

Notes:

1. Abbreviations:

LPR - Low Plasticity Residuum
MPR - Medium Plasticity Residuum
Wc - Natural Moisture Content
γd - Natural Dry Density
γt - Natural Total (Moist) Density
LL - Liquid Limit

SP - Swell Pressure
Consol. - Incremental Consolidation
HC - Hydraulic Conductivity
UC - Unconfined Compression
UU - Unconsolidated-Undrained Triaxial Shear
CIU' - Isotropically Consolidated-Undrained Triaxial Shear with Pore Pressure Measurements

Sample Information									Field Tests		Laboratory Index								Sieve/Hydrometer				Atterberg Limits				Dispersion			Proctor		Analytical						
Boring Number	Top Depth	Bottom Depth	GS Elev.	Top Elev.	Bottom Elev.	Sample ID	Stratum	Field USCS	Field SPT N-value	Pocket Pen.	Lab USCS	Wc	γd	γt	Est. e0	Est. Deg. of Sat	Assumed Gs	G_s	Gravel	Sand	Pass #200	Pass 2µm	LL	PL	PI	LI	Crumb	Double Hydro	Pinhole	MDD	OMC	Organic Content	pH (H_20)	pH ($CaCL_2$)	Resist.	Chlorides	Sulfates	Other Tests Performed
	feet	feet	NAVD88	NAVD88	NAVD88				(bpf)	(tsf)		(%)	(pcf)	(pcf)		(%)			(%)	(%)	(%)	(%)					(Gr)	(%)	(-)	(pcf)	(%)	(%)	(-)	(-)	(ohm-cm)	(mg/kg)	(mg/kg)	

PL - Plastic Limit

PI - Plasticity Index

LI - Liquidity Index

MDD - Maximum Dry Density

OMC - Optimum Moisture Content

CDDS - Consolidated Drained Direct Shear

8-19

Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53564

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)
-	Test Method	ASTM D2216
1	8-19 (0.0-2.0) P-1	17.5
2	8-19 (2.5-4.0) SS-2	13.6
3	8-19 (4.0-6.0) P-3 Layer A	17.6
5	8-19 (6.5-8.0) SS-4 Layer C	11.5
7	8-19 (8.0-10.0) P-5 Layer E	17.4
9	8-19 (13.0-15.0) ST-6	9.8
10	8-19 (18.5-20.0) SS-7	18.7
11	8-19 (23.5-25.0) SS-8	22.1
12	8-19 (28.5-30.0) SS-9	22.2

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

9-19

Client: AECOM TRI Log #: 53565

Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
2	9-19 (2.0-3.5) SS-2	9.7	-	89.8	40	20	20
4	9-19 (6.0-7.5) SS-4	14.2	-	-	-	-	-
5	9-19 (8.0-10.0) ST-5	19.6	-	97.5	74	24	50

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53765

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	9-19 (18.5-20.0) SS-7	12.9	-	-	-	-	-
2	9-19 (23.0-25.0) ST-8	13.7	-	86.4	50	21	29
4	9-19 (33.5-35.0) SS-10	21.0	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TRI ENVIRONMENTAL
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Client: AECOM TRI Log #: 53565

Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021

Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO_4/kg)	pH	
			(H_2O)	($CaCl_2$)
-	Test Method	ASTM D516	ASTM D4972 (method A)	
-	Method Detection Limit (MDL)	[5 mg/l]*	-	-
1	9-19 (0.0-2.0) P-1	300	8.03	7.92
3	9-19 (4.0-6.0) P-3	400	7.68	7.70
6	9-19 (13.0-15.0) P-6	1,300	7.92	7.69

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The and sulfat MDL is volumetric. Results are mass per mass of dry soil.

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Client: AECOM
TRI Log #: 53765
Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO_4/kg)	pH	
			(H_2O)	($CaCl_2$)
-	Test Method	ASTM D516	ASTM D4972 (method A)	
-	Method Detection Limit (MDL)	[5 mg/l]*	-	-
3	9-19 (28.0-30.0) P-9	600	7.90	7.70

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The sulfate MDL is volumetric. Results are mass per mass of dry soil.

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53565
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
1	9-19 (0.0-2.0) P-1	17.9	N/A	20.6	20.8	20.8	1	1	1	1
3	9-19 (4.0-6.0) P-3	32.6	N/A	20.6	20.8	20.8	1	1	1	1
6	9-19 (13.0-15.0) P-6	26.7	N/A	20.6	20.8	20.8	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53765
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
3	9-19 (28.0-30.0) P-9	21.9	N/A	20.6	20.8	20.8	1	1	1	1

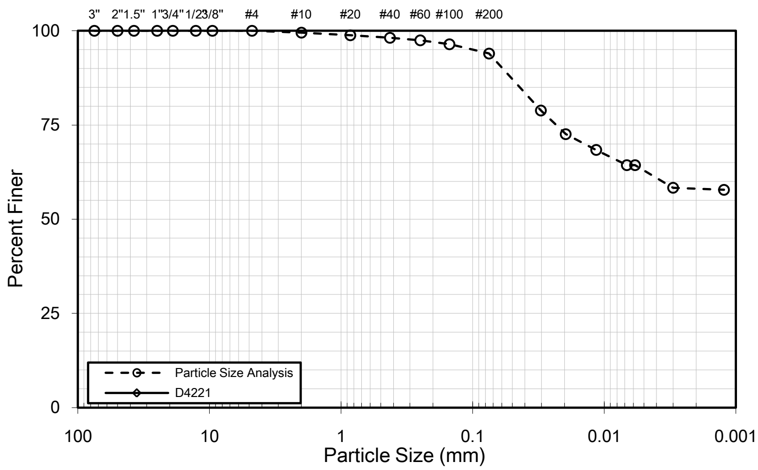
Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

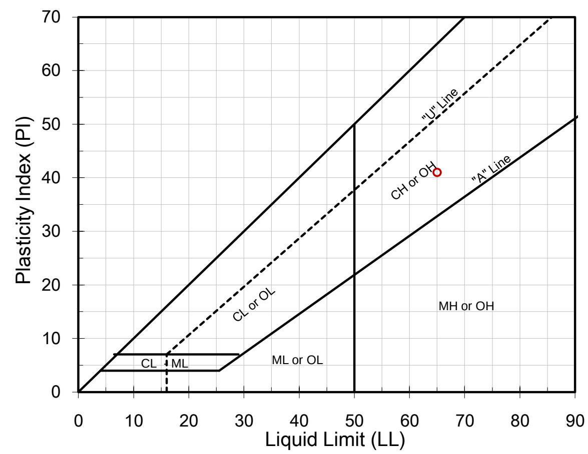
Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM | TRI Log #: 53565.1
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 9-19 (0.0-2.0) P-1





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel	Particle Size	Percent Passing	Particle Size	Percent Passing
			Sand				
-	mm		Fines	mm		mm	
3 in.	76.2	100.0		0.030	78.8	- -	- -
2 in.	50.8	100.0		0.020	72.6	- -	- -
1.5 in.	38.1	100.0		0.012	68.4	- -	- -
1 in.	25.4	100.0	0.0	0.007	64.3	- -	- -
3/4 in.	19.0	100.0		0.006	64.3	- -	- -
1/2 in.	12.7	100.0		0.003	58.3	- -	- -
3/8 in.	9.51	100.0		0.001	57.8	- -	- -
No. 4	4.76	100.0		Log-Linear Interpolation			
No. 10	2.00	99.5		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	98.8	6.0				
No. 40	0.420	98.1		mm		mm	
No. 60	0.250	97.5		0.005	63.0	0.005	- -
No. 100	0.149	96.4		0.002	58.1	0.002	- -
No. 200	0.074	94.0	94.0	N m,2μm,d	58	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	3.6E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	18.3	(0.05-0.002	23.3	(< 0.002 mm)	58.4

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	65
Plastic Limit	24
Plastic Index	41
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	24.3
Organic Content (%)	ASTM D2974-C	4.1
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021
Analysis & Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

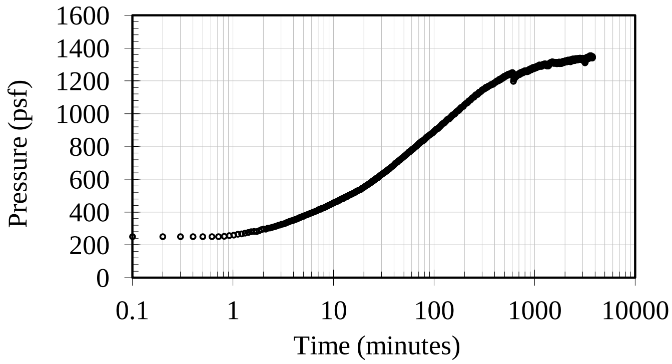
One-Dimensional Consolidation Properties of Soil

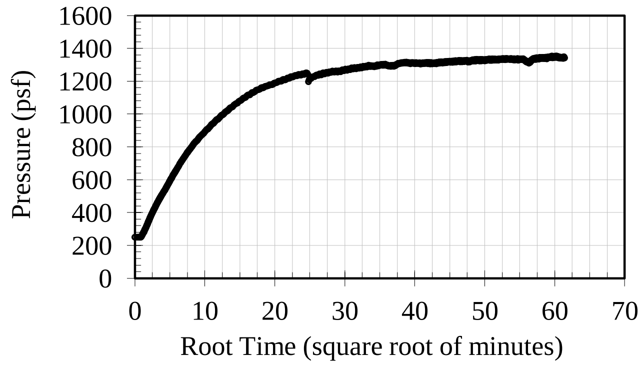
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 9-19 (0.0-2.0) P-1

TRI Log No.: 53565.1
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	18.3
Final Specimen Water Content (%)	22.1
Specimen Diameter (in)	2.498
Initial Specimen Height (in)	1.002
Initial Dry Unit Weight, γ_o lb_f/ft^3	98.0
Specific Gravity (Assumed)	2.75
Initial Void Ratio, e_o	0.688
Initial Degree of Saturation (%)	70.6

Swell Pressure (psf), Maximum Measured	1354





Note: The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. ***A client-prescribed seating stress pf 250 psf was utilized for testing.***

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

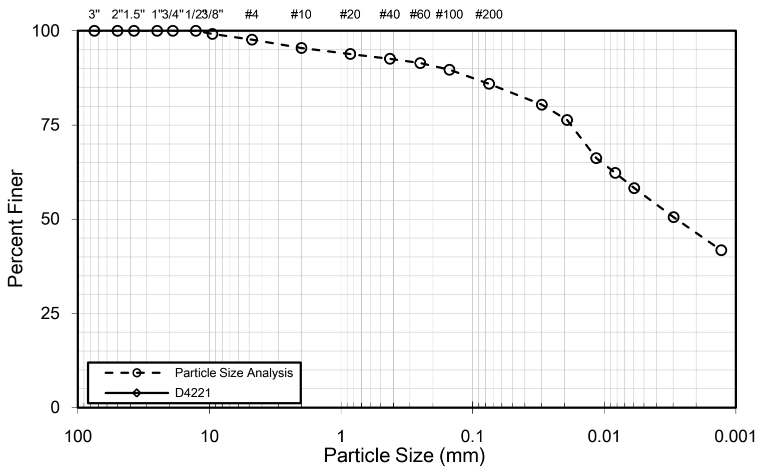
Particle Size, Atterberg Limit, and USCS Analyses for Soils

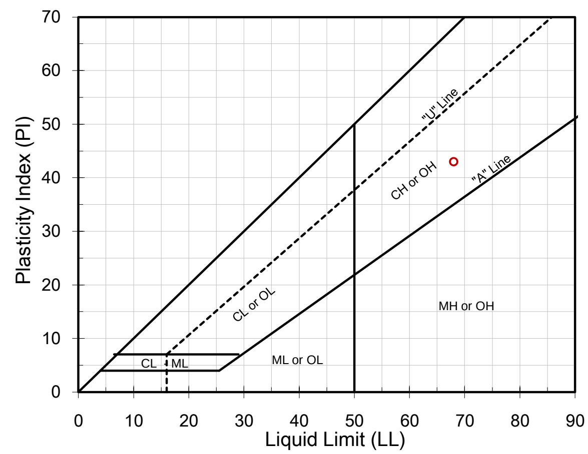
Client: AECOM

TRI Log #: 53565.3

Project: 60615067-1.4.14 Plum Creek 2

Sample ID: 9-19 (4.0-6.0) P-3





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0		0.030	80.4	- -	- -
2 in.	50.8	100.0		0.019	76.3	- -	- -
1.5 in.	38.1	100.0		0.012	66.2	- -	- -
1 in.	25.4	100.0	2.3	0.008	62.3	- -	- -
3/4 in.	19.0	100.0		0.006	58.2	- -	- -
1/2 in.	12.7	100.0		0.003	50.5	- -	- -
3/8 in.	9.51	99.2		0.001	41.8	- -	- -
No. 4	4.76	97.7		Log-Linear Interpolation			
No. 10	2.00	95.4		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	93.9					
No. 40	0.420	92.6	11.8	mm		mm	
No. 60	0.250	91.4		0.005	56.4	0.005	- -
No. 100	0.149	89.7		0.002	46.4	0.002	- -
No. 200	0.074	85.9	85.9	N m,2μm,d	46	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	2.8E-03	6.8E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	13.8	(0.05-0.002	37.6	(< 0.002 mm)	48.6

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	68
Plastic Limit	25
Plastic Index	43
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	16.2
Organic Content (%)	ASTM D2974-C	3.8
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021

Analysis & Quality Review/Date

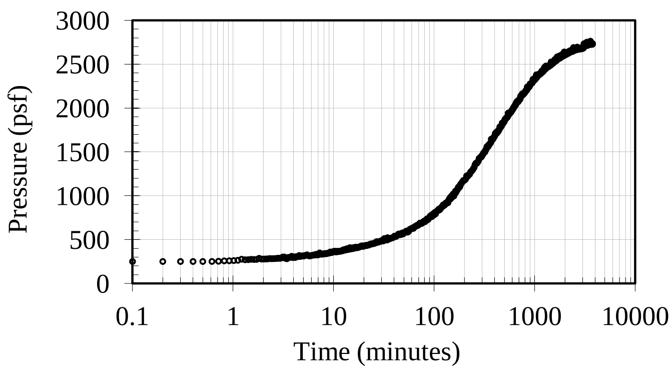
One-Dimensional Consolidation Properties of Soil

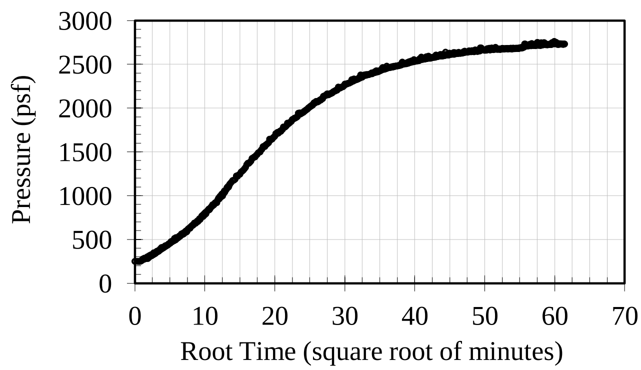
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 9-19 (4.0-6.0) P-3

TRI Log No.: 53565.3
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	16.7
Final Specimen Water Content (%)	21.1
Specimen Diameter (in)	2.497
Initial Specimen Height (in)	0.999
Initial Dry Unit Weight, γ_o lb_f/ft^3	104.9
Specific Gravity (Assumed)	2.75
Initial Void Ratio, e_o	0.577
Initial Degree of Saturation (%)	76.6

Swell Pressure (psf), Maximum Measured	2762



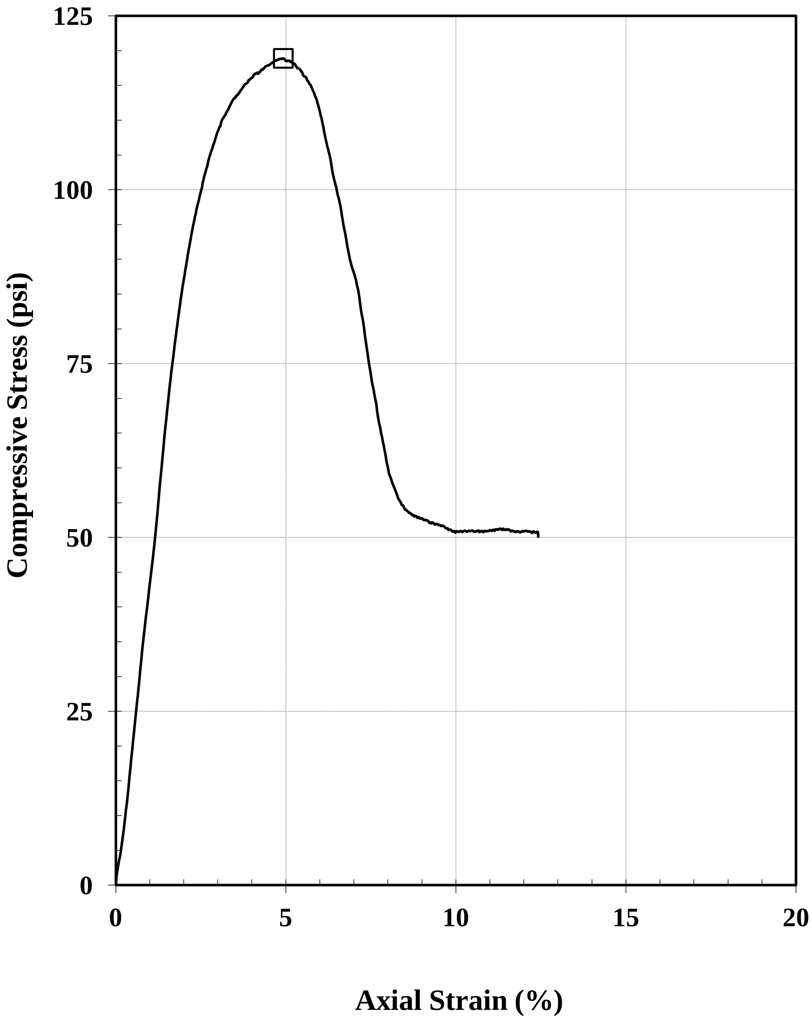


Note: The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. ***A client-prescribed seating stress pf 250 psf was utilized for testing.***

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

Unconfined Compression Test Report

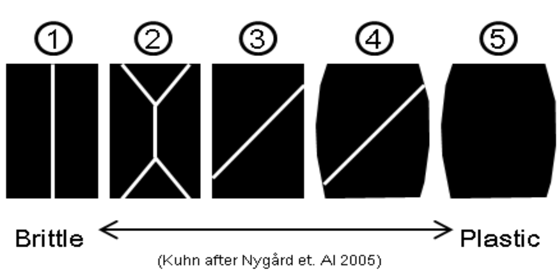
Client:	AECOM	TRI Log No.:	53565.5
Project:	60615067-1.4.14 Plum Creek 2	Type of Specimen:	Intact
Sample ID:	9-19 (8.0-10.0) ST-5	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.78
Avg. Height (in)	H_o	5.96
Avg, Water Content (%)	w_o	20.1
Bulk Density (pcf)	γ_{total}	128.3
Dry Density (pcf)	γ_{dry}	106.8
Saturation (%)	S_r	89.5
Void Ratio	e_o	0.61
Assumed Specific Gravity	G_s	2.75

Stresses at Failure	
Unconfined Compressive Strength (psi)	118.9
Axial Strain at Failure (%)	4.9
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	118.9
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	59.4

Failure Mode	3



Jeffrey A. Kuhn, Ph.D., P.E., 3/22/21
Quality Review/Date

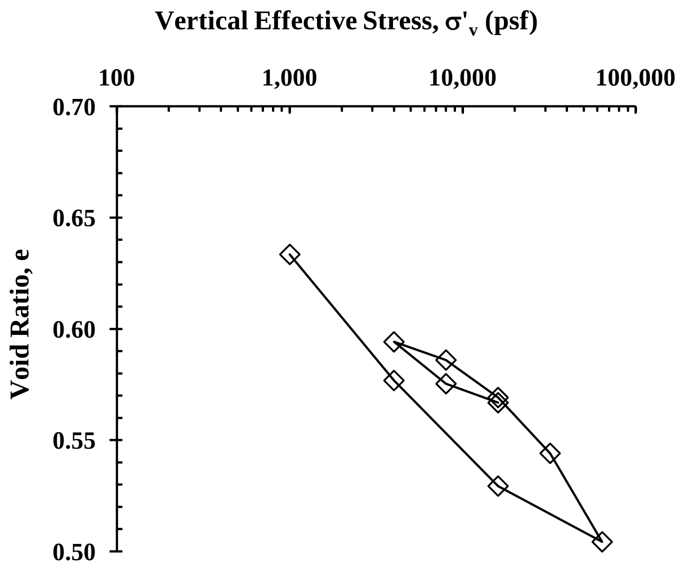
One-Dimensional Consolidation Properties of Soil

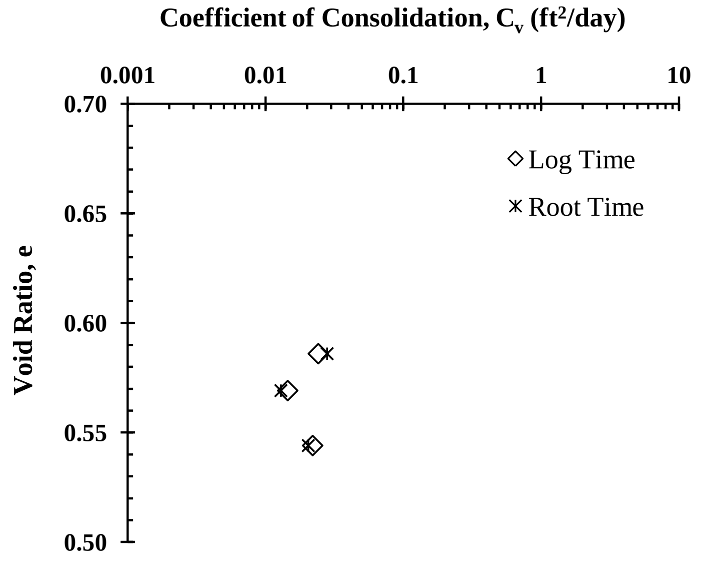
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 9-19 (8.0-10.0) ST-5

TRI Log No.: 53565.5
Test Method: ASTM D 2435, Method B

Soil Specimen Properties		
Initial Specimen Water Content (%)		19.2
Final Specimen Water Content (%)		24.7
Specimen Diameter (in)		2.495
Initial Specimen Height (in)		1.001
Final Specimen Height (in)		1.030
Final Differential Height (in)		-0.029
Initial Dry Unit Weight, γ_o lb_f/ft^3		104.1
Final Dry Unit Weight, γ_f lb_f/ft^3		101.2
Specific Gravity (Assumed)		2.75
Initial Void Ratio, e_o		0.588
Final Void Ratio, e_f		0.633
Initial Degree of Saturation (%)		86.4
Preconsolidation Pressure (psf)		≈13700
Swell Pressure (psf), Maximum Measured		6338
Compression Index, C_c	Min	-
	Max	0.083
Recompression Index, C_r	Min	0.027
	Max	0.056

Stage	σ'_v	e	Strain, ε	C_v (ft^2/day)	
(#)	(psf)	(-)	(%)	Log Time	Root Time
1	6,338	0.588	0.0	-	-
2	16,000	0.567	1.3	-	-
3	8,000	0.575	0.8	-	-
4	4,000	0.594	-0.4	-	3.5E-04
5	8,000	0.586	0.1	2.4E-02	2.8E-02
6	16,000	0.569	1.2	1.4E-02	1.3E-02
7	32,000	0.544	2.8	2.2E-02	2.0E-02
8	64,000	0.504	5.3	-	-
9	16,000	0.529	3.7	-	-
10	4,000	0.577	0.7	-	-
11	1,000	0.633	-2.9	-	-
12	-	-	-	-	-
13	-	-	-	-	-
14	-	-	-	-	-
15	-	-	-	-	-





The intact sample was provided by the client. A specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. Coefficient of Consolidation was determined using the Log Time and Root Time Methods. Calculations include machine deflections measured at each loading step. The preconsolidation pressure was determined using the Casagrande construction technique.

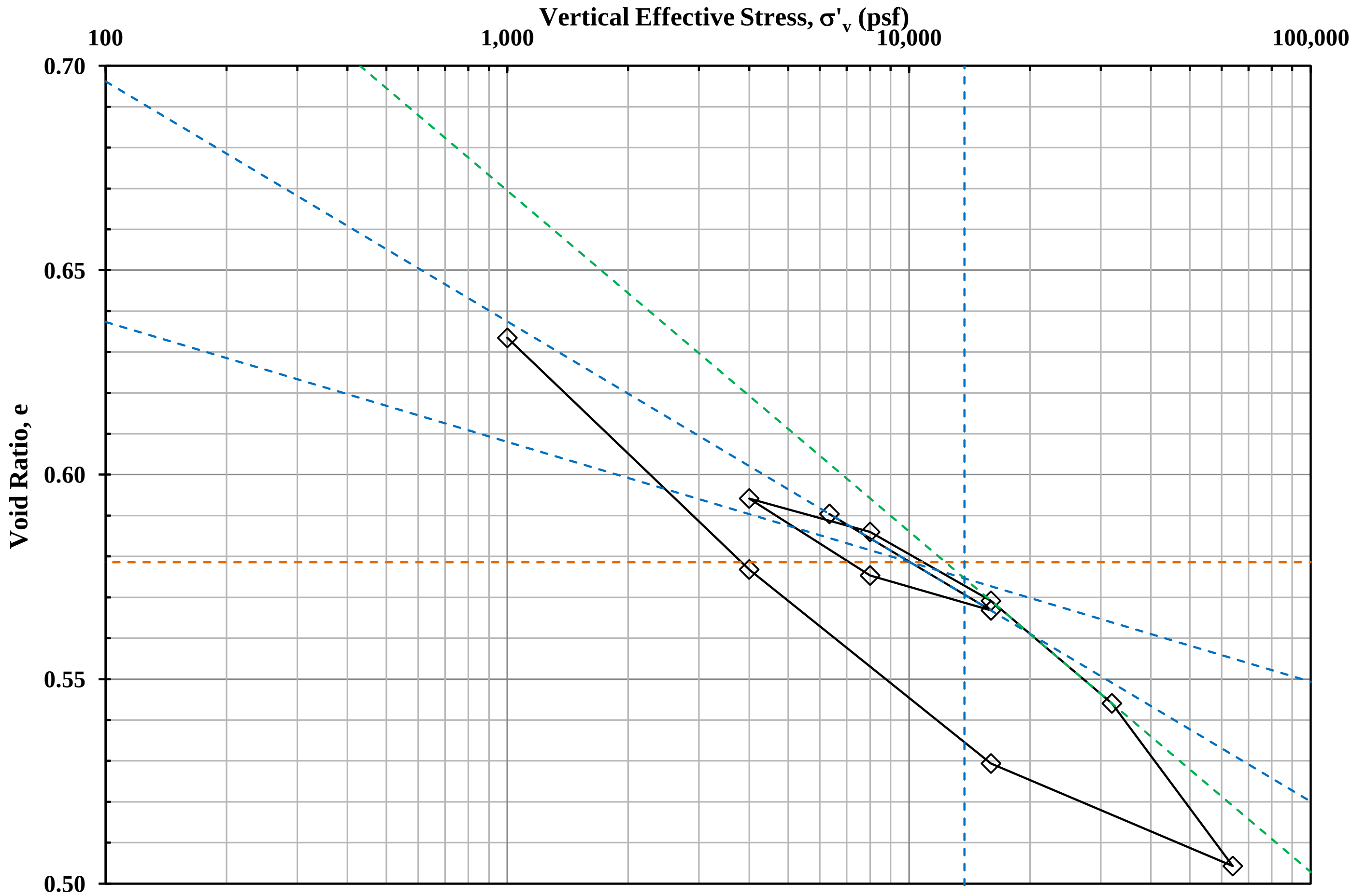
Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

One-Dimensional Consolidation Properties of Soil

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 9-19 (8.0-10.0) ST-5

TRI Log No.: 53565.5
Test Method: ASTM D 2435, Method B



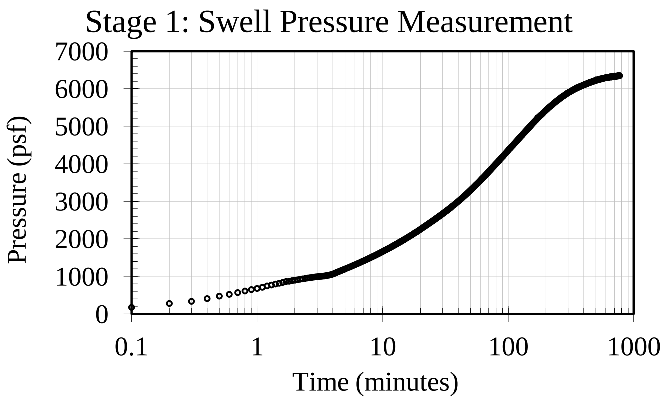
Stage	σ'v	log (σ'v)	e	δlog (σ'v)
(#)	(psf)	log (psf)	(-)	δe
1	6,338	3.80	0.590	-
2	16,000	4.20	0.567	0.059
3	8,000	3.90	0.575	-
4	4,000	3.60	0.594	-
5	8,000	3.90	0.586	0.027
6	16,000	4.20	0.569	0.056
7	32,000	4.51	0.544	0.083
8	64,000	4.81	0.504	0.132
9	16,000	4.20	0.529	-
10	4,000	3.60	0.577	-

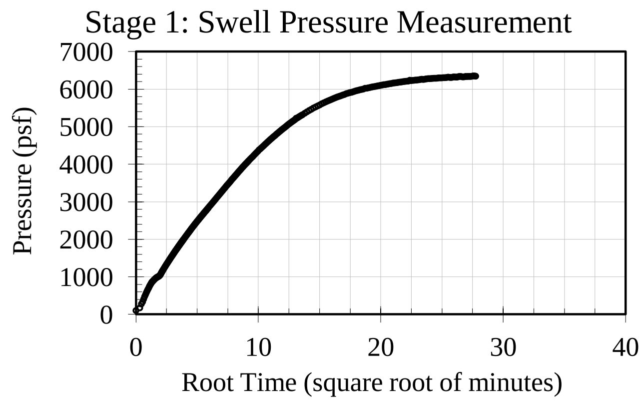
Stage	σ'v	log (σ'v)	e	δlog (σ'v)
(#)	(psf)	log (psf)	(-)	δe
11	1,000	3.00	0.633	-
12	-	-	-	-
13	-	-	-	-
14	-	-	-	-
15	-	-	-	-
16	-	-	-	-
17	-	-	-	-
18	-	-	-	-
19	-	-	-	-
20	-	-	-	-

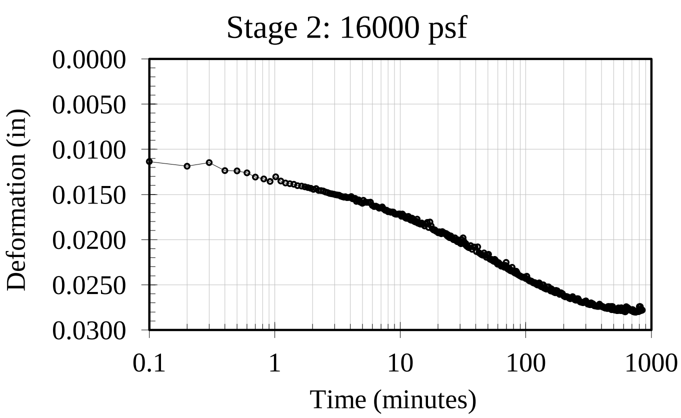
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

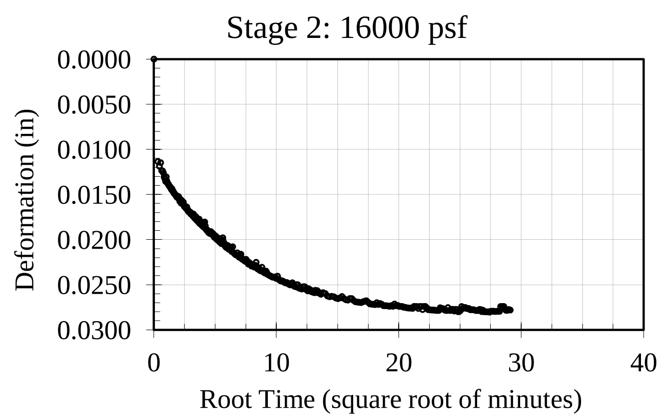
One-Dimensional Consolidation Properties of Soil

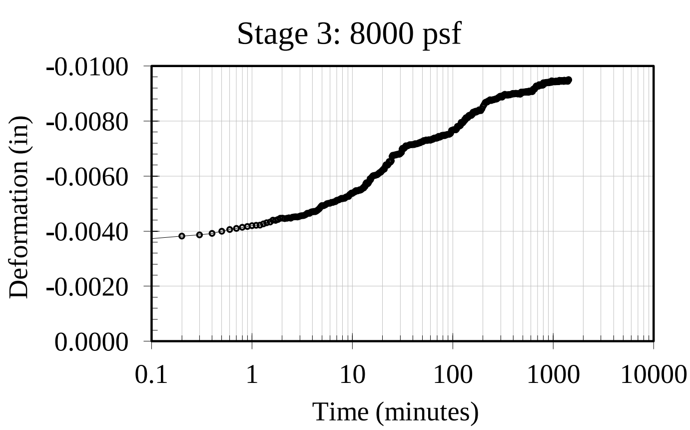
Client:	AECOM	TRI Log No.:	53565.5
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D 2435, Method B
Specimen:	9-19 (8.0-10.0) ST-5		

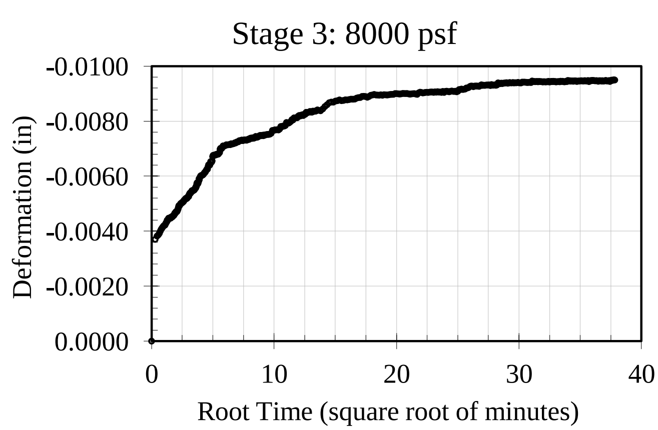








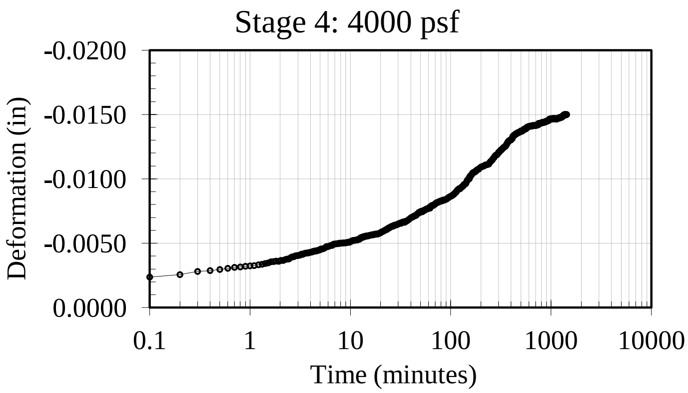


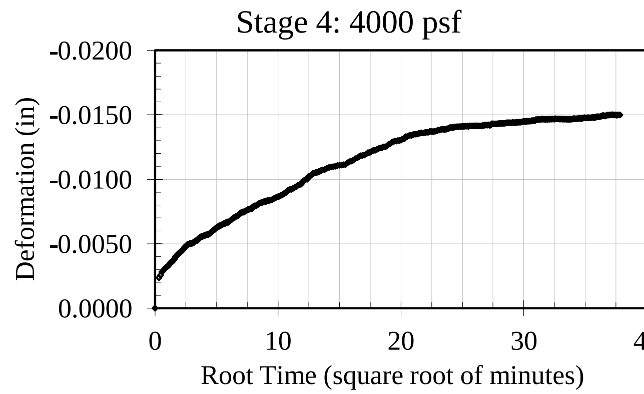


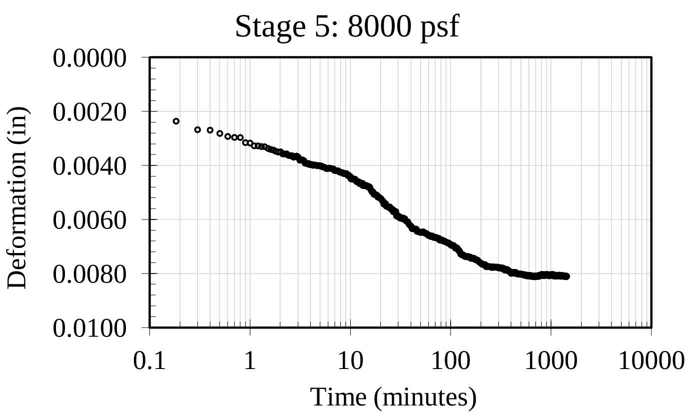
One-Dimensional Consolidation Properties of Soil

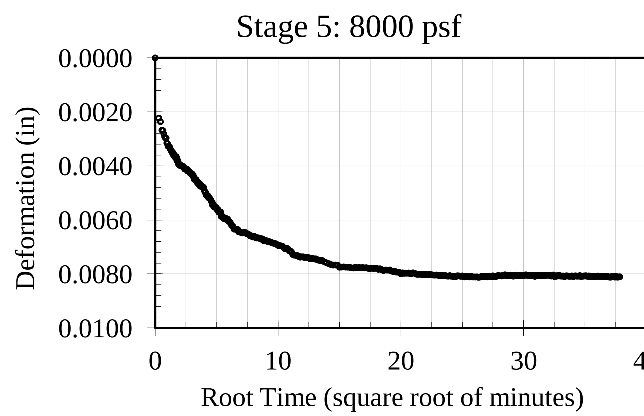
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 9-19 (8.0-10.0) ST-5

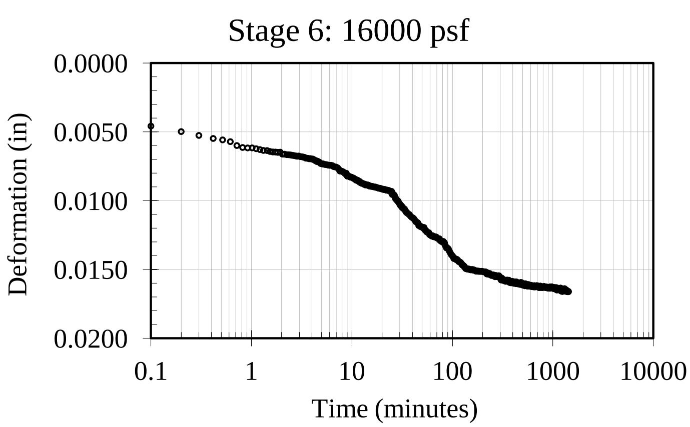
TRI Log No.: 53565.5
Test Method: ASTM D 2435, Method B

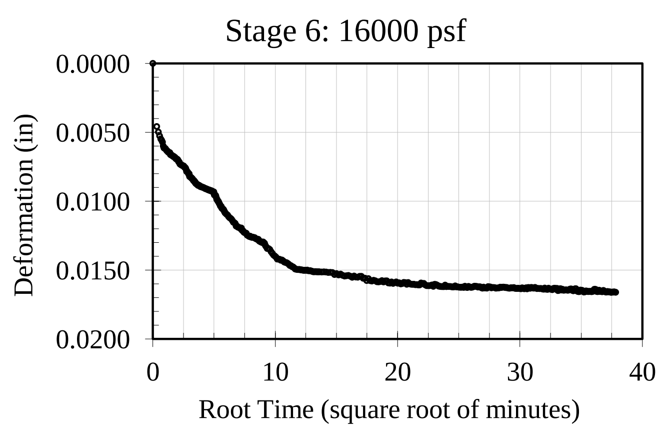












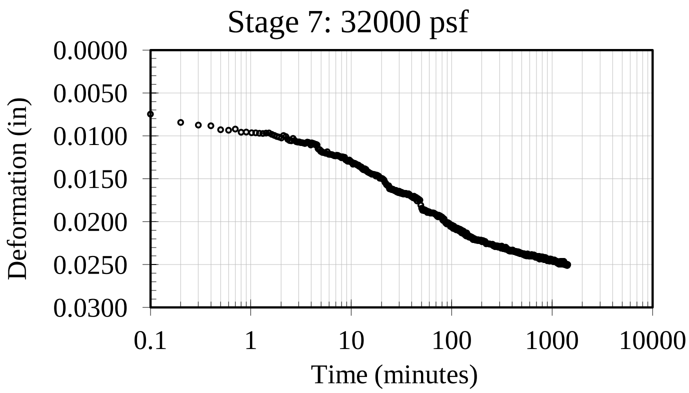
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

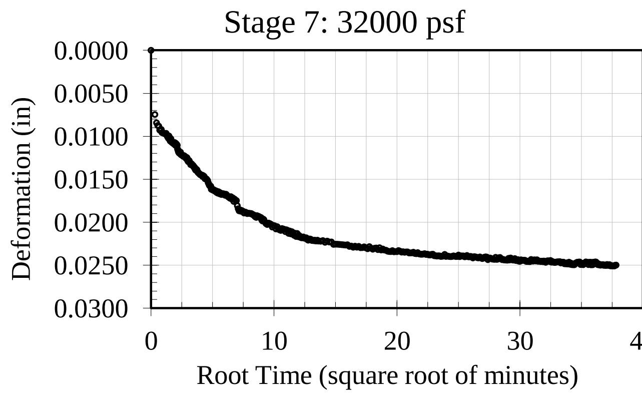
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

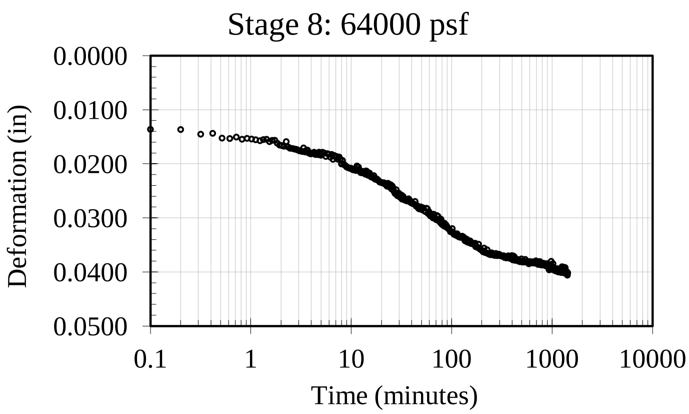
One-Dimensional Consolidation Properties of Soil

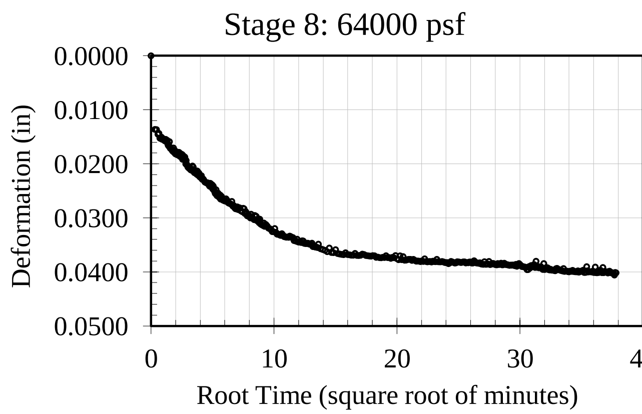
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 9-19 (8.0-10.0) ST-5

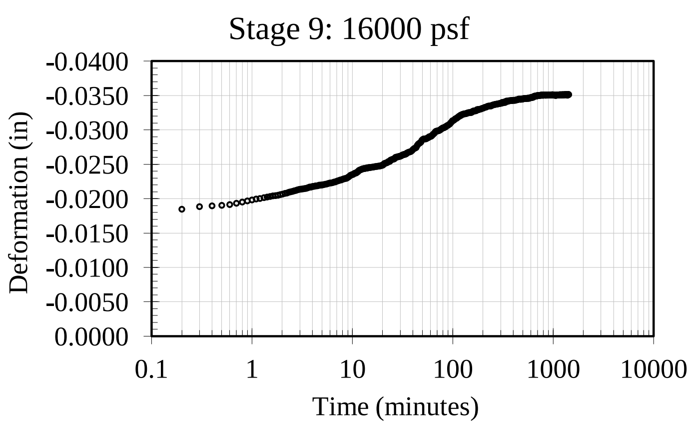
TRI Log No.: 53565.5
Test Method: ASTM D 2435, Method B

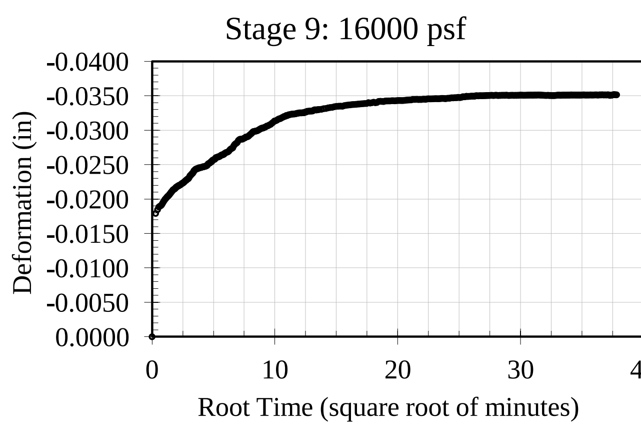










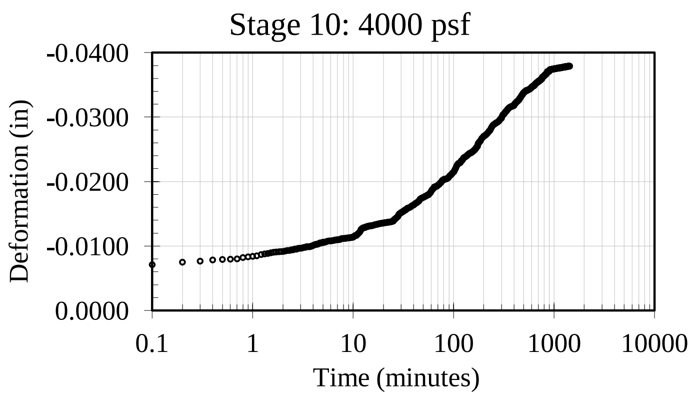


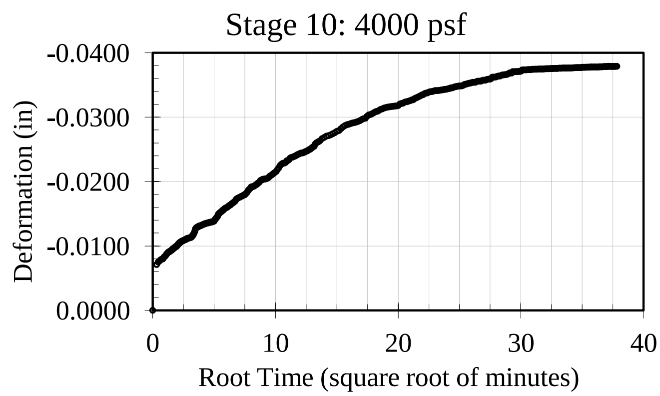
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

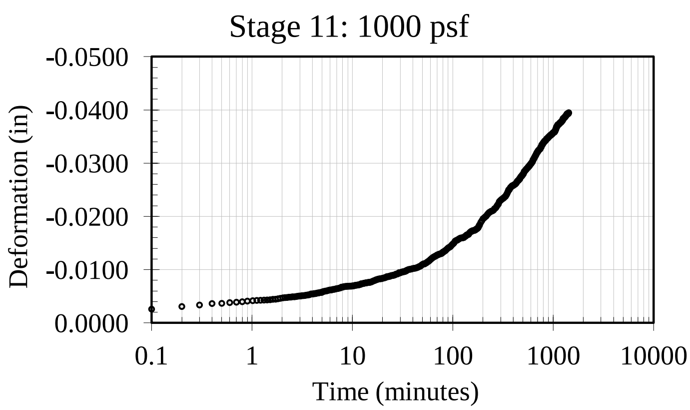
One-Dimensional Consolidation Properties of Soil

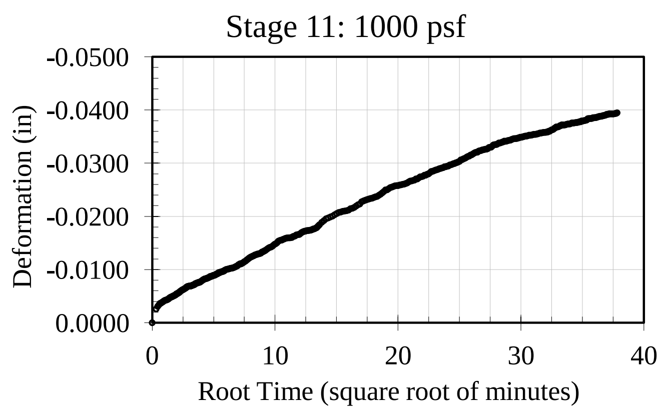
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 9-19 (8.0-10.0) ST-5

TRI Log No.: 53565.5
Test Method: ASTM D 2435, Method B









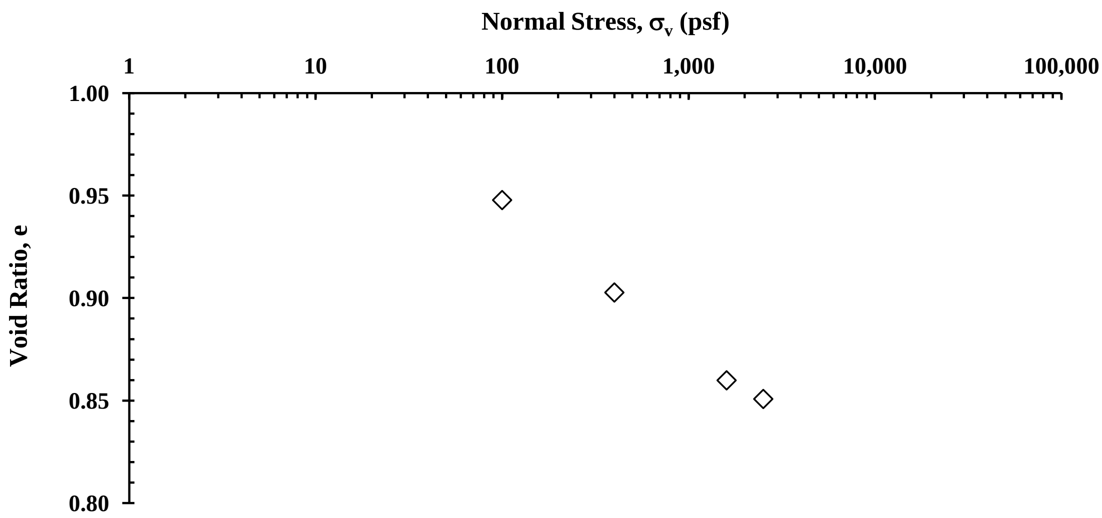
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Swell Pressure Measurement with Multistage Unloading

Client:	AECOM	TRI Log #:	53565.5
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D4546-B MOD
Specimen:	9-19 (8.0-10.0) ST-5		

Stage	Initial[1,2]	Normal Stress (psf)[3,4]				
Normal Stress (psf)	120	2,517	1,600	400	100	-
Water Content, ω (%)	37.0	-	-	-	27.4	-
Diameter, d (in)	2.486	-	-	-	-	-
Height, h (in)	1.005	1.005	1.010	1.033	1.057	-
Total Unit Weight (pcf)	126.9	-	-	-	126.9	-
Dry Unit Weight (pcf)	92.7	-	-	-	92.7	-
Void Ratio, e	0.851	0.851	0.860	0.903	0.948	-
Δe / Δlog(σ)	-	-	-0.046	-0.071	-0.075	-
Degree of Saturation, S (%)	≈100	-	-	-	76.5	-
Strain (%)[3,4]	0.000	0.000	-0.492	-2.807	-5.244	-

1. The intact sample was provided by the client. A specimen was trimmed from the sample using a trimming turntable and mounted. Gs was assumed to be 2.75. Calculations include measured machine deflections.
2. In the specimen ring.
3. Sign convention: (+) Compression/Collapse, (-) Expansion/Swell
4. Modification: The initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. Following the measurement of the swell pressure the sample was subsequently unloaded in stages.

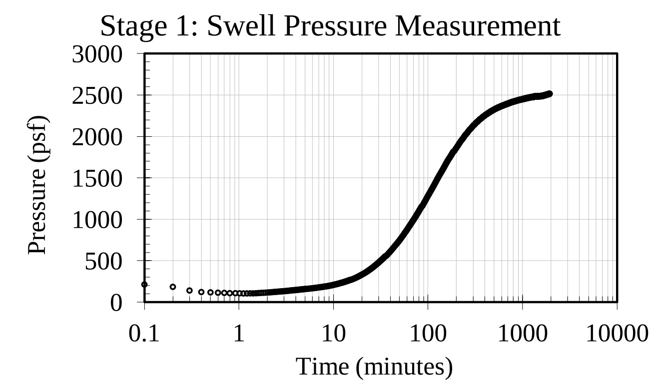


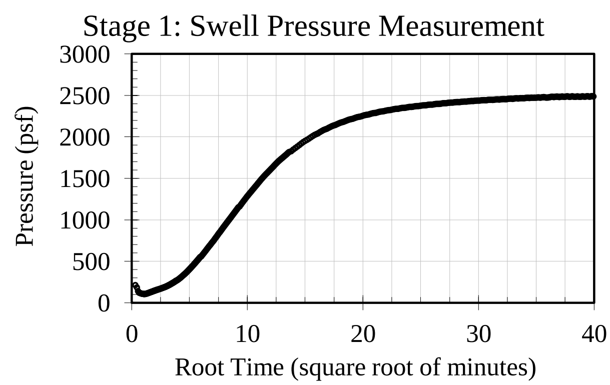
Jeffrey A. Kuhn, Ph.D., P.E. 3/22/2021
Analysis & Quality Review/Date

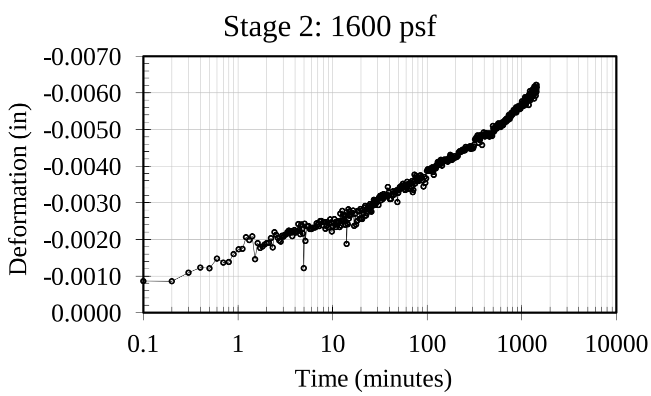
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

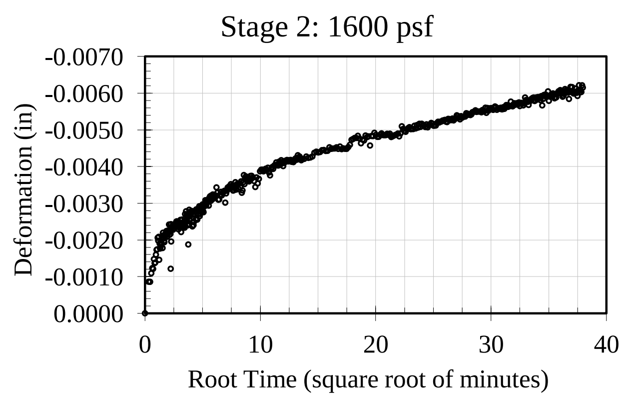
Swell Pressure Measurement with Multistage Unloading

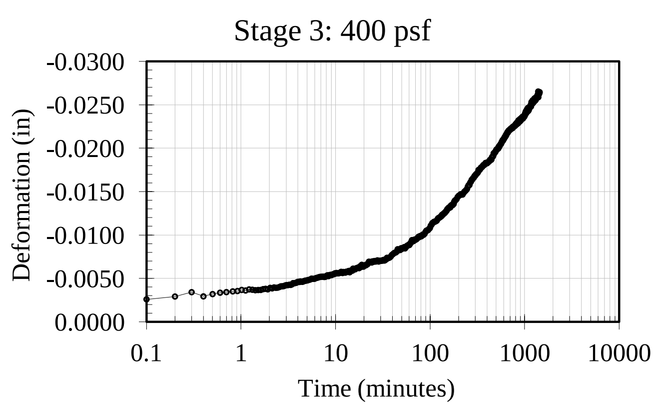
Client:	AECOM	TRI Log #:	53565.5
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D4546-B MOD
Specimen:	9-19 (8.0-10.0) ST-5		

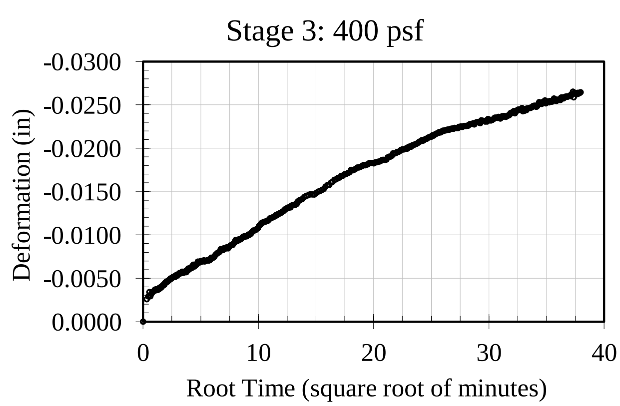








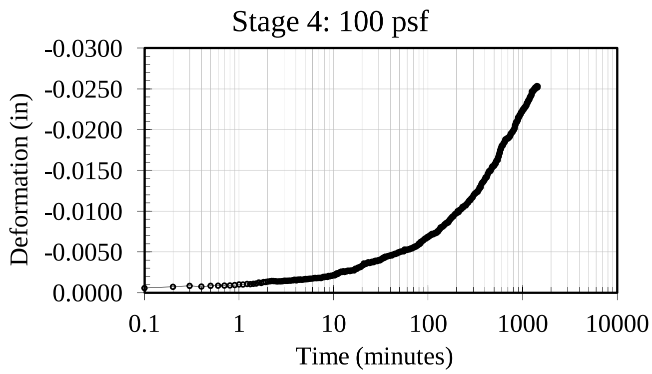


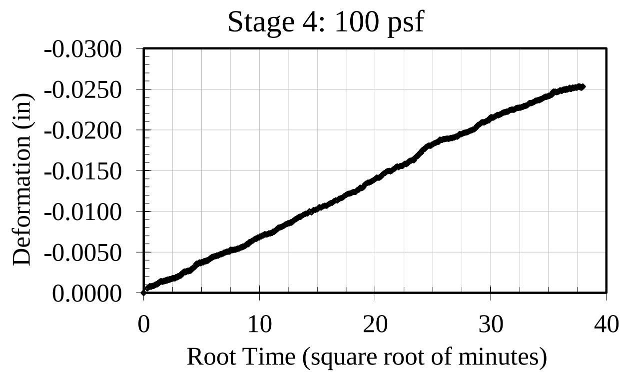


TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Swell Pressure Measurement with Multistage Unloading

Client:	AECOM	TRI Log #:	53565.5
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D4546-B MOD
Specimen:	9-19 (8.0-10.0) ST-5		

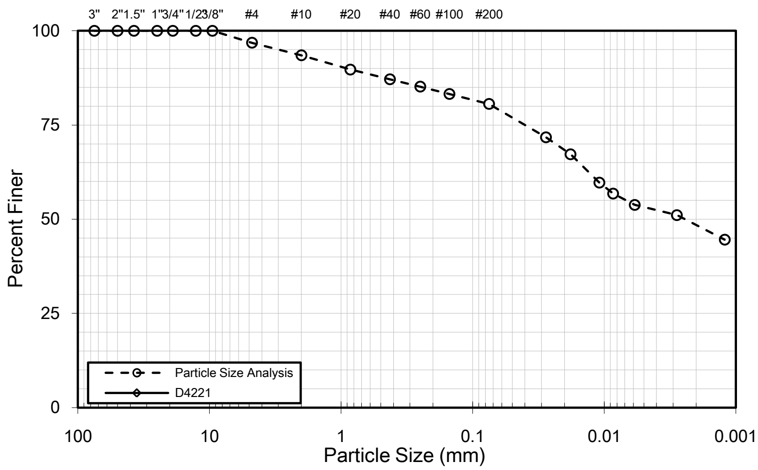


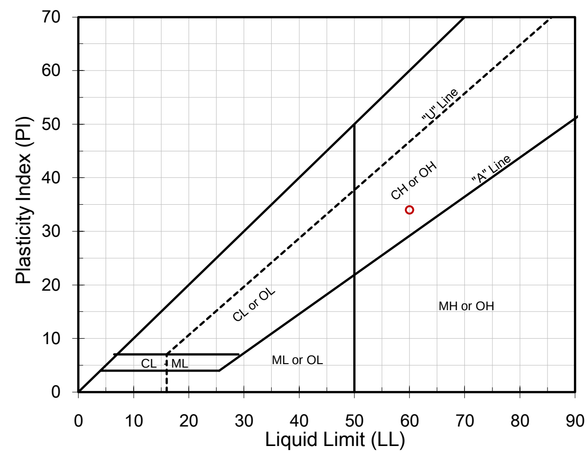


TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM   TRI Log #: 53565.6
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 9-19 (13.0-15.0) P-6





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	3.2	0.028	71.7	- -	- -
2 in.	50.8	100.0		0.018	67.2	- -	- -
1.5 in.	38.1	100.0		0.011	59.7	- -	- -
1 in.	25.4	100.0		0.009	56.8	- -	- -
3/4 in.	19.0	100.0		0.006	53.8	- -	- -
1/2 in.	12.7	100.0		0.003	51.1	- -	- -
3/8 in.	9.51	100.0		0.001	44.6	- -	- -
No. 4	4.76	96.8	16.2	Log-Linear Interpolation			
No. 10	2.00	93.5		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	89.7					
No. 40	0.420	87.1		mm		mm	
No. 60	0.250	85.2		0.005	53.2	0.005	- -
No. 100	0.149	83.2		0.002	48.5	0.002	- -
No. 200	0.074	80.6	80.6	N m,2µm,d	49	N m,2µm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	2.4E-03	1.1E-02	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	20.1	(0.05-0.002	28.1	(< 0.002 mm)	51.9

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	60
Plastic Limit	26
Plastic Index	34
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay with sand (CH)

Moisture Content (%)	ASTM D2216	18.4
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021
Analysis & Quality Review/Date

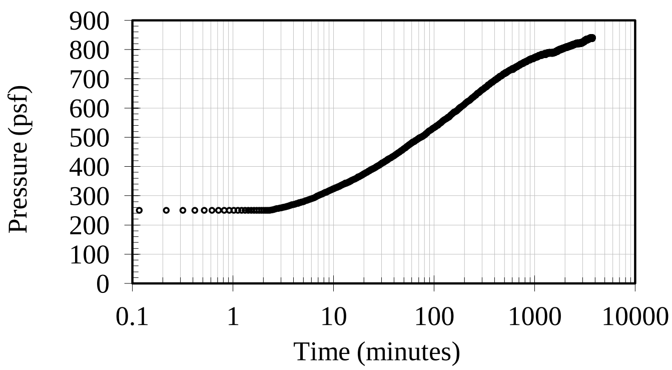
One-Dimensional Consolidation Properties of Soil

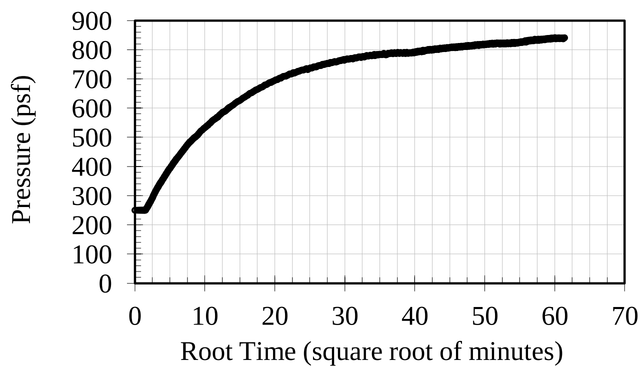
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 9-19 (13.0-15.0) P-6

TRI Log No.: 53565.6
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	20.5
Final Specimen Water Content (%)	24.4
Specimen Diameter (in)	2.496
Initial Specimen Height (in)	1.003
Initial Dry Unit Weight, γ_o lb_f/ft^3	97.9
Specific Gravity (Assumed)	2.75
Initial Void Ratio, e_o	0.689
Initial Degree of Saturation (%)	78.9

Swell Pressure (psf), Maximum Measured	841





Note: The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. ***A client-prescribed seating stress pf 250 psf was utilized for testing.***

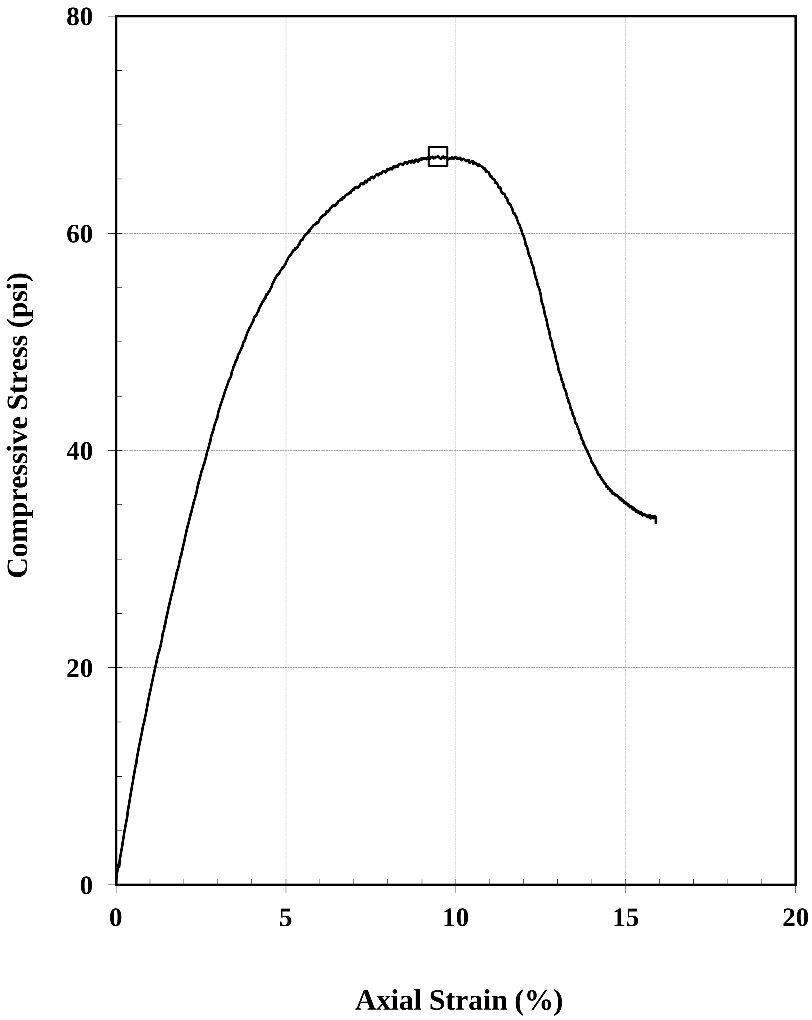
Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

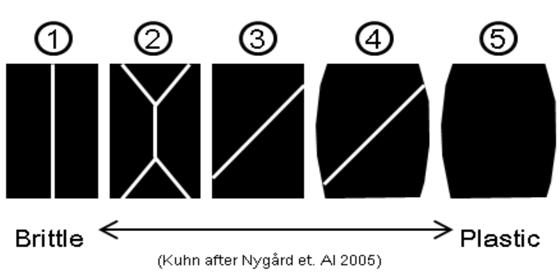
Client:	AECOM	TRI Log No.:	53765.2
Project:	60615067-1.4.14 Plum Creek 2	Type of Specimen:	Intact
Sample ID:	9-19 (23.0-25.0) ST-8	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.75
Avg. Height (in)	H_o	6.05
Avg, Water Content (%)	w_o	23.0
Bulk Density (pcf)	γ_{total}	128.7
Dry Density (pcf)	γ_{dry}	104.6
Saturation (%)	S_r	≈100
Void Ratio	e_o	0.61
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	67.1
Axial Strain at Failure (%)	9.5
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	67.1
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	33.5

Failure Mode	3



Jeffrey A. Kuhn, Ph.D., P.E., 3/22/21

Quality Review/Date

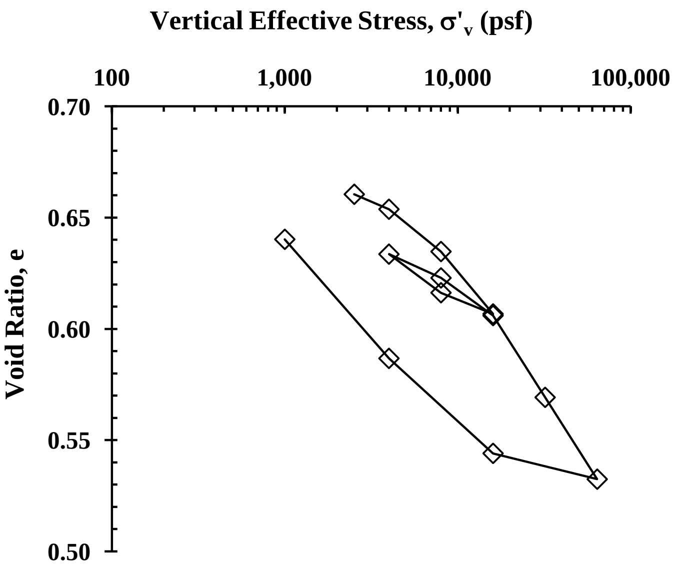
One-Dimensional Consolidation Properties of Soil

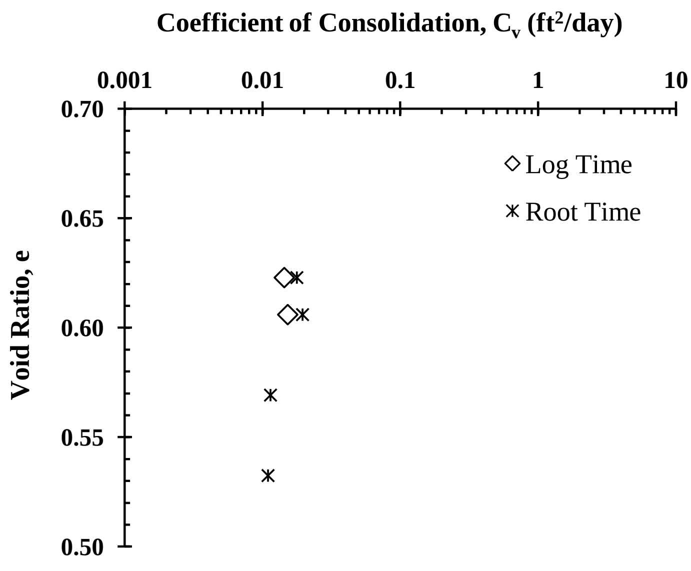
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 9-19 (23.0-25.0) ST-8

TRI Log No.: 53765.2
Test Method: ASTM D 2435, Method B

Soil Specimen Properties		
Initial Specimen Water Content (%)		21.1
Final Specimen Water Content (%)		23.8
Specimen Diameter (in)		2.500
Initial Specimen Height (in)		0.984
Final Specimen Height (in)		0.974
Final Differential Height (in)		0.010
Initial Dry Unit Weight, γ_o lb_f/ft^3		99.7
Final Dry Unit Weight, γ_f lb_f/ft^3		100.8
Specific Gravity (Assumed)		2.75
Initial Void Ratio, e_o		0.658
Final Void Ratio, e_f		0.640
Initial Degree of Saturation (%)		84.9
Preconsolidation Pressure (psf)		≈8700
Swell Pressure (psf), Maximum Measured		2521
Compression Index, C_c	Min	-
	Max	0.122
Recompression Index, C_r	Min	0.036
	Max	0.056

Stage (#)	σ'$_v$ (psf)	e (-)	Strain, ε (%)	C_v (ft^2/day) Log Time	C_v (ft^2/day) Root Time
1	2,521	0.658	0.0	-	-
2	4,000	0.654	0.2	-	-
3	8,000	0.635	1.4	-	-
4	16,000	0.607	3.1	-	-
5	8,000	0.616	2.5	-	-
6	4,000	0.634	1.5	-	-
7	8,000	0.623	2.1	1.4E-02	1.8E-02
8	16,000	0.606	3.1	1.5E-02	2.0E-02
9	32,000	0.569	5.3	-	1.1E-02
10	64,000	0.532	7.6	-	1.1E-02
11	16,000	0.544	6.9	-	-
12	4,000	0.587	4.3	-	-
13	1,000	0.640	1.1	-	-
14	-	-	-	-	-
15	-	-	-	-	-





The intact sample was provided by the client. A specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. Coefficient of Consolidation was determined using the Log Time and Root Time Methods. Calculations include machine deflections measured at each loading step. The preconsolidation pressure was determined using the Casagrande construction technique.

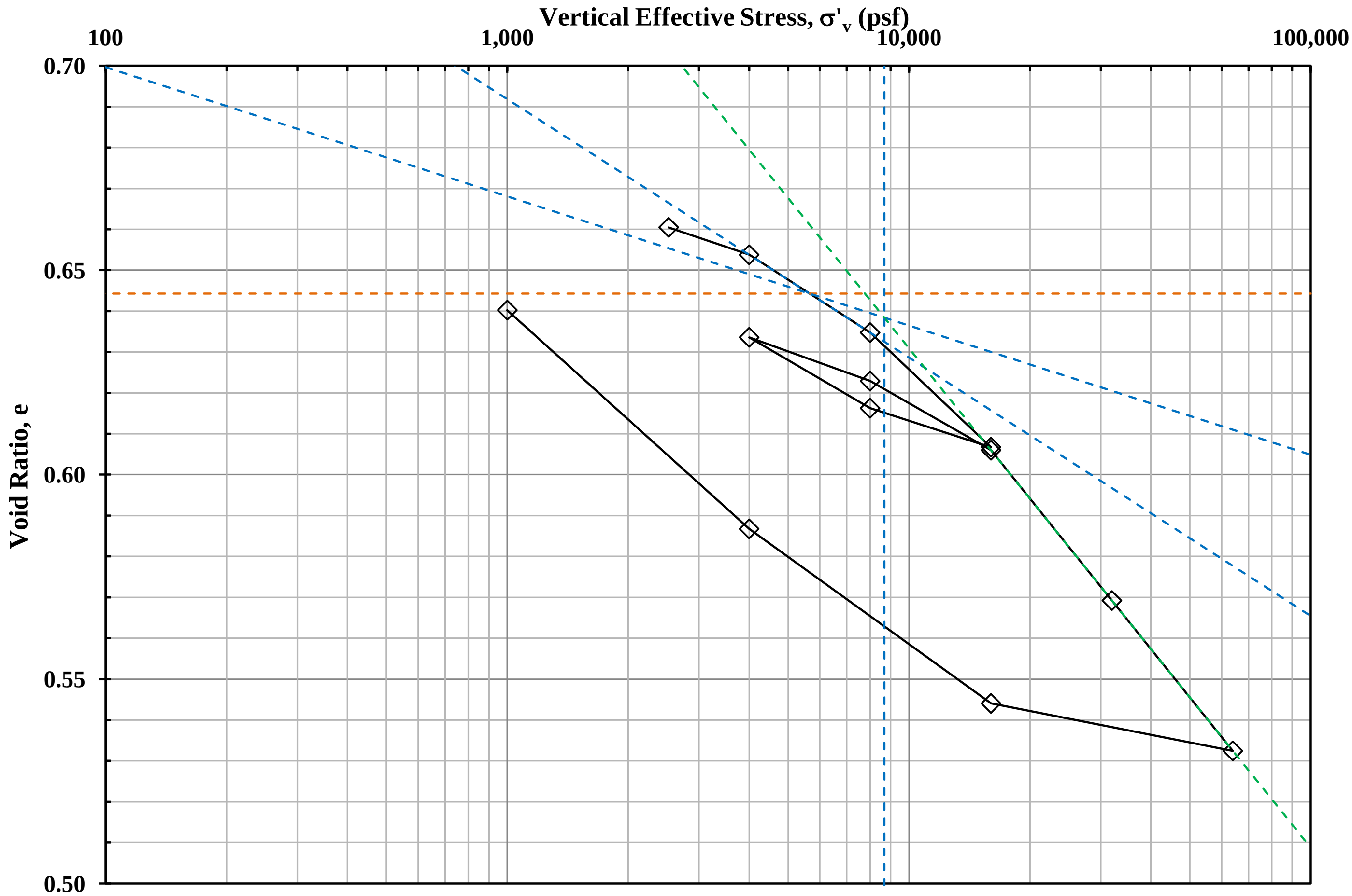
Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

One-Dimensional Consolidation Properties of Soil

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 9-19 (23.0-25.0) ST-8

TRI Log No.: 53765.2
Test Method: ASTM D 2435, Method B



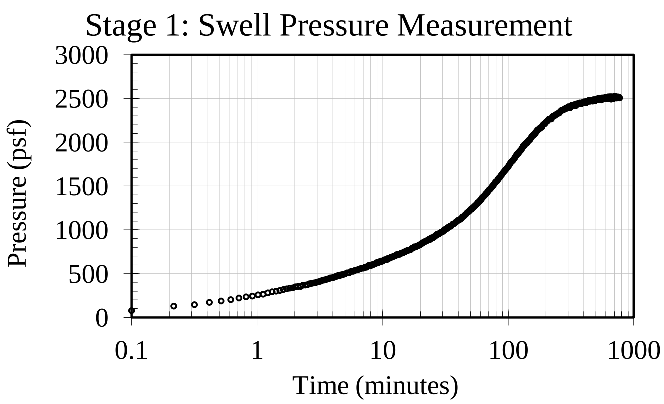
Stage	σ'v	log (σ'v)	e	δlog (σ'v)
(#)	(psf)	log (psf)	(-)	δe
1	2,521	3.40	0.660	-
2	4,000	3.60	0.654	0.034
3	8,000	3.90	0.635	0.063
4	16,000	4.20	0.607	0.093
5	8,000	3.90	0.616	-
6	4,000	3.60	0.634	-
7	8,000	3.90	0.623	0.036
8	16,000	4.20	0.606	0.056
9	32,000	4.51	0.569	0.122
10	64,000	4.81	0.532	0.122

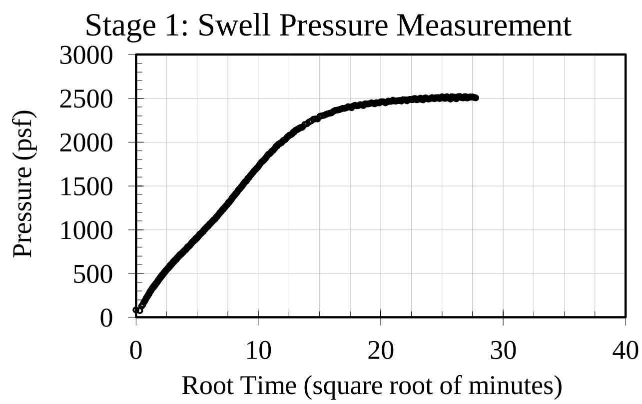
Stage	σ'v	log (σ'v)	e	δlog (σ'v)
(#)	(psf)	log (psf)	(-)	δe
11	16,000	4.20	0.544	-
12	4,000	3.60	0.587	-
13	1,000	3.00	0.640	-
14	-	-	-	-
15	-	-	-	-
16	-	-	-	-
17	-	-	-	-
18	-	-	-	-
19	-	-	-	-
20	-	-	-	-

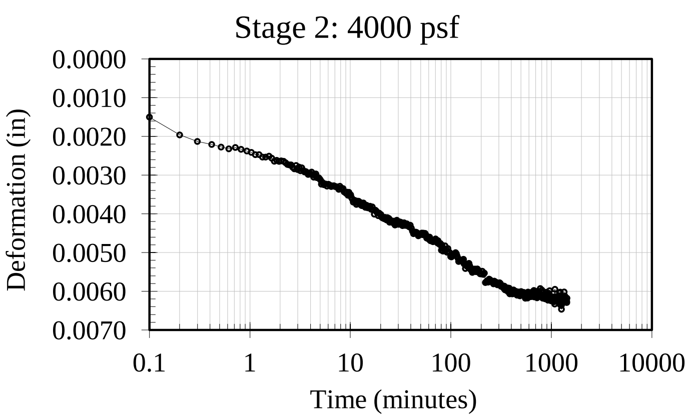
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

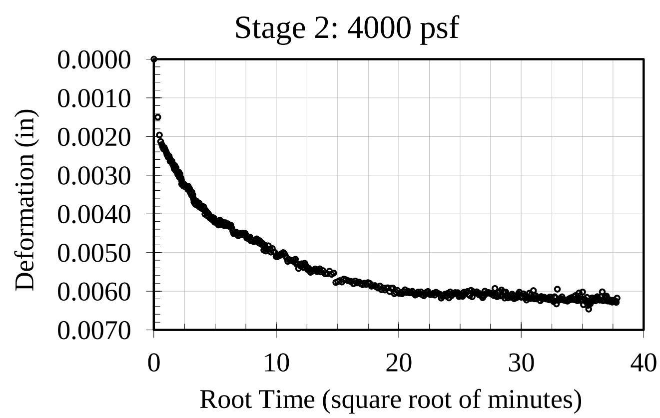
One-Dimensional Consolidation Properties of Soil

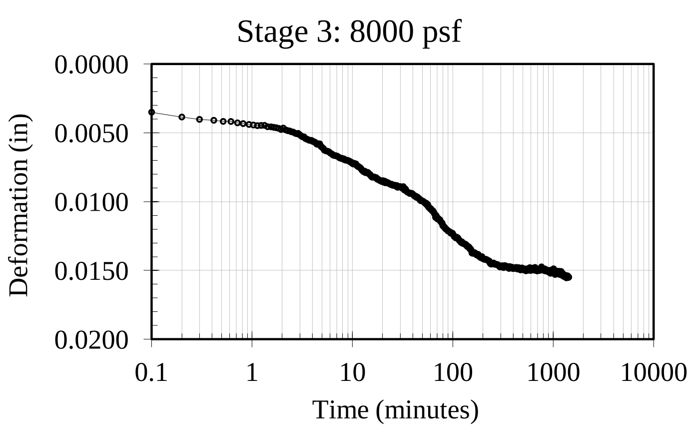
Client:	AECOM	TRI Log No.:	53765.2
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D 2435, Method B
Specimen:	9-19 (23.0-25.0) ST-8		

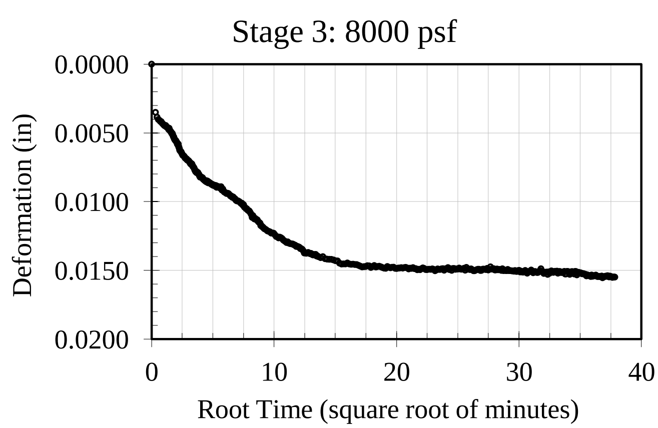










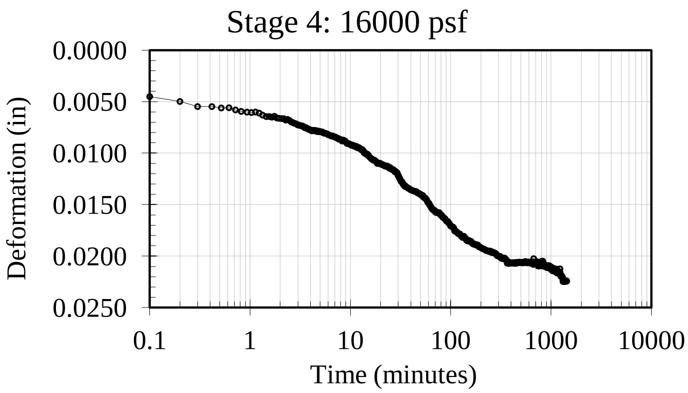


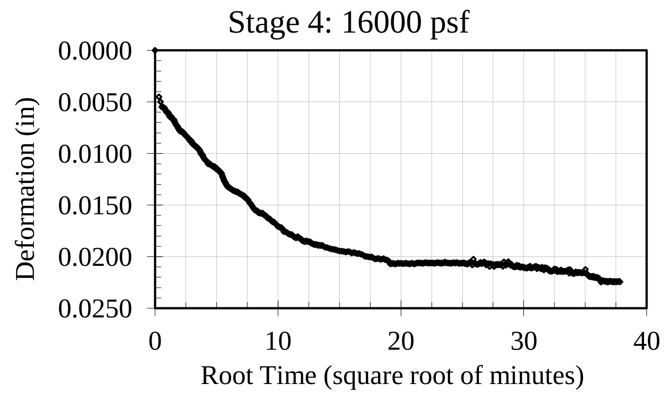
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

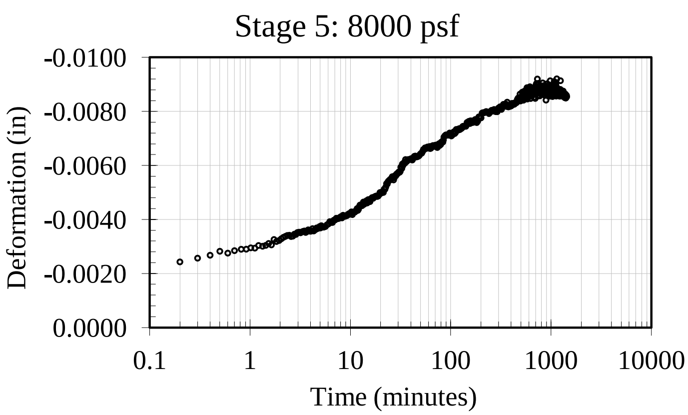
One-Dimensional Consolidation Properties of Soil

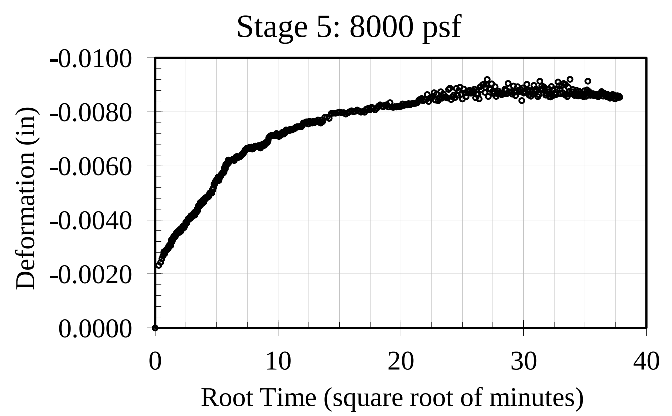
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 9-19 (23.0-25.0) ST-8

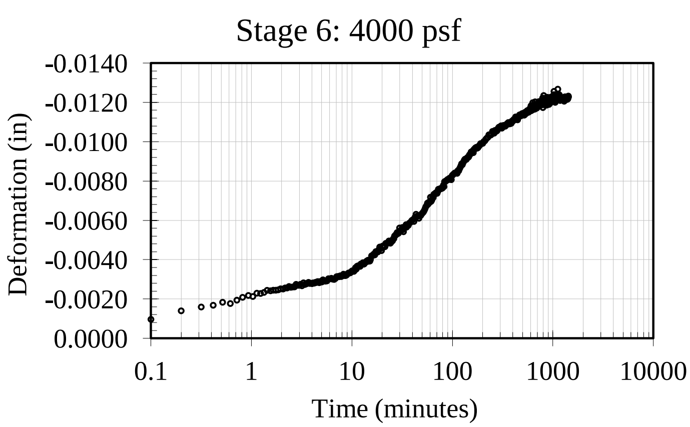
TRI Log No.: 53765.2
Test Method: ASTM D 2435, Method B

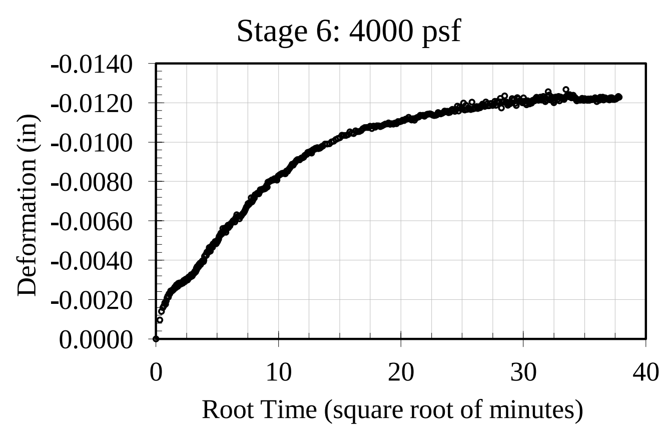










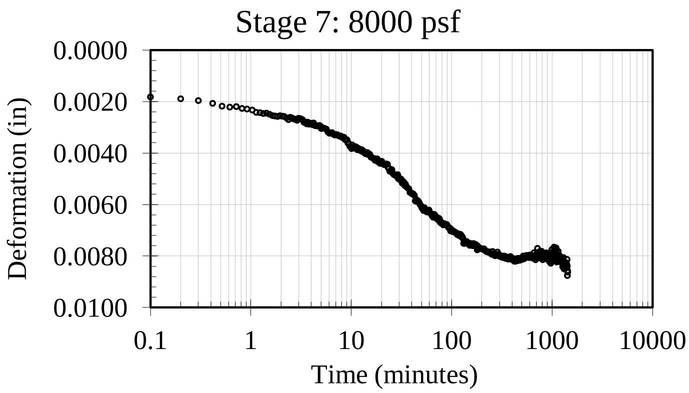


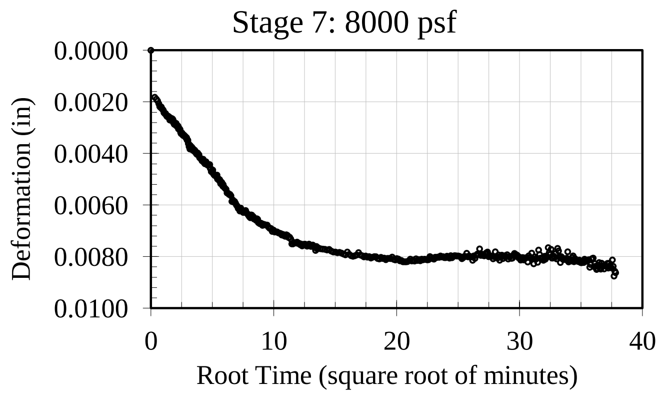
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

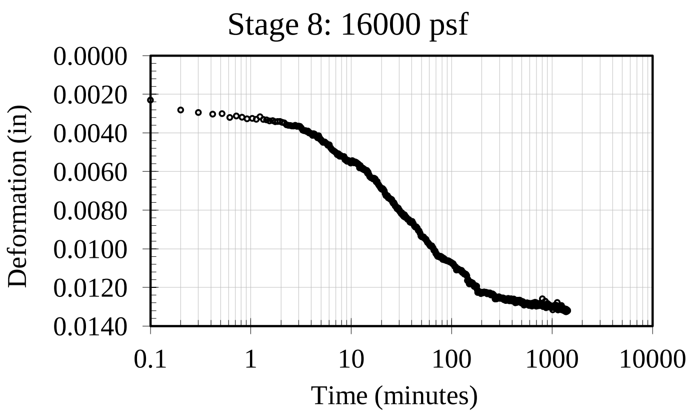
One-Dimensional Consolidation Properties of Soil

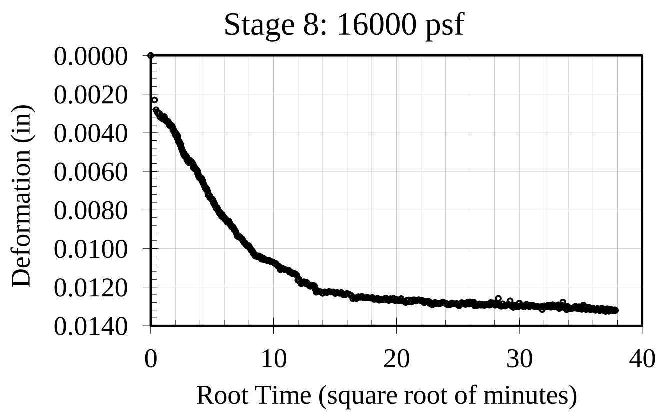
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 9-19 (23.0-25.0) ST-8

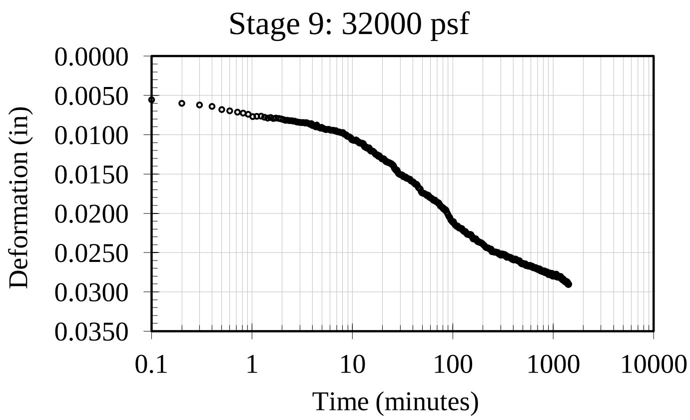
TRI Log No.: 53765.2
Test Method: ASTM D 2435, Method B

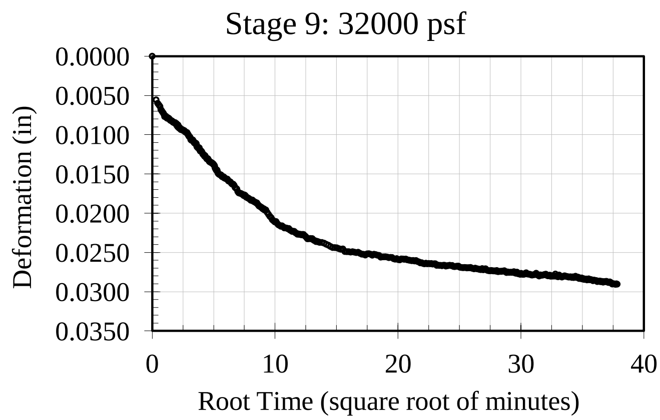








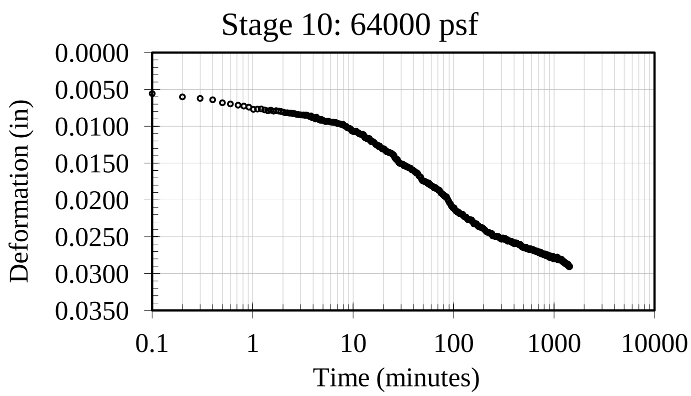


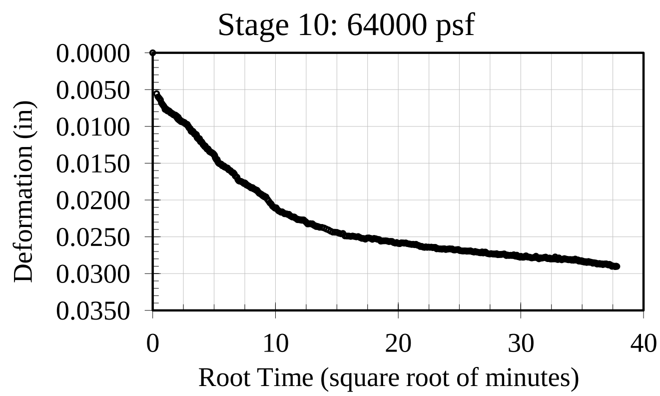


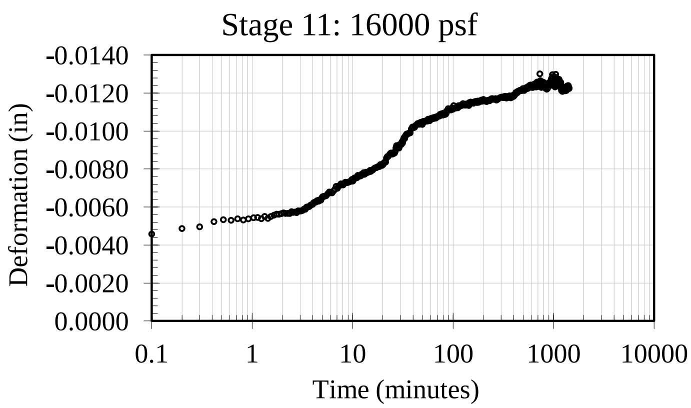
One-Dimensional Consolidation Properties of Soil

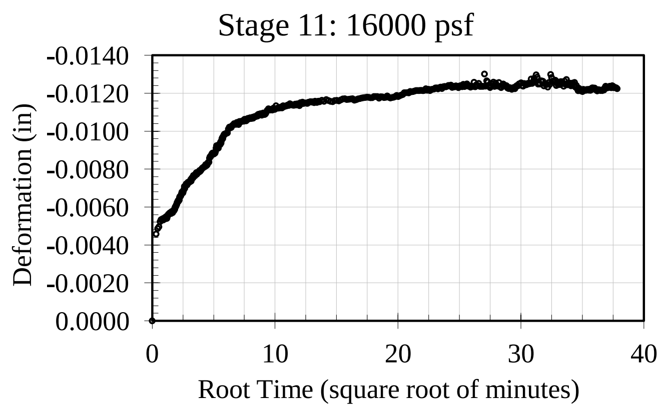
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 9-19 (23.0-25.0) ST-8

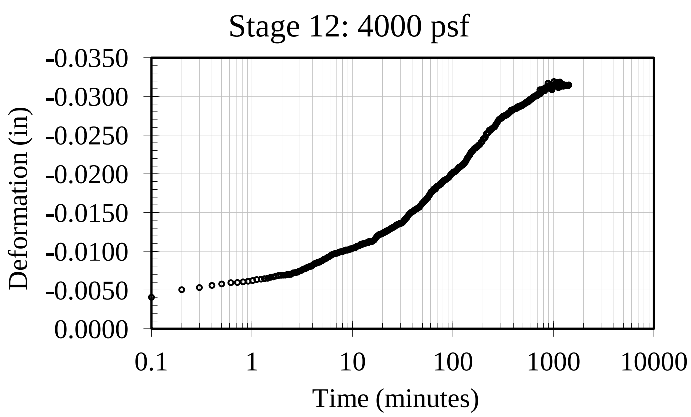
TRI Log No.: 53765.2
Test Method: ASTM D 2435, Method B

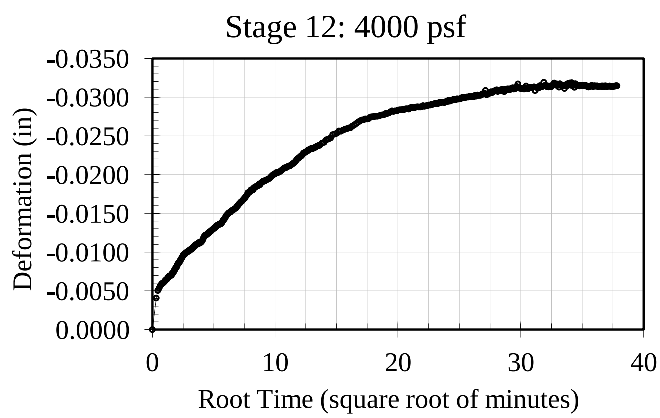










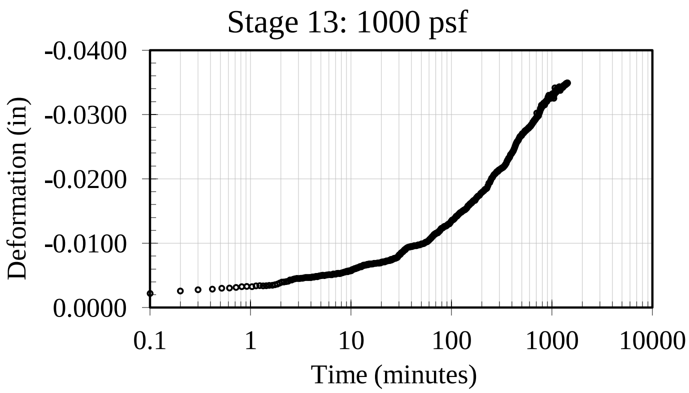


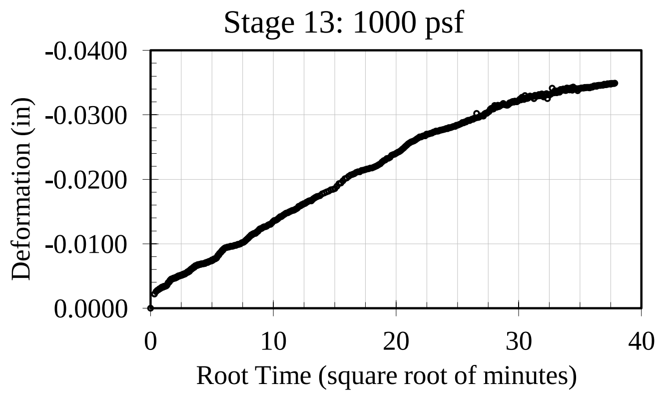
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

One-Dimensional Consolidation Properties of Soil

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 9-19 (23.0-25.0) ST-8

TRI Log No.: 53765.2
Test Method: ASTM D 2435, Method B





TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

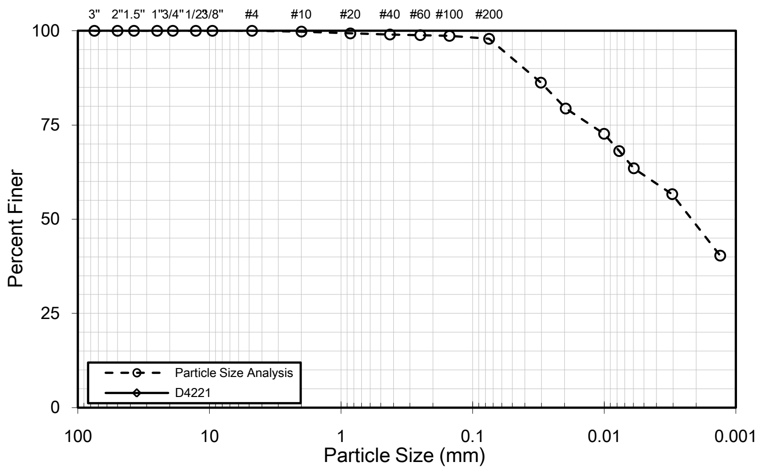
Particle Size, Atterberg Limit, and USCS Analyses for Soils

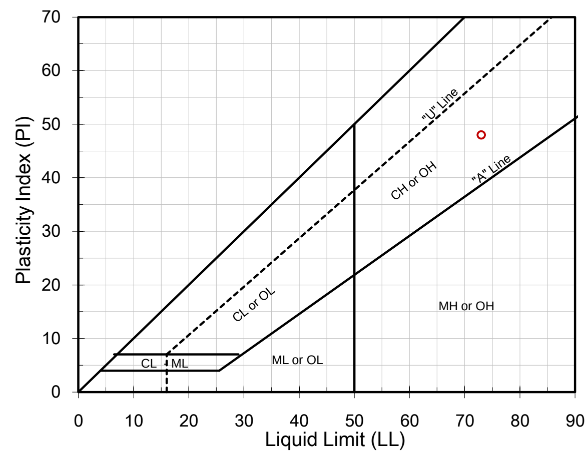
Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

Sample ID: 9-19 (28.0-30.0) P-9

TRI Log #: 53765.3





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.0	0.030	86.2	- -	- -
2 in.	50.8	100.0		0.020	79.4	- -	- -
1.5 in.	38.1	100.0		0.010	72.7	- -	- -
1 in.	25.4	100.0		0.008	68.1	- -	- -
3/4 in.	19.0	100.0		0.006	63.5	- -	- -
1/2 in.	12.7	100.0		0.003	56.6	- -	- -
3/8 in.	9.51	100.0		0.001	40.3	- -	- -
No. 4	4.76	100.0	2.1	Log-Linear Interpolation			
No. 10	2.00	99.8		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	99.3					
No. 40	0.420	99.0		mm		mm	
No. 60	0.250	98.9		0.005	61.7	0.005	- -
No. 100	0.149	98.7		0.002	48.5	0.002	- -
No. 200	0.074	97.9	97.9	N m,2μm,d	49	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	2.2E-03	4.2E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	12.0	(0.05-0.002	39.4	(< 0.002 mm)	48.6

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	73
Plastic Limit	25
Plastic Index	48
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	22.0
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021

Analysis & Quality Review/Date

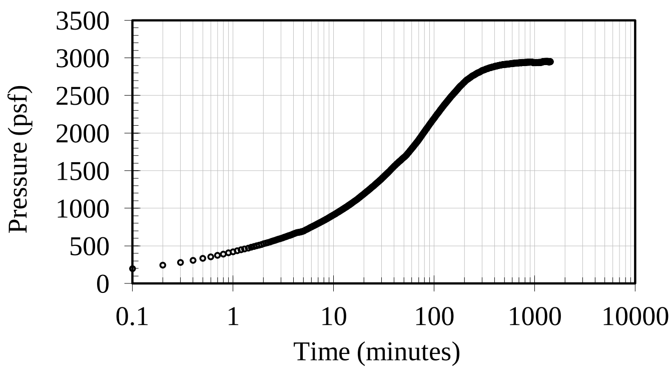
One-Dimensional Consolidation Properties of Soil

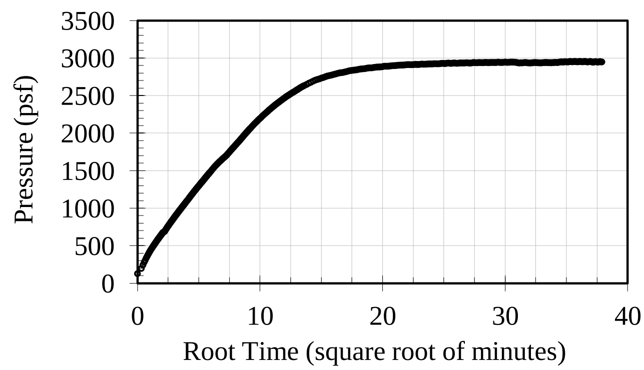
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 9-19 (28.0-30.0) P-9

TRI Log No.: 53765.3
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	19.7
Final Specimen Water Content (%)	23.0
Specimen Diameter (in)	2.495
Initial Specimen Height (in)	0.998
Initial Dry Unit Weight, γ_o lb_f/ft^3	101.9
Specific Gravity (Assumed)	2.75
Initial Void Ratio, e_o	0.622
Initial Degree of Saturation (%)	83.7

Swell Pressure (psf), Maximum Measured	2955





Note: The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. ***A client-prescribed seating stress pf 250 psf was utilized for testing.***

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

10-19

Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53566

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	10-19 (0.0-2.0) P-1	19.9	-	-	-	-	-
2	10-19 (2.0-3.5) SS-2	8.3	-	-	-	-	-
3	10-19 (4.0-6.0) P-3 Layer A	12.6	-	-	-	-	-
4	10-19 (4.0-6.0) P-3 Layer B	2.9	-	-	-	-	-
5	10-19 (6.0-8.0) ST-4	12.5	-	-	-	-	-
6	10-19 (8.0-9.5) SS-5 Layer A	14.3	-	-	-	-	-
7	10-19 (8.0-9.5) SS-5 Layer B	11.0	-	-	-	-	-
8	10-19 (13.0-15.0) P-6	25.3	-	-	-	-	-
9	10-19 (18.5-20.0) SS-7	11.7	-	-	-	-	-
10	10-19 (23.0-25.0) ST-8	14.4	-	-	-	-	-
11	10-19 (28.0-30.0) P-9	23.7	-	-	-	-	-
12	10-19 (33.0-35.0) ST-10	24.7	-	-	-	-	-
13	10-19 (38.5-40.0) SS-11	21.5	-	-	-	-	-
14	10-19 (43.0-45.0) P-12	17.8	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

11-19

Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 52918

Jeffrey A. Kuhn, Ph.D., P.E., 11/22/2020

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	11-19 (0.0-2.0) P-1	16.8	-	-	-	-	-
2	11-19 (2.0-3.5) SS-2	8.5	-	-	-	-	-
3	11-19 (4.0-6.0) ST-3	10.0	117.3	-	34	14	20
4	11-19 (6.0-8.0) P-4	14.7	-	-	-	-	-
5	11-19 (8.5-10.0) SS-5	13.3	-	-	-	-	-
6	11-19 (18.0-20.0) ST-7	18.2	-	82.8	55	19	36

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Client: AECOM TRI Log #: 53227

Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	11-19 (13.0-15.0) P-6	20.5	-	-	-	-	-
2	11-19 (23.5-25.0) SS-8	19.8	-	-	-	-	-
3	11-19 (28.0-30.0) P-9	19.4	-	-	-	-	-
4	11-19 (33.5-35.0) SS-10	17.3	-	-	-	-	-
5	11-19 (38.0-40.0) ST-11	21.1	-	94.3	73	25	48
6	11-19 (43.0-45.0) P-12	16.6	-	-	-	-	-
7	11-19 (48.5-50.0) SS-13	16.3	-	-	-	-	-
8	11-19 (53.0-55.0) ST-14	5.6	140.1	-	-	-	-
9	11-19 (53+2	2.0	-	-	-	-	-
10	11-19 (58.5-60.0) SS-16	1.1	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

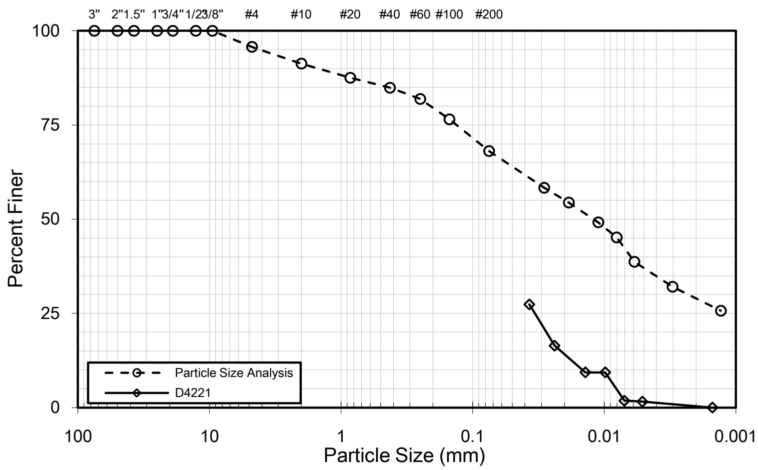
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

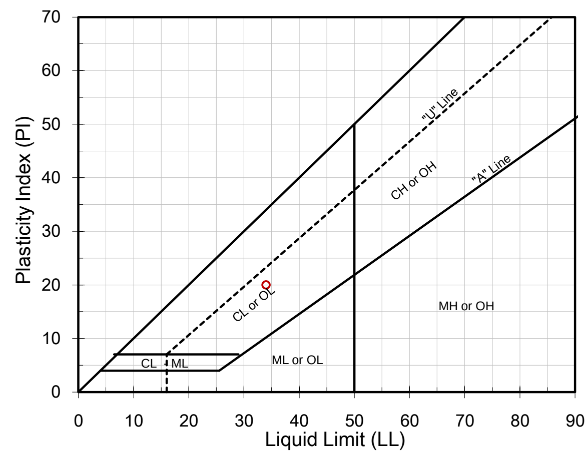
TRI ENVIRONMENTAL
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 11-19 (4.0-6.0) ST-3

TRI Log #: 52918.3





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	4.3	0.029	58.3	0.037	27.4
2 in.	50.8	100.0		0.019	54.4	0.024	16.4
1.5 in.	38.1	100.0		0.011	49.2	0.014	9.4
1 in.	25.4	100.0		0.008	45.2	0.010	9.4
3/4 in.	19.0	100.0		0.006	38.7	0.007	1.8
1/2 in.	12.7	100.0		0.003	32.1	0.005	1.6
3/8 in.	9.51	100.0		0.001	25.7	0.002	- -
No. 4	4.76	95.7	27.6	Log-Linear Interpolation			
No. 10	2.00	91.3		Particle Size (mm)	Percent Passing	Particle Size (mm)	Percent Passing
No. 20	0.841	87.5					
No. 40	0.420	84.9					
No. 60	0.250	81.9		0.005	37.1	0.005	- -
No. 100	0.149	76.5		0.002	29.0	0.002	- -
No. 200	0.074	68.1	68.1	N m,2μm,d	29	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	2.3E-03	1.2E-02	3.4E-02	- -	- -	-

USDA	Sand (%) (2.0-0.05 mm)		Silt (%) (0.05-0.002)		Clay (%) (< 0.002 mm)	
Clay Loam		31.4		36.9		31.8

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	34
Plastic Limit	14
Plastic Index	20
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Sandy lean clay (CL)

Moisture Content (%)	ASTM D2216	10.0
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 11/22/2020
Analysis & Quality Review/Date

Consolidated-Undrained Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 11-19 (18.0-20.0) ST-7

TRI Log #: 52918.6
Test Method: ASTM D4767

Specimens				
Identification	1	2	3	4
Depth/Elev. (ft)	-	-	-	-
Eff. Consol. Stress (psi)	6.9	17.4	34.7	-
Initial Specimen Properties				
Avg. Diameter (in)	1.43	1.44	1.46	-
Avg. Height (in)	3.33	3.21	3.28	-
Avg. Water Content (%)	10.8	5.7	11.1	-
Bulk Density (pcf)	130.1	123.7	128.7	-
Dry Density (pcf)	117.4	117.1	115.8	-
Specific Gravity (Assumed)	2.70			
Saturation (%)	66.9	34.8	66.0	-
Void Ratio, n	0.43	0.44	0.46	-
B-Value, End of Saturation	1.00	0.98	0.96	-

Test Setup	
Specimen Condition	Undisturbed / Intact
Specimen Preparation	Trimmed
Mounting Method	Wet
Consolidation	Isotropic

Post-Consolidation / Pre-Shear				
Void Ratio	0.43	0.41	0.41	-

Shear / Post-Shear				
Rate of Strain (%/hr)	0.35	0.30	0.30	-
Avg. Water Content (%)	19.6	26.9	22.1	-

At Failure								
Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$				Ratio, $(\sigma_1'/\sigma_3')_{max}$			
Axial Strain at Failure (%), $\varepsilon_{a,f}$	14.9	13.6	12.2	-	1.4	2.4	5.6	-
Minor Effective Stress (psi), $\sigma_3'_f$	10.9	16.8	29.3	-	2.8	11.0	25.4	-
Principal Stress Difference (psi), $(\sigma_1-\sigma_3)_f$	24.2	29.2	39.4	-	15.2	23.2	35.9	-
Pore Water Pressure, Δu_f (psi)	-3.8	0.7	5.4	-	4.2	6.4	9.3	-
Major Effective Stress (psi), $\sigma_1'_f$	35.0	45.9	68.6	-	18.0	34.2	61.3	-
Secant Friction Angle (degrees)	31.8	27.8	23.7	-	47.0	30.9	24.5	-
Effective Friction Angle (degrees)	16.9				18.3			
Effective Cohesion (psi)	5.7				4.6			

Note: The presented M-C parameters are based on a linear regression in modified stress space, across all assigned effective consolidation stresses. This fit does not purported to capture typical curvature of envelopes that may, in particular, be observed across broader range in effective stresses. Please note that the stresses associated with peak principal stress ratio and peak principal stress difference are presented in tabular form on the first page of the report. There are alternate interpretations to theses two failure criterion including but not limited to strain compatibility and post-peak.

Jeffrey A. Kuhn , Ph.D., P.E., 11/22/2020
Analysis & Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Consolidated-Undrained Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 11-19 (18.0-20.0) ST-7

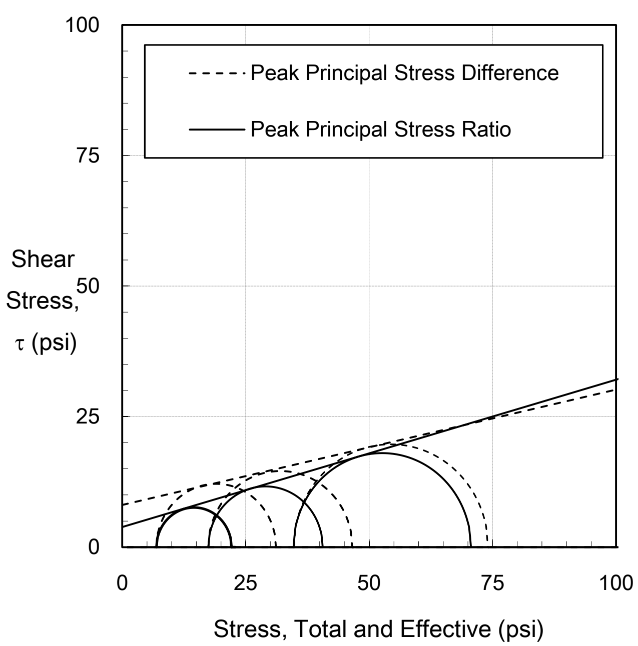
TRI Log #: 52918.6
Test Method: ASTM D4767

R / "Total Stress" Envelope			
Failure Criterion: Peak Principal Stress		Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Friction Angle (deg)	ϕ_R	12.5	15.8
Cohesion (psi)	c_R	8.1	3.8

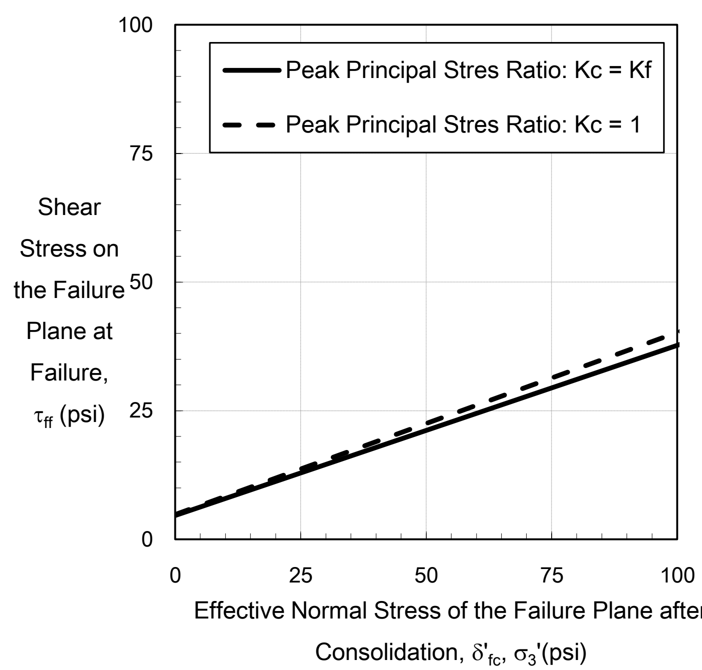
Kc = Kf Envelope, Effective Stress Envelope (Duncan et al. 1990)			
Failure Criterion: Peak Principal Stress		Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	ϕ'	16.9	18.3
Effective Cohesion (psi)	c'	5.7	4.6

Kc = 1 (τ_{ff} vs σ'_{fc}) Envelope, Total Stress Envelope (Duncan et al. 1990)			
Failure Criterion: Peak Principal Stress		Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Friction Angle (deg)	$d_{Kc=1}$	14.7	19.5
Cohesion (psi)	$\psi_{Kc=1}$	9.6	4.8

R / "Total Stress" Envelope



Three-Stage Rapid Drawdown Envelopes



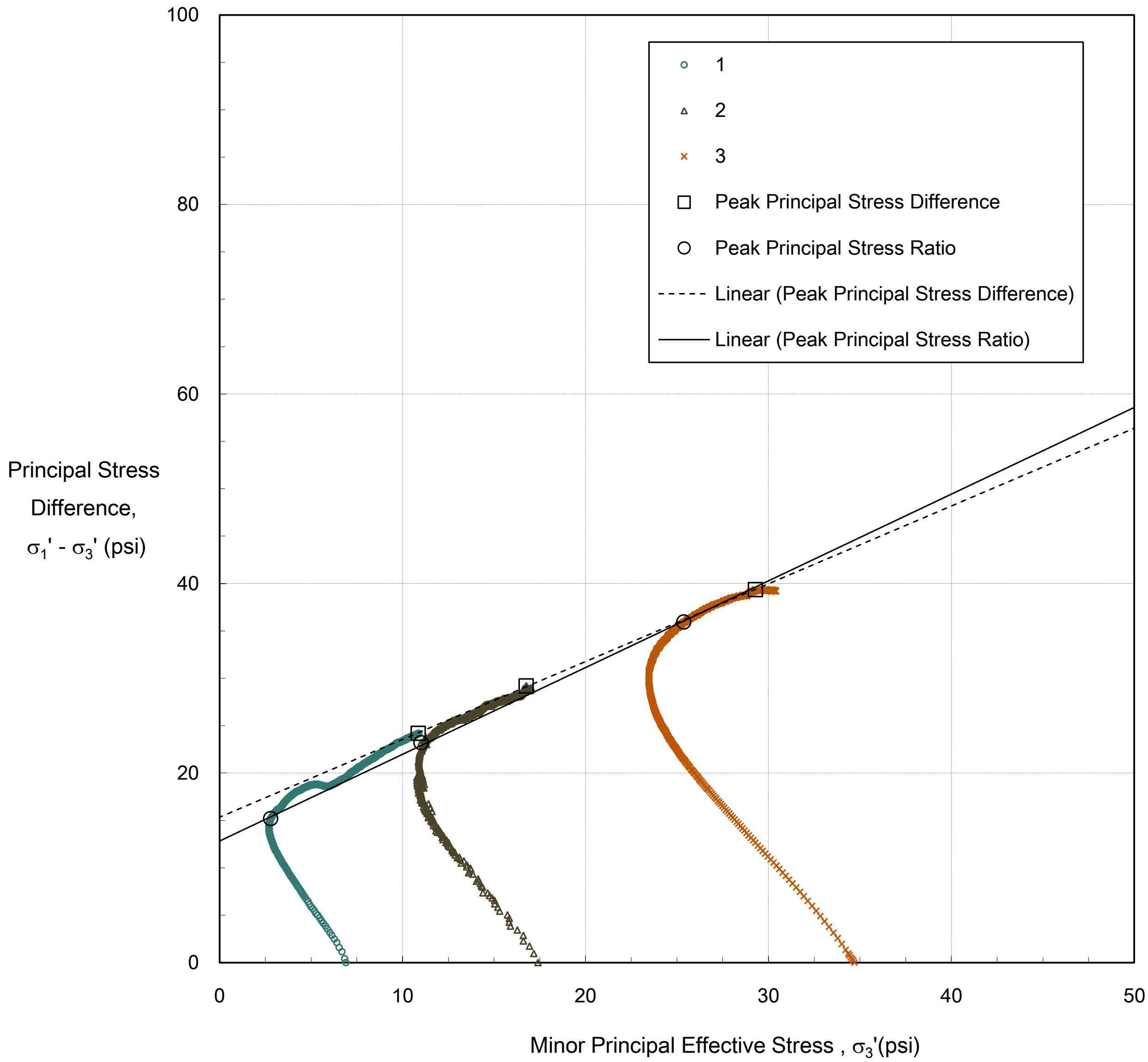
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Consolidated-Undrained Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 11-19 (18.0-20.0) ST-7

TRI Log #: 52918.6
Test Method: ASTM D4767

Modified Mohr-Coulomb



Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	16.9	18.3
Effective Cohesion (psi)	5.7	4.6

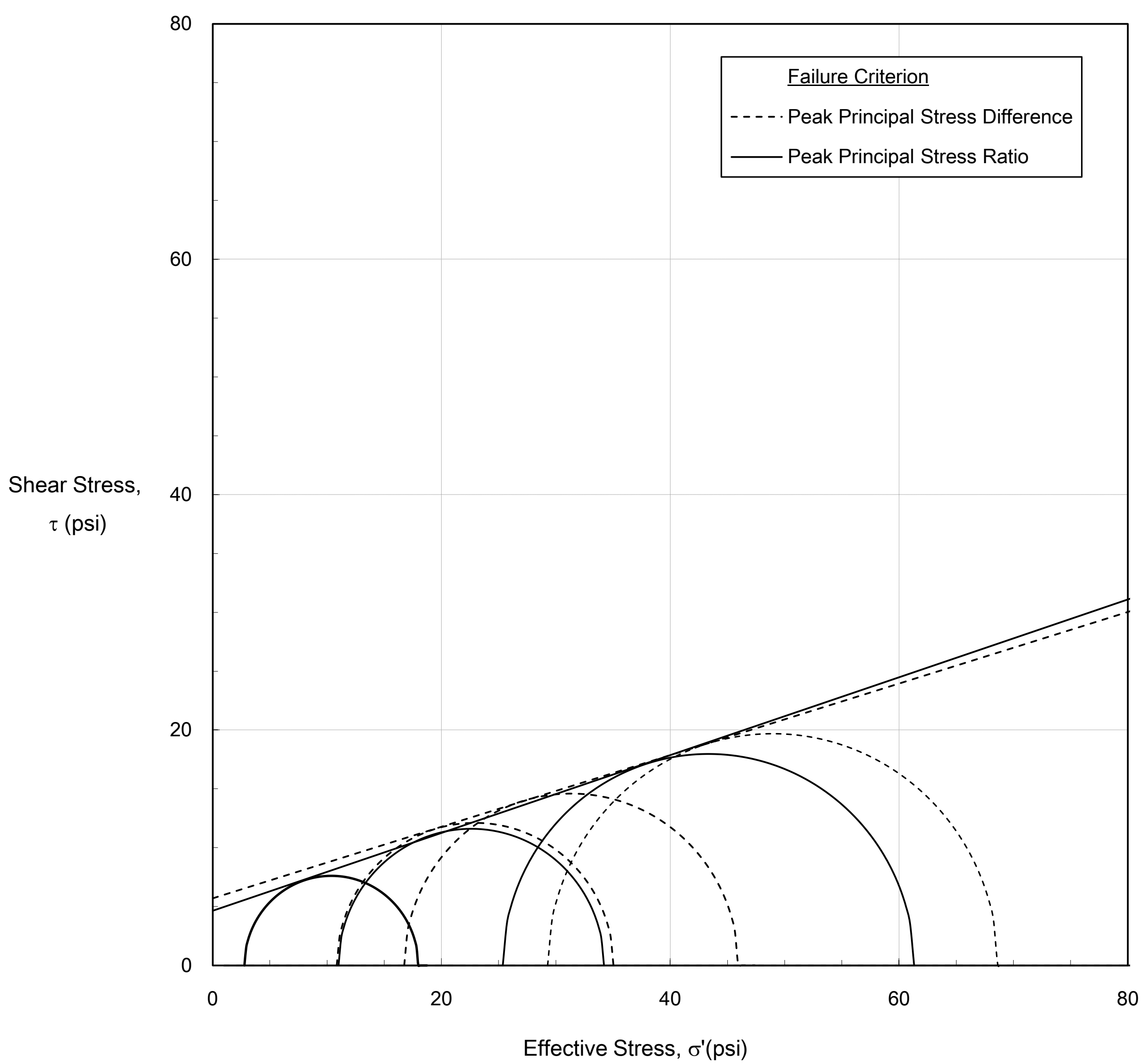
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Consolidated-Undrained Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 11-19 (18.0-20.0) ST-7

TRI Log #: 52918.6
Test Method: ASTM D4767

Mohr-Coulomb

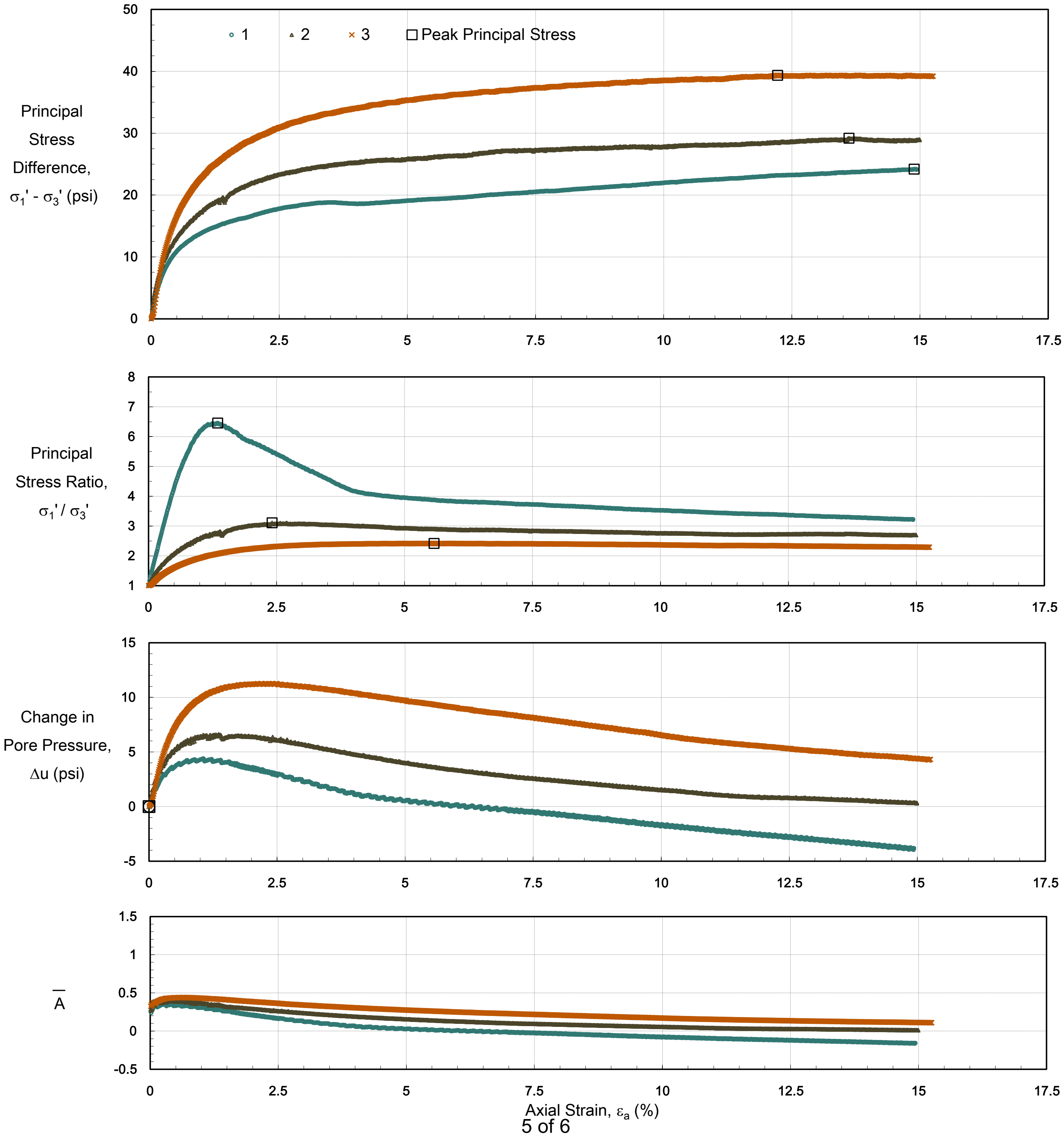


Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	16.9	18.3
Effective Cohesion (psi)	5.7	4.6

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Consolidated-Undrained Triaxial Compression

Client:	AECOM	TRI Log #:	52918.6
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D4767
Sample:	11-19 (18.0-20.0) ST-7		



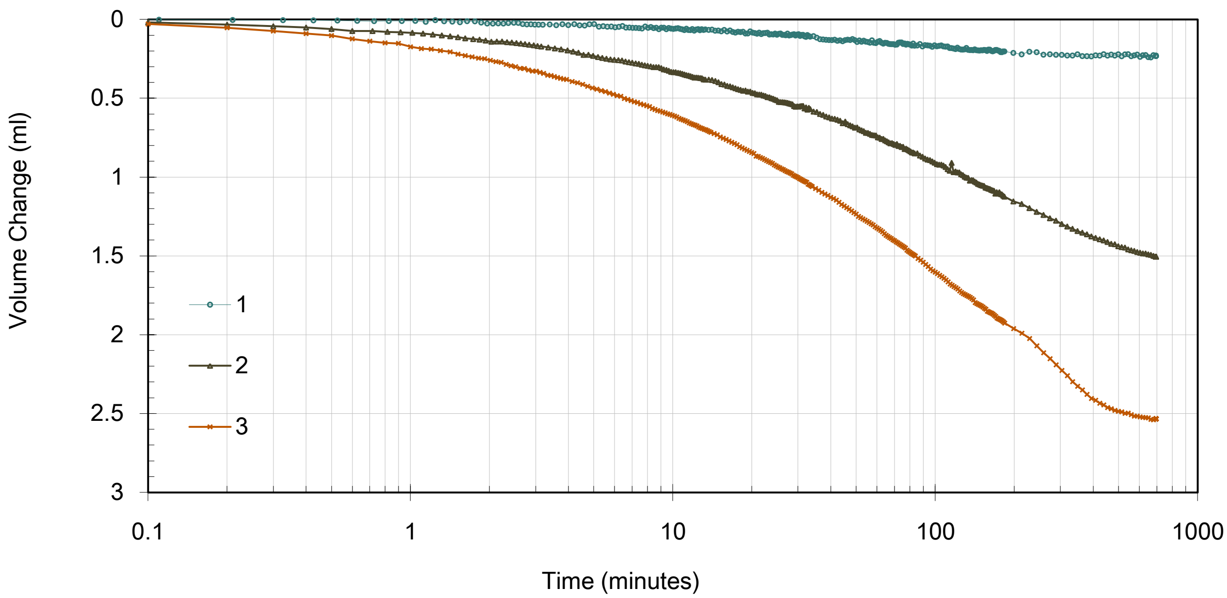
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

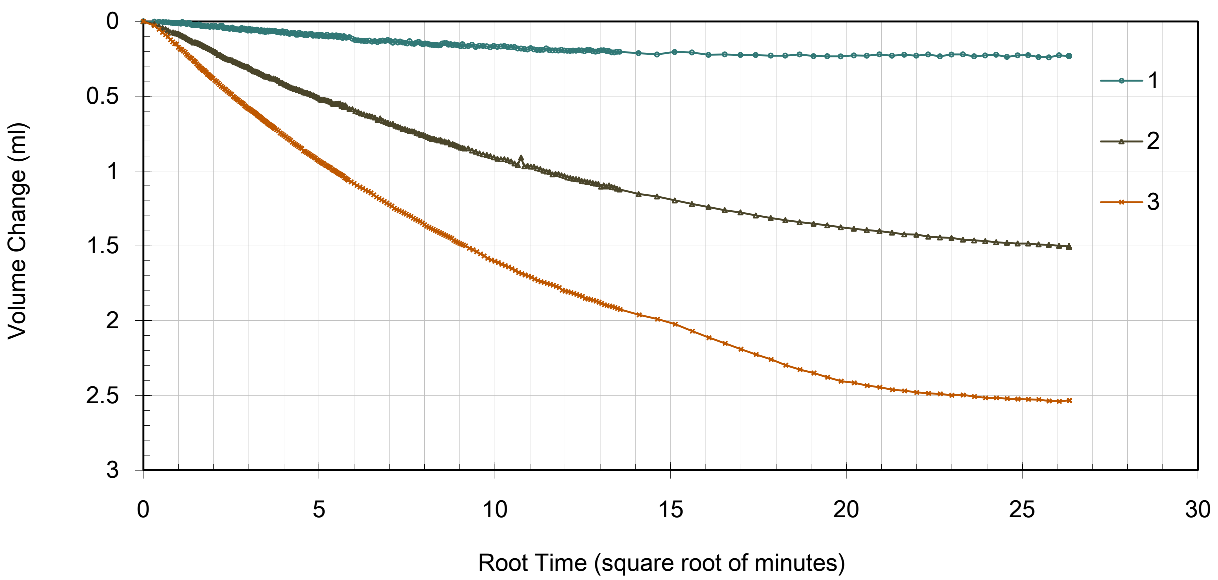
Consolidated-Undrained Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 11-19 (18.0-20.0) ST-7

TRI Log #: 52918.6
Test Method: ASTM D4767

Consolidation





TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 52918
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
3	11-19 (4.0-6.0) ST-3	3.5	33.5	22.0	22.1	22.7	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 11/22/2020
Quality Review/Date

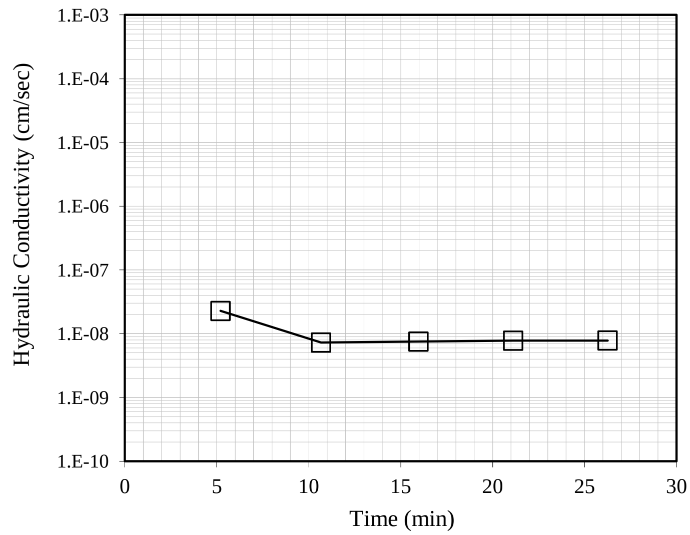
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Hydraulic Conductivity

Client: AECOM
Project: 606150067-1.4.14 Plum Creek 2
Sample ID: 11-19 (38.0-40.0) ST-11

TRI Log #: 53227.5
Test Method: ASTM D5084

Sample Condition	Initial	Final
	Undisturbed	Post-Test
Diameter (in)	2.85	2.88
Height (in)	4.23	4.25
Mass (g)	878.2	888.6
Sample Area (in^2)	6.39	6.50
Water Content (%)	22.3	29.2
Total Unit Weight (pcf)	123.8	122.4
Dry Unit Weight (pcf)	101.3	94.7
Specific Gravity (Assumed)	2.75	
Degree of Saturation	88.1	99.0
Void Ratio	0.69	0.81
Porosity	0.41	0.45
1 Pore Volume (cc)	181.4	203.2



Eff. Confining Stress (psi)	5.0
Back-Pressure	55.0
B-Value Prior to Permeation	0.89
Permeant	De-Aired Tap Water

Method F—Constant Volume–Falling Head by mercury, rising tailwater elevation			
Manometer Constants		Aa (cm^2)	0.767
M1	0.0302	Ap (cm^2)	0.0314
M2	1.041	Z_p (cm)	1.7
Time, t	Trial Constant, Z_1	Gradient	K_{20}
Min	-	-	cm/s
5.2	27.1	31.6	2.3E-08
10.7	26.8	31.3	7.3E-09
16.0	26.6	31.2	7.5E-09
21.1	26.5	31.0	7.8E-09
26.3	26.4	30.9	7.8E-09
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
Average, Last 2 Readings			**7.8E-09**

Specimen Image

Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021
Analysis & Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

12-19

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53567

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)
-	Test Method	ASTM D2216
1	12-19 (0.0-2.0) P-1	18.9
2	12-19 (2.0-3.5) SS-2	12.7
3	12-19 (4.0-6.0) P-3	2.3
4	12-19 (6.0-7.5) SS-4	10.5
5	12-19 (8.0-10.0) ST-5	19.3
6	12-19 (13.0-15.0) P-6	17.0
7	12-19 (18.5-20.0) SS-7	19.9
8	12-19 (23.0-25.0) ST-8	23.1
9	12-19 (28.0-30.0) P-9	21.2
10	12-19 (33.0-34.5) SS-10	21.1
11	12-19 (38.0-40.0) ST-11	23.9
12	12-19 (43.0-45.0) P-12	18.2
13	12-19 (48.0-50.0) ST-13	18.5
14	12-19 (53.0-54.5) SS-14	4.1
15	12-19 (58.5-60.0) SS-15	4.3

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

13-20

Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 59915

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	13-20 (0-2) P-1	17.3	-	-	-	-	-
2	13-20 (2-4) ST-2	-	-	-	64	27	37
3	13-20 (4-6) P-3	19.9	-	-	-	-	-
4	13-20 (6-8) ST-4	-	-	89.5	61	20	41
5	13-20 (8-9.5) SS-5	23.3	-	-	-	-	-
6	13-20 (13-15) P-6	23.4	-	-	-	-	-
7	13-20 (18-20) ST-7	-	-	99.2	52	18	34
8	13-20 (28-29.5) SS-8	23.7	-	-	-	-	-
9	13-20 (33-35) ST-9	24.1	-	-	-	-	-
10	13-20 (38-39.5) SS-10	20.2	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

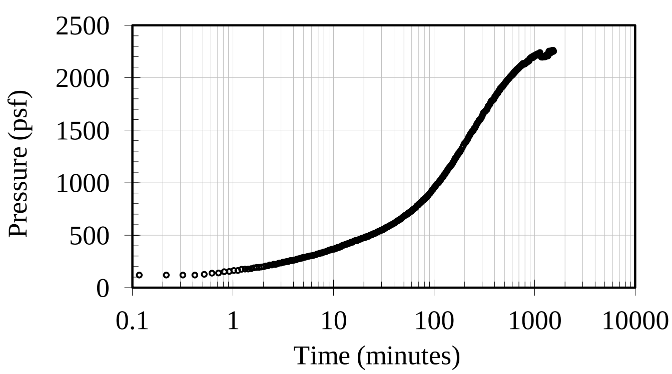
One-Dimensional Consolidation Properties of Soil

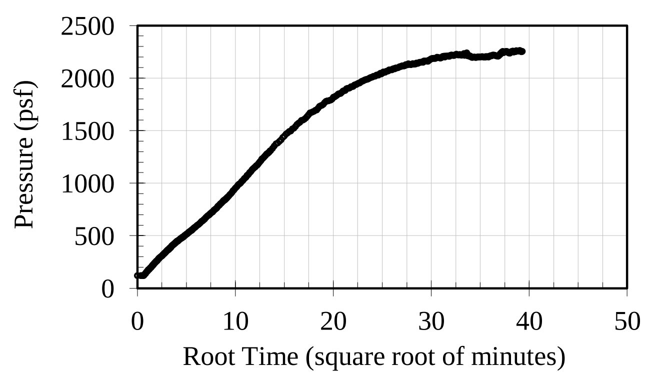
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 13-20 (2-4) ST-2

TRI Log No.: 59915.2
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	16.8
Final Specimen Water Content (%)	20.1
Specimen Diameter (in)	2.495
Initial Specimen Height (in)	1.001
Initial Dry Unit Weight, γ_o lb_f/ft^3	107.4
Specific Gravity (Assumed)	2.75
Initial Void Ratio, e_o	0.540
Initial Degree of Saturation (%)	82.3

Swell Pressure (psf), Maximum Measured	2262





Note: The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. ***A seating stress of 120 psf was utilized for testing.***

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

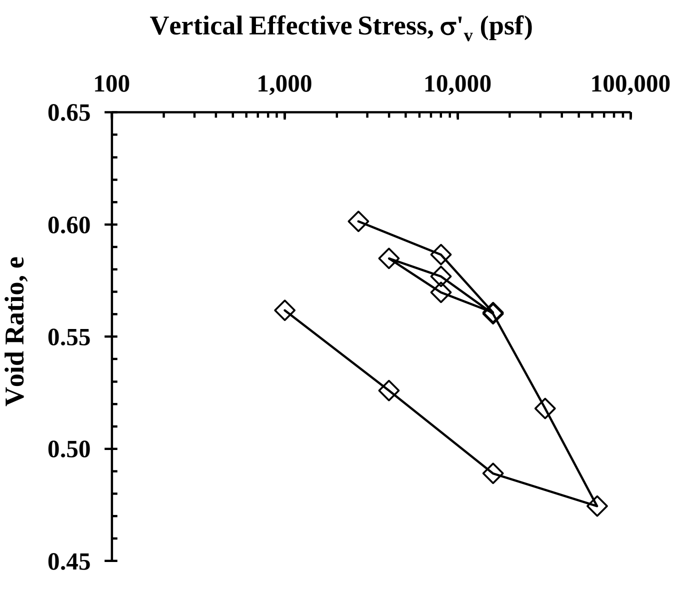
One-Dimensional Consolidation Properties of Soil

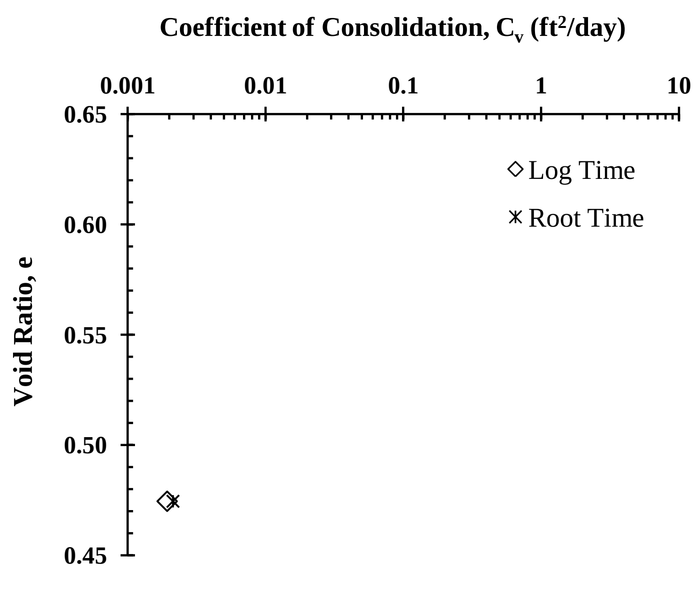
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 13-20 (6-8) ST-4

TRI Log No.: 59915.4
Test Method: ASTM D 2435, Method B

Soil Specimen Properties		
Initial Specimen Water Content (%)		20.8
Final Specimen Water Content (%)		16.0
Specimen Diameter (in)		2.495
Initial Specimen Height (in)		0.998
Final Specimen Height (in)		0.974
Final Differential Height (in)		0.024
Initial Dry Unit Weight, γ_o lb_f/ft^3		103.3
Final Dry Unit Weight, γ_f lb_f/ft^3		105.9
Specific Gravity (Assumed)		2.70
Initial Void Ratio, e_o		0.601
Final Void Ratio, e_f		0.562
Initial Degree of Saturation (%)		91.5
Preconsolidation Pressure (psf)		≈11400
Swell Pressure (psf), Maximum Measured		2666
Compression Index, C_c	Min	-
	Max	0.145
Recompression Index, C_r	Min	0.027
	Max	0.055

Stage	σ'$_v$	e	Strain, ε	C_v (ft^2/day)	
(#)	(psf)	(-)	(%)	Log Time	Root Time
1	2,666	0.601	0.0	-	-
2	8,000	0.587	0.9	-	-
3	16,000	0.561	2.5	-	-
4	8,000	0.570	2.0	-	-
5	4,000	0.585	1.0	-	-
6	8,000	0.577	1.5	-	-
7	16,000	0.560	2.6	-	-
8	32,000	0.518	5.2	-	-
9	64,000	0.474	7.9	1.9E-03	2.1E-03
10	16,000	0.489	7.0	-	-
11	4,000	0.526	4.7	-	-
12	1,000	0.562	2.5	-	-
13	-	-	-	-	-
14	-	-	-	-	-
15	-	-	-	-	-





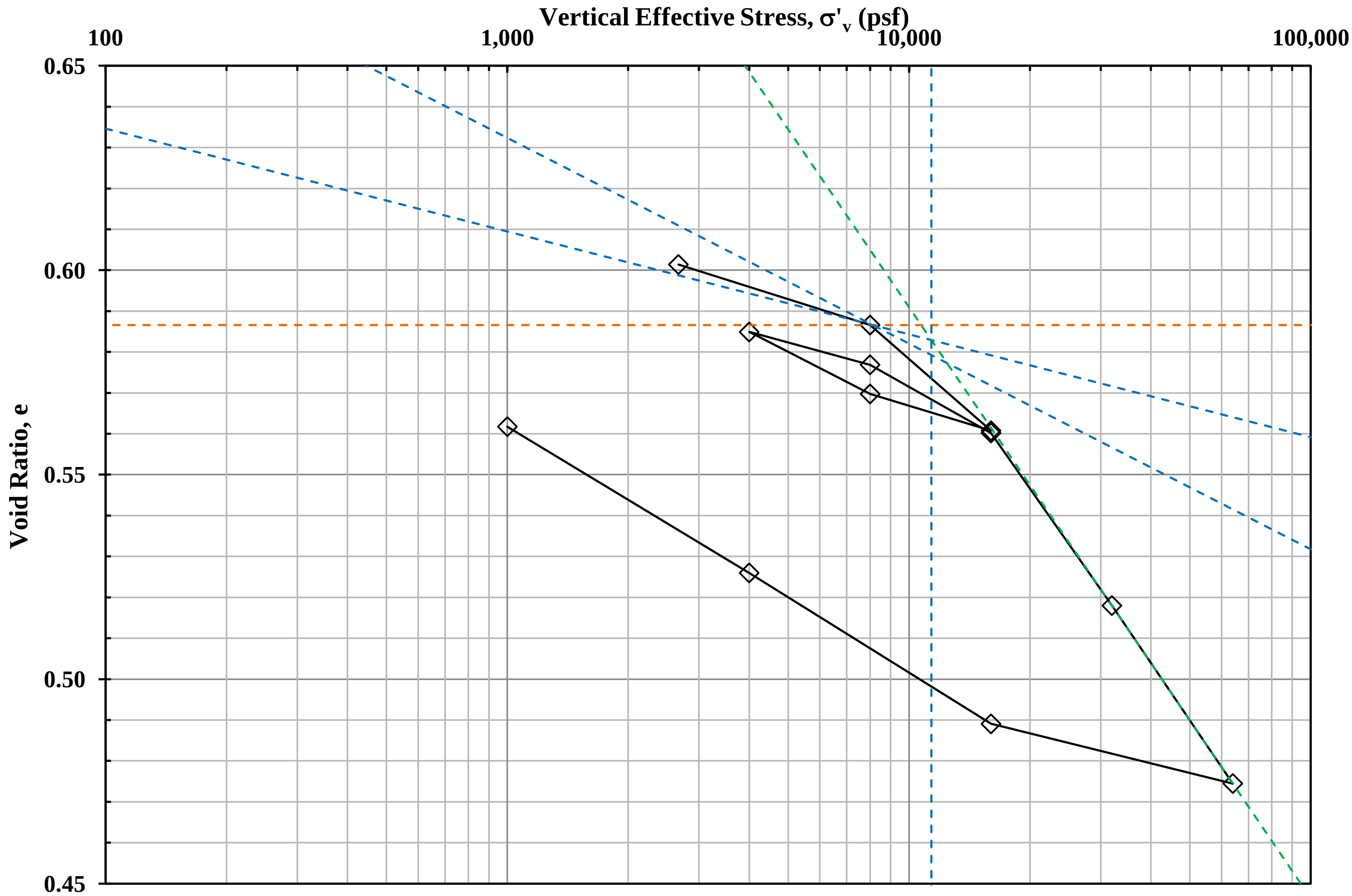
The intact sample was provided by the client. A specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. Coefficient of Consolidation was determined using the Log Time and Root Time Methods. Calculations include machine deflections measured at each loading step. The preconsolidation pressure was determined using the Casagrande construction technique.

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

One-Dimensional Consolidation Properties of Soil

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 13-20 (6-8) ST-4

TRI Log No.: 59915.4
Test Method: ASTM D 2435, Method B



Stage	σ'v	log (σ'v)	e	δlog (σ'v)
(#)	(psf)	log (psf)	(-)	δe
1	2,666	3.43	0.601	-
2	8,000	3.90	0.587	0.031
3	16,000	4.20	0.561	0.086
4	8,000	3.90	0.570	-
5	4,000	3.60	0.585	-
6	8,000	3.90	0.577	0.027
7	16,000	4.20	0.560	0.055
8	32,000	4.51	0.518	0.140
9	64,000	4.81	0.474	0.145
10	16,000	4.20	0.489	-

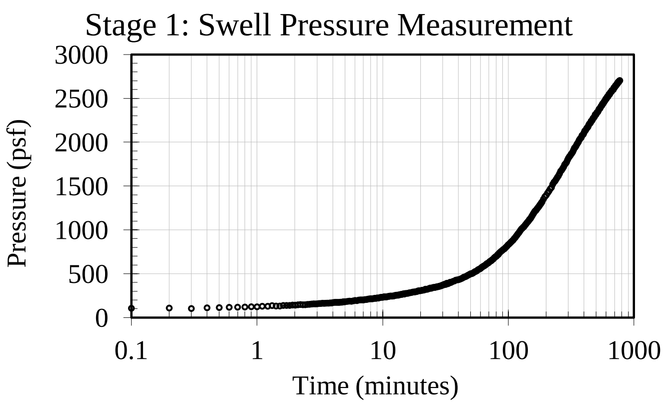
Stage	σ'v	log (σ'v)	e	δlog (σ'v)
(#)	(psf)	log (psf)	(-)	δe
11	4,000	3.60	0.526	-
12	1,000	3.00	0.562	-
13	-	-	-	-
14	-	-	-	-
15	-	-	-	-
16	-	-	-	-
17	-	-	-	-
18	-	-	-	-
19	-	-	-	-
20	-	-	-	-

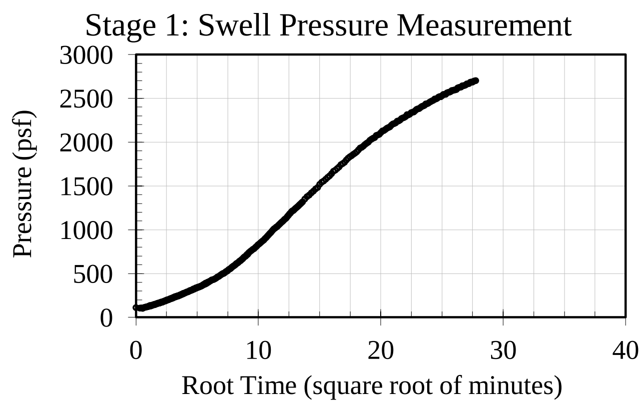
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

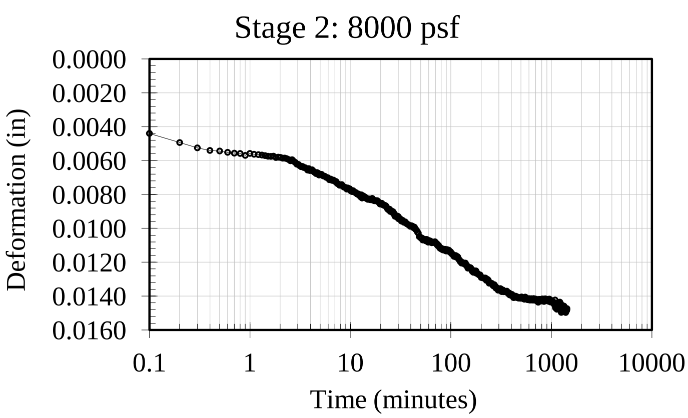
One-Dimensional Consolidation Properties of Soil

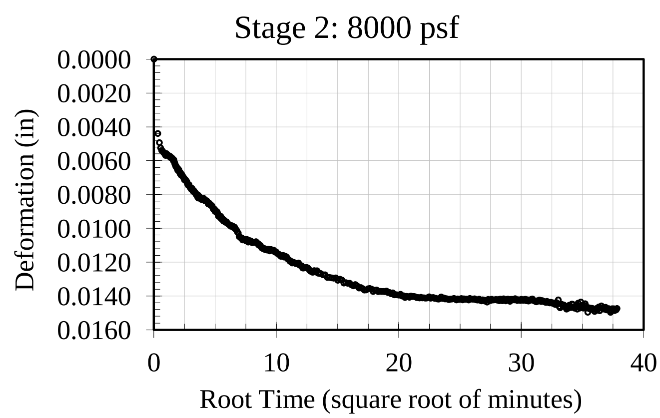
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 13-20 (6-8) ST-4

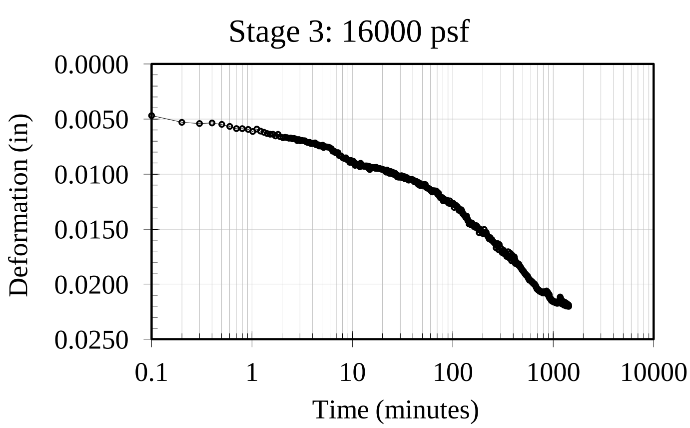
TRI Log No.: 59915.4
Test Method: ASTM D 2435, Method B

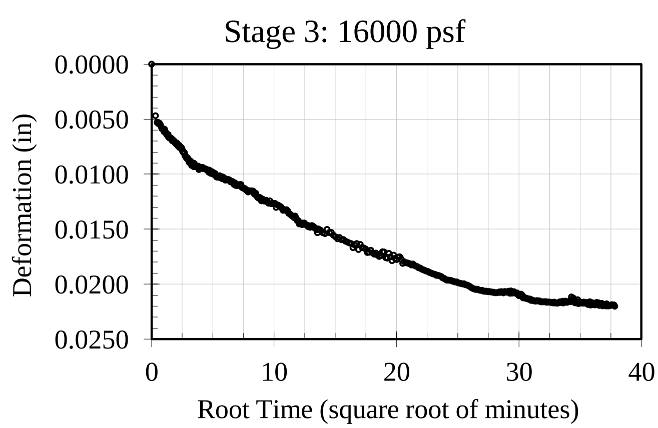










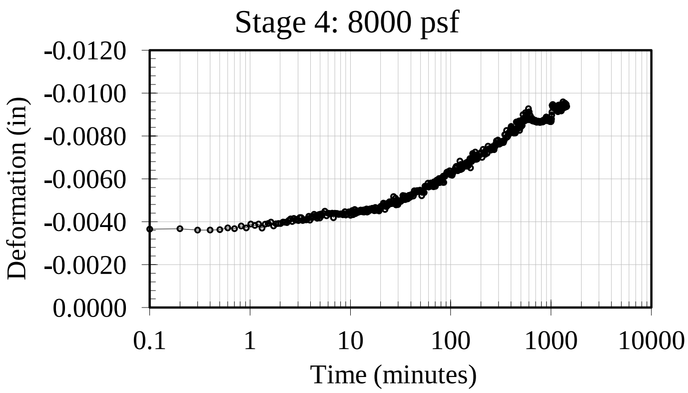


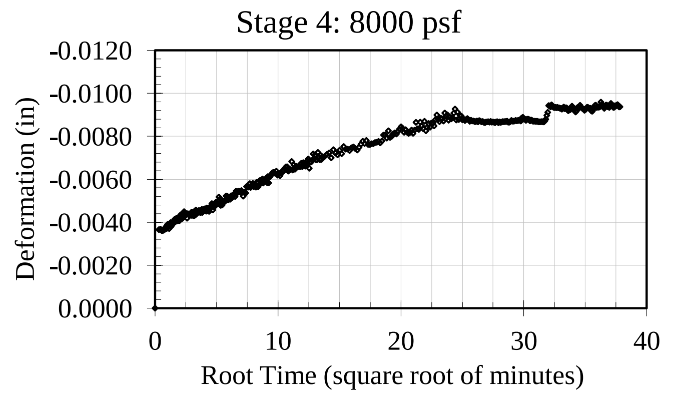
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

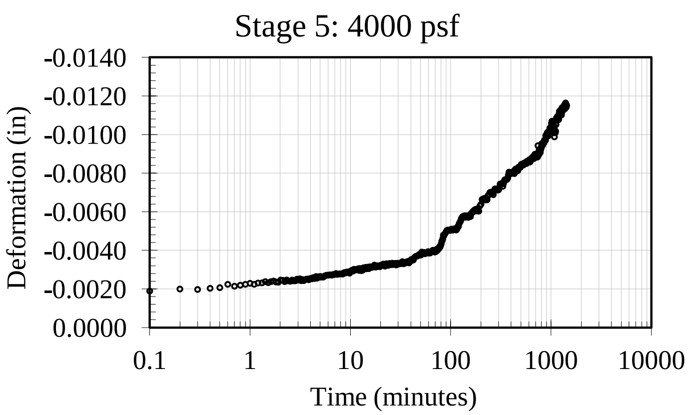
One-Dimensional Consolidation Properties of Soil

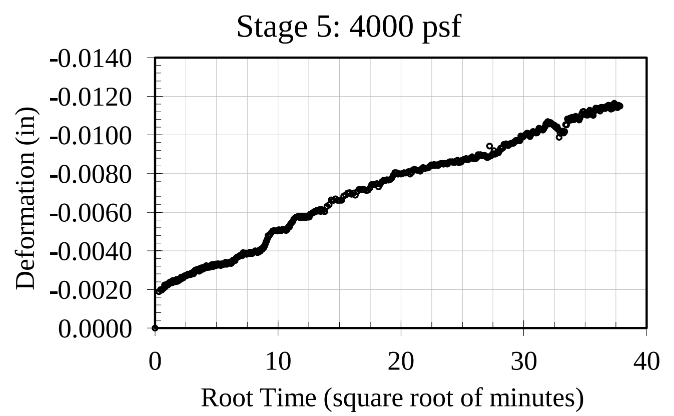
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 13-20 (6-8) ST-4

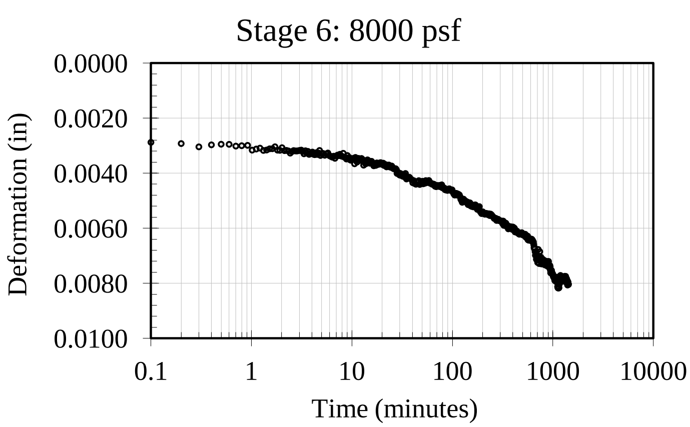
TRI Log No.: 59915.4
Test Method: ASTM D 2435, Method B

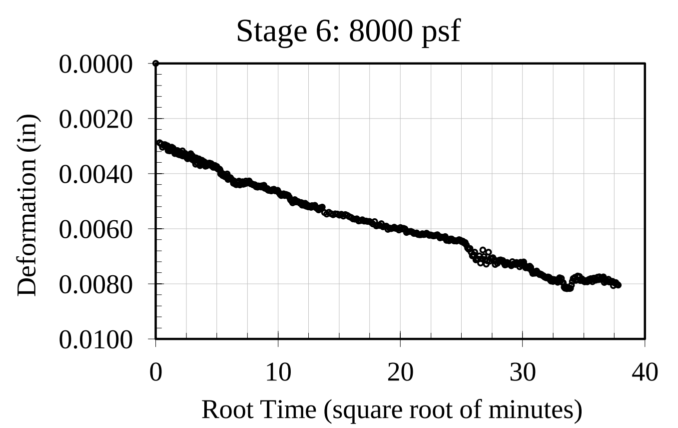










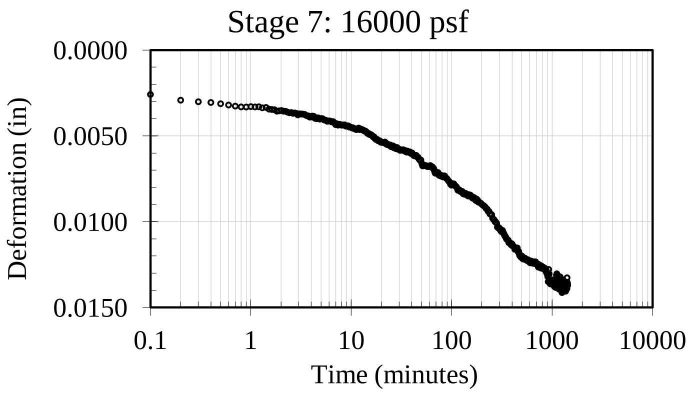


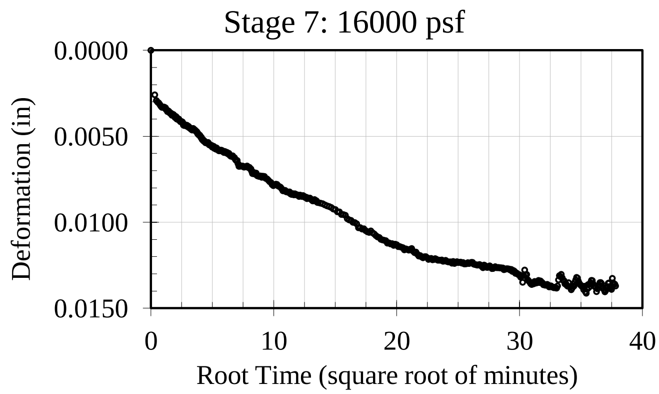
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

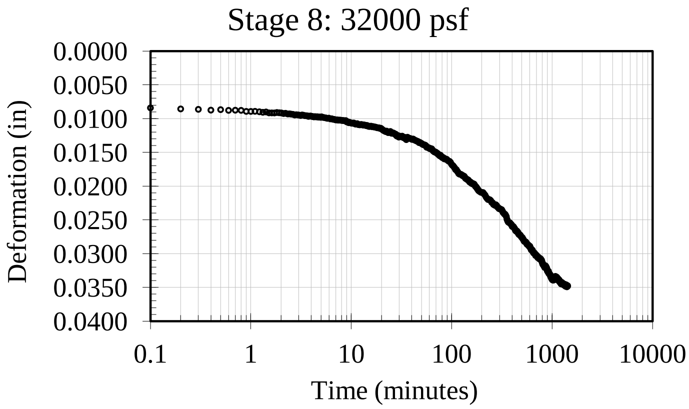
One-Dimensional Consolidation Properties of Soil

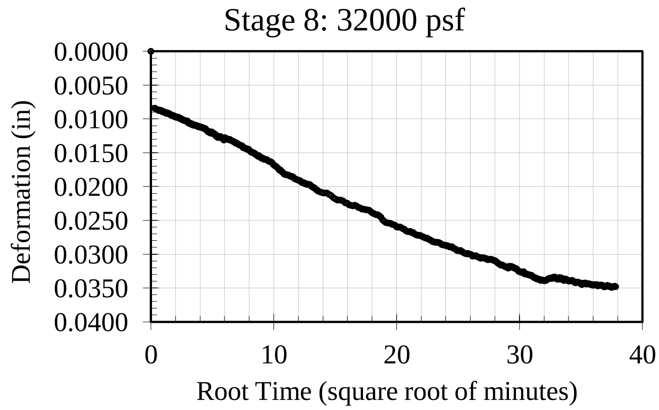
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 13-20 (6-8) ST-4

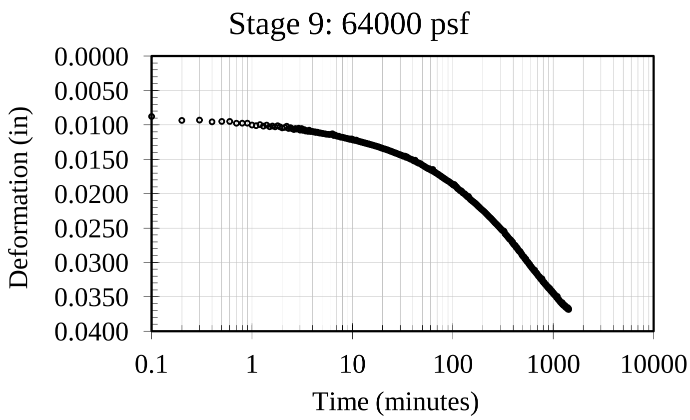
TRI Log No.: 59915.4
Test Method: ASTM D 2435, Method B

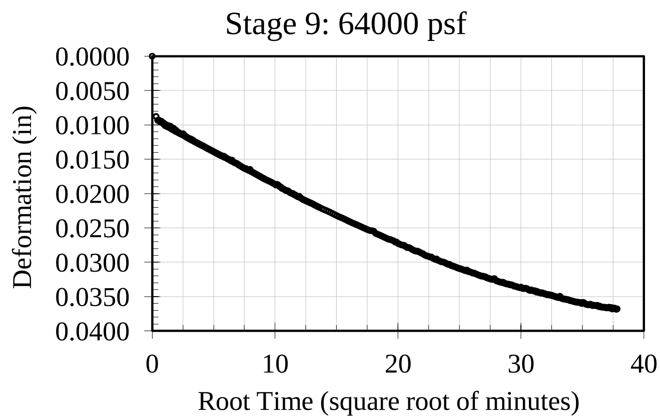










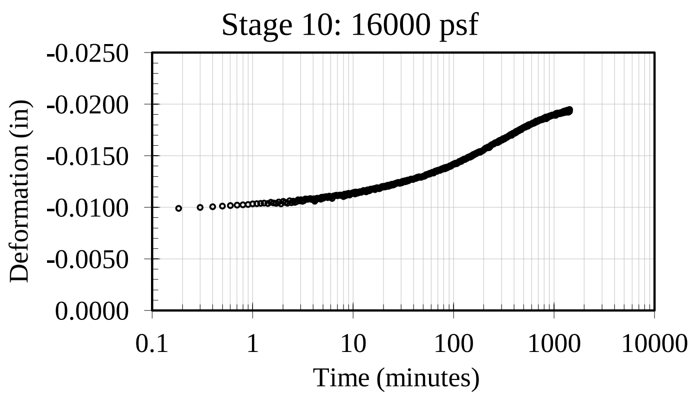


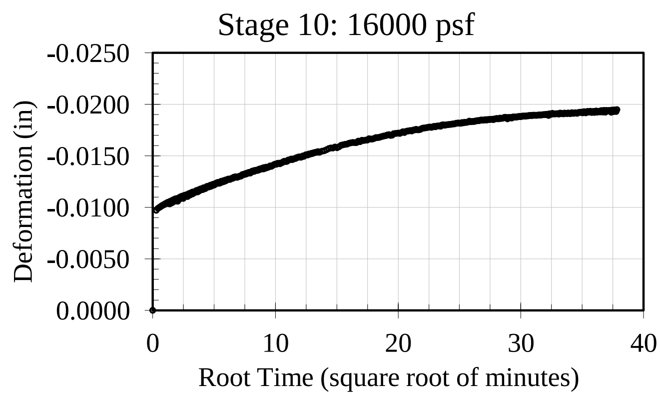
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

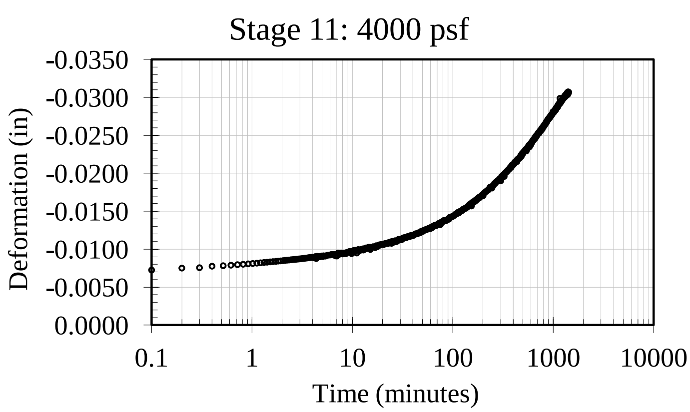
One-Dimensional Consolidation Properties of Soil

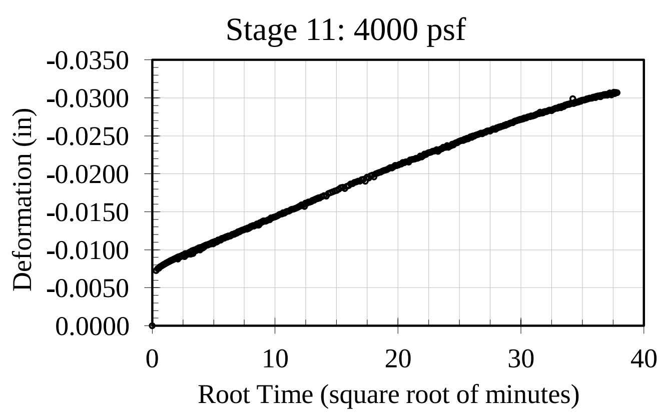
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 13-20 (6-8) ST-4

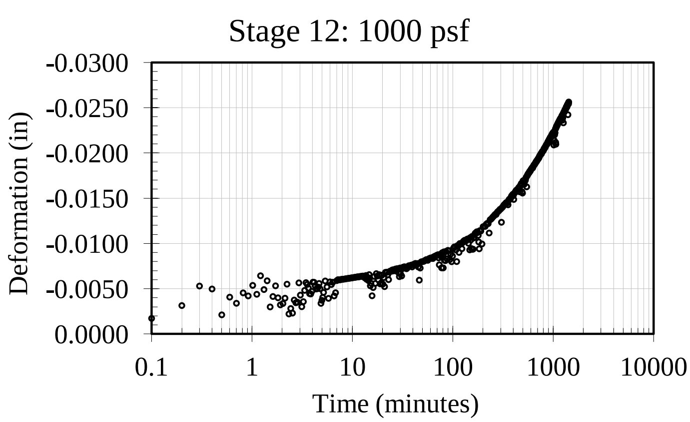
TRI Log No.: 59915.4
Test Method: ASTM D 2435, Method B

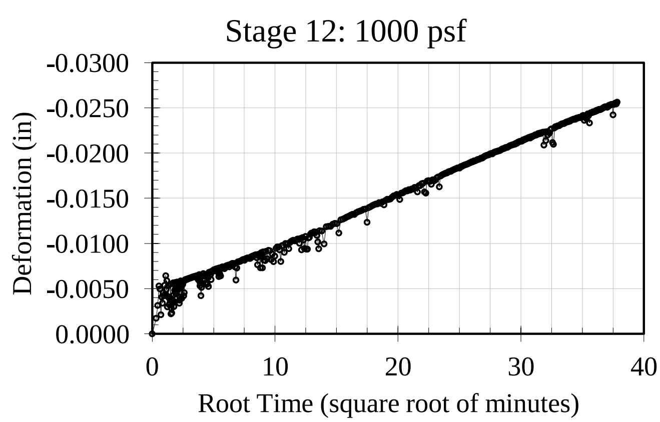










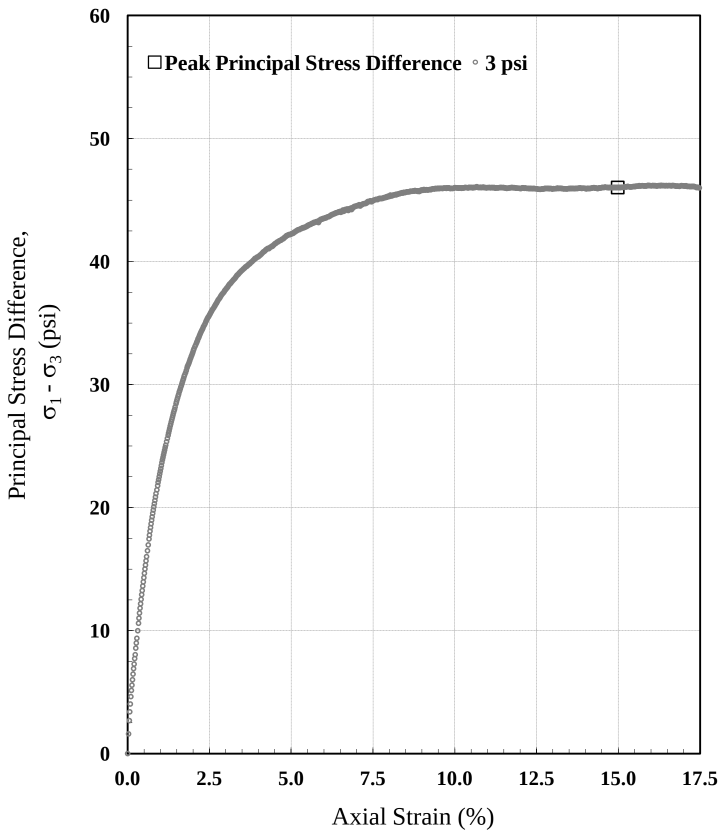


TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Unconsolidated-Undrained (Q) Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 13-20 (6-8) ST-4

TRI Log #: 59915.4
Test Method: ASTM D2850



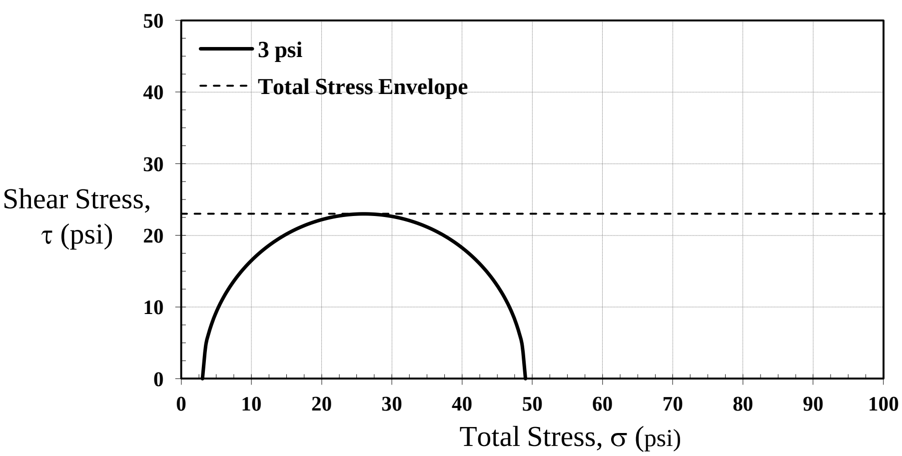
Test Parameters	
Minor Principal Stress (psi)	3.0
Rate of Strain (%/hr)	60

Initial Properties	
Avg. Diameter (in)	2.76
Avg. Height (in)	5.72
Avg. Water Content (%)	19.1
Bulk Density (pcf)	129.1
Dry Density (pcf)	108.4
Saturation (%)	91.1
Void Ratio	0.57
Specific Gravity (Assumed)	2.73

At Failure - Maximum Deviator Stress	
Axial Strain at Failure (%)	15.0
Minor Total Stress (psi)	3.0
Major Total Stress (psi)	49.0
Principal Stress Diff. (psi)	46.0

Total Stress Envelope	
Friction Angle (deg)	0
Undrained Shear Strength, S_u (psi)	23.0
S_u / σ_3	7.7

Note: The calculated value of specimen saturation was less than 95%. The Mohr failure envelope was taken as a horizontal straight line, but noting that the calculated value of saturation indicates a partially saturated specimen.



Jeffrey A. Kuhn , Ph.D., P.E., 3/22/2021
Analysis & Quality Review/Date

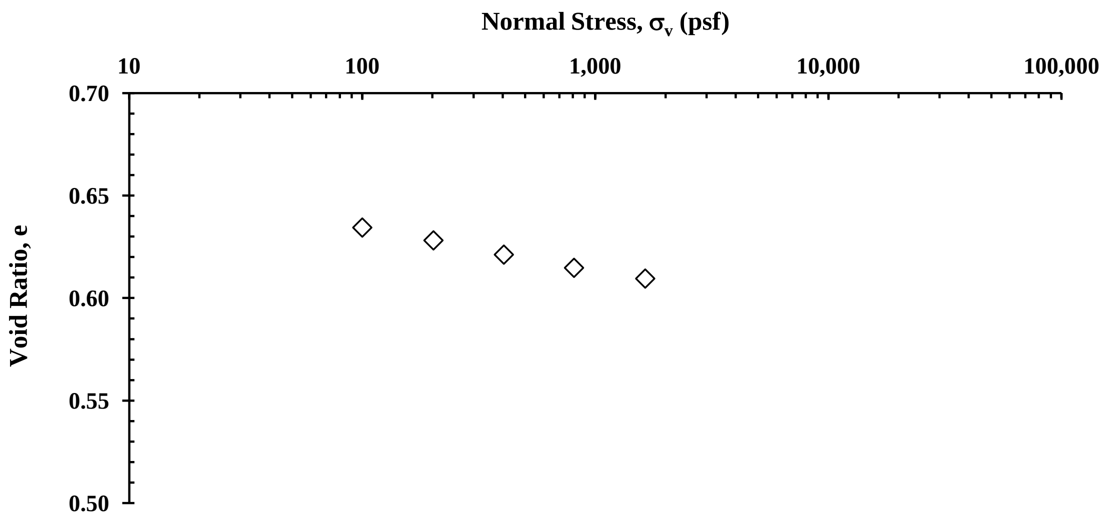
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Swell Pressure Measurement with Multistage Unloading

Client:	AECOM	TRI Log #:	59915.4
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D4546-B MOD
Specimen:	13-20 (6-8) ST-4		

Stage	Initial[1,2]	Normal Stress (psf)[3,4]				
Normal Stress (psf)	120	1,637	810	405	202	100
Water Content, ω (%)	20.7	-	-	-	21.2	21.2
Diameter, d (in)	2.500	-	-	-	-	-
Height, h (in)	0.984	0.984	0.988	0.991	0.996	1.000
Total Unit Weight (pcf)	128.6	-	-	-	-	128.6
Dry Unit Weight (pcf)	106.6	-	-	-	-	106.6
Void Ratio, e	0.610	0.610	0.615	0.621	0.628	0.634
$\Delta e / \Delta \log(\sigma)$	-	-	-0.017	-0.021	-0.023	-0.021
Degree of Saturation, S (%)	89.8	-	-	-	-	88.6
Strain (%)[3,4]	0.000	0.000	-0.326	-0.726	-1.157	-1.547

1. The intact sample was provided by the client. A specimen was trimmed from the sample using a trimming turntable and mounted. Gs was assumed to be 2.75. Calculations include measured machine deflections.
2. In the specimen ring.
3. Sign convention: (+) Compression/Collapse, (-) Expansion/Swell
4. Modification: The initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. Following the measurement of the swell pressure the sample was subsequently unloaded in stages.

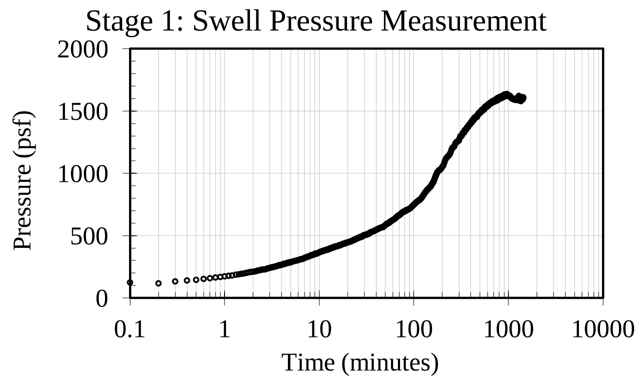


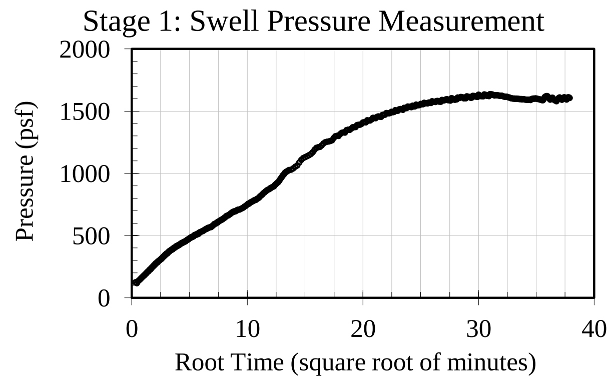
Jeffrey A. Kuhn, Ph.D., P.E. 3/22/2021
Analysis & Quality Review/Date

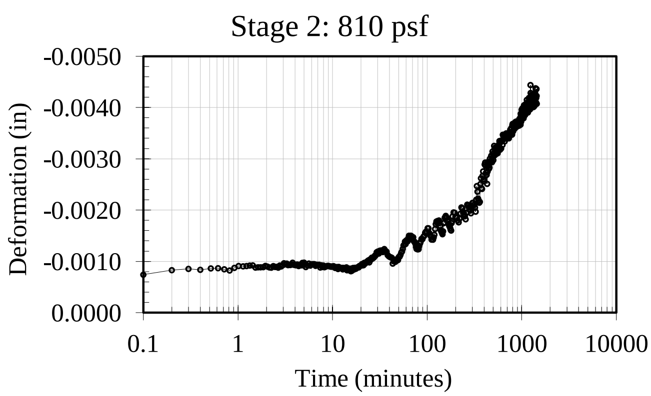
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

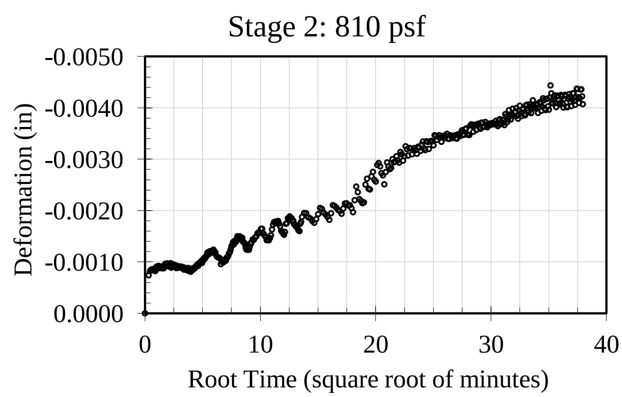
Swell Pressure Measurement with Multistage Unloading

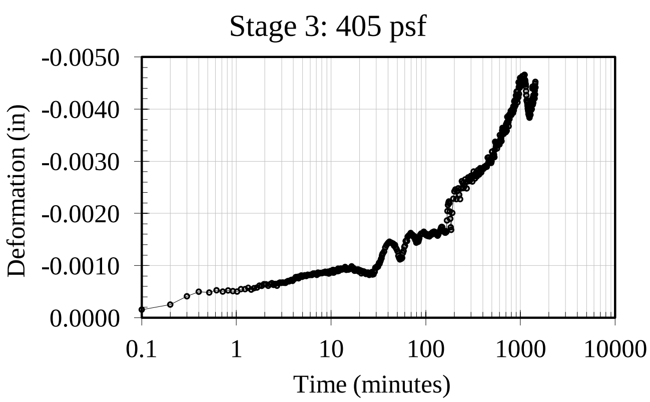
Client:	AECOM	TRI Log #:	59915.4
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D4546-B MOD
Specimen:	13-20 (6-8) ST-4		

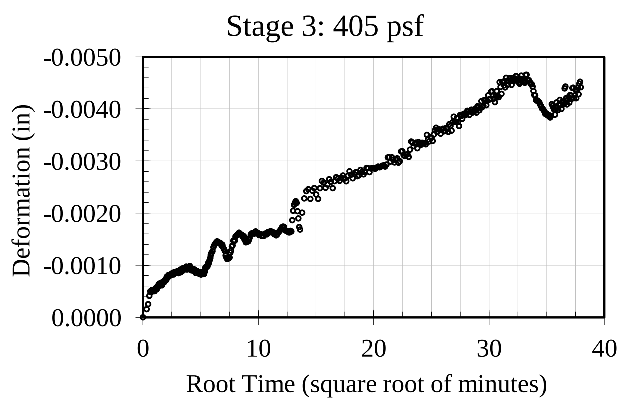








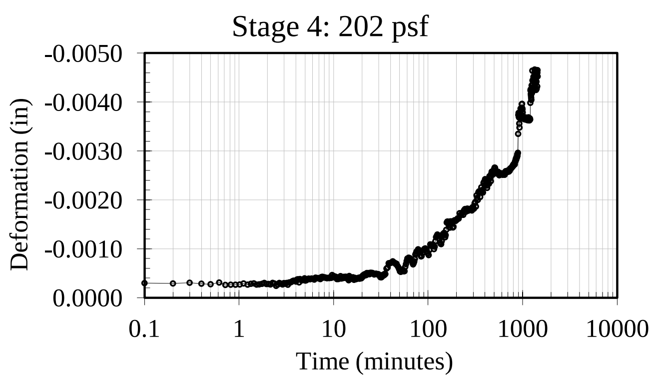


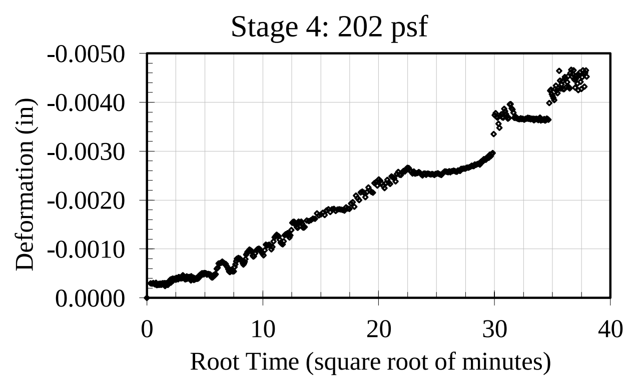


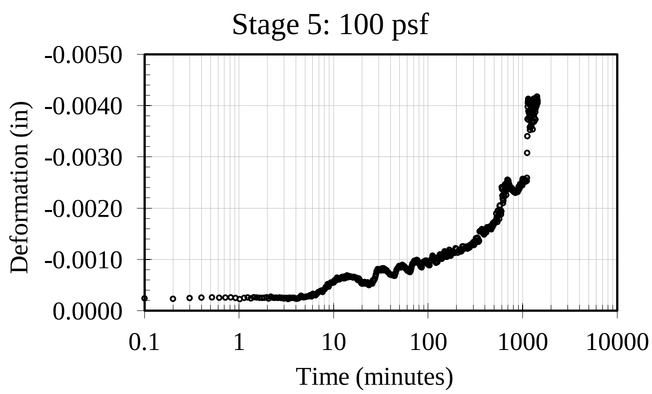
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

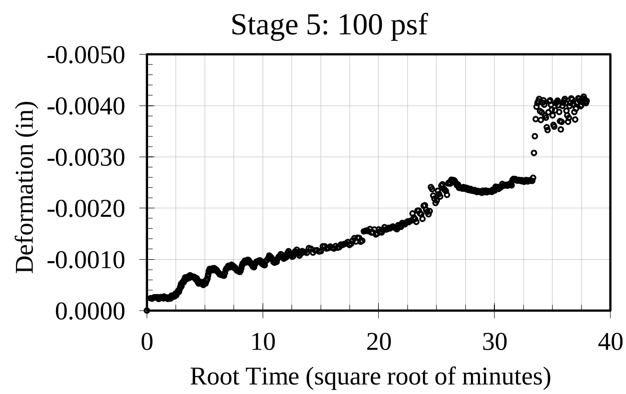
Swell Pressure Measurement with Multistage Unloading

Client:	AECOM	TRI Log #:	59915.4
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D4546-B MOD
Specimen:	13-20 (6-8) ST-4		









TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

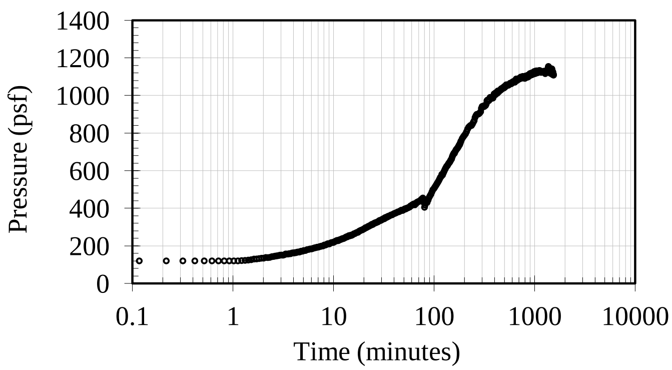
One-Dimensional Consolidation Properties of Soil

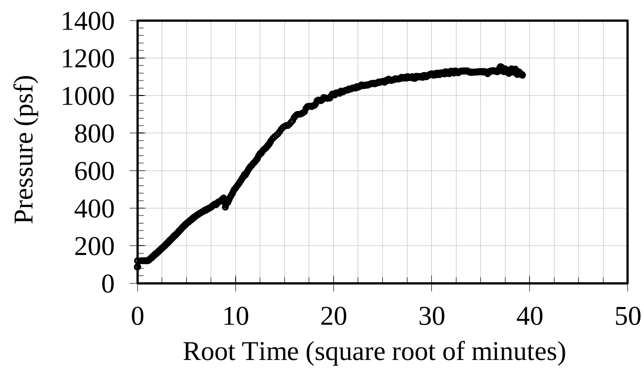
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 13-20 (18-20) ST-7

TRI Log No.: 59915.7
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	29.5
Final Specimen Water Content (%)	28.9
Specimen Diameter (in)	2.497
Initial Specimen Height (in)	0.992
Initial Dry Unit Weight, γ_o lb_f/ft^3	87.0
Specific Gravity (Assumed)	2.75
Initial Void Ratio, e_o	0.901
Initial Degree of Saturation (%)	86.7

Swell Pressure (psf), Maximum Measured	1154





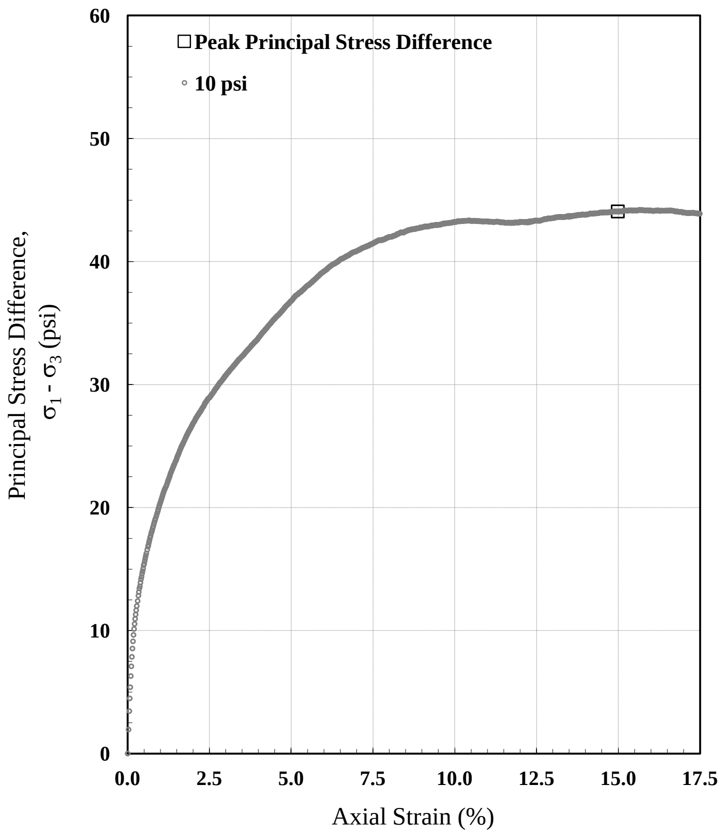
Note: The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. ***A seating stress of 120 psf was utilized for testing.***

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconsolidated-Undrained (Q) Triaxial Compression

Client:	AECOM	TRI Log #:	59915.7
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D2850
Sample:	13-20 (18-20) ST-7		



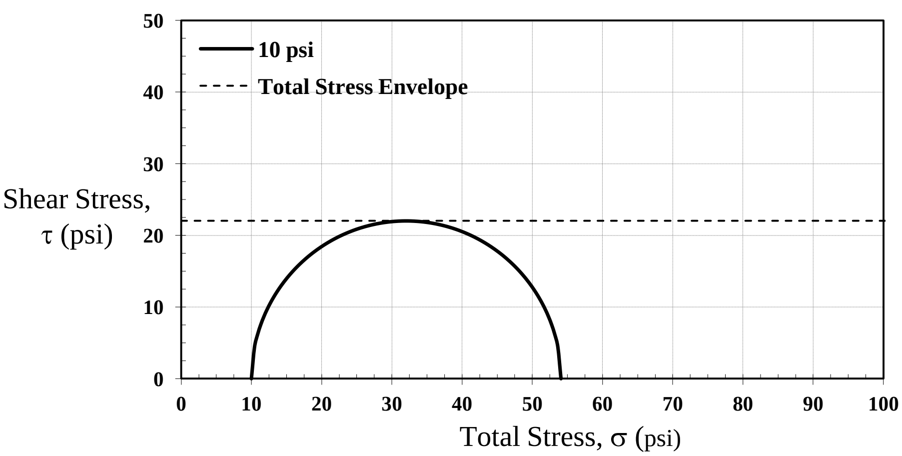
Test Parameters	
Minor Principal Stress (psi)	10.0
Rate of Strain (%/hr)	60

Initial Properties	
Avg. Diameter (in)	2.76
Avg. Height (in)	5.69
Avg. Water Content (%)	23.1
Bulk Density (pcf)	127.1
Dry Density (pcf)	103.3
Saturation (%)	96.9
Void Ratio	0.65
Specific Gravity (Assumed)	2.73

At Failure - Maximum Deviator Stress	
Axial Strain at Failure (%)	15.0
Minor Total Stress (psi)	10.0
Major Total Stress (psi)	54.1
Principal Stress Diff. (psi)	44.1

Total Stress Envelope	
Friction Angle (deg)	0
Undrained Shear Strength, S_u (psi)	22.0
S_u / σ_3	2.2

Note: The calculated value of specimen saturation was approximately 95% or greater. The Mohr failure envelope was taken as a horizontal straight line.



Jeffrey A. Kuhn , Ph.D., P.E., 3/22/2021

Analysis & Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

14-20

Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 59916

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	14-20 (0-0.83) P-1A	16.3	-	-	-	-	-
3	14-20 (2-4) ST-2	-	-	-	53	20	33
4	14-20 (4-6) P-3	14.4	-	-	-	-	-
5	14-20 (6-8) P-4	12.3	-	-	-	-	-
6	14-20 (8-9.5) SS-5	22.1	-	-	-	-	-
7	14-20 (13-13.83) P-6A	21.3	-	-	-	-	-
9	14-20 (18-20) ST-7	24.3	-	80.9	58	20	38
10	14-20 (23-24.5) SS-8	14.7	-	-	-	-	-
11	14-20 (28-30) ST-9	24.8	-	-	-	-	-
12	14-20 (33-35) P-10	23.3	-	-	-	-	-
13	14-20 (38-40) ST-11	24.0	-	-	-	-	-

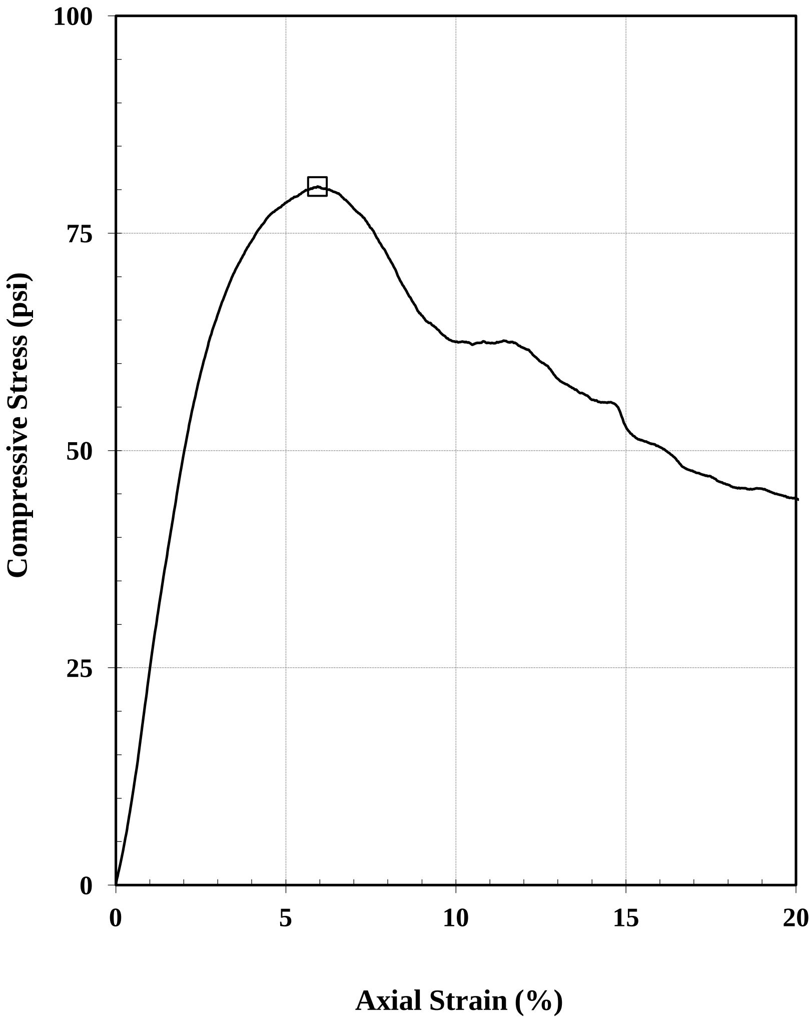
Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Unconfined Compression Test Report

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

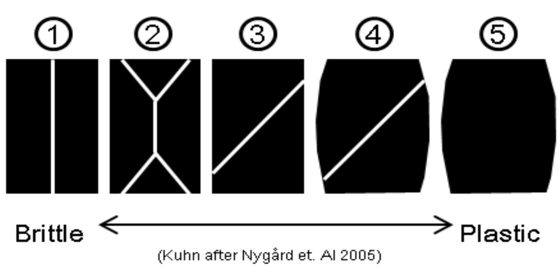
Client:	AECOM	TRI Log No.:	59916.3
Project:	60615067-1.4.14 Plum Creek 2	Type of Specimen:	Intact
Sample ID:	14-20 (2-4) ST-2	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.78
Avg. Height (in)	H_o	5.77
Avg, Water Content (%)	w_o	15.3
Bulk Density (pcf)	γ_{total}	125.0
Dry Density (pcf)	γ_{dry}	108.4
Saturation (%)	S_r	69.8
Void Ratio	e_o	0.58
Assumed Specific Gravity	G_s	2.75

Stresses at Failure	
Unconfined Compressive Strength (psi)	80.4
Axial Strain at Failure (%)	5.9
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	80.4
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	40.2

Failure Mode	4



Jeffrey A. Kuhn, Ph.D., P.E., 3/22/21
Quality Review/Date

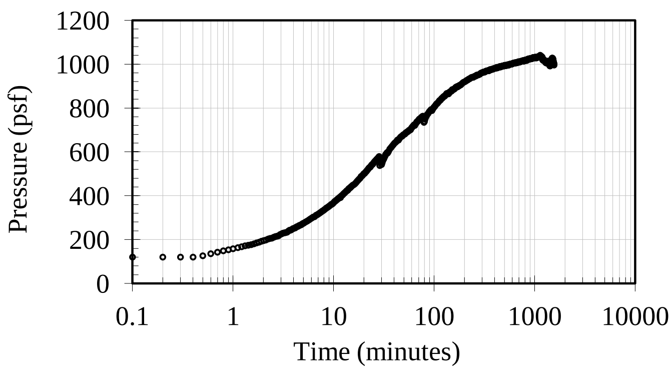
One-Dimensional Consolidation Properties of Soil

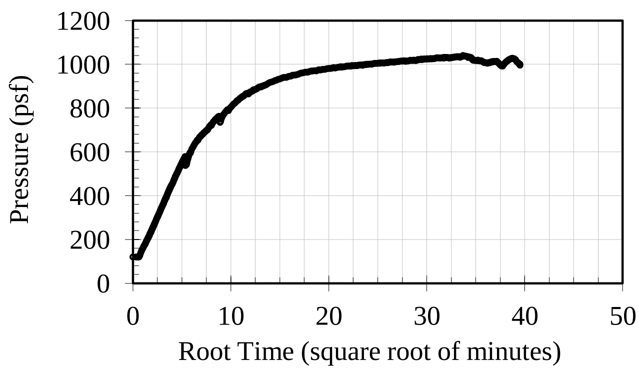
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 14-20 (18-20) ST-7

TRI Log No.: 59916.9
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	22.6
Final Specimen Water Content (%)	24.6
Specimen Diameter (in)	2.494
Initial Specimen Height (in)	1.000
Initial Dry Unit Weight, γ_o lb_f/ft^3	95.8
Specific Gravity (Assumed)	2.75
Initial Void Ratio, e_o	0.726
Initial Degree of Saturation (%)	82.5

Swell Pressure (psf), Maximum Measured	1040





Note: The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. ***A seating stress of 120 psf was utilized for testing.***

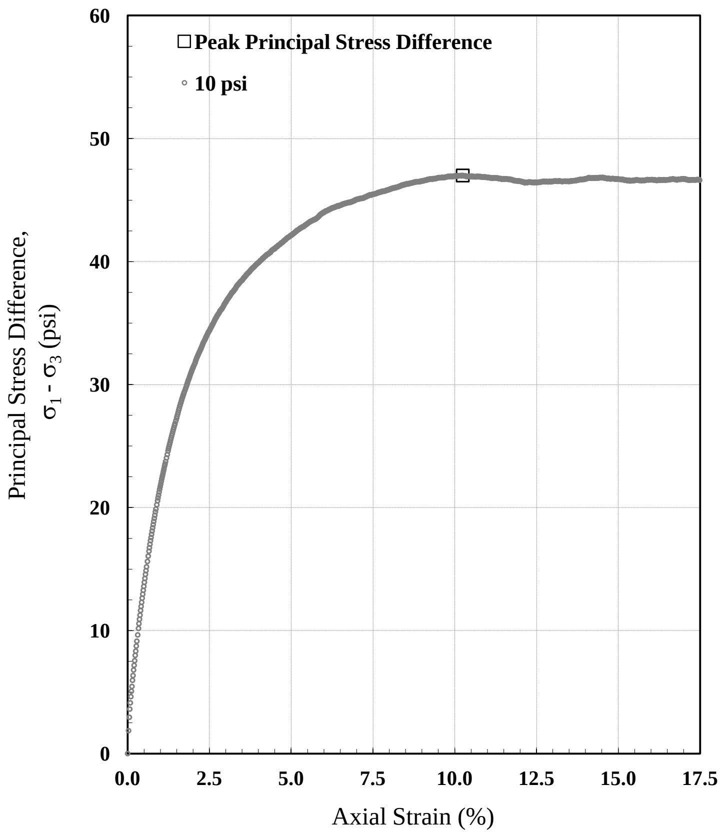
Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Unconsolidated-Undrained (Q) Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 14-20 (18-20) ST-7

TRI Log #: 59916.9
Test Method: ASTM D2850



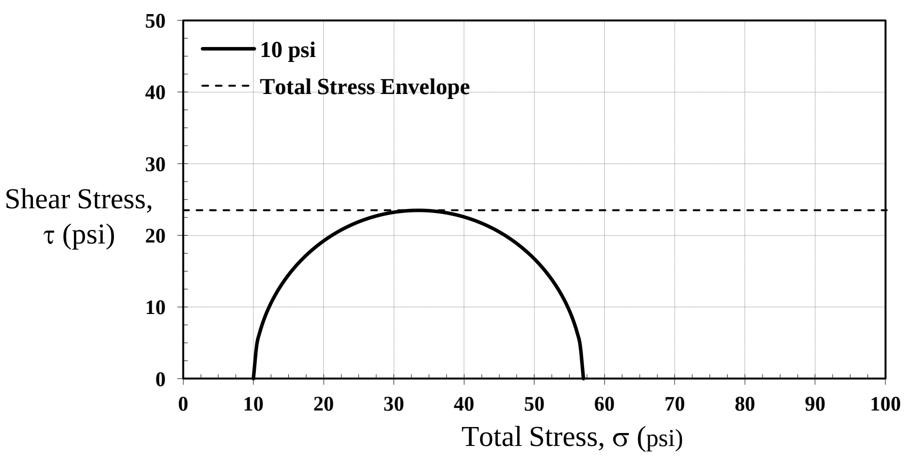
Test Parameters	
Minor Principal Stress (psi)	10.0
Rate of Strain (%/hr)	60

Initial Properties	
Avg. Diameter (in)	2.77
Avg. Height (in)	5.53
Avg. Water Content (%)	21.0
Bulk Density (pcf)	129.8
Dry Density (pcf)	107.3
Saturation (%)	96.2
Void Ratio	0.60
Specific Gravity (Assumed)	2.75

At Failure - Maximum Deviator Stress	
Axial Strain at Failure (%)	10.2
Minor Total Stress (psi)	10.0
Major Total Stress (psi)	57.0
Principal Stress Diff. (psi)	47.0

Total Stress Envelope	
Friction Angle (deg)	0
Undrained Shear Strength, S_u (psi)	23.5
S_u / σ_3	2.3

Note: The calculated value of specimen saturation was approximately 95% or greater. The Mohr failure envelope was taken as a horizontal straight line.



Jeffrey A. Kuhn , Ph.D., P.E., 3/22/2021

Analysis & Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

15-19

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53555

Jeffrey A. Kuhn, Ph.D., P.E., 4/24/2021

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)
-	Test Method	ASTM D2216
1	15-19 (0.0-2.0) P-1 Sample A	16.6
2	15-19 (0.0-2.0) P-1 Sample A+B	-
3	15-19 (2.0-3.5) SS-2	9.1
4	15-19 (4.0-6.0) P-3 Sample C	15.3
5	15-19 (4.0-6.0) P-3 Sample D	-
6	15-19 (6.0-8.0) ST-4	14.0
7	15-19 (8.0-10.0) SS-5	11.5
8	15-19 (13.0-15.0) ST-6	19.3
9	15-19 (18.0-20.0) P-7	18.6
10	15-19 (23.5-25.0) SS-8	17.0
11	15-19 (33.0-35.0) P-10	19.2
12	15-19 (38.0-40.0) P-11	18.5
13	15-19 (43.5-45.0) SS-12	12.3
14	15-19 (28.0-30.0) ST-9	20.6

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

101-19

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53187

Jeffrey A. Kuhn, Ph.D., P.E., 5/26/2021
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	101-19 (0.0-2.0) P-1	22.1	-	-	-	-	-
2	101-19 (2.0-3.5) SS-2	14.6	-	90.6	69	21	48
3	101-19 (4.0-6.0) P-3 Layer A	25.6	-	91.8	90	27	63
4	101-19 (4.0-6.0) P-3 Layer B	11.5	-	-	-	-	-
5	101-19 (6.0-7.5) SS-4	6.2	-	33.3	39	19	20
6	101-19 (8.0-10.0) P-5	12.4	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

COC Line #	Sample Identification	Organic Content (%)
-	Test Method	ASTM D2974
2	101-19 (2.0-3.5) SS-2	4.0

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Client: AECOM

TRI Log #: 53187

Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 5/26/2021
Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO_4/kg)
-	Test Method	ASTM C1580
-	Method Detection Limit (MDL)	[5 mg/l]*
2	101-19 (2.0-3.5) SS-2	1,500
3	101-19 (4.0-6.0) P-3 Layer A	700

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53187
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
2	101-19 (2.0-3.5) SS-2	100.9	N/A	18.5	18.7	18.8	1	1	1	1
3	101-19 (4.0-6.0) P-3 Layer A	4.3	N/A	18.5	18.7	18.8	1	1	1	1
5	101-19 (6.0-7.5) SS-4	18.6	N/A	18.5	18.7	18.8	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 5/26/2021
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

102-19

TRI ENVIRONMENTAL
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53189

Jeffrey A. Kuhn, Ph.D., P.E., 11/22/2020
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	102-19 (0.0-2.0) P-1	18.4	-	89.9	59	22	37
2	102-19 (2.0-3.5) SS-2	7.7	-	-	-	-	-
3	102-19 (4.0-6.0) ST-3	7.1	128.0	47.5	35	13	22
4	102-19 (6.0-7.5) SS-4	5.0	-	-	-	-	-
5	102-19 (8.0-10.0) P-5	21.5	-	98.7	65	20	45

Note: NL = No Liquid Limit; NP = No Plastic Limit

COC Line #	Sample Identification	Organic Content (%)
-	Test Method	ASTM D2974
1	102-19 (0.0-2.0) P-1	4.3

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53189

Jeffrey A. Kuhn, Ph.D., P.E., 11/22/2020

Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO_4/kg)
-	Test Method	ASTM D516
-	Method Detection Limit (MDL)	[5 mg/l]*
1	102-19 (0.0-2.0) P-1	500
3	102-19 (4.0-6.0) ST-3	900
5	102-19 (8.0-10.0) P-5	1,400

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The sulfate MDL is volumetric. Results are mass per mass of dry soil.

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

103-19

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53191

Jeffrey A. Kuhn, Ph.D., P.E., 5/26/2021
Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO_4/kg)
-	Test Method	ASTM D516
-	Method Detection Limit (MDL)	[5 mg/l]*
1	103-19 (0.0-2.0) P-1	4,300
5	103-19 (6.0-7.5) SS-4	2,000

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The sulfate MDL is volumetric. Results are mass per mass of dry soil.

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Client: AECOM　　　　TRI Log #: 53191

Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 5/26/2021

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	103-19 (0.0-2.0) P-1	21.5	-	90.8	77	25	52
2	103-19 (2.0-3.5) SS-2	14.2	-	-	-	-	-
3	103-19 (4.0-6.0) P-3 Layer A	15.9	-	-	-	-	-
5	103-19 (6.0-7.5) SS-4	6.3	-	58.5	32	13	19
6	103-19 (8.0-10.0) P-5 Layer A	14.0	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53191
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
1	103-19 (0.0-2.0) P-1	32.8	N/A	18.5	18.7	18.8	1	1	1	1
5	103-19 (6.0-7.5) SS-4	20.3	N/A	18.5	18.7	18.8	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 5/26/2021
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

104-19

Client: AECOM　　TRI Log #: 53188
Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 11/22/2020
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	104-19 (0.0-2.0) P-1	29.7	-	94.7	62	17	45
2	104-19 (2.0-3.5) SS-2	14.9	-	-	-	-	-
3	104-19 (4.0-6.0) P-3	14.9	-	95.7	51	19	32
4	104-19 (6.0-7.5) SS-4	14.9	-	-	-	-	-
5	104-19 (8.0-10.0) P-5 Layer A	16.5	-	92.5	51	18	33

Note: NL = No Liquid Limit; NP = No Plastic Limit

COC Line #	Sample Identification	Organic Content (%)
-	Test Method	ASTM D2974
1	104-19 (0.0-2.0) P-1	6.7

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53188

Jeffrey A. Kuhn, Ph.D., P.E., 5/27/2021
Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO_4/kg)
-	Test Method	ASTM C1580
-	Method Detection Limit (MDL)	[5 mg/l]*
1	104-19 (0.0-2.0) P-1	5,900
3	104-19 (4.0-6.0) P-3	7,900
5	104-19 (8.0-10.0) P-5 Layer A	10,600

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The sulfate MDL is volumetric. Results are mass per mass of dry soil.

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

105-19

Client: AECOM — TRI Log #: 53190
Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 5/26/2021
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	105-19 (0.0-2.0) P-1	16.5	-	92.1	59	23	36
2	105-19 (2.0-3.5) SS-2	9.5	-	-	-	-	-
3	105-19 (4.0-6.0) P-3 Layer A	16.8	-	-	-	-	-
5	105-19 (6.0-7.5) SS-4	12.0	-	91.2	52	19	33
6	105-19 (8.0-10.0) P-5	21.9	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

COC Line #	Sample Identification	Organic Content (%)
-	Test Method	ASTM D2974
1	105-19 (0.0-2.0) P-1	3.2
2	105-19 (2.0-3.5) SS-2	2.6

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Client: AECOM　　　　TRI Log #: 53190
Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 5/26/2021
Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO_4/kg)
-	Test Method	ASTM D516
-	Method Detection Limit (MDL)	[5 mg/l]*
1	105-19 (0.0-2.0) P-1	800
5	105-19 (6.0-7.5) SS-4	8,900

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The sulfate MDL is volumetric. Results are mass per mass of dry soil.

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

106-19

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53192

Jeffrey A. Kuhn, Ph.D., P.E., 5/26/2021
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
2	106-19 (2.0-3.5) SS-2 Layer A	5.4	-	-	-	-	-
6	106-19 (6.0-7.5) SS-4	2.9	-	18.7	-	-	-
7	106-19 (8.0-10.0) P-5	24.7	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

COC Line #	Sample Identification	Organic Content (%)
-	Test Method	ASTM D2974
4	106-19 (4.0-6.0) P-3 Layer A	5.2

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53192

Jeffrey A. Kuhn, Ph.D., P.E., 5/26/2021
Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO_4/kg)
-	Test Method	ASTM C1580
-	Method Detection Limit (MDL)	[5 mg/l]*
1	106-19 (0.0-2.0) P-1	1,400
4	106-19 (4.0-6.0) P-3 Layer A	700

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The chloride and sulfate MDLs are volumetric. Results are mass per mass of dry soil.

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53192
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
1	106-19 (0.0-2.0) P-1	19.6	N/A	18.5	18.7	20.3	1	1	1	1
4	106-19 (4.0-6.0) P-3 Layer A	21.6	N/A	18.5	18.7	20.3	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 5/26/2021
Quality Review/Date

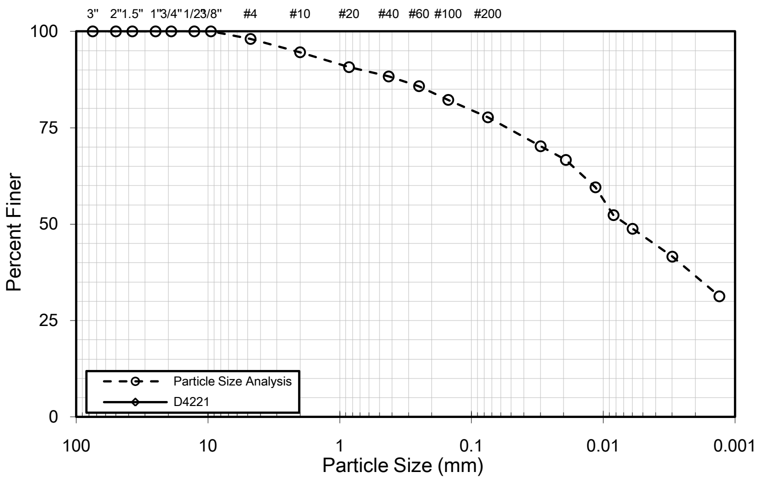
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

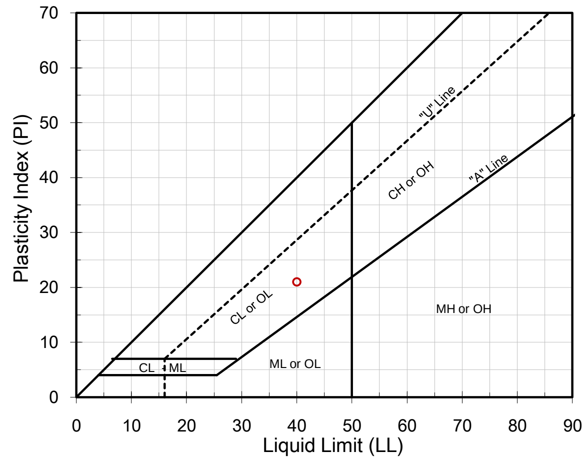
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM — TRI Log #: 53192.1
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 106-19 (0.0-2.0) P-1





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	2.0	0.030	70.2	- -	- -
2 in.	50.8	100.0		0.019	66.7	- -	- -
1.5 in.	38.1	100.0		0.011	59.6	- -	- -
1 in.	25.4	100.0		0.008	52.3	- -	- -
3/4 in.	19.0	100.0		0.006	48.8	- -	- -
1/2 in.	12.7	100.0		0.003	41.6	- -	- -
3/8 in.	9.51	100.0		0.001	31.3	- -	- -
No. 4	4.76	98.0	20.3	Log-Linear Interpolation			
No. 10	2.00	94.6		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	90.7		mm		mm	
No. 40	0.420	88.3					
No. 60	0.250	85.8		0.005	46.9	0.005	- -
No. 100	0.149	82.2		0.002	36.6	0.002	- -
No. 200	0.074	77.7	77.7	N m,2µm,d 37		N m,2µm,nd -	
D_X (mm), Log-Linear Interpolation						Percent Dispersion	
10	30	50	60	Cu	Cc	(ASTM D4221)	
- -	- -	6.7E-03	1.2E-02	- -	- -	-	
USDA	Sand (%) (2.0-0.05 mm)	22.6	Silt (%) (0.05-0.002)	38.7	Clay (%) (< 0.002 mm)	38.7	
Clay Loam							

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	40
Plastic Limit	19
Plastic Index	21
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Lean clay with sand (CL)

Moisture Content (%)	ASTM D2216	11.4
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 5/26/2021
Analysis & Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

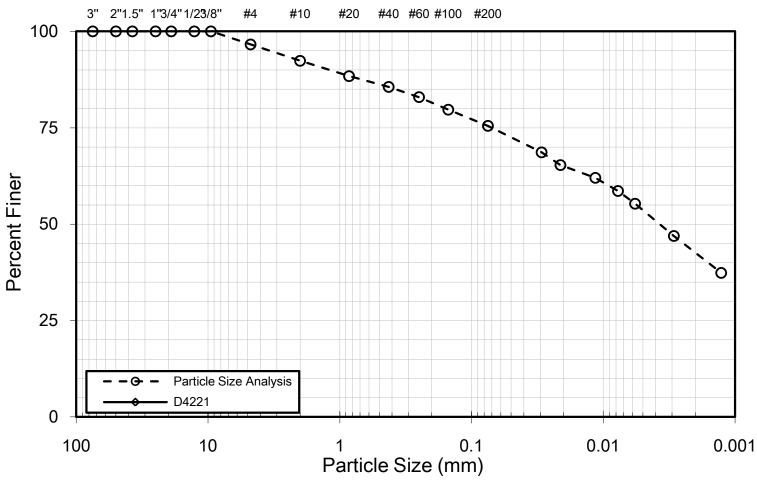
Particle Size, Atterberg Limit, and USCS Analyses for Soils

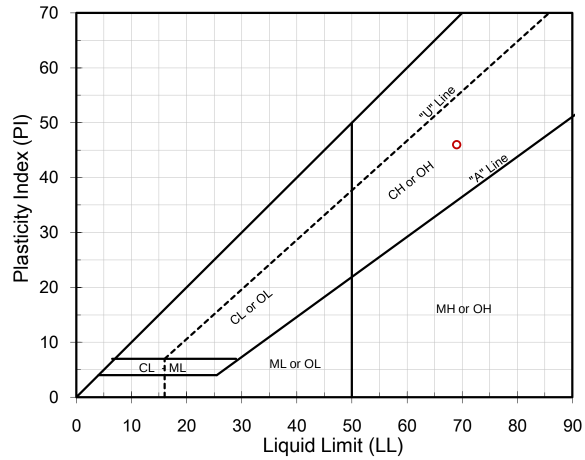
Client: AECOM

TRI Log #: 53192.4

Project: 60615067-1.4.14 Plum Creek 2

Sample ID: 106-19 (4.0-6.0)P-3 Layer A





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel	Particle Size	Percent Passing	Particle Size	Percent Passing
			Sand				
-	mm		Fines	mm		mm	
3 in.	76.2	100.0		0.029	68.6	- -	- -
2 in.	50.8	100.0		0.021	65.3	- -	- -
1.5 in.	38.1	100.0		0.011	62.0	- -	- -
1 in.	25.4	100.0	3.4	0.008	58.6	- -	- -
3/4 in.	19.0	100.0		0.006	55.3	- -	- -
1/2 in.	12.7	100.0		0.003	46.9	- -	- -
3/8 in.	9.51	100.0		0.001	37.4	- -	- -
No. 4	4.76	96.6		Log-Linear Interpolation			
No. 10	2.00	92.4		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	88.4	21.1				
No. 40	0.420	85.6		mm		mm	
No. 60	0.250	83.0		0.005	53.6	0.005	- -
No. 100	0.149	79.7		0.002	42.6	0.002	- -
No. 200	0.074	75.5	75.5	N m,2µm,d	43	N m,2µm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	3.7E-03	9.1E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	22.5	(0.05-0.002)	31.4	(< 0.002 mm)	46.1

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	69
Plastic Limit	23
Plastic Index	46
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay with sand (CH)

Moisture Content (%)	ASTM D2216	21.0
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 5/26/2021

Analysis & Quality Review/Date

1301-19

Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 52921

Jeffrey A. Kuhn, Ph.D., P.E., 11/22/2020

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	1301-19 (0.0-2.0) G-1	23.1	-	90.8	67	23	44
2	1301-19 (2.0-4.0) G-2	13.1	-	96.4	-	-	-
5	1301-19 (8.0-10.0) G-5	20.2	-	91.1	63	18	45

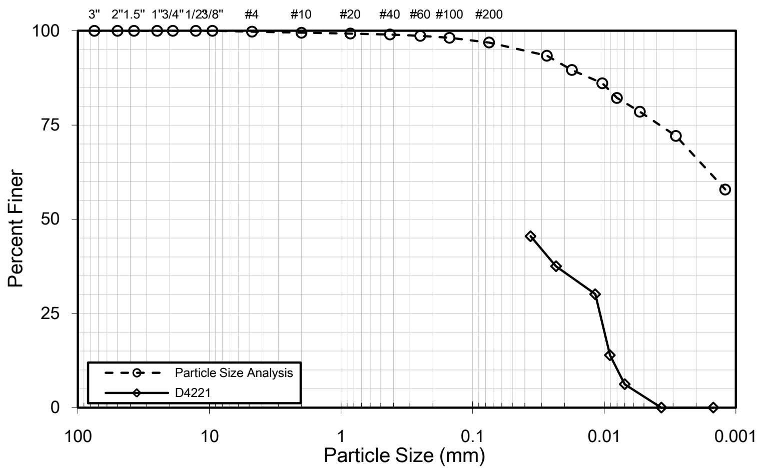
Note: NL = No Liquid Limit; NP = No Plastic Limit

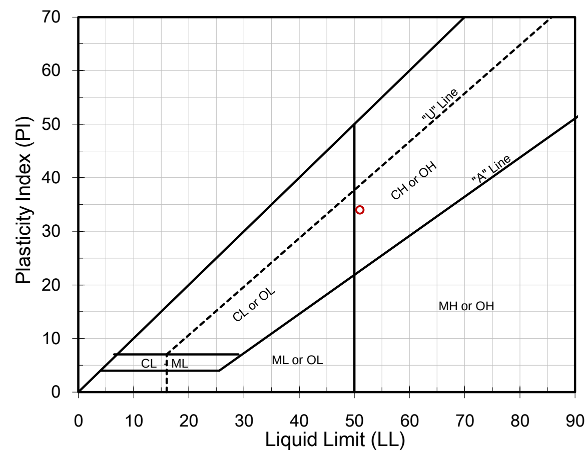
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 1301-19 (4.0-6.0) G-3

TRI Log #: 52921.3





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.2	0.027	93.4	0.036	45.5
2 in.	50.8	100.0		0.018	89.6	0.023	37.5
1.5 in.	38.1	100.0		0.010	86.1	0.012	30.1
1 in.	25.4	100.0		0.008	82.2	0.009	13.9
3/4 in.	19.0	100.0		0.005	78.5	0.007	6.2
1/2 in.	12.7	100.0		0.003	72.1	0.004	0.0
3/8 in.	9.51	100.0		0.001	57.9	0.001	0.0
No. 4	4.76	99.8	2.9	Log-Linear Interpolation			
No. 10	2.00	99.5		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	99.3					
No. 40	0.420	99.0		mm		mm	
No. 60	0.250	98.7		0.005	77.8	0.005	3.0
No. 100	0.149	98.1		0.002	66.2	0.002	0.0
No. 200	0.074	96.9	96.9	N m,2μm,d	66	N m,2μm,nd	0

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	1.4E-03	- -	- -	0

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	5.3	(0.05-0.002	28.2	(< 0.002 mm)	66.5

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	51
Plastic Limit	17
Plastic Index	34
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	14.9
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

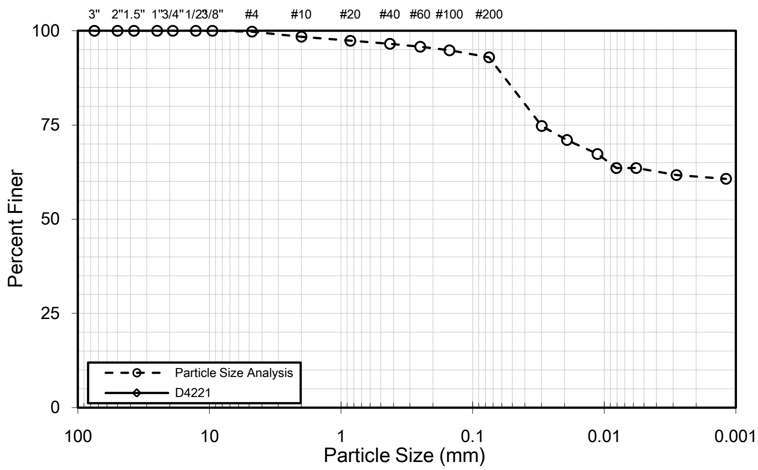
Jeffrey A. Kuhn, Ph.D, P.E. 11/22/2020
Analysis & Quality Review/Date

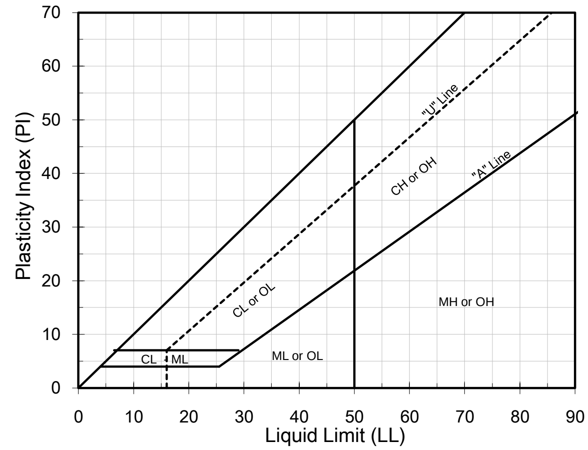
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client:	AECOM	TRI Log #:	52921.4
Project:	60615067-1.4.14 Plum Creek 2		
Sample ID:	1301-19 (6.0-8.0) G-4		





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.2	0.030	74.7	- -	- -
2 in.	50.8	100.0		0.019	71.0	- -	- -
1.5 in.	38.1	100.0		0.011	67.3	- -	- -
1 in.	25.4	100.0		0.008	63.6	- -	- -
3/4 in.	19.0	100.0		0.006	63.6	- -	- -
1/2 in.	12.7	100.0		0.003	61.7	- -	- -
3/8 in.	9.51	100.0		0.001	60.7	- -	- -
No. 4	4.76	99.8	6.8	Log-Linear Interpolation			
No. 10	2.00	98.4		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	97.4					
No. 40	0.420	96.5		mm		mm	
No. 60	0.250	95.8		0.005	63.2	0.005	- -
No. 100	0.149	94.8		0.002	61.3	0.002	- -
No. 200	0.074	93.0	93.0	N m,2μm,d	61	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	- -	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	21.1	(0.05-0.002	16.6	(< 0.002 mm)	62.3

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	- -
Plastic Limit	- -
Plastic Index	- -
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
- -

Moisture Content (%)	ASTM D2216	20.6
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 11/22/2020

Analysis & Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 52921
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
1	1301-19 (0.0-2.0) G-1	5.7	50.5	21.0	21.7	22.5	1	1	1	1
3	1301-19 (4.0-6.0) G-3	4.4	40.2	21.0	21.7	22.5	1	1	1	1
5	1301-19 (8.0-10.0) G-5	5.9	49.3	21.0	21.7	22.5	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 11/22/2020
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

1302-19

Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 52922

Jeffrey A. Kuhn, Ph.D., P.E., 11/22/2020

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
3	1302-19 (4.0-6.0) G-3	-	-	90.3	56	22	34
4	1302-19 (6.0-6.5) G-4	-	-	98.0	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

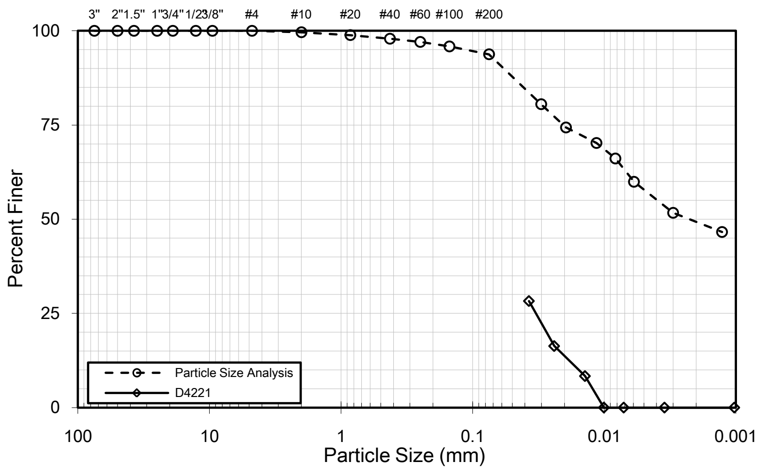
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

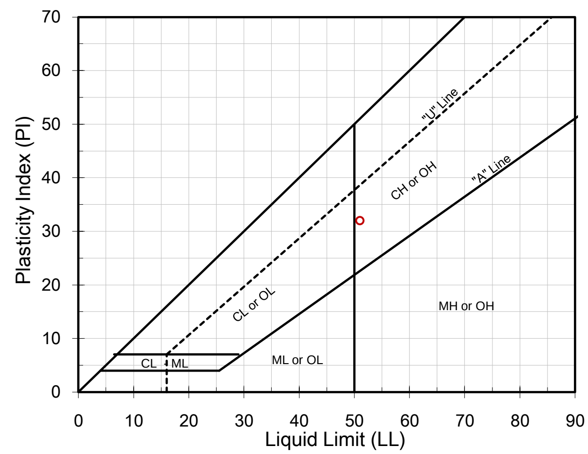
Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM TRI Log #: 52922.1

Project: 60615067-1.4.14 Plum Creek 2

Sample ID: 1302-19 (0.0-2.0) G-1





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.0	0.030	80.5	0.037	28.3
2 in.	50.8	100.0		0.020	74.3	0.024	16.3
1.5 in.	38.1	100.0		0.011	70.2	0.014	8.4
1 in.	25.4	100.0		0.008	66.1	0.010	0.0
3/4 in.	19.0	100.0		0.006	59.9	0.007	0.0
1/2 in.	12.7	100.0		0.003	51.7	0.003	0.0
3/8 in.	9.51	100.0		0.001	46.6	0.001	0.0
No. 4	4.76	100.0	6.2	Log-Linear Interpolation			
No. 10	2.00	99.6		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	98.9					
No. 40	0.420	97.9		mm		mm	
No. 60	0.250	97.1		0.005	57.8	0.005	0.0
No. 100	0.149	95.9		0.002	49.3	0.002	0.0
No. 200	0.074	93.8	93.8	N m,2μm,d	49	N m,2μm,nd	0

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	2.3E-03	6.0E-03	- -	- -	0

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	16.8	(0.05-0.002	33.7	(< 0.002 mm)	49.5

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	51
Plastic Limit	19
Plastic Index	32
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	18.9
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

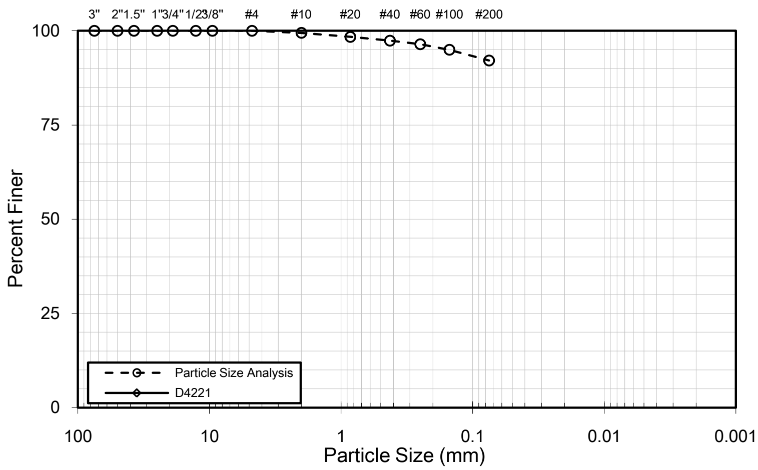
Jeffrey A. Kuhn, Ph.D, P.E. 11/22/2020

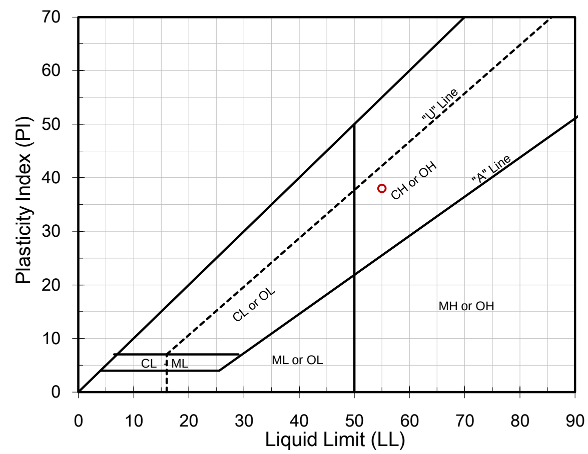
Analysis & Quality Review/Date

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 1302-19 (2.0-4.0) G-2

TRI Log #: 52922.2





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel	Particle Size	Percent Passing	Particle Size	Percent Passing
			Sand				
-	mm		Fines	mm		mm	
3 in.	76.2	100.0	0.0	- -	- -	- -	- -
2 in.	50.8	100.0		- -	- -	- -	- -
1.5 in.	38.1	100.0		- -	- -	- -	- -
1 in.	25.4	100.0		- -	- -	- -	- -
3/4 in.	19.0	100.0		- -	- -	- -	- -
1/2 in.	12.7	100.0		- -	- -	- -	- -
3/8 in.	9.51	100.0		- -	- -	- -	- -
No. 4	4.76	100.0	7.9	Log-Linear Interpolation			
No. 10	2.00	99.5		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	98.4					
No. 40	0.420	97.4		mm		mm	
No. 60	0.250	96.4		0.005	- -	0.005	- -
No. 100	0.149	95.0		0.002	- -	0.002	- -
No. 200	0.074	92.1	92.1	N m,2µm,d	-	N m,2µm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	- -	- -	- -	-

USDA	Sand (%) (2.0-0.05 mm)		Silt (%) (0.05-0.002		Clay (%) (< 0.002 mm)	
- -		- -		- -		- -

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	55
Plastic Limit	17
Plastic Index	38
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	18.1
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 11/22/2020
Analysis & Quality Review/Date

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067 - 1.4.14 Plum Creek 2

TRI Log #: 52922
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
1	1302-19 (0.0-2.0) G-1	4.5	30.4	19.7	20.3	22.2	1	2	2	2
3	1302-19 (4.0-6.0) G-3	5.8	48.6	22.0	22.1	22.2	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 11/22/2020
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

1701-19

Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 59051

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Organic Content (%)	Atterberg Limits		
				Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D2974	ASTM D4318, Method A : Multipoint		
1	1701-20 G-1 (0-2)	9.3	2.4	34	15	19
2	1701-20 G-2 (3.5)	19.8	-	-	-	-
3	1701-20 G-3 (3.5-4.5)	16.2	-	-	-	-
4	1701-20 G-4 (6-8)	19.9	-	63	21	42
5	1701-20 G-5 (8-9)	21.1	-	-	-	-
6	1701-20 G-6 (9-10)	23.2	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Client: AECOM

TRI Log #: 59051

Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021

Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO_4/kg)
-	Test Method	ASTM D516
-	Method Detection Limit (MDL)	[5 mg/l]*
1	1701-20 G-1 (0-2)	1,100
4	1701-20 G-4 (6-8)	8,000

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The sulfate MDL is volumetric. Results are mass per mass of dry soil.

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client:	AECOM	TRI Log #:	59051
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
1	1701-20 G-1 (0-2)	3.3	28.8	20.2	20.6	22.0	1	1	1	1
4	1701-20 G-4 (6-8)	5.2	43.9	20.2	20.6	22.0	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

1702-19 and 1703-19

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 59052

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Organic Content (%)	Atterberg Limits		
				Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D2974	ASTM D4318, Method A : Multipoint		
1	1702-20 G-1 (0-2)	15.3	5.4	57	22	35
2	1702-20 G-2 (2-4)	17.3	-	-	-	-
3	1703-20 G-1 (0-2)	18.3	-	-	-	-
4	1703-20 G-2 (3-4)	19.1	-	56	20	36
5	1703-20 G-3 (4-6)	19.0	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 59052

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO_4/kg)
-	Test Method	ASTM D516
-	Method Detection Limit (MDL)	[5 mg/l]*
1	1702-20 G-1 (0-2)	500
4	1703-20 G-2 (3-4)	900

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The sulfate MDL is volumetric. Results are mass per mass of dry soil.

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 59052
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
1	1702-20 G-1 (0-2)	5.8	42.6	20.2	20.6	22.0	1	1	1	1
4	1703-20 G-2 (3-4)	4.6	45.4	20.2	20.6	22.0	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

1704-19

Client: AECOM TRI Log #: 59053

Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
2	1704-20 G-2 (2.5-3)	18.8	-	-	-	-	-
3	1704-20 G-3 (3-3.5)	19.1	-	-	-	-	-
4	1704-20 G-4 (4-4.5)	20.7	-	-	67	24	43
5	1704-20 G-5 (5-5.5)	19.8	-	-	-	-	-
6	1704-20 G-6 (6-6.5)	23.8	-	-	-	-	-
7	1704-20 G-7 (8-8.5)	24.3	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Client: AECOM TRI Log #: 59053

Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021

Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO_4/kg)
-	Test Method	ASTM D516
-	Method Detection Limit (MDL)	[5 mg/l]*
1	1704-20 G-1 (0-2.5)	700
4	1704-20 G-4 (4-4.5)	8,200
8	1704-20 G-8 (10-10.5)	2,300

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The sulfate MDL is volumetric. Results are mass per mass of dry soil.

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 59053
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
1	1704-20 G-1 (0-2.5)	5.9	48.8	20.2	20.6	22.0	1	1	1	1
4	1704-20 G-4 (4-4.5)	5.5	45.8	20.2	20.6	22.0	1	1	1	1
8	1704-20 G-8 (10-10.5)	4.5	35.9	20.2	20.6	22.0	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

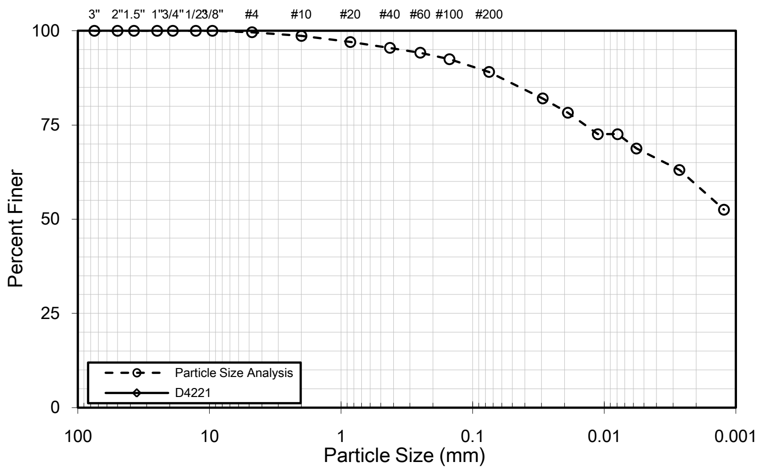
Particle Size, Atterberg Limit, and USCS Analyses for Soils

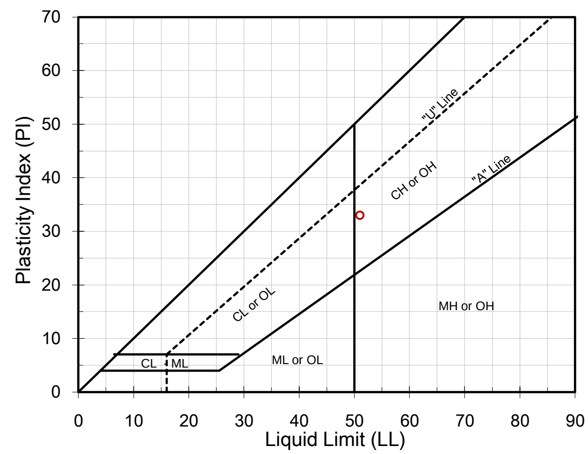
Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

Sample ID: 1704-20 G-1 (0-2.5)

TRI Log #: 59053.1





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.4	0.029	82.1	- -	- -
2 in.	50.8	100.0		0.019	78.3	- -	- -
1.5 in.	38.1	100.0		0.011	72.6	- -	- -
1 in.	25.4	100.0		0.008	72.6	- -	- -
3/4 in.	19.0	100.0		0.006	68.8	- -	- -
1/2 in.	12.7	100.0		0.003	63.0	- -	- -
3/8 in.	9.51	100.0		0.001	52.5	- -	- -
No. 4	4.76	99.6	10.5	Log-Linear Interpolation			
No. 10	2.00	98.6		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	97.0					
No. 40	0.420	95.5		mm		mm	
No. 60	0.250	94.2		0.005	67.8	0.005	- -
No. 100	0.149	92.5		0.002	59.1	0.002	- -
No. 200	0.074	89.1	89.1	N m,2µm,d	59	N m,2µm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	2.1E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	14.7	(0.05-0.002	25.4	(< 0.002 mm)	59.9

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	51
Plastic Limit	18
Plastic Index	33
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	17.9
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

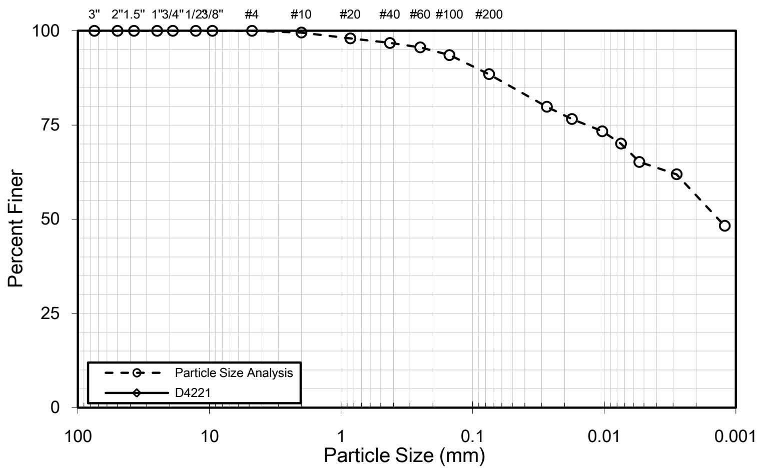
Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021

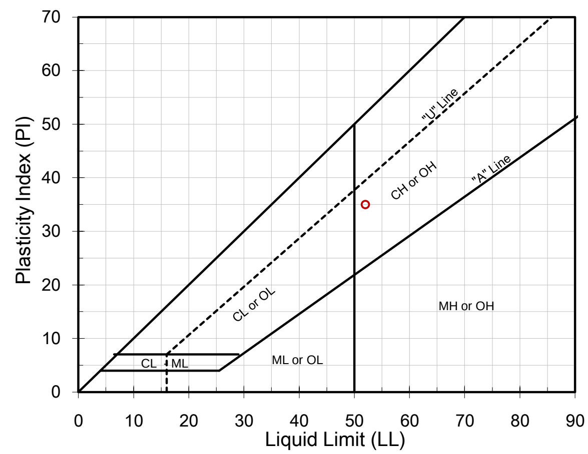
Analysis & Quality Review/Date

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 1704-20 G-8 (10-10.5)

TRI Log #: 59053.8





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0		0.027	79.8	- -	- -
2 in.	50.8	100.0		0.018	76.6	- -	- -
1.5 in.	38.1	100.0		0.010	73.3	- -	- -
1 in.	25.4	100.0	0.0	0.007	70.1	- -	- -
3/4 in.	19.0	100.0		0.005	65.2	- -	- -
1/2 in.	12.7	100.0		0.003	61.9	- -	- -
3/8 in.	9.51	100.0		0.001	48.3	- -	- -
No. 4	4.76	100.0		Log-Linear Interpolation			
No. 10	2.00	99.5		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	98.0	11.5	mm		mm	
No. 40	0.420	96.8					
No. 60	0.250	95.6		0.005	64.8	0.005	- -
No. 100	0.149	93.5		0.002	56.4	0.002	- -
No. 200	0.074	88.5	88.5	N m,2μm,d	56	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	1.4E-03	2.5E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	17.0	(0.05-0.002	26.4	(< 0.002 mm)	56.7

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	52
Plastic Limit	17
Plastic Index	35
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	18.0
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021
Analysis & Quality Review/Date

1705-19

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 59913

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	1705-20 (0-1) G-1a	13.9	-	-	-	-	-
2	1705-20 (2-4) G-1b	23.2	-	-	-	-	-
3	1705-20 (4-5) G-2a	22.0	-	-	-	-	-
4	1705-20 (5-6) G-2b	20.4	-	-	-	-	-
5	1705-20 (6-8) G-3	21.3	-	-	-	-	-
6	1705-20 (8-10) G-4	23.8	-	-	-	-	-

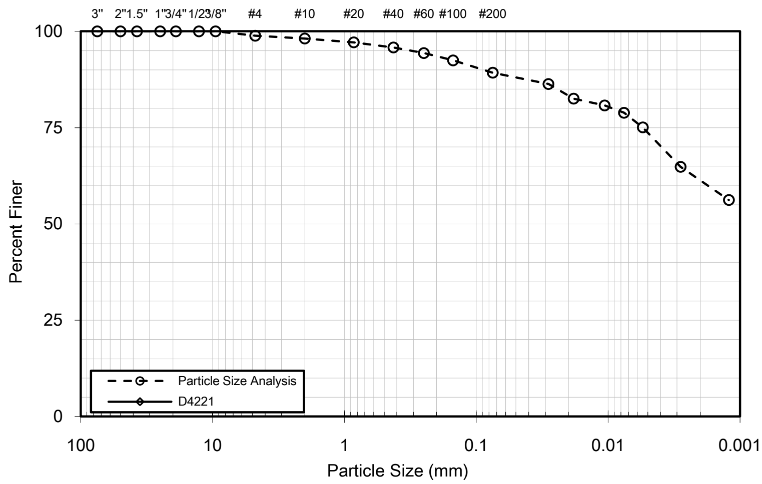
Note: NL = No Liquid Limit; NP = No Plastic Limit

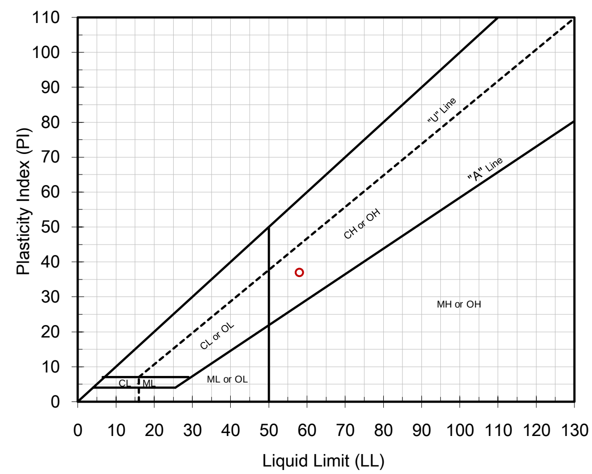
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

COMP-100A

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client:	AECOM	TRI Log #:	62896.1
Project:	60615067-1.4.14 Plum Creek 2		
Sample ID:	COMP-100A		





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0		0.028	86.3	- -	- -
2 in.	50.8	100.0		0.018	82.5	- -	- -
1.5 in.	38.1	100.0		0.011	80.8	- -	- -
1 in.	25.4	100.0	1.1	0.008	78.9	- -	- -
3/4 in.	19.0	100.0		0.005	75.1	- -	- -
1/2 in.	12.7	100.0		0.003	64.8	- -	- -
3/8 in.	9.51	100.0		0.001	56.2	- -	- -
No. 4	4.76	98.9		Log-Linear Interpolation			
No. 10	2.00	98.1		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	97.1	9.6	mm		mm	
No. 40	0.420	95.8					
No. 60	0.250	94.4		0.005	73.7	0.005	- -
No. 100	0.149	92.5		0.002	61.3	0.002	- -
No. 200	0.074	89.3	89.3	N m,2µm,d	61	N m,2µm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	1.8E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	10.4	(0.05-0.002	27.1	(< 0.002 mm)	62.5

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	58
Plastic Limit	21
Plastic Index	37
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	7.2
Organic Content (%)	ASTM D2974-C	5.2
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

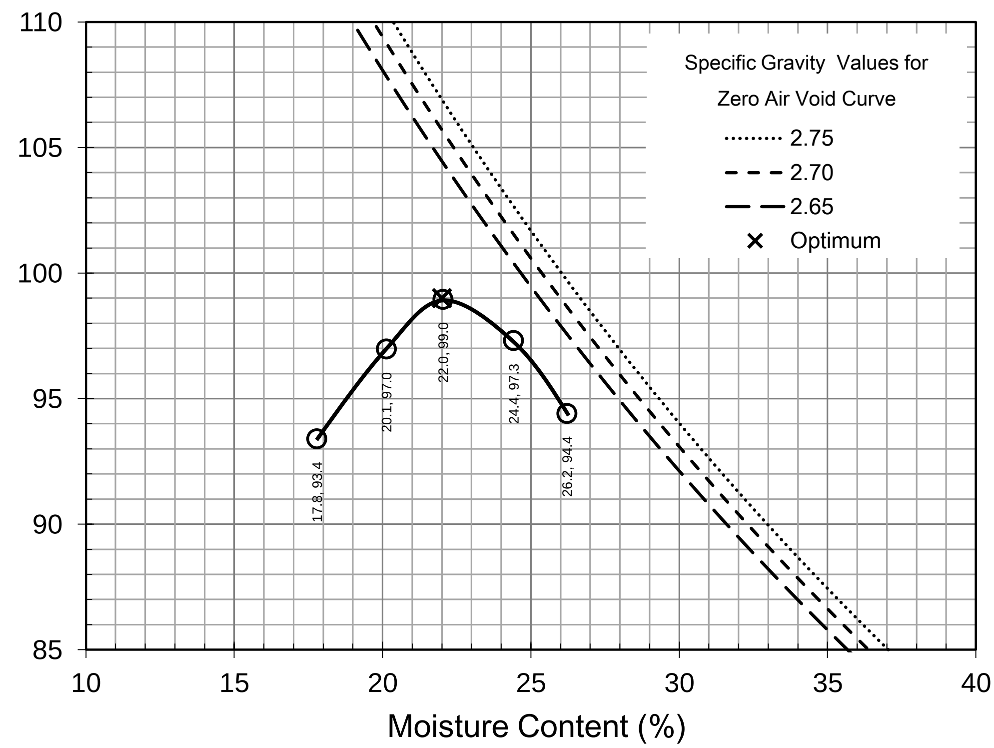
Jeffrey A. Kuhn, Ph.D, P.E. 5/10/2021
Analysis & Quality Review/Date

Laboratory Compaction Characteristics of Soil Using Standard Effort (ASTM D698) with Correction for Oversize Particles (ASTM D4718)

Client: AECOM	TRI Log #: 62896.1
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: COMP-100A

Compaction Effort	-	Standard
Method	-	A
Rammer Type	-	Automatic
Maximum Dry Density	pcf	99.0
Optimum Water Content	%	22.0

Oversize Particle / "Rock" Correction (ASTM D4718)		
Oversized Particles	%	- -
Maximum Dry Density	pcf	- -
Optimum Water Content	%	- -



Jeffrey A. Kuhn, Ph.D, P.E., 4/19/2021
Quality Review / Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

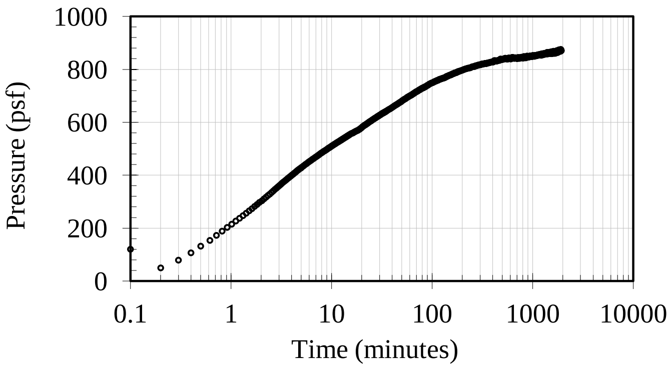
One-Dimensional Consolidation Properties of Soil

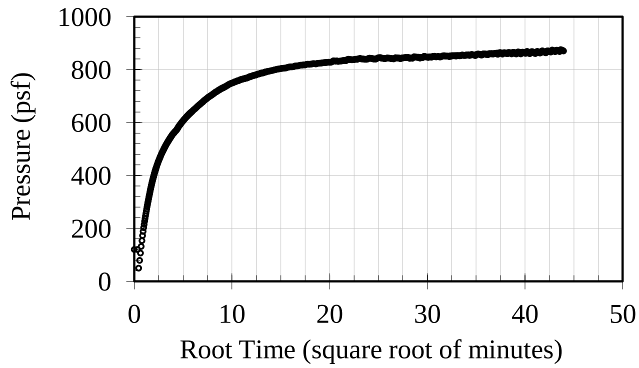
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: COMP-100A

TRI Log No.: 62896.1
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	22.3
Final Specimen Water Content (%)	27.2
Specimen Diameter (in)	2.500
Initial Specimen Height (in)	1.000
Initial Dry Unit Weight, γ_o lb_f/ft^3	89.0
Specific Gravity (ASTM D854)	2.62
Initial Void Ratio, e_o	0.837
Initial Degree of Saturation (%)	70.6

Swell Pressure (psf), Maximum Measured	875





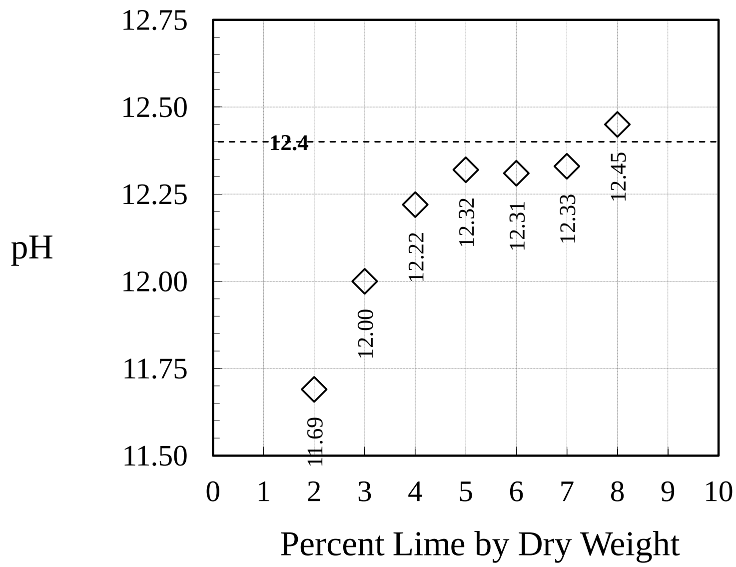
Note: The remolded specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. **A seating stress of 120 psf was utilized for testing**.

Jeffrey A. Kuhn, Ph.D., P.E., 5/10/2021
Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Using pH to Estimate the Soil-Lime Proportion Requirement for Soil Stabilization (ASTM D6276)

Client: AECOM TRI Log #: 62896.1
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: COMP-100A



Percent Lime by Dry Weight	pH
2.0	11.69
3.0	12.00
4.0	12.22
5.0	12.32
6.0	12.31
7.0	12.33
8.0	12.45

Lowest Percent Lime by Dry Weight to yield a pH of 12.4 or Greater
8.0

Jeffrey A. Kuhn, Ph.D, P.E. 5/10/2021
Analysis & Quality Review/Date

Admixing Lime to Reduce Plasticity Index of Soils (Tex-112-E)

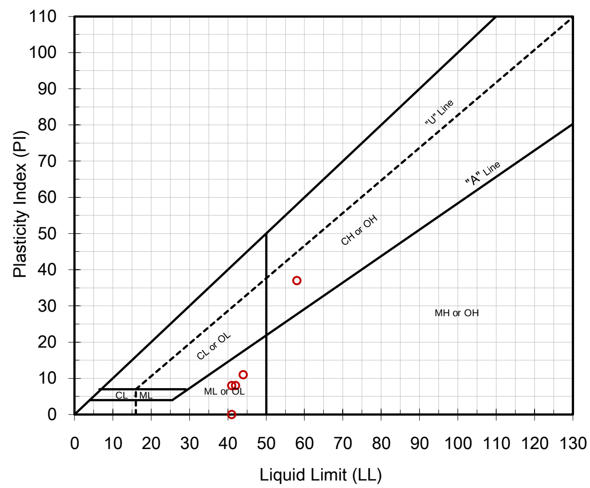
Client: AECOM

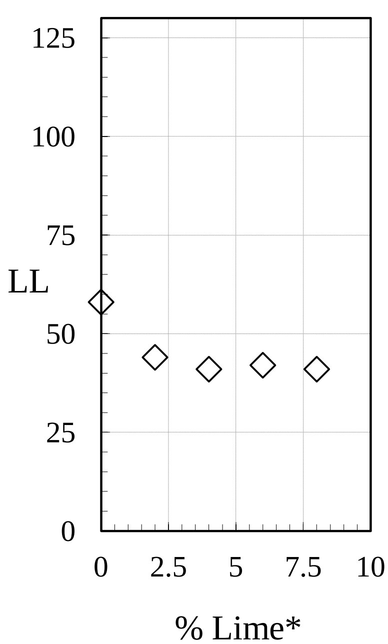
TRI Log #: 62896.1

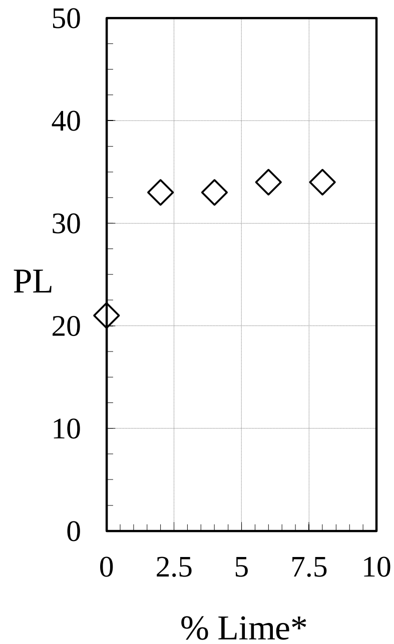
Project: 60615067-1.4.14 Plum Creek 2

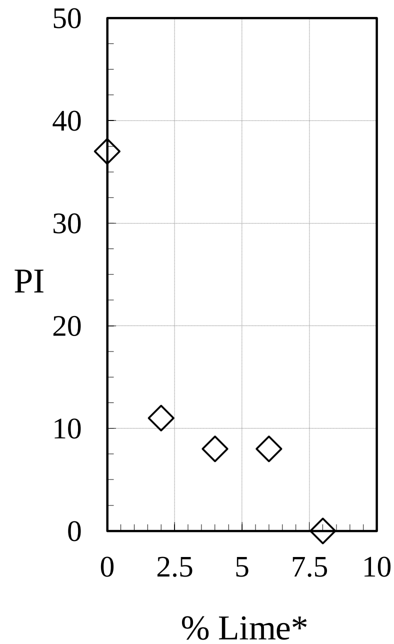
Sample ID: COMP-100A

Percent Lime by Dry Weight	Atterberg Limits		
	Liquid Limit	Plastic Limit	Plasticity Index
	ASTM D4318, Method A : Multipoint		
0	58	21	37
2.0	44	33	11
4.0	41	33	8
6.0	42	34	8
8.0	41	34	-









*Percent Lime by Dry Unit Weight

Jeffrey A. Kuhn, Ph.D, P.E. 5/10/2021

Analysis & Quality Review/Date

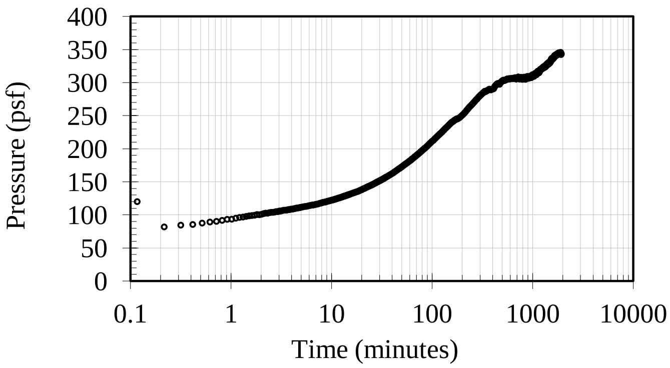
One-Dimensional Consolidation Properties of Soil

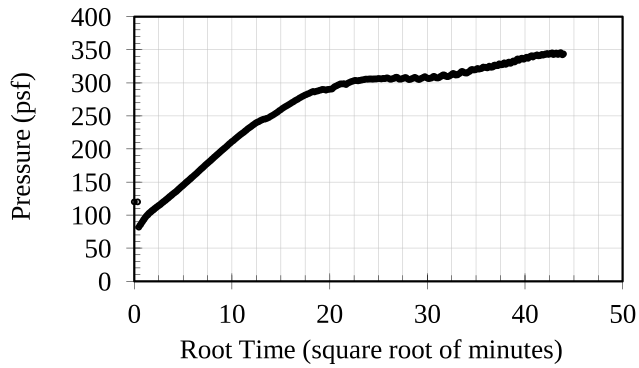
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: COMP-100A

TRI Log No.: 62896.2
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	26.3
Final Specimen Water Content (%)	27.5
Specimen Diameter (in)	2.500
Initial Specimen Height (in)	1.000
Initial Dry Unit Weight, γ_o lb_f/ft^3	89.0
Specific Gravity (ASTM D854)	2.62
Initial Void Ratio, e_o	0.837
Initial Degree of Saturation (%)	83.3

Swell Pressure (psf), Maximum Measured	346





Note: The remolded specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. **A seating stress of 120 psf was utilized for testing**.

Jeffrey A. Kuhn, Ph.D., P.E., 5/10/2021
Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 62896

Jeffrey A. Kuhn, Ph.D., P.E., 5/12/2021

Quality Review/Date

Analytical

COC Line #	Sample Identification	Chloride Content (mg/kg)	Sulfate Content (mg SO_4/kg)	pH		Resistivity (ohm-cm)
				(H_2O)	($CaCl_2$)	
-	Test Method	ASTM D512	ASTM D516	ASTM D4972 (method A)		ASTM G57
-	Method Detection Limit (MDL)	[5 mg/l]*	[5 mg/l]*	-	-	-
1	COMP-100A	300	7,000	8.02	7.84	370

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The chloride and sulfate MDLs are volumetric. Results are mass per mass of dry soil.

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 62896
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
1	COMP-100A	23.8	N/A	18.5	19.1	22.5	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 5/10/2021
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

COMP-100B

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

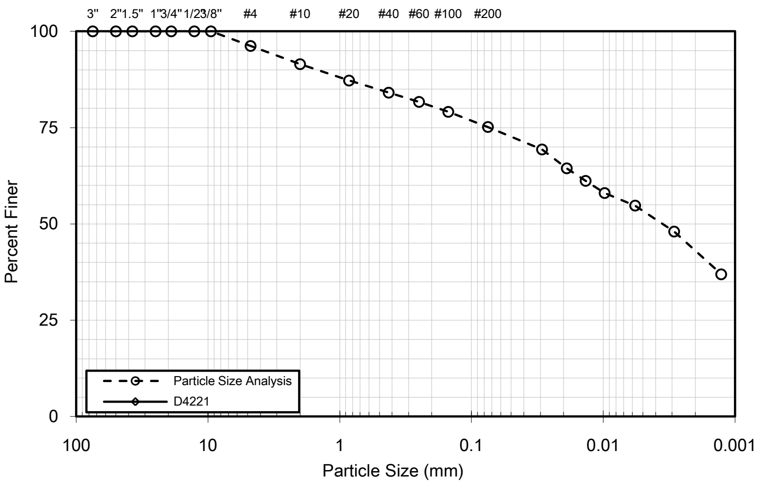
Particle Size, Atterberg Limit, and USCS Analyses for Soils

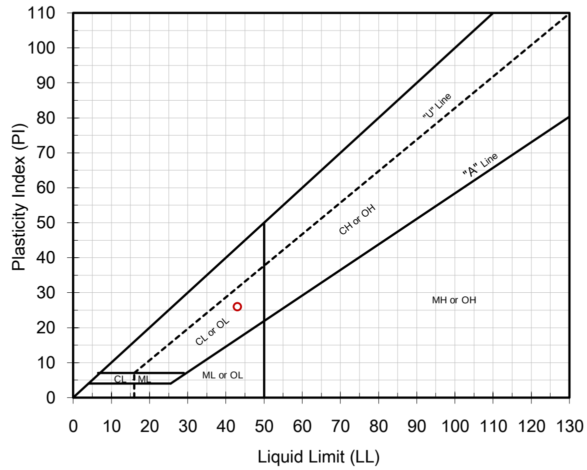
Client: AECOM

Project: Plum Creek 2 - 60615067, Task 1.4.14

Sample ID: COMP-100B

TRI Log #: 62867.1





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	3.8	0.029	69.3	- -	- -
2 in.	50.8	100.0		0.019	64.4	- -	- -
1.5 in.	38.1	100.0		0.014	61.2	- -	- -
1 in.	25.4	100.0		0.010	58.0	- -	- -
3/4 in.	19.0	100.0		0.006	54.8	- -	- -
1/2 in.	12.7	100.0		0.003	48.0	- -	- -
3/8 in.	9.51	100.0		0.001	36.9	- -	- -
No. 4	4.76	96.2	21.0	Log-Linear Interpolation			
No. 10	2.00	91.5		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	87.2					
No. 40	0.420	84.1		mm		mm	
No. 60	0.250	81.7		0.005	53.4	0.005	- -
No. 100	0.149	79.1		0.002	43.0	0.002	- -
No. 200	0.074	75.2	75.2	N m,2µm,d	43	N m,2µm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	3.5E-03	1.2E-02	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	21.1	(0.05-0.002	31.9	(< 0.002 mm)	47.0

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	43
Plastic Limit	17
Plastic Index	26
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Lean clay with sand (CL)

Moisture Content (%)	ASTM D2216	7.1
Organic Content (%)	ASTM D2974-C	3.8
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 5/6/2021

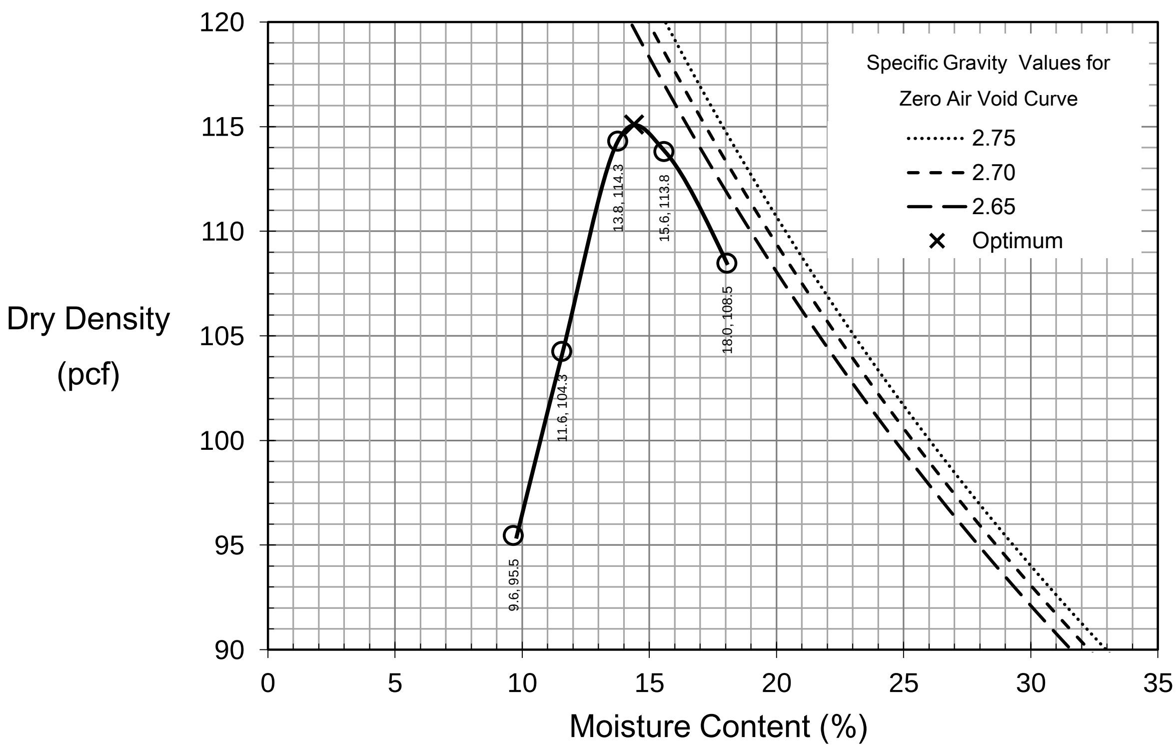
Analysis & Quality Review/Date

Laboratory Compaction Characteristics of Soil Using Standard Effort (ASTM D698) with Correction for Oversize Particles (ASTM D4718)

Client:	AECOM	TRI Log #:	62867.1
Project:	Plum Creek 2 - 60615067, Task 1.4.14		
Sample ID:	COMP-100B		

Compaction Effort	-	Standard
Method	-	A
Rammer Type	-	Automatic
Maximum Dry Density	pcf	115.1
Optimum Water Content	%	14.4

Oversize Particle / "Rock" Correction (ASTM D4718)		
Oversized Particles	%	- -
Maximum Dry Density	pcf	- -
Optimum Water Content	%	- -



Jeffrey A. Kuhn, Ph.D, P.E., 4/19/2021

Quality Review / Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

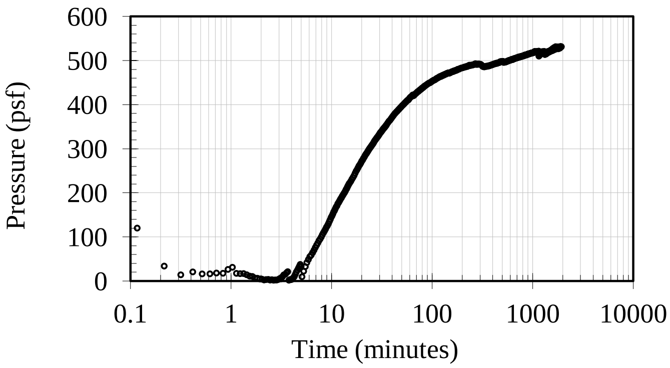
One-Dimensional Consolidation Properties of Soil

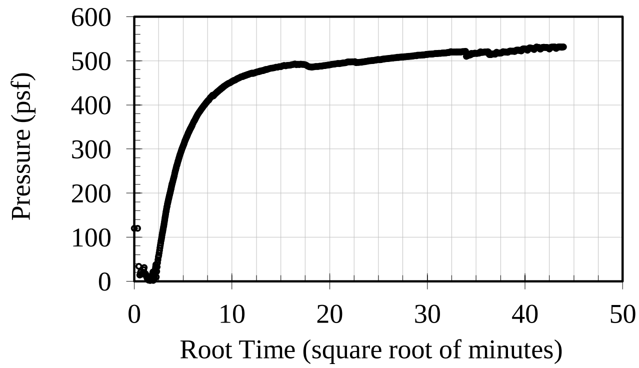
Client: AECOM
Project: Plum Creek 2 - 60615067, Task 1.4.14
Specimen: COMP-100B

TRI Log No.: 62867.1
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	14.4
Final Specimen Water Content (%)	20.1
Specimen Diameter (in)	2.500
Initial Specimen Height (in)	1.000
Initial Dry Unit Weight, γ_o lb_f/ft^3	109.0
Specific Gravity (ASTM D854)	2.77
Initial Void Ratio, e_o	0.517
Initial Degree of Saturation (%)	73.8

Swell Pressure (psf), Maximum Measured	532





Note: The remolded specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. **A seating stress of 120 psf was utilized for testing**.

Jeffrey A. Kuhn, Ph.D., P.E., 5/6/2021
Quality Review/Date

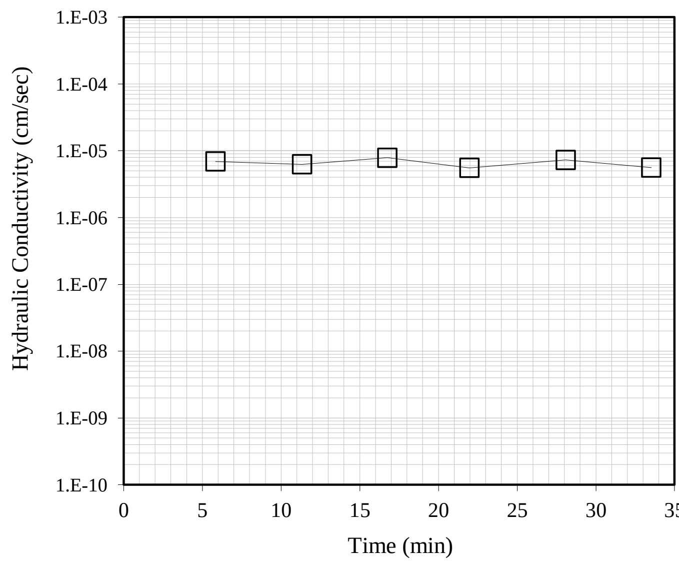
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Hydraulic Conductivity

Client: AECOM
Project: Plum Creek - 60615067, Task 1.4.14
Sample ID: COMP-100B

TRI Log #: 62867.1
Test Method: ASTM D5084

Sample Condition	Initial	Final
	Remolded	Post-Test
Diameter (in)	2.80	2.83
Height (in)	1.50	1.49
Mass (g)	302.5	317.3
Sample Area (in^2)	6.16	6.30
Water Content (%)	14.4	19.8
Total Unit Weight (pcf)	124.7	128.7
Dry Unit Weight (pcf)	109.0	107.4
Specific Gravity (Assumed)	2.75	
Degree of Saturation	69.0	91.1
Void Ratio	0.57	0.60
Porosity	0.36	0.37
1 Pore Volume (cc)	55.2	57.5



Eff. Confining Stress (psi)	5.0
Back-Pressure	80.0
B-Value Prior to Permeation	0.95
Permeant	De-Aired Tap Water

Specimen Image

Method C—Falling Head, rising tailwater elevation			
Time, t	Initial Gradient	Final Gradient	K_{20}
Min	-	-	cm/s
5.8	6.0	5.9	6.9E-06
11.3	5.9	5.7	6.3E-06
16.8	5.7	5.6	7.9E-06
22.0	5.6	5.5	5.6E-06
28.1	5.5	5.3	7.3E-06
33.5	5.3	5.2	5.6E-06
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
Average, Last 4 Readings			**6.6E-06**

Jeffrey A. Kuhn, Ph.D, P.E. 5/6/2021
Analysis & Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Consolidated-Undrained Triaxial Compression

Client: AECOM
Project: Plum Creek - 60615067, Task 1.4.14
Sample: COMP-100B

TRI Log #: 62867.2
Test Method: ASTM D4767

Specimens				
Identification	1	2	3	4
Depth/Elev. (ft)	-	-	-	-
Eff. Consol. Stress (psi)	7.0	17.0	35.0	-
Initial Specimen Properties				
Avg. Diameter (in)	2.00	2.00	2.00	-
Avg. Height (in)	4.50	4.50	4.50	-
Avg. Water Content (%)	17.4	17.4	17.4	-
Bulk Density (pcf)	128.0	128.0	128.0	-
Dry Density (pcf)	109.0	109.0	109.0	-
Specific Gravity (Assumed)	2.70			
Saturation (%)	86.1	86.1	86.1	-
Void Ratio, n	0.55	0.55	0.55	-
B-Value, End of Saturation	0.95	1.00	0.97	-

Test Setup	
Specimen Condition	Remolded
Specimen Preparation	Kneading and Impact Compaction, Six Lifts
Mounting Method	Wet
Consolidation	Isotropic

Post-Consolidation / Pre-Shear				
Void Ratio	0.55	0.53	0.50	-

Shear / Post-Shear				
Rate of Strain (%/hr)	0.25	0.25	0.25	-
Avg. Water Content (%)	17.5	18.0	16.1	-

At Failure								
Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$				Ratio, $(\sigma_1'/\sigma_3')_{max}$			
Axial Strain at Failure (%), $\varepsilon_{a,f}$	15.0	13.6	15.0	-	0.8	1.5	4.2	-
Minor Effective Stress (psi), $\sigma_3'{}_f$	8.9	13.9	24.7	-	1.9	6.0	17.3	-
Principal Stress Difference (psi), $(\sigma_1-\sigma_3)_f$	20.6	30.3	43.5	-	15.6	21.1	35.9	-
Pore Water Pressure, Δu_f (psi)	-1.9	3.2	10.2	-	5.1	11.0	17.6	-
Major Effective Stress (psi), $\sigma_1'{}_f$	29.5	44.2	68.2	-	17.5	27.1	53.2	-
Secant Friction Angle (degrees)	32.5	31.4	27.9	-	53.9	39.7	30.6	-
Effective Friction Angle (degrees)	24.4				23.3			
Effective Cohesion (psi)	3.0				4.4			

Note: The presented M-C parameters are based on a linear regression in modified stress space, across all assigned effective consolidation stresses. This fit does not purported to capture typical curvature of envelopes that may, in particular, be observed across broader range in effective stresses. Please note that the stresses associated with peak principal stress ratio and peak principal stress difference are presented in tabular form on the first page of the report. There are alternate interpretations to theses two failure criterion including but not limited to strain compatibility and post-peak.

Jeffrey A. Kuhn , Ph.D., P.E., 5/10/2021
Analysis & Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Consolidated-Undrained Triaxial Compression

Client: AECOM
Project: Plum Creek - 60615067, Task 1.4.14
Sample: COMP-100B

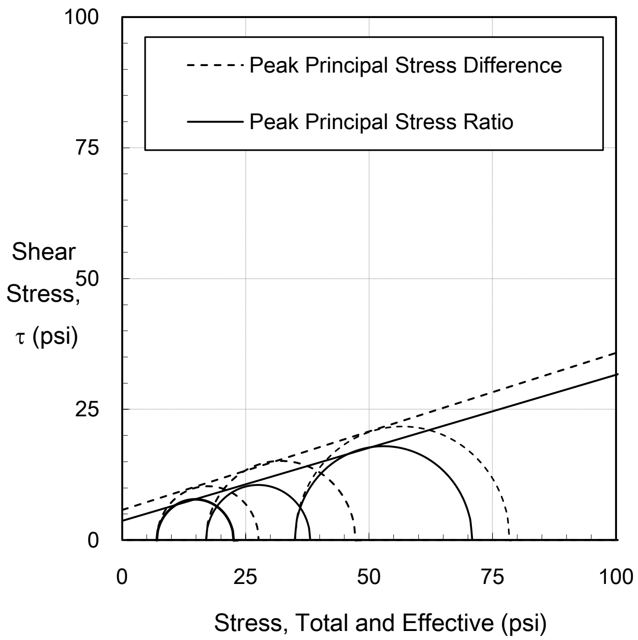
TRI Log #: 62867.2
Test Method: ASTM D4767

R / "Total Stress" Envelope			
Failure Criterion: Peak Principal Stress		Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Friction Angle (deg)	ϕ_R	16.7	15.6
Cohesion (psi)	c_R	5.8	3.7

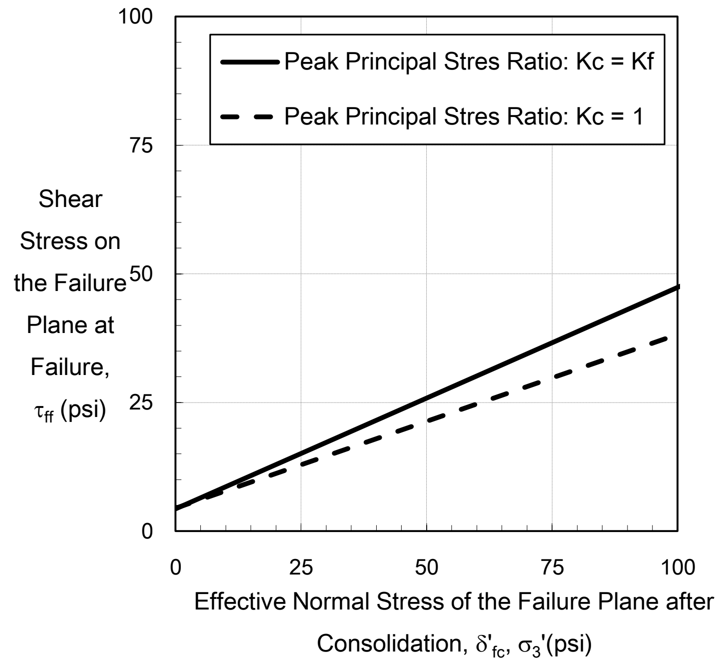
Kc = Kf Envelope, Effective Stress Envelope (Duncan et al. 1990)			
Failure Criterion: Peak Principal Stress		Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	ϕ'	24.4	23.3
Effective Cohesion (psi)	c'	3.0	4.4

Kc = 1 (τ_{ff} vs σ'_{fc}) Envelope, Total Stress Envelope (Duncan et al. 1990)			
Failure Criterion: Peak Principal Stress		Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Friction Angle (deg)	$d_{Kc=1}$	20.2	18.7
Cohesion (psi)	$\psi_{Kc=1}$	7.1	4.5

R / "Total Stress" Envelope



Three-Stage Rapid Drawdown Envelopes

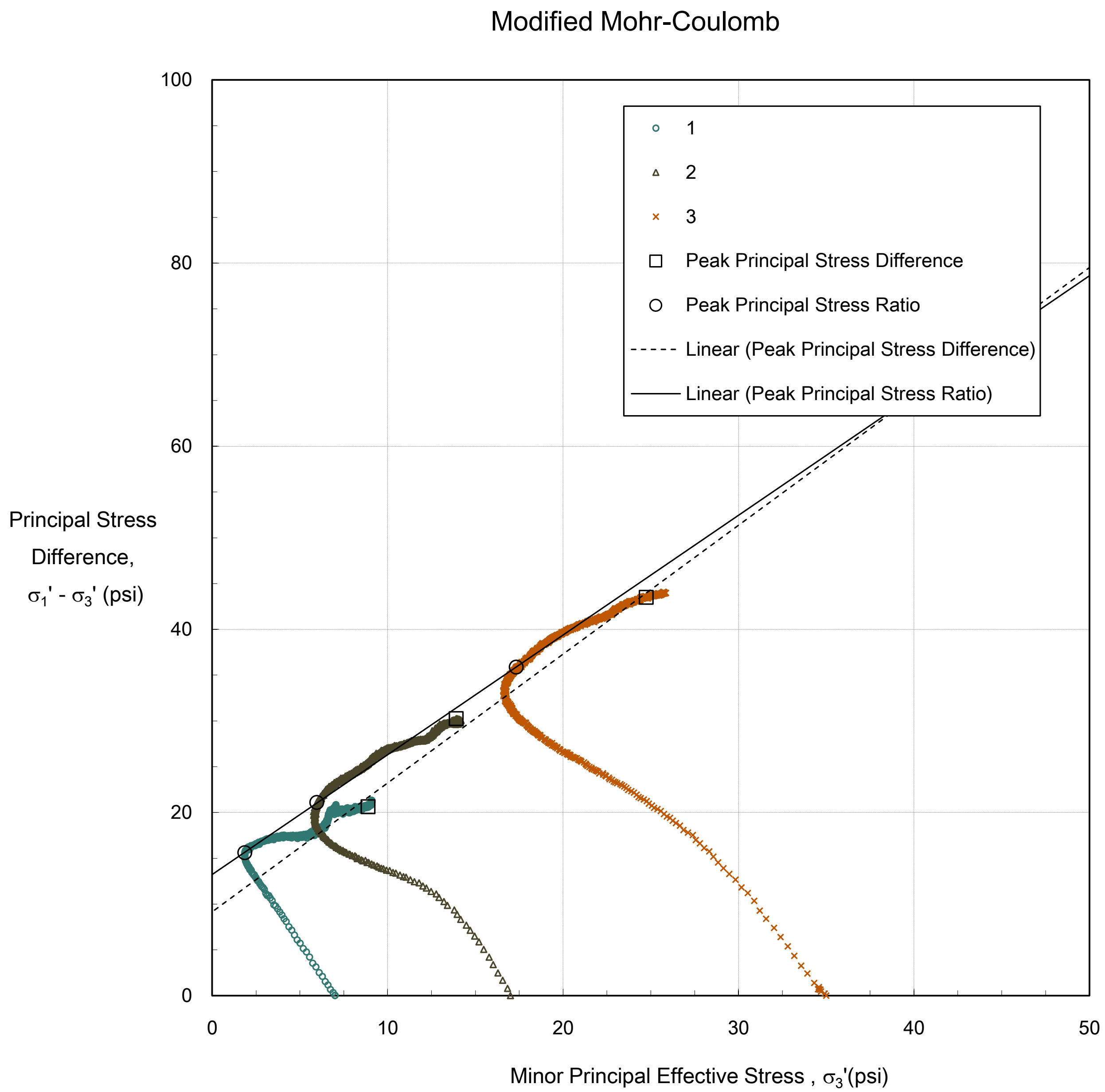


TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Consolidated-Undrained Triaxial Compression

Client: AECOM
Project: Plum Creek - 60615067, Task 1.4.14
Sample: COMP-100B

TRI Log #: 62867.2
Test Method: ASTM D4767



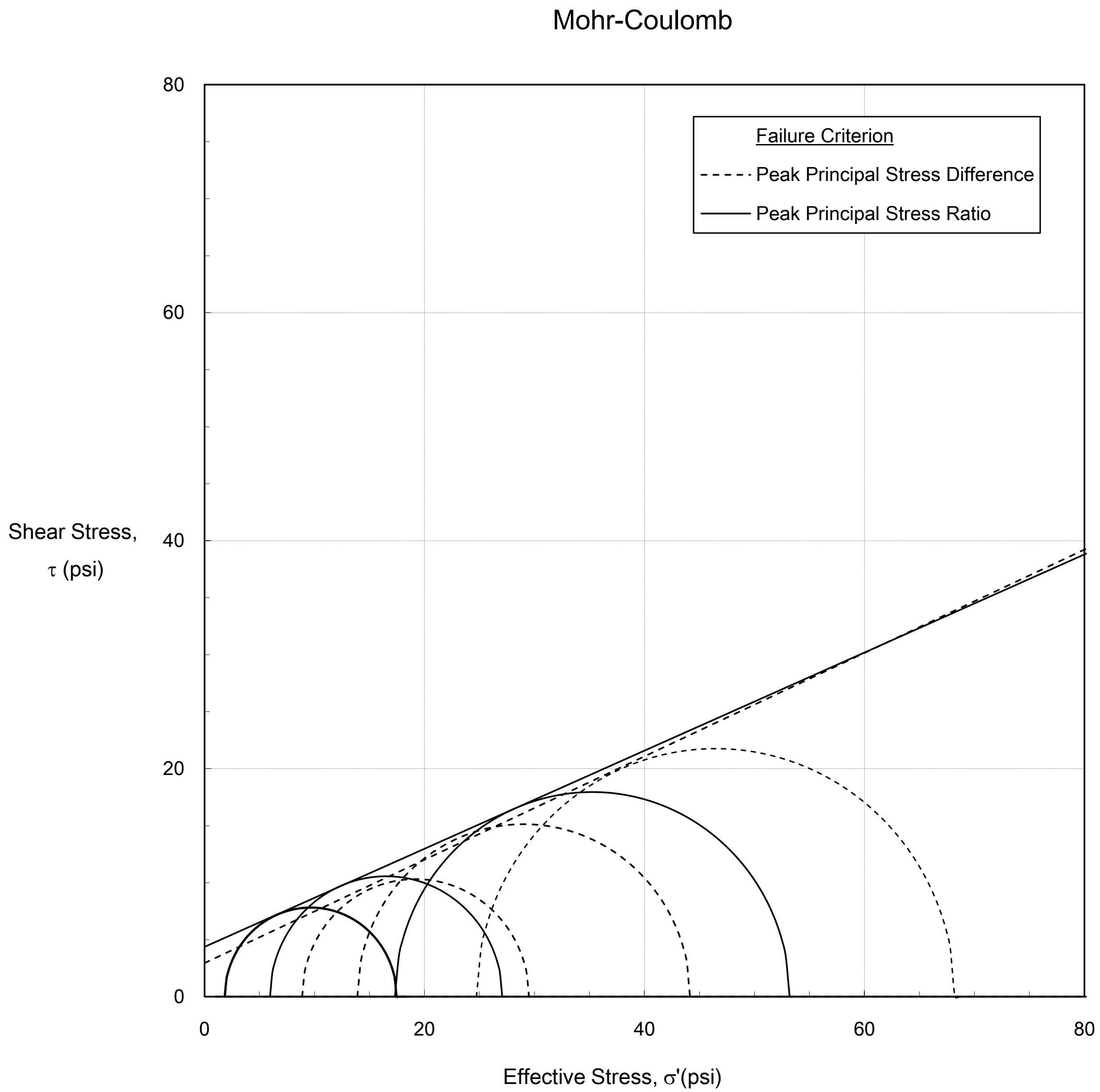
Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	24.4	23.3
Effective Cohesion (psi)	3.0	4.4

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Consolidated-Undrained Triaxial Compression

Client: AECOM
Project: Plum Creek - 60615067, Task 1.4.14
Sample: COMP-100B

TRI Log #: 62867.2
Test Method: ASTM D4767



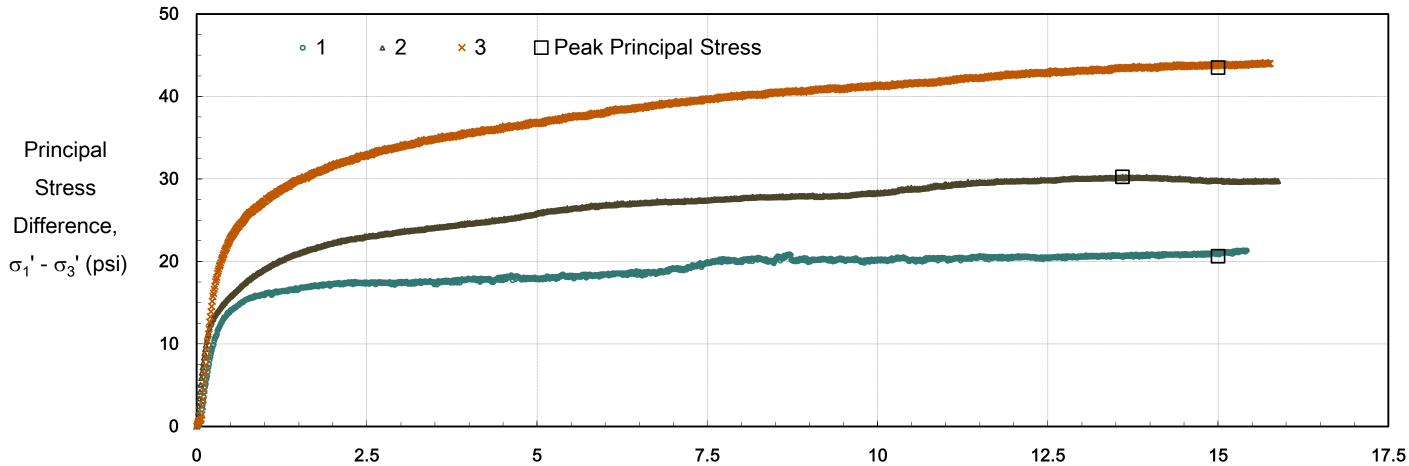
Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	24.4	23.3
Effective Cohesion (psi)	3.0	4.4

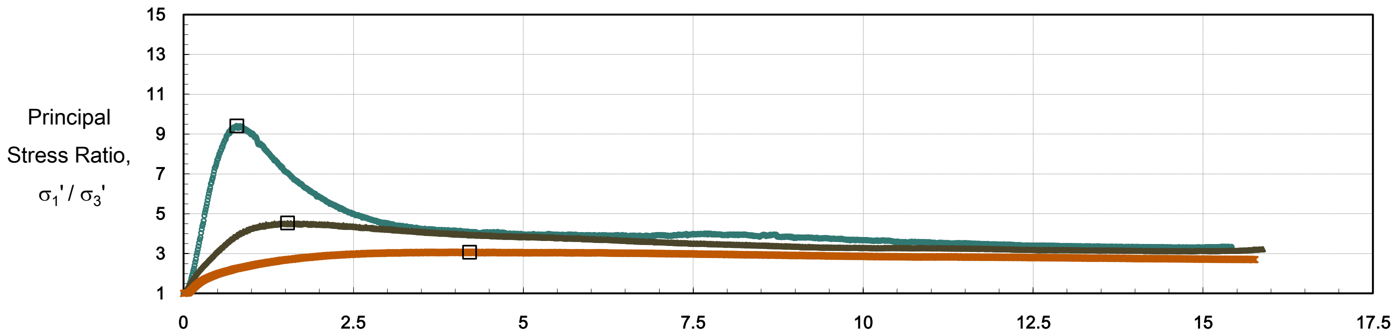
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

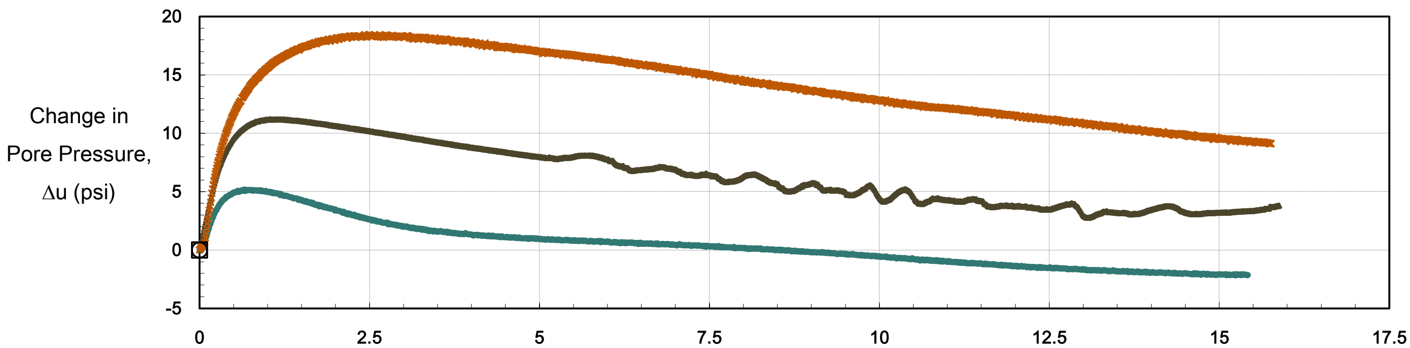
Consolidated-Undrained Triaxial Compression

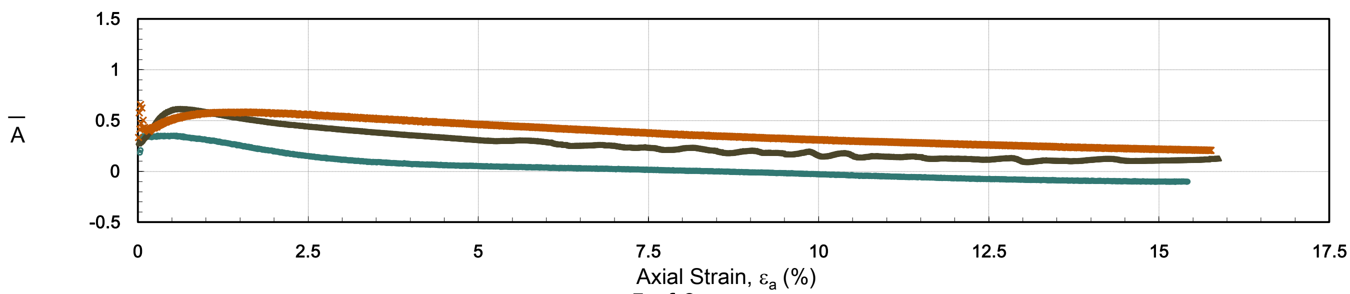
Client: AECOM
Project: Plum Creek - 60615067, Task 1.4.14
Sample: COMP-100B

TRI Log #: 62867.2
Test Method: ASTM D4767









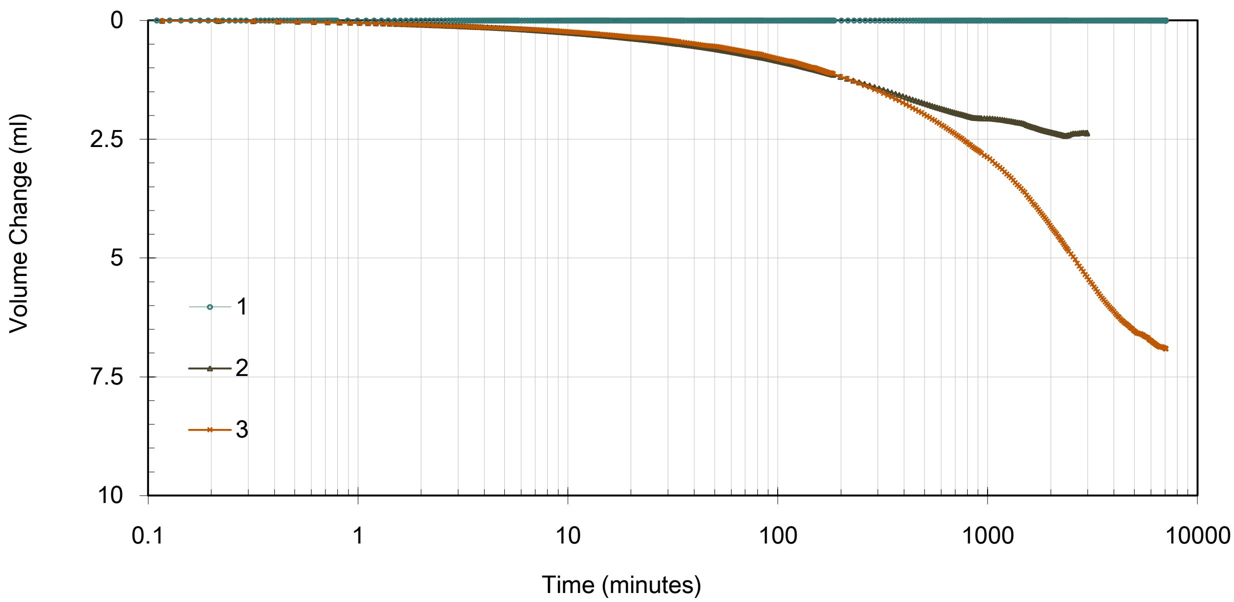
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

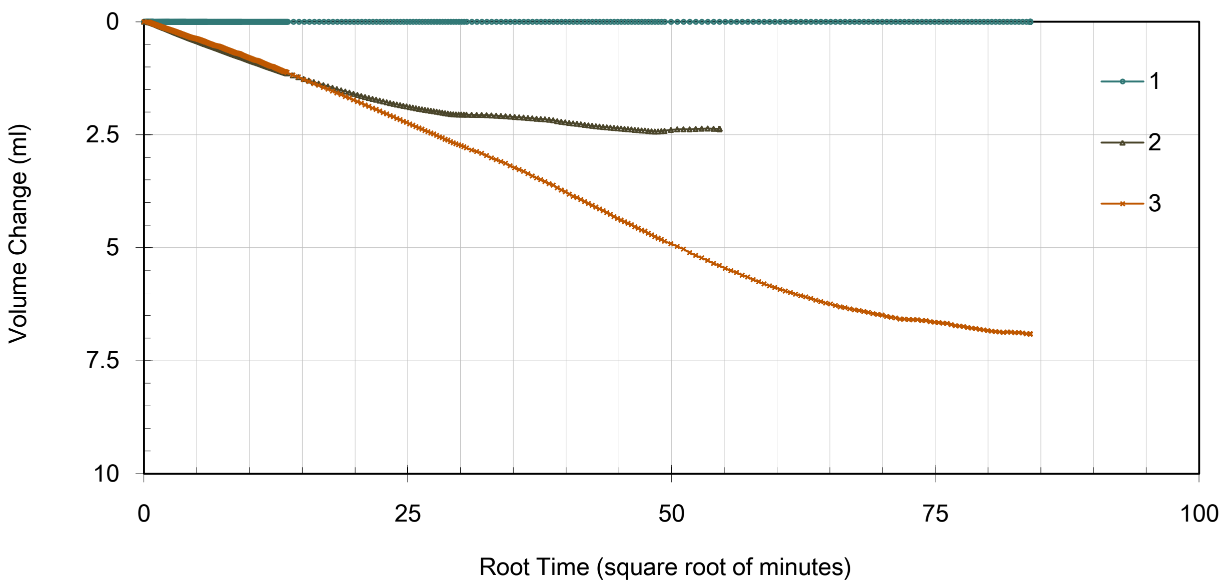
Consolidated-Undrained Triaxial Compression

Client: AECOM
Project: Plum Creek - 60615067, Task 1.4.14
Sample: COMP-100B

TRI Log #: 62867.2
Test Method: ASTM D4767

Consolidation





TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

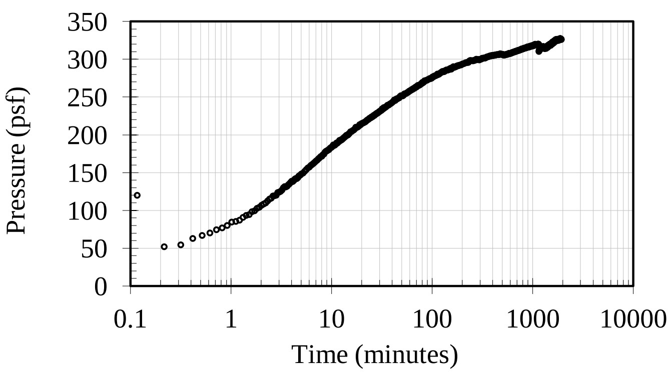
One-Dimensional Consolidation Properties of Soil

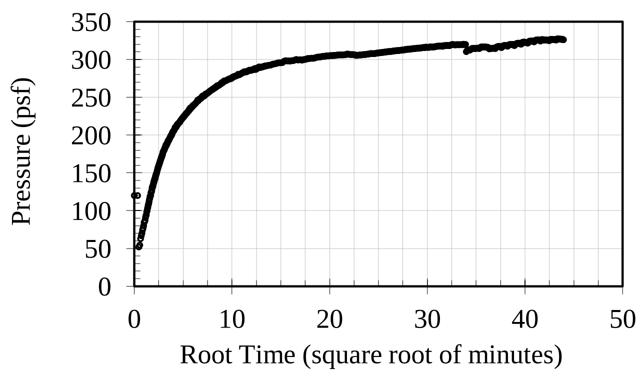
Client: AECOM
Project: Plum Creek 2 - 60615067, Task 1.4.14
Specimen: COMP-100B

TRI Log No.: 62867.3
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	16.4
Final Specimen Water Content (%)	19.4
Specimen Diameter (in)	2.500
Initial Specimen Height (in)	1.000
Initial Dry Unit Weight, γ_o lb_f/ft^3	109.0
Specific Gravity (Assumed)	2.75
Initial Void Ratio, e_o	0.517
Initial Degree of Saturation (%)	84.1

Swell Pressure (psf), Maximum Measured	327





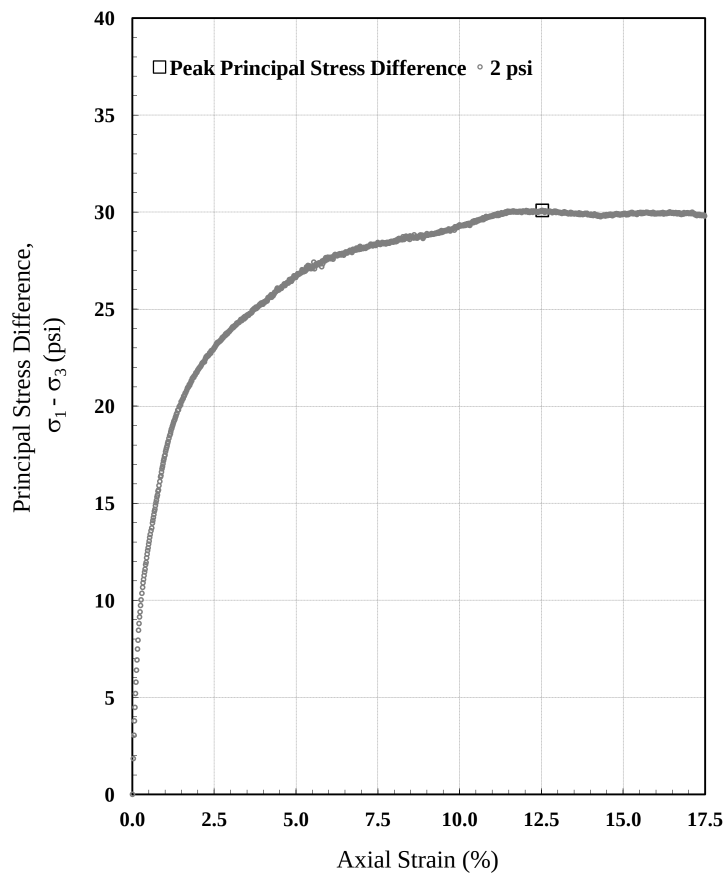
Note: The remolded specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. **A seating stress of 120 psf was utilized for testing**.

Jeffrey A. Kuhn, Ph.D., P.E., 5/6/2021
Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Unconsolidated-Undrained (Q) Triaxial Compression

Client:	AECOM	TRI Log #:	62867.3
Project:	Plum Creek - 60615067, Task 1.4.14	Test Method:	ASTM D2850
Sample:	COMP-100B		



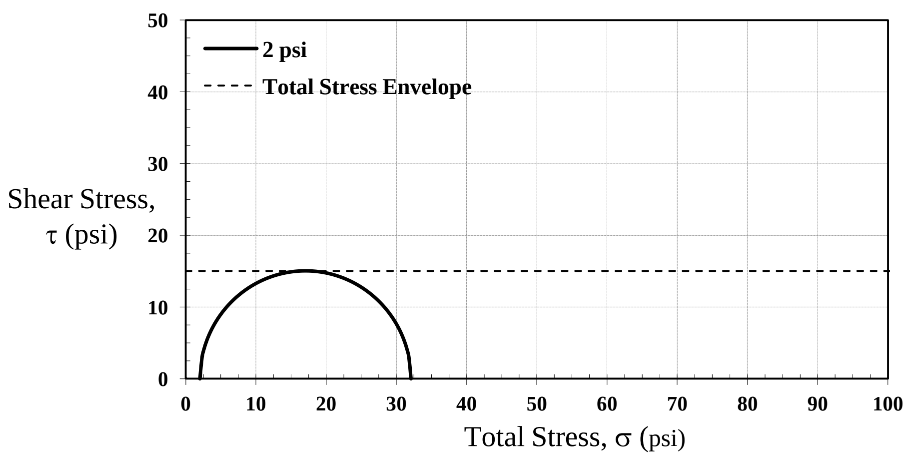
Test Parameters	
Minor Principal Stress (psi)	2.0
Rate of Strain (%/hr)	60

Initial Properties	
Avg. Diameter (in)	2.00
Avg. Height (in)	4.50
Avg. Water Content (%)	16.4
Bulk Density (pcf)	126.9
Dry Density (pcf)	109.0
Saturation (%)	78.5
Void Ratio	0.57
Specific Gravity (Assumed)	2.75

At Failure - Maximum Deviator Stress	
Axial Strain at Failure (%)	12.5
Minor Total Stress (psi)	2.0
Major Total Stress (psi)	32.1
Principal Stress Diff. (psi)	30.1

Total Stress Envelope	
Friction Angle (deg)	0
Undrained Shear Strength, S_u (psi)	15.0
S_u / σ_3	7.5

Note: The calculated value of specimen saturation was less than 95%. The Mohr failure envelope was taken as a horizontal straight line, but noting that the calculated value of saturation indicates a partially saturated specimen.



Jeffrey A. Kuhn , Ph.D., P.E., 5/6/2021

Analysis & Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

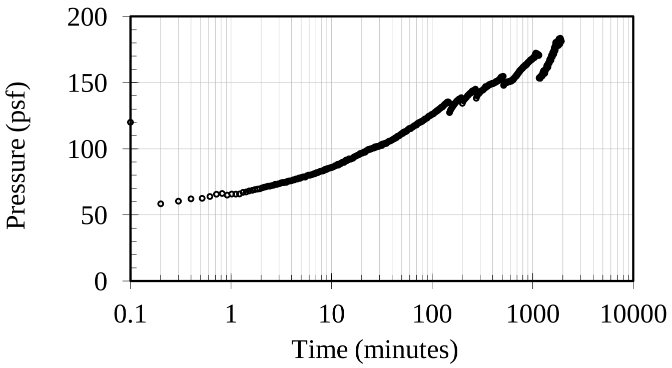
One-Dimensional Consolidation Properties of Soil

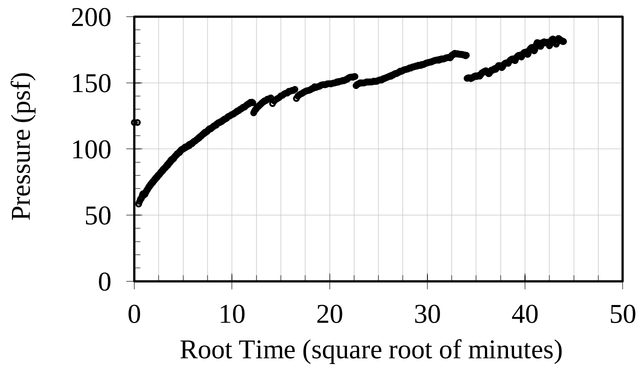
Client: AECOM
Project: Plum Creek 2 - 60615067, Task 1.4.14
Specimen: COMP-100B

TRI Log No.: 62867.4
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	18.4
Final Specimen Water Content (%)	19.3
Specimen Diameter (in)	2.500
Initial Specimen Height (in)	1.000
Initial Dry Unit Weight, γ_o lb_f/ft^3	109.0
Specific Gravity (Assumed)	2.75
Initial Void Ratio, e_o	0.517
Initial Degree of Saturation (%)	94.3

Swell Pressure (psf), Maximum Measured	184





Note: The remolded specimen inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. **A seating stress of 120 psf was utilized for testing**.

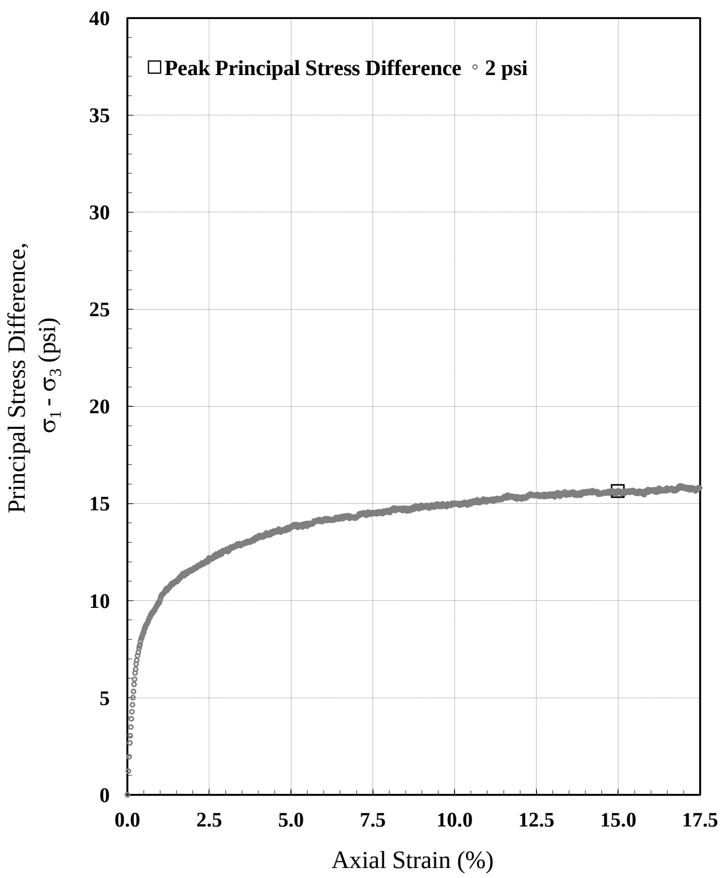
Jeffrey A. Kuhn, Ph.D., P.E., 5/6/2021
Quality Review/Date

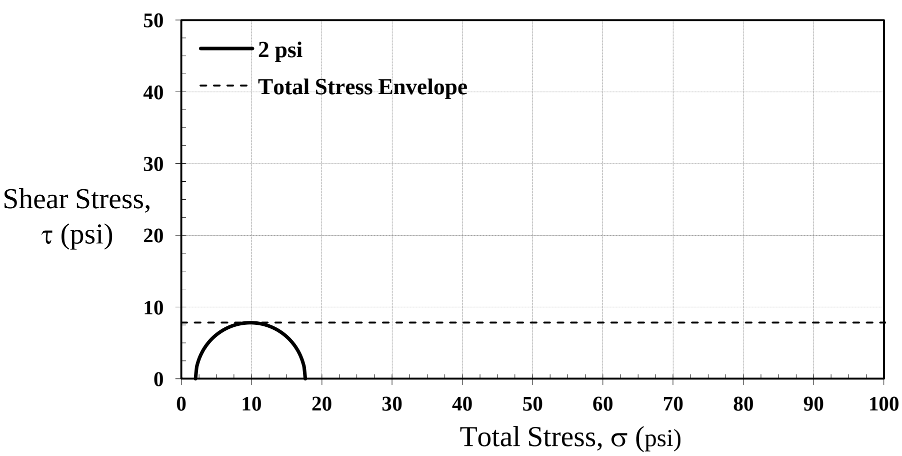
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Unconsolidated-Undrained (Q) Triaxial Compression

Client: AECOM
Project: Plum Creek - 60615067, Task 1.4.14
Sample: COMP-100B

TRI Log #: 62867.4
Test Method: ASTM D2850





Test Parameters	
Minor Principal Stress (psi)	2.0
Rate of Strain (%/hr)	60

Initial Properties	
Avg. Diameter (in)	2.00
Avg. Height (in)	4.50
Avg. Water Content (%)	18.4
Bulk Density (pcf)	129.1
Dry Density (pcf)	109.0
Saturation (%)	88.1
Void Ratio	0.57
Specific Gravity (Assumed)	2.75

At Failure - Maximum Deviator Stress	
Axial Strain at Failure (%)	15.0
Minor Total Stress (psi)	2.0
Major Total Stress (psi)	17.6
Principal Stress Diff. (psi)	15.6

Total Stress Envelope	
Friction Angle (deg)	0
Undrained Shear Strength, S_u (psi)	7.8
S_u / σ_3	3.9

Note: The calculated value of specimen saturation was less than 95%. The Mohr failure envelope was taken as a horizontal straight line, but noting that the calculated value of saturation indicates a partially saturated specimen.

Jeffrey A. Kuhn , Ph.D., P.E., 5/6/2021
Analysis & Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Client: AECOM TRI Log #: 62867

Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 5/6/2021

Quality Review/Date

Analytical

COC Line #	Sample Identification	Chloride Content (mg/kg)	Sulfate Content (mg SO_4/kg)	pH		Resistivity (ohm-cm)
				(H_2O)	($CaCl_2$)	
-	Test Method	ASTM D512	ASTM D516	ASTM D4972 (method A)		ASTM G57
-	Method Detection Limit (MDL)	[5 mg/l]*	[5 mg/l]*	-	-	-
1	COMP-100B	300	2,000	8.27	8.03	660

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The chloride and sulfate MDLs are volumetric. Results are mass per mass of dry soil.

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: Plum Creek - 60615067, Task 1.4.14

TRI Log #: 62867
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
1	COMP-100B	17.7	N/A	18.9	18.7	20.4	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

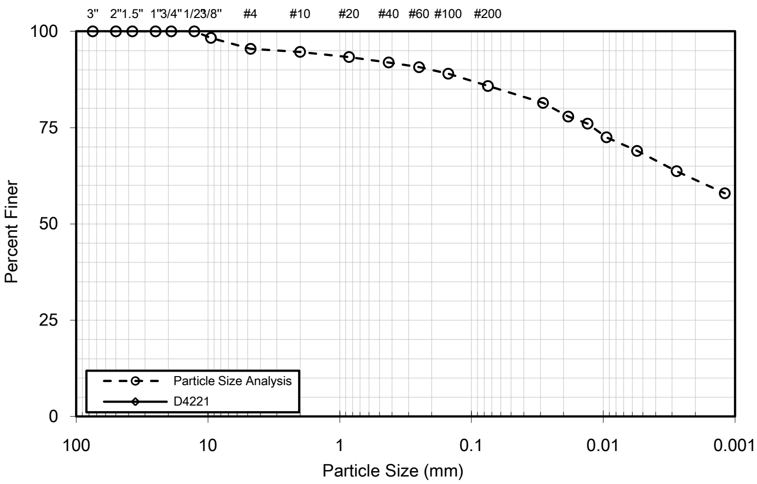
Jeffrey A. Kuhn, Ph.D., P.E., 5/26/2021
Quality Review/Date

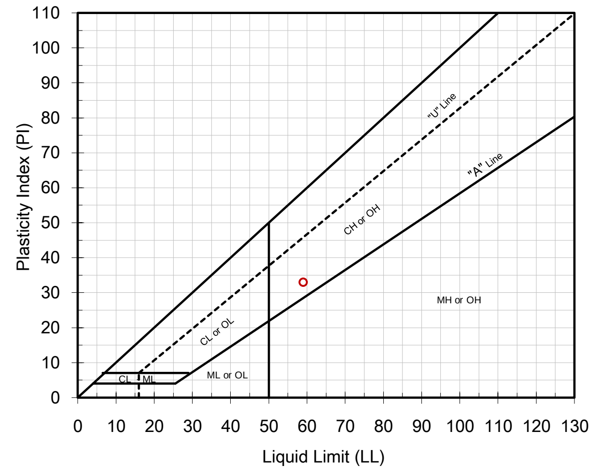
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

COMP-400A

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client:	AECOM	TRI Log #:	62866.1
Project:	Plum Creek 2 - 60615067, Task 1.4.14		
Sample ID:	COMP-400A		





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0		0.029	81.4	- -	- -
2 in.	50.8	100.0		0.018	77.9	- -	- -
1.5 in.	38.1	100.0		0.013	76.0	- -	- -
1 in.	25.4	100.0	4.5	0.009	72.5	- -	- -
3/4 in.	19.0	100.0		0.006	69.0	- -	- -
1/2 in.	12.7	100.0		0.003	63.7	- -	- -
3/8 in.	9.51	98.3		0.001	58.0	- -	- -
No. 4	4.76	95.5		Log-Linear Interpolation			
No. 10	2.00	94.7		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	93.3		mm		mm	
No. 40	0.420	91.9	9.7				
No. 60	0.250	90.7		0.005	68.2	0.005	- -
No. 100	0.149	89.0		0.002	61.5	0.002	- -
No. 200	0.074	85.8	85.8	N m,2µm,d	62	N m,2µm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	1.6E-03	- -	- -	-

USDA	Sand (%) (2.0-0.05 mm)	12.2	Silt (%) (0.05-0.002)	22.9	Clay (%) (< 0.002 mm)	64.9
Clay						

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	59
Plastic Limit	26
Plastic Index	33
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	9.9
Organic Content (%)	ASTM D2974-C	5.0
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

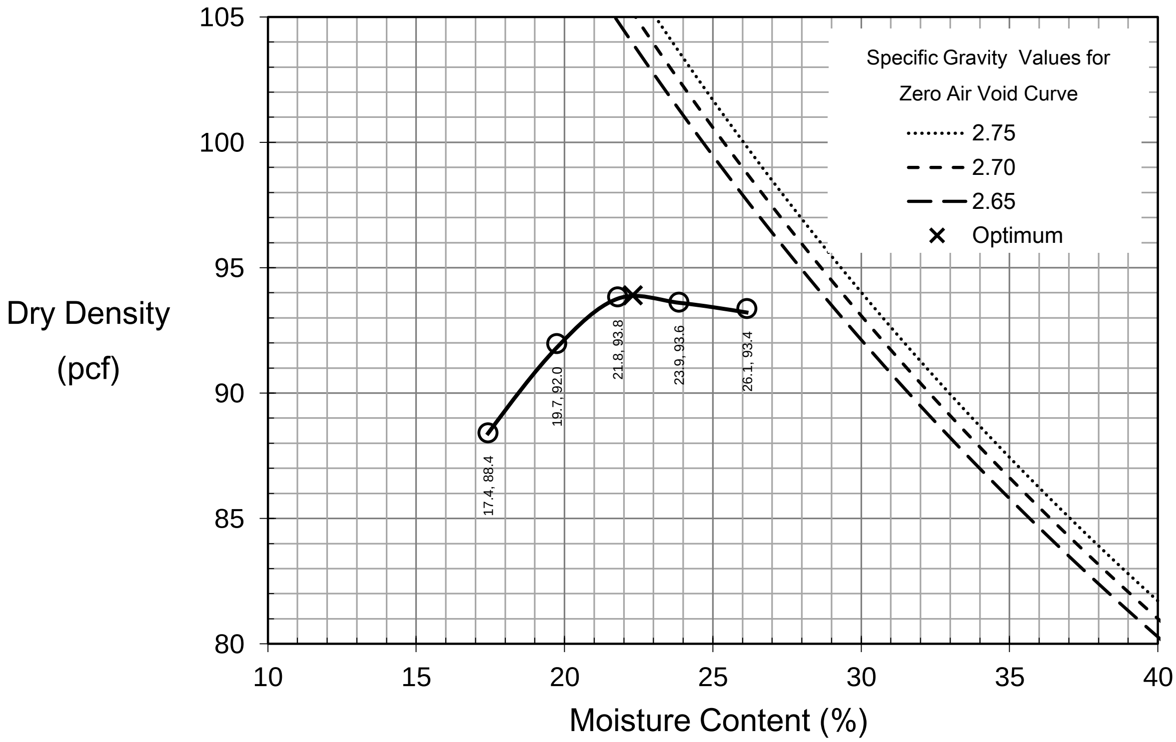
Jeffrey A. Kuhn, Ph.D, P.E. 5/10/2021
Analysis & Quality Review/Date

Laboratory Compaction Characteristics of Soil Using Standard Effort (ASTM D698) with Correction for Oversize Particles (ASTM D4718)

Client: AECOM
TRI Log #: 62866.1
Project: Plum Creek 2 - 60615067, Task 1.4.14
Sample ID: COMP-400A

Compaction Effort	-	Standard
Method	-	A
Rammer Type	-	Automatic
Maximum Dry Density	pcf	93.9
Optimum Water Content	%	22.3

Oversize Particle / "Rock" Correction (ASTM D4718)		
Oversized Particles	%	- -
Maximum Dry Density	pcf	- -
Optimum Water Content	%	- -



Jeffrey A. Kuhn, Ph.D, P.E., 4/19/2021
Quality Review / Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

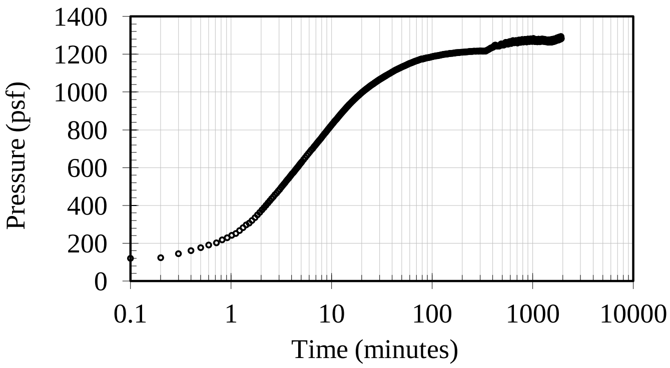
One-Dimensional Consolidation Properties of Soil

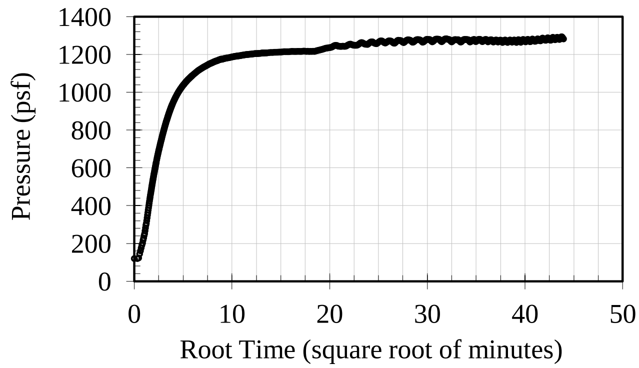
Client: AECOM
Project: Plum Creek 2 - 60615067, Task 1.4.14
Specimen: COMP-400A

TRI Log No.: 62866.1
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	22.3
Final Specimen Water Content (%)	29.1
Specimen Diameter (in)	2.500
Initial Specimen Height (in)	1.000
Initial Dry Unit Weight, γ_o lb_f/ft^3	89.0
Specific Gravity (ASTM D854)	2.60
Initial Void Ratio, e_o	0.859
Initial Degree of Saturation (%)	68.8

Swell Pressure (psf), Maximum Measured	1294



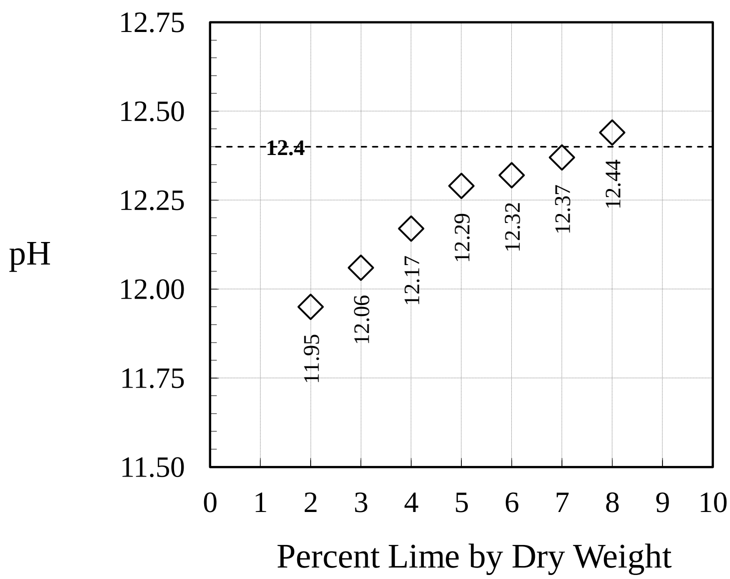


Note: The remolded specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. **A seating stress of 120 psf was utilized for testing**.

Jeffrey A. Kuhn, Ph.D., P.E., 5/11/2021
Quality Review/Date

Using pH to Estimate the Soil-Lime Proportion Requirement for Soil Stabilization (ASTM D6276)

Client: AECOM
TRI Log #: 62866.1
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: COMP-400A



Percent Lime by Dry Weight	pH
2.0	11.95
3.0	12.06
4.0	12.17
5.0	12.29
6.0	12.32
7.0	12.37
8.0	12.44

Lowest Percent Lime by Dry Weight to yield a pH of 12.4 or Greater
8.0

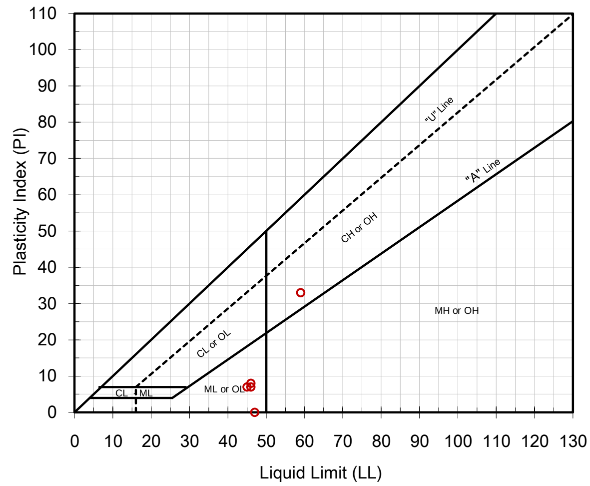
Jeffrey A. Kuhn, Ph.D, P.E. 4/30/2021
Analysis & Quality Review/Date

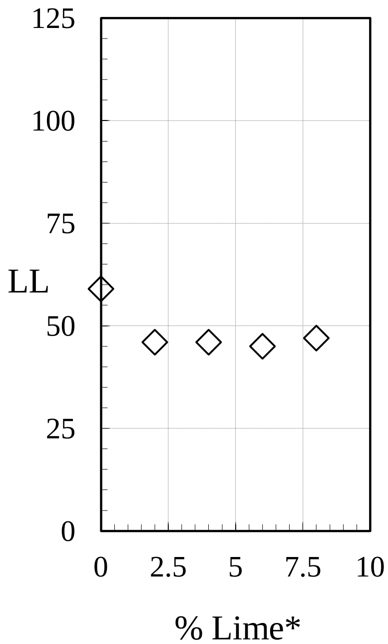
Admixing Lime to Reduce Plasticity Index of Soils (Tex-112-E)

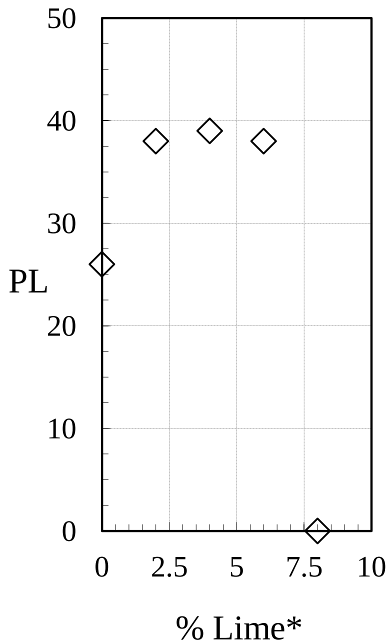
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: COMP-400A

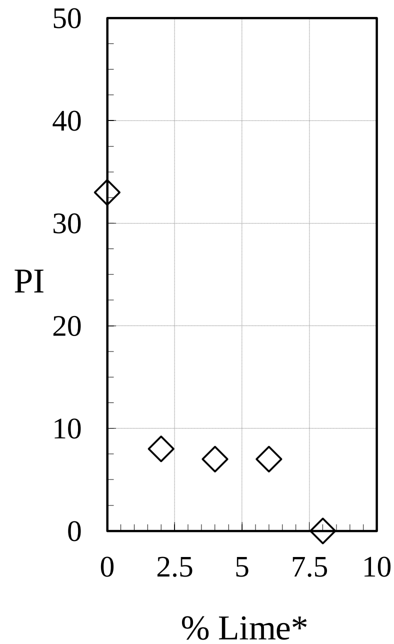
TRI Log #: 62866.1

Percent Lime by Dry Weight	Atterberg Limits		
	Liquid Limit	Plastic Limit	Plasticity Index
	ASTM D4318, Method A : Multipoint		
0.0	59	26	33
2.0	46	38	8
4.0	46	39	7
6.0	45	38	7
8.0	47	NP	-









*Percent Lime by Dry Unit Weight

Jeffrey A. Kuhn, Ph.D, P.E. 5/11/2021
Analysis & Quality Review/Date

TRI Environmental | 9063 Bee Cave Rd., Austin, TX 78733, USA | 512-263-5944 | www.tri-env.com

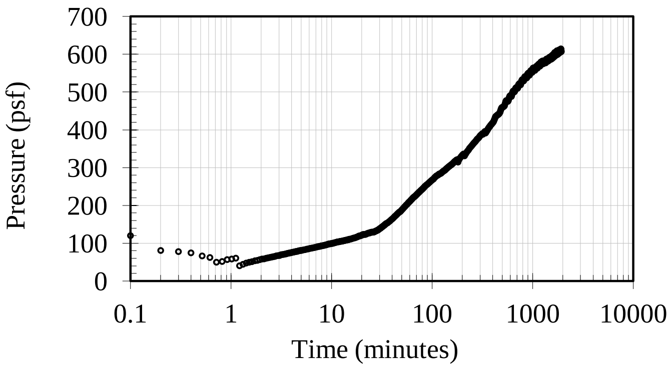
One-Dimensional Consolidation Properties of Soil

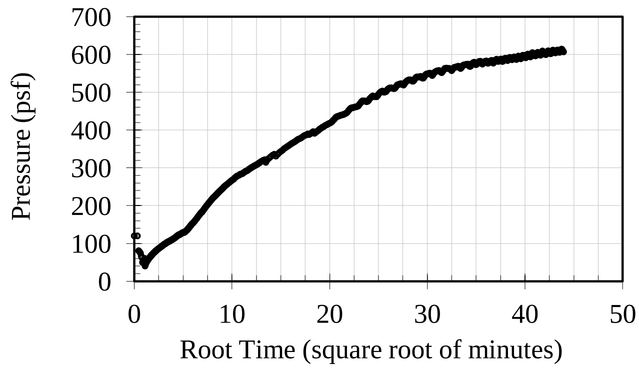
Client: AECOM
Project: Plum Creek 2 - 60615067, Task 1.4.14
Specimen: COMP-400A

TRI Log No.: 62866.2
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	26.3
Final Specimen Water Content (%)	28.4
Specimen Diameter (in)	2.500
Initial Specimen Height (in)	1.000
Initial Dry Unit Weight, γ_o lb_f/ft^3	89.0
Specific Gravity (ASTM D854)	2.60
Initial Void Ratio, e_o	0.859
Initial Degree of Saturation (%)	81.1

Swell Pressure (psf), Maximum Measured	614





Note: The remolded specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. **A seating stress of 120 psf was utilized for testing**.

Jeffrey A. Kuhn, Ph.D., P.E., 5/11/2021
Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 62866

Jeffrey A. Kuhn, Ph.D., P.E., 5/10/2021

Quality Review/Date

Analytical

COC Line #	Sample Identification	Chloride Content (mg/kg)	Sulfate Content (mg SO_4/kg)	pH		Resistivity (ohm-cm)
				(H_2O)	($CaCl_2$)	
-	Test Method	ASTM D512	ASTM D516	ASTM D4972 (method A)		ASTM G57
-	Method Detection Limit (MDL)	[5 mg/l]*	[5 mg/l]*	-	-	-
1	COMP-400A	180	2,700	8.04	7.79	1,210

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The chloride and sulfate MDLs are volumetric. Results are mass per mass of dry soil.

TRI Environmental, Inc.

9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: Plum Creek - 60615067, Task 1.4.14

TRI Log #: 62866
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
1	COMP-400A	20.4	N/A	18.9	18.7	20.4	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 5/10/2021
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

COMP-1700A

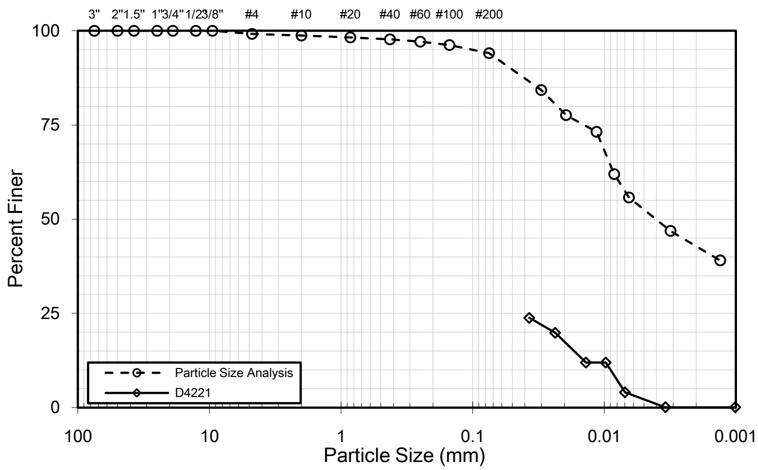
TRI ENVIRONMENTAL

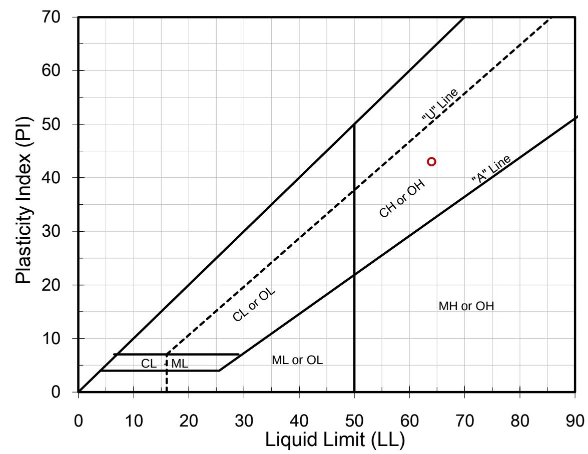
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client:	AECOM
Project:	60615067-1.4.14 Plum Creek 2
Sample ID:	COMP-1700A
TRI Log #:	60056.1





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm		Fines	mm		mm	
3 in.	76.2	100.0	0.8	0.030	84.3	0.037	23.8
2 in.	50.8	100.0		0.020	77.6	0.024	19.8
1.5 in.	38.1	100.0		0.011	73.2	0.014	11.9
1 in.	25.4	100.0		0.008	62.0	0.010	11.9
3/4 in.	19.0	100.0		0.006	55.8	0.007	4.0
1/2 in.	12.7	100.0		0.003	46.9	0.003	0.1
3/8 in.	9.51	100.0		0.001	39.1	0.001	0.1
No. 4	4.76	99.2	5.1	Log-Linear Interpolation			
No. 10	2.00	98.8		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	98.3					
No. 40	0.420	97.7		mm		mm	
No. 60	0.250	97.1		0.005	52.6	0.005	2.2
No. 100	0.149	96.2		0.002	42.9	0.002	0.1
No. 200	0.074	94.1	94.1	N m,2µm,d	43	N m,2µm,nd	0

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	4.0E-03	7.7E-03	- -	- -	0

USDA	Sand (%)		Silt (%)		Clay (%)	
Silty Clay	(2.0-0.05 mm)	12.9	(0.05-0.002	43.7	(< 0.002 mm)	43.4

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	64
Plastic Limit	21
Plastic Index	43
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	5.8
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 11/3/2020

Analysis & Quality Review/Date

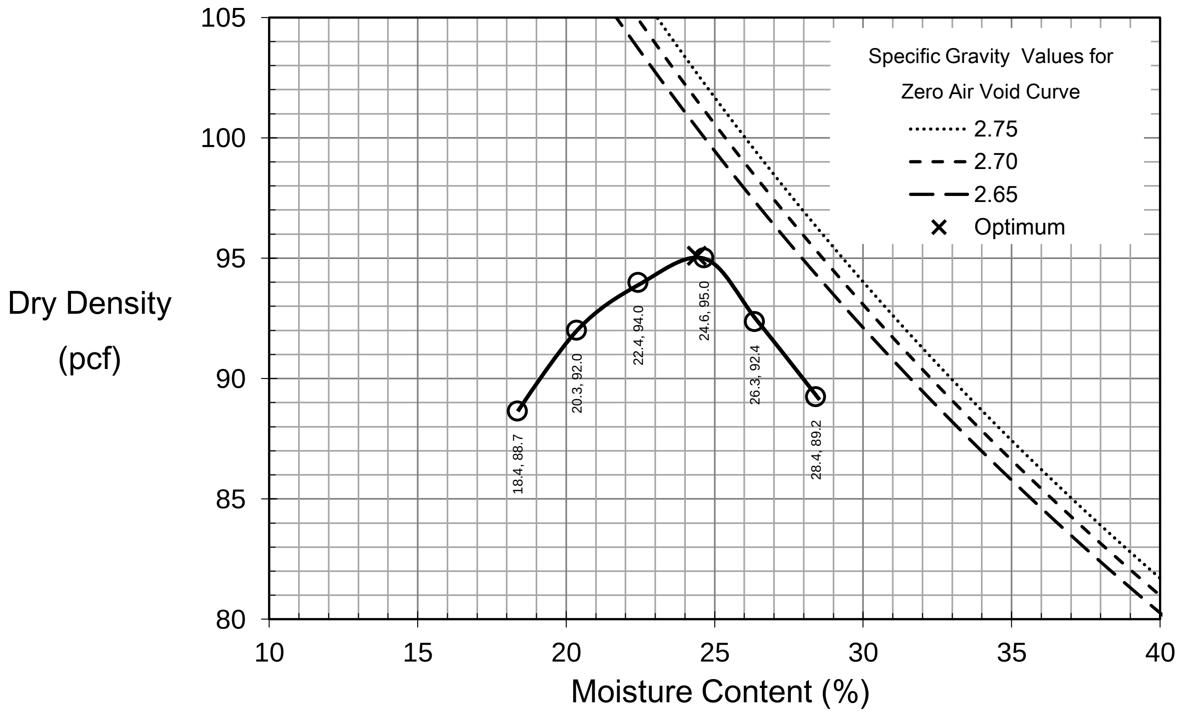
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Laboratory Compaction Characteristics of Soil Using Standard Effort (ASTM D698)

Client: AECOM
TRI Log #: 60056.1
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: COMP-1700A

Compaction Effort	-	Standard
Method	-	A
Rammer Type	-	Automatic
Maximum Dry Density	pcf	95.1
Optimum Water Content	%	24.4

Oversize Particle / "Rock" Correction (ASTM D4718)		
Oversized Particles	%	- -
Maximum Dry Density	pcf	- -
Optimum Water Content	%	- -

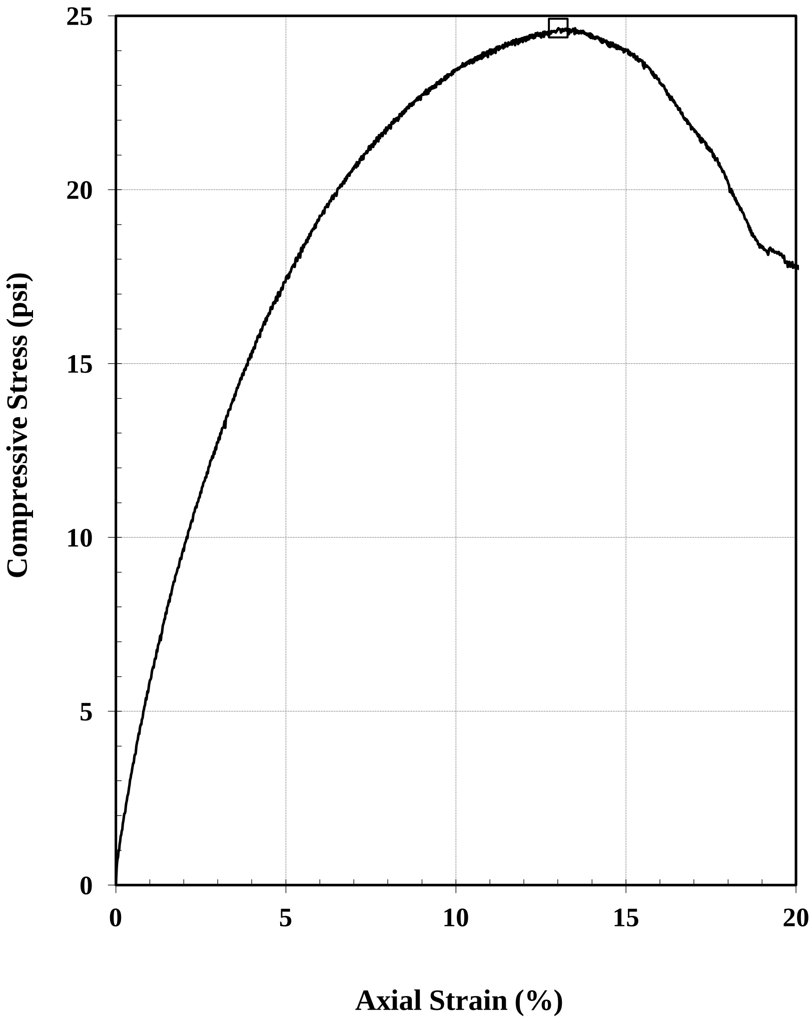


Jeffrey A. Kuhn, Ph.D, P.E., 10/29/2020
Quality Review / Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Unconfined Compression Test Report

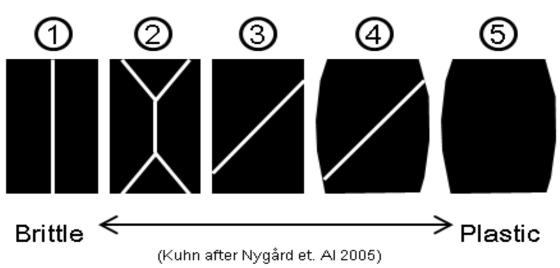
Client:	AECOM	TRI Log No.:	60056.1
Project:	60615067-1.4.14 Plum Creek 2	Type of Specimen:	Remolded
Sample ID:	COMP-1700A	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.00
Avg. Height (in)	H_o	4.49
Avg, Water Content (%)	w_o	24.5
Bulk Density (pcf)	γ_{total}	112.7
Dry Density (pcf)	γ_{dry}	90.5
Saturation (%)	S_r	77.1
Void Ratio	e_o	0.86
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	24.7
Axial Strain at Failure (%)	13.0
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	24.7
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	12.3

Failure Mode	4



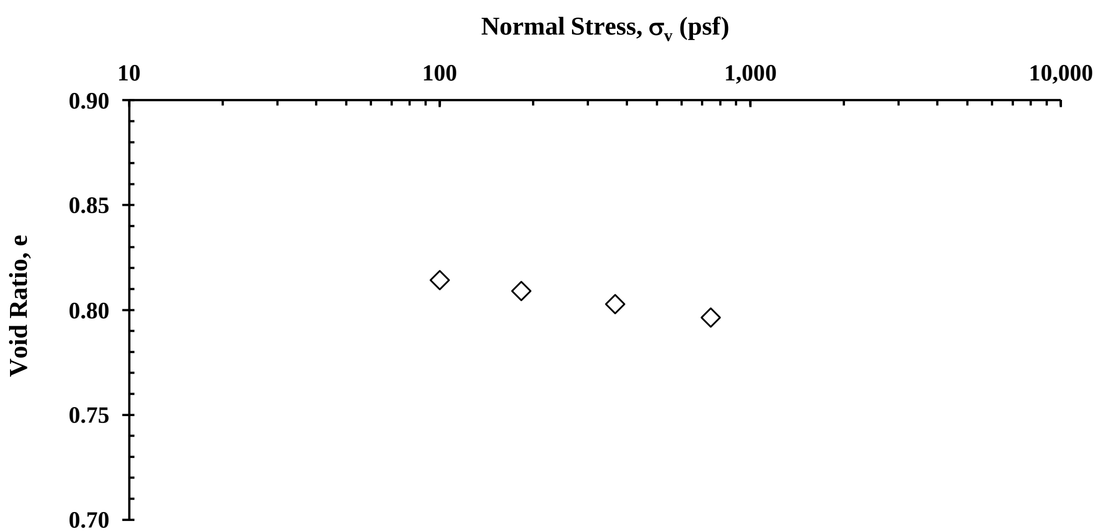
Jeffrey A. Kuhn, Ph.D., P.E., 11/3/20
Quality Review/Date

Swell Pressure Measurement with Multistage Unloading

Client:	AECOM	TRI Log #:	60056.1
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D4546-B MOD
Specimen:	COMP_1700A		

Stage	Initial[1,2]	Normal Stress (psf)[3,4]				
Normal Stress (psf)	120	746	367	183	100	-
Water Content, ω (%)	24.4	-	-	-	26.7	-
Diameter, d (in)	2.500	-	-	-	-	-
Height, h (in)	1.000	1.000	1.004	1.007	1.010	-
Total Unit Weight (pcf)	112.3	-	-	-	112.3	-
Dry Unit Weight (pcf)	90.3	-	-	-	90.3	-
Void Ratio, e	0.796	0.796	0.803	0.809	0.814	-
Δe / Δlog(σ)	-	-	-0.021	-0.021	-0.020	-
Degree of Saturation, S (%)	79.7	-	-	-	85.1	-
Strain (%)[3,4]	0.000	0.000	-0.357	-0.705	-0.994	-

1. A specific gravity of 2.60 was measured in accordance with ASTM D854. Calculations include measured machine deflections.
2. In the specimen ring.
3. Sign convention: (+) Compression/Collapse, (-) Expansion/Swell
4. Modification: The initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. Following the measurement of the swell pressure the sample was subsequently unloaded in a series of stages.



Jeffrey A. Kuhn, Ph.D., P.E. 5/10/2021

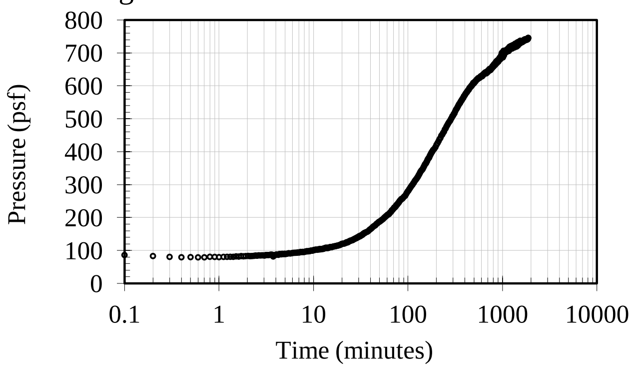
Analysis & Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

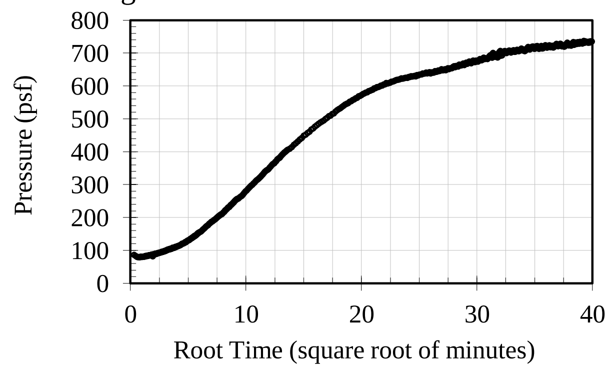
Swell Pressure Measurement with Multistage Unloading

Client:	AECOM	TRI Log #:	60056.1
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D4546-B MOD
Specimen:	COMP_1700A		

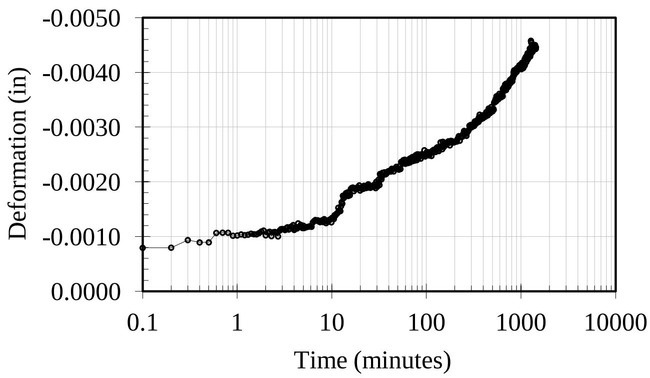
Stage 1: Swell Pressure Measurement



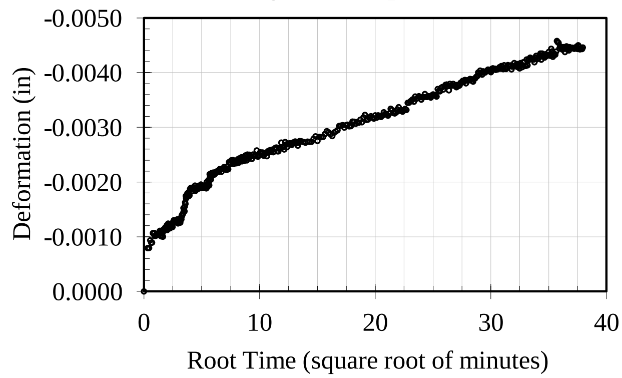
Stage 1: Swell Pressure Measurement



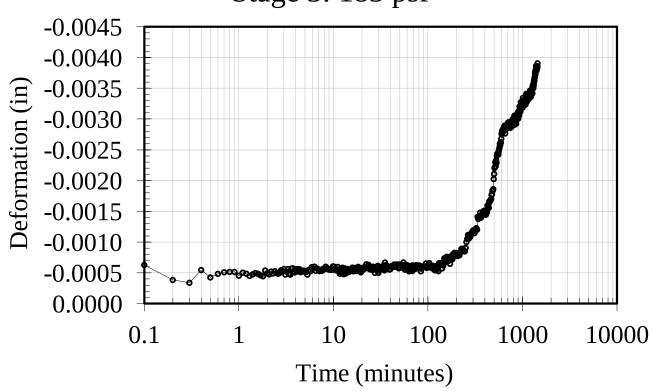
Stage 2: 367 psf



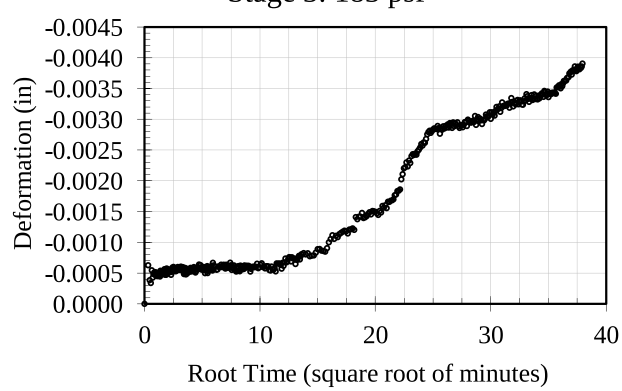
Stage 2: 367 psf



Stage 3: 183 psf



Stage 3: 183 psf



TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

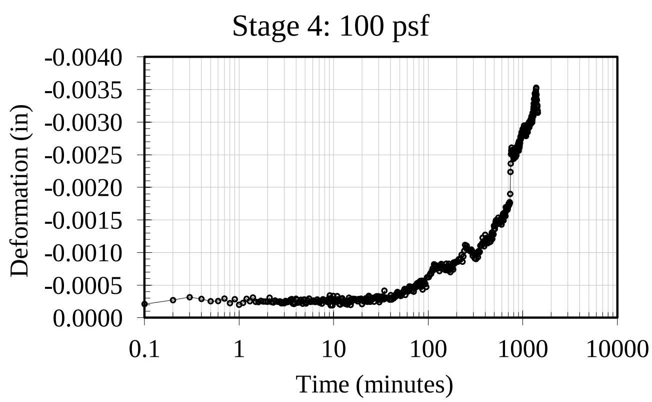
Swell Pressure Measurement with Multistage Unloading

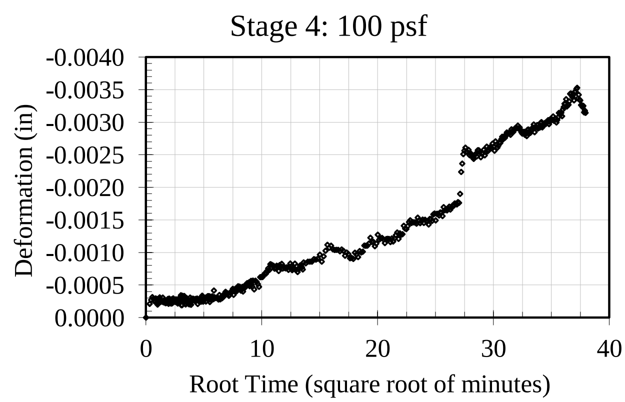
Client:	AECOM	TRI Log #:	60056.1
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D4546-B MOD
Specimen:	COMP_1700A		

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Swell Pressure Measurement with Multistage Unloading

Client:	AECOM	TRI Log #:	60056.1
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D4546-B MOD
Specimen:	COMP_1700A		



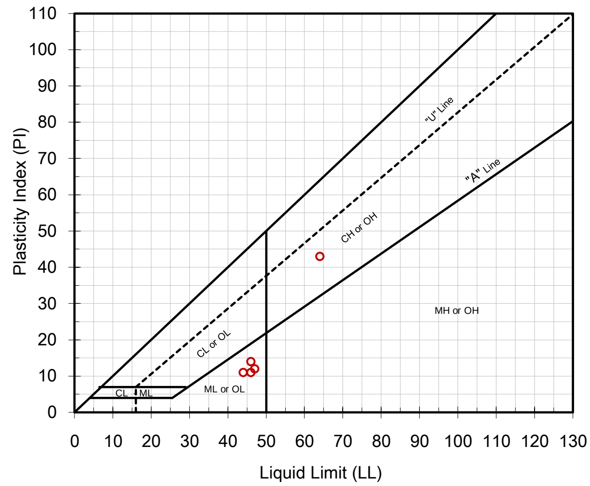


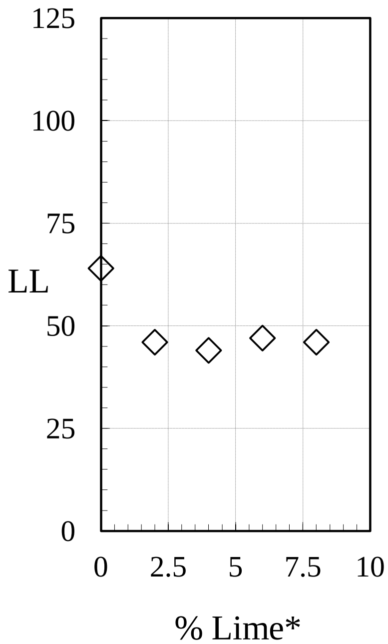
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

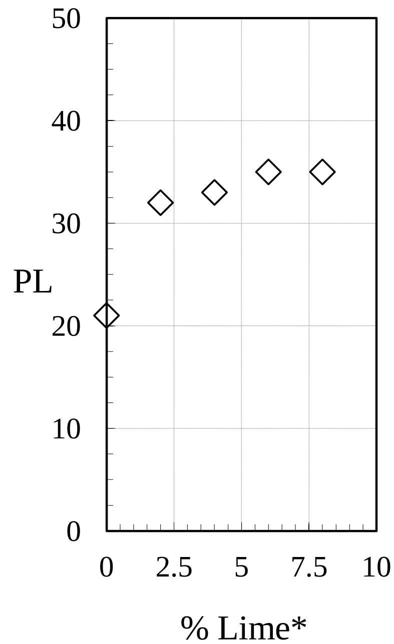
Admixing Lime to Reduce Plasticity Index of Soils (Tex-112-E)

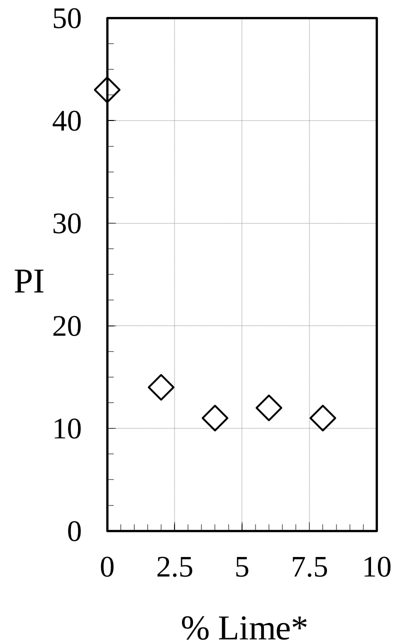
Client: AECOM
TRI Log #: 60056.1
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: COMP-1700A

Percent Lime by Dry Weight	Atterberg Limits		
	Liquid Limit	Plastic Limit	Plasticity Index
	ASTM D4318, Method A : Multipoint		
0	64	21	43
2.0	46	32	14
4.0	44	33	11
6.0	47	35	12
8.0	46	35	11







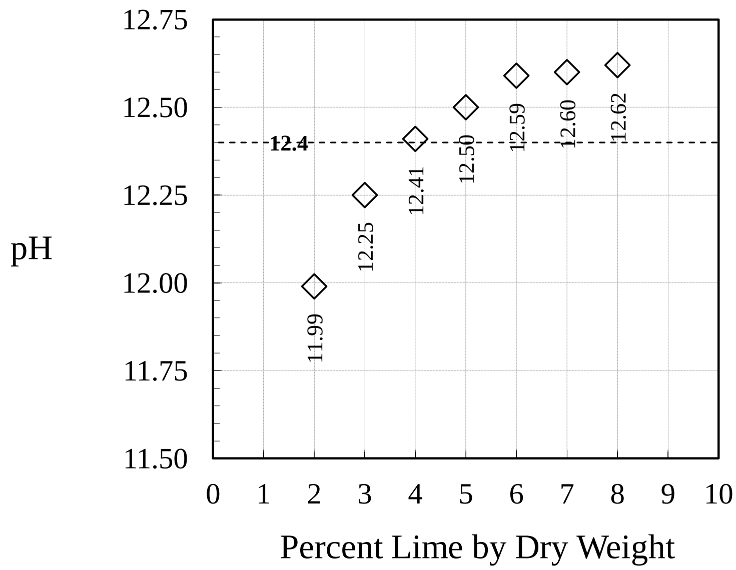


Jeffrey A. Kuhn, Ph.D, P.E. 5/10/2021
Analysis & Quality Review/Date

*Percent Lime by Dry Unit Weight

Using pH to Estimate the Soil-Lime Proportion Requirement for Soil Stabilization (ASTM D6276)

Client: AECOM — TRI Log #: 60056.1
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: Lime Amended Testing



Percent Lime by Dry Weight	pH
2.0	11.99
3.0	12.25
4.0	12.41
5.0	12.50
6.0	12.59
7.0	12.60
8.0	12.62

Lowest Percent Lime by Dry Weight to yield a pH of 12.4 or Greater
4.0

Jeffrey A. Kuhn, Ph.D, P.E. 11/3/2020
Analysis & Quality Review/Date

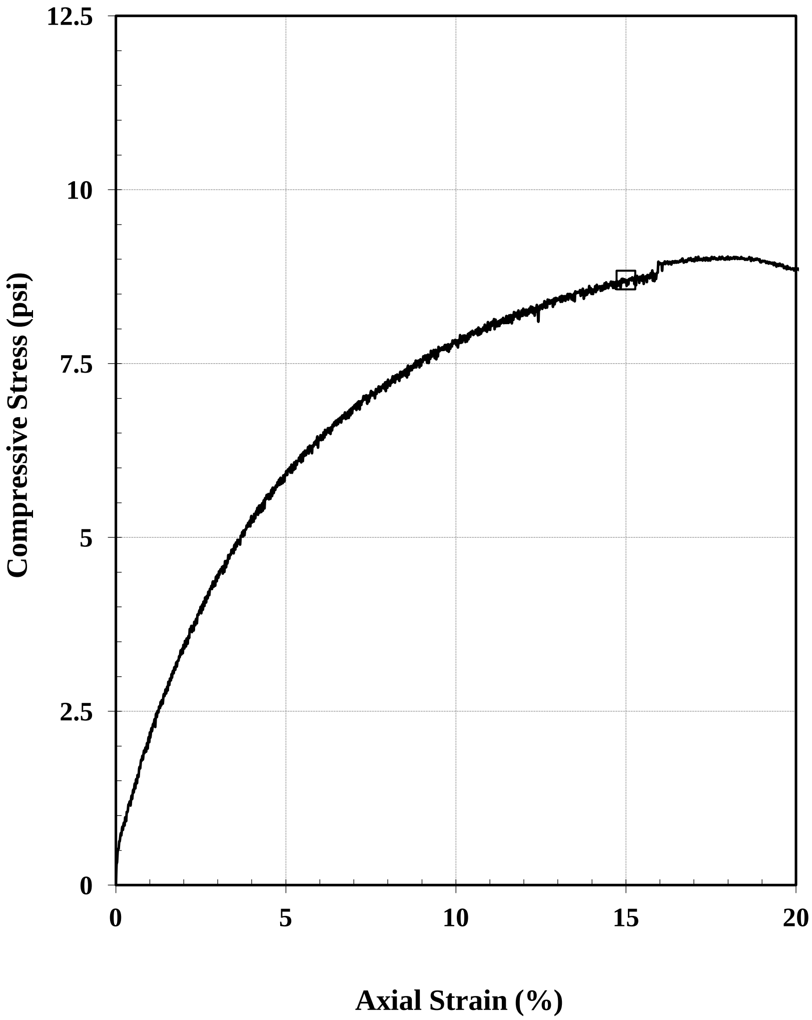
TRI Environmental | 9063 Bee Cave Rd., Austin, TX 78733, USA | 512-263-5944 | www.tri-env.com

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

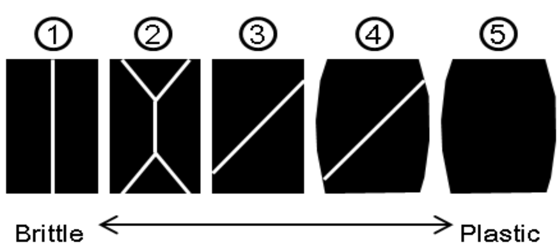
Client:	AECOM	TRI Log No.:	60056.3
Project:	60615067-1.4.14 Plum Creek 2	Type of Specimen:	Remolded
Sample ID:	COMP-1700A	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.01
Avg. Height (in)	H_o	4.47
Avg, Water Content (%)	w_o	28.6
Bulk Density (pcf)	γ_{total}	115.1
Dry Density (pcf)	γ_{dry}	89.5
Saturation (%)	S_r	87.8
Void Ratio	e_o	0.88
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	8.7
Axial Strain at Failure (%)	15.0
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	8.7
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	4.4

Failure Mode	4



(Kuhn after Nygård et. Al 2005)

Jeffrey A. Kuhn, Ph.D., P.E., 11/3/20

Quality Review/Date

Client: AECOM
TRI Log #: 60056
Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 11/3/2020
Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO_4/kg)	Chloride Content (mg/kg)	Resistivity (ohm-cm)	pH	
					(H_2O)	($CaCl_2$)
-	Test Method	ASTM C1580	ASTM D512	ASTM G57	ASTM D4972 (method A)	
-	Method Detection Limit (MDL)	[5 mg/l]*	[5 mg/l]*	-	-	-
1	COMP-1700A	4,200	300	500	7.80	7.69

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The chloride and sulfate MDLs are volumetric. Results are mass per mass of dry soil.

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 60056
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
1	COMP-1700A	5.7	43.6	20.8	21.0	21.0	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 11/3/2020
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

201-19

Client: AECOM
Project: 60615067, Task 1.4.14 - Plum Creek 2

TRI Log #: 53195

Jeffrey A. Kuhn, Ph.D., P.E., 4/27/2020
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D 2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	201-19 (0.0-2.0) P-1 Layer A	26.4	-	-	-	-	-
4	201-19 (4.0-5.5) SS-3 Layer A	12.0	-	93.0	23	14	9
6	201-19 (6.0-8.0) P-4	19.7	-	-	-	-	-
7	201-19 (8.0-9.5) SS-5	23.5	-	-	-	-	-
9	201-19 (18.0-20.0) P-7	23.4	-	-	-	-	-
10	201-19 (23.5-25.0) SS-8	21.7	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067, Task 1.4.14 - Plum Creek 2

TRI Log #: 53195
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
3	201-19 (2.0-4.0) ST-2	11.8	N/A	19.7	20.9	21.0	1	1	1	1
8	201-19 (13.0-15.0) ST-6	32.1	N/A	20.0	19.5	22.0	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 4/23/2020
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

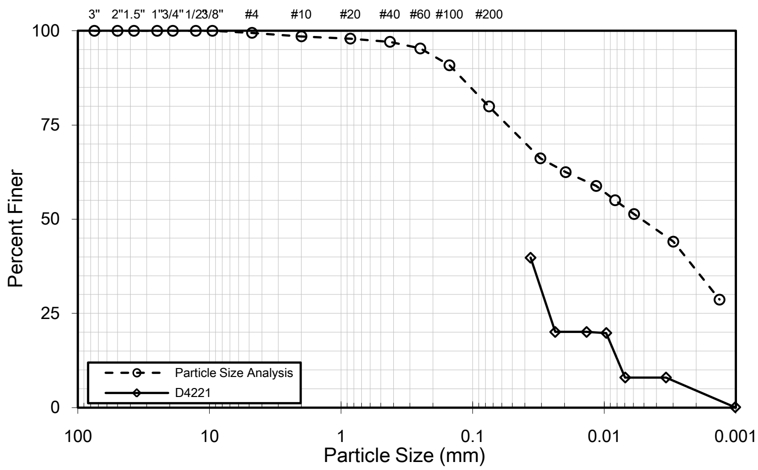
Particle Size, Atterberg Limit, and USCS Analyses for Soils

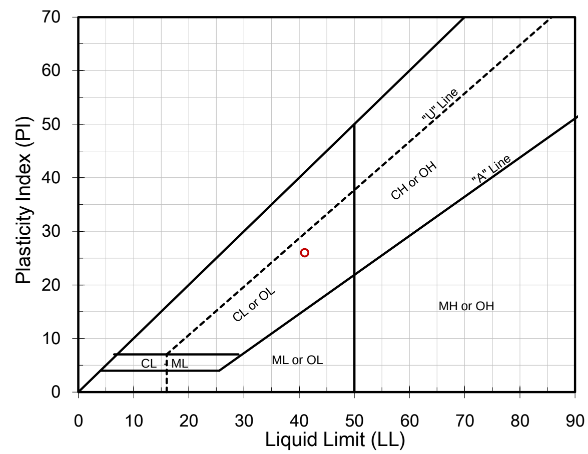
Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

Sample ID: 201-19 (2.0-4.0) ST-2

TRI Log #: 53195.3





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.5	0.031	66.1	0.036	39.8
2 in.	50.8	100.0		0.020	62.5	0.024	20.1
1.5 in.	38.1	100.0		0.012	58.8	0.014	20.1
1 in.	25.4	100.0		0.008	55.0	0.010	19.8
3/4 in.	19.0	100.0		0.006	51.4	0.007	8.0
1/2 in.	12.7	100.0		0.003	44.0	0.003	8.0
3/8 in.	9.51	100.0		0.001	28.6	0.001	0.1
No. 4	4.76	99.5	19.6	Log-Linear Interpolation			
No. 10	2.00	98.5		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	97.9					
No. 40	0.420	97.1		mm		mm	
No. 60	0.250	95.3		0.005	49.5	0.005	8.0
No. 100	0.149	90.9		0.002	36.4	0.002	4.5
No. 200	0.074	79.9	79.9	N m,2µm,d	36	N m,2µm,nd	5

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	1.4E-03	5.2E-03	1.4E-02	- -	- -	14

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay Loam	(2.0-0.05 mm)	29.0	(0.05-0.002	34.1	(< 0.002 mm)	37.0

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	41
Plastic Limit	15
Plastic Index	26
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Lean clay with sand (CL)

Moisture Content (%)	ASTM D2216	12.3
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 4/27/2020

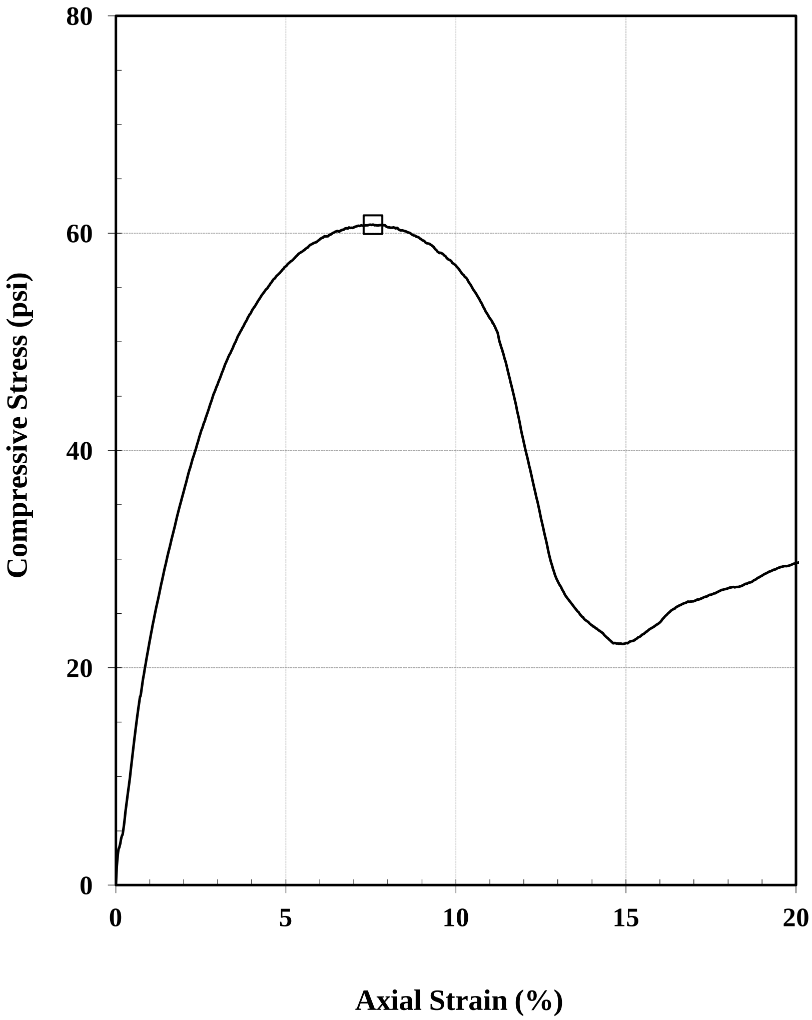
Analysis & Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

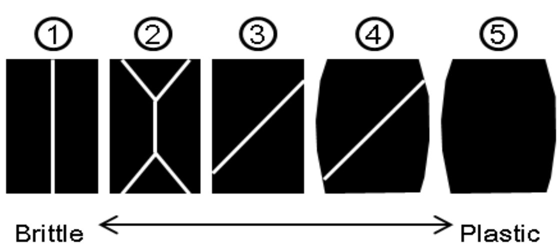
Client:	AECOM	TRI Log No.:	53195.3
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	201-19 (2.0-4.0) ST-2	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.77
Avg. Height (in)	H_o	5.55
Avg, Water Content (%)	w_o	11.8
Bulk Density (pcf)	γ_{total}	136.9
Dry Density (pcf)	γ_{dry}	122.5
Saturation (%)	S_r	95.0
Void Ratio	e_o	0.38
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	60.8
Axial Strain at Failure (%)	7.6
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	60.8
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	30.4

Failure Mode	2



(Kuhn after Nygård et. Al 2005)

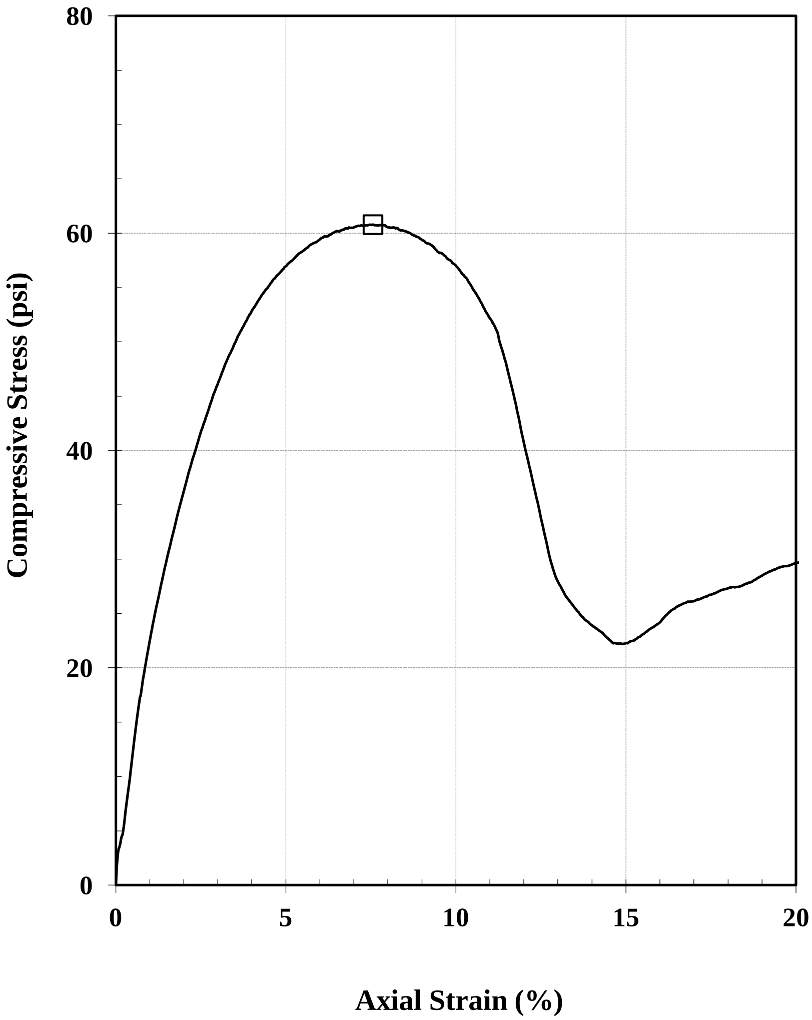
Jeffrey A. Kuhn, Ph.D., P.E., 4/9/20

Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

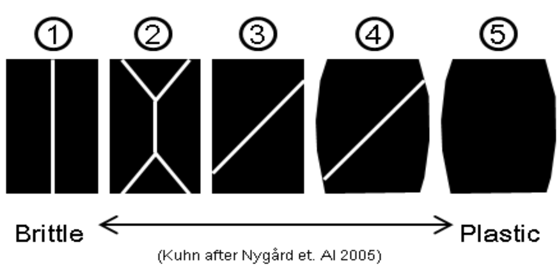
Client:	AECOM	TRI Log No.:	53195.3
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	201-19 (2.0-4.0) ST-2	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.77
Avg. Height (in)	H_o	5.55
Avg, Water Content (%)	w_o	11.8
Bulk Density (pcf)	γ_{total}	136.9
Dry Density (pcf)	γ_{dry}	122.5
Saturation (%)	S_r	95.0
Void Ratio	e_o	0.38
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	60.8
Axial Strain at Failure (%)	7.6
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	60.8
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	30.4

Failure Mode	2



(Kuhn after Nygård et. Al 2005)

Jeffrey A. Kuhn, Ph.D., P.E., 4/9/20
Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

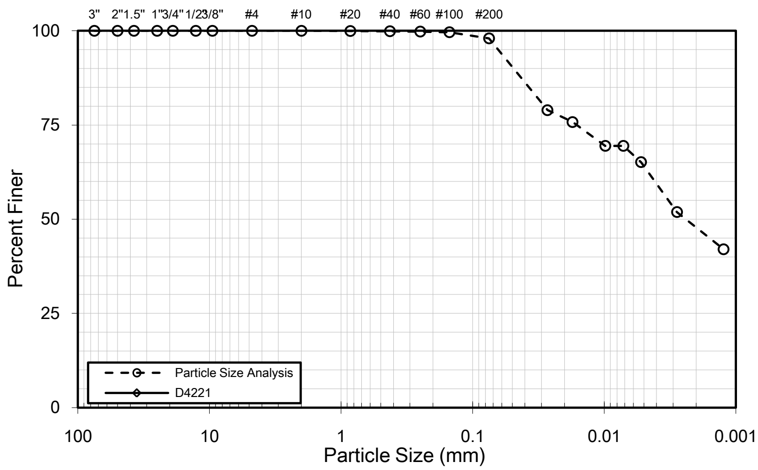
Particle Size, Atterberg Limit, and USCS Analyses for Soils

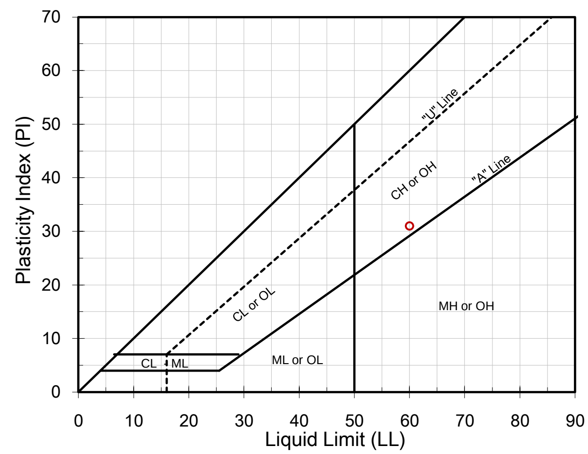
Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

Sample ID: 201-19 (13.0-15.0) ST-6

TRI Log #: 53195.8





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.0	0.027	78.9	- -	- -
2 in.	50.8	100.0		0.017	75.8	- -	- -
1.5 in.	38.1	100.0		0.010	69.5	- -	- -
1 in.	25.4	100.0		0.007	69.5	- -	- -
3/4 in.	19.0	100.0		0.005	65.2	- -	- -
1/2 in.	12.7	100.0		0.003	51.9	- -	- -
3/8 in.	9.51	100.0		0.001	42.0	- -	- -
No. 4	4.76	100.0	2.0	Log-Linear Interpolation			
No. 10	2.00	100.0		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	99.9					
No. 40	0.420	99.9		mm		mm	
No. 60	0.250	99.8		0.005	64.1	0.005	- -
No. 100	0.149	99.6		0.002	47.8	0.002	- -
No. 200	0.074	98.0	98.0	N m,2μm,d	48	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	2.4E-03	4.1E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	18.1	(0.05-0.002	34.1	(< 0.002 mm)	47.8

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	60
Plastic Limit	29
Plastic Index	31
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	23.9
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 4/27/2020

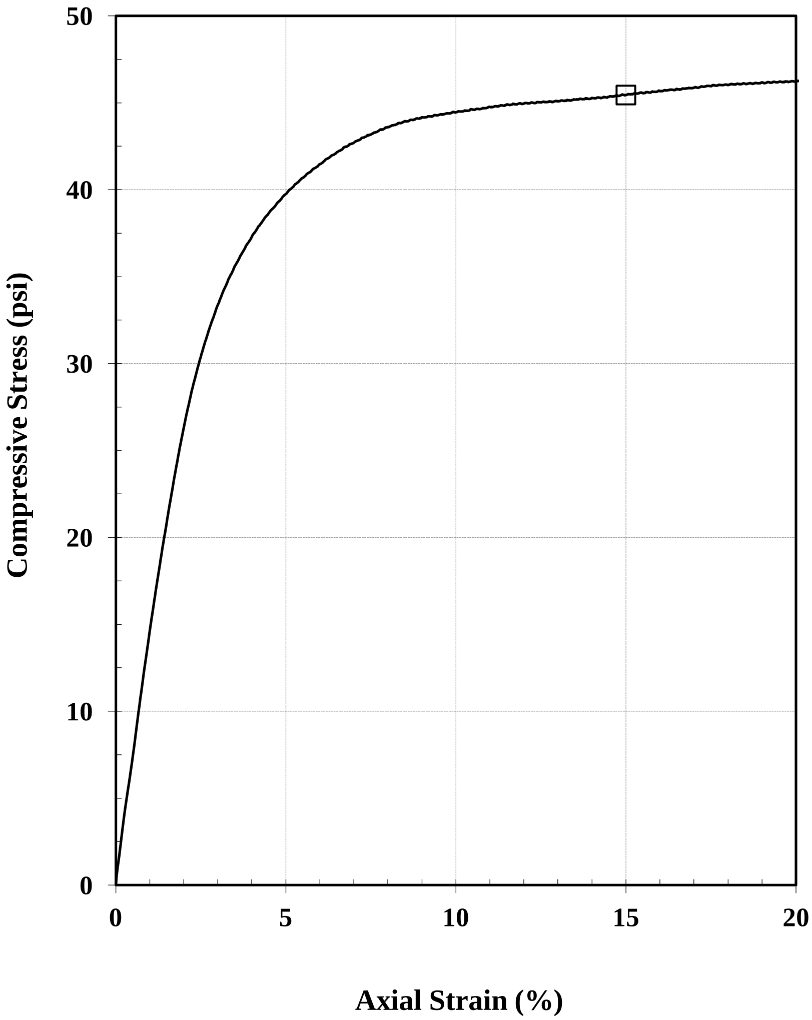
Analysis & Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

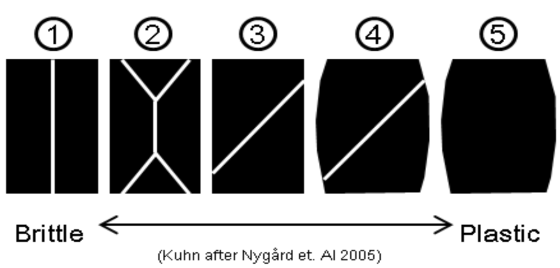
Client:	AECOM	TRI Log No.:	53195.8
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	201-19 (13.0-15.0) ST-6	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.77
Avg. Height (in)	H_o	5.60
Avg, Water Content (%)	w_o	17.8
Bulk Density (pcf)	γ_{total}	128.1
Dry Density (pcf)	γ_{dry}	108.7
Saturation (%)	S_r	98.8
Void Ratio	e_o	0.55
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	45.4
Axial Strain at Failure (%)	15.0
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	45.4
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	22.7

Failure Mode	5



Jeffrey A. Kuhn, Ph.D., P.E., 4/9/20

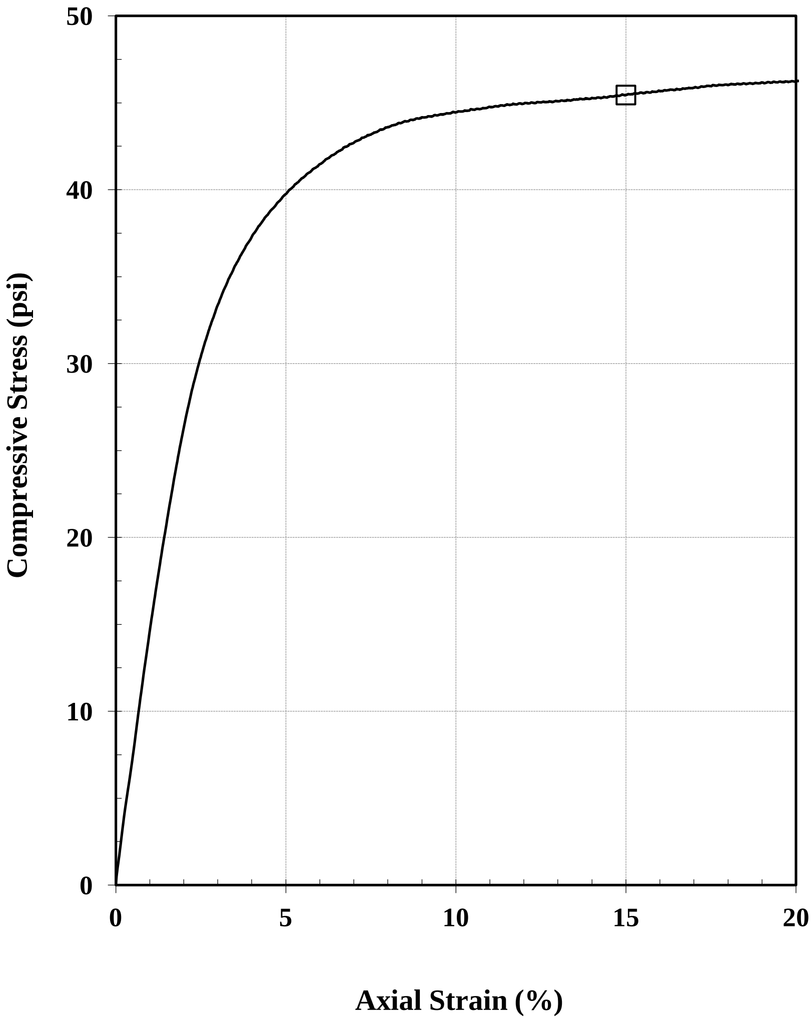
Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

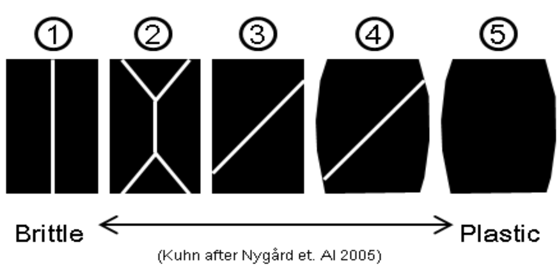
Client:	AECOM	TRI Log No.:	53195.8
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	201-19 (13.0-15.0) ST-6	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.77
Avg. Height (in)	H_o	5.60
Avg, Water Content (%)	w_o	17.8
Bulk Density (pcf)	γ_{total}	128.1
Dry Density (pcf)	γ_{dry}	108.7
Saturation (%)	S_r	98.8
Void Ratio	e_o	0.55
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	45.4
Axial Strain at Failure (%)	15.0
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	45.4
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	22.7

Failure Mode	5



Jeffrey A. Kuhn, Ph.D., P.E., 4/9/20

Quality Review/Date

202-19

Client: AECOM　　TRI Log #: 53196

Project: 60615067, Task 1.4.14 - Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 4/27/2020

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216		ASTM D1140	ASTM D4318, Method A : Multipoint		
1	202-19 (0.0-2.0) P-1 Layer A	21.5	-	-	-	-	-
4	202-19 (4.0-5.5) SS-3	4.8	-	-	-	-	-
5	202-19 (6.0-8.0) P-4	10.5	-	-	30	12	18
7	202-19 (13.5-15.0) SS-6	20.4	-	-	-	-	-
8	202-19 (18.0-20.0) P-7	23.2	-	-	51	21	30
9	202-19 (23.5-25.0) SS-8 Layer A	21.9	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

TRI ENVIRONMENTAL
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: Plum Creek 2 - Task 1.4.14

TRI Log #: 53196
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
3	202-19 (2.0-4.0) ST-2	21.2	N/A	20.0	19.5	19.5	1	1	2	1
6	202-19 (8.0-10.0) ST-5	25.8	N/A	20.0	19.5	22.0	2	2	2	2

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.

Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.

Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.

Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 4/27/2020
Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

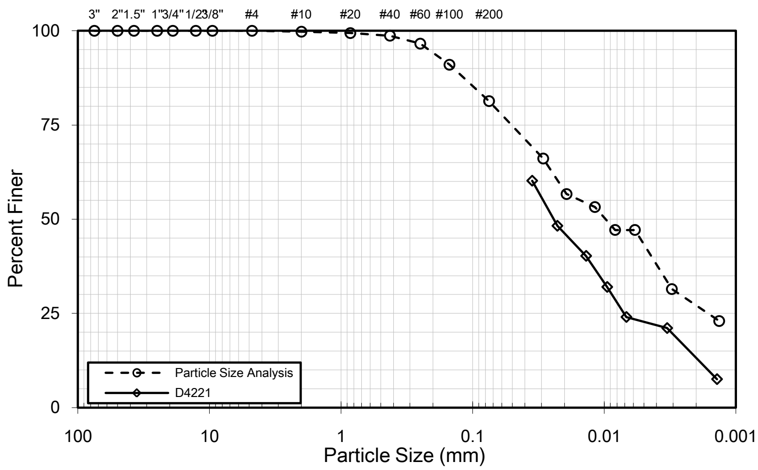
Particle Size, Atterberg Limit, and USCS Analyses for Soils

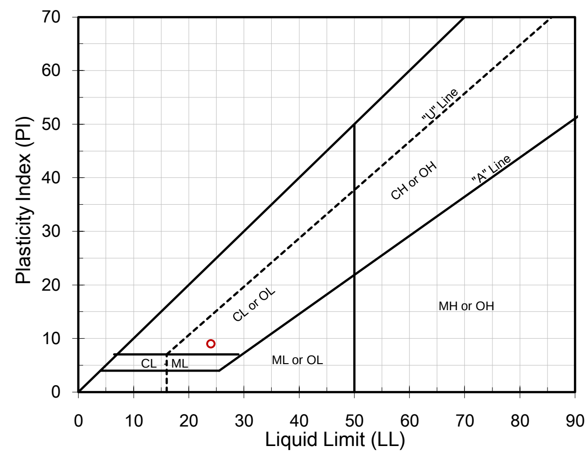
Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

Sample ID: 202-19 (2.0-4.0) ST-2

TRI Log #: 53196.3





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.0	0.029	66.1	0.035	60.2
2 in.	50.8	100.0		0.019	56.7	0.023	48.2
1.5 in.	38.1	100.0		0.012	53.2	0.014	40.3
1 in.	25.4	100.0		0.008	47.2	0.009	32.0
3/4 in.	19.0	100.0		0.006	47.2	0.007	24.0
1/2 in.	12.7	100.0		0.003	31.4	0.003	21.1
3/8 in.	9.51	100.0		0.001	23.0	0.001	7.6
No. 4	4.76	100.0	18.7	Log-Linear Interpolation			
No. 10	2.00	99.8		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	99.4					
No. 40	0.420	98.7		mm		mm	
No. 60	0.250	96.6		0.005	43.4	0.005	22.8
No. 100	0.149	91.0		0.002	27.1	0.002	13.2
No. 200	0.074	81.3	81.3	N m,2μm,d	27	N m,2μm,nd	13

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	2.7E-03	9.8E-03	2.2E-02	- -	- -	48

USDA	Sand (%) (2.0-0.05 mm)		Silt (%) (0.05-0.002)		Clay (%) (< 0.002 mm)	
Clay Loam		29.4		43.4		27.2

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	24
Plastic Limit	15
Plastic Index	9
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Lean clay with sand (CL)

Moisture Content (%)	ASTM D2216	9.1
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 4/27/2020

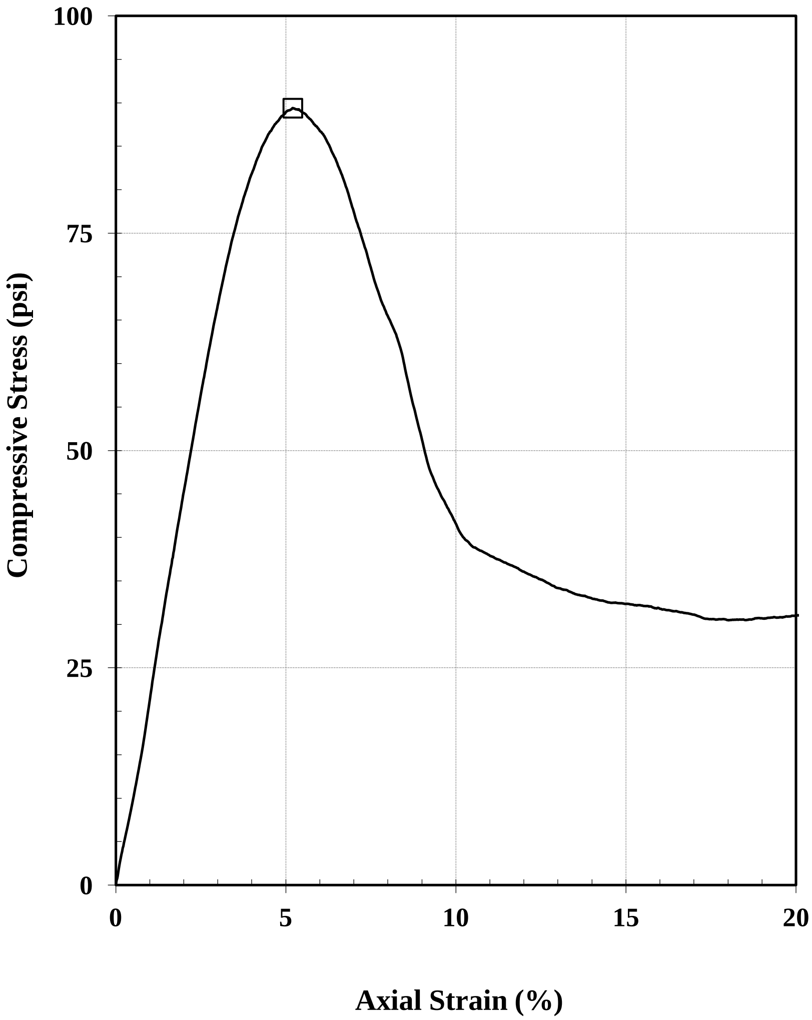
Analysis & Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

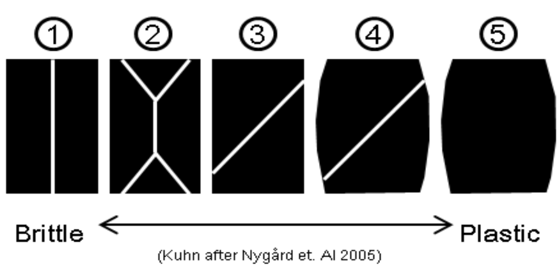
Client:	AECOM	TRI Log No.:	53196.3
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	202-19 (2.0-4.0) ST-2	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.76
Avg. Height (in)	H_o	5.57
Avg, Water Content (%)	w_o	11.4
Bulk Density (pcf)	γ_{total}	134.6
Dry Density (pcf)	γ_{dry}	120.8
Saturation (%)	S_r	80.3
Void Ratio	e_o	0.40
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	89.4
Axial Strain at Failure (%)	5.2
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	89.4
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	44.7

Failure Mode	2

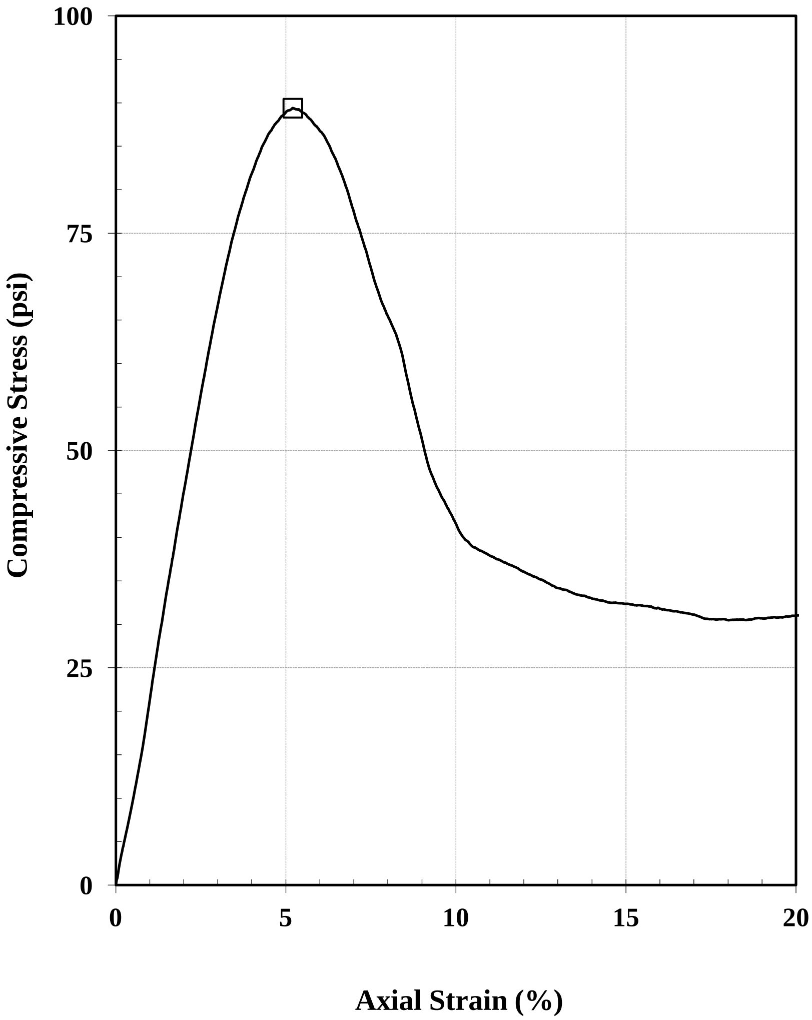


Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20

Quality Review/Date

Unconfined Compression Test Report

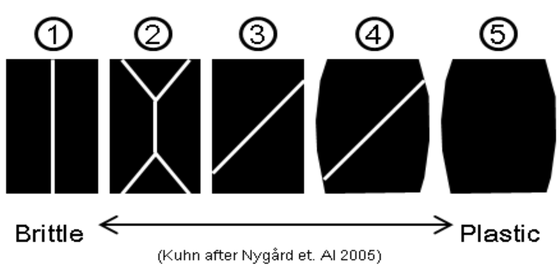
Client:	AECOM	TRI Log No.:	53196.3
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	202-19 (2.0-4.0) ST-2	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.76
Avg. Height (in)	H_o	5.57
Avg, Water Content (%)	w_o	11.4
Bulk Density (pcf)	γ_{total}	134.6
Dry Density (pcf)	γ_{dry}	120.8
Saturation (%)	S_r	80.3
Void Ratio	e_o	0.40
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	89.4
Axial Strain at Failure (%)	5.2
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	89.4
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	44.7

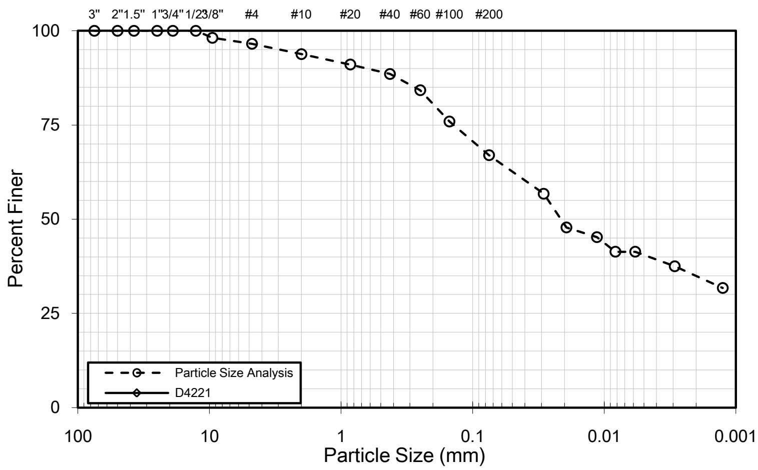
Failure Mode	2

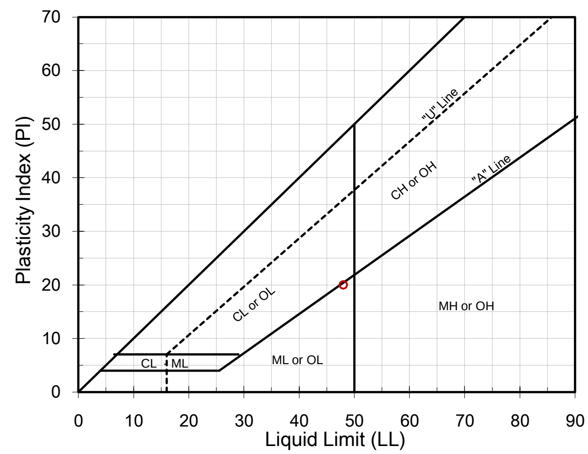


Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client:	AECOM	TRI Log #:	53196.6
Project:	60615067-1.4.14 Plum Creek 2		
Sample ID:	202-19 (8.0-10.0) ST-5		





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm		Fines	mm		mm	
3 in.	76.2	100.0	3.4	0.029	56.8	- -	- -
2 in.	50.8	100.0		0.019	47.8	- -	- -
1.5 in.	38.1	100.0		0.011	45.2	- -	- -
1 in.	25.4	100.0		0.008	41.4	- -	- -
3/4 in.	19.0	100.0		0.006	41.4	- -	- -
1/2 in.	12.7	100.0		0.003	37.5	- -	- -
3/8 in.	9.51	98.1		0.001	31.7	- -	- -
No. 4	4.76	96.6	29.6	Log-Linear Interpolation			
No. 10	2.00	93.8		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	91.1		mm		mm	
No. 40	0.420	88.5					
No. 60	0.250	84.2		0.005	40.5	0.005	- -
No. 100	0.149	75.9		0.002	34.9	0.002	- -
No. 200	0.074	67.0	67.0	N m,2μm,d 35		N m,2μm,nd -	

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	2.1E-02	3.9E-02	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay Loam	(2.0-0.05 mm)	34.4	(0.05-0.002	28.4	(< 0.002 mm)	37.2

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	48
Plastic Limit	28
Plastic Index	20
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Sandy lean clay (CL)

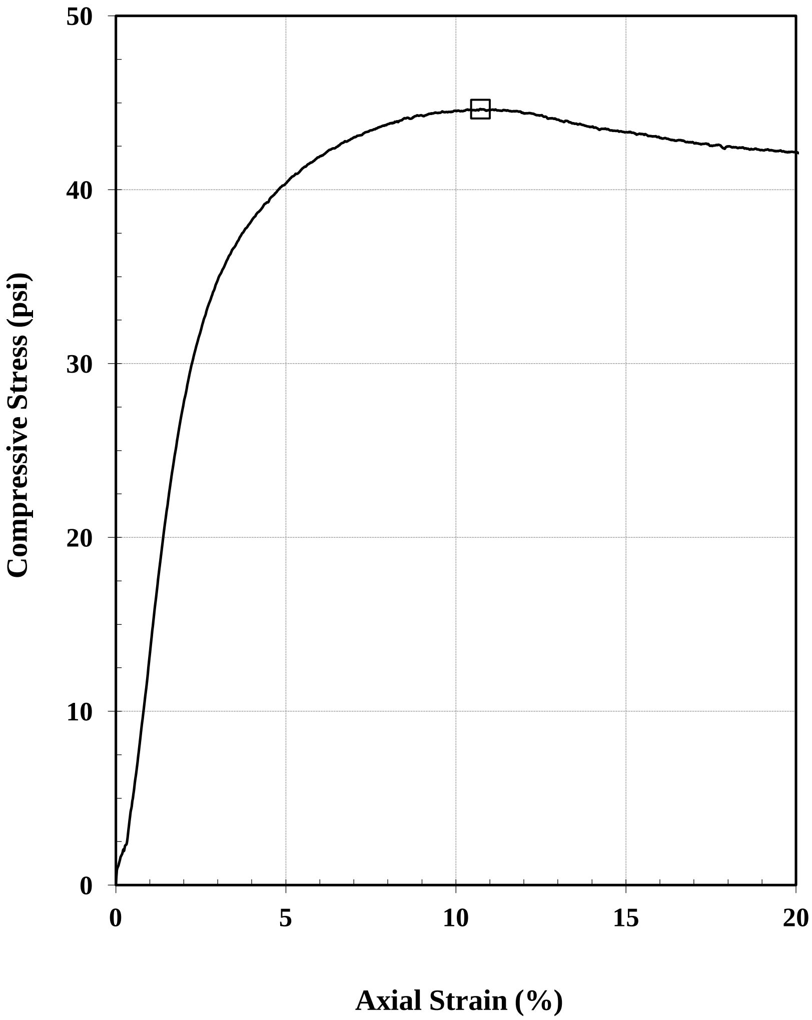
Moisture Content (%)	ASTM D2216	13.0
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 4/27/2020
Analysis & Quality Review/Date

Unconfined Compression Test Report

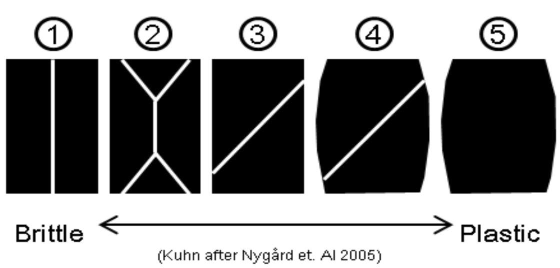
Client:	AECOM	TRI Log No.:	53196.6
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	202-19 (8.0-10.0) ST-5	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.76
Avg. Height (in)	H_o	5.35
Avg, Water Content (%)	w_o	16.0
Bulk Density (pcf)	γ_{total}	137.0
Dry Density (pcf)	γ_{dry}	118.1
Saturation (%)	S_r	98.8
Void Ratio	e_o	0.43
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	44.6
Axial Strain at Failure (%)	10.7
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	44.6
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	22.3

Failure Mode	2

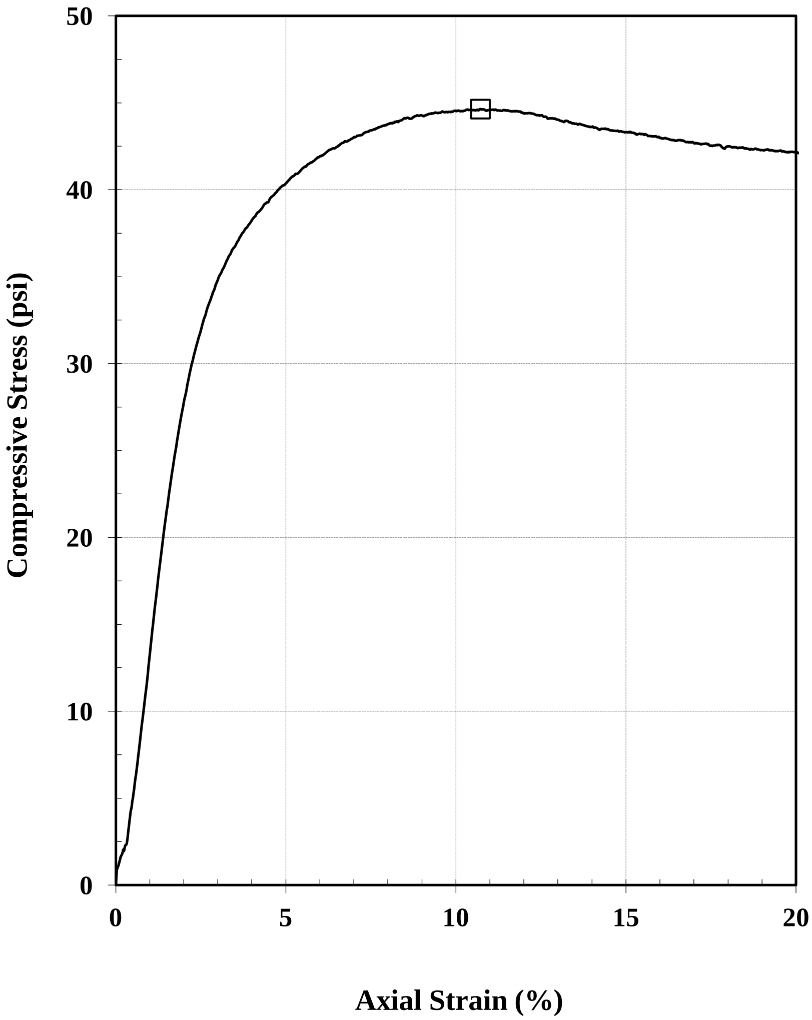


Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

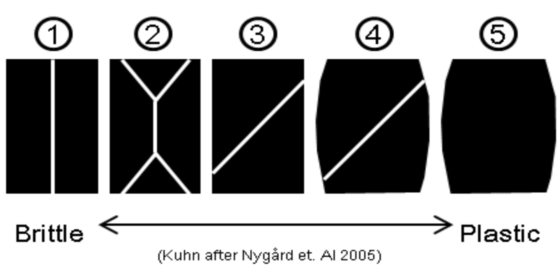
Client:	AECOM	TRI Log No.:	53196.6
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	202-19 (8.0-10.0) ST-5	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.76
Avg. Height (in)	H_o	5.35
Avg, Water Content (%)	w_o	16.0
Bulk Density (pcf)	γ_{total}	137.0
Dry Density (pcf)	γ_{dry}	118.1
Saturation (%)	S_r	98.8
Void Ratio	e_o	0.43
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	44.6
Axial Strain at Failure (%)	10.7
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	44.6
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	22.3

Failure Mode	2



Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

203-19

Client: AECOM

TRI Log #: 53222

Project: Plum Creek 2 - Task 1.4.14

Jeffrey A. Kuhn, Ph.D., P.E., 4/27/2020

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	203-19 (0.0-2.0) P-1	23.5	-	-	-	-	-
2	203-19 (2.0-3.5) SS-2 Layer A	18.9	-	-	-	-	-
3	203-19 (2.0-3.5) SS-2 Layer B	8.5	-	-	-	-	-
5	203-19 (6.0-8.0) P-4 Layer A	7.1	-	-	-	-	-
6	203-19 (6.0-8.0) P-4 Layer B	8.7	113.4	34.8	18	11	7
7	203-19 (8.0-9.5) SS-5	11.0	-	46.8	NL	NP	-
8	203-19 (13.0-15.0) P-6 Layer A	10.8	-	66.9	-	-	-
9	203-19 (13.0-15.0) P-6 Layer B	21.1	-	-	-	-	-
10	203-19 (18.5-20.0) SS-7	21.6	-	98.6	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: Plum Creek 2 - Task 1.4.14
TRI Log #: 53222
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
4	203-19 (4.0-6.0) ST-3	18.2	N/A	20.0	19.6	22.0	1	1	1	1
11	203-19 (23.0-25.0) ST-8	18.6	N/A	20.0	19.5	22.0	2	3	3	3

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 4/23/2020
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

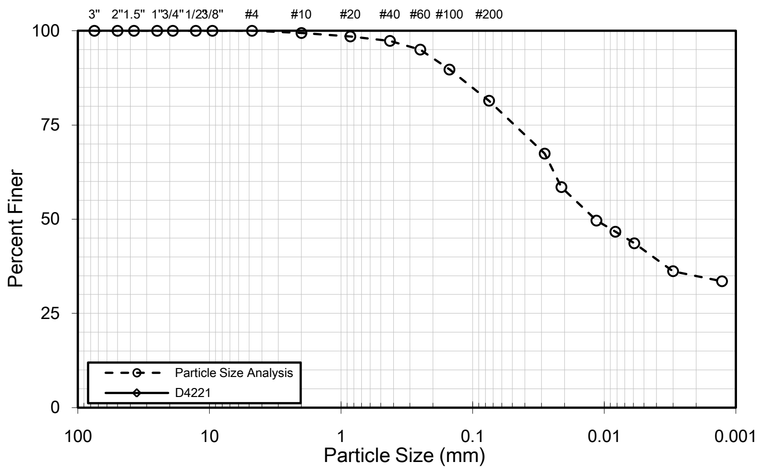
Particle Size, Atterberg Limit, and USCS Analyses for Soils

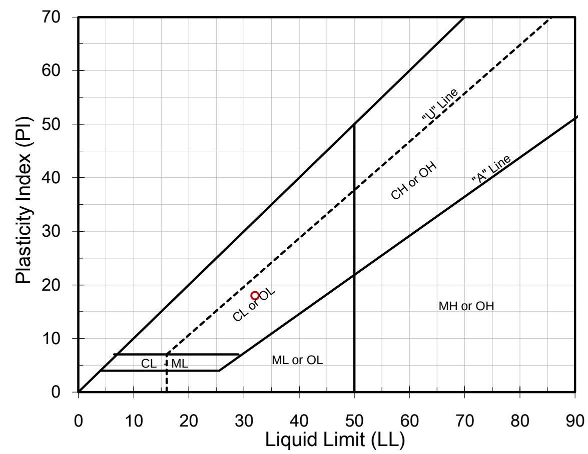
Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

Sample ID: 203-19 (4.0-6.0) ST-3

TRI Log #: 53222.4





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.0	0.028	67.4	- -	- -
2 in.	50.8	100.0		0.021	58.5	- -	- -
1.5 in.	38.1	100.0		0.011	49.6	- -	- -
1 in.	25.4	100.0		0.008	46.7	- -	- -
3/4 in.	19.0	100.0		0.006	43.6	- -	- -
1/2 in.	12.7	100.0		0.003	36.2	- -	- -
3/8 in.	9.51	100.0		0.001	33.5	- -	- -
No. 4	4.76	100.0	18.6	Log-Linear Interpolation			
No. 10	2.00	99.4		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	98.5					
No. 40	0.420	97.3		mm		mm	
No. 60	0.250	95.0		0.005	41.8	0.005	- -
No. 100	0.149	89.7		0.002	34.9	0.002	- -
No. 200	0.074	81.4	81.4	N m,2μm,d	35	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	1.2E-02	2.2E-02	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay Loam	(2.0-0.05 mm)	27.9	(0.05-0.002	37.0	(< 0.002 mm)	35.1

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	32
Plastic Limit	14
Plastic Index	18
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Lean clay with sand (CL)

Moisture Content (%)	ASTM D2216	10.4
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

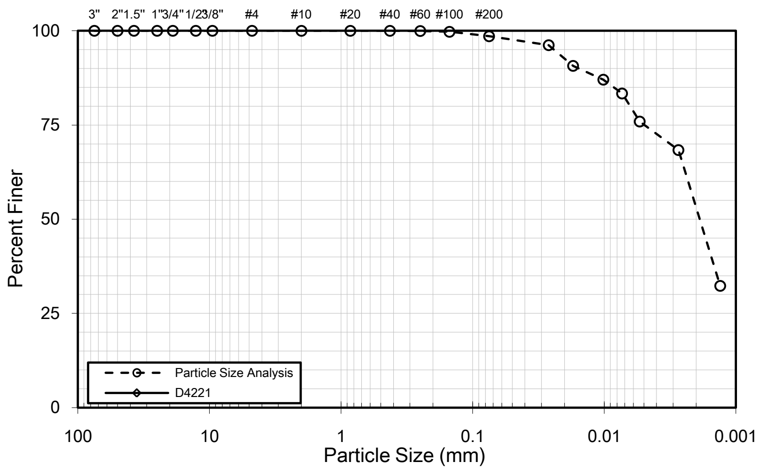
Jeffrey A. Kuhn, Ph.D, P.E. 4/27/2020

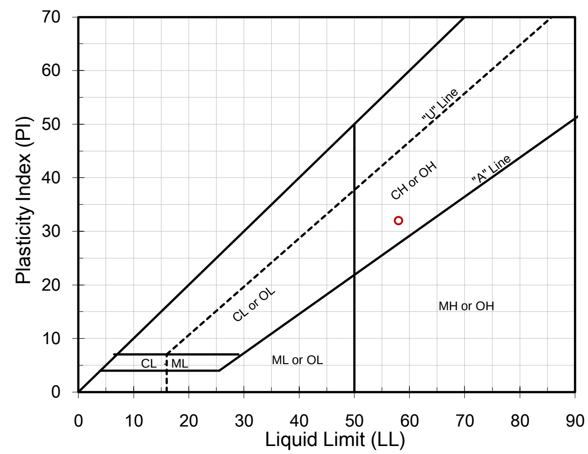
Analysis & Quality Review/Date

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 203-19 (23.0-25.0) ST-8

TRI Log #: 53222.11





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.0	0.026	96.2	- -	- -
2 in.	50.8	100.0		0.017	90.7	- -	- -
1.5 in.	38.1	100.0		0.010	87.0	- -	- -
1 in.	25.4	100.0		0.007	83.4	- -	- -
3/4 in.	19.0	100.0		0.005	75.9	- -	- -
1/2 in.	12.7	100.0		0.003	68.3	- -	- -
3/8 in.	9.51	100.0		0.001	32.3	- -	- -
No. 4	4.76	100.0	1.5	Log-Linear Interpolation			
No. 10	2.00	100.0		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	100.0					
No. 40	0.420	100.0		mm		mm	
No. 60	0.250	99.9		0.005	75.1	0.005	- -
No. 100	0.149	99.7		0.002	53.0	0.002	- -
No. 200	0.074	98.5	98.5	N m,2µm,d	53	N m,2µm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	1.9E-03	2.3E-03	- -	- -	-

USDA	Sand (%) (2.0-0.05 mm)		Silt (%) (0.05-0.002)		Clay (%) (< 0.002 mm)	
Silty Clay		3.3		43.7		53.0

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	58
Plastic Limit	26
Plastic Index	32
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	23.6
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Austin Gonzales 4/27/2020
Analysis & Quality Review/Date

204-19

Client: AECOM
Project: Plum Creek 2 - Task 1.4.14

TRI Log #: 53224

Jeffrey A. Kuhn, Ph.D., P.E., 4/27/2020
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D7263		ASTM D1140	ASTM D4318, Method A : Multipoint		
1	204-19 (0.0-2.0) P-1 Layer A	23.3	-	-	-	-	-
2	204-19 (0.0-2.0) P-1 Layer B	10.9	-	-	-	-	-
4	204-19 (4.0-5.5) SS-3 Layer A	20.0	-	-	-	-	-
5	204-19 (4.0-5.5) SS-3 Layer B	6.8	-	-	-	-	-
6	204-19 (6.0-8.0) P-4 Layer A	22.4	-	-	68	22	46
7	204-19 (6.0-8.0) P-4 Layer B	14.7	-	-	-	-	-
8	204-19 (8.0-9.5) SS-5 Layer A	9.2	-	-	-	-	-
9	204-19 (8.0-9.5) SS-5 Layer B	19.5	-	-	-	-	-
11	204-19 (18.0-20.0) P-7	20.8	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067, Task 1.4.14 - Plum Creek 2

TRI Log #: 53224
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	(1 hr)
3	204-19 (2.0-4.0) ST-2	[redacted]								
10	204-19 (13.0-15.0) ST-6	31.2	N/A	20.0	19.0	19.0	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 4/23/2020
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

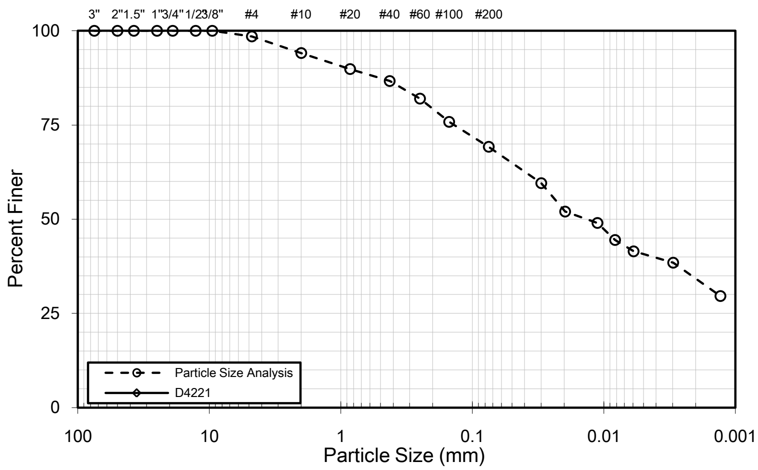
Particle Size, Atterberg Limit, and USCS Analyses for Soils

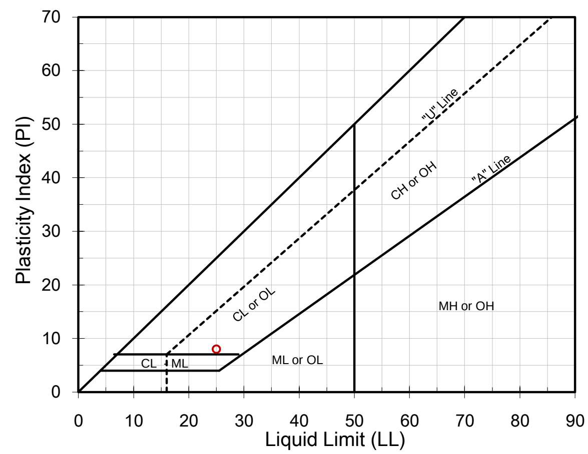
Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

Sample ID: 204-19 (2.0-4.0) ST-2

TRI Log #: 53224.3





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0		0.030	59.6	- -	- -
2 in.	50.8	100.0		0.020	52.0	- -	- -
1.5 in.	38.1	100.0		0.011	49.0	- -	- -
1 in.	25.4	100.0	1.5	0.008	44.5	- -	- -
3/4 in.	19.0	100.0		0.006	41.5	- -	- -
1/2 in.	12.7	100.0		0.003	38.4	- -	- -
3/8 in.	9.51	100.0		0.001	29.6	- -	- -
No. 4	4.76	98.5		Log-Linear Interpolation			
No. 10	2.00	94.1		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	89.8	29.3				
No. 40	0.420	86.7		mm		mm	
No. 60	0.250	82.0		0.005	40.7	0.005	- -
No. 100	0.149	75.8		0.002	34.2	0.002	- -
No. 200	0.074	69.2	69.2	N m,2μm,d	34	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	1.3E-03	1.3E-02	3.1E-02	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay Loam	(2.0-0.05 mm)	32.2	(0.05-0.002	31.4	(< 0.002 mm)	36.3

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	25
Plastic Limit	17
Plastic Index	8
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Sandy lean clay (CL)

Moisture Content (%)	ASTM D2216	8.0
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 4/27/2020

Analysis & Quality Review/Date

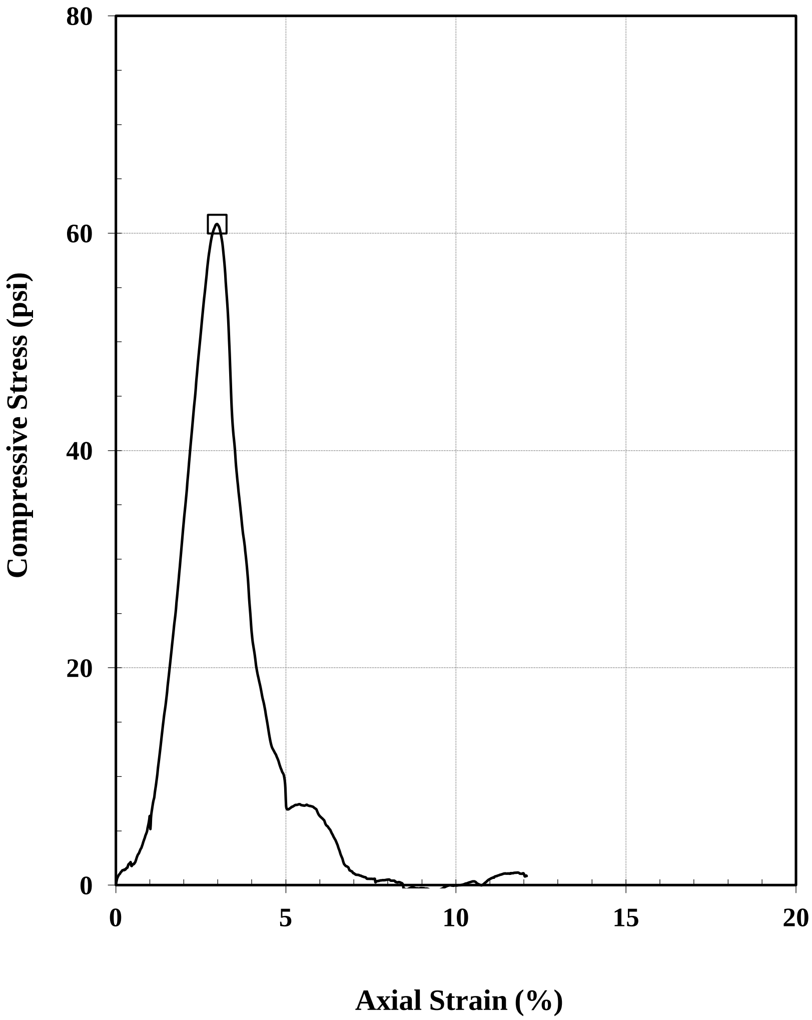
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

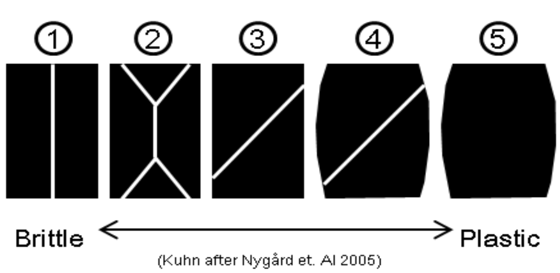
Client:	AECOM	TRI Log No.:	53224.3
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	204-19 (2.0-4.0) ST-2	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.86
Avg. Height (in)	H_o	5.35
Avg, Water Content (%)	w_o	8.1
Bulk Density (pcf)	γ_{total}	125.7
Dry Density (pcf)	γ_{dry}	116.3
Saturation (%)	S_r	47.5
Void Ratio	e_o	0.45
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	60.8
Axial Strain at Failure (%)	3.0
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	60.8
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	30.4

Failure Mode	2



Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20

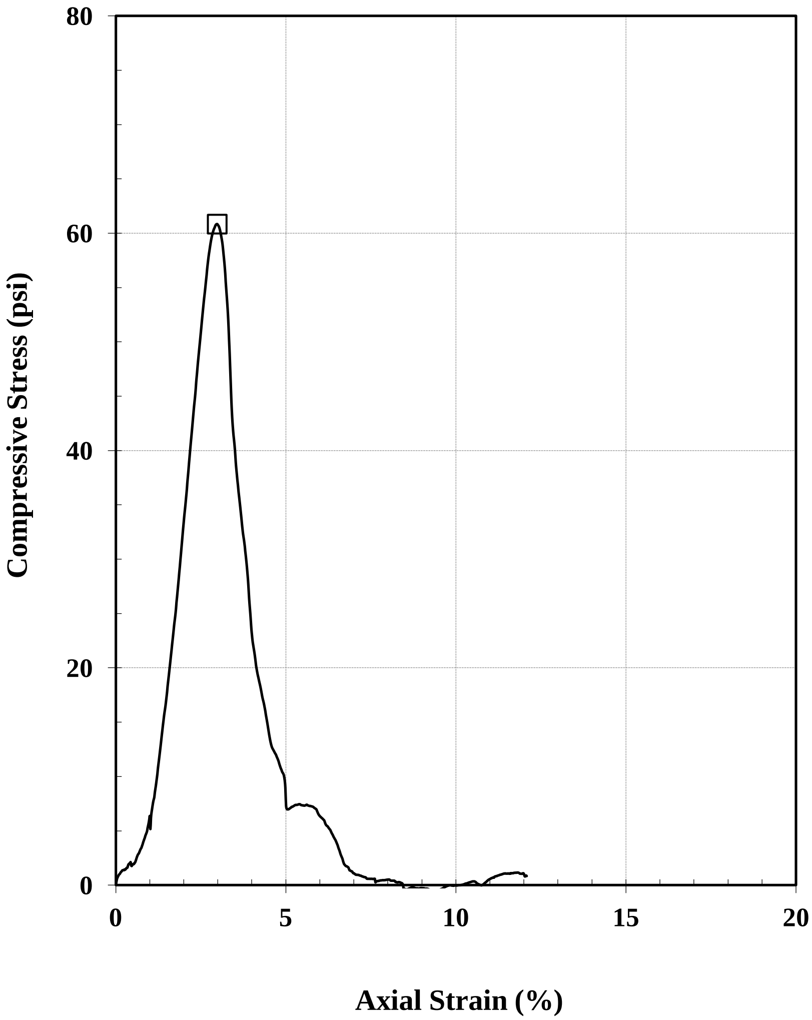
Quality Review/Date

TRI Environmental, Inc.

9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Unconfined Compression Test Report

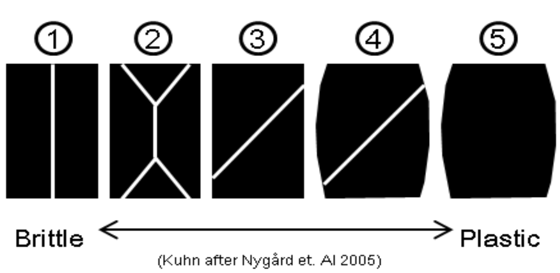
Client:	AECOM	TRI Log No.:	53224.3
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	204-19 (2.0-4.0) ST-2	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.86
Avg. Height (in)	H_o	5.35
Avg, Water Content (%)	w_o	8.1
Bulk Density (pcf)	γ_{total}	125.7
Dry Density (pcf)	γ_{dry}	116.3
Saturation (%)	S_r	47.5
Void Ratio	e_o	0.45
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	60.8
Axial Strain at Failure (%)	3.0
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	60.8
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	30.4

Failure Mode	2



Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

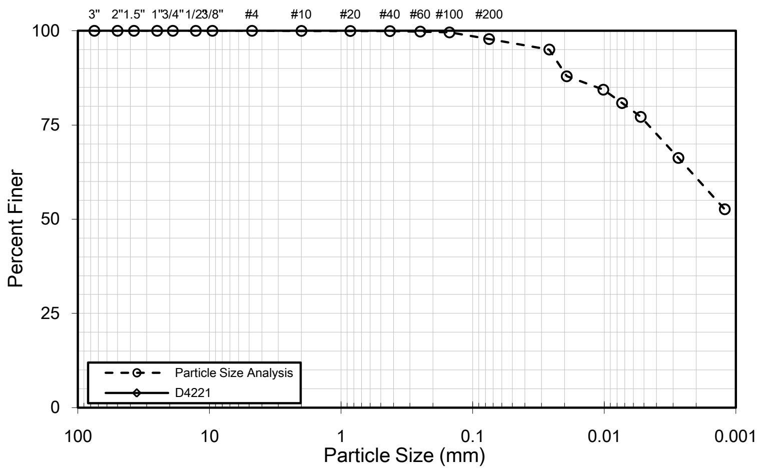
Particle Size, Atterberg Limit, and USCS Analyses for Soils

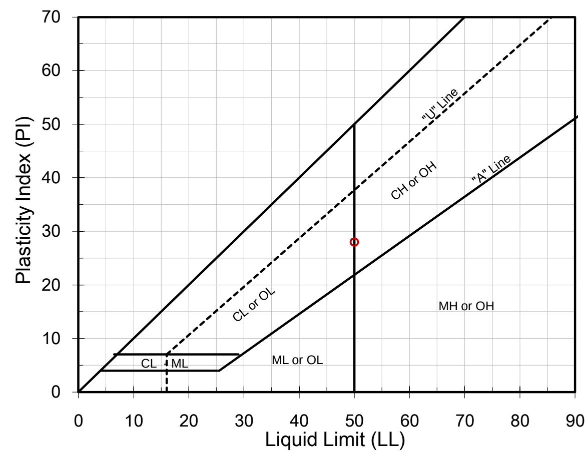
Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

Sample ID: 204-19 (13.0-15.0) ST-6

TRI Log #: 53224.10





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.0	0.026	95.0	- -	- -
2 in.	50.8	100.0		0.019	87.9	- -	- -
1.5 in.	38.1	100.0		0.010	84.4	- -	- -
1 in.	25.4	100.0		0.007	80.8	- -	- -
3/4 in.	19.0	100.0		0.005	77.1	- -	- -
1/2 in.	12.7	100.0		0.003	66.3	- -	- -
3/8 in.	9.51	100.0		0.001	52.6	- -	- -
No. 4	4.76	100.0	2.2	Log-Linear Interpolation			
No. 10	2.00	100.0		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	100.0					
No. 40	0.420	99.9		mm		mm	
No. 60	0.250	99.8		0.005	76.3	0.005	- -
No. 100	0.149	99.6		0.002	61.0	0.002	- -
No. 200	0.074	97.8	97.8	N m,2µm,d	61	N m,2µm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	1.9E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	4.2	(0.05-0.002	34.8	(< 0.002 mm)	61.0

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	50
Plastic Limit	22
Plastic Index	28
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	21.1
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

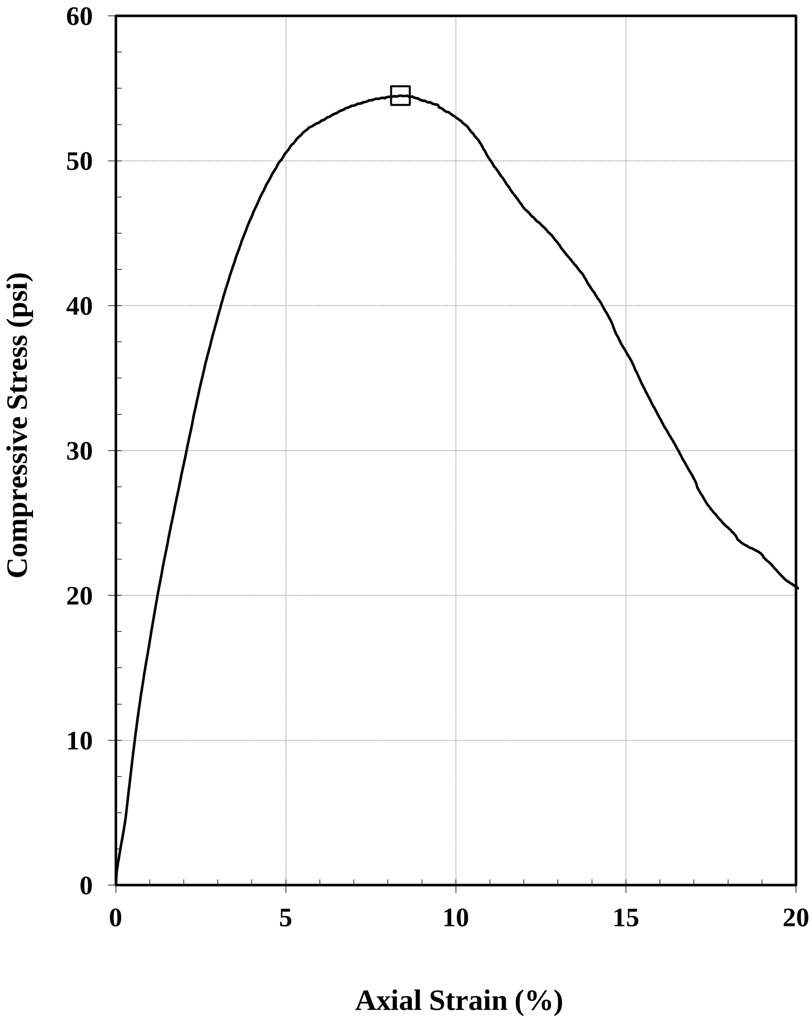
Jeffrey A. Kuhn, Ph.D, P.E. 4/27/2020

Analysis & Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

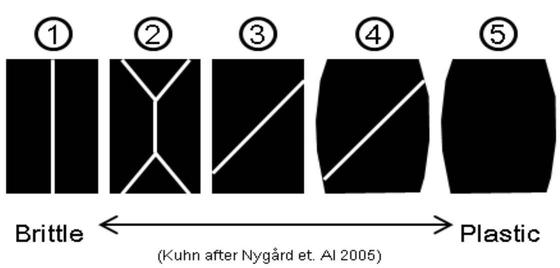
Client:	AECOM	TRI Log No.:	53224.10
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	204-19 (130-15.0) ST-6	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.84
Avg. Height (in)	H_o	5.59
Avg, Water Content (%)	w_o	18.3
Bulk Density (pcf)	γ_{total}	131.1
Dry Density (pcf)	γ_{dry}	110.8
Saturation (%)	S_r	92.3
Void Ratio	e_o	0.52
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	54.5
Axial Strain at Failure (%)	8.4
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	54.5
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	27.2

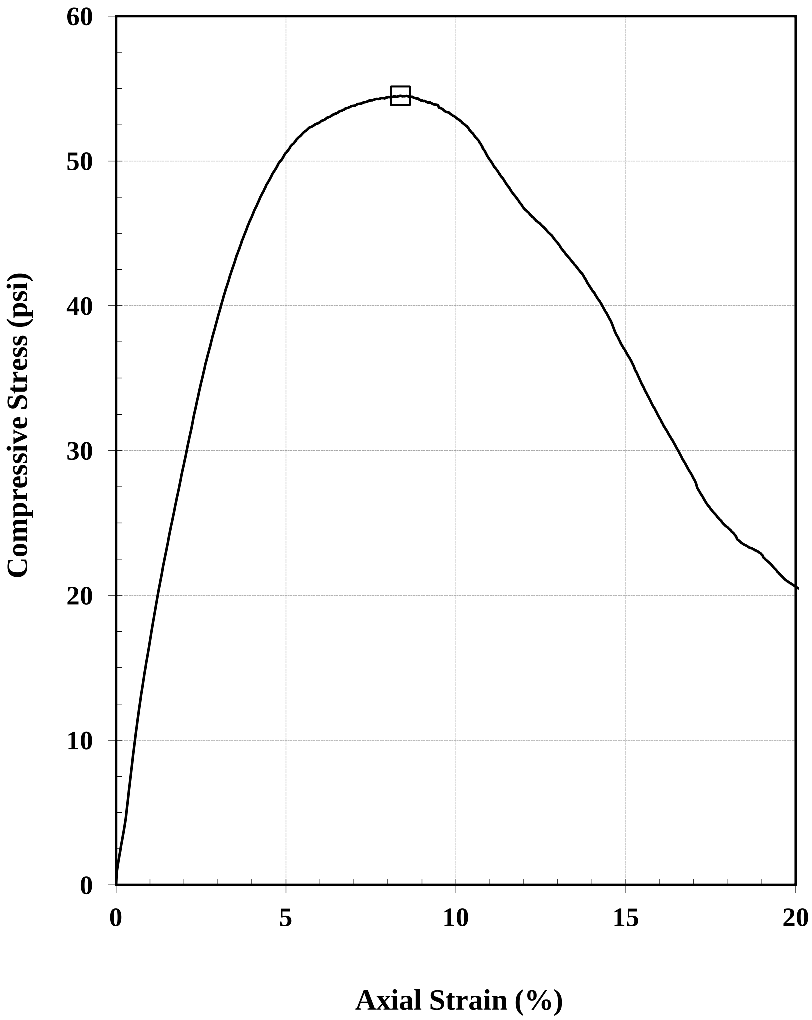
Failure Mode	2



Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

Unconfined Compression Test Report

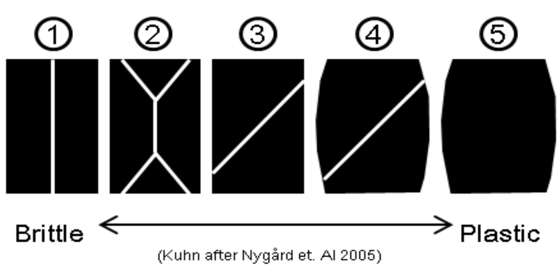
Client:	AECOM	TRI Log No.:	53224.10
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	204-19 (130-15.0) ST-6	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.84
Avg. Height (in)	H_o	5.59
Avg, Water Content (%)	w_o	18.3
Bulk Density (pcf)	γ_{total}	131.1
Dry Density (pcf)	γ_{dry}	110.8
Saturation (%)	S_r	92.3
Void Ratio	e_o	0.52
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	54.5
Axial Strain at Failure (%)	8.4
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	54.5
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	27.2

Failure Mode	2



Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

205-19

Client: AECOM　　　　TRI Log #: 53226

Project: Plum Creek 2 - Task 1.4.14

Jeffrey A. Kuhn, Ph.D., P.E., 4/27/2020

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D7263		ASTM D1140	ASTM D4318, Method A : Multipoint		
1	205-19 (0.0-2.0) P-1	23.1	-	-	53	21	32
2	205-19 (2.0-3.5) SS-2	11.7	-	-	-	-	-
3	205-19 (4.0-6.0) P-3 Layer A	19.3	-	-	-	-	-
4	205-19 (4.0-6.0) P-3 Layer B	16.9	-	-	-	-	-
5	205-19 (6.0-7.5) SS-4	19.2	-	-	-	-	-
7	205-19 (13.0-15.0) P-6	21.7	-	-	-	-	-
8	205-19 (18.5-20.0) SS-7	22.7	-	-	-	-	-
9	205-19 (23.0-25.0) ST-8	21.6	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067, Task 1.4.14 - Plum Creek 2

TRI Log #: 53226
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
6	205-19 (8.0-10.0) ST-5	35.5	N/A	22.0	20.0	19.0	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 4/23/2020
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

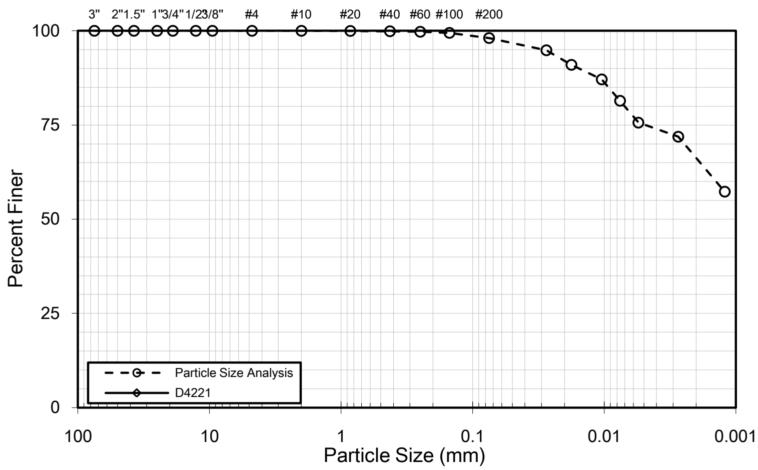
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

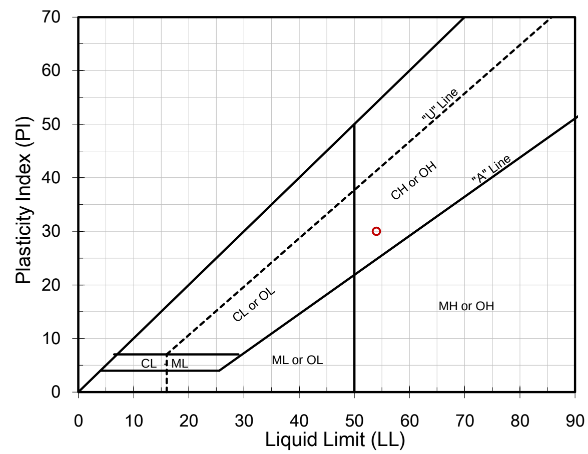
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 205-19 (8.0-10.0) ST-5

TRI Log #: 53226.6





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.0	0.027	94.8	- -	- -
2 in.	50.8	100.0		0.018	91.0	- -	- -
1.5 in.	38.1	100.0		0.010	87.1	- -	- -
1 in.	25.4	100.0		0.008	81.4	- -	- -
3/4 in.	19.0	100.0		0.005	75.6	- -	- -
1/2 in.	12.7	100.0		0.003	71.9	- -	- -
3/8 in.	9.51	100.0		0.001	57.3	- -	- -
No. 4	4.76	100.0	1.9	Log-Linear Interpolation			
No. 10	2.00	100.0		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	100.0		mm		mm	
No. 40	0.420	99.9					
No. 60	0.250	99.7		0.005	75.1	0.005	- -
No. 100	0.149	99.4		0.002	66.3	0.002	- -
No. 200	0.074	98.1	98.1	N m,2µm,d	66	N m,2µm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	1.4E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	4.4	(0.05-0.002	29.3	(< 0.002 mm)	66.3

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	54
Plastic Limit	24
Plastic Index	30
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	21.1
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 4/27/2020

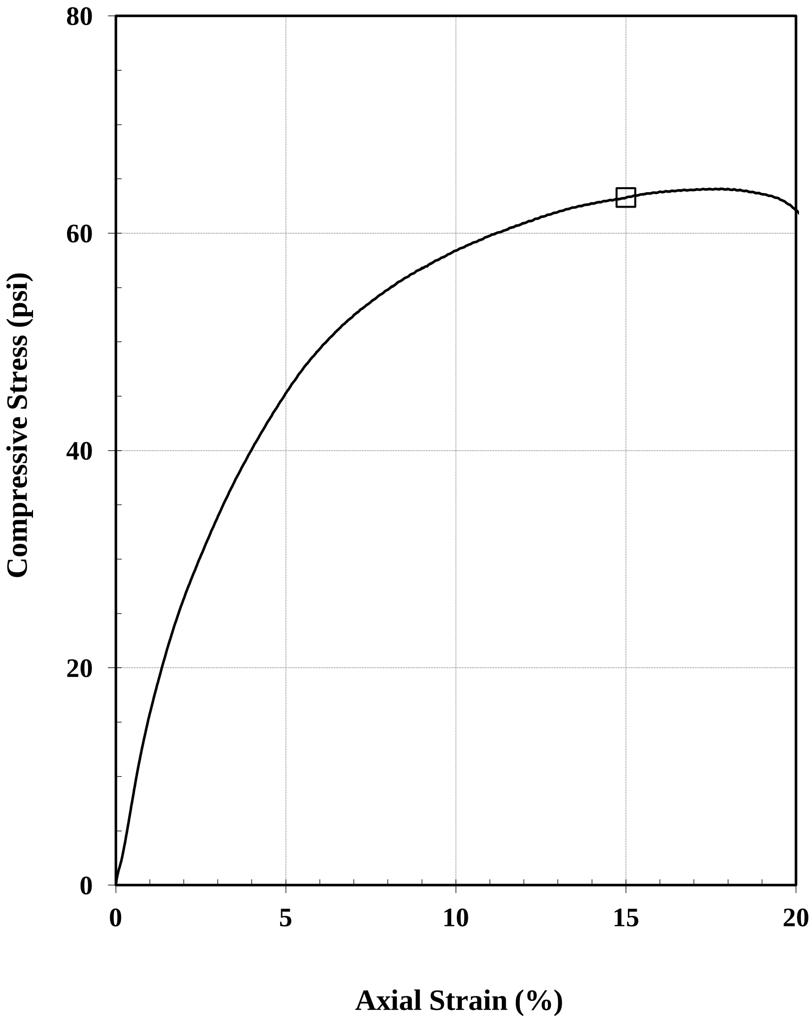
Analysis & Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

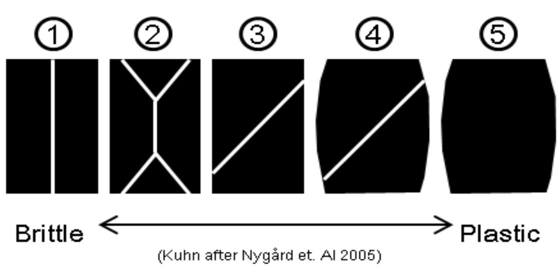
Client:	AECOM	TRI Log No.:	53226.6
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	205-19 (8.0-10.0) ST-5	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.85
Avg. Height (in)	H_o	5.45
Avg, Water Content (%)	w_o	20.6
Bulk Density (pcf)	γ_{total}	125.5
Dry Density (pcf)	γ_{dry}	104.1
Saturation (%)	S_r	90.1
Void Ratio	e_o	0.62
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	63.3
Axial Strain at Failure (%)	15.0
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	63.3
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	31.6

Failure Mode	4



Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20

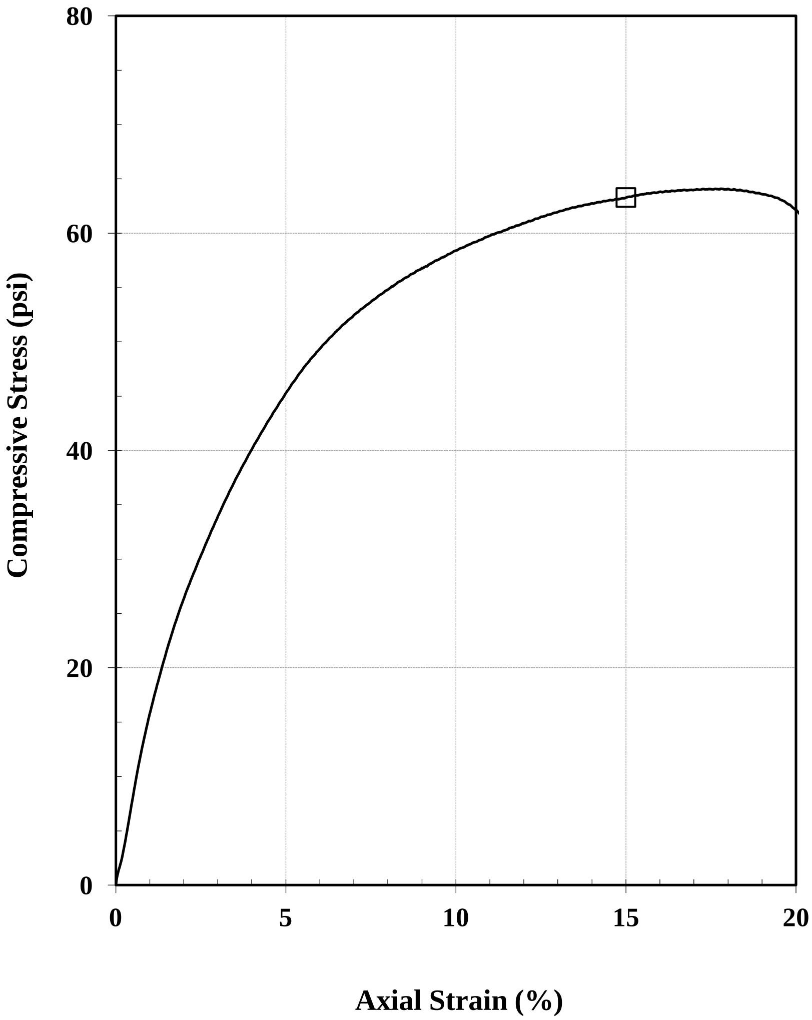
Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

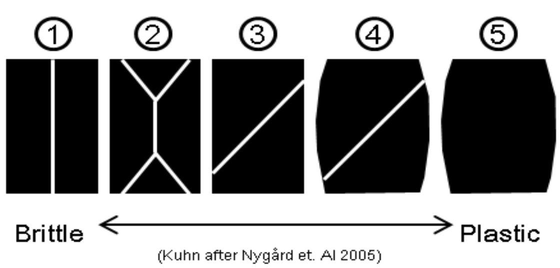
Client:	AECOM	TRI Log No.:	53226.6
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	205-19 (8.0-10.0) ST-5	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.85
Avg. Height (in)	H_o	5.45
Avg, Water Content (%)	w_o	20.6
Bulk Density (pcf)	γ_{total}	125.5
Dry Density (pcf)	γ_{dry}	104.1
Saturation (%)	S_r	90.1
Void Ratio	e_o	0.62
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	63.3
Axial Strain at Failure (%)	15.0
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	63.3
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	31.6

Failure Mode	4



Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20

Quality Review/Date

206-19

Client: AECOM
Project: Plum Creek 2 - Task 1.4.14

TRI Log #: 53228

Jeffrey A. Kuhn, Ph.D., P.E., 4/27/2020
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D7263		ASTM D1140	ASTM D4318, Method A : Multipoint		
1	206-19 (0.0-2.0) P-1	19.4	-	-	-	-	-
2	206-19 (2.0-3.5) SS-2 Layer A	14.2	-	-	-	-	-
3	206-19 (2.0-3.5) SS-2 Layer B	4.3	-	-	68	23	45
4	206-19 (2.0-3.5) SS-2 Layer C	5.2	-	-	-	-	-
5	206-19 (4.0-6.0) P-3 Layer A	19.7	-	-	-	-	-
6	206-19 (4.0-6.0) P-3 Layer B	8.9	127.9	17.7	NL	NP	-
7	206-19 (6.0-7.5) SS-4	5.8	-	23.5	-	-	-
9	206-19 (13.0-15.0) P-6	23.5	-	-	-	-	-
11	206-19 (23.5-25.0) SS-8	23.5	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TRI ENVIRONMENTAL

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM

Project: 60615067, Task 1.4.14 - Plum Creek 2

TRI Log #: 53228

Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
8	206-19 (8.0-10.0) ST-5	24.9	N/A	22.0	20.0	19.0	1	1	1	1
10	206-19 (18.0-20.0) ST-7	[redacted]								

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 4/23/2020

Quality Review/Date

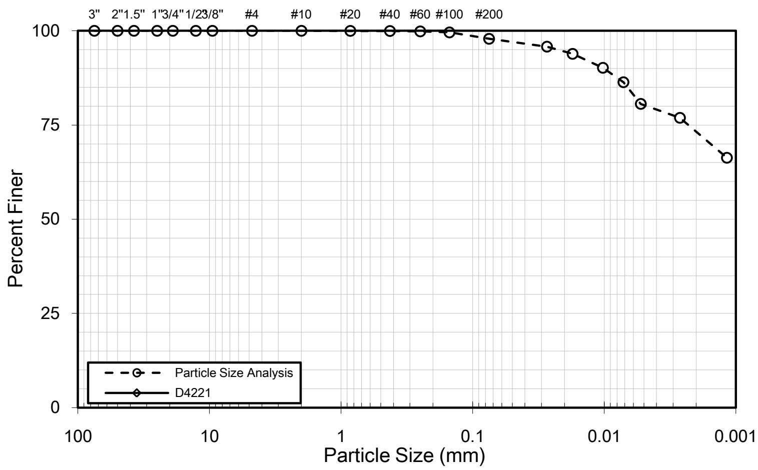
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

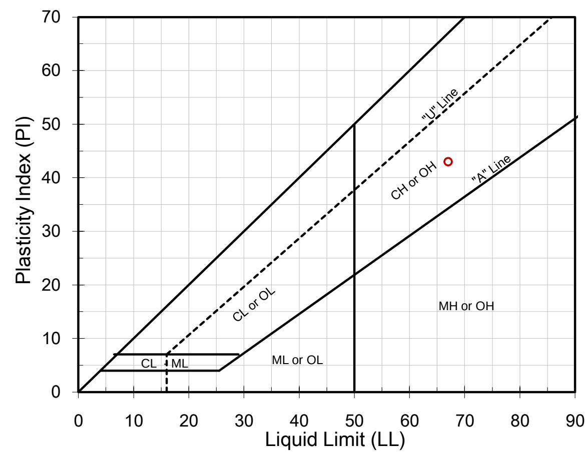
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client:	AECOM	TRI Log #:	53228.8
Project:	60615067-1.4.14 Plum Creek 2		
Sample ID:	206-19 (8.0-10.0) ST-5		





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel	Particle Size	Percent Passing	Particle Size	Percent Passing
			Sand				
-	mm		Fines	mm		mm	
3 in.	76.2	100.0	0.0	0.027	95.8	- -	- -
2 in.	50.8	100.0		0.017	93.9	- -	- -
1.5 in.	38.1	100.0		0.010	90.2	- -	- -
1 in.	25.4	100.0		0.007	86.3	- -	- -
3/4 in.	19.0	100.0		0.005	80.6	- -	- -
1/2 in.	12.7	100.0		0.003	76.9	- -	- -
3/8 in.	9.51	100.0		0.001	66.3	- -	- -
No. 4	4.76	100.0	2.1	Log-Linear Interpolation			
No. 10	2.00	100.0		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	100.0					
No. 40	0.420	100.0		mm		mm	
No. 60	0.250	99.8		0.005	80.3	0.005	- -
No. 100	0.149	99.6		0.002	73.2	0.002	- -
No. 200	0.074	97.9	97.9	N m,2µm,d	73	N m,2µm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	**Cu**	**Cc**	(ASTM D4221)
- -	- -	- -	- -	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	3.6	(0.05-0.002	23.2	(< 0.002 mm)	73.2

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	67
Plastic Limit	24
Plastic Index	43
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	23.7
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 4/27/2020

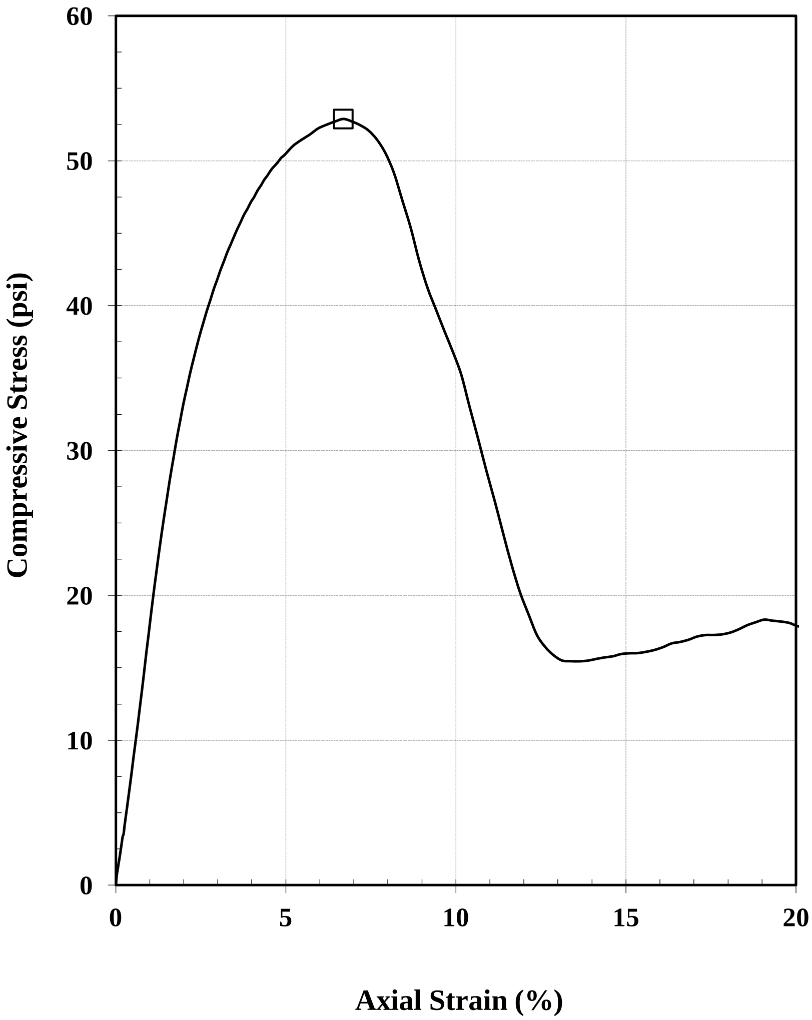
Analysis & Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

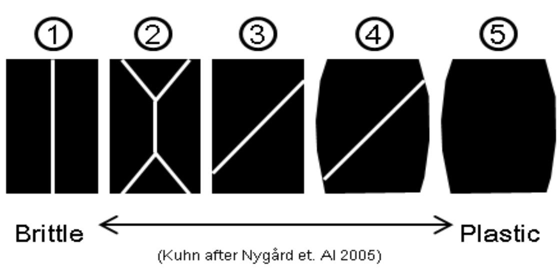
Client:	AECOM	TRI Log No.:	53228.8
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	206-19 (8.0-10.0) ST-5	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.77
Avg. Height (in)	H_o	5.48
Avg, Water Content (%)	w_o	24.9
Bulk Density (pcf)	γ_{total}	126.3
Dry Density (pcf)	γ_{dry}	101.1
Saturation (%)	S_r	99.4
Void Ratio	e_o	0.67
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	52.9
Axial Strain at Failure (%)	6.7
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	52.9
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	26.4

Failure Mode	2



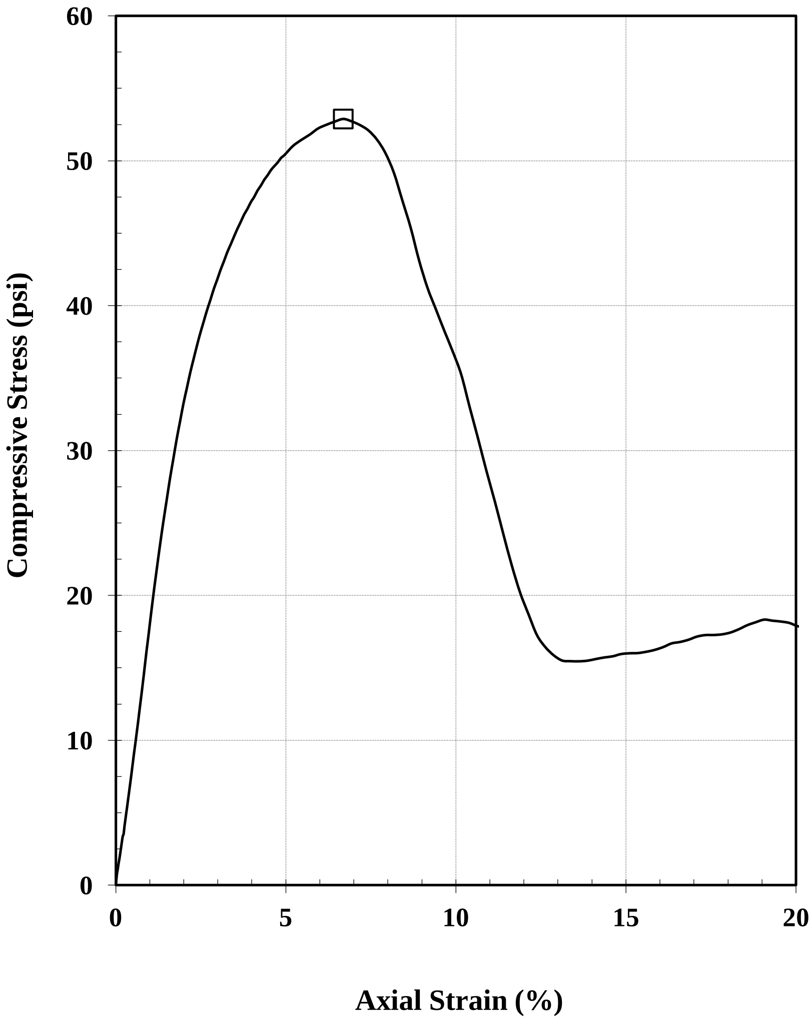
Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20

Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

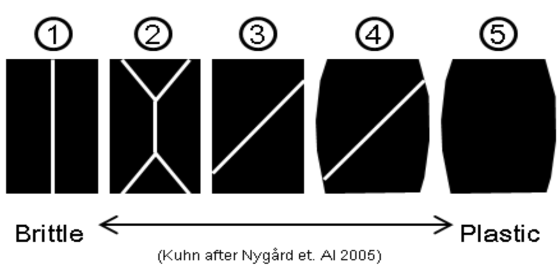
Client:	AECOM	TRI Log No.:	53228.8
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	206-19 (8.0-10.0) ST-5	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.77
Avg. Height (in)	H_o	5.48
Avg, Water Content (%)	w_o	24.9
Bulk Density (pcf)	γ_{total}	126.3
Dry Density (pcf)	γ_{dry}	101.1
Saturation (%)	S_r	99.4
Void Ratio	e_o	0.67
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	52.9
Axial Strain at Failure (%)	6.7
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	52.9
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	26.4

Failure Mode	2



Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

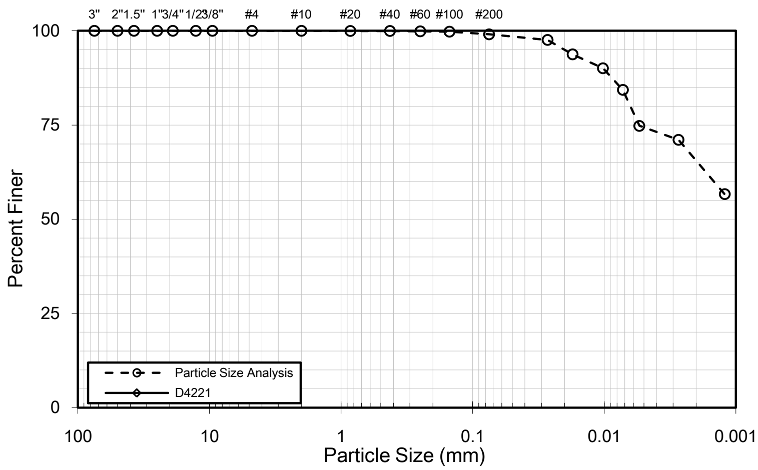
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

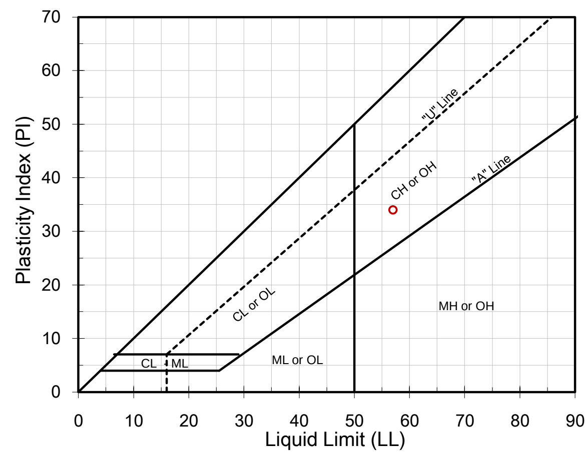
Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM   TRI Log #: 53228.10

Project: 60615067-1.4.14 Plum Creek 2

Sample ID: 206-19 (18.0-20.0) ST-7





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.0	0.027	97.6	- -	- -
2 in.	50.8	100.0		0.017	93.8	- -	- -
1.5 in.	38.1	100.0		0.010	90.1	- -	- -
1 in.	25.4	100.0		0.007	84.3	- -	- -
3/4 in.	19.0	100.0		0.005	74.8	- -	- -
1/2 in.	12.7	100.0		0.003	71.1	- -	- -
3/8 in.	9.51	100.0		0.001	56.7	- -	- -
No. 4	4.76	100.0	0.9	Log-Linear Interpolation			
No. 10	2.00	100.0		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	100.0					
No. 40	0.420	100.0		mm		mm	
No. 60	0.250	99.9		0.005	74.3	0.005	- -
No. 100	0.149	99.8		0.002	65.6	0.002	- -
No. 200	0.074	99.1	99.1	N m,2µm,d	66	N m,2µm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	1.5E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	2.1	(0.05-0.002	32.3	(< 0.002 mm)	65.6

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	57
Plastic Limit	23
Plastic Index	34
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	22.1
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 4/27/2020

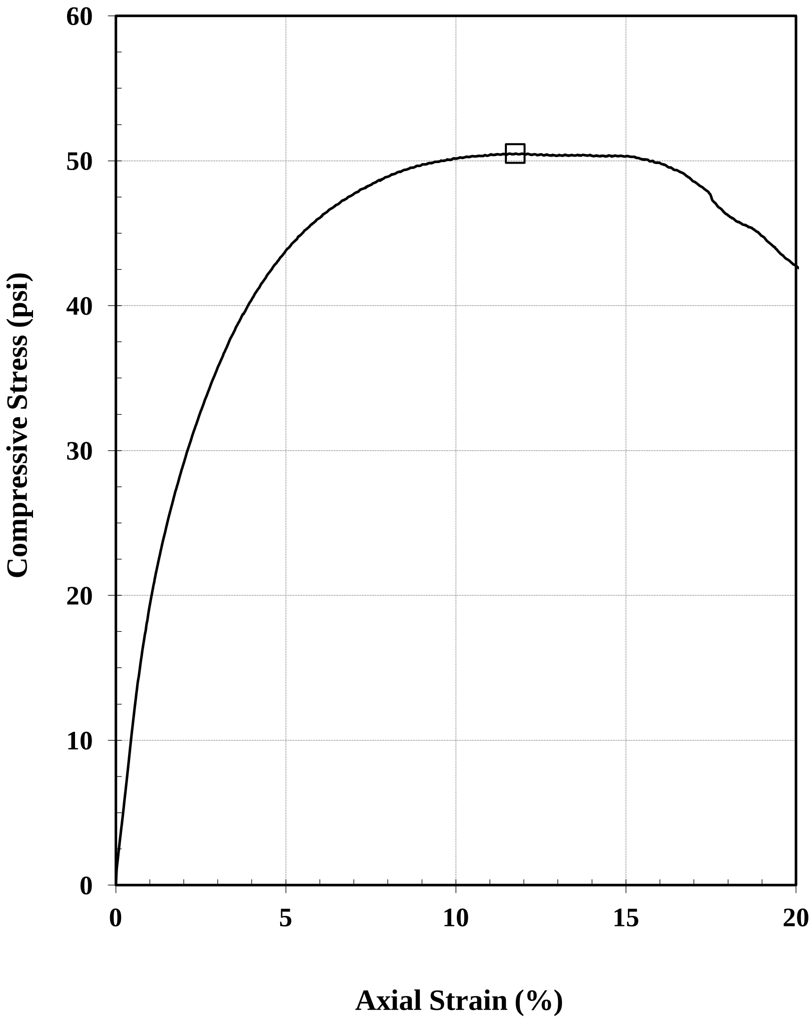
Analysis & Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

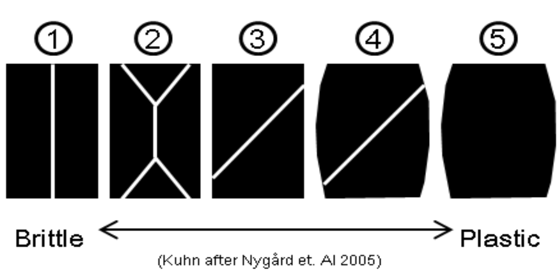
Client:	AECOM	TRI Log No.:	53228.10
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	206-19 (18.0-20.0) ST-7	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.80
Avg. Height (in)	H_o	5.46
Avg, Water Content (%)	w_o	22.5
Bulk Density (pcf)	γ_{total}	126.3
Dry Density (pcf)	γ_{dry}	103.1
Saturation (%)	S_r	95.8
Void Ratio	e_o	0.64
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	50.5
Axial Strain at Failure (%)	11.7
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	50.5
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	25.3

Failure Mode	4



Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20

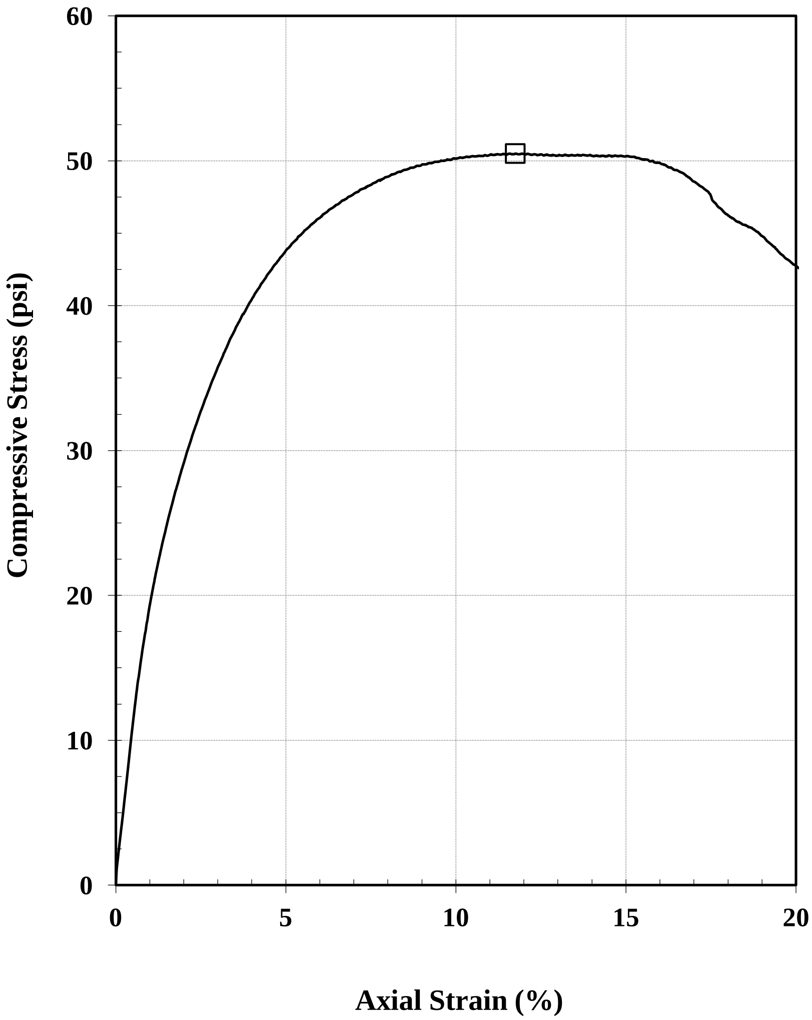
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

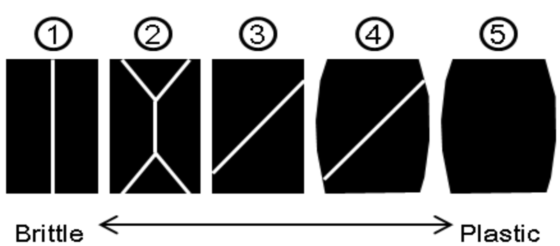
Client:	AECOM	TRI Log No.:	53228.10
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	206-19 (18.0-20.0) ST-7	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.80
Avg. Height (in)	H_o	5.46
Avg, Water Content (%)	w_o	22.5
Bulk Density (pcf)	γ_{total}	126.3
Dry Density (pcf)	γ_{dry}	103.1
Saturation (%)	S_r	95.8
Void Ratio	e_o	0.64
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	50.5
Axial Strain at Failure (%)	11.7
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	50.5
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	25.3

Failure Mode	4



(Kuhn after Nygård et. Al 2005)

Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

207-19

Client: AECOM TRI Log #: 53221

Project: 60615067, Task 1.4.14 - Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 4/27/2020

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216		ASTM D1140	ASTM D4318, Method A : Multipoint		
1	207-19 (0.0-2.0) P-1	13.5	-	-	-	-	-
3	207-19 (4.0-5.5) SS-3 Layer A	21.3	-	-	-	-	-
4	207-19 (4.0-5.5) SS-3 Layer B	6.0	-	-	-	-	-
5	207-19 (6.0-8.0) P-4	8.5	123.1	-	35	15	20
6	207-19 (8.0-9.5) SS-5	12.2	-	-	37	14	23
7	207-19 (13.0-15.0) P-6	21.0	-	-	-	-	-
9	207-19 (23.5-25.0) SS-8	21.2	-	-	-	-	-
10	207-19 (28.0-30.0) P-9	21.4	-	-	-	-	-
11	207-19 (33.0-35.0) ST-10	20.3	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067, Task 1.4.14 - Plum Creek 2

TRI Log #: 53221
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
2	207-19 (2.0-4.0) ST-2	19.0	N/A	20.0	19.5	22.0	1	2	2	2
8	207-19 (13.0-15.0) ST-7	33.9	N/A	20.0	19.5	22.0	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 4/23/2020
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TRI ENVIRONMENTAL

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

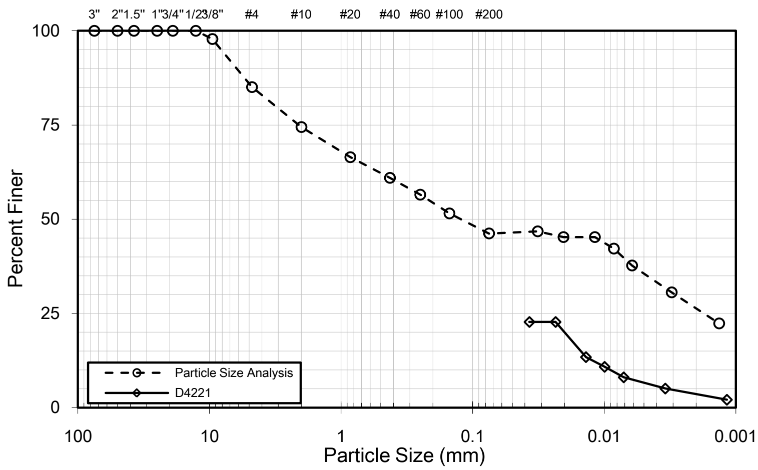
Particle Size, Atterberg Limit, and USCS Analyses for Soils

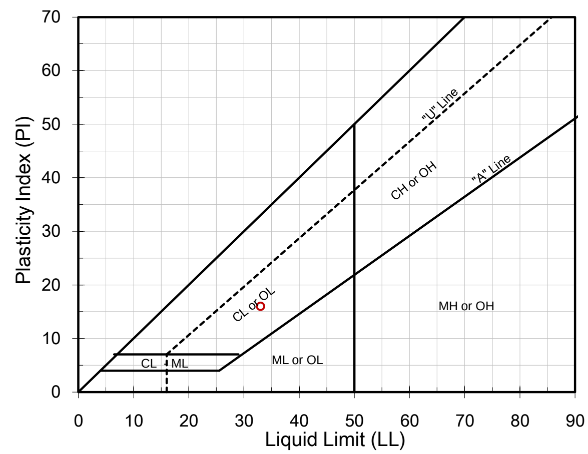
Client: AECOM

TRI Log #: 53221.2

Project: 60615067-1.4.14 Plum Creek 2

Sample ID: 207-19 (2.0-4.0) ST-2





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	14.9	0.032	46.8	0.037	22.7
2 in.	50.8	100.0		0.020	45.2	0.023	22.7
1.5 in.	38.1	100.0		0.012	45.2	0.014	13.4
1 in.	25.4	100.0		0.008	42.2	0.010	10.8
3/4 in.	19.0	100.0		0.006	37.7	0.007	8.0
1/2 in.	12.7	100.0		0.003	30.6	0.003	5.0
3/8 in.	9.51	97.8		0.001	22.3	0.001	2.1
No. 4	4.76	85.1	38.9	Log-Linear Interpolation			
No. 10	2.00	74.5		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	66.5		mm		mm	
No. 40	0.420	61.0					
No. 60	0.250	56.5		0.005	35.6	0.005	6.6
No. 100	0.149	51.5		0.002	26.3	0.002	3.6
No. 200	0.074	46.2	46.2	N m,2µm,d: 26		N m,2µm,nd: 4	

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	2.9E-03	1.2E-01	3.8E-01	- -	- -	15

USDA	Sand (%) (2.0-0.05 mm)		Silt (%) (0.05-0.002)		Clay (%) (< 0.002 mm)	
Clay Loam		33.2		31.5		35.3

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	33
Plastic Limit	17
Plastic Index	16
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Clayey sand (SC)

Moisture Content (%)	ASTM D2216	21.6
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

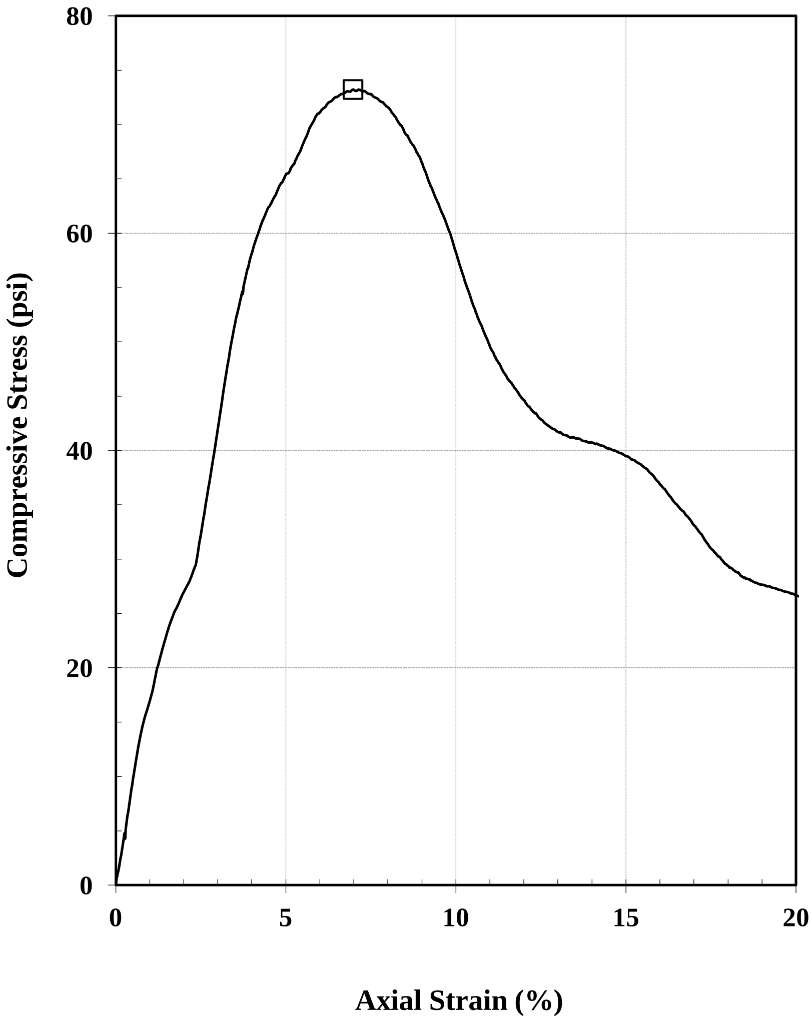
Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 4/27/2020

Analysis & Quality Review/Date

Unconfined Compression Test Report

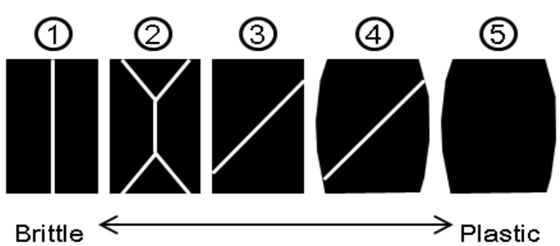
Client:	AECOM	TRI Log No.:	53221.2
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	207-19 (2.0-4.0) ST-2	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.77
Avg. Height (in)	H_o	5.54
Avg, Water Content (%)	w_o	12.6
Bulk Density (pcf)	γ_{total}	131.1
Dry Density (pcf)	γ_{dry}	116.5
Saturation (%)	S_r	81.6
Void Ratio	e_o	0.45
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	73.2
Axial Strain at Failure (%)	7.0
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	73.2
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	36.6

Failure Mode	1



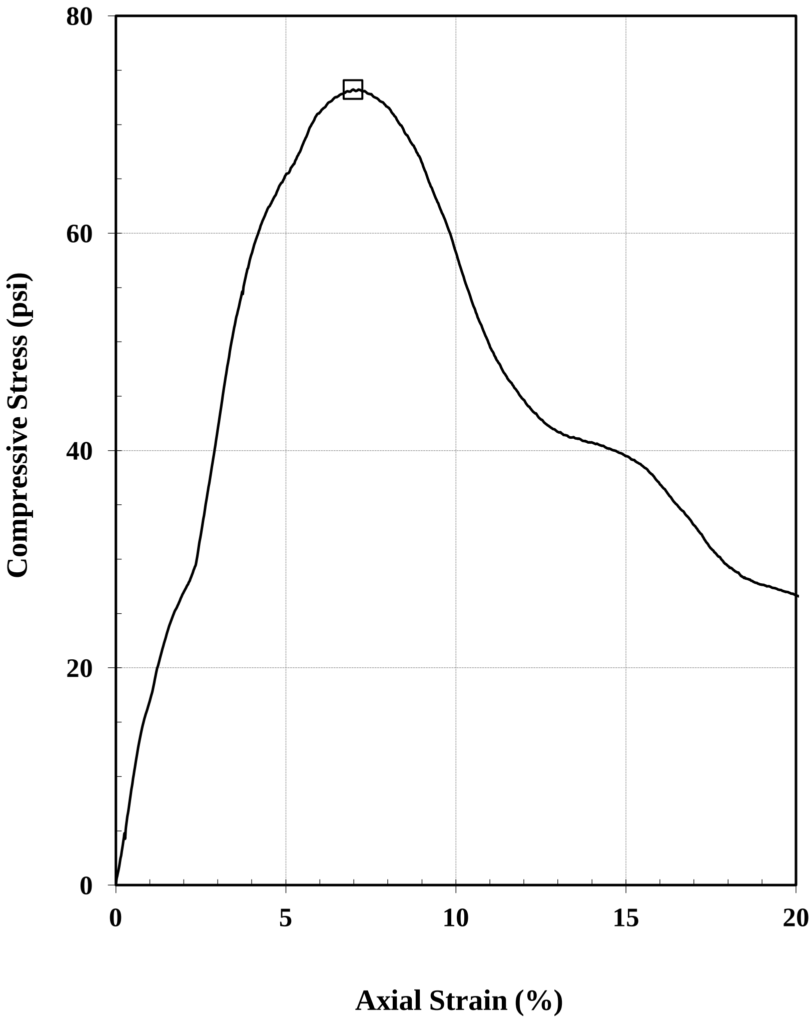
(Kuhn after Nygård et. Al 2005)

Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

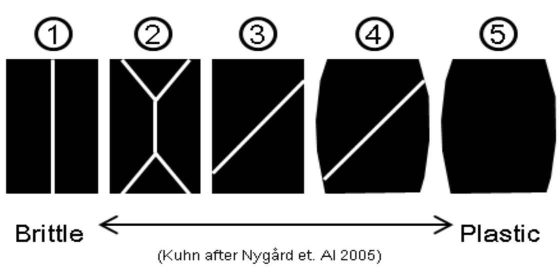
Client:	AECOM	TRI Log No.:	53221.2
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	207-19 (2.0-4.0) ST-2	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.77
Avg. Height (in)	H_o	5.54
Avg, Water Content (%)	w_o	12.6
Bulk Density (pcf)	γ_{total}	131.1
Dry Density (pcf)	γ_{dry}	116.5
Saturation (%)	S_r	81.6
Void Ratio	e_o	0.45
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	73.2
Axial Strain at Failure (%)	7.0
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	73.2
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	36.6

Failure Mode	1



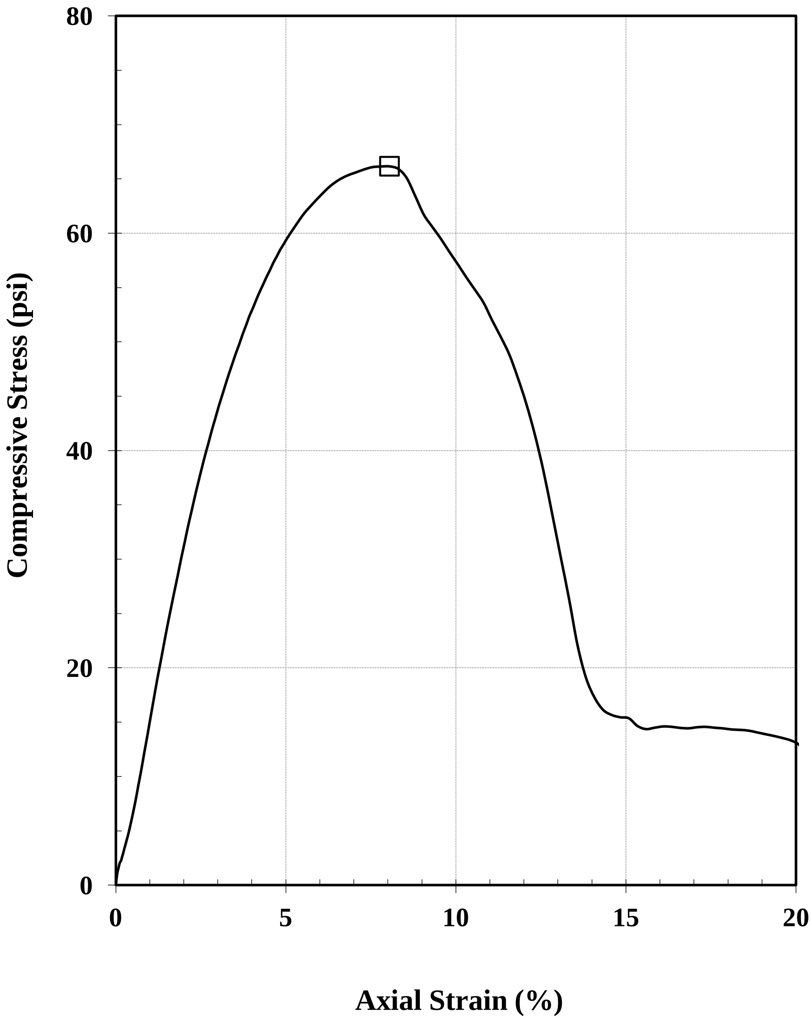
Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

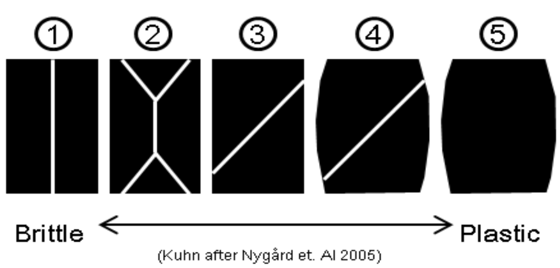
Client:	AECOM	TRI Log No.:	53221.8
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	207-19 (18.0-0.0) ST-7	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.77
Avg. Height (in)	H_o	5.50
Avg, Water Content (%)	w_o	22.1
Bulk Density (pcf)	γ_{total}	128.0
Dry Density (pcf)	γ_{dry}	104.9
Saturation (%)	S_r	97.6
Void Ratio	e_o	0.61
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	66.2
Axial Strain at Failure (%)	8.0
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	66.2
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	33.1

Failure Mode	2

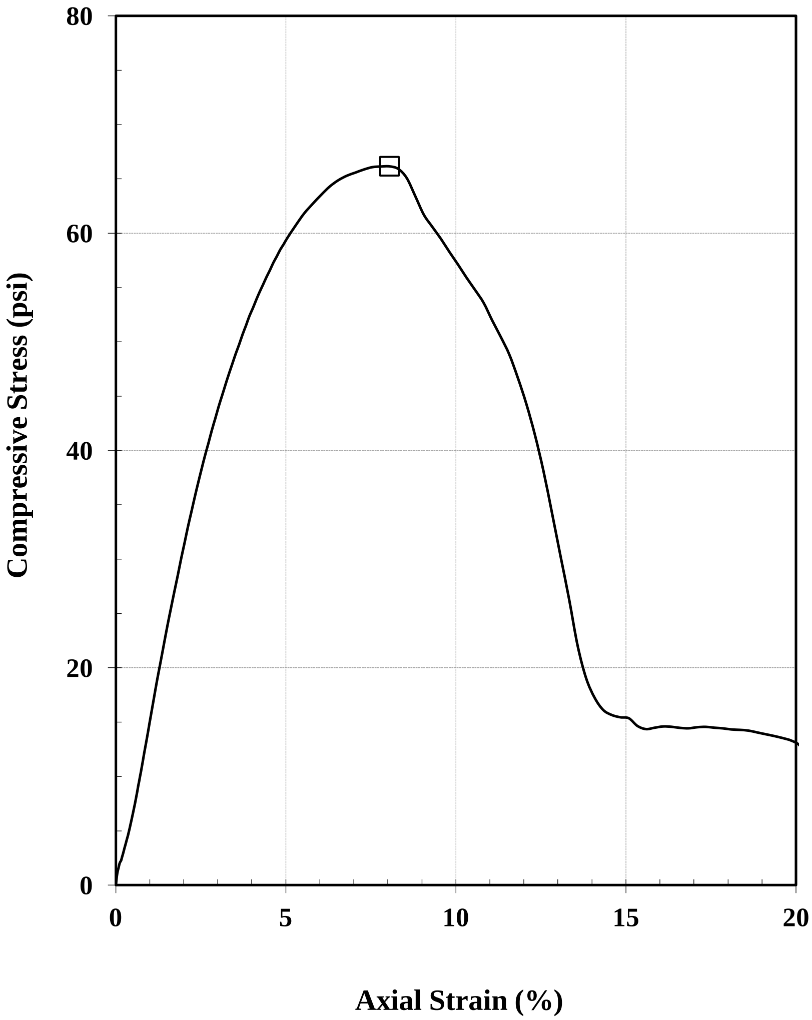


Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20

Quality Review/Date

Unconfined Compression Test Report

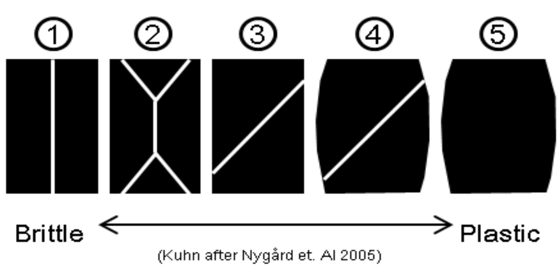
Client:	AECOM	TRI Log No.:	53221.8
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	207-19 (18.0-0.0) ST-7	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.77
Avg. Height (in)	H_o	5.50
Avg, Water Content (%)	w_o	22.1
Bulk Density (pcf)	γ_{total}	128.0
Dry Density (pcf)	γ_{dry}	104.9
Saturation (%)	S_r	97.6
Void Ratio	e_o	0.61
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	66.2
Axial Strain at Failure (%)	8.0
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	66.2
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	33.1

Failure Mode	2



Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

TRI ENVIRONMENTAL

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

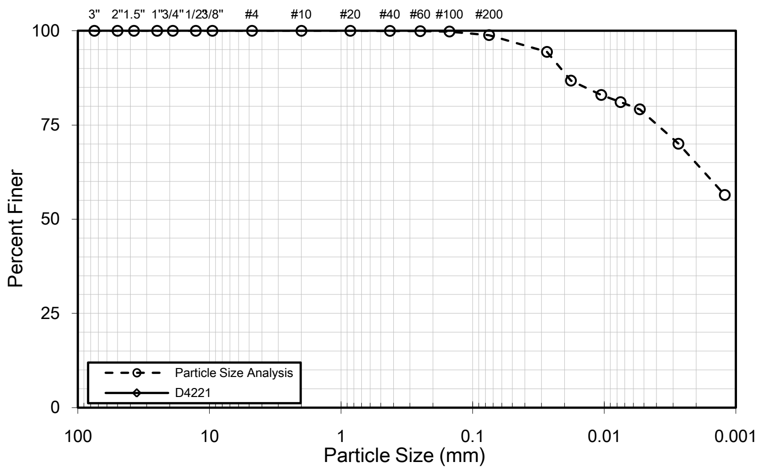
Particle Size, Atterberg Limit, and USCS Analyses for Soils

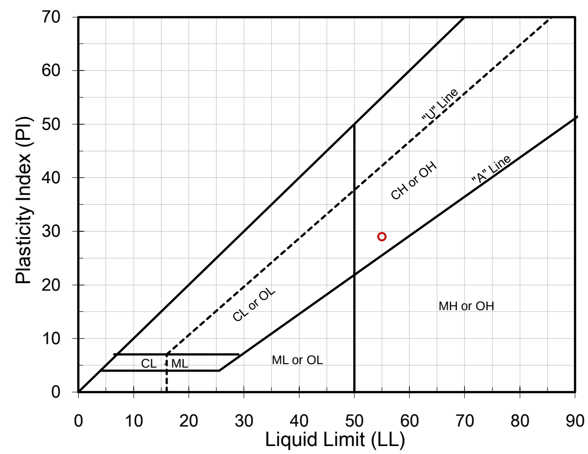
Client: AECOM

Project: Plum Creek 2 - Task 1.4.14

Sample ID: 207-19 (18.0-20.0) ST-7

TRI Log #: 53221.8





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.0	0.027	94.4	- -	- -
2 in.	50.8	100.0		0.018	86.8	- -	- -
1.5 in.	38.1	100.0		0.011	83.0	- -	- -
1 in.	25.4	100.0		0.008	81.1	- -	- -
3/4 in.	19.0	100.0		0.005	79.2	- -	- -
1/2 in.	12.7	100.0		0.003	70.0	- -	- -
3/8 in.	9.51	100.0		0.001	56.4	- -	- -
No. 4	4.76	100.0	1.1	Log-Linear Interpolation			
No. 10	2.00	100.0		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	100.0					
No. 40	0.420	100.0		mm		mm	
No. 60	0.250	99.9		0.005	78.2	0.005	- -
No. 100	0.149	99.8		0.002	64.8	0.002	- -
No. 200	0.074	98.9	98.9	N m,2μm,d	65	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	1.5E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	4.8	(0.05-0.002)	30.4	(< 0.002 mm)	64.8

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	55
Plastic Limit	26
Plastic Index	29
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	21.9
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 4/27/2020

Analysis & Quality Review/Date

208-19

Client: AECOM TRI Log #: 53223

Project: 60615067, Task 1.4.14 - Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 4/27/2020

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	208-19 (0.0-2.0) P-1 Layer A	22.0	-	-	-	-	-
2	208-19 (0.0-2.0) P-1 Layer B	13.9	-	-	-	-	-
4	208-19 (4.0-5.5) SS-3 Layer A	15.4	-	-	-	-	-
5	208-19 (4.0-5.5) SS-3 Layer B	8.3	-	-	-	-	-
6	208-19 (6.0-8.0) P-4	13.8	117.2	75.8	39	15	24
7	208-19 (8.0-9.5) SS-5	13.5	-	-	25	10	15
9	208-19 (18.0-20.0) P-7	20.0	-	-	-	-	-
10	208-19 (23.5-25.0) SS-8 Layer A	19.2	-	-	-	-	-
11	208-19 (23.5-25.0) SS-8	20.3	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067, Task 1.4.14 - Plum Creek 2

TRI Log #: 53223
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
3	208-19 (2.0-4.0) ST-2	20.6	N/A	20.0	19.0	19.0	1	1	1	1
8	208-19 (13.0-15.0) ST-6	22.0	N/A	20.0	19.0	19.0	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 4/23/2020
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TRI ENVIRONMENTAL

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

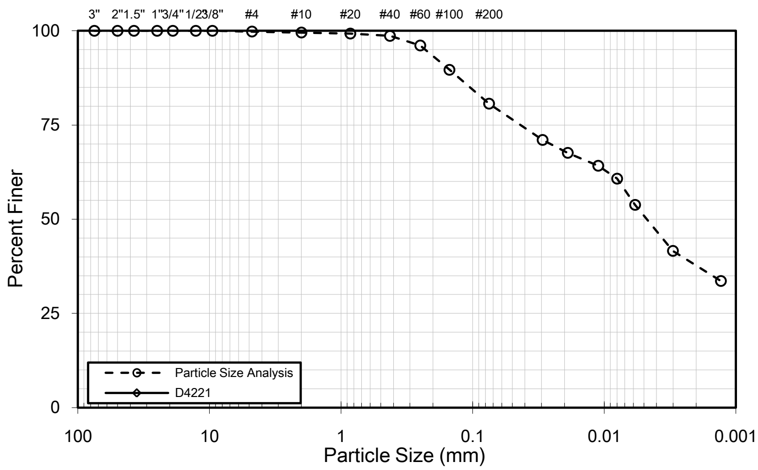
Particle Size, Atterberg Limit, and USCS Analyses for Soils

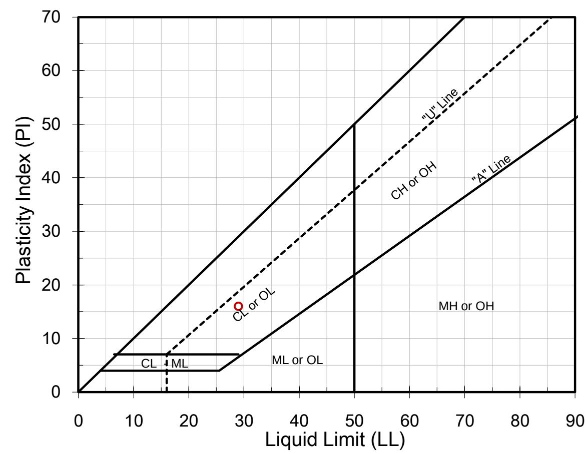
Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

Sample ID: 208-19 (2.0-4.0) ST-2

TRI Log #: 53223.3





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.2	0.029	71.0	- -	- -
2 in.	50.8	100.0		0.019	67.6	- -	- -
1.5 in.	38.1	100.0		0.011	64.2	- -	- -
1 in.	25.4	100.0		0.008	60.8	- -	- -
3/4 in.	19.0	100.0		0.006	53.8	- -	- -
1/2 in.	12.7	100.0		0.003	41.6	- -	- -
3/8 in.	9.51	100.0		0.001	33.6	- -	- -
No. 4	4.76	99.8	19.1	Log-Linear Interpolation			
No. 10	2.00	99.5		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	99.3		mm		mm	
No. 40	0.420	98.6					
No. 60	0.250	96.1		0.005	51.0	0.005	- -
No. 100	0.149	89.6		0.002	37.7	0.002	- -
No. 200	0.074	80.7	80.7	N m,2μm,d	38	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	4.7E-03	7.7E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay Loam	(2.0-0.05 mm)	25.0	(0.05-0.002	37.1	(< 0.002 mm)	37.9

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	29
Plastic Limit	13
Plastic Index	16
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Lean clay with sand (CL)

Moisture Content (%)	ASTM D2216	7.8
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

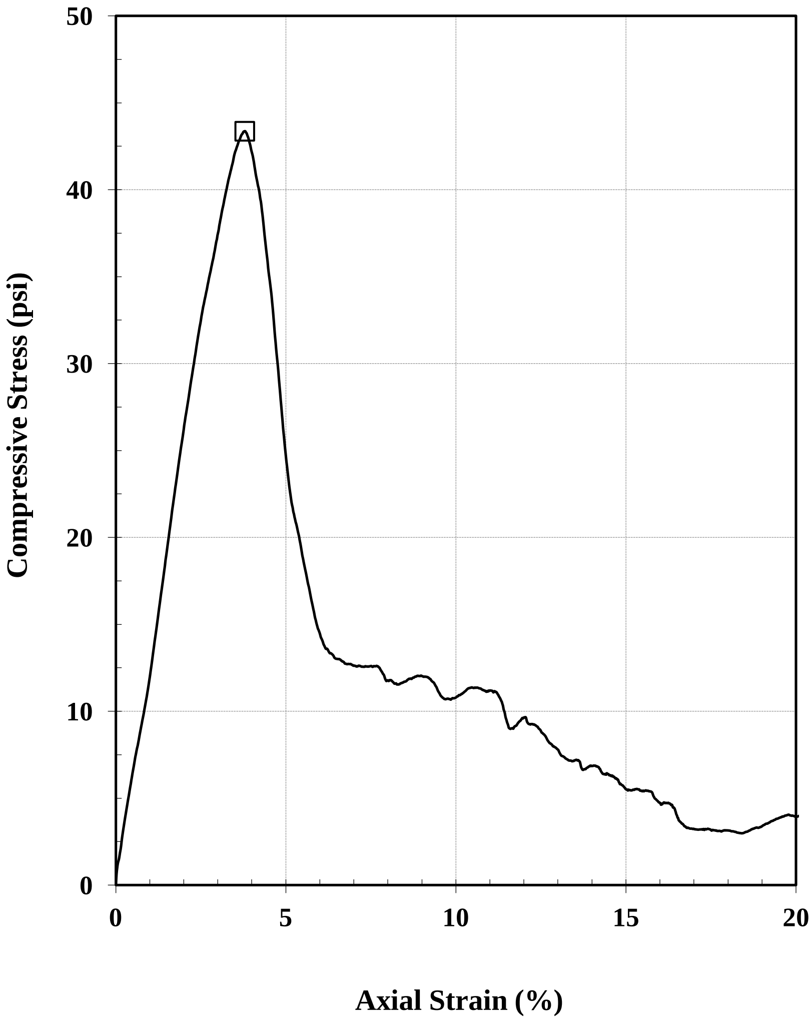
Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 4/27/2020

Analysis & Quality Review/Date

Unconfined Compression Test Report

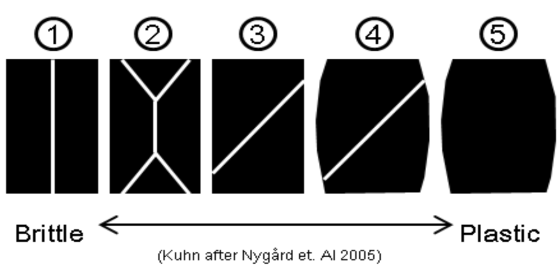
Client:	AECOM	TRI Log No.:	53223.3
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	208-19 (2.0-4.0) ST-2	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.86
Avg. Height (in)	H_o	5.45
Avg, Water Content (%)	w_o	10.2
Bulk Density (pcf)	γ_{total}	125.3
Dry Density (pcf)	γ_{dry}	113.6
Saturation (%)	S_r	55.7
Void Ratio	e_o	0.48
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	43.4
Axial Strain at Failure (%)	3.8
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	43.4
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	21.7

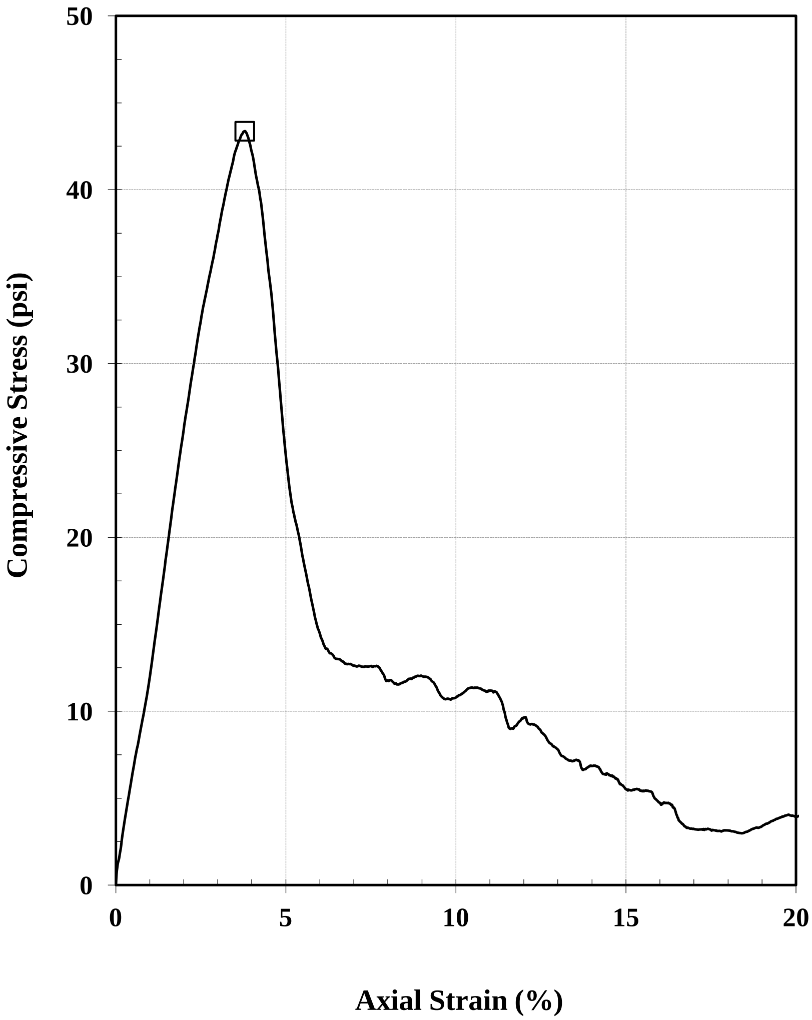
Failure Mode	1



Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

Unconfined Compression Test Report

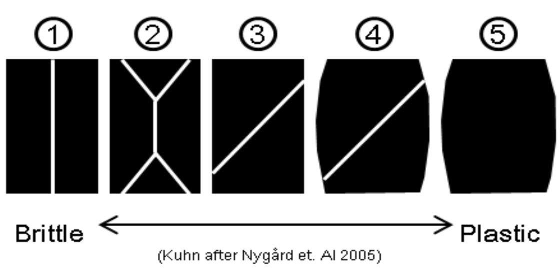
Client:	AECOM	TRI Log No.:	53223.3
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	208-19 (2.0-4.0) ST-2	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.86
Avg. Height (in)	H_o	5.45
Avg, Water Content (%)	w_o	10.2
Bulk Density (pcf)	γ_{total}	125.3
Dry Density (pcf)	γ_{dry}	113.6
Saturation (%)	S_r	55.7
Void Ratio	e_o	0.48
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	43.4
Axial Strain at Failure (%)	3.8
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	43.4
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	21.7

Failure Mode	1



Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

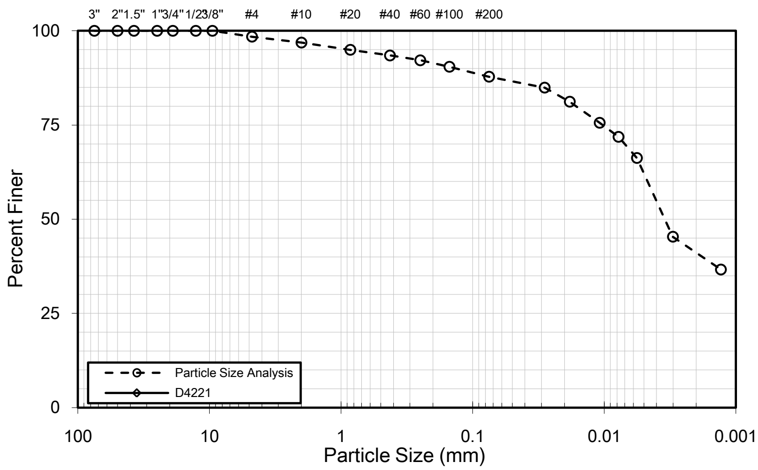
Particle Size, Atterberg Limit, and USCS Analyses for Soils

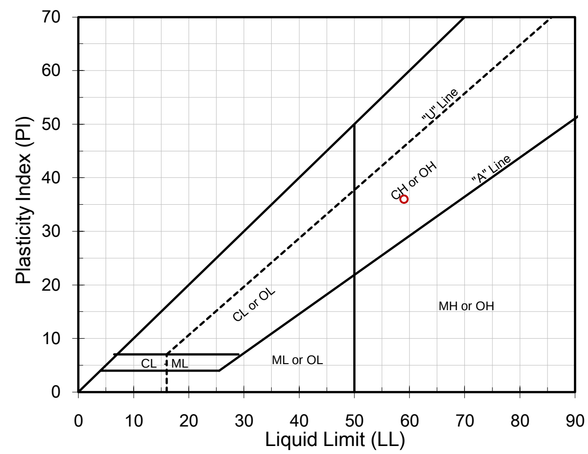
Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

Sample ID: 208-19 (13.0-15.0) ST-6

TRI Log #: 53223.8





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	1.6	0.028	84.9	- -	- -
2 in.	50.8	100.0		0.018	81.2	- -	- -
1.5 in.	38.1	100.0		0.011	75.6	- -	- -
1 in.	25.4	100.0		0.008	71.9	- -	- -
3/4 in.	19.0	100.0		0.006	66.3	- -	- -
1/2 in.	12.7	100.0		0.003	45.3	- -	- -
3/8 in.	9.51	100.0		0.001	36.6	- -	- -
No. 4	4.76	98.4	10.6	Log-Linear Interpolation			
No. 10	2.00	96.9		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	95.0		mm		mm	
No. 40	0.420	93.4					
No. 60	0.250	92.2		0.005	62.3	0.005	- -
No. 100	0.149	90.5		0.002	41.1	0.002	- -
No. 200	0.074	87.8	87.8	N m,2μm,d	41	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	3.5E-03	4.7E-03	- -	- -	-

USDA	Sand (%) (2.0-0.05 mm)		Silt (%) (0.05-0.002		Clay (%) (< 0.002 mm)	
Silty Clay		10.7		46.9		42.4

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	59
Plastic Limit	23
Plastic Index	36
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	19.1
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 4/27/2020

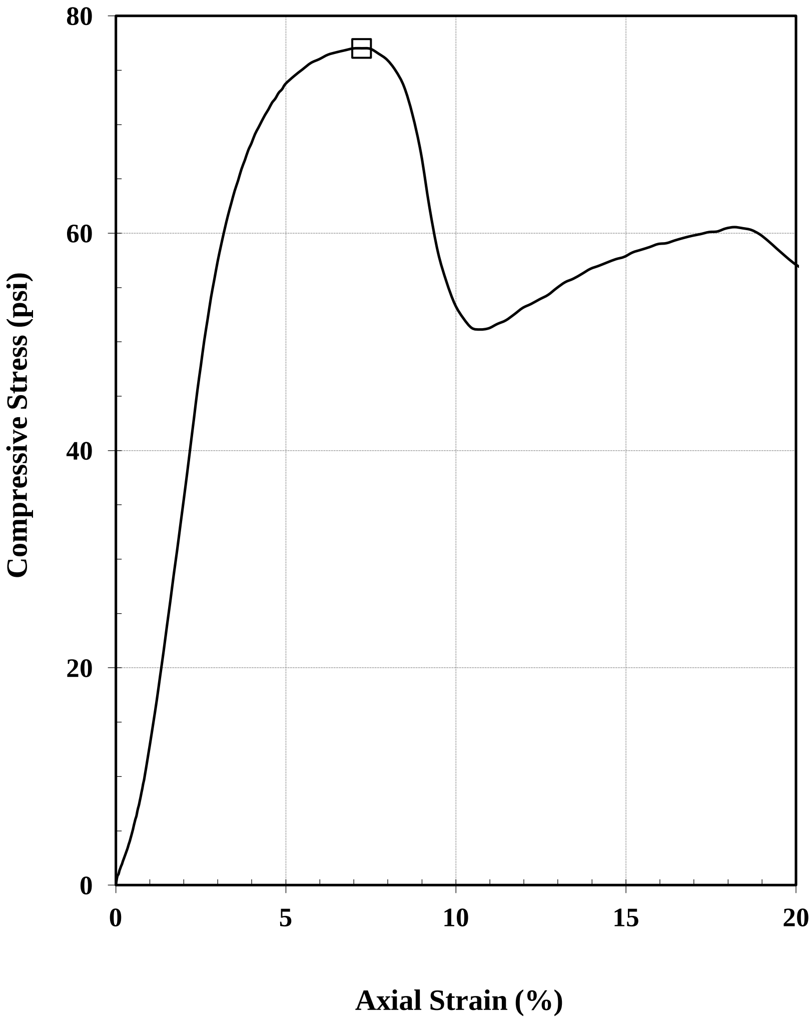
Analysis & Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

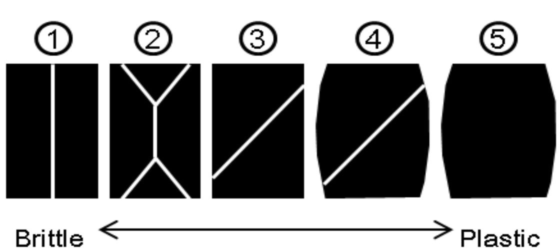
Client:	AECOM	TRI Log No.:	53223.8
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	208-19 (13.0-15.0) ST-6	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.77
Avg. Height (in)	H_o	5.45
Avg, Water Content (%)	w_o	21.1
Bulk Density (pcf)	γ_{total}	124.8
Dry Density (pcf)	γ_{dry}	103.0
Saturation (%)	S_r	90.3
Void Ratio	e_o	0.64
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	77.0
Axial Strain at Failure (%)	7.2
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	77.0
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	38.5

Failure Mode	1



(Kuhn after Nygård et. Al 2005)

Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20

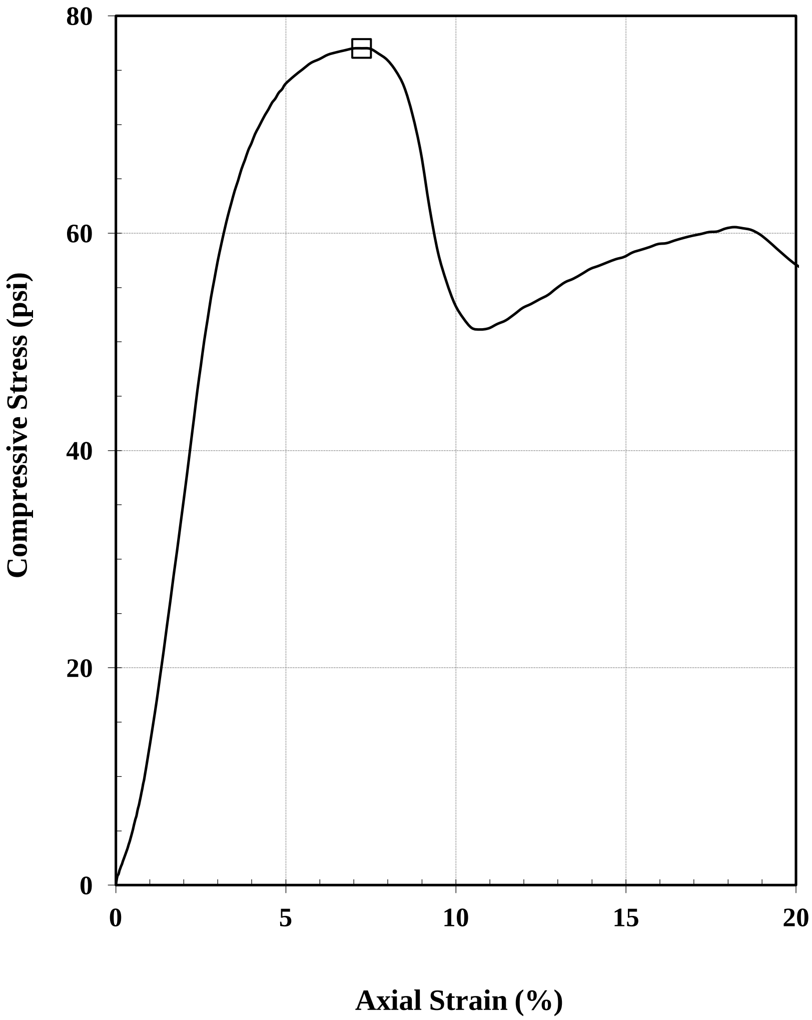
Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

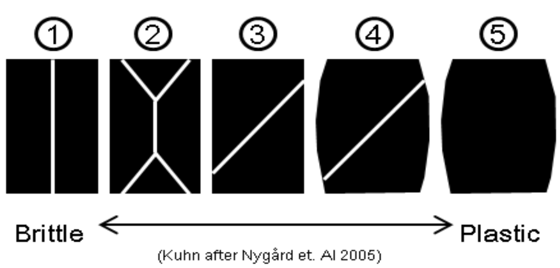
Client:	AECOM	TRI Log No.:	53223.8
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	208-19 (13.0-15.0) ST-6	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.77
Avg. Height (in)	H_o	5.45
Avg, Water Content (%)	w_o	21.1
Bulk Density (pcf)	γ_{total}	124.8
Dry Density (pcf)	γ_{dry}	103.0
Saturation (%)	S_r	90.3
Void Ratio	e_o	0.64
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	77.0
Axial Strain at Failure (%)	7.2
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	77.0
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	38.5

Failure Mode	1



Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20

Quality Review/Date

209-19

Client: AECOM
Project: Plum Creek 2 - Task 1.4.14

TRI Log #: 53225

Jeffrey A. Kuhn, Ph.D., P.E., 4/27/2020
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D7263		ASTM D1140	ASTM D4318, Method A : Multipoint		
1	209-19 (0.0-2.0) P-1 Layer A	25.3	-	-	-	-	-
2	209-19 (0.0-2.0) P-1 Layer B	15.8	-	-	-	-	-
3	209-19 (2.0-3.5) SS-2	6.6	-	-	-	-	-
4	209-19 (4.0-6.0) P-3 Layer A	21.2	-	-	-	-	-
5	209-19 (4.0-6.0) P-3 Layer B	17.5	-	-	-	-	-
7	209-19 (8.0-9.5) SS-5	20.2	-	-	-	-	-
8	209-19 (13.0-15.0) P-6	21.5	-	-	-	-	-
10	209-19 (23.5-25.0) SS-8	22.7	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

TRI ENVIRONMENTAL

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: Plum Creek 2 - Task 1.4.14

TRI Log #: 53225
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	(1 hr)
6	209-19 (6.0-8.0) ST-4	40.4	N/A	22.0	20.0	19.0	1	1	1	1
9	209-19 (18.0-20.0) ST-7	36.3	N/A	22.0	20.0	19.0	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 4/23/2020

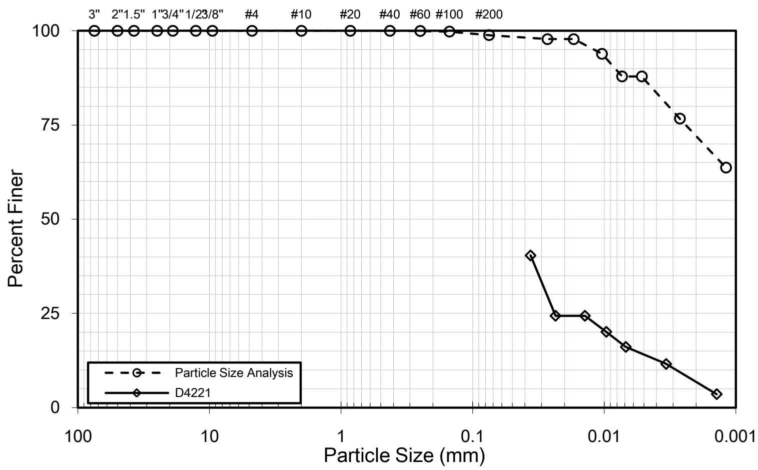
Quality Review/Date

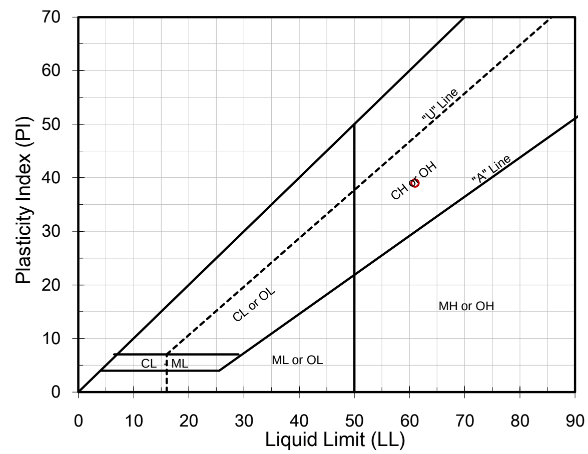
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 209-19 (6.0-8.0) ST-4

TRI Log #: 53225.6





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.0	0.027	97.8	0.036	40.4
2 in.	50.8	100.0		0.017	97.8	0.023	24.4
1.5 in.	38.1	100.0		0.010	93.9	0.014	24.4
1 in.	25.4	100.0		0.007	87.9	0.010	20.1
3/4 in.	19.0	100.0		0.005	87.9	0.007	16.1
1/2 in.	12.7	100.0		0.003	76.7	0.003	11.6
3/8 in.	9.51	100.0		0.001	63.7	0.001	3.6
No. 4	4.76	100.0	1.1	Log-Linear Interpolation			
No. 10	2.00	100.0		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	100.0		mm		mm	
No. 40	0.420	100.0					
No. 60	0.250	100.0		0.005	87.3	0.005	14.1
No. 100	0.149	99.8		0.002	72.1	0.002	6.8
No. 200	0.074	98.9	98.9	N m,2μm,d	72	N m,2μm,nd	7

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	- -	- -	- -	10

USDA	Sand (%) (2.0-0.05 mm)	Silt (%) (0.05-0.002)	Clay (%) (< 0.002 mm)
Clay	1.9	26.0	72.1

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	61
Plastic Limit	22
Plastic Index	39
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	19.6
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

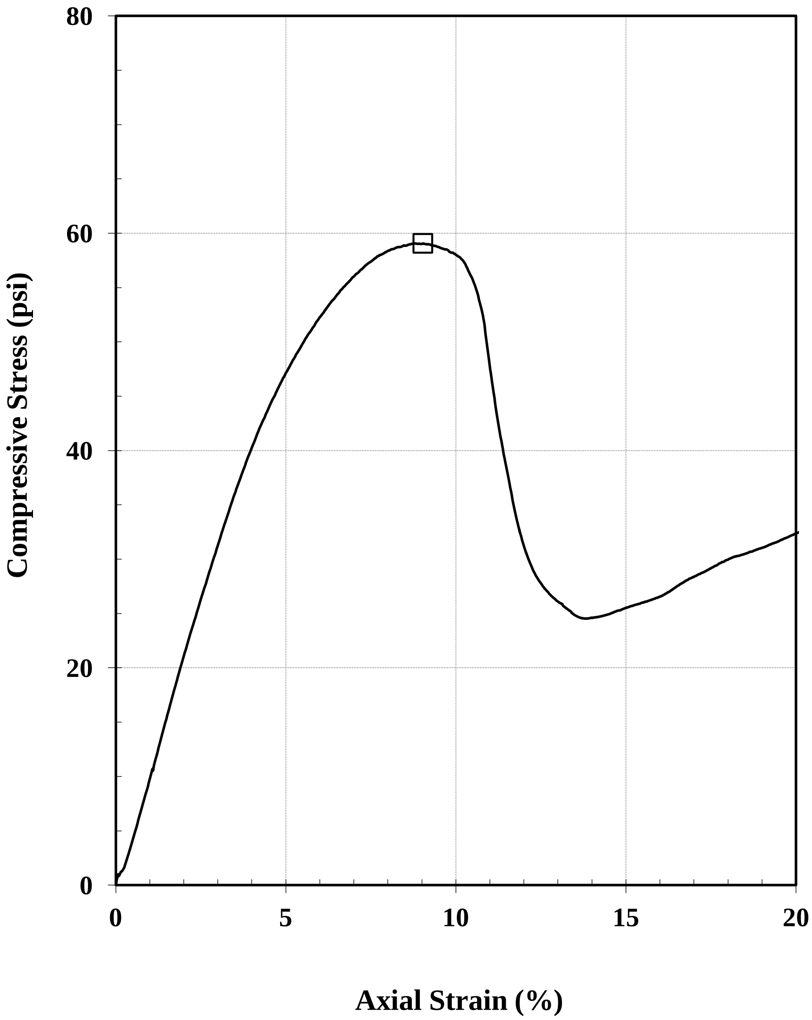
Jeffrey A. Kuhn, Ph.D, P.E. 4/27/2020
Analysis & Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

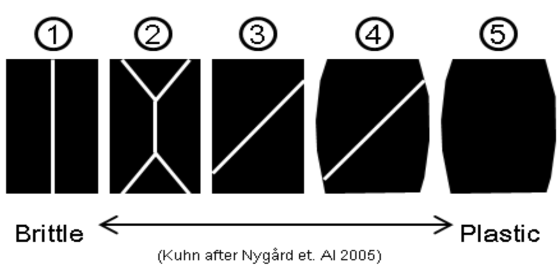
Client:	AECOM	TRI Log No.:	53225.6
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	209-19 (6.0-8.0) ST-4	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.85
Avg. Height (in)	H_o	5.63
Avg, Water Content (%)	w_o	22.0
Bulk Density (pcf)	γ_{total}	127.6
Dry Density (pcf)	γ_{dry}	104.6
Saturation (%)	S_r	≈100
Void Ratio	e_o	0.61
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	59.1
Axial Strain at Failure (%)	9.0
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	59.1
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	29.5

Failure Mode	3



Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20

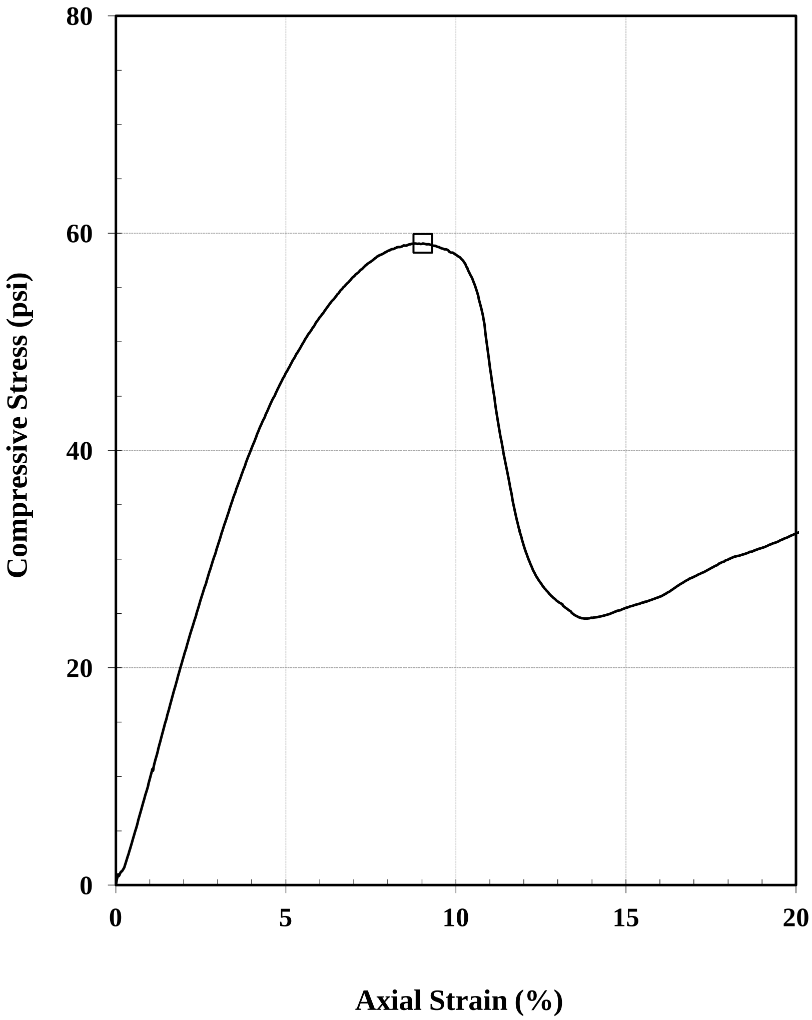
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

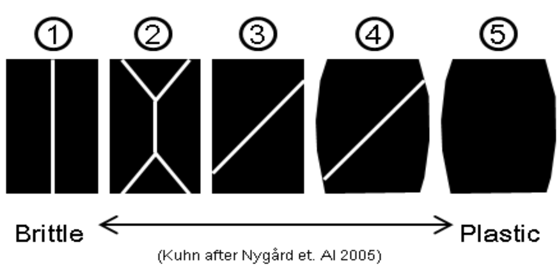
Client:	AECOM	TRI Log No.:	53225.6
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	209-19 (6.0-8.0) ST-4	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.85
Avg. Height (in)	H_o	5.63
Avg, Water Content (%)	w_o	22.0
Bulk Density (pcf)	γ_{total}	127.6
Dry Density (pcf)	γ_{dry}	104.6
Saturation (%)	S_r	≈100
Void Ratio	e_o	0.61
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	59.1
Axial Strain at Failure (%)	9.0
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	59.1
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	29.5

Failure Mode	3

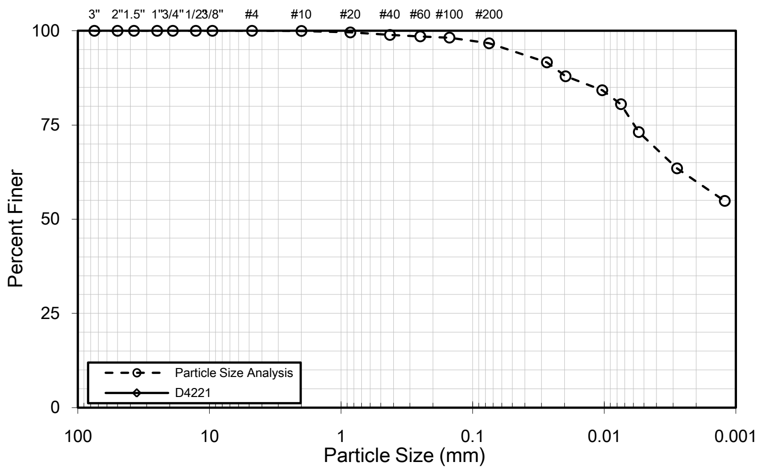


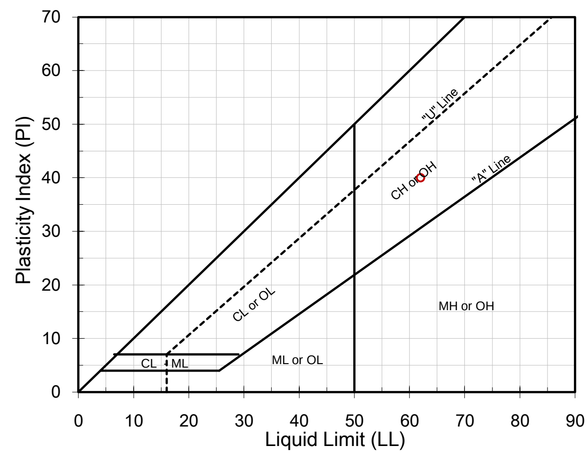
Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 209-19 (18.0-20.0) ST-7

TRI Log #: 53225.9





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.0	0.027	91.6	- -	- -
2 in.	50.8	100.0		0.020	87.9	- -	- -
1.5 in.	38.1	100.0		0.010	84.2	- -	- -
1 in.	25.4	100.0		0.007	80.5	- -	- -
3/4 in.	19.0	100.0		0.005	73.1	- -	- -
1/2 in.	12.7	100.0		0.003	63.5	- -	- -
3/8 in.	9.51	100.0		0.001	54.9	- -	- -
No. 4	4.76	100.0	3.3	Log-Linear Interpolation			
No. 10	2.00	100.0		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	99.6					
No. 40	0.420	98.9		mm		mm	
No. 60	0.250	98.5		0.005	71.9	0.005	- -
No. 100	0.149	98.2		0.002	60.0	0.002	- -
No. 200	0.074	96.7	96.7	N m,2μm,d	60	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	2.0E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	7.2	(0.05-0.002	32.8	(< 0.002 mm)	60.0

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	62
Plastic Limit	22
Plastic Index	40
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	21.4
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

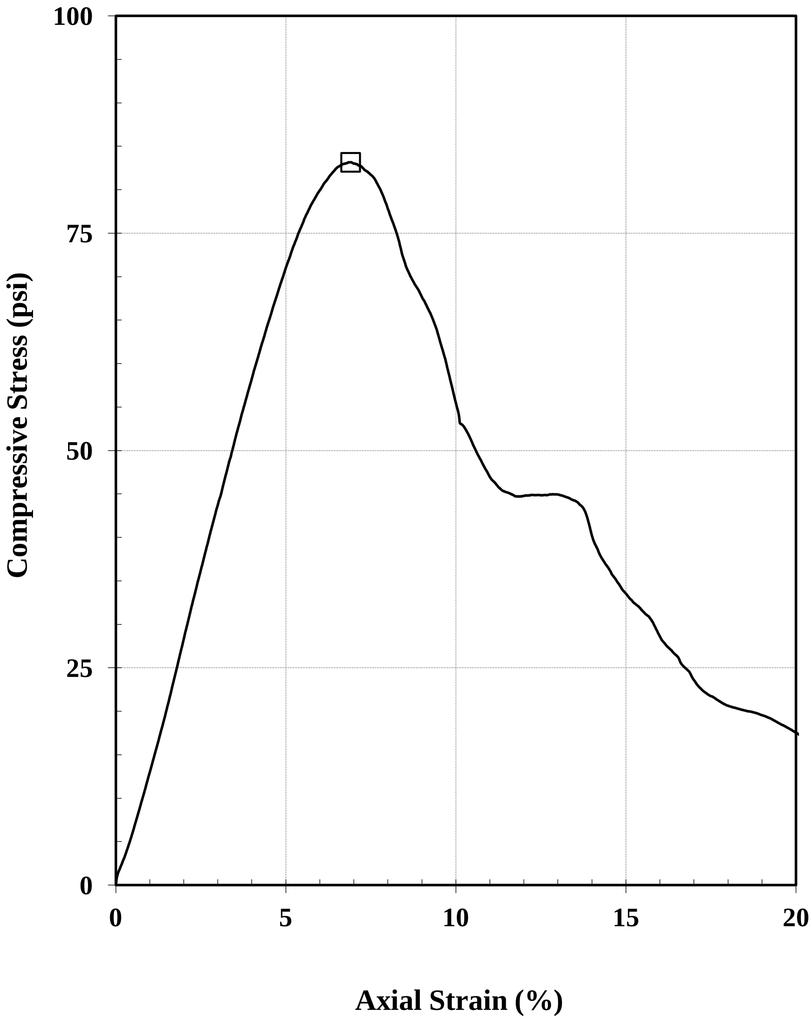
Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 4/27/2020
Analysis & Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

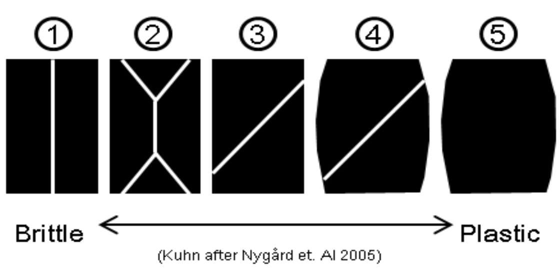
Client:	AECOM	TRI Log No.:	53225.9
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	209-19 (18.0-20.0) ST-7	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.84
Avg. Height (in)	H_o	5.38
Avg, Water Content (%)	w_o	21.7
Bulk Density (pcf)	γ_{total}	129.1
Dry Density (pcf)	γ_{dry}	106.1
Saturation (%)	S_r	98.6
Void Ratio	e_o	0.59
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	83.2
Axial Strain at Failure (%)	6.9
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	83.2
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	41.6

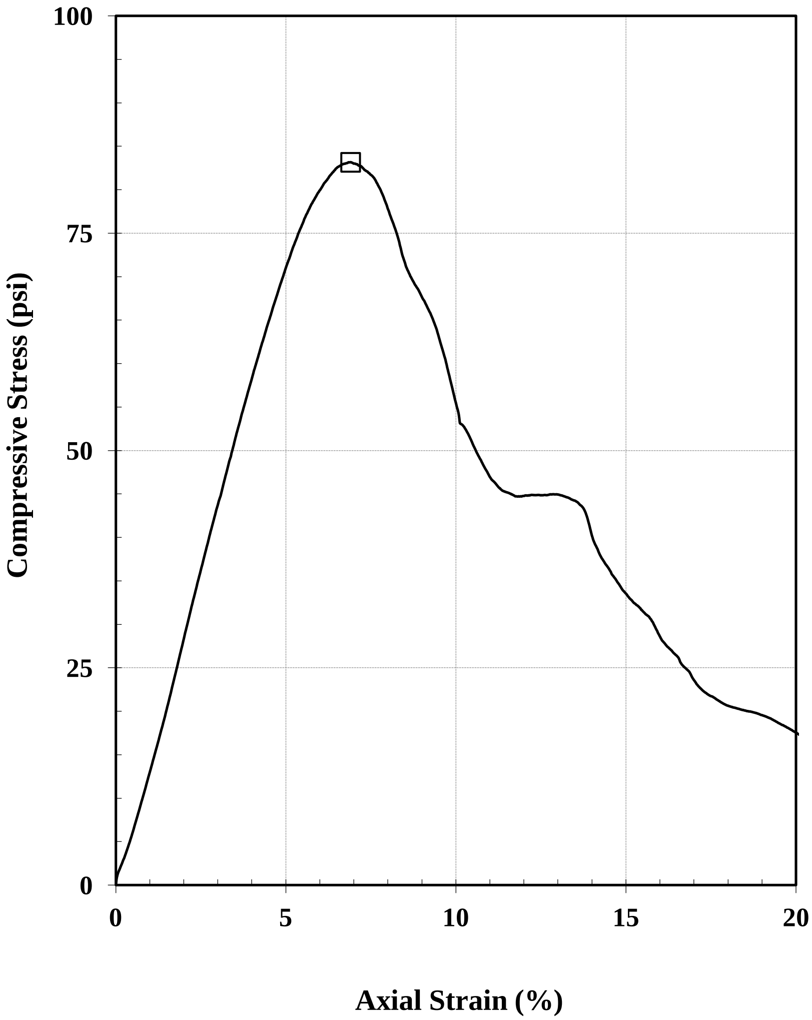
Failure Mode	2



Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

Unconfined Compression Test Report

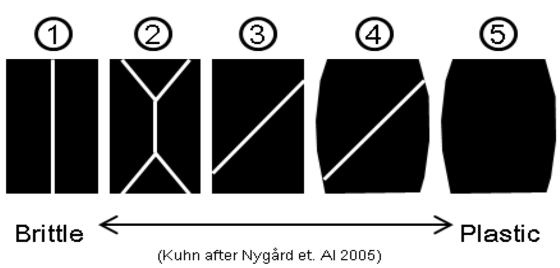
Client:	AECOM	TRI Log No.:	53225.9
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	209-19 (18.0-20.0) ST-7	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.84
Avg. Height (in)	H_o	5.38
Avg, Water Content (%)	w_o	21.7
Bulk Density (pcf)	γ_{total}	129.1
Dry Density (pcf)	γ_{dry}	106.1
Saturation (%)	S_r	98.6
Void Ratio	e_o	0.59
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	83.2
Axial Strain at Failure (%)	6.9
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	83.2
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	41.6

Failure Mode	2



Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

210-19

Client: AECOM

TRI Log #: 52915

Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 4/27/2020

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	210-19 (0.0-2.0) P-1	20.3	107.6	71.8	53	21	32
2	210-19 (2.0-3.5) SS-2	28.2	-	-	-	-	-
3	210-19 (4.0-6.0) P-3	15.2	-	-	-	-	-
4	210-19 (6.0-8.0) P-4	19.1	-	-	-	-	-
6	210-19 (13.5-15.0) SS-6	20.6	-	-	-	-	-
8	210-19 (23.5-25.0) SS-8	18.5	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067, Task 1.4.14 - Plum Creek 2

TRI Log #: 52915
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
5	210-19 (8.0-10.0) ST-5	36.3	N/A	20.0	19.5	22.0	1	1	1	1
7	210-19 (18.0-20.0) ST-7	29.4	N/A	20.0	19.5	22.0	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

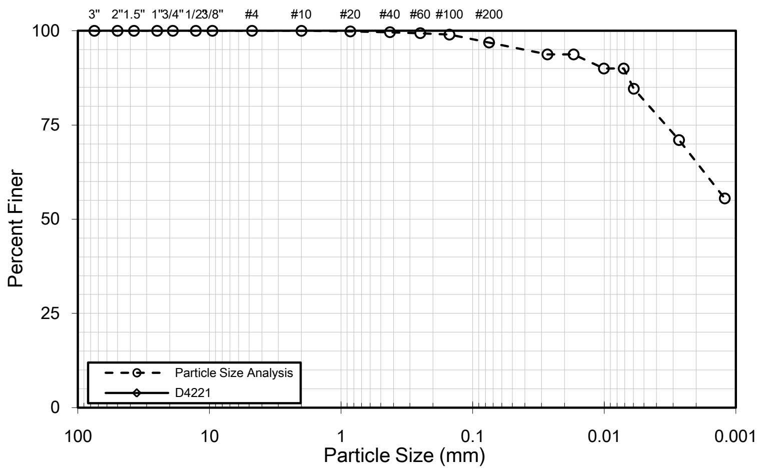
Jeffrey A. Kuhn, Ph.D., P.E., 4/23/2020
Quality Review/Date

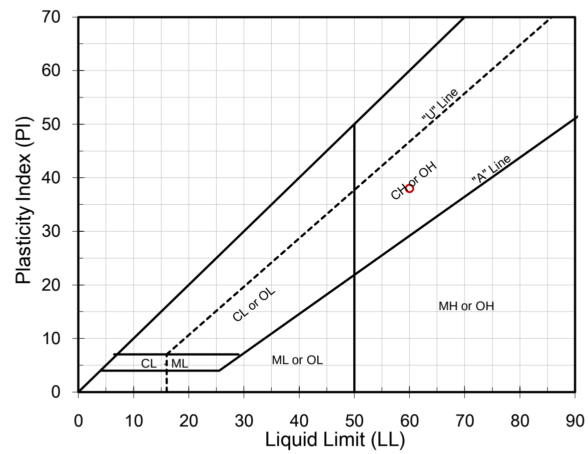
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 210-19 (8.0-10.0) ST-5

TRI Log #: 52915.5





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.0	0.027	93.7	- -	- -
2 in.	50.8	100.0		0.017	93.7	- -	- -
1.5 in.	38.1	100.0		0.010	90.0	- -	- -
1 in.	25.4	100.0		0.007	90.0	- -	- -
3/4 in.	19.0	100.0		0.006	84.6	- -	- -
1/2 in.	12.7	100.0		0.003	71.0	- -	- -
3/8 in.	9.51	100.0		0.001	55.5	- -	- -
No. 4	4.76	100.0	3.1	Log-Linear Interpolation			
No. 10	2.00	100.0		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	99.8		mm		mm	
No. 40	0.420	99.6					
No. 60	0.250	99.4		0.005	81.6	0.005	- -
No. 100	0.149	99.0		0.002	65.2	0.002	- -
No. 200	0.074	96.9	96.9	N m,2µm,d	65	N m,2µm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	1.5E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	5.4	(0.05-0.002	29.4	(< 0.002 mm)	65.2

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	60
Plastic Limit	22
Plastic Index	38
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	20.5
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 4/27/2020
Analysis & Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

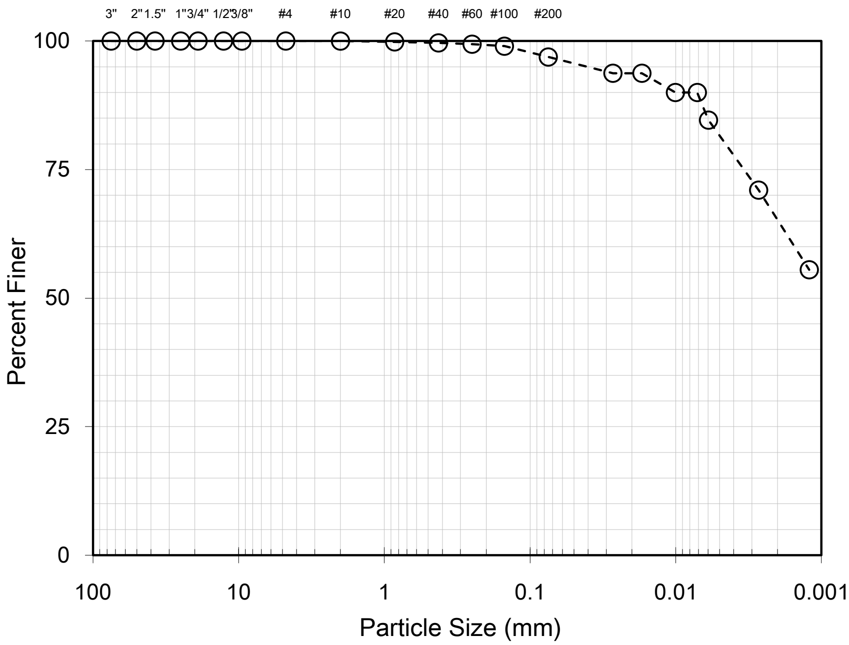
Particle Size, Atterberg Limit, and USCS Analyses for Soils

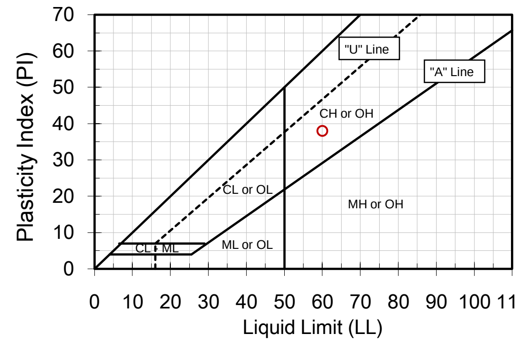
Client: AECOM

Project: Plum Creek 2 - Task 1.4.14

Sample ID: 210-19 (8.0-10.0) ST-5

TRI Log #: 52915.5





Atterberg Limits	
(ASTM D4318, Method A : Multipoint, Air Dried)	
Liquid Limit	60
Plastic Limit	22
Plastic Index	38
(NL = No Liquid Limit, NP = No Plastic Limit)	

Mechanical Sieve		
(ASTM D422)		
Sieve Designation		Percent Passing
-	mm	
3 in.	76.2	100.0
2 in.	50.8	100.0
1.5 in.	38.1	100.0
1 in.	25.4	100.0
3/4 in.	19.0	100.0
1/2 in.	12.7	100.0
3/8 in.	9.51	100.0
No. 4	4.76	100.0
No. 10	2.00	100.0
No. 20	0.841	99.8
No. 40	0.420	99.6
No. 60	0.250	99.4
No. 100	0.149	99.0
No. 200	0.074	96.9

Hydrometer Analysis	
(ASTM D422)	
Particle Size	Percent Passing
mm	
0.027	93.7
0.017	93.7
0.010	90.0
0.007	90.0
0.006	84.6
0.003	71.0
0.001	55.5

Log-Linear Interpolation	
Particle Size	Percent Passing
mm	
0.005	81.6
0.002	65.2

D_X (mm), Log-Linear Interpolation			
10	30	50	60
- -	- -	- -	1.5E-03

Cu	Cc
- -	- -

Gravel	Sand	Fines
0.0	3.1	96.9

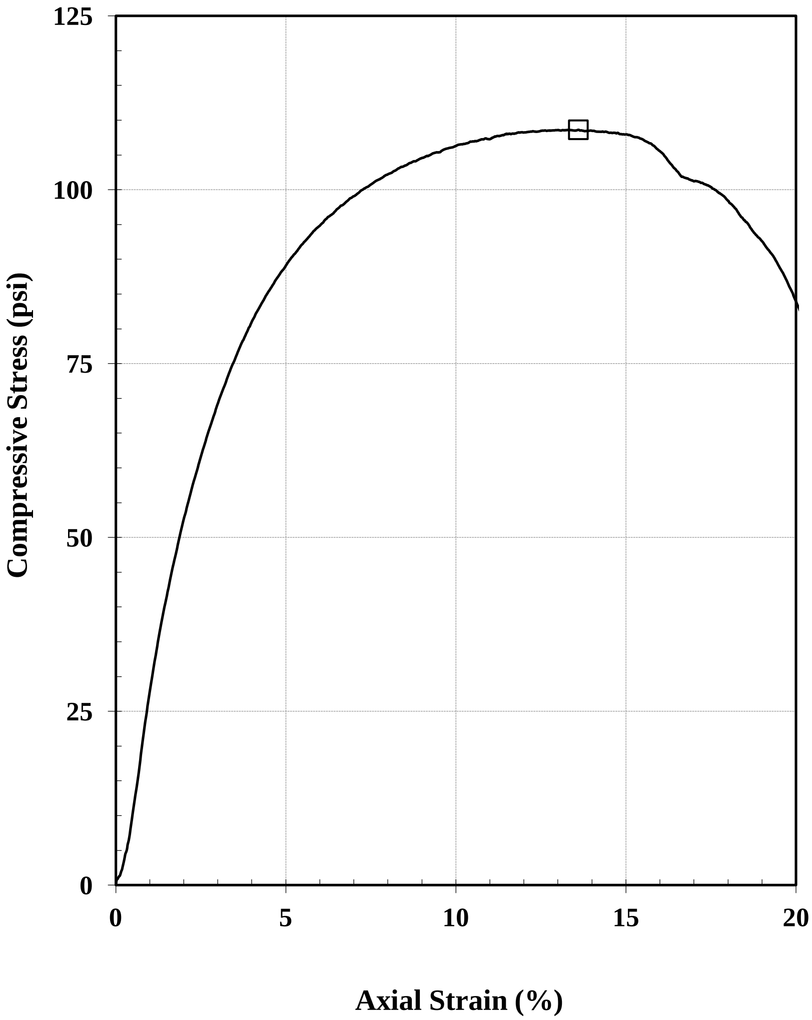
USCS Classification (ASTM D2487)	
Fat clay (CH)	
Moisture Content (%)	(ASTM D2216)
20.5	

Richard S. Lacey, P.E. 4/9/2020

Analysis & Quality Review/Date

Unconfined Compression Test Report

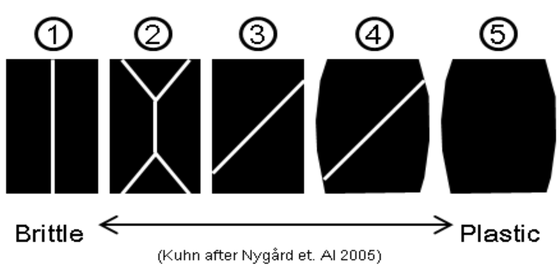
Client:	AECOM	TRI Log No.:	52915.5
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	210-19 (8.0-10.0) ST-5	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.85
Avg. Height (in)	H_o	5.56
Avg, Water Content (%)	w_o	17.8
Bulk Density (pcf)	γ_{total}	132.4
Dry Density (pcf)	γ_{dry}	112.4
Saturation (%)	S_r	94.2
Void Ratio	e_o	0.50
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	108.6
Axial Strain at Failure (%)	13.6
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	108.6
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	54.3

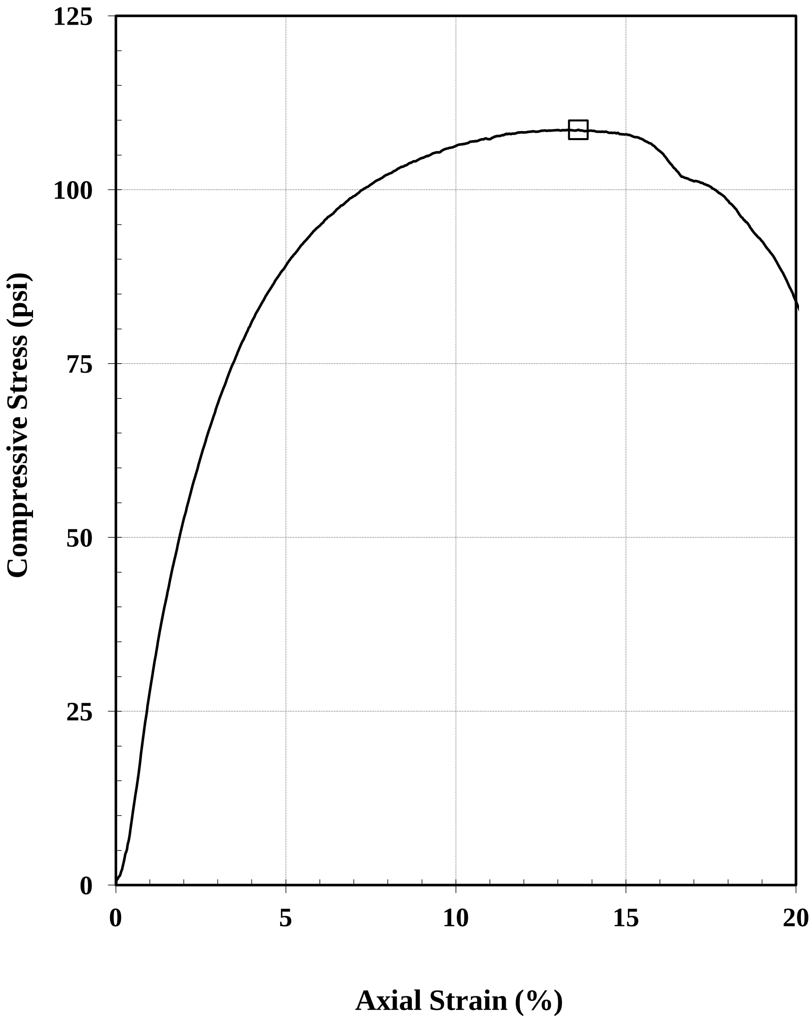
Failure Mode	4



Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

Unconfined Compression Test Report

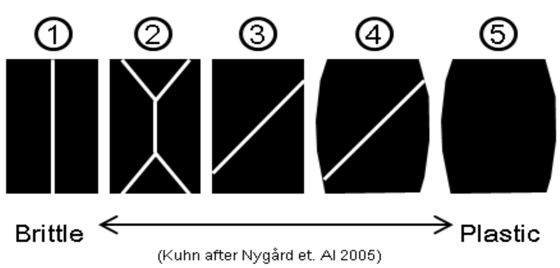
Client:	AECOM	TRI Log No.:	52915.5
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	210-19 (8.0-10.0) ST-5	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.85
Avg. Height (in)	H_o	5.56
Avg, Water Content (%)	w_o	17.8
Bulk Density (pcf)	γ_{total}	132.4
Dry Density (pcf)	γ_{dry}	112.4
Saturation (%)	S_r	94.2
Void Ratio	e_o	0.50
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	108.6
Axial Strain at Failure (%)	13.6
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	108.6
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	54.3

Failure Mode	4



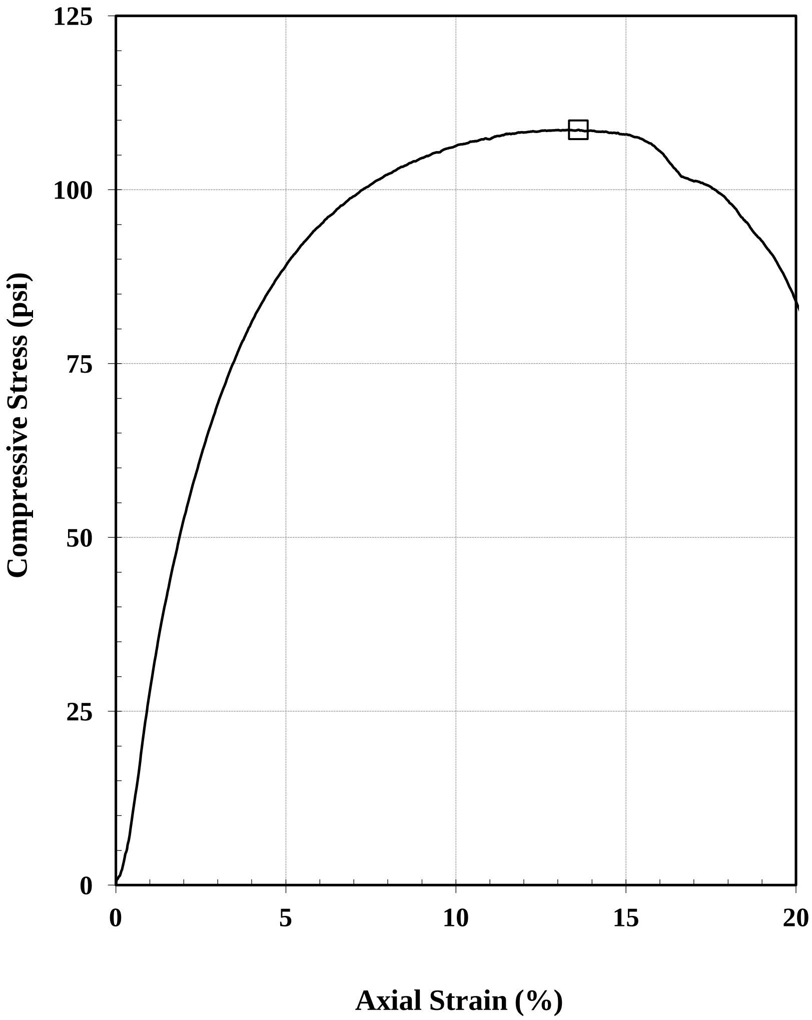
Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

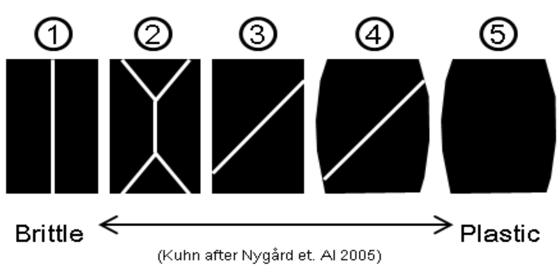
Client:	AECOM	TRI Log No.:	52915.5
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	210-19 (8.0-10.0) ST-5	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.85
Avg. Height (in)	H_o	5.56
Avg, Water Content (%)	w_o	17.8
Bulk Density (pcf)	γ_{total}	132.4
Dry Density (pcf)	γ_{dry}	112.4
Saturation (%)	S_r	94.2
Void Ratio	e_o	0.50
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	108.6
Axial Strain at Failure (%)	13.6
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	108.6
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	54.3

Failure Mode	4

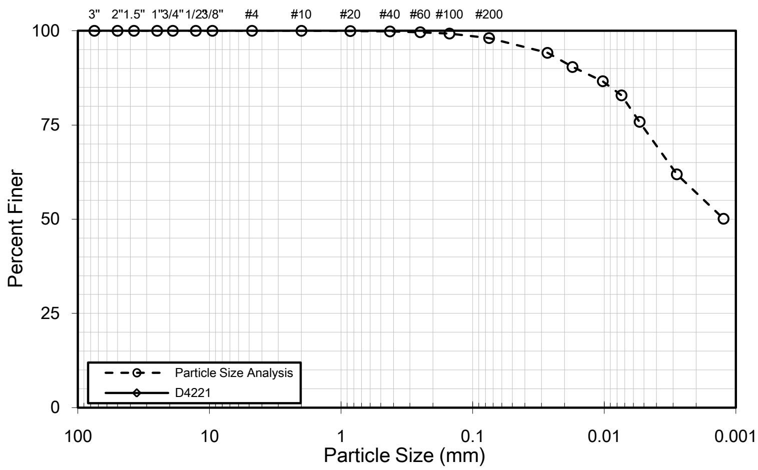


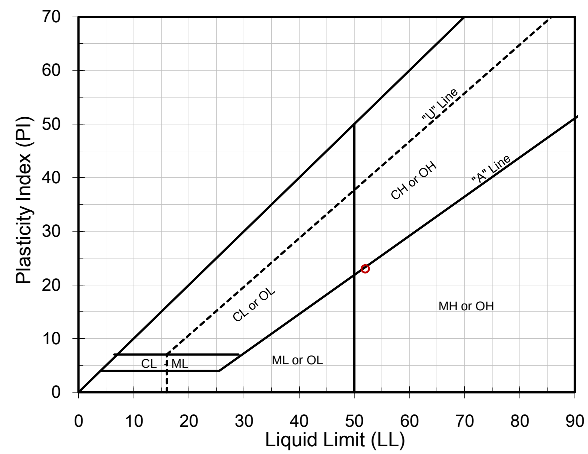
Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20

Quality Review/Date

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM | TRI Log #: 52915.7
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 210-19 (18.0-20.0) ST-7





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel	Particle Size	Percent Passing	Particle Size	Percent Passing
			Sand				
-	mm		Fines	mm		mm	
3 in.	76.2	100.0	0.0	0.027	94.2	- -	- -
2 in.	50.8	100.0		0.017	90.4	- -	- -
1.5 in.	38.1	100.0		0.010	86.6	- -	- -
1 in.	25.4	100.0		0.007	82.9	- -	- -
3/4 in.	19.0	100.0		0.005	75.8	- -	- -
1/2 in.	12.7	100.0		0.003	61.9	- -	- -
3/8 in.	9.51	100.0		0.001	50.1	- -	- -
No. 4	4.76	100.0	1.9	Log-Linear Interpolation			
No. 10	2.00	100.0		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	99.9					
No. 40	0.420	99.8		mm		mm	
No. 60	0.250	99.6		0.005	74.3	0.005	- -
No. 100	0.149	99.3		0.002	57.0	0.002	- -
No. 200	0.074	98.1	98.1	N m,2μm,d	57	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	2.5E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	5.0	(0.05-0.002	38.0	(< 0.002 mm)	57.0

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	52
Plastic Limit	29
Plastic Index	23
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	22.9
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

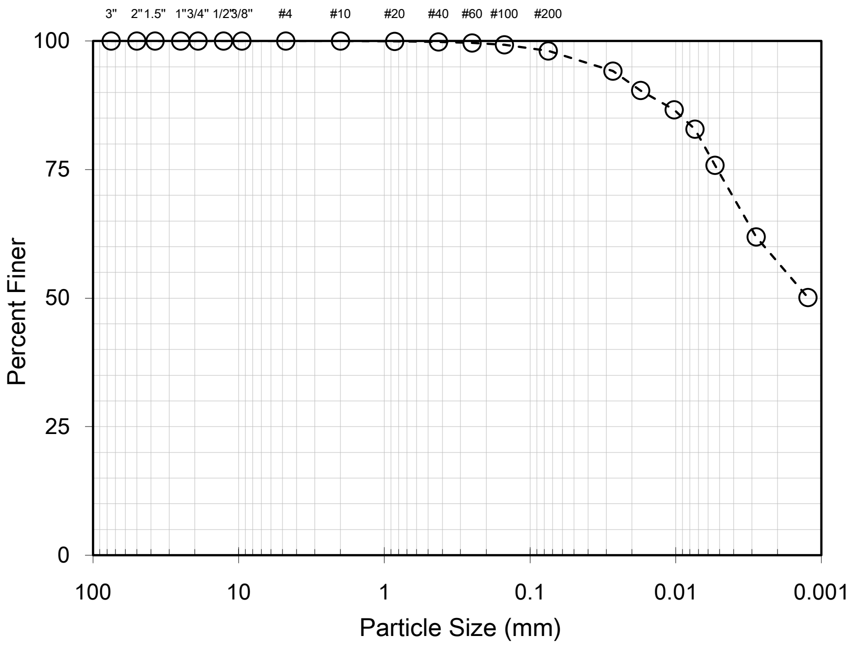
Jeffrey A. Kuhn, Ph.D, P.E. 4/27/2020
Analysis & Quality Review/Date

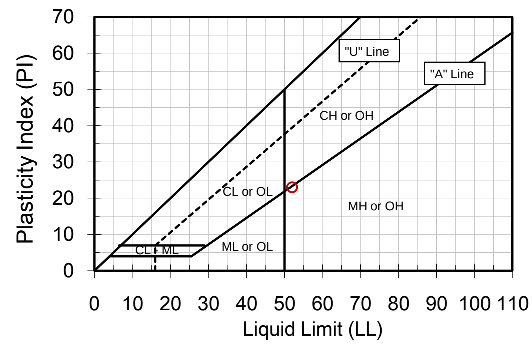
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM
Project: 60615067, Task 1.4.14 - Plum Creek 2
Sample ID: 210-19 (18.0-20.0) ST-7

TRI Log #: 52915.7





Atterberg Limits	
(ASTM D4318, Method A : Multipoint, Air Dried)	
Liquid Limit	52
Plastic Limit	29
Plastic Index	23
(NL = No Liquid Limit, NP = No Plastic Limit)	

Mechanical Sieve		
(ASTM D422)		
Sieve Designation		Percent Passing
-	mm	
3 in.	76.2	100.0
2 in.	50.8	100.0
1.5 in.	38.1	100.0
1 in.	25.4	100.0
3/4 in.	19.0	100.0
1/2 in.	12.7	100.0
3/8 in.	9.51	100.0
No. 4	4.76	100.0
No. 10	2.00	100.0
No. 20	0.841	99.9
No. 40	0.420	99.8
No. 60	0.250	99.6
No. 100	0.149	99.3
No. 200	0.074	98.1

Hydrometer Analysis	
(ASTM D422)	
Particle Size	Percent Passing
mm	
0.027	94.2
0.017	90.4
0.010	86.6
0.007	82.9
0.005	75.8
0.003	61.9
0.001	50.1

Log-Linear Interpolation	
Particle Size	Percent Passing
mm	
0.005	74.3
0.002	57.0

D_X (mm), Log-Linear Interpolation			
10	30	50	60
- -	- -	- -	2.5E-03

Cu	Cc
- -	- -

Gravel	Sand	Fines
0.0	1.9	98.1

USCS Classification (ASTM D2487)	
Fat clay (CH)	
Moisture Content (%)	(ASTM D2216)
22.9	

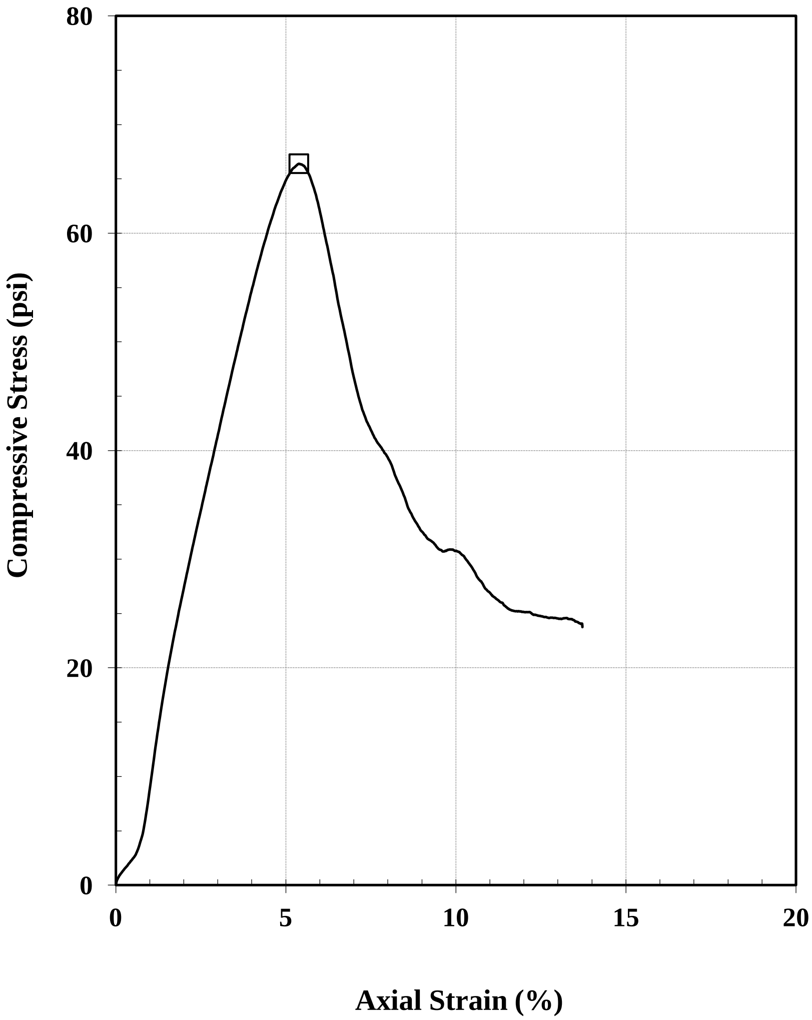
Richard S. Lacey, P.E. 4/9/2020
Analysis & Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

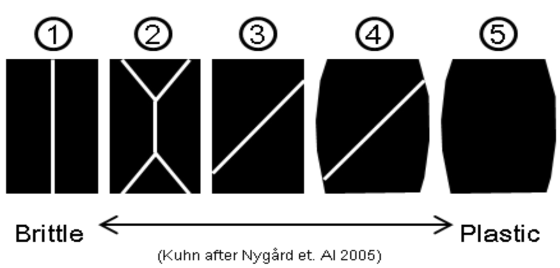
Client:	AECOM	TRI Log No.:	52915.7
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	210-19 (18.0-20.0) ST-7	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.86
Avg. Height (in)	H_o	5.69
Avg, Water Content (%)	w_o	22.4
Bulk Density (pcf)	γ_{total}	127.0
Dry Density (pcf)	γ_{dry}	103.8
Saturation (%)	S_r	96.9
Void Ratio	e_o	0.62
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	66.4
Axial Strain at Failure (%)	5.4
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	66.4
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	33.2

Failure Mode	2



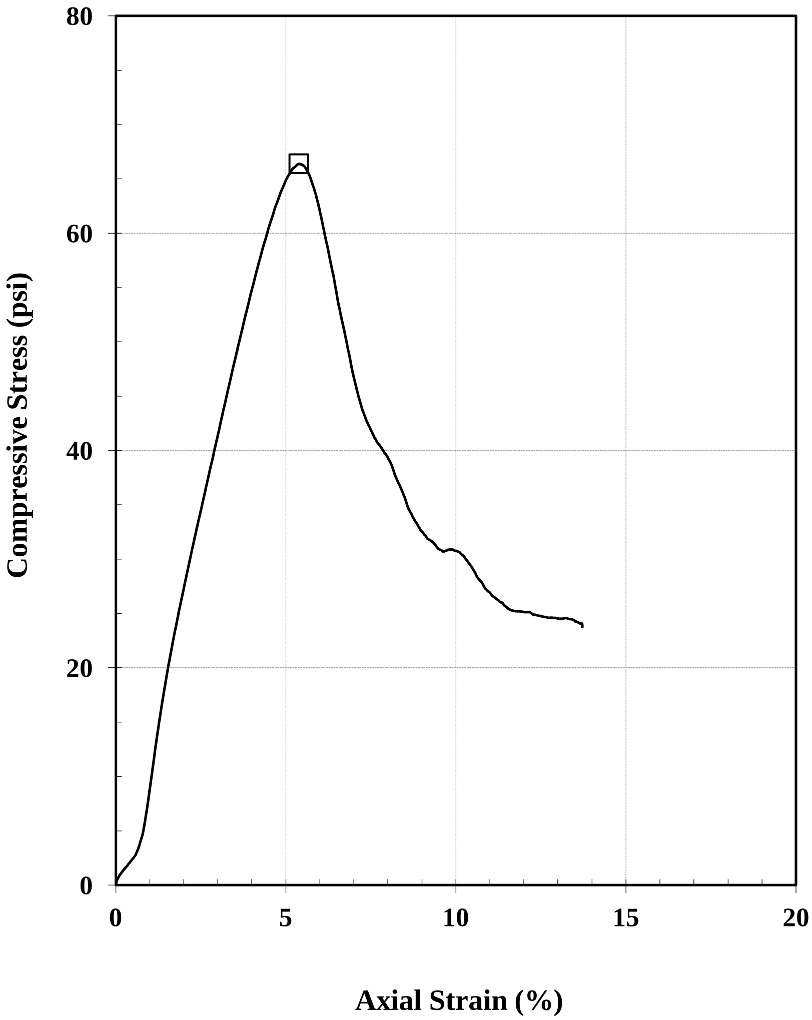
Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

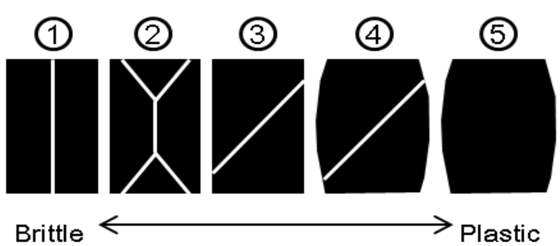
Client:	AECOM	TRI Log No.:	52915.7
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	210-19 (18.0-20.0) ST-7	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.86
Avg. Height (in)	H_o	5.69
Avg, Water Content (%)	w_o	22.4
Bulk Density (pcf)	γ_{total}	127.0
Dry Density (pcf)	γ_{dry}	103.8
Saturation (%)	S_r	96.9
Void Ratio	e_o	0.62
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	66.4
Axial Strain at Failure (%)	5.4
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	66.4
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	33.2

Failure Mode	2



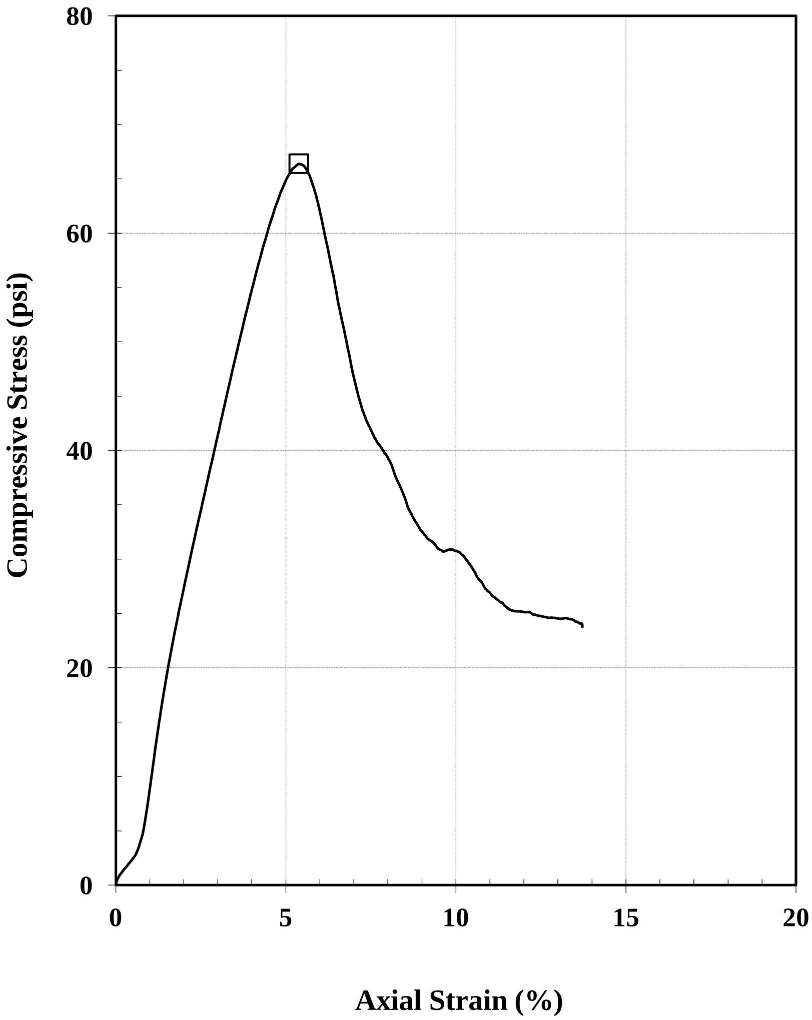
(Kuhn after Nygård et. Al 2005)

Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20

Quality Review/Date

Unconfined Compression Test Report

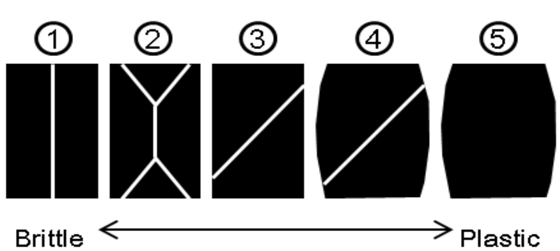
Client:	AECOM	TRI Log No.:	52915.7
Project:	60615067, Task 1.4.14 - Plum Creek 2	Type of Specimen:	Intact
Sample ID:	210-19 (18.0-20.0) ST-7	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.86
Avg. Height (in)	H_o	5.69
Avg, Water Content (%)	w_o	22.4
Bulk Density (pcf)	γ_{total}	127.0
Dry Density (pcf)	γ_{dry}	103.8
Saturation (%)	S_r	96.9
Void Ratio	e_o	0.62
Assumed Specific Gravity	G_s	2.70

Stresses at Failure	
Unconfined Compressive Strength (psi)	66.4
Axial Strain at Failure (%)	5.4
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	66.4
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	33.2

Failure Mode	2



(Kuhn after Nygård et. Al 2005)

Jeffrey A. Kuhn, Ph.D., P.E., 4/8/20
Quality Review/Date

TRI ENVIRONMENTAL
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Client: AECOM TRI Log #: 52915

Project: 60615067, Task 1.4.14 - Plum Creek 2

Richard S. Lacey, P.E. 4/23/2020

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	210-19 (0.0-2.0) P-1	20.3	107.6	71.8	53	21	32
2	210-19 (2.0-3.5) SS-2	28.2	-	-	-	-	-
3	210-19 (4.0-6.0) P-3	15.2	-	-	-	-	-
4	210-19 (6.0-8.0) P-4	19.1	-	-	-	-	-
5	210-19 (8.0-10.0) ST-5	-	-	-	60	22	38
6	210-19 (13.5-15.0) SS-6	20.6	-	-	-	-	-
7	210-19 (18.0-20.0) ST-7	-	-	-	52	29	23
8	210-19 (23.5-25.0) SS-8	18.5	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067, Task 1.4.14 - Plum Creek 2

TRI Log #: 52915
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
5	210-19 (8.0-10.0) ST-5	36.3	N/A	20.0	19.5	22.0	1	1	1	1
7	210-19 (18.0-20.0) ST-7	29.4	N/A	20.0	19.5	22.0	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 4/23/2020
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

304-19

Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53556

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021

Quality Review/Date

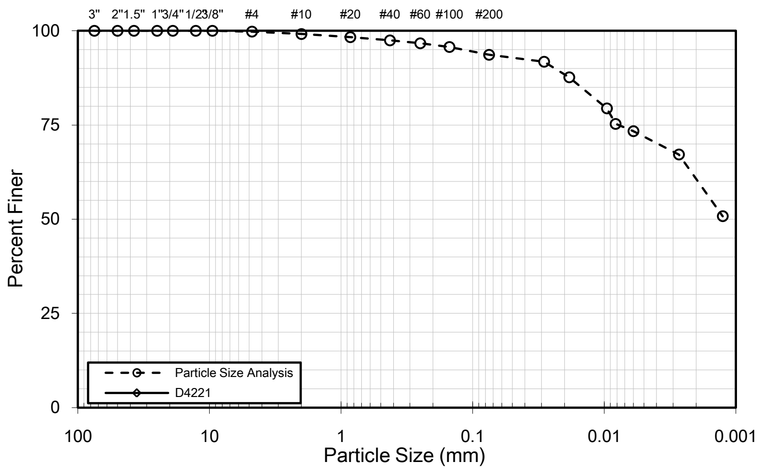
COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
2	304-19 (0.0-2.0) P-1 Layer A	23.8	93.9	-	-	-	-
3	304-19 (0.0-2.0) P-1 Layer B	18.4	-	-	-	-	-
4	304-19 (2.5-4.0) SS-2 Layer C	13.7	-	-	-	-	-
5	304-19 (2.5-4.0) SS-2 Layer D	14.9	-	-	-	-	-
6	304-19 (4.0-6.0) P-3	22.1	96.7	-	-	-	-
7	304-19 (6.0-8.0) ST-4	24.3	-	91.0	76	21	55
8	304-19 (8.5-10.0) SS-5	20.0	-	-	-	-	-
9	304-19 (13.0-15.0) P-6	27.4	94.7	-	-	-	-
10	304-19 (18.0-20.0) ST-7	20.0	-	97.5	80	21	59
11	304-19 (23.5-25.0) SS-8	20.0	-	-	-	-	-
12	304-19 (28.0-30.0) ST-9	18.6	-	96.1	60	21	39
13	304-19 (33.5-35.0) SS-10	15.0	-	-	-	-	-

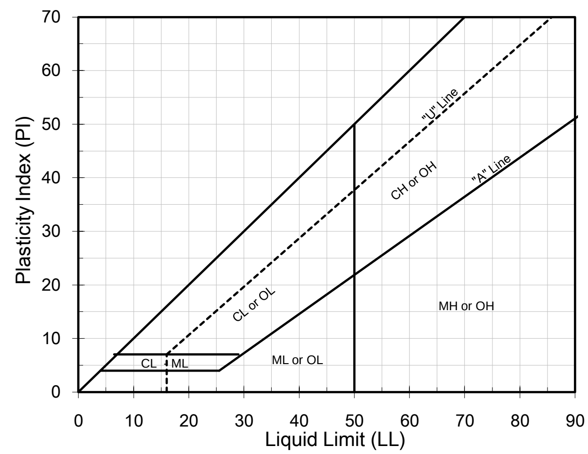
Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM — TRI Log #: 53556.6
Project: 60615607-1.4.14 Plum Creek 2
Sample ID: 304-19 (4.0-6.0) P-3





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.2	0.029	91.8	- -	- -
2 in.	50.8	100.0		0.018	87.7	- -	- -
1.5 in.	38.1	100.0		0.010	79.4	- -	- -
1 in.	25.4	100.0		0.008	75.3	- -	- -
3/4 in.	19.0	100.0		0.006	73.4	- -	- -
1/2 in.	12.7	100.0		0.003	67.2	- -	- -
3/8 in.	9.51	100.0		0.001	50.8	- -	- -
No. 4	4.76	99.8	6.2	Log-Linear Interpolation			
No. 10	2.00	99.1		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	98.3					
No. 40	0.420	97.5		mm		mm	
No. 60	0.250	96.7		0.005	71.9	0.005	- -
No. 100	0.149	95.7		0.002	60.7	0.002	- -
No. 200	0.074	93.6	93.6	N m,2μm,d	61	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	1.9E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	6.4	(0.05-0.002	32.3	(< 0.002 mm)	61.3

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	- -
Plastic Limit	- -
Plastic Index	- -
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Note: Greater than 5% Fines - D4318 required for USCS classification

Moisture Content (%)	ASTM D2216	22.1
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

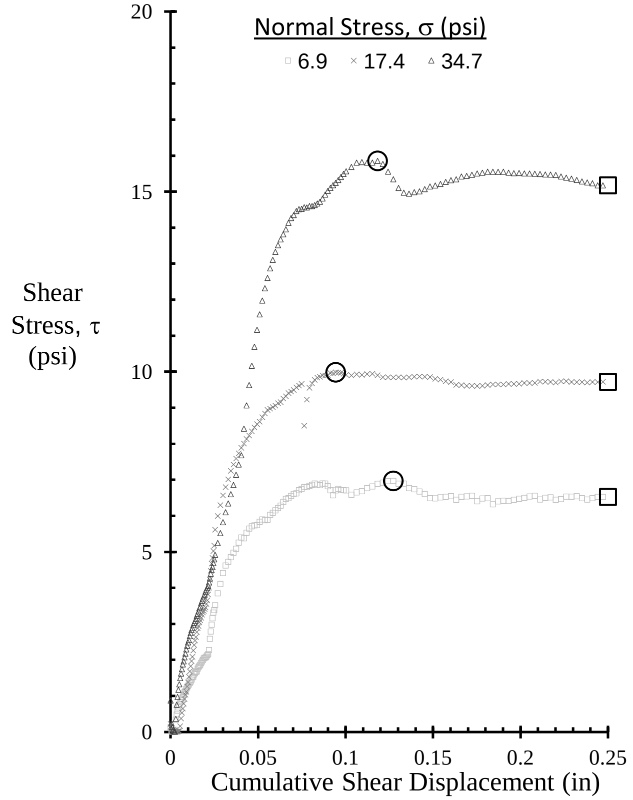
Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

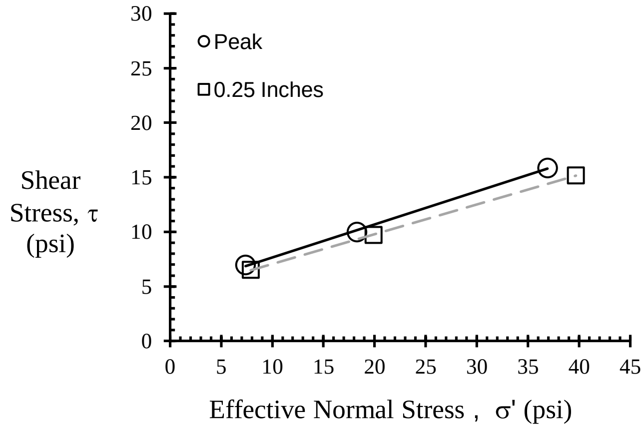
Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021
Analysis & Quality Review/Date

Direct Shear of Soil Under Consolidated-Drained Conditions

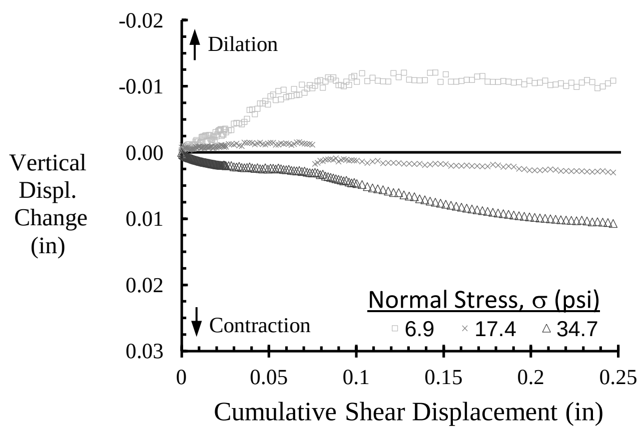
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 304-19 (6.0-8.0) ST-4

TRI Log#: 53556.7
Test Method: ASTM D3080





Note: Area Correction Has Been Applied



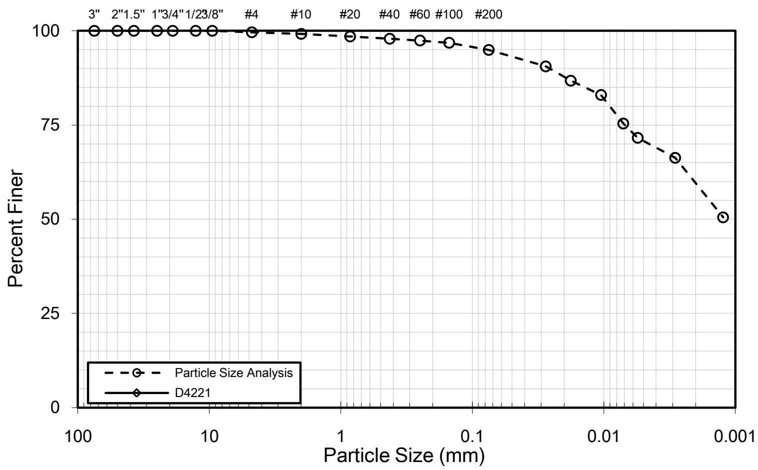
	Specimen Number	1	2	3
Initial Condition	Diameter, in	2.50	2.50	2.50
	Height, in	1.00	1.00	1.00
	Water Content, %	16.8	15.0	18.5
	Saturation, %	72.0	66.4	81.0
	Dry Density, pcf	104.6	105.7	105.4
	Void Ratio	0.64	0.62	0.63
	Consolidation Stress, σ' (psi)	6.9	17.4	34.7
Post-Consol	Height, in	1.00	0.98	0.99
	Dry Density, pcf	105.0	107.4	106.5
	Void Ratio	0.62	0.59	0.60
	Displacement rate (in/min)	1E-04		
	Final Water Content, %	29.8	28.6	27.1
Peak	Normal Stress, σ' (psi)	7.38	18.28	36.92
	Shear Stress, τ (psi)	6.97	9.99	15.85
	Secant Friction Angle, Degrees	43.4	28.6	23.2
	Displacement (in)	0.13	0.09	0.12
	ϕ'_d, degrees	16.8		
	c'_d, psi	4.6		
0.25 Inches	Normal Stress, σ' (psi)	7.89	19.90	39.69
	Shear Stress, τ (psi)	6.53	9.72	15.17
	Secant Friction Angle, Degrees	39.6	26.0	20.9
	ϕ'_d, degrees	15.2		
	c'_d, psi	4.3		

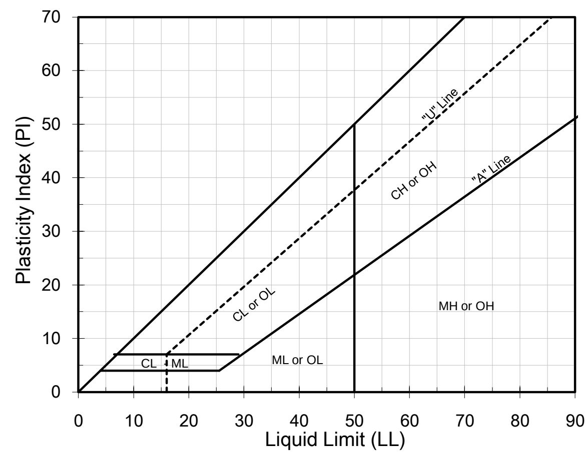
Note: The intact soil sample was extruded and specimens were prepared using a trimming turntable. A specific gravity of 2.75 was assumed for weight-volume calculations.

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/21
Analysis & Quality Review/Date

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM TRI Log #: 53556.9
Project: 60615607-1.4.14 Plum Creek 2
Sample ID: 304-19 (13.0-15.0) P-6





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.4	0.028	90.6	- -	- -
2 in.	50.8	100.0		0.018	86.8	- -	- -
1.5 in.	38.1	100.0		0.010	83.0	- -	- -
1 in.	25.4	100.0		0.007	75.4	- -	- -
3/4 in.	19.0	100.0		0.006	71.6	- -	- -
1/2 in.	12.7	100.0		0.003	66.3	- -	- -
3/8 in.	9.51	100.0		0.001	50.5	- -	- -
No. 4	4.76	99.6	4.7	Log-Linear Interpolation			
No. 10	2.00	99.2		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	98.5					
No. 40	0.420	97.9		mm		mm	
No. 60	0.250	97.4		0.005	70.8	0.005	- -
No. 100	0.149	96.8		0.002	59.5	0.002	- -
No. 200	0.074	94.9	94.9	N m,2μm,d	60	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	2.1E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	7.5	(0.05-0.002	32.5	(< 0.002 mm)	60.0

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	- -
Plastic Limit	- -
Plastic Index	- -
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Note: Greater than 5% Fines - D4318 required for USCS classification

Moisture Content (%)	ASTM D2216	27.4
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

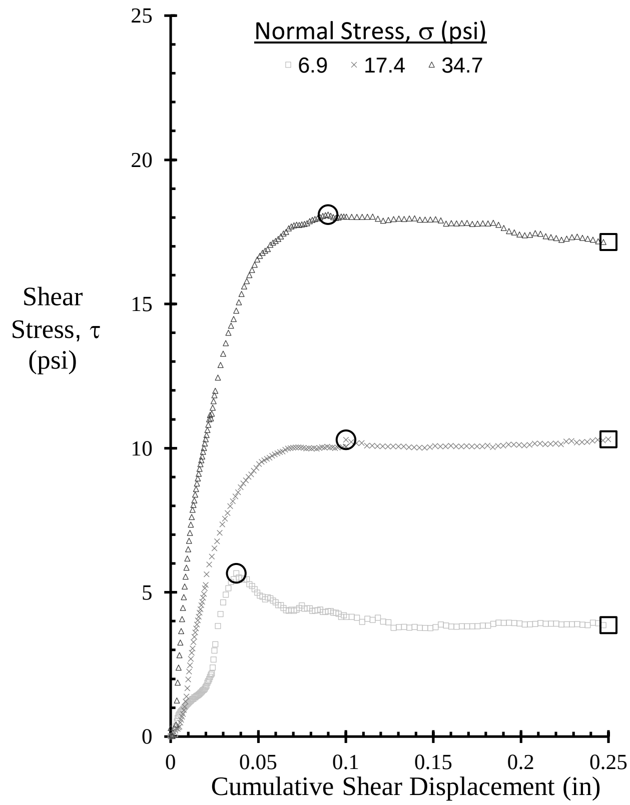
Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

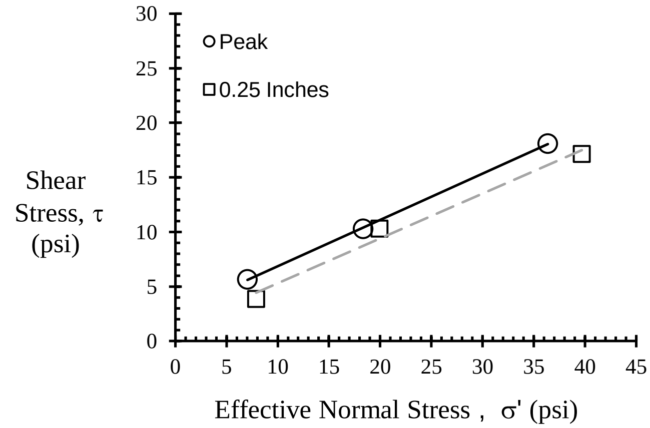
Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021
Analysis & Quality Review/Date

Direct Shear of Soil Under Consolidated-Drained Conditions

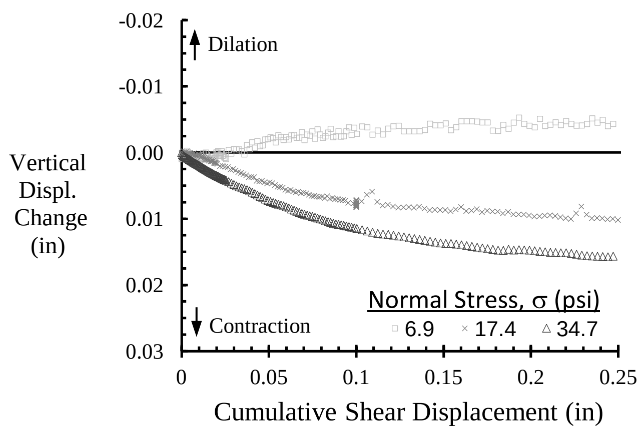
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 304-19 (18.0-20.0) ST-7

TRI Log#: 53556.10
Test Method: ASTM D3080





Note: Area Correction Has Been Applied



	Specimen Number	1	2	3
Initial Condition	Diameter, in	2.50	2.50	2.50
	Height, in	1.00	1.00	1.00
	Water Content, %	22.2	21.7	22.9
	Saturation, %	85.9	80.0	87.4
	Dry Density, pcf	100.4	98.3	99.7
	Void Ratio	0.71	0.75	0.72
	Consolidation Stress, σ' (psi)	6.9	17.4	34.7
Post-Consol	Height, in	0.99	0.97	0.99
	Dry Density, pcf	101.0	101.2	101.1
	Void Ratio	0.69	0.68	0.69
	Displacement rate (in/min)	1E-04		
	Final Water Content, %	27.2	26.0	27.3
Peak	Normal Stress, σ' (psi)	7.03	18.33	36.36
	Shear Stress, τ (psi)	5.66	10.29	18.10
	Secant Friction Angle, Degrees	38.8	29.3	26.5
	Displacement (in)	0.04	0.10	0.09
	ϕ'_d, degrees	23.0		
	c'_d, psi	2.6		
0.25 Inches	Normal Stress, σ' (psi)	7.89	19.93	39.69
	Shear Stress, τ (psi)	3.86	10.31	17.15
	Secant Friction Angle, Degrees	26.1	27.3	23.4
	ϕ'_d, degrees	22.3		
	c'_d, psi	1.2		

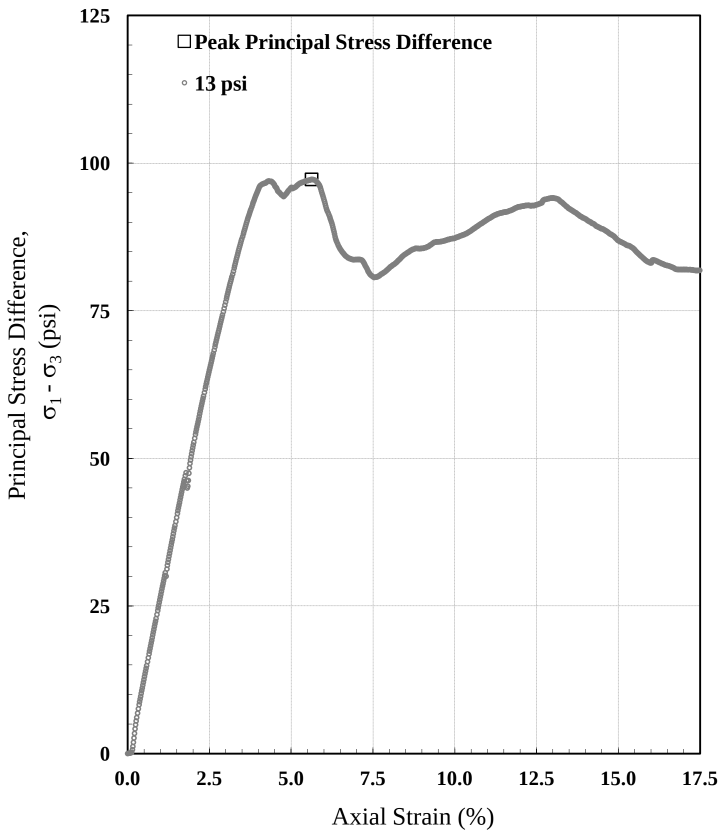
Note: The intact soil sample was extruded and specimens were prepared using a trimming turntable. A specific gravity of 2.75 was assumed for weight-volume calculations.

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/21
Analysis & Quality Review/Date

Unconsolidated-Undrained (Q) Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 304-19 (28.0-30.0) ST-9

TRI Log #: 53556.12
Test Method: ASTM D2850



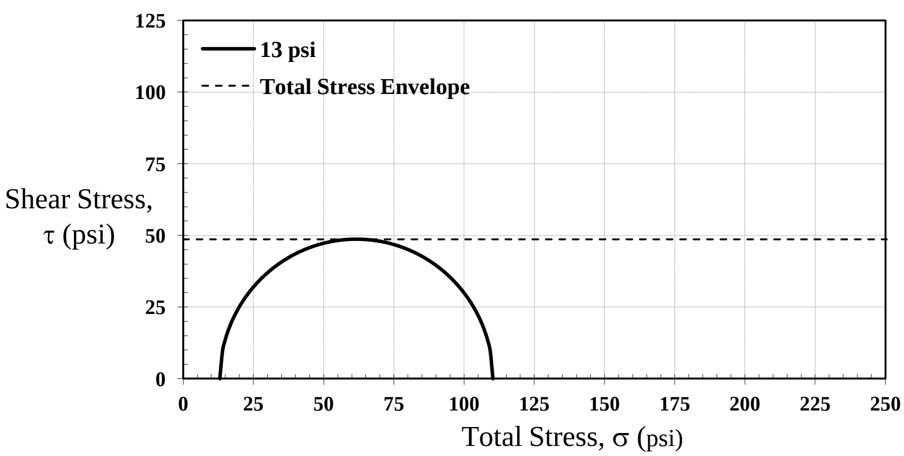
Test Parameters	
Minor Principal Stress (psi)	13.0
Rate of Strain (%/hr)	60

Initial Properties	
Avg. Diameter (in)	2.80
Avg. Height (in)	5.54
Avg. Water Content (%)	17.8
Bulk Density (pcf)	131.1
Dry Density (pcf)	111.3
Saturation (%)	90.3
Void Ratio	0.54
Specific Gravity (Assumed)	2.75

At Failure - Maximum Deviator Stress	
Axial Strain at Failure (%)	5.6
Minor Total Stress (psi)	13.0
Major Total Stress (psi)	110.2
Principal Stress Diff. (psi)	97.2

Total Stress Envelope	
Friction Angle (deg)	0
Undrained Shear Strength, S_u (psi)	48.6
S_u / σ_3	3.7

Note: The calculated value of specimen saturation was less than 95%. The Mohr failure envelope was taken as a horizontal straight line, but noting that the calculated value of saturation indicates a partially saturated specimen.



Jeffrey A. Kuhn , Ph.D., P.E., 3/22/2021
Analysis & Quality Review/Date

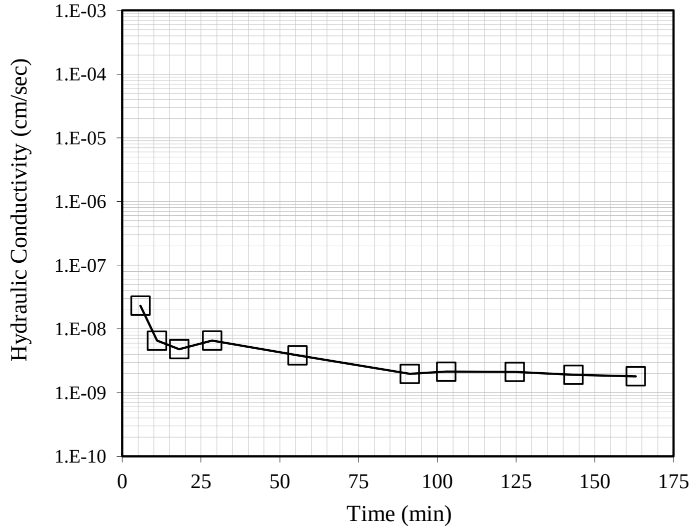
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Hydraulic Conductivity

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 304-19 (28.0-30.0) ST-9

TRI Log #: 53556.12
Test Method: ASTM D5084

Sample Condition	Initial	Final
	Undisturbed	Post-Test
Diameter (in)	2.75	2.78
Height (in)	3.31	3.34
Mass (g)	664.4	673.5
Sample Area (in^2)	5.95	6.08
Water Content (%)	21.8	25.1
Total Unit Weight (pcf)	128.4	126.2
Dry Unit Weight (pcf)	105.5	100.9
Specific Gravity (Assumed)	2.75	
Degree of Saturation	95.5	98.5
Void Ratio	0.63	0.70
Porosity	0.39	0.41
1 Pore Volume (cc)	124.4	137.2



Eff. Confining Stress (psi)	13.0
Back-Pressure	80.0
B-Value Prior to Permeation	0.87
Permeant	De-Aired Tap Water

Method F—Constant Volume–Falling Head by mercury, rising tailwater elevation			
Manometer Constants		Aa (cm^2)	0.767
M1	0.0302	Ap (cm^2)	0.0314
M2	1.041	Z_p (cm)	1.7
Time, t	Trial Constant, Z_1	Gradient	K_{20}
Min	-	-	cm/s
11.0	26.4	39.5	6.5E-09
18.1	26.3	39.3	4.8E-09
28.5	26.2	39.2	6.6E-09
55.6	26.0	38.9	3.8E-09
91.3	25.7	38.4	2.0E-09
102.9	25.5	38.1	2.1E-09
124.6	25.4	38.0	2.1E-09
143.3	25.3	37.8	1.9E-09
163.0	25.2	37.6	1.8E-09
Average, Last 2 Readings			**1.9E-09**

Specimen Image

Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021
Analysis & Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

305-19

Client: AECOM TRI Log #: 53560

Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 3/21/2021

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	305-19 (0.0-2.0) P-1 Part A	17.2	107.5	-	71	23	48
3	305-19 (2.5-4.0) SS-2	5.1	-	-	-	-	-
4	305-19 (4.0-6.0) ST-3	-	-	89.4	48	21	27
5	305-19 (6.0-8.0) P-4	18.3	-	-	-	-	-
7	305-19 (13.0-15.0) P-6	24.4	-	-	-	-	-
8	305-19 (18.0-20.0) ST-7	19.8	-	95.5	60	25	35
9	305-19 (23.5-25.0) SS-8 Part C	11.5	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53560
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
1	305-19 (0.0-2.0) P-1 Part A	5.3	46.4	22.0	22.1	22.2	1	1	1	1
6	305-19 (8.5-10.0) SS-5	3.7	39.7	22.0	22.1	22.2	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

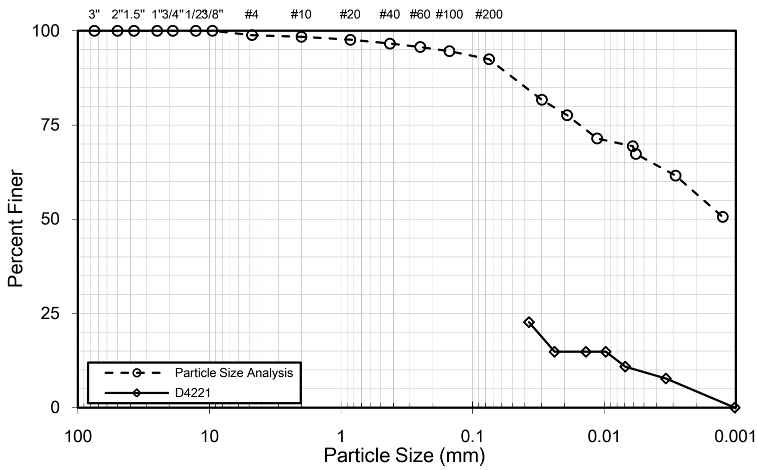
Particle Size, Atterberg Limit, and USCS Analyses for Soils

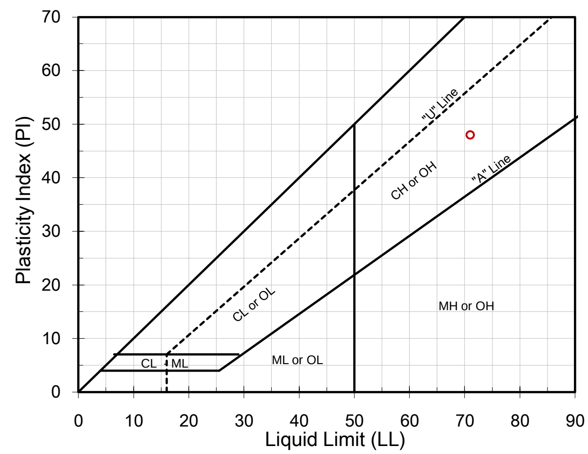
Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

Sample ID: 305-19 (0.0-2.0) P-1 Part A

TRI Log #: 53560.1





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0		0.030	81.7	0.037	22.7
2 in.	50.8	100.0		0.019	77.6	0.024	14.8
1.5 in.	38.1	100.0		0.011	71.4	0.014	14.8
1 in.	25.4	100.0	1.1	0.006	69.4	0.010	14.8
3/4 in.	19.0	100.0		0.006	67.3	0.007	10.9
1/2 in.	12.7	100.0		0.003	61.6	0.003	7.7
3/8 in.	9.51	100.0		0.001	50.6	0.001	0.0
No. 4	4.76	98.9		Log-Linear Interpolation			
No. 10	2.00	98.4		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	97.6					
No. 40	0.420	96.6	6.4	mm		mm	
No. 60	0.250	95.7		0.005	66.2	0.005	9.4
No. 100	0.149	94.6		0.002	56.8	0.002	4.3
No. 200	0.074	92.5	92.5	N m,2µm,d	57	N m,2µm,nd	4

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	2.5E-03	- -	- -	7

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	14.9	(0.05-0.002	27.4	(< 0.002 mm)	57.7

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	71
Plastic Limit	23
Plastic Index	48
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	17.2
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021

Analysis & Quality Review/Date

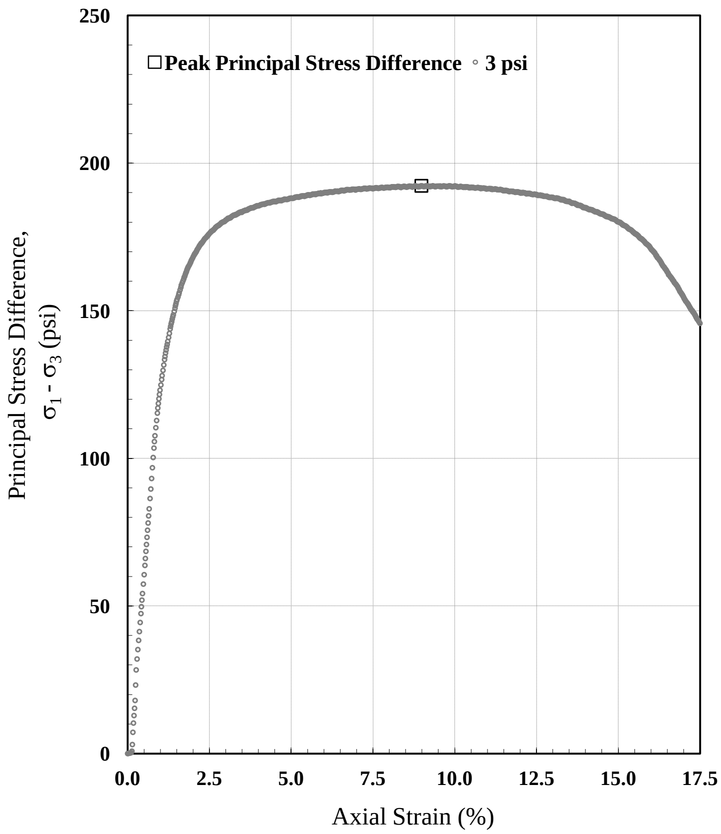
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconsolidated-Undrained (Q) Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 305-19 (4.0-6.0) ST-3

TRI Log #: 53560.4
Test Method: ASTM D2850



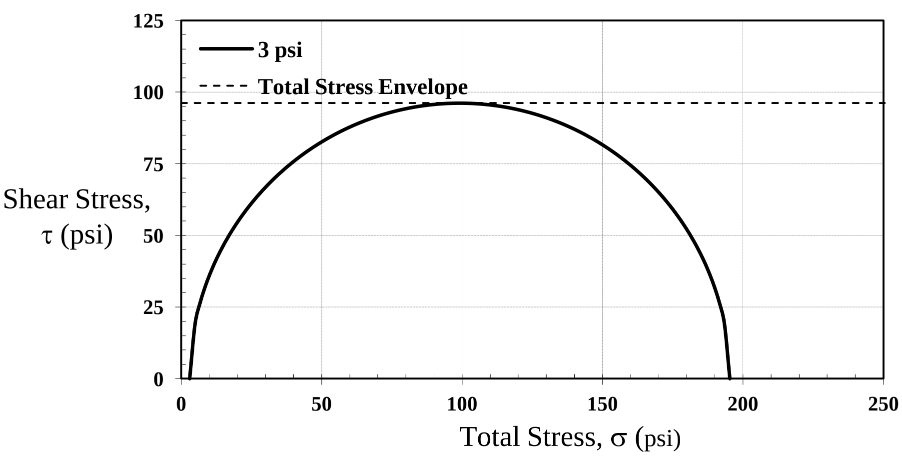
Test Parameters	
Minor Principal Stress (psi)	3.0
Rate of Strain (%/hr)	60

Initial Properties	
Avg. Diameter (in)	2.76
Avg. Height (in)	5.73
Avg. Water Content (%)	15.9
Bulk Density (pcf)	132.4
Dry Density (pcf)	114.2
Saturation (%)	87.0
Void Ratio	0.50
Specific Gravity (Assumed)	2.75

At Failure - Maximum Deviator Stress	
Axial Strain at Failure (%)	9.0
Minor Total Stress (psi)	3.0
Major Total Stress (psi)	195.3
Principal Stress Diff. (psi)	192.3

Total Stress Envelope	
Friction Angle (deg)	0
Undrained Shear Strength, S_u (psi)	96.2
S_u / σ_3	32.1

Note: The calculated value of specimen saturation was less than 95%. The Mohr failure envelope was taken as a horizontal straight line, but noting that the calculated value of saturation indicates a partially saturated specimen.



Jeffrey A. Kuhn , Ph.D., P.E., 3/22/2021

Analysis & Quality Review/Date

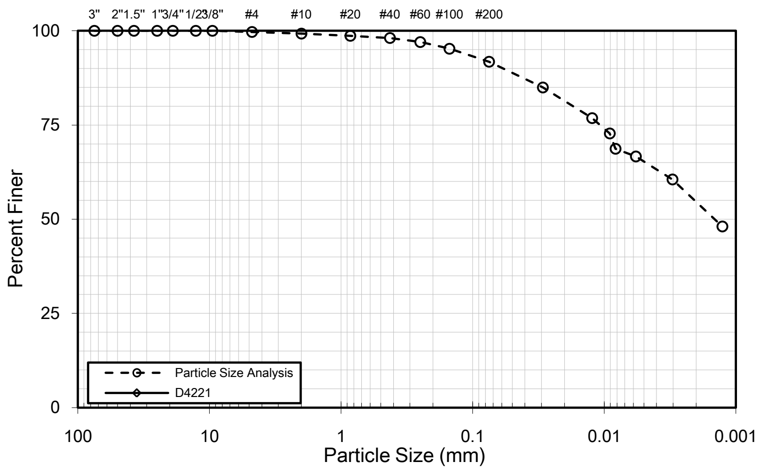
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

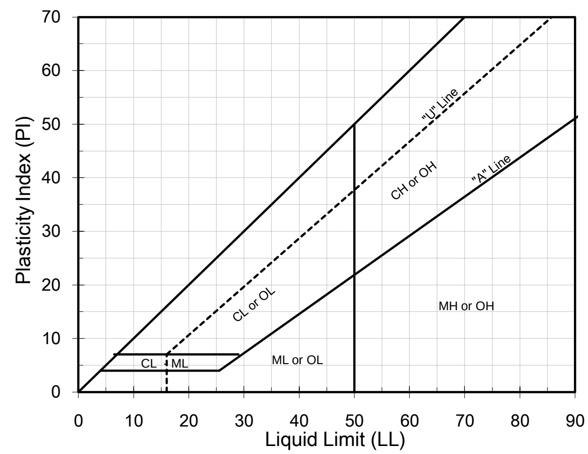
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client:	AECOM	TRI Log #:	53560.6
Project:	60615067-1.4.14 Plum Creek 2		
Sample ID:	305-19 (8.5-10.0) SS-5		





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm		Fines	mm		mm	
3 in.	76.2	100.0	0.3	0.029	85.0	- -	- -
2 in.	50.8	100.0		0.012	76.8	- -	- -
1.5 in.	38.1	100.0		0.009	72.8	- -	- -
1 in.	25.4	100.0		0.008	68.7	- -	- -
3/4 in.	19.0	100.0		0.006	66.6	- -	- -
1/2 in.	12.7	100.0		0.003	60.5	- -	- -
3/8 in.	9.51	100.0		0.001	48.1	- -	- -
No. 4	4.76	99.7	7.9	Log-Linear Interpolation			
No. 10	2.00	99.3		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	98.7					
No. 40	0.420	98.1		mm		mm	
No. 60	0.250	97.0		0.005	65.3	0.005	- -
No. 100	0.149	95.2		0.002	54.6	0.002	- -
No. 200	0.074	91.8	91.8	N m,2μm,d	55	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	1.4E-03	2.9E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	12.6	(0.05-0.002	32.4	(< 0.002 mm)	55.0

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	- -
Plastic Limit	- -
Plastic Index	- -
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Note: Greater than 5% Fines - D4318 required for USCS classification

Moisture Content (%)	ASTM D2216	17.9
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021

Analysis & Quality Review/Date

Consolidated-Undrained Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 305-19 (18.0-20.0) ST-7

TRI Log #: 53560.8
Test Method: ASTM D4767

Specimens				
Identification	1	2	3	4
Depth/Elev. (ft)	-	-	-	-
Eff. Consol. Stress (psi)	6.9	20.8	34.7	-
Initial Specimen Properties				
Avg. Diameter (in)	1.45	1.42	1.49	-
Avg. Height (in)	3.08	3.23	2.81	-
Avg. Water Content (%)	18.3	19.2	14.6	-
Bulk Density (pcf)	128.1	124.3	127.0	-
Dry Density (pcf)	108.3	104.2	110.9	-
Specific Gravity (Assumed)	2.70			
Saturation (%)	88.9	84.2	75.8	-
Void Ratio, n	0.56	0.62	0.52	-
B-Value, End of Saturation	1.00	0.98	0.95	-

Test Setup	
Specimen Condition	Undisturbed / Intact
Specimen Preparation	Trimmed
Mounting Method	Wet
Consolidation	Isotropic

Post-Consolidation / Pre-Shear				
Void Ratio	0.56	0.59	0.49	-

Shear / Post-Shear				
Rate of Strain (%/hr)	0.25	0.25	0.25	-
Avg. Water Content (%)	19.1	24.0	19.7	-

At Failure								
Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$				Ratio, $(\sigma_1'/\sigma_3')_{max}$			
Axial Strain at Failure (%), $\varepsilon_{a,f}$	9.7	15.0	15.0	-	0.9	5.9	5.1	-
Minor Effective Stress (psi), $\sigma_3'_f$	13.2	20.9	27.4	-	3.2	15.1	12.9	-
Principal Stress Difference (psi), $(\sigma_1-\sigma_3)_f$	47.3	31.7	103.4	-	19.8	26.7	68.5	-
Pore Water Pressure, Δu_f (psi)	-6.3	-0.2	7.3	-	3.8	5.4	21.7	-
Major Effective Stress (psi), $\sigma_1'_f$	60.5	52.6	130.8	-	23.0	41.8	81.4	-
Secant Friction Angle (degrees)	39.9	25.6	40.8	-	49.3	27.9	46.5	-
Effective Friction Angle (degrees)	Refer to Secant Friction Angles							
Effective Cohesion (psi)	Pre- and Post-Test Image Presented on Supplemental Report Page							

Note: The presented M-C parameters are based on a linear regression in modified stress space, across all assigned effective consolidation stresses. This fit does not purported to capture typical curvature of envelopes that may, in particular, be observed across broader range in effective stresses. Please note that the stresses associated with peak principal stress ratio and peak principal stress difference are presented in tabular form on the first page of the report. There are alternate interpretations to theses two failure criterion including but not limited to strain compatibility and post-peak.

Jeffrey A. Kuhn , Ph.D., P.E., 3/22/2021
Analysis & Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Consolidated-Undrained Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 305-19 (18.0-20.0) ST-7

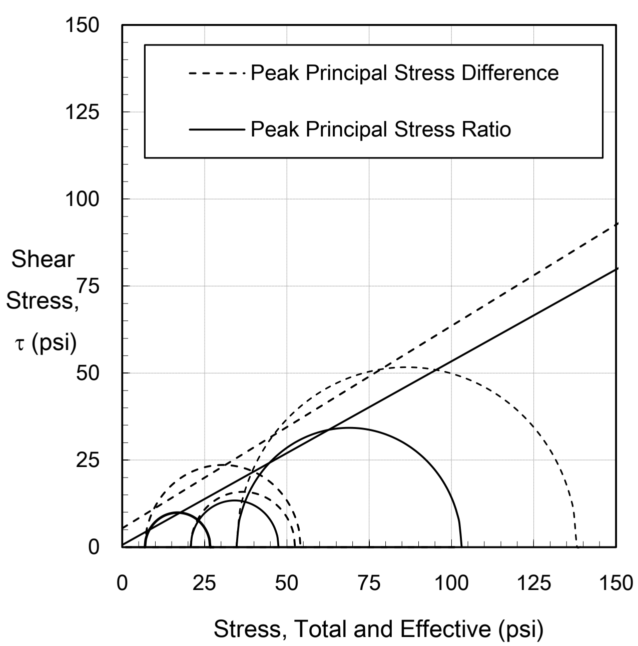
TRI Log #: 53560.8
Test Method: ASTM D4767

R / "Total Stress" Envelope			
Failure Criterion: Peak Principal Stress		Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Friction Angle (deg)	ϕ_R	30.2	27.8
Cohesion (psi)	c_R	5.4	0.6

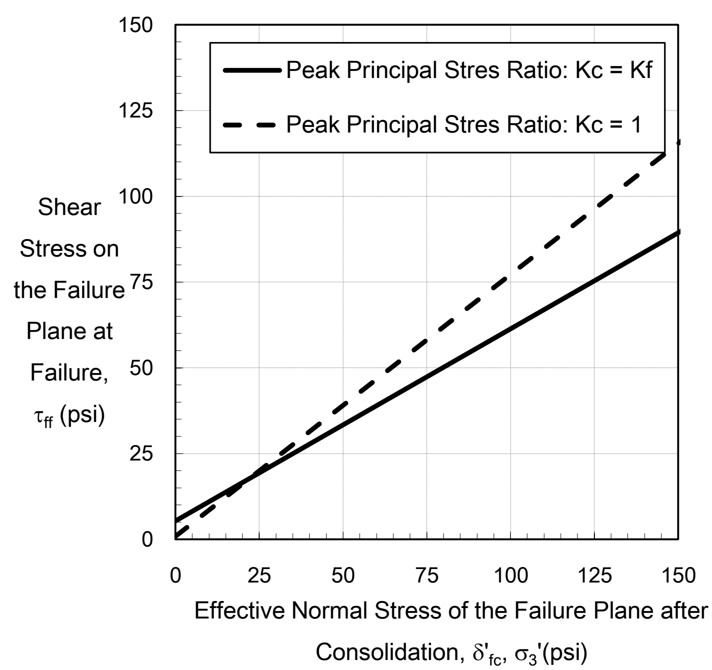
Kc = Kf Envelope, Effective Stress Envelope (Duncan et al. 1990)			
Failure Criterion: Peak Principal Stress		Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	ϕ'	40.9	29.2
Effective Cohesion (psi)	c'	-3.9	5.4

Kc = 1 (τ_{ff} vs σ'_{fc}) Envelope, Total Stress Envelope (Duncan et al. 1990)			
Failure Criterion: Peak Principal Stress		Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Friction Angle (deg)	$d_{Kc=1}$	37.4	37.4
Cohesion (psi)	$\psi_{Kc=1}$	7.1	0.8

R / "Total Stress" Envelope



Three-Stage Rapid Drawdown Envelopes

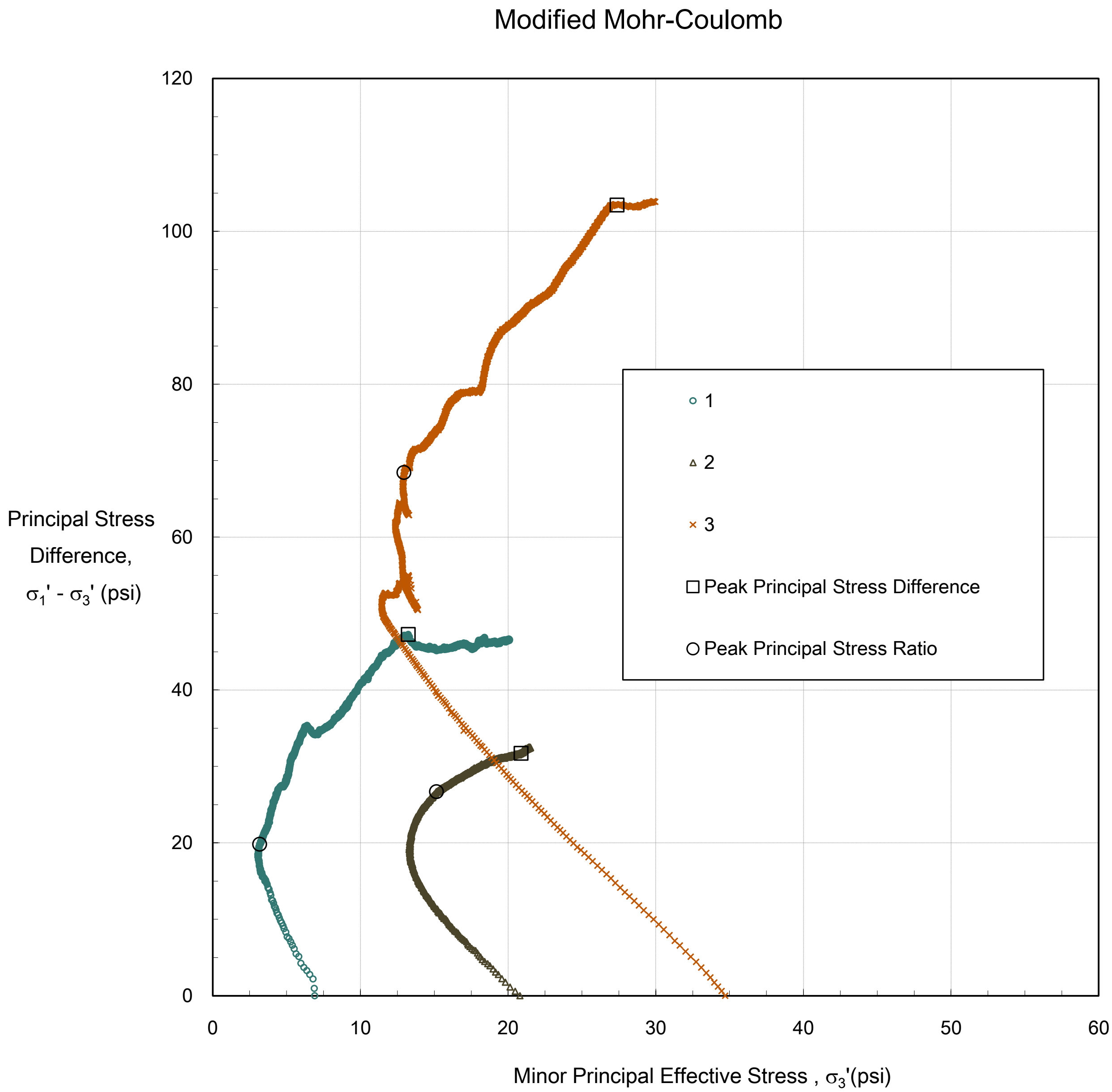


TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Consolidated-Undrained Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 305-19 (18.0-20.0) ST-7

TRI Log #: 53560.8
Test Method: ASTM D4767



Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	Refer to Secant Frition Angles	
Effective Cohesion (psi)		

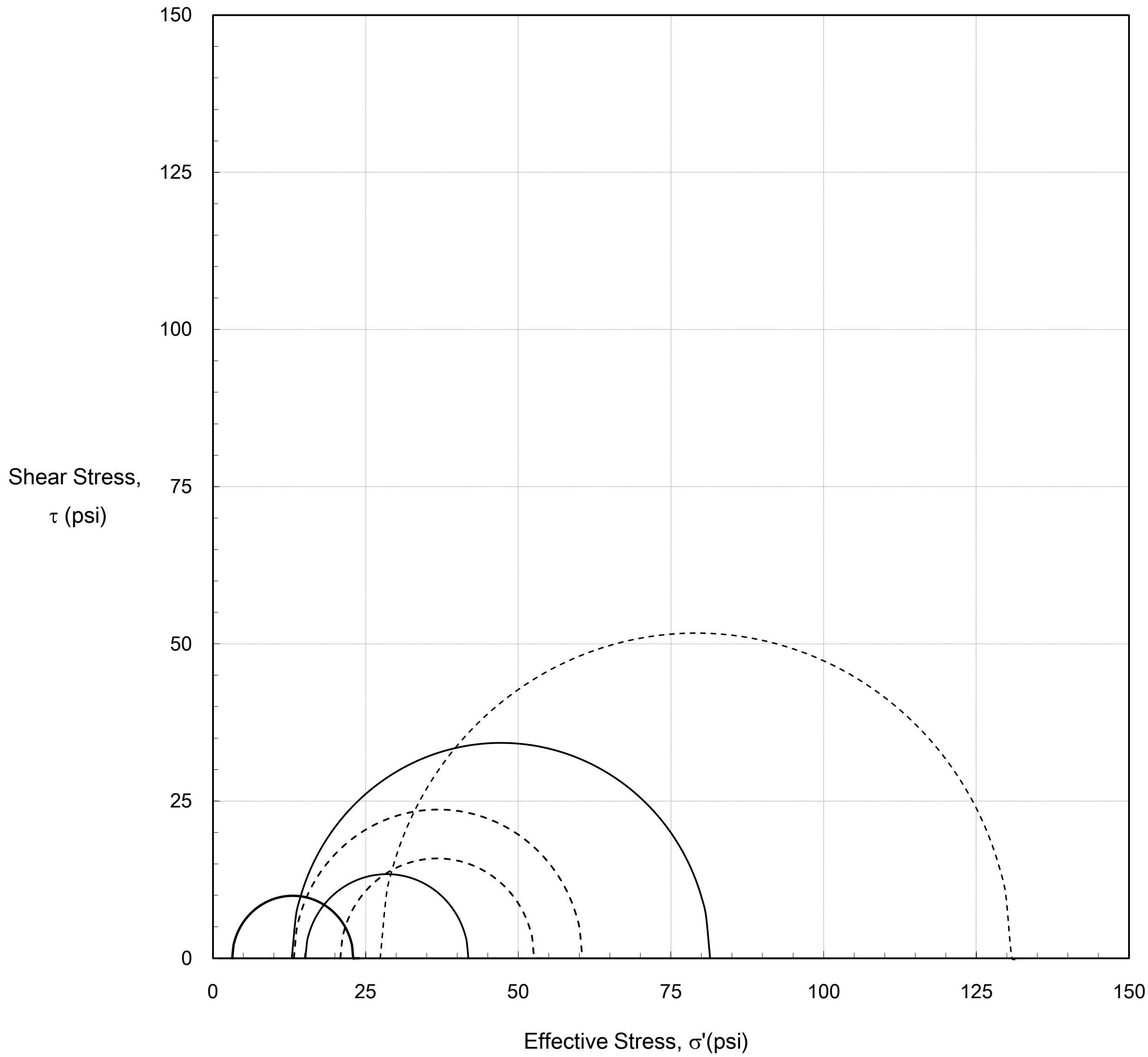
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Consolidated-Undrained Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 305-19 (18.0-20.0) ST-7

TRI Log #: 53560.8
Test Method: ASTM D4767

Mohr-Coulomb



Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	Refer to Secant Frition Angles	
Effective Cohesion (psi)		

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

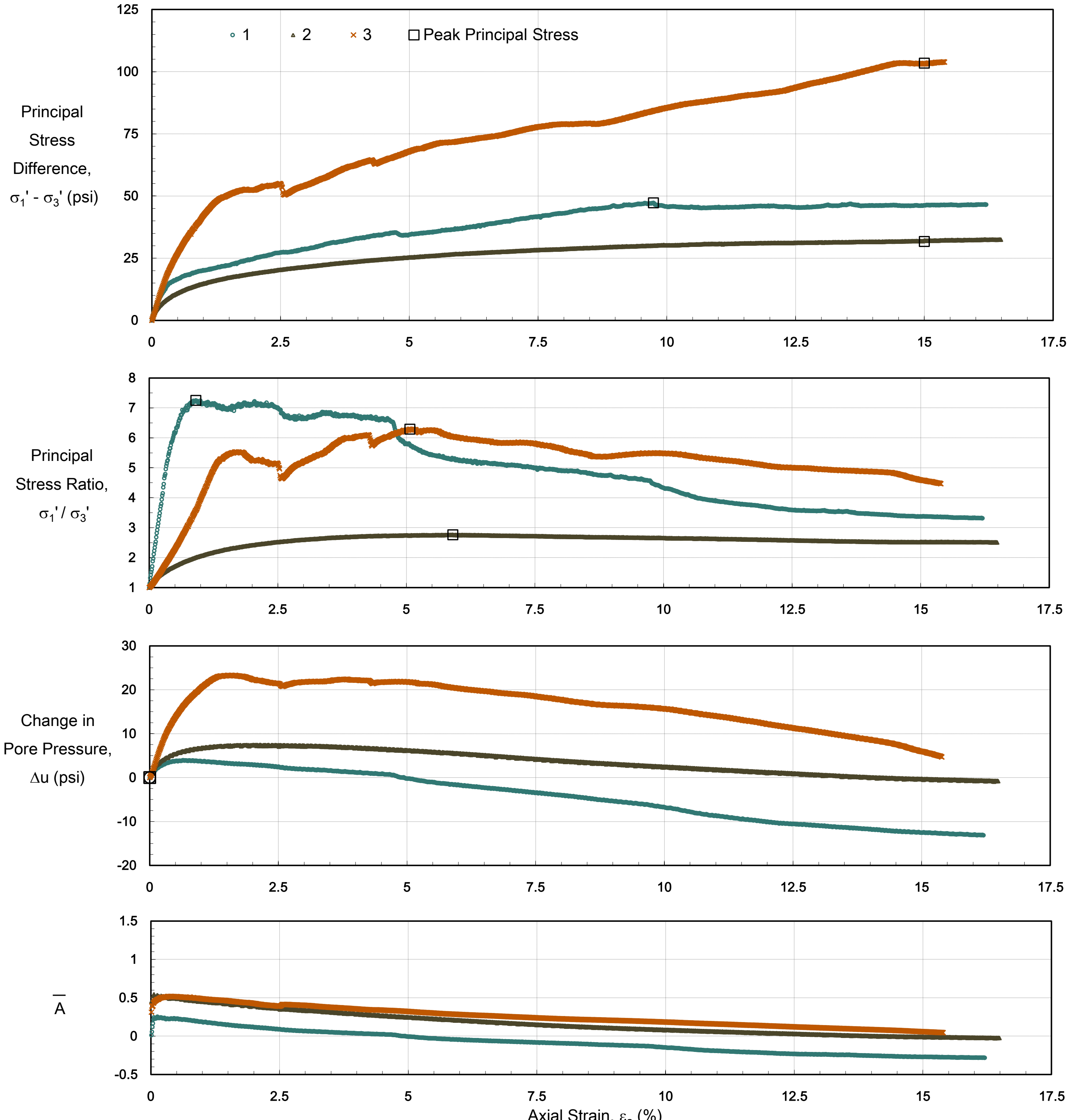
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Consolidated-Undrained Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 305-19 (18.0-20.0) ST-7

TRI Log #: 53560.8
Test Method: ASTM D4767



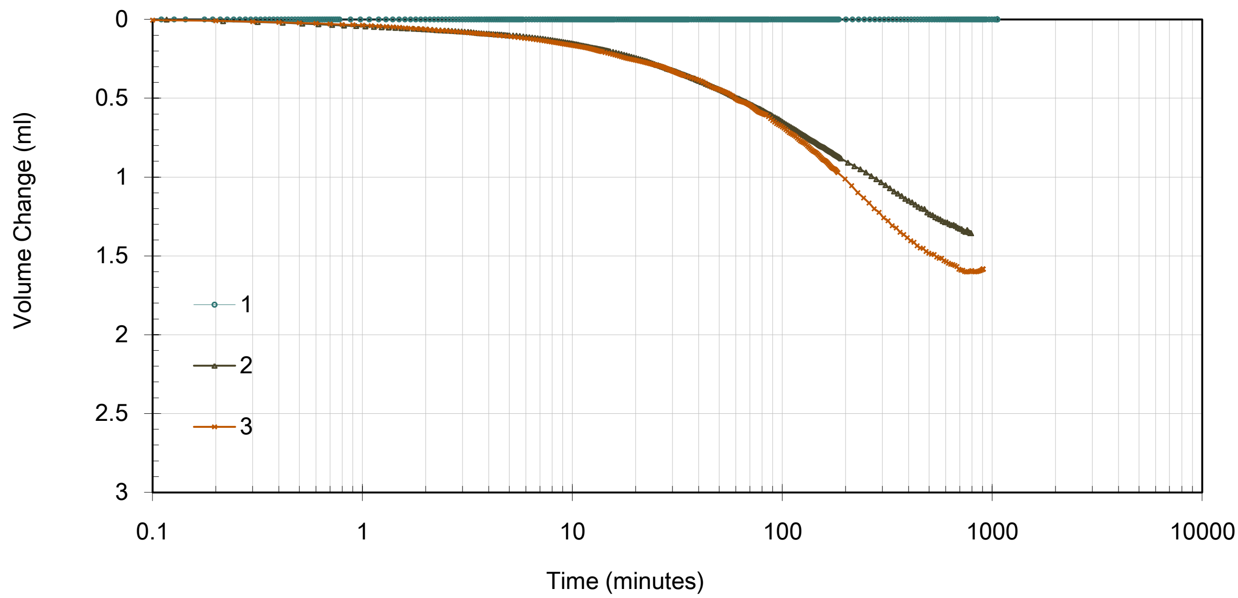
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

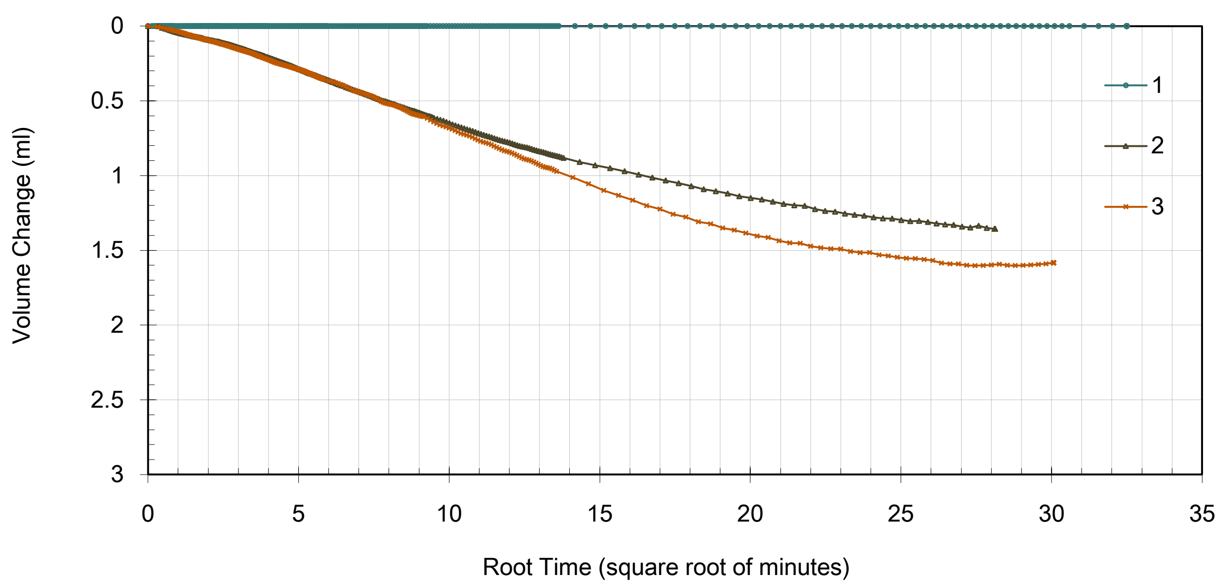
Consolidated-Undrained Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 305-19 (18.0-20.0) ST-7

TRI Log #: 53560.8
Test Method: ASTM D4767

Consolidation





TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Consolidated-Undrained Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 305-19 (18.0-20.0) ST-7

TRI Log #: 53560.8
Test Method: ASTM D4767

	Sample / Specimen Images		
	6.9	20.8	34.7
Post-Trim, Pre-Mount			
Post-Shear			

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

401-20

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 59911

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	401-20 (0-2) P-1	22.4	101.0	-	58	21	37
3	401-20 (4-6) P-3	16.9	-	89.9	-	-	-
4	401-20 (6-8) P-4	16.8	115.5	92.1	73	23	50
5	401-20 (8-10) P-5	20.4	-	-	-	-	-
6	401-20 (13-15) P-6	23.8	-	98.3	75	24	51
7	401-20 (18-20) P-7	23.1	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 59911

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO_4/kg)
-	Test Method	ASTM D516
-	Method Detection Limit (MDL)	[5 mg/l]*
1	401-20 (0-2) P-1	500
4	401-20 (6-8) P-4	6,700
6	401-20 (13-15) P-6	600

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The sulfate MDL is volumetric. Results are mass per mass of dry soil.

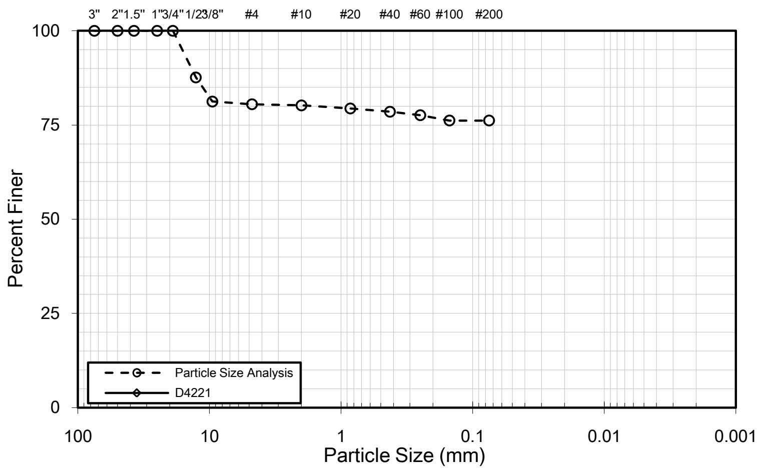
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

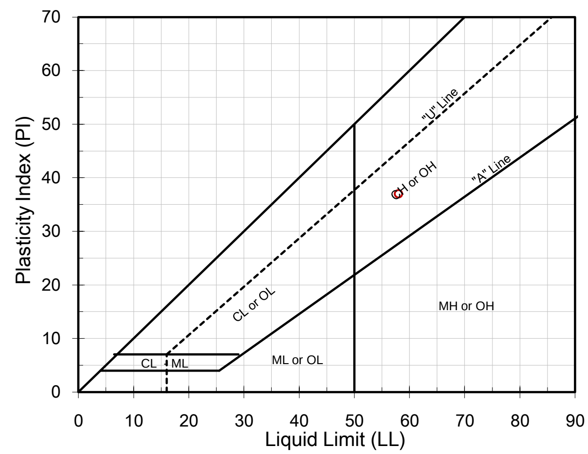
TRI ENVIRONMENTAL
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 401-20 (0-2) P-1

TRI Log #: 59911.1





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0		- -	- -	- -	- -
2 in.	50.8	100.0		- -	- -	- -	- -
1.5 in.	38.1	100.0		- -	- -	- -	- -
1 in.	25.4	100.0	19.5	- -	- -	- -	- -
3/4 in.	19.0	100.0		- -	- -	- -	- -
1/2 in.	12.7	87.6		- -	- -	- -	- -
3/8 in.	9.51	81.2		- -	- -	- -	- -
No. 4	4.76	80.5		Log-Linear Interpolation			
No. 10	2.00	80.2		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	79.4					
No. 40	0.420	78.5	4.3	mm		mm	
No. 60	0.250	77.6		0.005	- -	0.005	- -
No. 100	0.149	76.2		0.002	- -	0.002	- -
No. 200	0.074	76.2	76.2	N m,2µm,d	-	N m,2µm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	**Cu**	**Cc**	(ASTM D4221)
- -	- -	- -	- -	- -	- -	-

USDA	Sand (%) (2.0-0.05 mm)		Silt (%) (0.05-0.002		Clay (%) (< 0.002 mm)	
- -		- -		- -		- -

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	58
Plastic Limit	21
Plastic Index	37
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay with gravel (CH)

Moisture Content (%)	ASTM D2216	22.4
Organic Content (%)	ASTM D2974-C	4.1
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

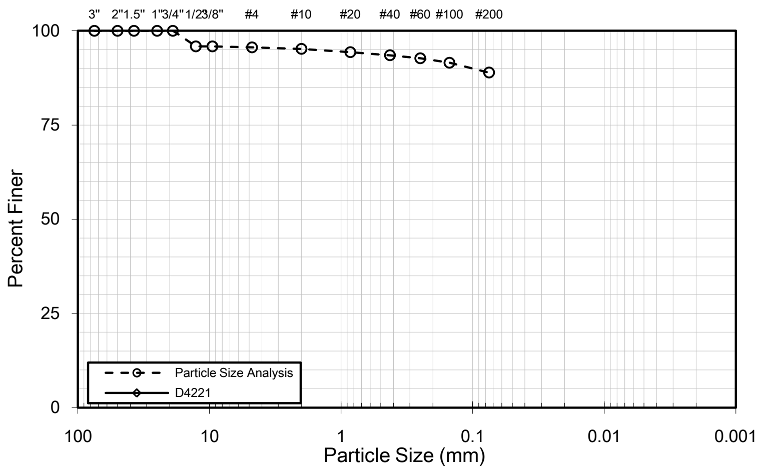
Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021
Analysis & Quality Review/Date

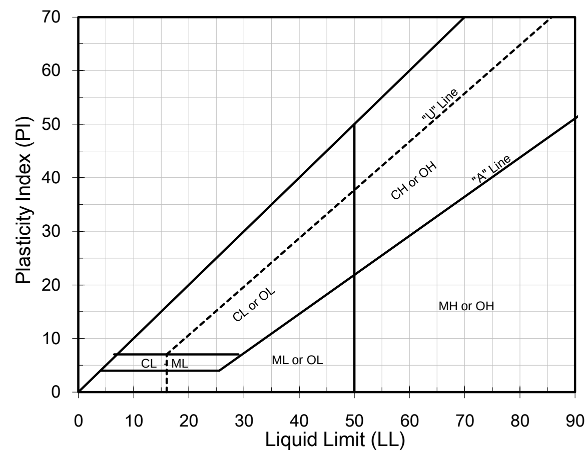
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 401-20 (2-4) P-2

TRI Log #: 59911.2





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	4.4	- -	- -	- -	- -
2 in.	50.8	100.0		- -	- -	- -	- -
1.5 in.	38.1	100.0		- -	- -	- -	- -
1 in.	25.4	100.0		- -	- -	- -	- -
3/4 in.	19.0	100.0		- -	- -	- -	- -
1/2 in.	12.7	95.9		- -	- -	- -	- -
3/8 in.	9.51	95.9		- -	- -	- -	- -
No. 4	4.76	95.6	6.7	Log-Linear Interpolation			
No. 10	2.00	95.2		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	94.3					
No. 40	0.420	93.5		mm		mm	
No. 60	0.250	92.7		0.005	- -	0.005	- -
No. 100	0.149	91.5		0.002	- -	0.002	- -
No. 200	0.074	88.9	88.9	N m,2μm,d	-	N m,2μm,nd	-
D_X (mm), Log-Linear Interpolation						Percent Dispersion	
10	30	50	60	Cu	Cc	(ASTM D4221)	
- -	- -	- -	- -	- -	- -	-	
USDA		Sand (%) (2.0-0.05 mm)	- -	Silt (%) (0.05-0.002	- -	Clay (%) (< 0.002 mm)	- -
- -							

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	- -
Plastic Limit	- -
Plastic Index	- -
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Note: Greater than 5% Fines - D4318 required for USCS classification

Moisture Content (%)	ASTM D2216	18.8
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021
Analysis & Quality Review/Date

402-20

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 59912

Jeffrey A. Kuhn, Ph.D., P.E., 3/24/2021
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Fines (%)	Organic Content (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D1140	ASTM D2974	ASTM D4318, Method A : Multipoint		
1	402-20 (0-2) P-1	23.1	-	3.9	-	-	-
2	402-20 (2-4) P-2	20.3	93.4	-	82	20	62
3	402-20 (4-5) P-3A	15.7	-	-	-	-	-
4	402-20 (5-6) P-3B	15.5	-	-	-	-	-
5	402-20 (6-8) P-4	17.2	95.0	-	67	19	48
6	402-20 (8-10) P-5	22.6	98.3	-	73	21	52
7	402-20 (13-15) P-6	24.2	-	-	-	-	-
8	402-20 (18-20) P-7	25.3	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 59911
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
1	401-20 (0-2) P-1	24.2	N/A	18.5	18.7	20.3	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 5/26/2021
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 59912

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO_4/kg)
-	Test Method	ASTM C1580
-	Method Detection Limit (MDL)	[5 mg/l]*
2	402-20 (2-4) P-2	600
5	402-20 (6-8) P-4	17,700
6	402-20 (8-10) P-5	900

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The sulfate MDL is volumetric. Results are mass per mass of dry soil.

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

601-19

Client: AECOM TRI Log #: 53193

Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
2	601-19 (2.0-3.5) SS-2	14.7	-	-	-	-	-
3	601-19 (4.0-6.0) ST-3	25.4	-	96.2	64	29	35
7	601-19 (13.0-15.0) ST-6	23.8	-	97.1	67	23	44
8	601-19 (18.0-20.0) P-7	22.4	-	-	-	-	-
9	601-19 (23.5-25.0) SS-8	20.4	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

COC Line #	Sample Identification	Organic Content (%)
-	Test Method	ASTM D2974
1	601-19 (0.0-2.0) P-1	4.7
4	601-19 (6.0-8.0) P-4 Layer A	1.4
6	601-19 (8.0-9.5) SS-5	1.1

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53193

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO_4/kg)	pH	
			(H_2O)	($CaCl_2$)
-	Test Method	ASTM D516	ASTM D4972 (method A)	
-	Method Detection Limit (MDL)	[5 mg/l]*	-	-
1	601-19 (0.0-2.0) P-1	500	8.08	8.03
4	601-19 (6.0-8.0) P-4 Layer A	700	8.29	7.86
8	601-19 (18.0-20.0) P-7	800	7.92	7.72

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The sulfate MDL is volumetric. Results are mass per mass of dry soil.

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53193
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
1	601-19 (0.0-2.0) P-1	26.4	N/A	20.6	20.8	20.8	1	1	1	1
4	601-19 (6.0-8.0) P-4 Layer A	20.2	N/A	20.6	20.8	20.8	1	1	1	1
8	601-19 (18.0-20.0) P-7	24.4	N/A	20.6	20.8	20.8	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

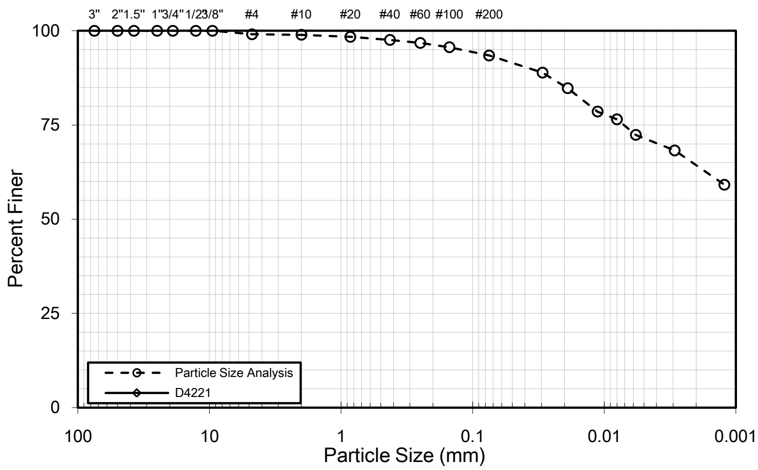
Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

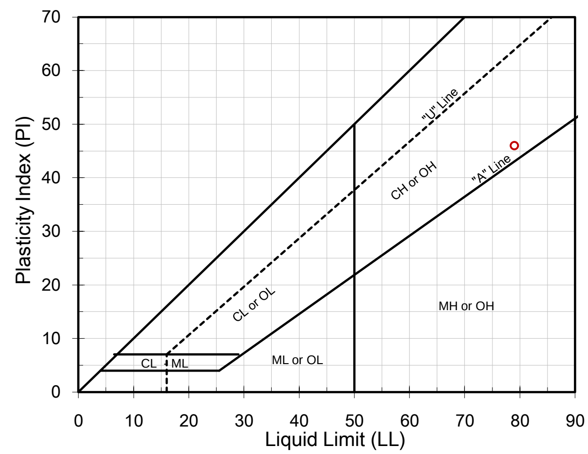
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 601-19 (0.0-2.0) P-1

TRI Log #: 53193.1





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.9	0.029	88.9	- -	- -
2 in.	50.8	100.0		0.019	84.8	- -	- -
1.5 in.	38.1	100.0		0.011	78.6	- -	- -
1 in.	25.4	100.0		0.008	76.5	- -	- -
3/4 in.	19.0	100.0		0.006	72.4	- -	- -
1/2 in.	12.7	100.0		0.003	68.2	- -	0.0
3/8 in.	9.51	100.0		0.001	59.1	- -	0.0
No. 4	4.76	99.1	5.7	Log-Linear Interpolation			
No. 10	2.00	99.0		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	98.4					
No. 40	0.420	97.6		mm		mm	
No. 60	0.250	96.8		0.005	71.5	0.005	- -
No. 100	0.149	95.6		0.002	64.3	0.002	- -
No. 200	0.074	93.4	93.4	N m,2μm,d	64	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	1.3E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	8.9	(0.05-0.002	26.1	(< 0.002 mm)	64.9

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	79
Plastic Limit	33
Plastic Index	46
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	21.9
Organic Content (%)	ASTM D2974-C	4.7
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021
Analysis & Quality Review/Date

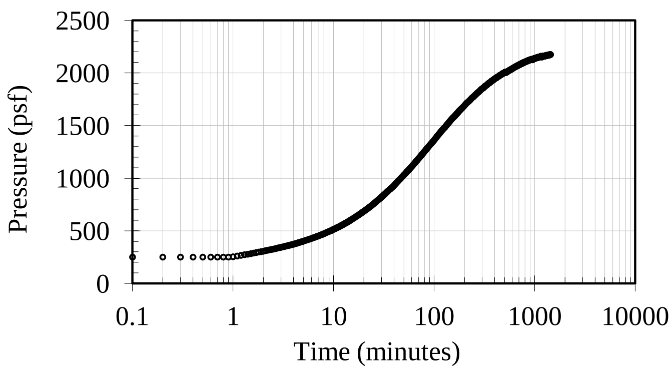
One-Dimensional Consolidation Properties of Soil

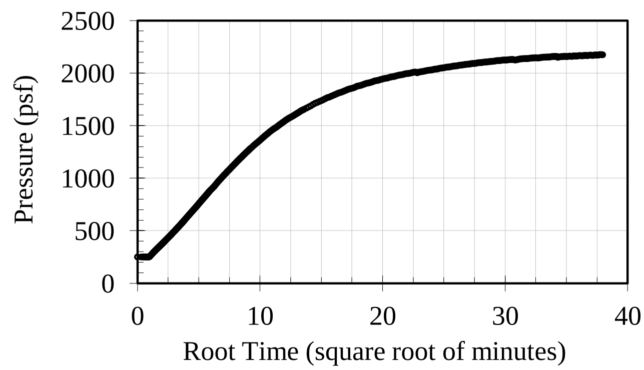
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 601-19 (0.0-2.0) P-1

TRI Log No.: 53193.1
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	17.6
Final Specimen Water Content (%)	27.2
Specimen Diameter (in)	2.499
Initial Specimen Height (in)	0.997
Initial Dry Unit Weight, γ_o lb_f/ft^3	96.0
Specific Gravity (Assumed)	2.75
Initial Void Ratio, e_o	0.722
Initial Degree of Saturation (%)	64.7

Swell Pressure (psf), Maximum Measured	2175





Note: The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. ***A client-prescribed seating stress pf 250 psf was utilized for testing.***

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

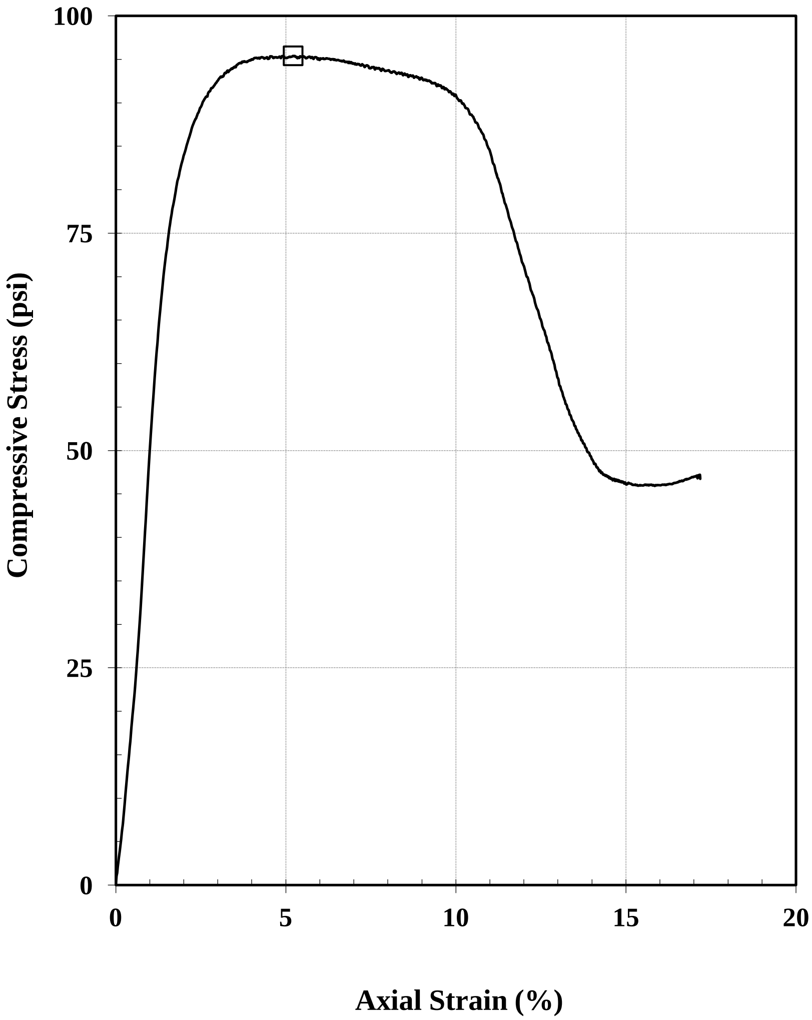
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

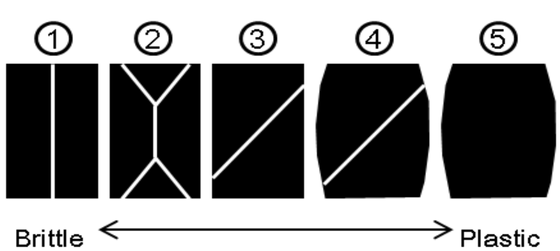
Client:	AECOM	TRI Log No.:	53193.3
Project:	60615067-1.4.14 Plum Creek 2	Type of Specimen:	Intact
Sample ID:	601-19 (4.0-6.0) ST-3	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.76
Avg. Height (in)	H_o	6.06
Avg, Water Content (%)	w_o	20.7
Bulk Density (pcf)	γ_{total}	123.6
Dry Density (pcf)	γ_{dry}	102.4
Saturation (%)	S_r	77.1
Void Ratio	e_o	0.68
Assumed Specific Gravity	G_s	2.75

Stresses at Failure	
Unconfined Compressive Strength (psi)	95.4
Axial Strain at Failure (%)	5.2
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	95.4
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	47.7

Failure Mode	3



(Kuhn after Nygård et. Al 2005)

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/21

Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

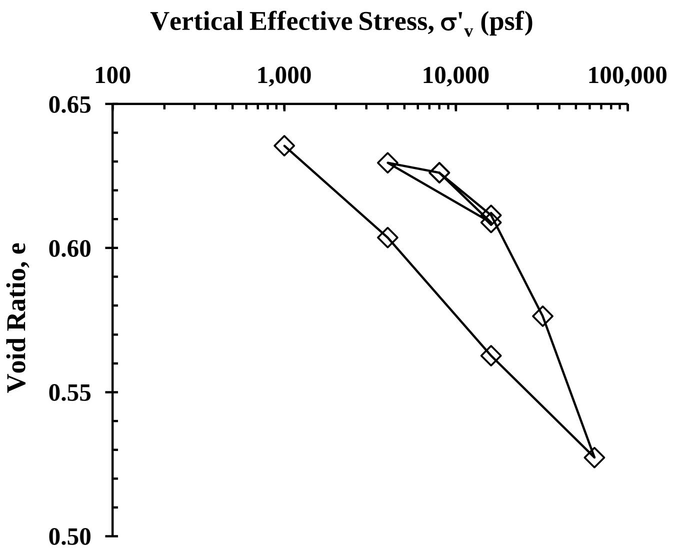
One-Dimensional Consolidation Properties of Soil

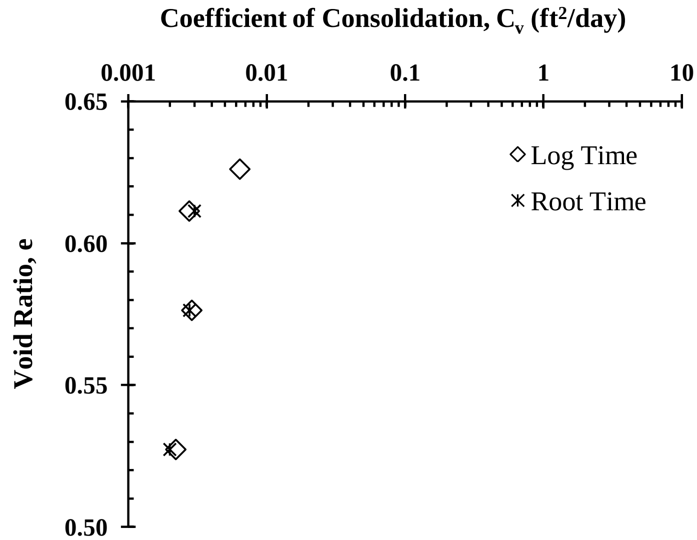
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 601-19 (4.0-6.0) ST-3

TRI Log No.: 53193.3
Test Method: ASTM D 2435, Method B

Soil Specimen Properties		
Initial Specimen Water Content (%)		21.0
Final Specimen Water Content (%)		24.9
Specimen Diameter (in)		2.498
Initial Specimen Height (in)		0.986
Final Specimen Height (in)		0.988
Final Differential Height (in)		-0.002
Initial Dry Unit Weight, γ_o lb_f/ft^3		101.3
Final Dry Unit Weight, γ_f lb_f/ft^3		101.1
Specific Gravity (Assumed)		2.75
Initial Void Ratio, e_o		0.633
Final Void Ratio, e_f		0.635
Initial Degree of Saturation (%)		88.0
Preconsolidation Pressure (psf)		≈19700
Swell Pressure (psf), Maximum Measured		3364
Compression Index, C_c	Min	-
	Max	0.163
Recompression Index, C_r	Min	0.011
	Max	0.049

Stage	σ'_v	e	Strain, ε	C_v (ft^2/day)	
(#)	(psf)	(-)	(%)	Log Time	Root Time
1	3,364	0.633	0.0	-	-
2	8,000	0.626	0.4	-	-
3	16,000	0.609	1.5	-	-
4	4,000	0.630	0.2	-	-
5	8,000	0.626	0.4	6.4E-03	-
6	16,000	0.611	1.3	2.8E-03	3.0E-03
7	32,000	0.576	3.5	2.9E-03	2.8E-03
8	64,000	0.527	6.5	2.2E-03	2.0E-03
9	16,000	0.563	4.3	-	-
10	4,000	0.604	1.8	-	-
11	1,000	0.635	-0.1	-	-
12	-	-	-	-	-
13	-	-	-	-	-
14	-	-	-	-	-
15	-	-	-	-	-





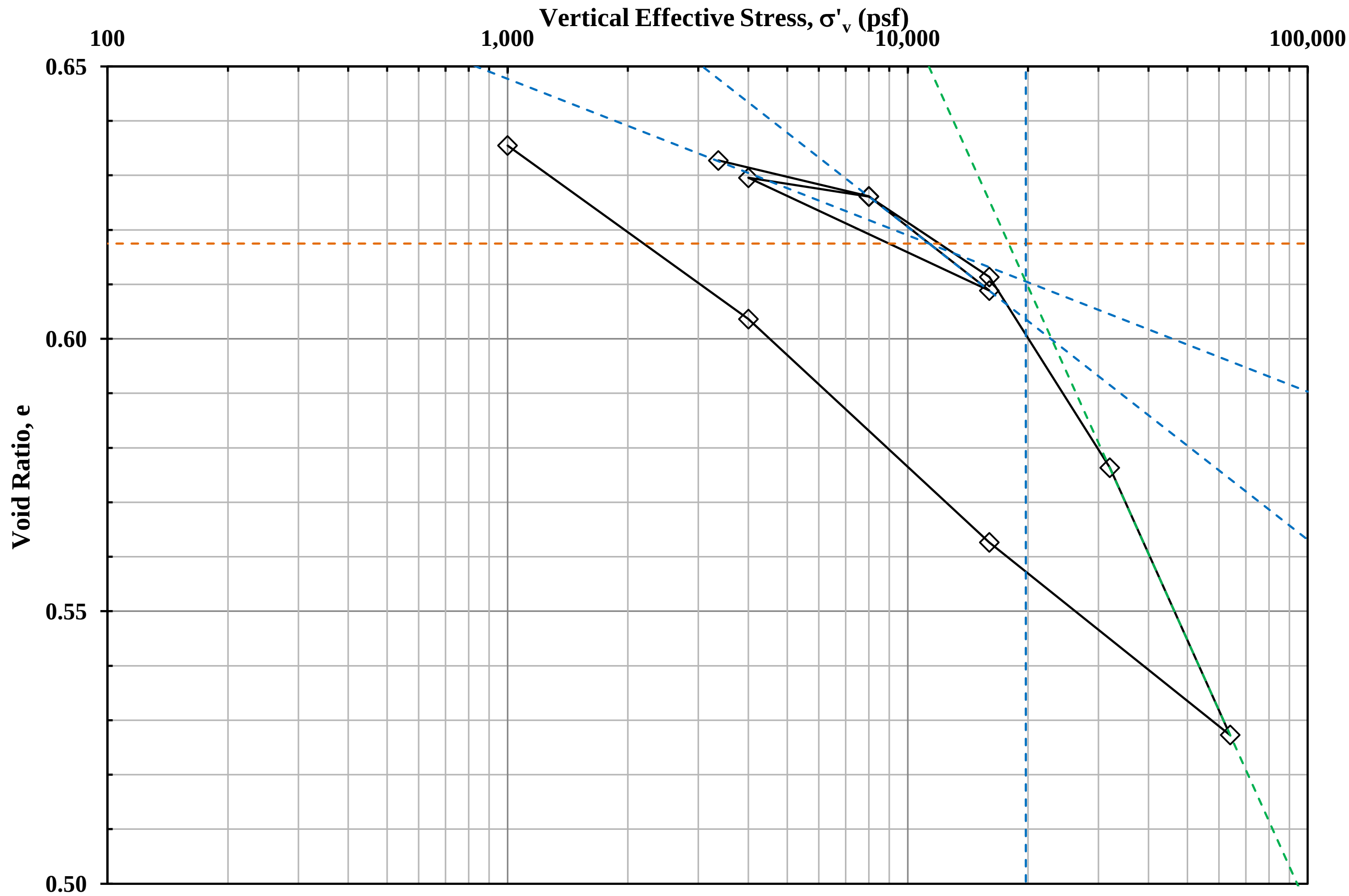
The intact sample was provided by the client. A specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. Coefficient of Consolidation was determined using the Log Time and Root Time Methods. Calculations include machine deflections measured at each loading step. The preconsolidation pressure was determined using the Casagrande construction technique.

Jeffrey A. Kuhn, Ph.D., P.E., 5/27/2021
Quality Review/Date

One-Dimensional Consolidation Properties of Soil

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 601-19 (4.0-6.0) ST-3

TRI Log No.: 53193.3
Test Method: ASTM D 2435, Method B



Stage	σ'v	log (σ'v)	e	δlog (σ'v)
(#)	(psf)	log (psf)	(-)	δe
1	3,364	3.53	0.633	-
2	8,000	3.90	0.626	0.018
3	16,000	4.20	0.609	0.057
4	4,000	3.60	0.630	-
5	8,000	3.90	0.626	0.011
6	16,000	4.20	0.611	0.049
7	32,000	4.51	0.576	0.116
8	64,000	4.81	0.527	0.163
9	16,000	4.20	0.563	-
10	4,000	3.60	0.604	-

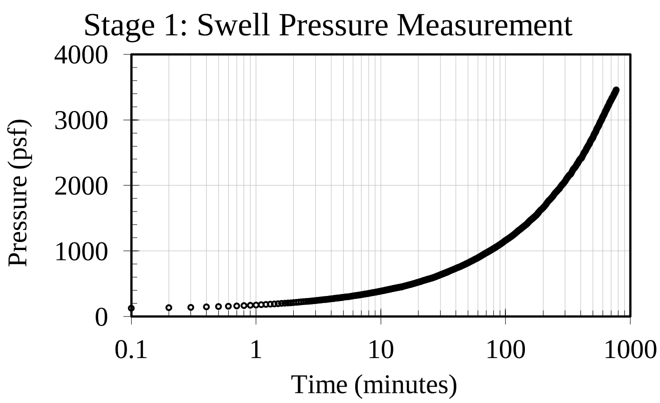
Stage	σ'v	log (σ'v)	e	δlog (σ'v)
(#)	(psf)	log (psf)	(-)	δe
11	1,000	3.00	0.635	-
12	-	-	-	-
13	-	-	-	-
14	-	-	-	-
15	-	-	-	-
16	-	-	-	-
17	-	-	-	-
18	-	-	-	-
19	-	-	-	-
20	-	-	-	-

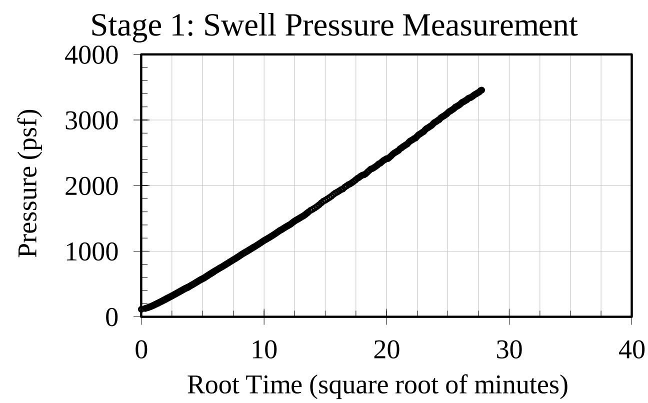
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

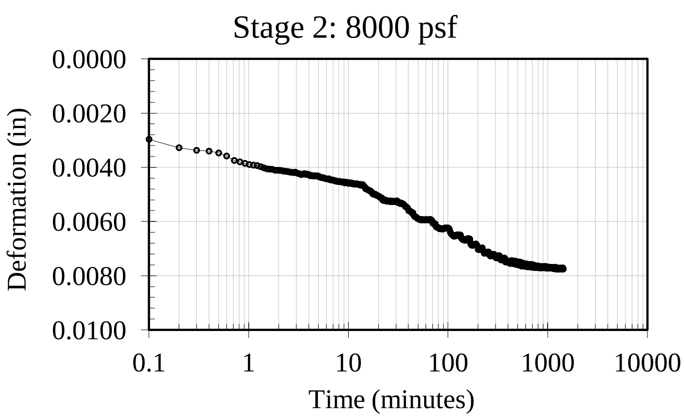
One-Dimensional Consolidation Properties of Soil

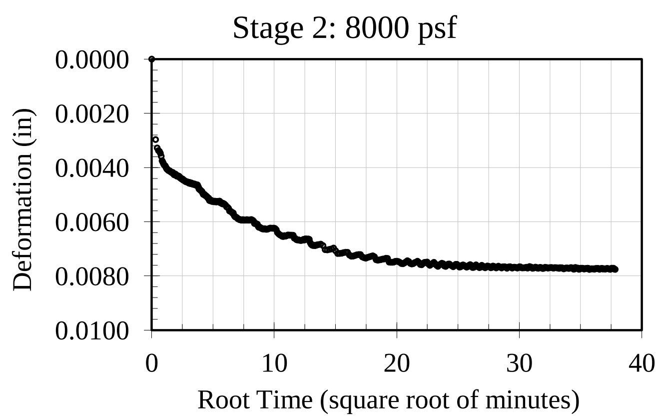
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 601-19 (4.0-6.0) ST-3

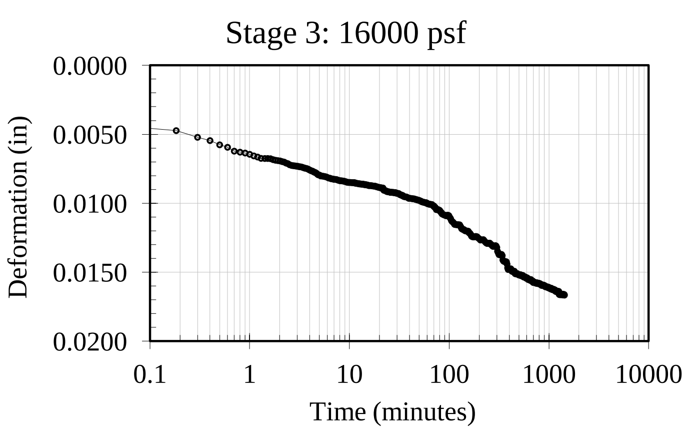
TRI Log No.: 53193.3
Test Method: ASTM D 2435, Method B

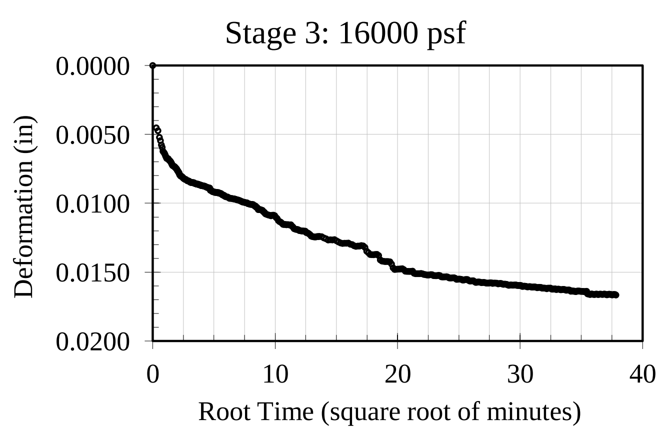










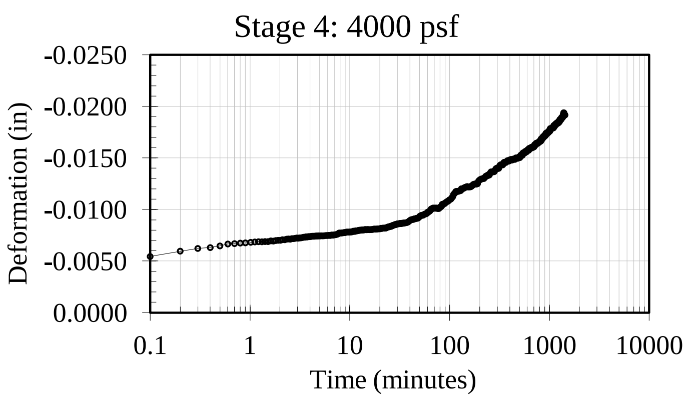


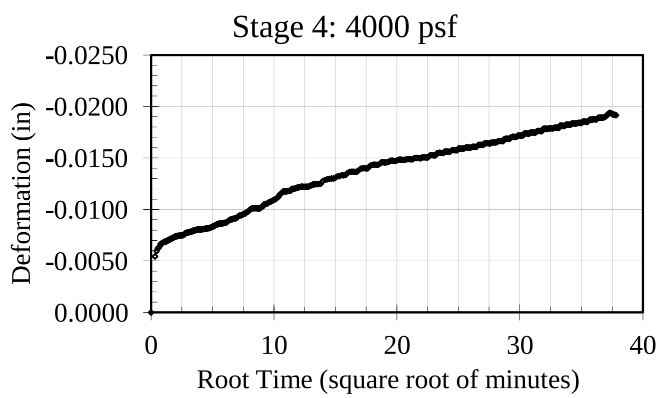
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

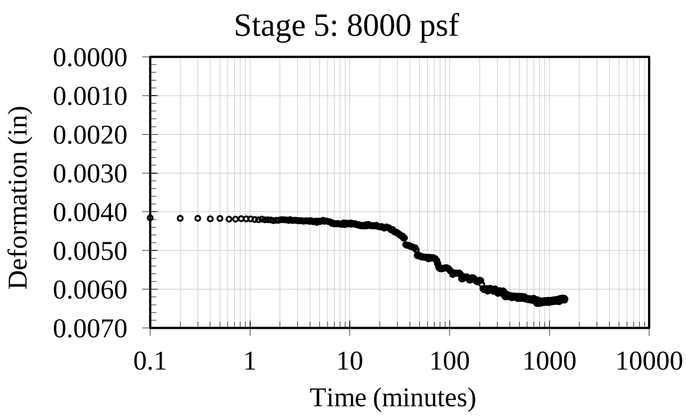
One-Dimensional Consolidation Properties of Soil

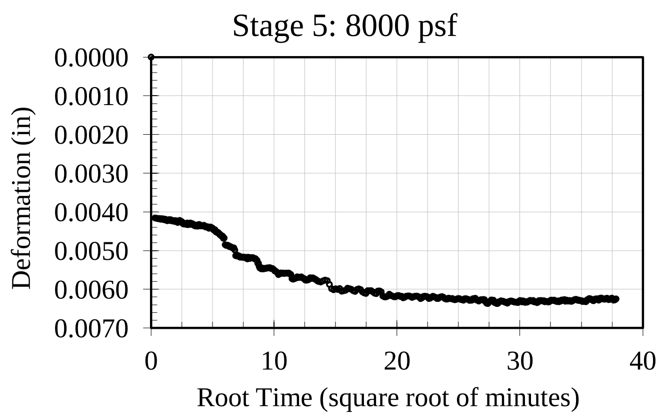
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 601-19 (4.0-6.0) ST-3

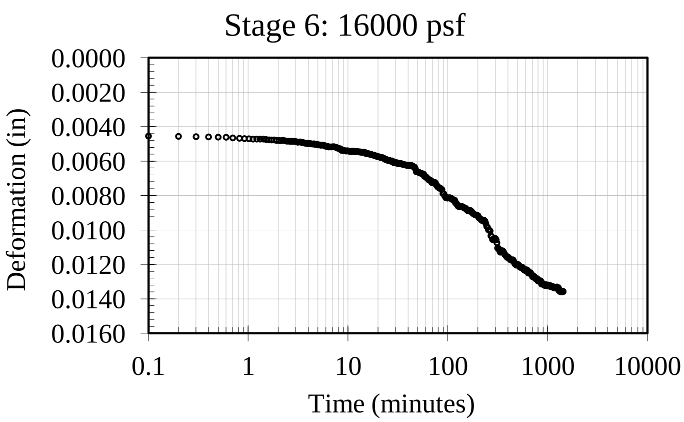
TRI Log No.: 53193.3
Test Method: ASTM D 2435, Method B

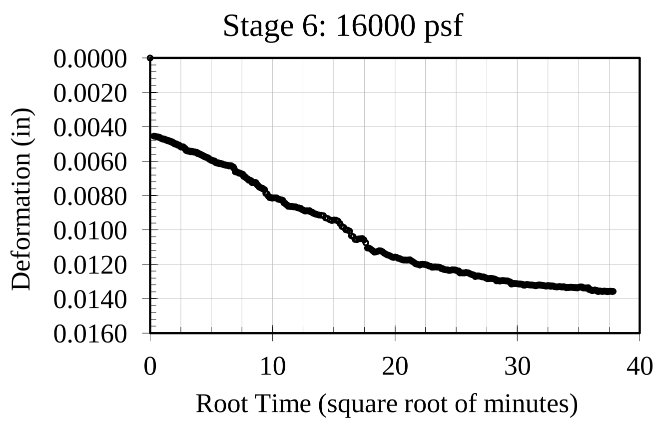










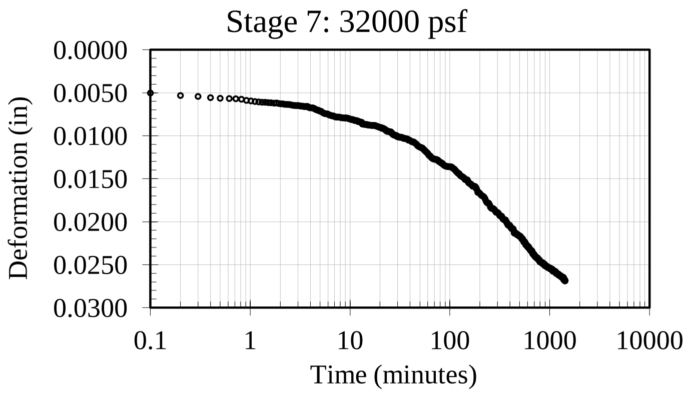


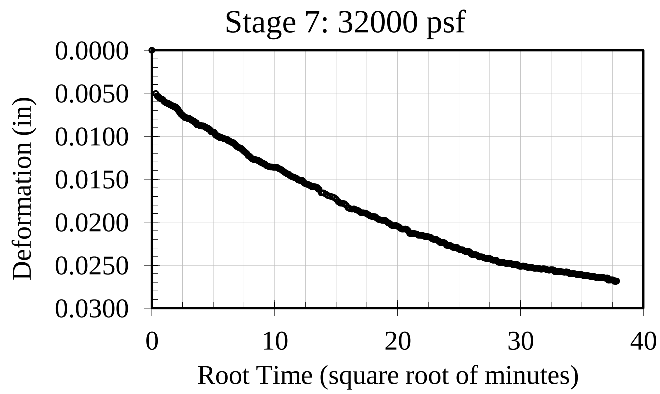
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

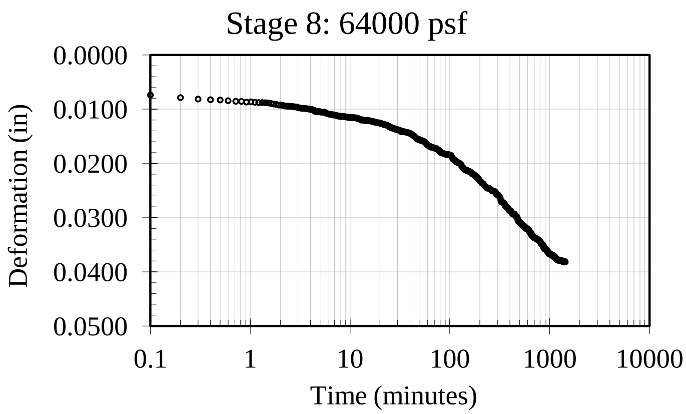
One-Dimensional Consolidation Properties of Soil

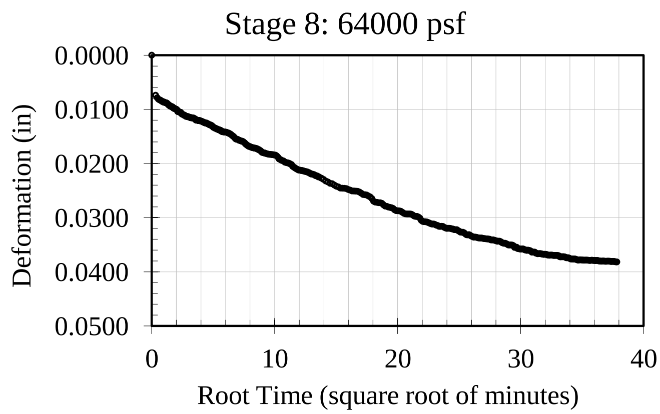
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 601-19 (4.0-6.0) ST-3

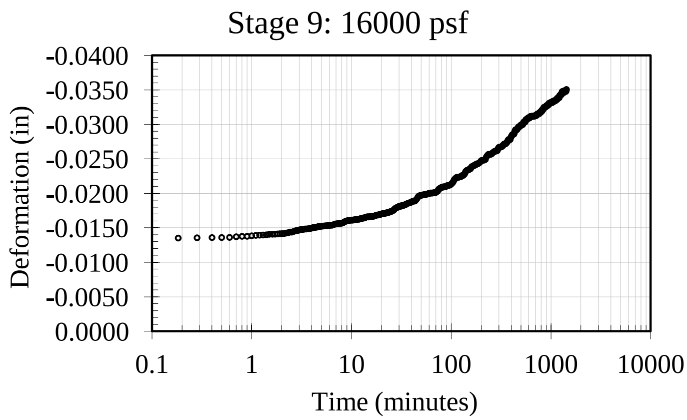
TRI Log No.: 53193.3
Test Method: ASTM D 2435, Method B

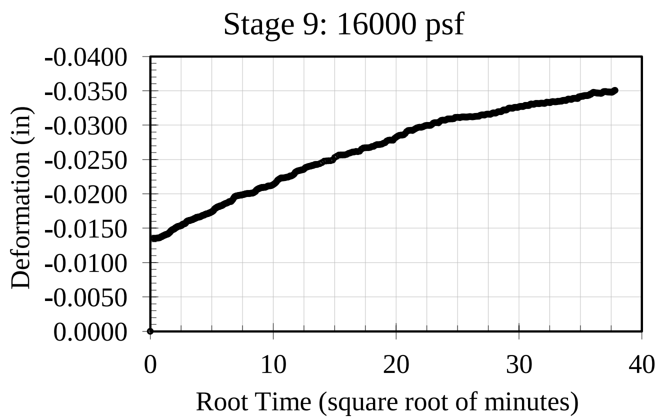






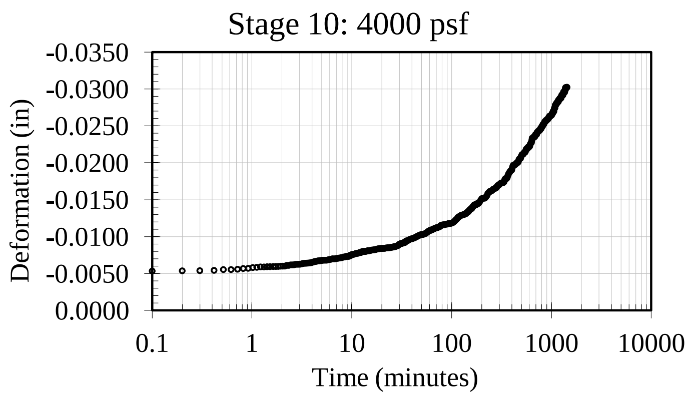


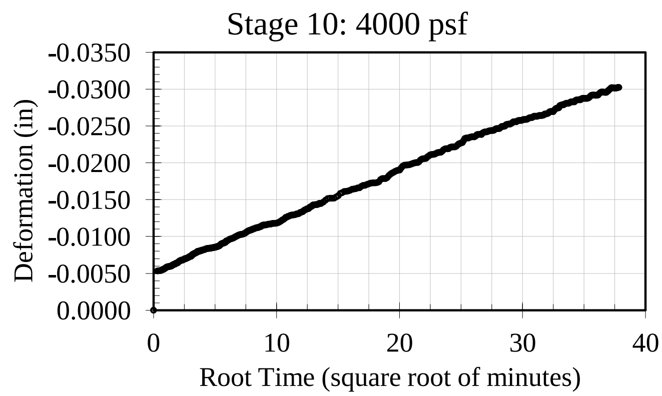


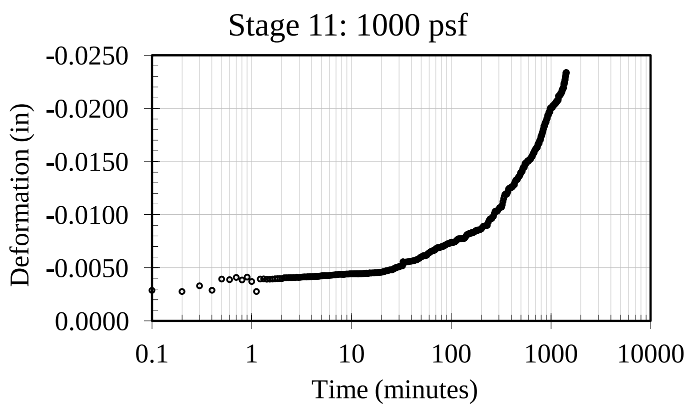


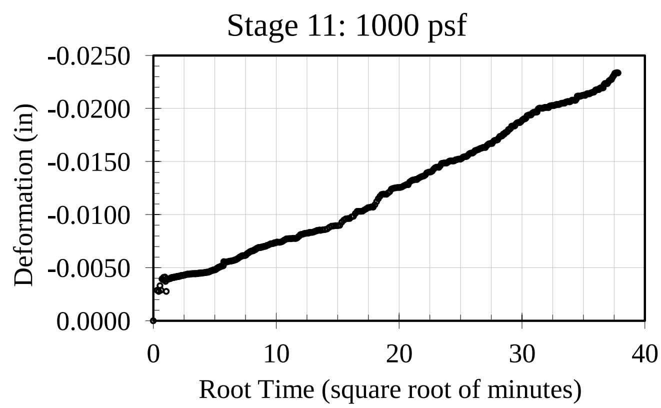
One-Dimensional Consolidation Properties of Soil

Client:	AECOM	TRI Log No.:	53193.3
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D 2435, Method B
Specimen:	601-19 (4.0-6.0) ST-3		









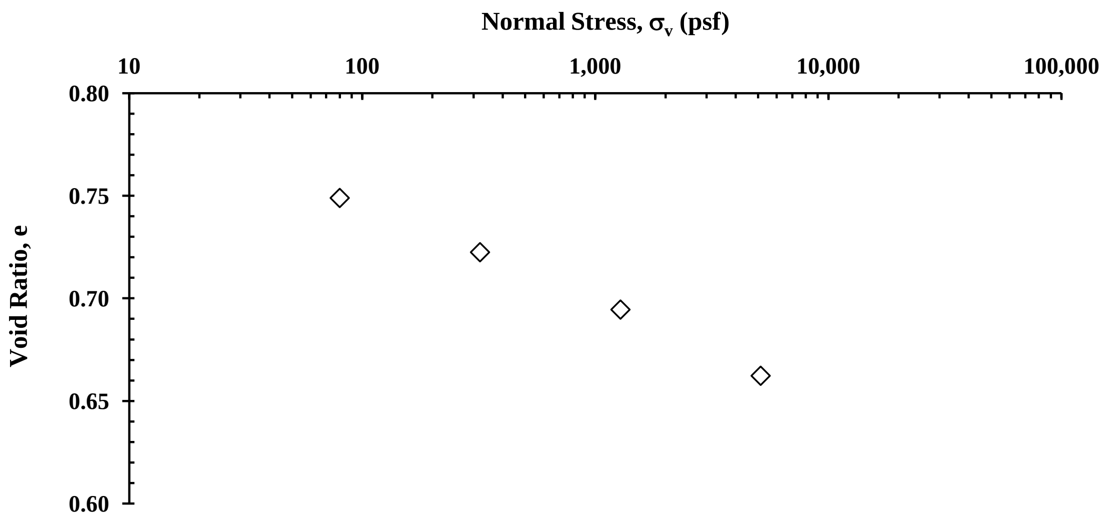
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Swell Pressure Measurement with Multistage Unloading

Client:	AECOM	TRI Log #:	53193.3
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D4546-B MOD
Specimen:	601-19 (4.0-6.0) ST-3		

Stage	Initial[1,2]	Normal Stress (psf)[3,4]				
Normal Stress (psf)	120	5,121	1,282	320	80	-
Water Content, ω (%)	21.0	-	-	-	24.9	-
Diameter, d (in)	2.495	-	-	-	-	-
Height, h (in)	0.998	0.998	1.017	1.034	1.050	-
Total Unit Weight (pcf)	124.9	-	-	-	124.9	-
Dry Unit Weight (pcf)	103.2	-	-	-	103.2	-
Void Ratio, e	0.662	0.662	0.695	0.722	0.749	-
$\Delta e / \Delta \log(\sigma)$	-	-	-0.054	-0.046	-0.044	-
Degree of Saturation, S (%)	84.1	-	-	-	88.3	-
Strain (%)[3,4]	0.000	0.000	-1.941	-3.623	-5.214	-

1. The intact sample was provided by the client. A specimen was trimmed from the sample using a trimming turntable and mounted. Gs was assumed to be 2.75. Calculations include measured machine deflections.
2. In the specimen ring.
3. Sign convention: (+) Compression/Collapse, (-) Expansion/Swell
4. Modification: The initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. Following the measurement of the swell pressure the sample was subsequently unloaded in stages.

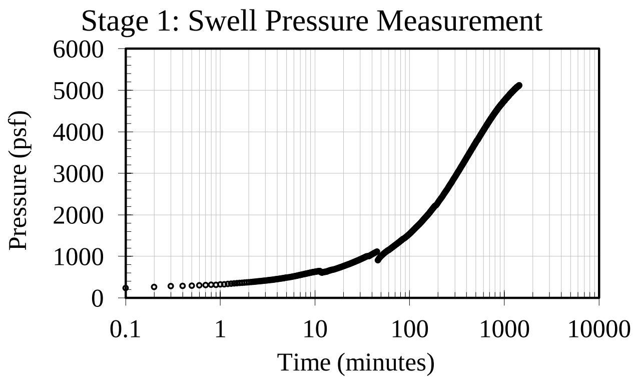


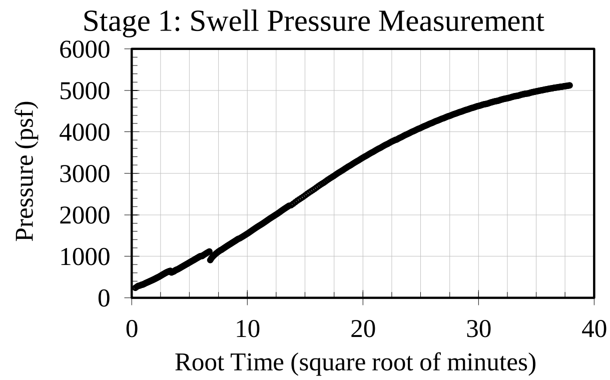
Jeffrey A. Kuhn, Ph.D., P.E. 3/22/2021
Analysis & Quality Review/Date

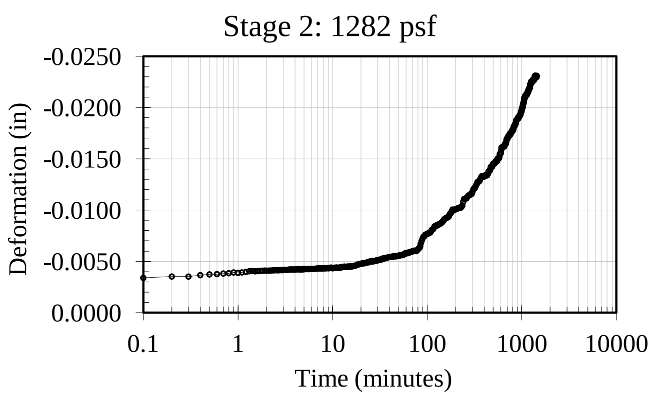
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

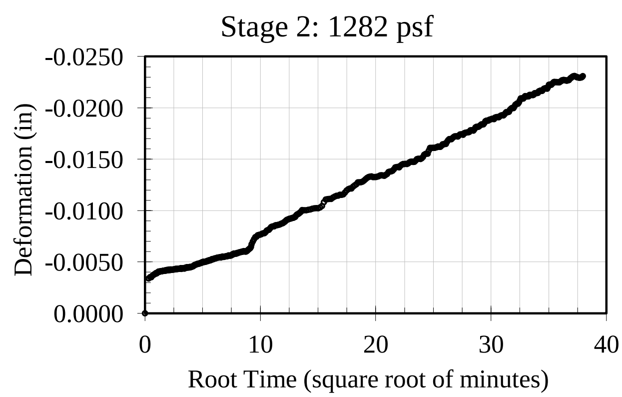
Swell Pressure Measurement with Multistage Unloading

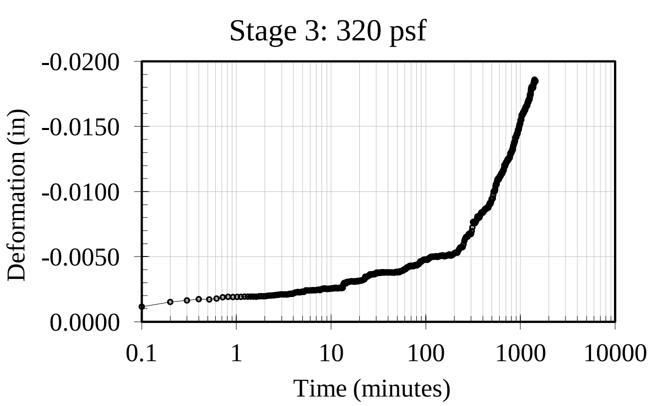
Client:	AECOM	TRI Log #:	53193.3
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D4546-B MOD
Specimen:	601-19 (4.0-6.0) ST-3		

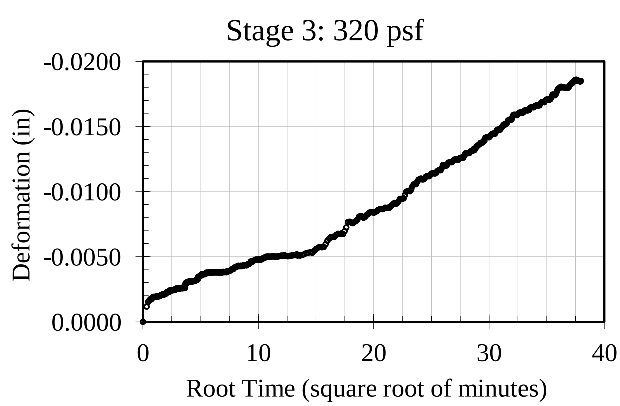








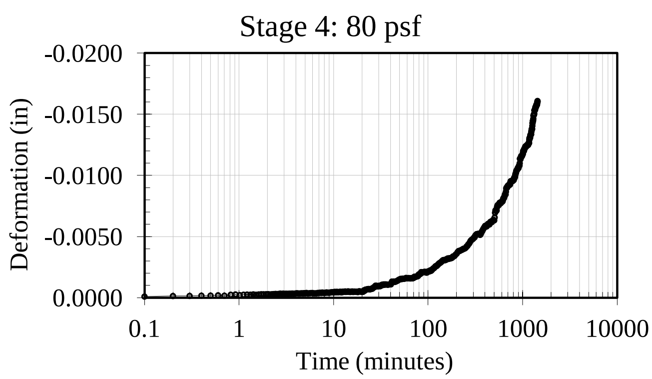


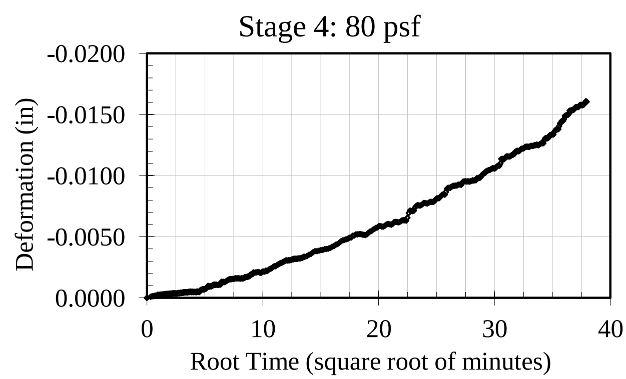


TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Swell Pressure Measurement with Multistage Unloading

Client:	AECOM	TRI Log #:	53193.3
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D4546-B MOD
Specimen:	601-19 (4.0-6.0) ST-3		





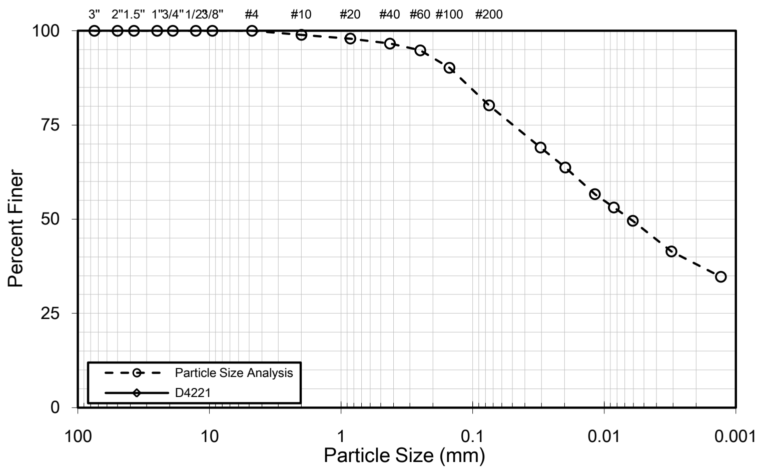
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

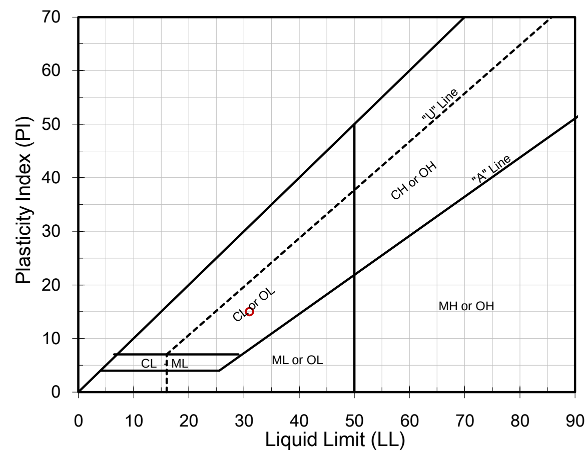
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 601-19 (6.0-8.0) P-4 Layer A

TRI Log #: 53193.4





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.0	0.030	69.0	- -	- -
2 in.	50.8	100.0		0.020	63.7	- -	- -
1.5 in.	38.1	100.0		0.012	56.6	- -	- -
1 in.	25.4	100.0		0.008	53.1	- -	- -
3/4 in.	19.0	100.0		0.006	49.6	- -	- -
1/2 in.	12.7	100.0		0.003	41.4	- -	- -
3/8 in.	9.51	100.0		0.001	34.7	- -	- -
No. 4	4.76	100.0	19.8	Log-Linear Interpolation			
No. 10	2.00	98.9		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	97.9					
No. 40	0.420	96.6		mm		mm	
No. 60	0.250	94.8		0.005	47.3	0.005	- -
No. 100	0.149	90.2		0.002	38.1	0.002	- -
No. 200	0.074	80.2	80.2	N m,2μm,d	38	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	6.3E-03	1.5E-02	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay Loam	(2.0-0.05 mm)	26.6	(0.05-0.002	34.8	(< 0.002 mm)	38.5

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	31
Plastic Limit	16
Plastic Index	15
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Lean clay with sand (CL)

Moisture Content (%)	ASTM D2216	13.0
Organic Content (%)	ASTM D2974-C	1.4
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021
Analysis & Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

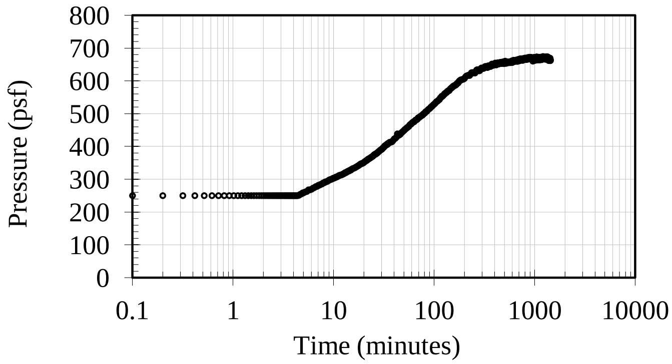
One-Dimensional Consolidation Properties of Soil

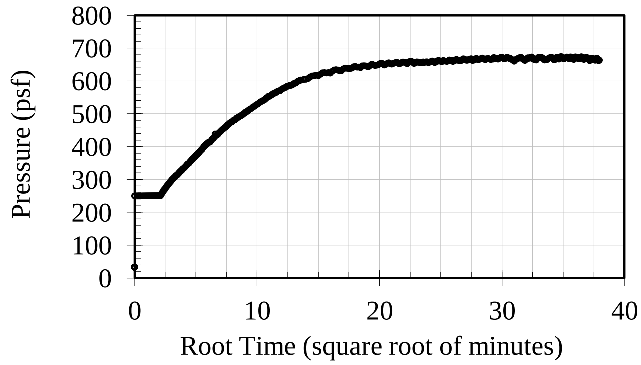
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 601-19 (6.0-8.0) P-4 Layer A

TRI Log No.: 53193.4
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	10.6
Final Specimen Water Content (%)	13.3
Specimen Diameter (in)	2.496
Initial Specimen Height (in)	1.003
Initial Dry Unit Weight, γ_o lb_f/ft^3	116.6
Specific Gravity (Assumed)	2.75
Initial Void Ratio, e_o	0.418
Initial Degree of Saturation (%)	66.9

Swell Pressure (psf), Maximum Measured	674





Note: The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. ***A client-prescribed seating stress pf 250 psf was utilized for testing.***

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

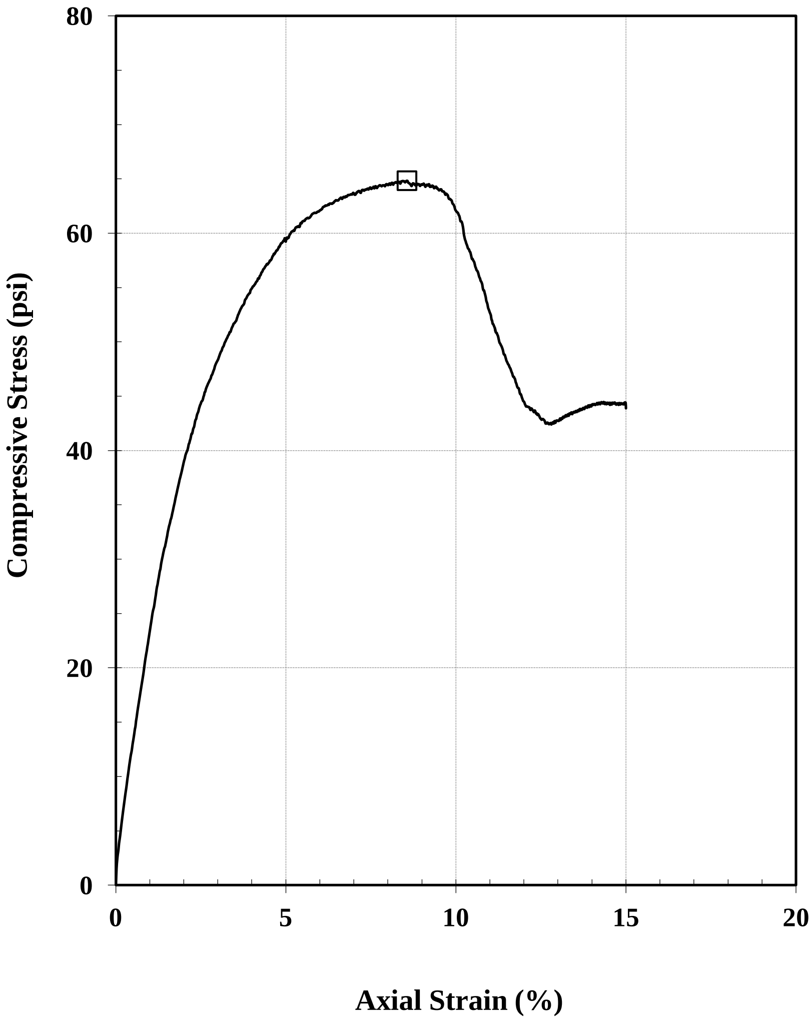
ENVIRONMENTAL

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

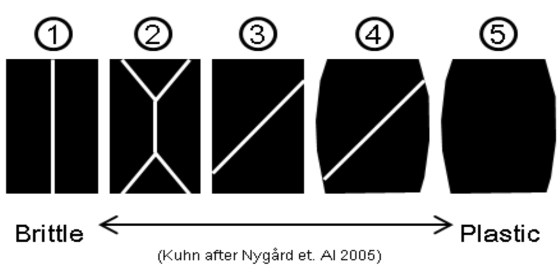
Client:	AECOM	TRI Log No.:	53193.7
Project:	60615067-1.4.14 Plum Creek 2	Type of Specimen:	Intact
Sample ID:	601-19 (13.0-15.0) ST-6	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.76
Avg. Height (in)	H_o	6.06
Avg, Water Content (%)	w_o	15.3
Bulk Density (pcf)	γ_{total}	132.2
Dry Density (pcf)	γ_{dry}	114.6
Saturation (%)	S_r	88.5
Void Ratio	e_o	0.50
Assumed Specific Gravity	G_s	2.75

Stresses at Failure	
Unconfined Compressive Strength (psi)	64.8
Axial Strain at Failure (%)	8.6
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	64.8
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	32.4

Failure Mode	4



Jeffrey A. Kuhn, Ph.D., P.E., 3/22/21

Quality Review/Date

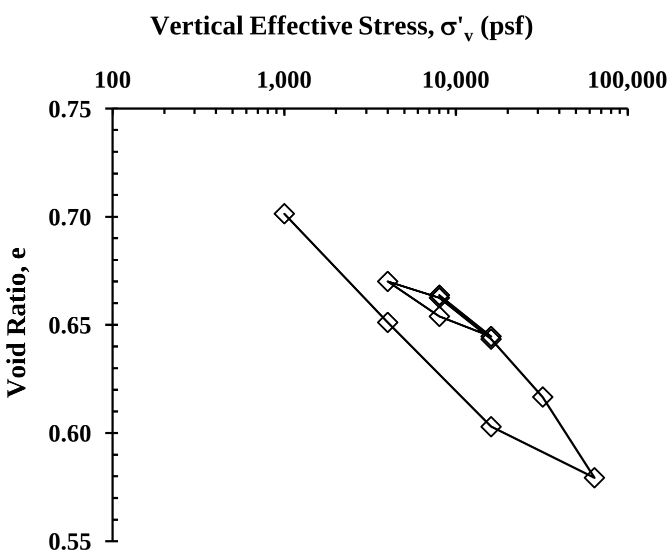
One-Dimensional Consolidation Properties of Soil

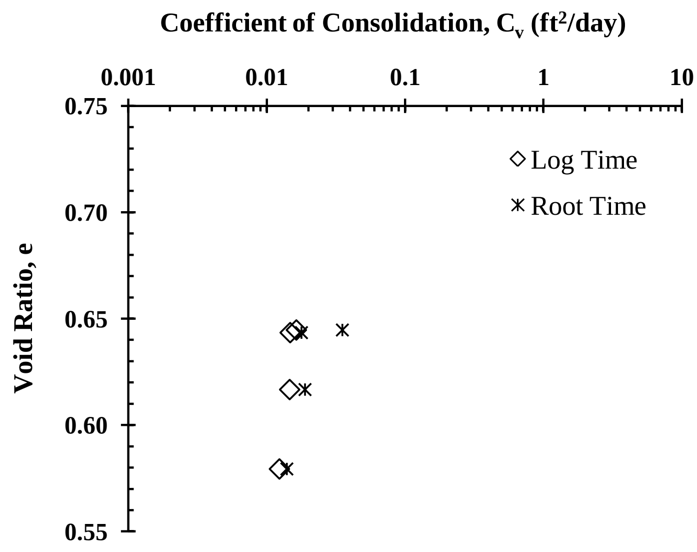
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 601-19 (13.0-15.0) ST-6

TRI Log No.: 53193.7
Test Method: ASTM D 2435, Method B

Soil Specimen Properties		
Initial Specimen Water Content (%)		21.4
Final Specimen Water Content (%)		25.4
Specimen Diameter (in)		2.495
Initial Specimen Height (in)		1.006
Final Specimen Height (in)		1.025
Final Differential Height (in)		-0.019
Initial Dry Unit Weight, γ_o lb_f/ft^3		99.0
Final Dry Unit Weight, γ_f lb_f/ft^3		97.2
Specific Gravity (Assumed)		2.75
Initial Void Ratio, e_o		0.670
Final Void Ratio, e_f		0.701
Initial Degree of Saturation (%)		84.7
Preconsolidation Pressure (psf)		≈17900
Swell Pressure (psf), Maximum Measured		3373
Compression Index, C_c	Min	-
	Max	0.124
Recompression Index, C_r	Min	0.025
	Max	0.063

Stage	σ'$_v$	e	Strain, ε	C_v (ft^2/day)	
(#)	(psf)	(-)	(%)	Log Time	Root Time
1	3,373	0.670	0.0	-	-
2	8,000	0.664	0.4	-	-
3	16,000	0.645	1.5	1.6E-02	3.5E-02
4	8,000	0.654	1.0	-	-
5	4,000	0.670	0.0	-	-
6	8,000	0.663	0.5	-	-
7	16,000	0.643	1.6	1.5E-02	1.8E-02
8	32,000	0.617	3.2	1.5E-02	1.9E-02
9	64,000	0.579	5.4	1.2E-02	1.4E-02
10	16,000	0.603	4.0	-	-
11	4,000	0.651	1.1	-	-
12	1,000	0.701	-1.9	-	-
13	-	-	-	-	-
14	-	-	-	-	-
15	-	-	-	-	-





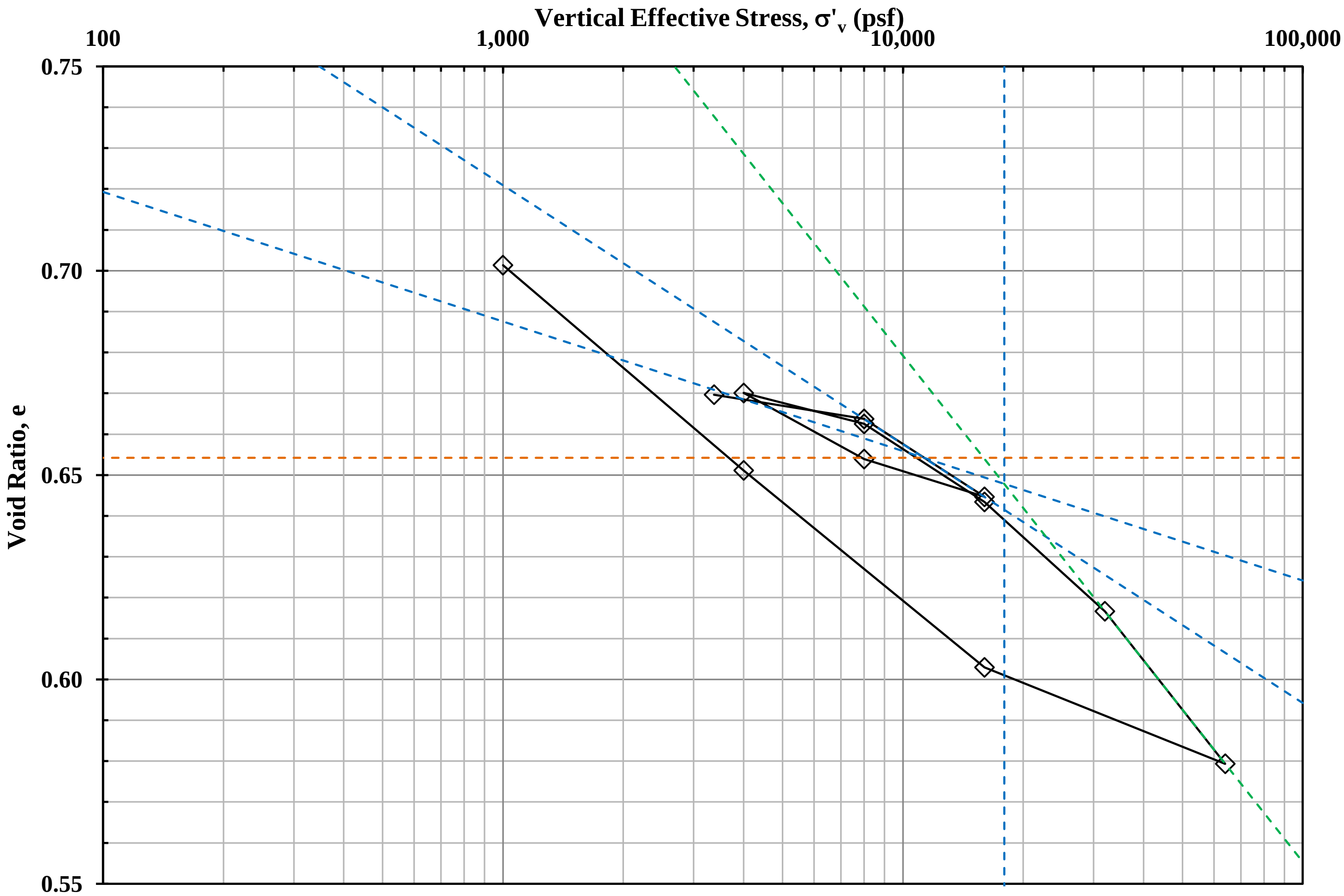
The intact sample was provided by the client. A specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. Coefficient of Consolidation was determined using the Log Time and Root Time Methods. Calculations include machine deflections measured at each loading step. The preconsolidation pressure was determined using the Casagrande construction technique.

Jeffrey A. Kuhn, Ph.D., P.E., 5/27/2021
Quality Review/Date

One-Dimensional Consolidation Properties of Soil

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 601-19 (13.0-15.0) ST-6

TRI Log No.: 53193.7
Test Method: ASTM D 2435, Method B



Stage	σ'v	log (σ'v)	e	δlog (σ'v)
(#)	(psf)	log (psf)	(-)	δe
1	3,373	3.53	0.670	-
2	8,000	3.90	0.664	0.016
3	16,000	4.20	0.645	0.063
4	8,000	3.90	0.654	-
5	4,000	3.60	0.670	-
6	8,000	3.90	0.663	0.025
7	16,000	4.20	0.643	0.063
8	32,000	4.51	0.617	0.089
9	64,000	4.81	0.579	0.124
10	16,000	4.20	0.603	-

Stage	σ'v	log (σ'v)	e	δlog (σ'v)
(#)	(psf)	log (psf)	(-)	δe
11	4,000	3.60	0.651	-
12	1,000	3.00	0.701	-
13	-	-	-	-
14	-	-	-	-
15	-	-	-	-
16	-	-	-	-
17	-	-	-	-
18	-	-	-	-
19	-	-	-	-
20	-	-	-	-

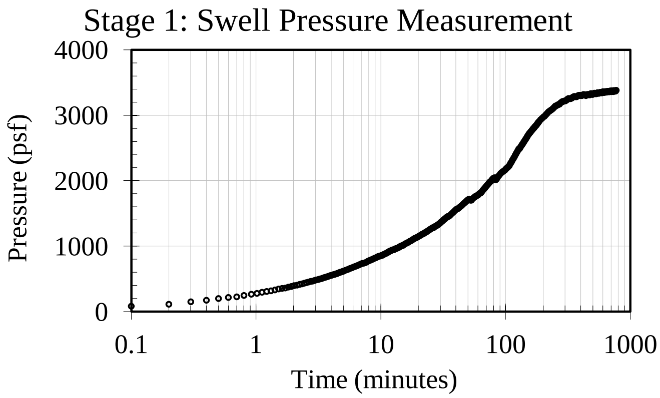
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

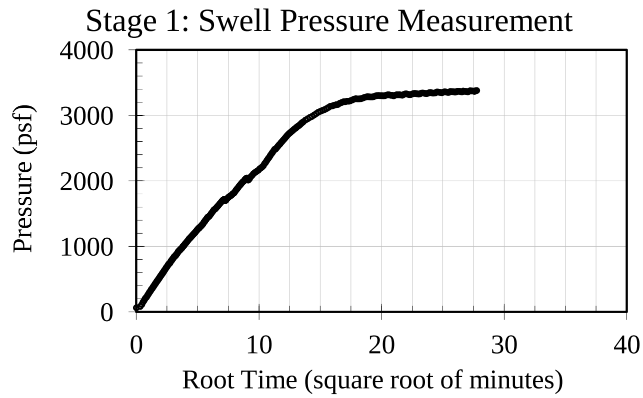
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

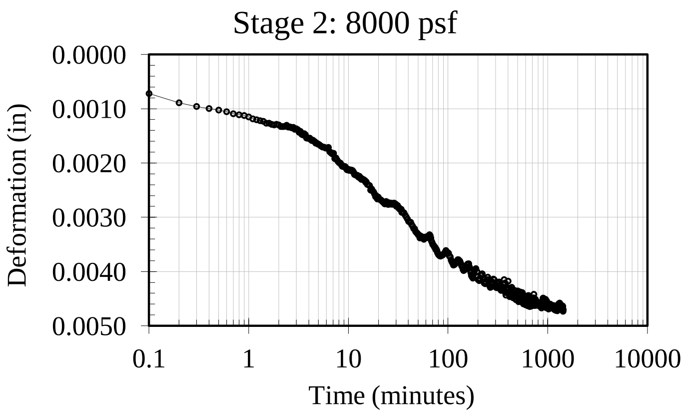
One-Dimensional Consolidation Properties of Soil

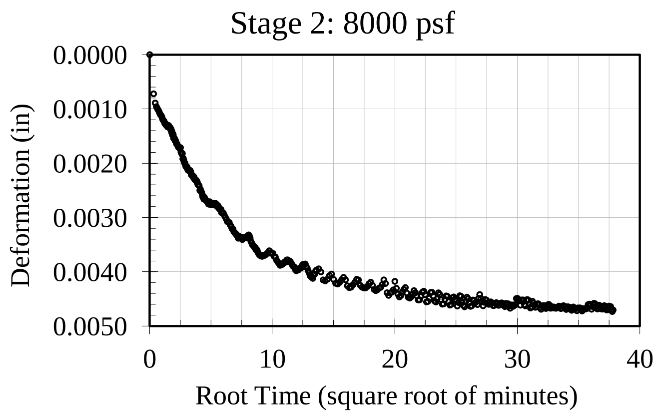
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 601-19 (13.0-15.0) ST-6

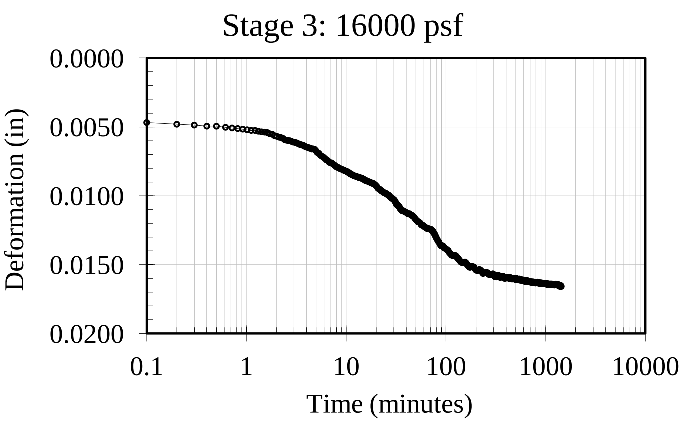
TRI Log No.: 53193.7
Test Method: ASTM D 2435, Method B

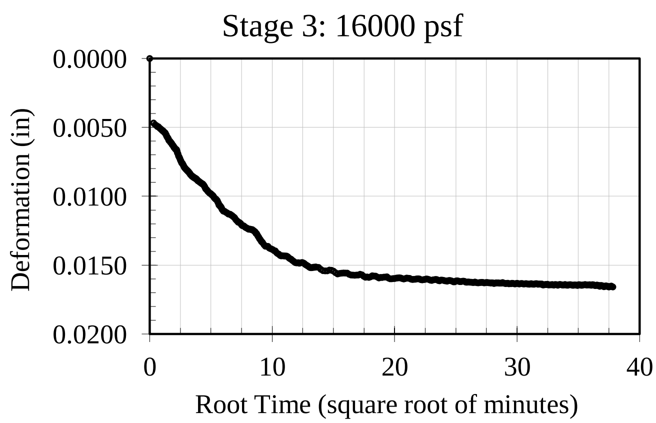










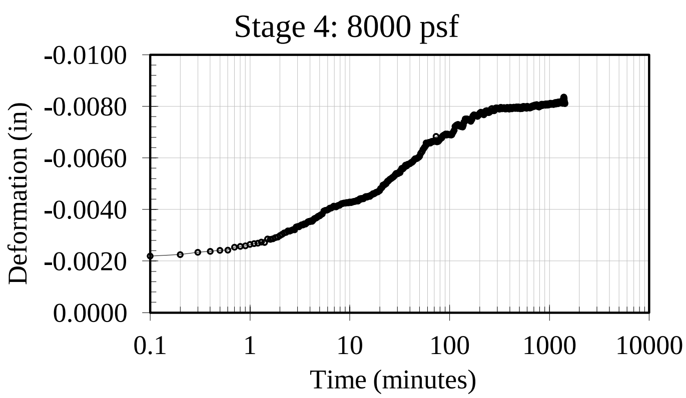


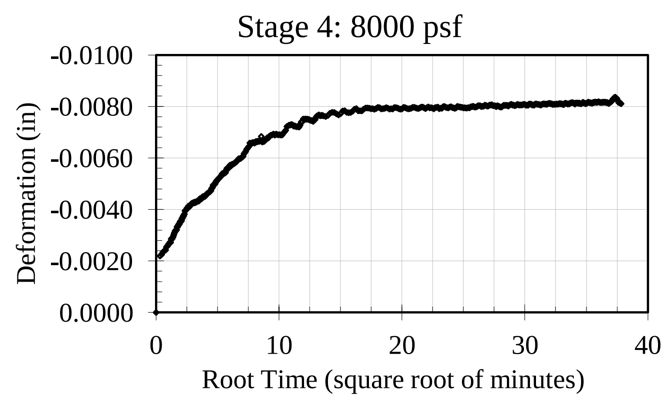
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

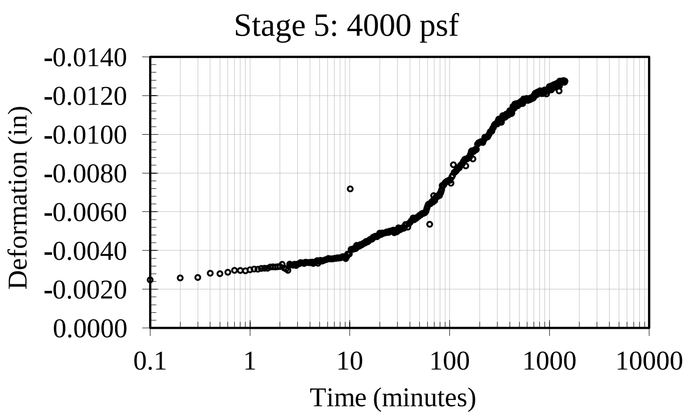
One-Dimensional Consolidation Properties of Soil

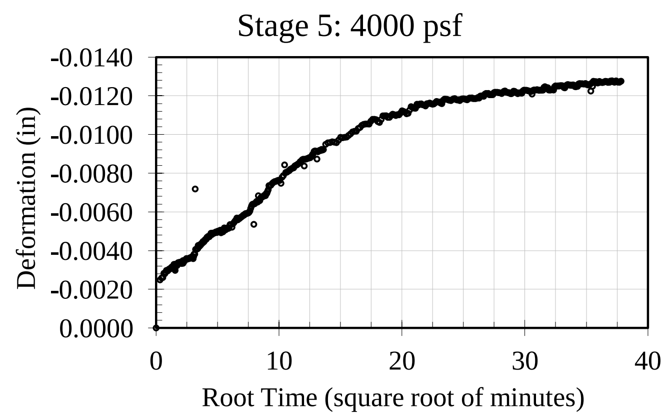
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 601-19 (13.0-15.0) ST-6

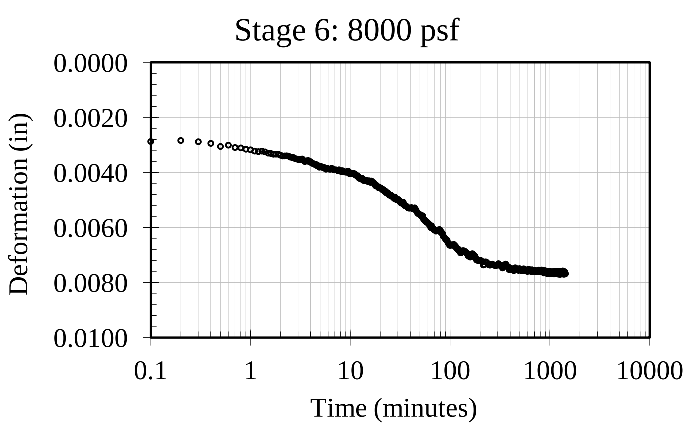
TRI Log No.: 53193.7
Test Method: ASTM D 2435, Method B

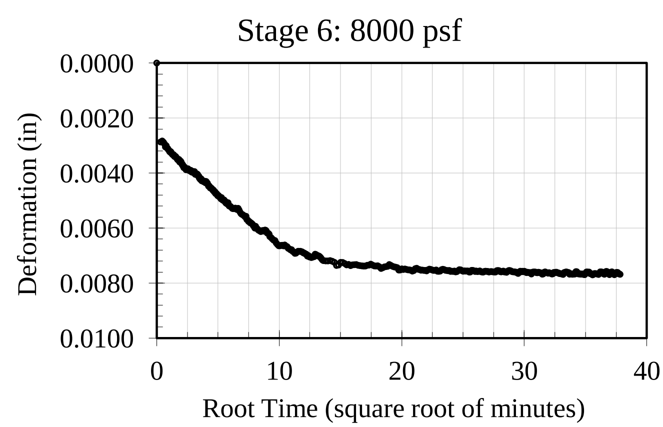










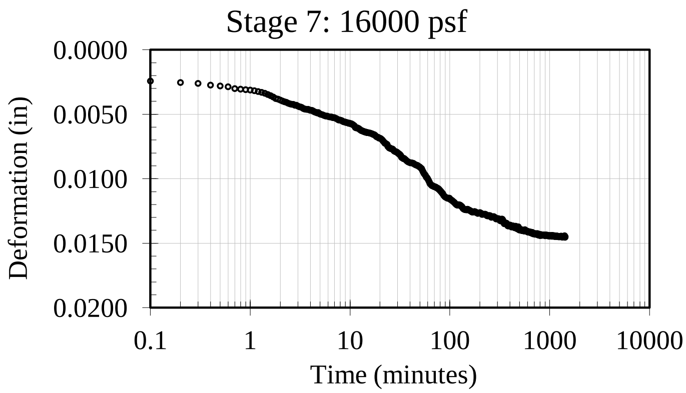


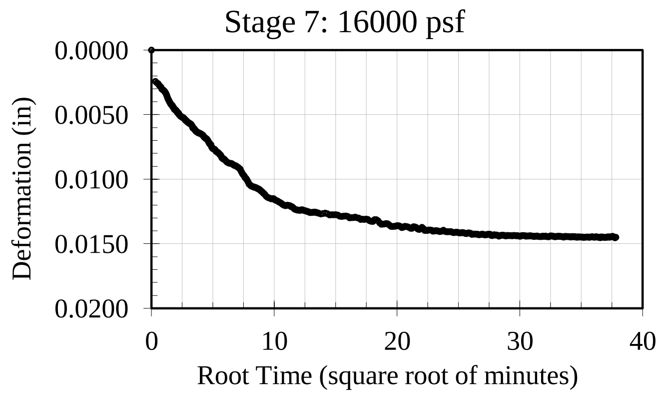
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

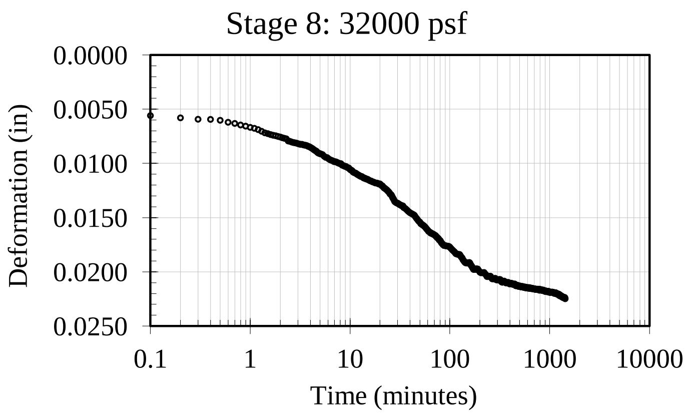
One-Dimensional Consolidation Properties of Soil

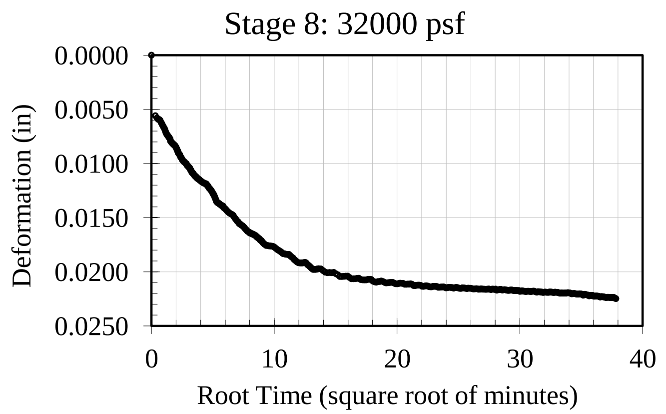
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 601-19 (13.0-15.0) ST-6

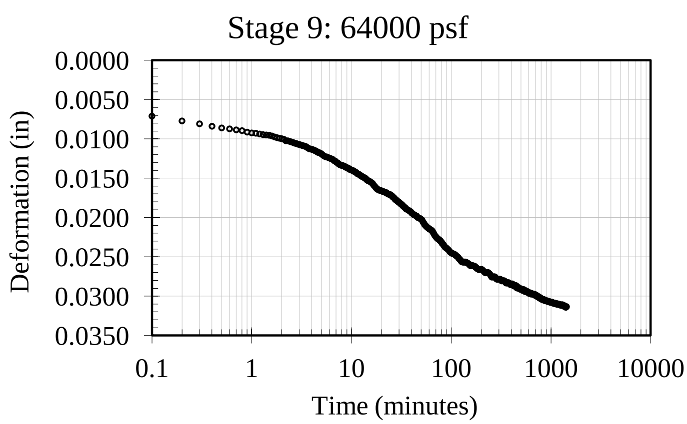
TRI Log No.: 53193.7
Test Method: ASTM D 2435, Method B

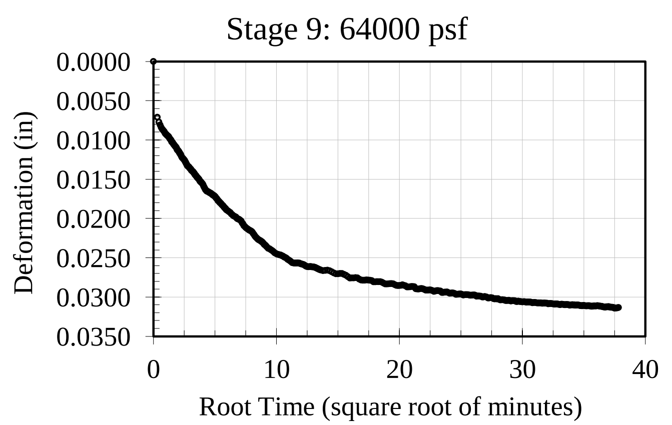








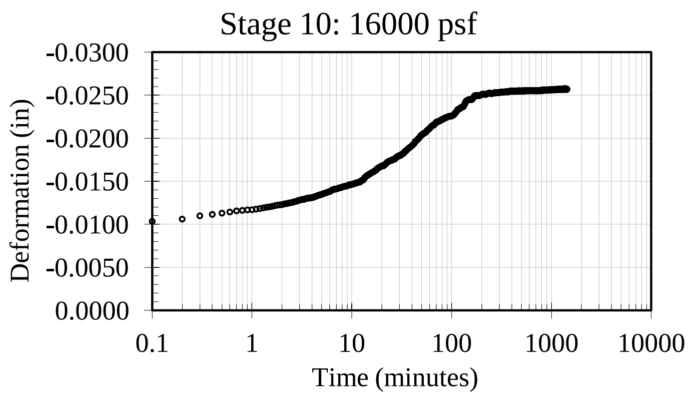


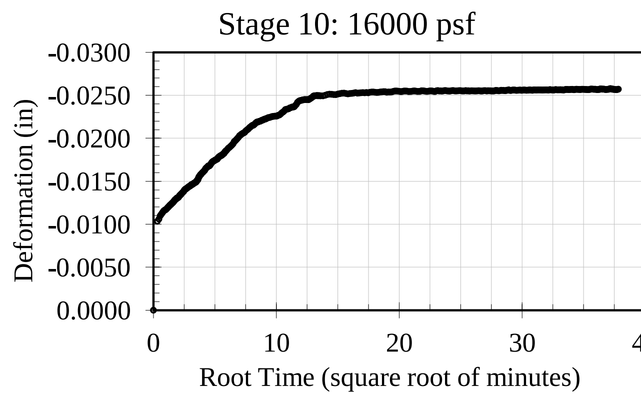


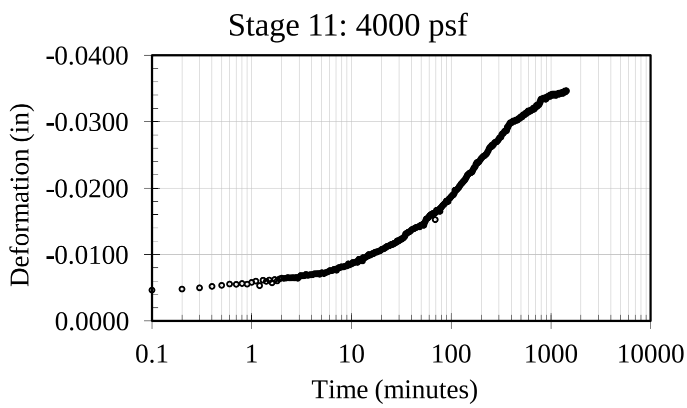
One-Dimensional Consolidation Properties of Soil

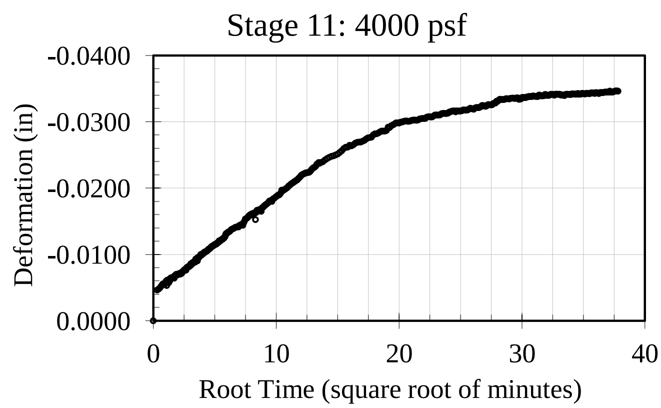
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 601-19 (13.0-15.0) ST-6

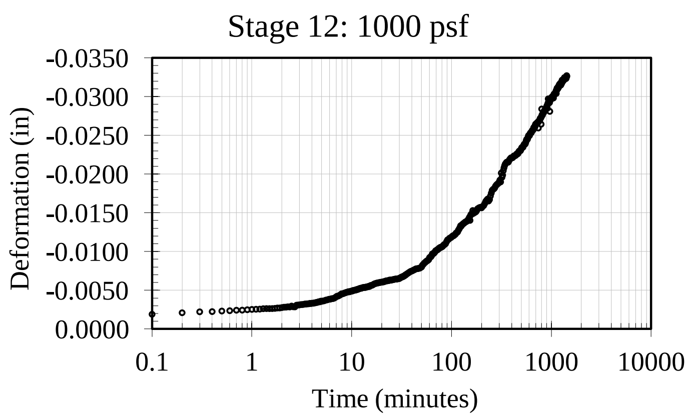
TRI Log No.: 53193.7
Test Method: ASTM D 2435, Method B

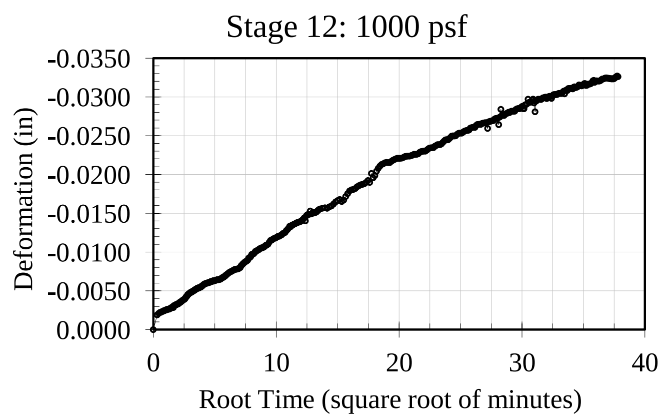












TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

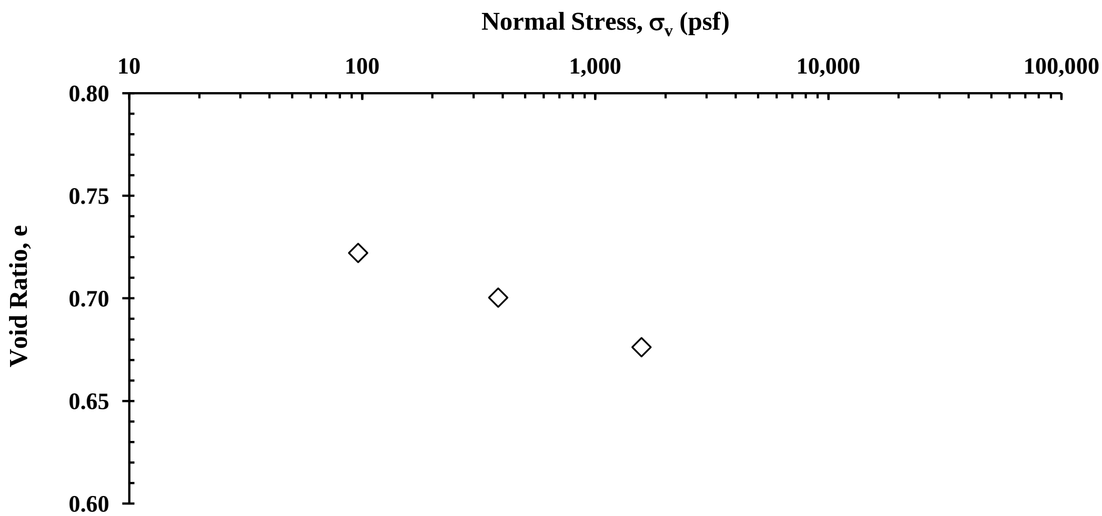
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Swell Pressure Measurement with Multistage Unloading

Client:	AECOM	TRI Log #:	53193.7
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D4546-B MOD
Specimen:	601-19 (13.0-15.0) ST-6		

Stage	Initial[1,2]	Normal Stress (psf)[3,4]				
Normal Stress (psf)	120	1,578	383	96	-	-
Water Content, ω (%)	21.4	-	-	25.4	-	-
Diameter, d (in)	2.499	-	-	-	-	-
Height, h (in)	1.006	1.006	1.021	1.034	-	-
Total Unit Weight (pcf)	124.2	-	-	124.2	-	-
Dry Unit Weight (pcf)	102.3	-	-	102.3	-	-
Void Ratio, e	0.676	0.676	0.700	0.722	-	-
$\Delta e / \Delta \log(\sigma)$	-	-	-0.039	-0.036	-	-
Degree of Saturation, S (%)	83.9	-	-	-	-	-
Strain (%)[3,4]	0.000	0.000	-1.442	-2.741	-	-

1. The intact sample was provided by the client. A specimen was trimmed from the sample using a trimming turntable and mounted. Gs was assumed to be 2.75. Calculations include measured machine deflections.
2. In the specimen ring.
3. Sign convention: (+) Compression/Collapse, (-) Expansion/Swell
4. Modification: The initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. Following the measurement of the swell pressure the sample was subsequently unloaded in stages.



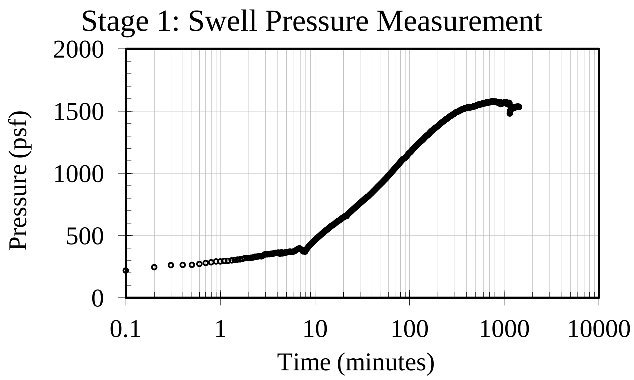
Jeffrey A. Kuhn, Ph.D., P.E. 3/22/2021

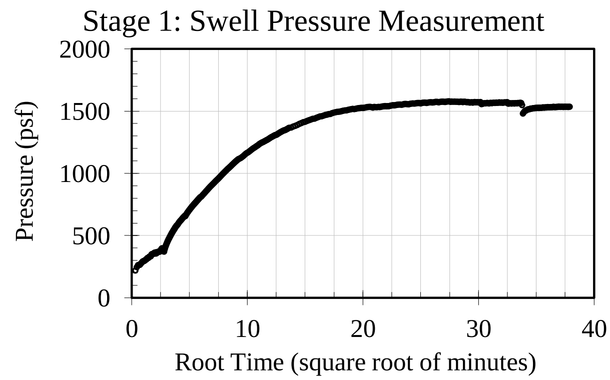
Analysis & Quality Review/Date

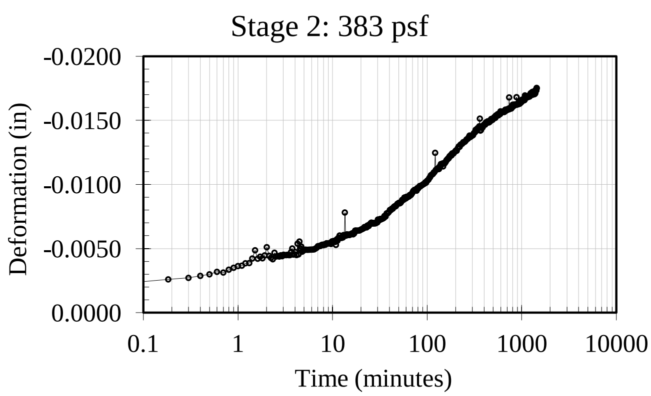
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

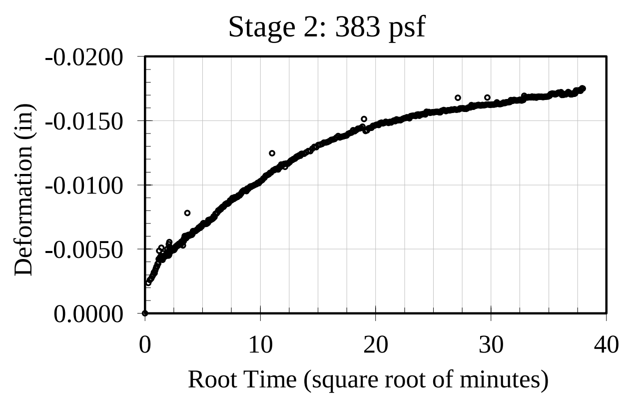
Swell Pressure Measurement with Multistage Unloading

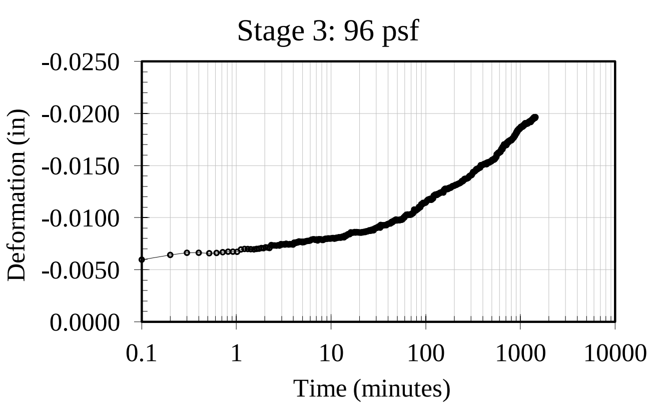
Client:	AECOM	TRI Log #:	53193.7
Project:	60615067-1.4.14 Plum Creek 2	Test Method:	ASTM D4546-B MOD
Specimen:	601-19 (13.0-15.0) ST-6		

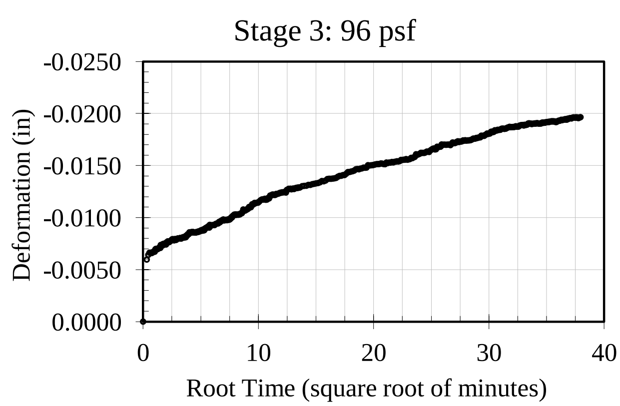








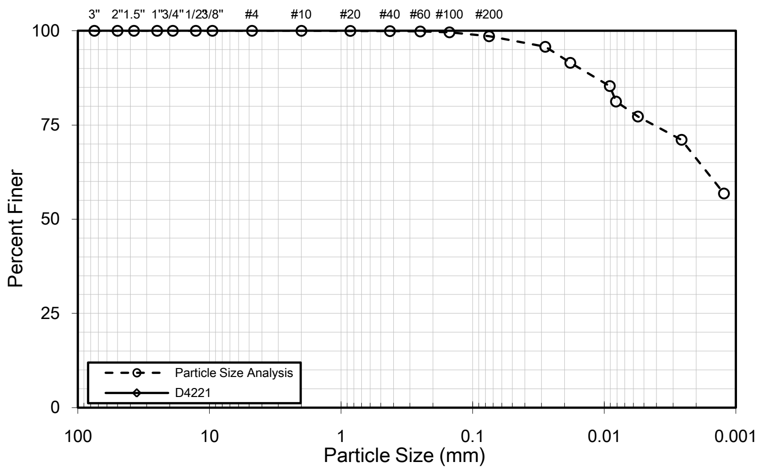


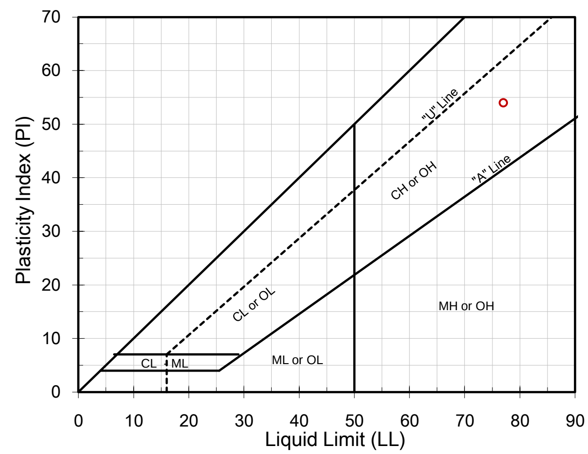


Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 601-19 (18.0-20.0) P-7

TRI Log #: 53193.8





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.0	0.028	95.7	- -	- -
2 in.	50.8	100.0		0.018	91.5	- -	- -
1.5 in.	38.1	100.0		0.009	85.3	- -	- -
1 in.	25.4	100.0		0.008	81.2	- -	- -
3/4 in.	19.0	100.0		0.006	77.2	- -	- -
1/2 in.	12.7	100.0		0.003	71.1	- -	- -
3/8 in.	9.51	100.0		0.001	56.8	- -	- -
No. 4	4.76	100.0	1.5	Log-Linear Interpolation			
No. 10	2.00	100.0		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	100.0		mm		mm	
No. 40	0.420	99.9					
No. 60	0.250	99.8		0.005	76.4	0.005	- -
No. 100	0.149	99.6		0.002	66.2	0.002	- -
No. 200	0.074	98.5	98.5	N m,2μm,d	66	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	1.5E-03	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	3.7	(0.05-0.002)	30.1	(< 0.002 mm)	66.2

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	77
Plastic Limit	23
Plastic Index	54
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	22.4
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021
Analysis & Quality Review/Date

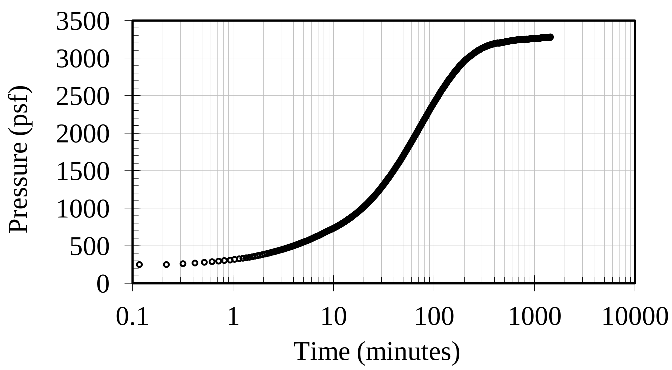
One-Dimensional Consolidation Properties of Soil

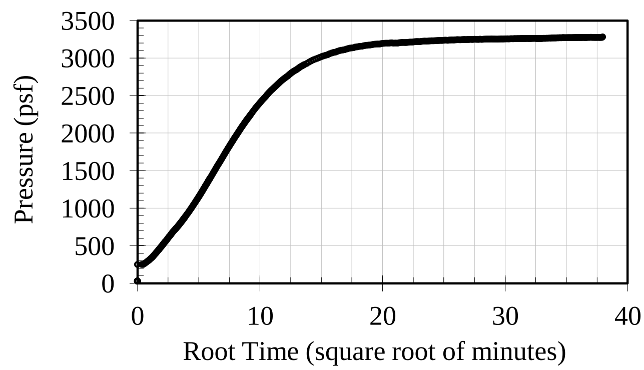
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 601-19 (18.0-20.0) P-7

TRI Log No.: 53193.8
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	17.6
Final Specimen Water Content (%)	22.5
Specimen Diameter (in)	2.494
Initial Specimen Height (in)	1.000
Initial Dry Unit Weight, γ_o lb_f/ft^3	106.0
Specific Gravity (Assumed)	2.75
Initial Void Ratio, e_o	0.560
Initial Degree of Saturation (%)	83.1

Swell Pressure (psf), Maximum Measured	3282





Note: The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. ***A client-prescribed seating stress pf 250 psf was utilized for testing.***

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

602-19

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Client: AECOM

Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53194

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	602-19 (0.0-2.0) P-1	15.8	-	-	-	-	-
2	602-19 (2.0-3.5) SS-2	12.6	-	-	-	-	-
3	602-19 (4.0-6.0) P-3 Layer A	18.9	-	-	-	-	-
5	602-19 (6.0-8.0) ST-4	17.3	-	-	-	-	-
6	602-19 (8.0-9.5) SS-5	17.5	-	-	-	-	-
7	602-19 (13.0-15.0) ST-6	20.6	-	-	-	-	-
8	602-19 (18.0-20.0) P-7	19.4	-	-	-	-	-
9	602-19 (23.5-25.0) SS-8	17.6	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.

9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

603-19

Client: AECOM TRI Log #: 53561
Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	603-19 (0.0-2.0) P-1	19.0	111.3	-	67	19	48
2	603-19 (2.0-3.5) SS-2	12.9	-	-	-	-	-
3	603-19 (4.0-6.0) P-3 Layer A	21.7	99.0	87.9	62	21	41
5	603-19 (6.0-7.5) SS-4	14.2	-	-	-	-	-
6	603-19 (8.0-10.0) ST-5	15.6	-	95.0	62	22	40
8	603-19 (18.5-20.0) SS-7	17.8	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53561

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO_4/kg)
-	Test Method	ASTM D516
-	Method Detection Limit (MDL)	[5 mg/l]*
1	603-19 (0.0-2.0) P-1	500
3	603-19 (4.0-6.0) P-3 Layer A	600
7	603-19 (13.0-15.0) P-6	10,900

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The sulfate MDL is volumetric. Results are mass per mass of dry soil.

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53561
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
1	603-19 (0.0-2.0) P-1	4.9	46.3	21.8	21.9	22.6	1	1	1	1
3	603-19 (4.0-6.0) P-3 Layer A	5.7	59.3	21.8	21.9	22.6	1	1	1	1
7	603-19 (13.0-15.0) P-6	4.5	56.6	21.8	21.8	22.3	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

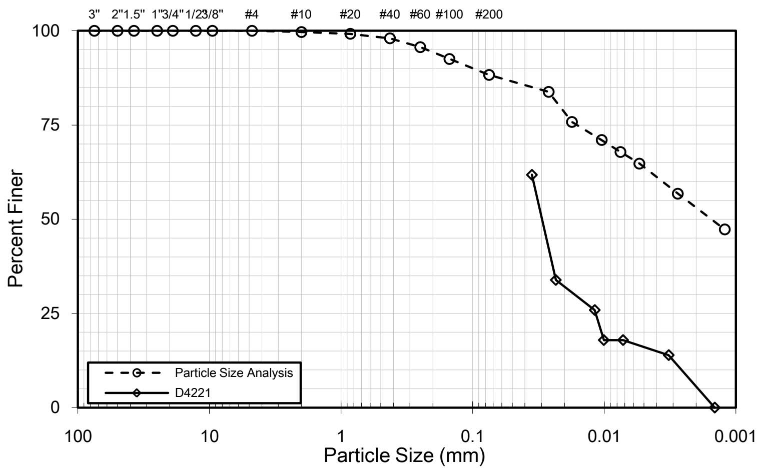
Particle Size, Atterberg Limit, and USCS Analyses for Soils

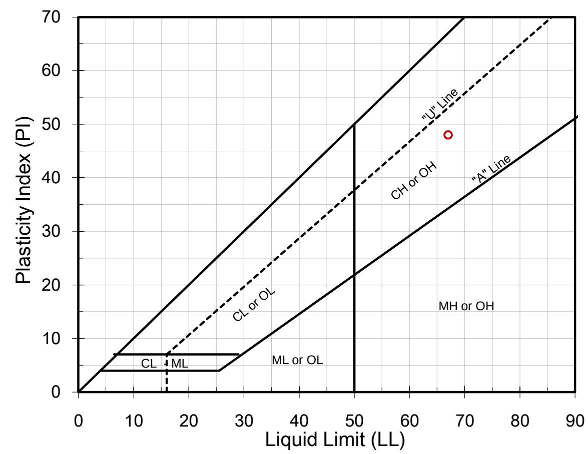
Client: AECOM

Project: 60615067 - 1.4-.14 Plum Creek 2

Sample ID: 603-19 (0.0-2.0) P-1

TRI Log #: 53561.1





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.0	0.026	83.8	0.035	61.8
2 in.	50.8	100.0		0.018	75.8	0.023	33.9
1.5 in.	38.1	100.0		0.010	71.0	0.012	25.9
1 in.	25.4	100.0		0.008	67.8	0.010	17.9
3/4 in.	19.0	100.0		0.005	64.7	0.007	17.9
1/2 in.	12.7	100.0		0.003	56.8	0.003	13.9
3/8 in.	9.51	100.0		0.001	47.3	0.001	0.0
No. 4	4.76	100.0	11.7	Log-Linear Interpolation			
No. 10	2.00	99.7		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	99.2					
No. 40	0.420	98.0		mm		mm	
No. 60	0.250	95.7		0.005	63.8	0.005	16.1
No. 100	0.149	92.5		0.002	53.1	0.002	5.6
No. 200	0.074	88.3	88.3	N m,2µm,d	53	N m,2µm,nd	6

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	1.5E-03	3.6E-03	- -	- -	11

USDA	Sand (%) (2.0-0.05 mm)		Silt (%) (0.05-0.002		Clay (%) (< 0.002 mm)	
Clay		13.6		33.1		53.3

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	67
Plastic Limit	19
Plastic Index	48
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Fat clay (CH)

Moisture Content (%)	ASTM D2216	19.0
Organic Content (%)	ASTM D2974-C	5.4
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021

Analysis & Quality Review/Date

TRI Environmental, Inc.

9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

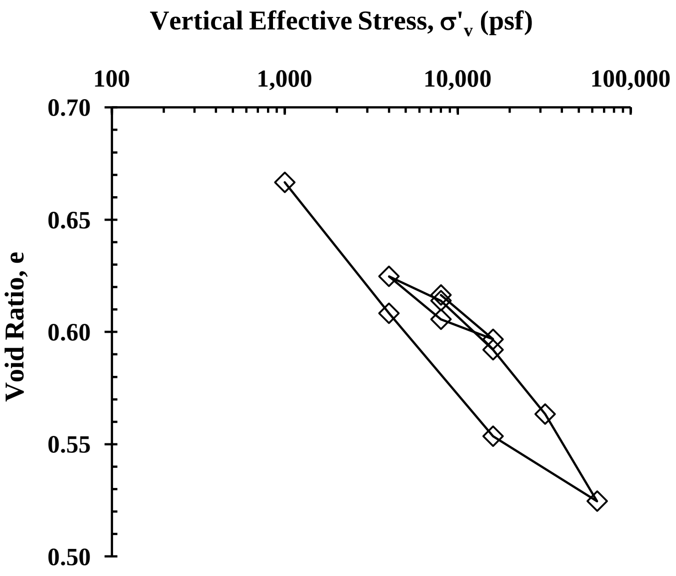
One-Dimensional Consolidation Properties of Soil

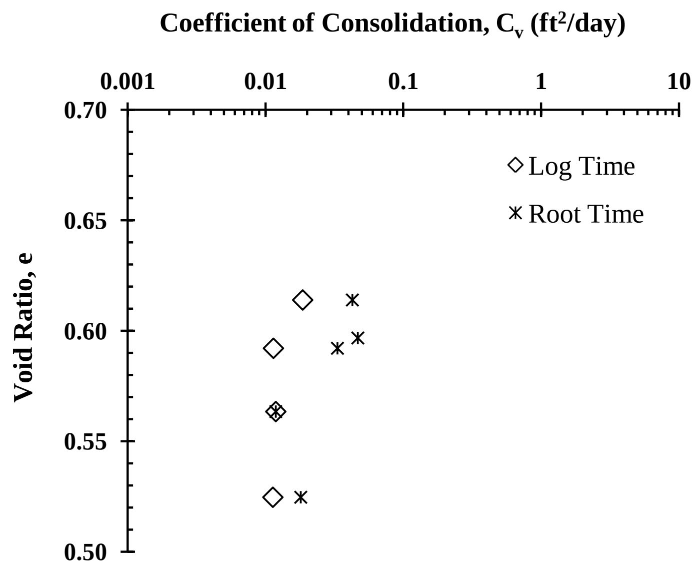
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 603-19 (8.0-10.0) ST-5

TRI Log No.: 53561.6
Test Method: ASTM D 2435, Method B

Soil Specimen Properties		
Initial Specimen Water Content (%)		20.2
Final Specimen Water Content (%)		23.2
Specimen Diameter (in)		2.496
Initial Specimen Height (in)		0.996
Final Specimen Height (in)		1.022
Final Differential Height (in)		-0.026
Initial Dry Unit Weight, γ_o lb_f/ft^3		101.8
Final Dry Unit Weight, γ_f lb_f/ft^3		99.2
Specific Gravity (Assumed)		2.75
Initial Void Ratio, e_o		0.624
Final Void Ratio, e_f		0.667
Initial Degree of Saturation (%)		85.6
Preconsolidation Pressure (psf)		≈16200
Swell Pressure (psf), Maximum Measured		5200
Compression Index, C_c	Min	-
	Max	0.129
Recompression Index, C_r	Min	0.036
	Max	0.073

Stage	σ'$_v$	e	Strain, ε	C_v (ft^2/day)	
(#)	(psf)	(-)	(%)	Log Time	Root Time
1	5,200	0.624	0.0	-	-
2	8,000	0.616	0.5	-	-
3	16,000	0.597	1.7	-	4.7E-02
4	8,000	0.606	1.1	-	-
5	4,000	0.625	0.0	-	-
6	8,000	0.614	0.6	1.9E-02	4.3E-02
7	16,000	0.592	2.0	1.1E-02	3.3E-02
8	32,000	0.563	3.7	1.2E-02	1.2E-02
9	64,000	0.525	6.1	1.1E-02	1.8E-02
10	16,000	0.554	4.3	-	-
11	4,000	0.608	1.0	-	-
12	1,000	0.667	-2.6	-	-
13	-	-	-	-	-
14	-	-	-	-	-
15	-	-	-	-	-





The intact sample was provided by the client. A specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. Coefficient of Consolidation was determined using the Log Time and Root Time Methods. Calculations include machine deflections measured at each loading step. The preconsolidation pressure was determined using the Casagrande construction technique.

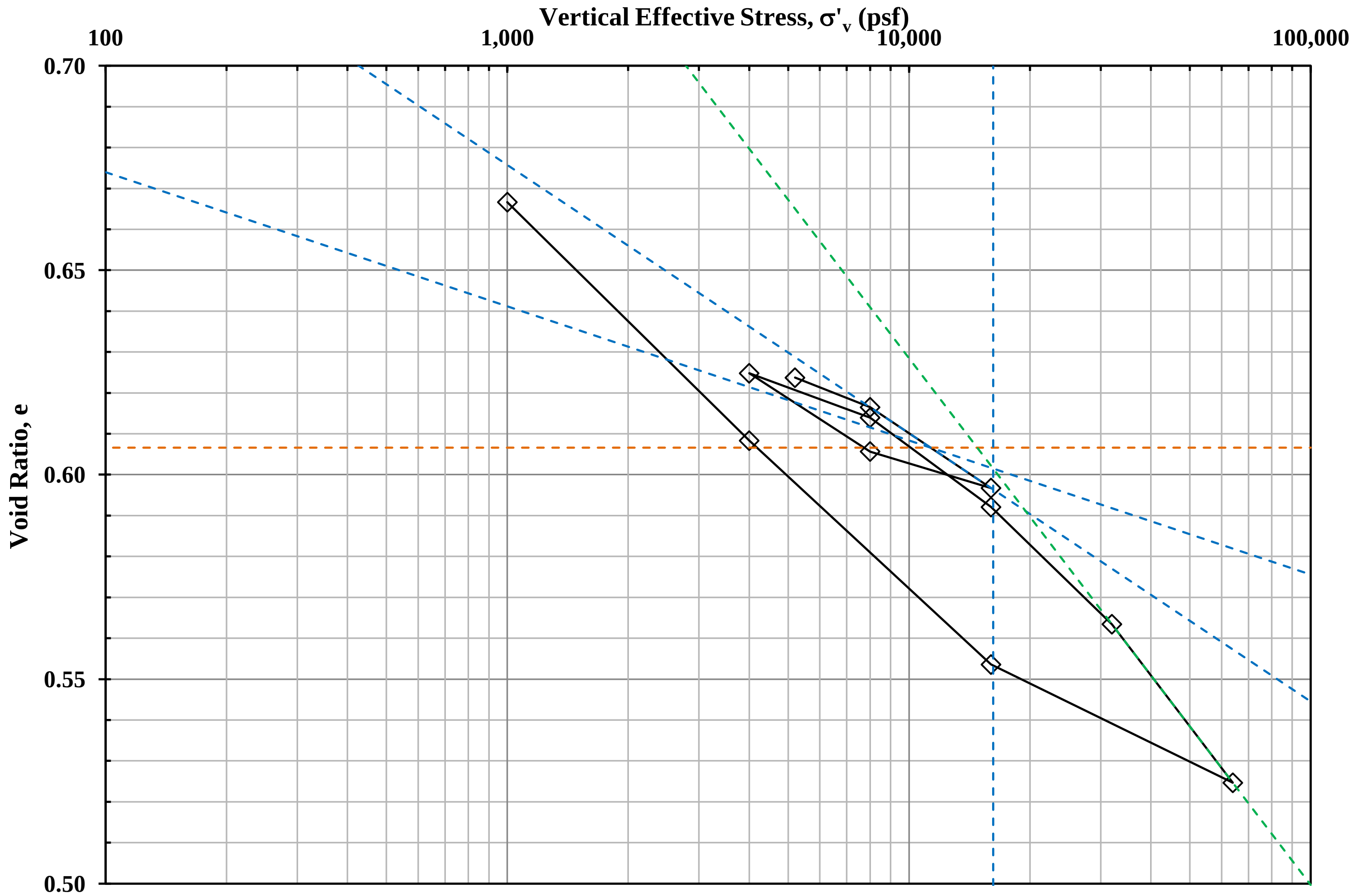
Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

One-Dimensional Consolidation Properties of Soil

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 603-19 (8.0-10.0) ST-5

TRI Log No.: 53561.6
Test Method: ASTM D 2435, Method B



Stage (#)	σ'v (psf)	log (σ'v) log (psf)	e (-)	δlog (σ'v) / δe
1	5,200	3.72	0.624	-
2	8,000	3.90	0.616	0.039
3	16,000	4.20	0.597	0.066
4	8,000	3.90	0.606	-
5	4,000	3.60	0.625	-
6	8,000	3.90	0.614	0.036
7	16,000	4.20	0.592	0.073
8	32,000	4.51	0.563	0.095
9	64,000	4.81	0.525	0.129
10	16,000	4.20	0.554	-

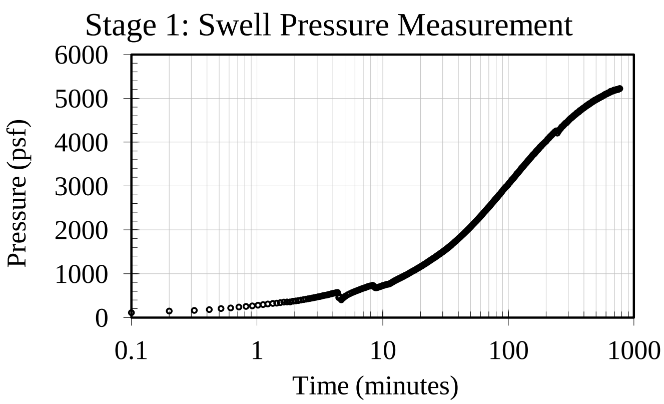
Stage (#)	σ'v (psf)	log (σ'v) log (psf)	e (-)	δlog (σ'v) / δe
11	4,000	3.60	0.608	-
12	1,000	3.00	0.667	-
13	-	-	-	-
14	-	-	-	-
15	-	-	-	-
16	-	-	-	-
17	-	-	-	-
18	-	-	-	-
19	-	-	-	-
20	-	-	-	-

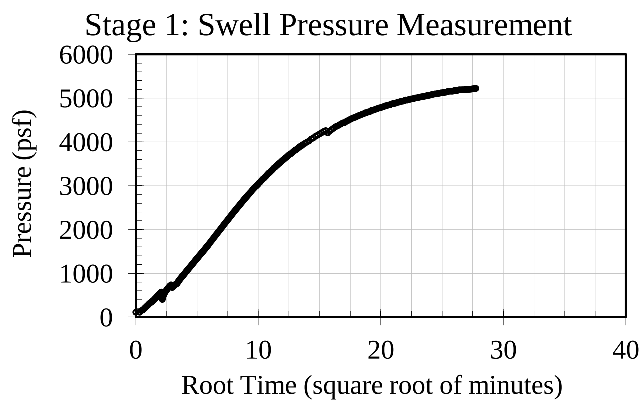
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

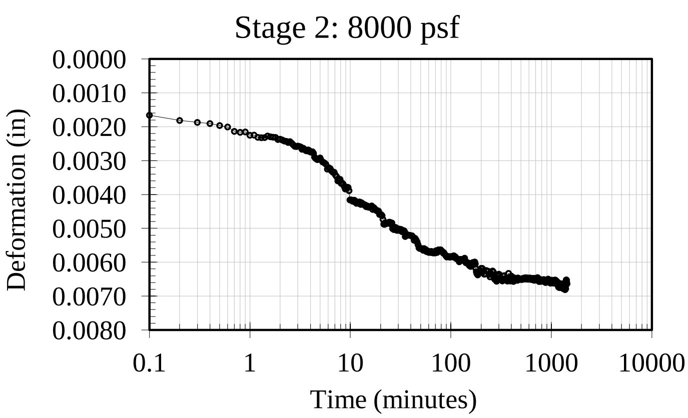
One-Dimensional Consolidation Properties of Soil

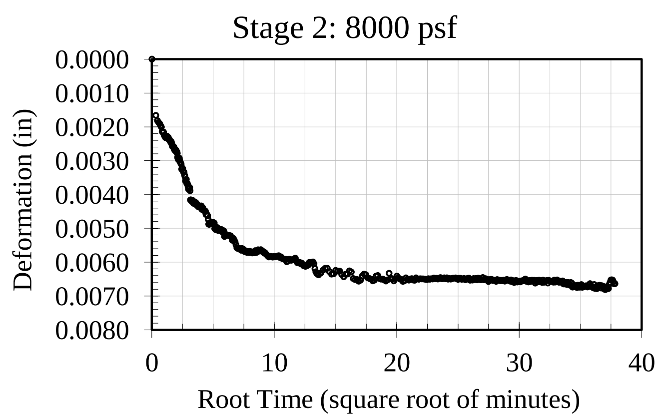
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 603-19 (8.0-10.0) ST-5

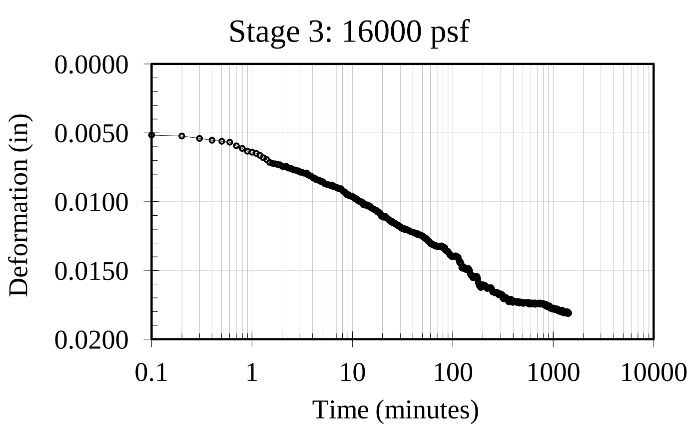
TRI Log No.: 53561.6
Test Method: ASTM D 2435, Method B

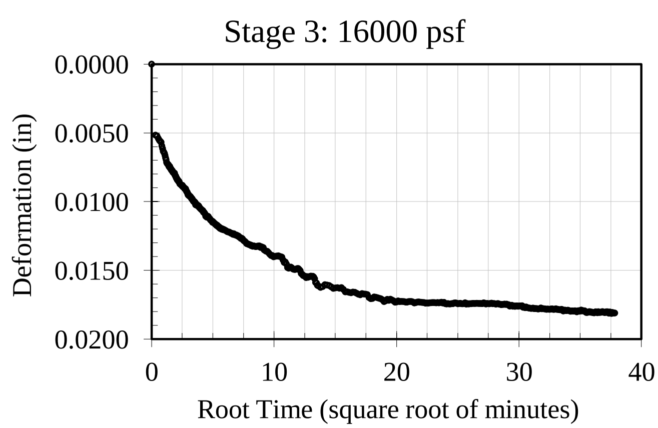












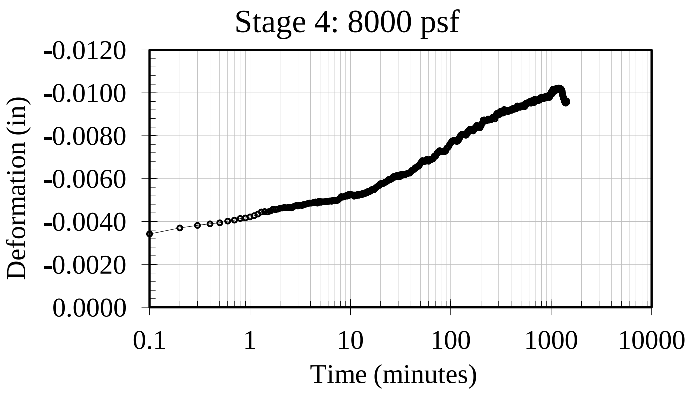
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

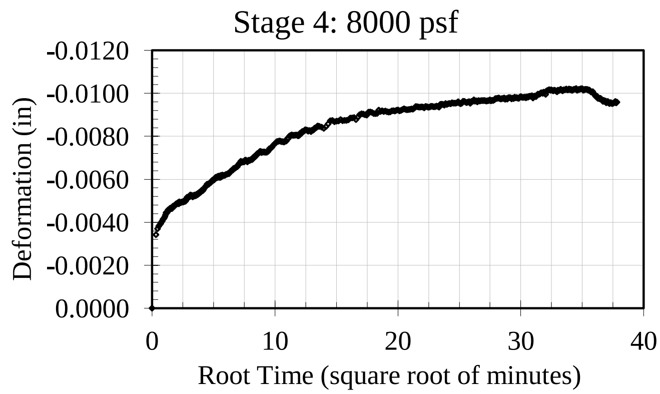
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

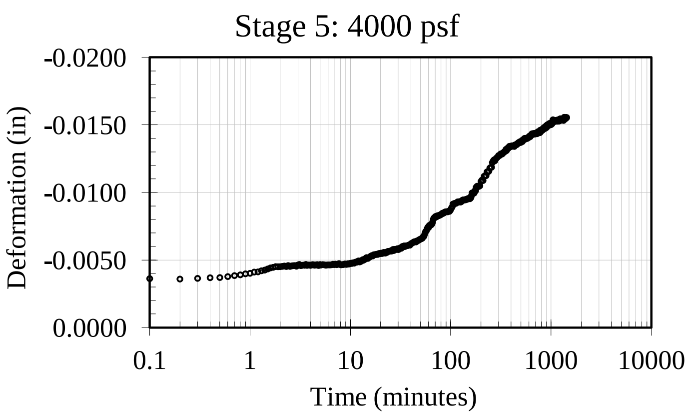
One-Dimensional Consolidation Properties of Soil

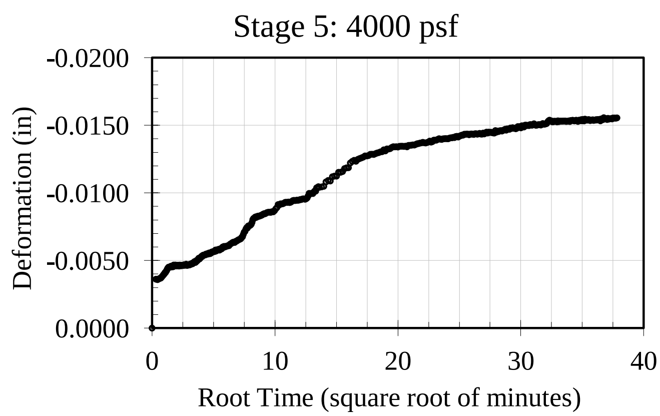
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 603-19 (8.0-10.0) ST-5

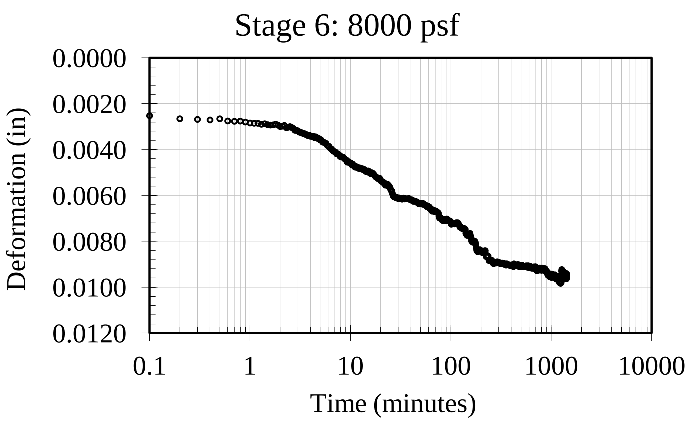
TRI Log No.: 53561.6
Test Method: ASTM D 2435, Method B

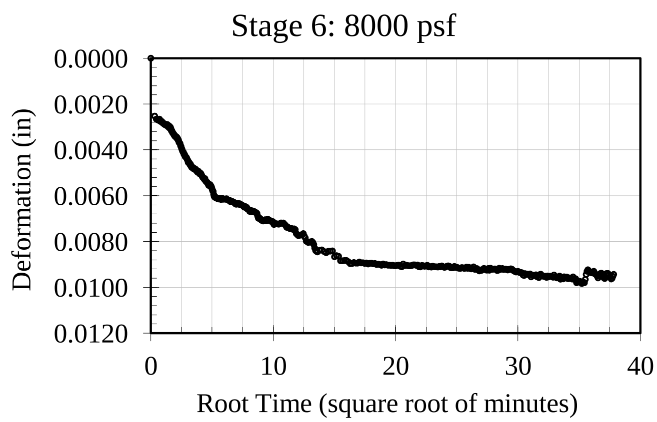










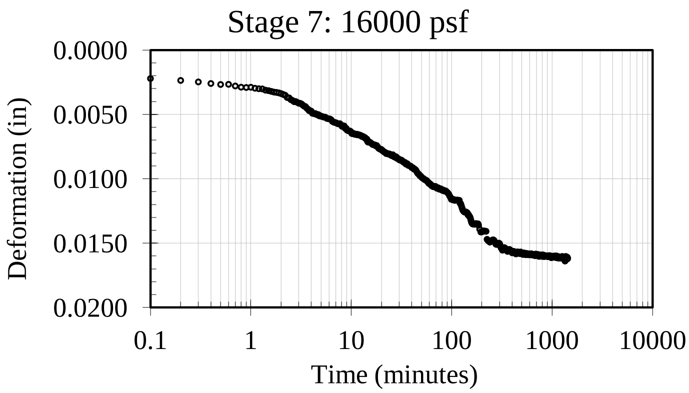


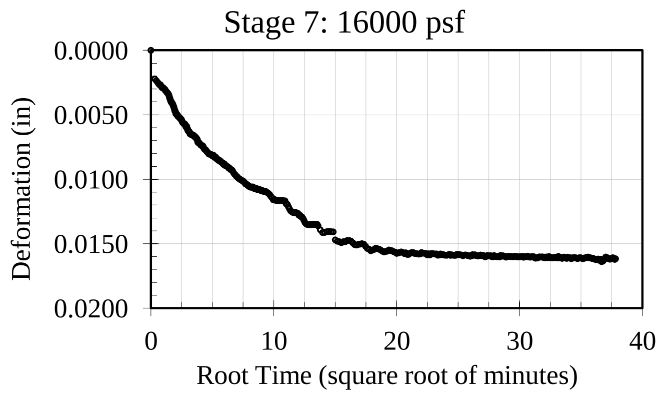
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

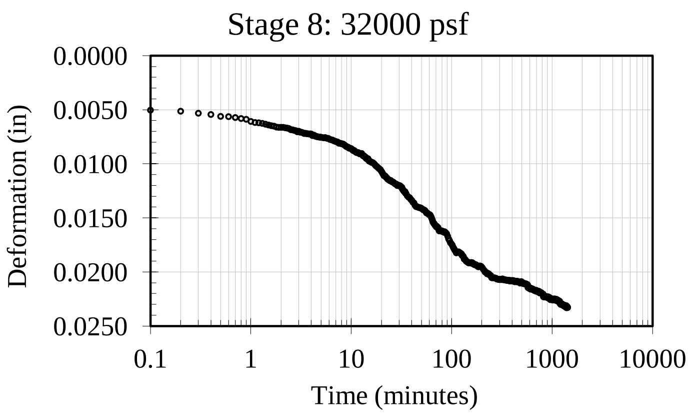
One-Dimensional Consolidation Properties of Soil

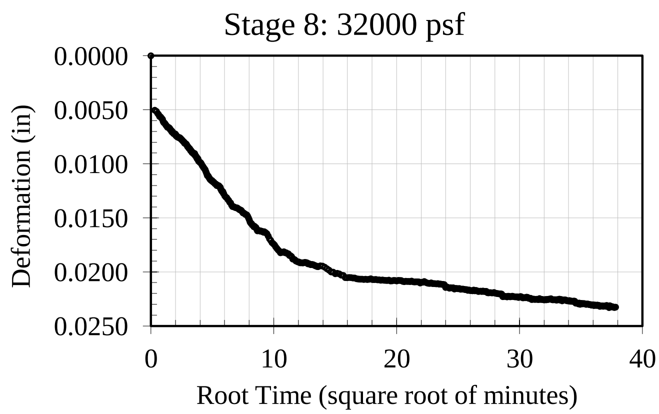
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 603-19 (8.0-10.0) ST-5

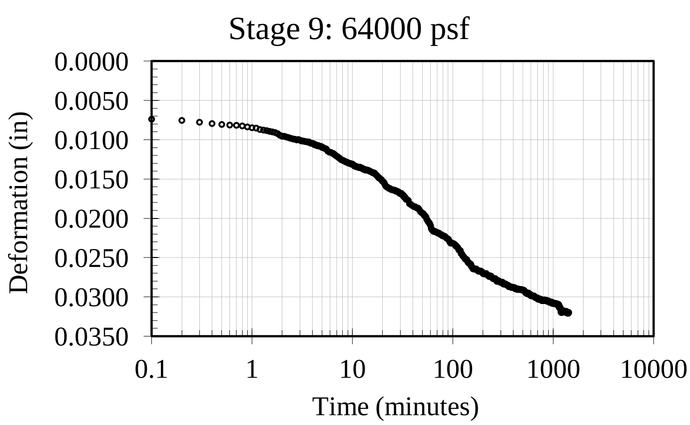
TRI Log No.: 53561.6
Test Method: ASTM D 2435, Method B

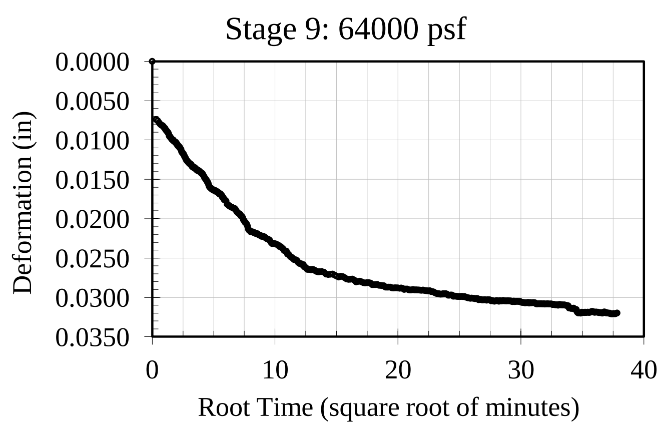








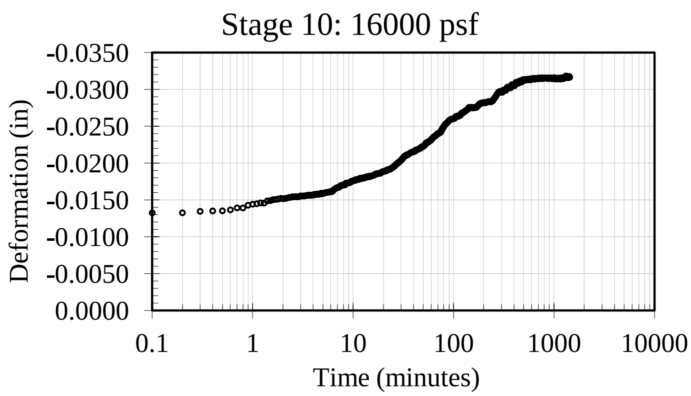


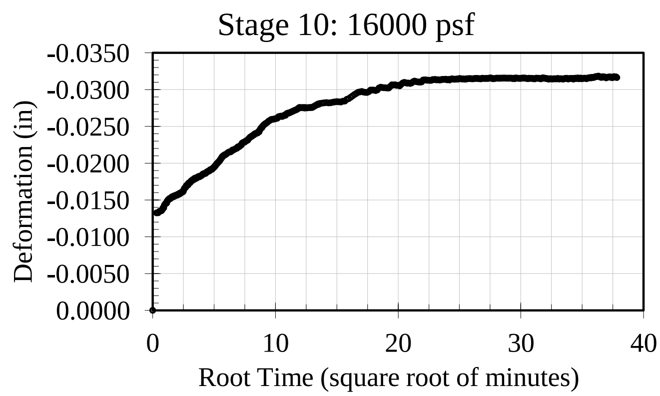


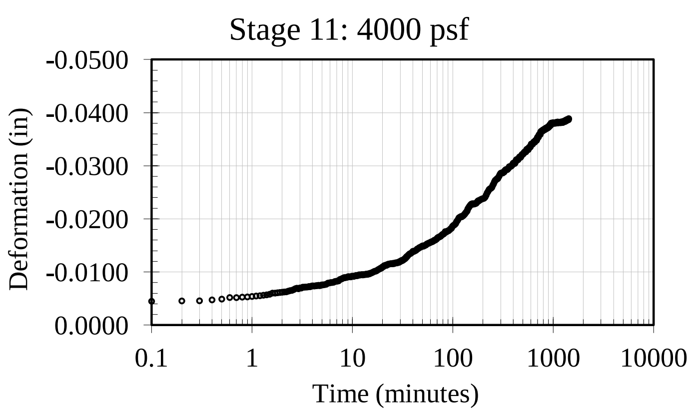
One-Dimensional Consolidation Properties of Soil

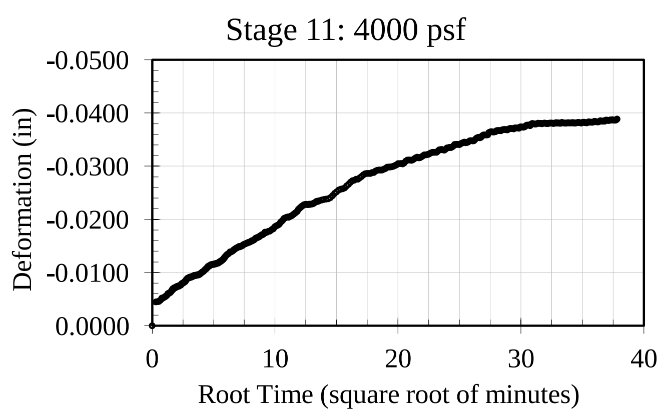
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 603-19 (8.0-10.0) ST-5

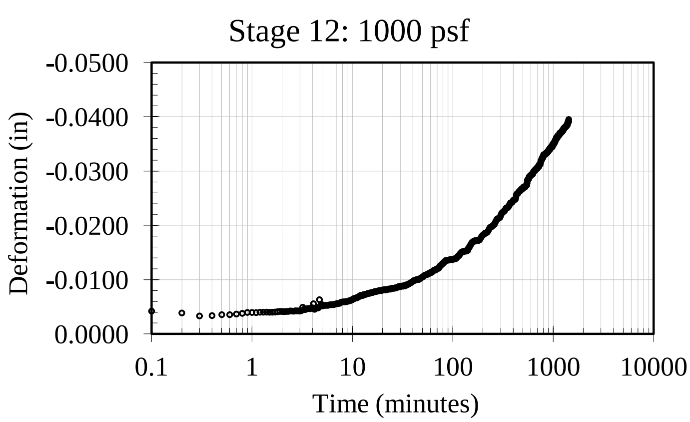
TRI Log No.: 53561.6
Test Method: ASTM D 2435, Method B

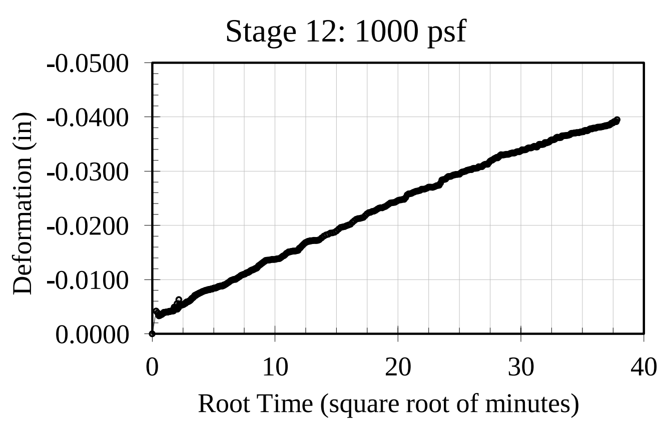












TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

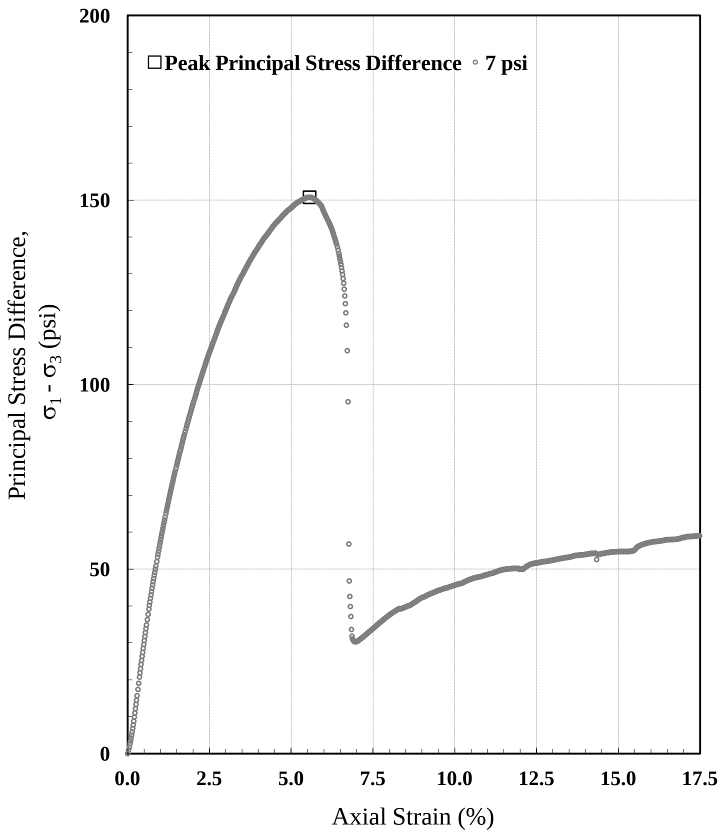
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconsolidated-Undrained (Q) Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 603-19 (8.0-10.0) ST-5

TRI Log #: 53561.6
Test Method: ASTM D2850



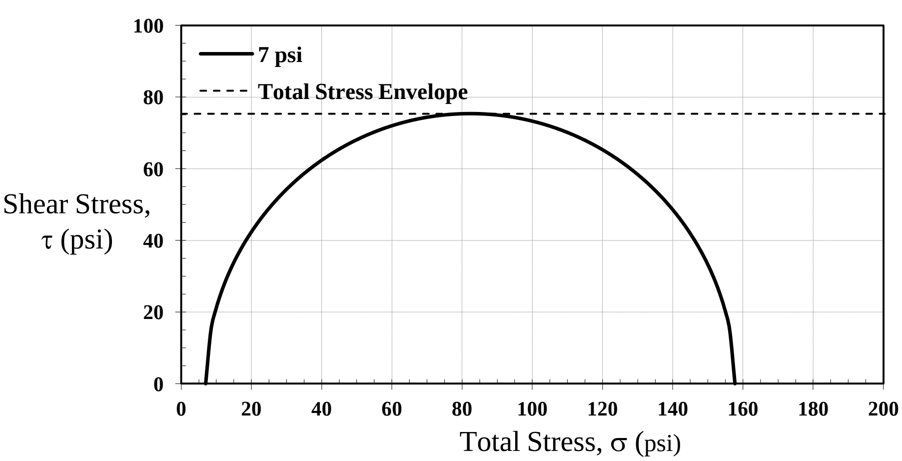
Test Parameters	
Minor Principal Stress (psi)	7.0
Rate of Strain (%/hr)	60

Initial Properties	
Avg. Diameter (in)	2.77
Avg. Height (in)	5.71
Avg. Water Content (%)	20.1
Bulk Density (pcf)	129.4
Dry Density (pcf)	107.7
Saturation (%)	94.2
Void Ratio	0.58
Specific Gravity (Assumed)	2.73

At Failure - Maximum Deviator Stress	
Axial Strain at Failure (%)	5.6
Minor Total Stress (psi)	7.0
Major Total Stress (psi)	157.8
Principal Stress Diff. (psi)	150.8

Total Stress Envelope	
Friction Angle (deg)	0
Undrained Shear Strength, S_u (psi)	75.4
S_u / σ_3	10.8

Note: The calculated value of specimen saturation was less than 95%. The Mohr failure envelope was taken as a horizontal straight line, but noting that the calculated value of saturation indicates a partially saturated specimen.



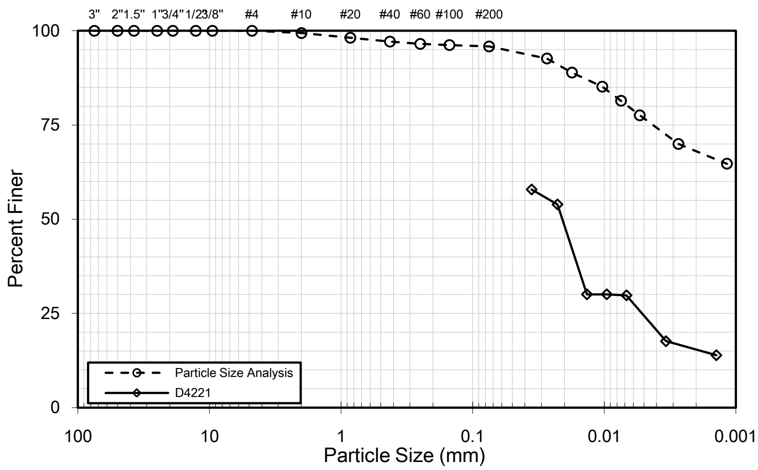
Jeffrey A. Kuhn , Ph.D., P.E., 3/22/2021

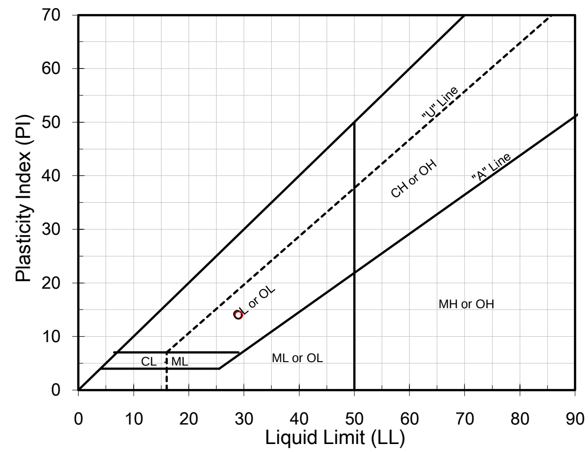
Analysis & Quality Review/Date

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client: AECOM
Project: 60615067 - 1.4-.14 Plum Creek 2
Sample ID: 603-19 (13.0-15.0) P-6

TRI Log #: 53561.7





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel	Particle Size	Percent Passing	Particle Size	Percent Passing
			Sand				
-	mm		Fines	mm		mm	
3 in.	76.2	100.0	0.0	0.027	92.6	0.036	57.9
2 in.	50.8	100.0		0.018	88.9	0.023	53.9
1.5 in.	38.1	100.0		0.010	85.2	0.014	30.1
1 in.	25.4	100.0		0.007	81.4	0.010	30.1
3/4 in.	19.0	100.0		0.005	77.6	0.007	29.8
1/2 in.	12.7	100.0		0.003	70.0	0.003	17.6
3/8 in.	9.51	100.0		0.001	64.7	0.001	13.9
No. 4	4.76	100.0	4.2	Log-Linear Interpolation			
No. 10	2.00	99.4		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	98.1					
No. 40	0.420	97.1		mm		mm	
No. 60	0.250	96.5		0.005	76.8	0.005	24.4
No. 100	0.149	96.2		0.002	68.1	0.002	15.4
No. 200	0.074	95.8	95.8	N m,2μm,d	68	N m,2μm,nd	15

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	- -	- -	- -	- -	22

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	5.8	(0.05-0.002	25.7	(< 0.002 mm)	68.5

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	29
Plastic Limit	15
Plastic Index	14
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Lean clay (CL)

Moisture Content (%)	ASTM D2216	21.1
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021
Analysis & Quality Review/Date

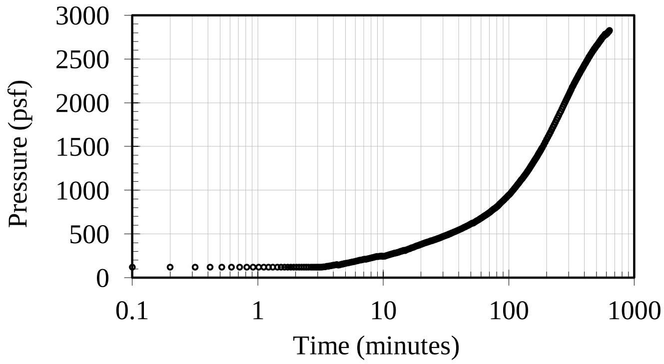
One-Dimensional Consolidation Properties of Soil

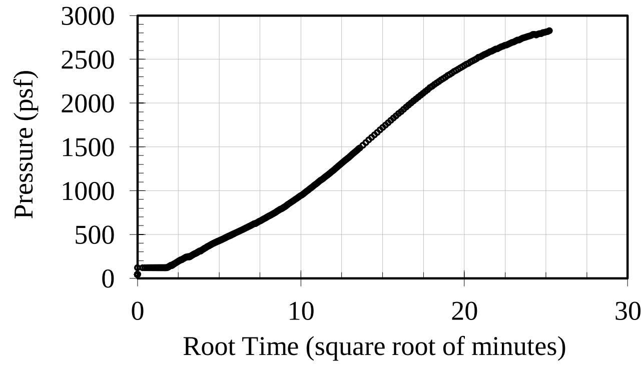
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 603-19 (13.0-15.0) P-6

TRI Log No.: 53561.7
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	20.3
Final Specimen Water Content (%)	24.7
Specimen Diameter (in)	2.497
Initial Specimen Height (in)	1.003
Initial Dry Unit Weight, γ_o lb_f/ft^3	99.1
Specific Gravity (Assumed)	2.75
Initial Void Ratio, e_o	0.668
Initial Degree of Saturation (%)	80.4

Swell Pressure (psf), Maximum Measured	2826





Note: The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. ***A seating stress of 120 psf was utilized for testing.***

Jeffrey A. Kuhn, Ph.D., P.E., 3/21/2021
Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

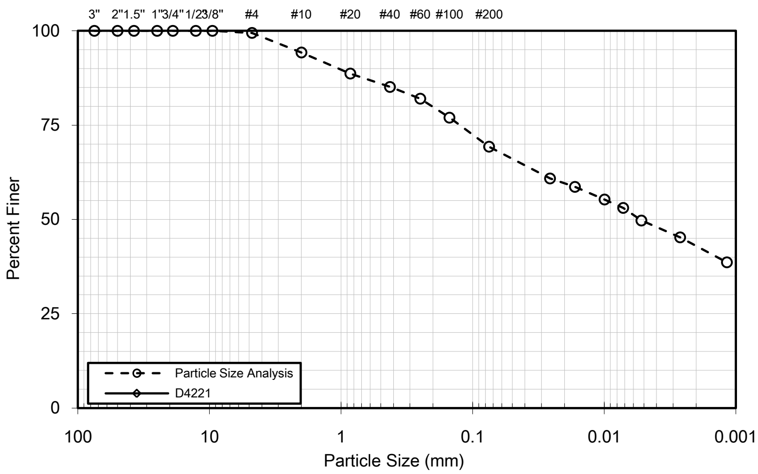
Particle Size, Atterberg Limit, and USCS Analyses for Soils

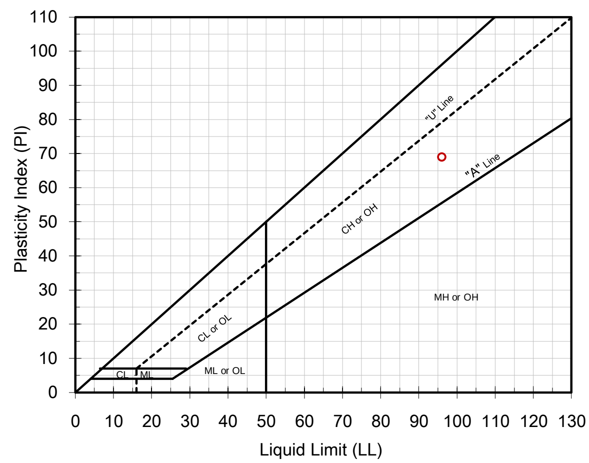
Client: AECOM

Project: 60615067 - 1.4-.14 Plum Creek 2

Sample ID: 603-19 (23.5-25.0) SS-8

TRI Log #: 53561.9





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.5	0.026	60.9	- -	- -
2 in.	50.8	100.0		0.017	58.6	- -	- -
1.5 in.	38.1	100.0		0.010	55.3	- -	- -
1 in.	25.4	100.0		0.007	53.0	- -	- -
3/4 in.	19.0	100.0		0.005	49.7	- -	- -
1/2 in.	12.7	100.0		0.003	45.2	- -	- -
3/8 in.	9.51	100.0		0.001	38.6	- -	- -
No. 4	4.76	99.5	30.2	Log-Linear Interpolation			
No. 10	2.00	94.3		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	88.7					
No. 40	0.420	85.1		mm		mm	
No. 60	0.250	82.0		0.005	49.4	0.005	- -
No. 100	0.149	77.0		0.002	43.0	0.002	- -
No. 200	0.074	69.3	69.3	N m,2μm,d	43	N m,2μm,nd	-

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	5.4E-03	2.2E-02	- -	- -	-

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	30.1	(0.05-0.002	24.3	(< 0.002 mm)	45.6

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	96
Plastic Limit	27
Plastic Index	69
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Sandy fat clay (CH)

Moisture Content (%)	ASTM D2216	4.2
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021

Analysis & Quality Review/Date

604-19

Client: AECOM

TRI Log #: 52916

Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 1/19/2021

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	604-19 (0.0-2.0) P-1	19.1	-	-	-	-	-
2	604-19 (2.0-3.5) SS-2	8.4	-	-	-	-	-
3	604-19 (4.0-6.0) ST-3	11.0	-	-	-	-	-
4	604-19 (6.0-8.0) P-4	10.7	-	-	-	-	-
5	604-19 (8.5-10.0) SS-5	12.5	-	-	-	-	-
6	604-19 (13.5-15.0) P-6	19.0	-	-	-	-	-
7	604-19 (18.0-20.0) P-7	20.0	-	-	-	-	-
8	604-19 (23.5-25.0) SS-8	7.4	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

605-19

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 53563

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)
-	Test Method	ASTM D2216
1	605-19 (0.0-2.0) P-1	18.3
2	605-19 (2.0-3.5) SS-2	11.7
3	605-19 (4.0-6.0) ST-1	14.1
4	605-19 (6.0-8.0) P-4	16.5
5	605-19 (8.0-9.5) SS-5	14.8
6	605-19 (13.0-15.0) ST-6	18.7
7	605-19 (18.0-20.0) P-7	17.3
8	605-19 (23.5-25.0) SS-8	18.4

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

701-19

Client: AECOM TRI Log #: 59917

Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021

Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	701-20 (0-2) P-1	22.1	-	-	-	-	-
2	701-20 (2-4) ST-2	-	-	-	51	20	31
3	701-20 (4-5.5) SS-3	10.3	-	-	-	-	-
4	701-20 (6-8) ST-4	-	-	-	57	19	38
5	701-20 (8-10) P-5	11.6	-	-	-	-	-
6	701-20 (13-15) ST-6	25.4	-	-	-	-	-
7	701-20 (18-19.5) SS-7	24.1	-	-	-	-	-
8	701-20 (23-25) ST-8	-	-	-	66	22	44
9	701-20 (28-29.5) SS-9	18.4	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

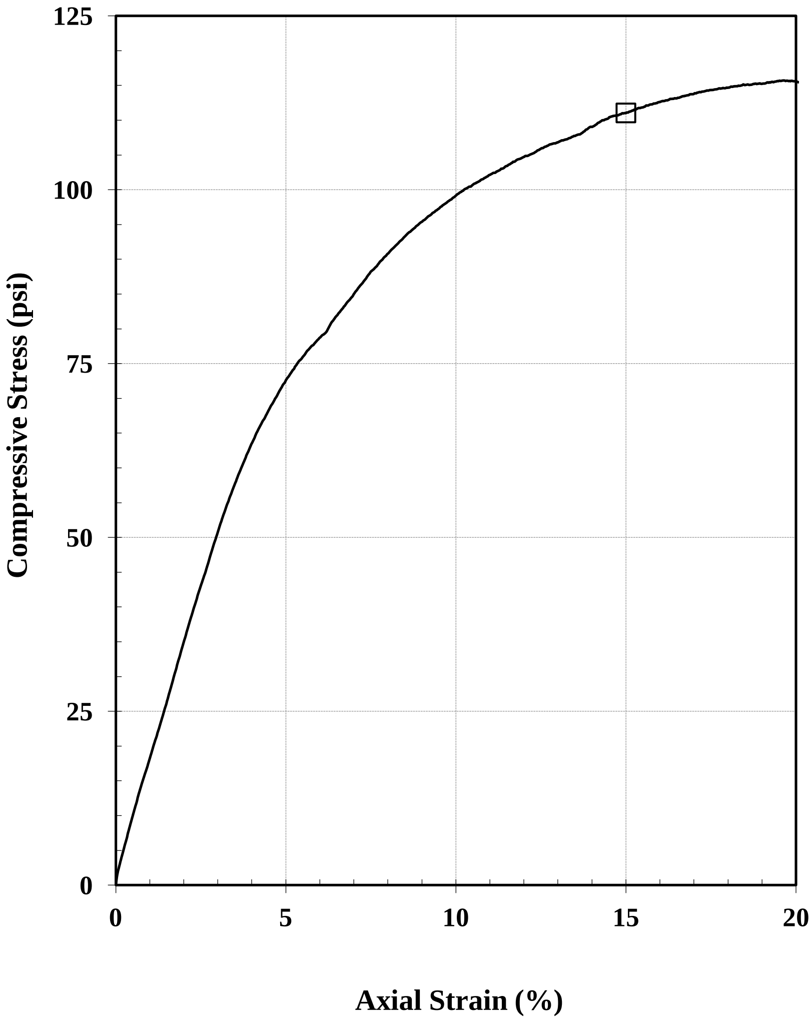
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

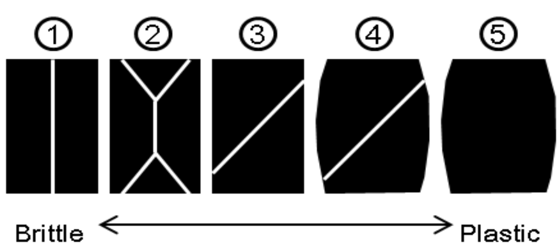
Client:	AECOM	TRI Log No.:	59917.2
Project:	60615067-1.4.14 Plum Creek 2	Type of Specimen:	Intact
Sample ID:	701-20 (2-4) ST-2	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.73
Avg. Height (in)	H_o	5.55
Avg, Water Content (%)	w_o	18.3
Bulk Density (pcf)	γ_{total}	130.7
Dry Density (pcf)	γ_{dry}	110.5
Saturation (%)	S_r	88.8
Void Ratio	e_o	0.55
Assumed Specific Gravity	G_s	2.75

Stresses at Failure	
Unconfined Compressive Strength (psi)	111.0
Axial Strain at Failure (%)	15.0
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	111.0
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	55.5

Failure Mode	4



(Kuhn after Nygård et. Al 2005)

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/21

Quality Review/Date

TRI Environmental, Inc.

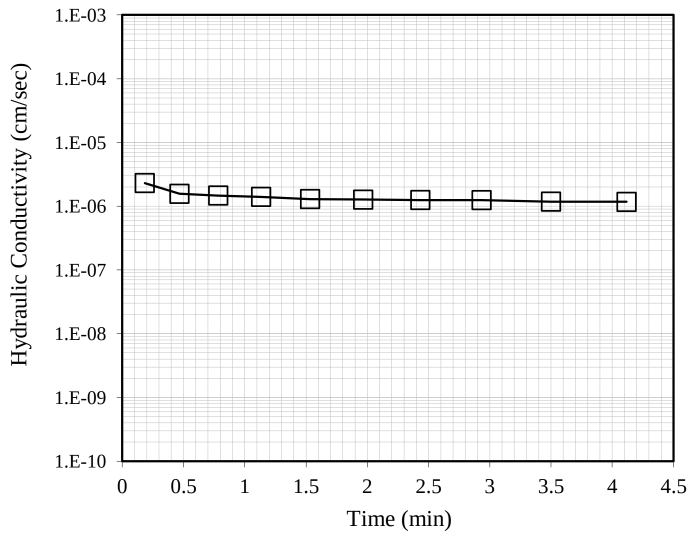
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Hydraulic Conductivity

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: 701-20 (6-8) ST-4

TRI Log #: 59917.4
Test Method: ASTM D5084

Sample Condition	Initial	Final
	Undisturbed	Post-Test
Diameter (in)	2.71	2.73
Height (in)	3.44	3.48
Mass (g)	726.5	740.0
Sample Area (in^2)	5.79	5.86
Water Content (%)	11.2	15.5
Total Unit Weight (pcf)	138.8	138.2
Dry Unit Weight (pcf)	124.8	119.7
Specific Gravity (Assumed)	2.75	
Degree of Saturation	82.2	98.2
Void Ratio	0.38	0.43
Porosity	0.27	0.30
1 Pore Volume (cc)	89.2	101.0



Eff. Confining Stress (psi)	3.0
Back-Pressure	80.0
B-Value Prior to Permeation	0.99
Permeant	De-Aired Tap Water

Method F—Constant Volume–Falling Head by mercury, rising tailwater elevation			
Manometer Constants		Aa (cm^2)	0.767
M1	0.0302	Ap (cm^2)	0.0314
M2	1.041	Z_p (cm)	1.7
Time, t	Trial Constant, Z_1	Gradient	K_{20}
Min	-	-	cm/s
0.5	22.2	31.8	1.6E-06
0.8	21.1	30.3	1.5E-06
1.1	20.1	28.8	1.4E-06
1.5	19.0	27.3	1.3E-06
2.0	18.0	25.8	1.3E-06
2.4	17.0	24.3	1.3E-06
2.9	15.9	22.8	1.2E-06
3.5	14.9	21.4	1.2E-06
4.1	13.8	19.9	1.2E-06
Average, Last 2 Readings			**1.2E-06**

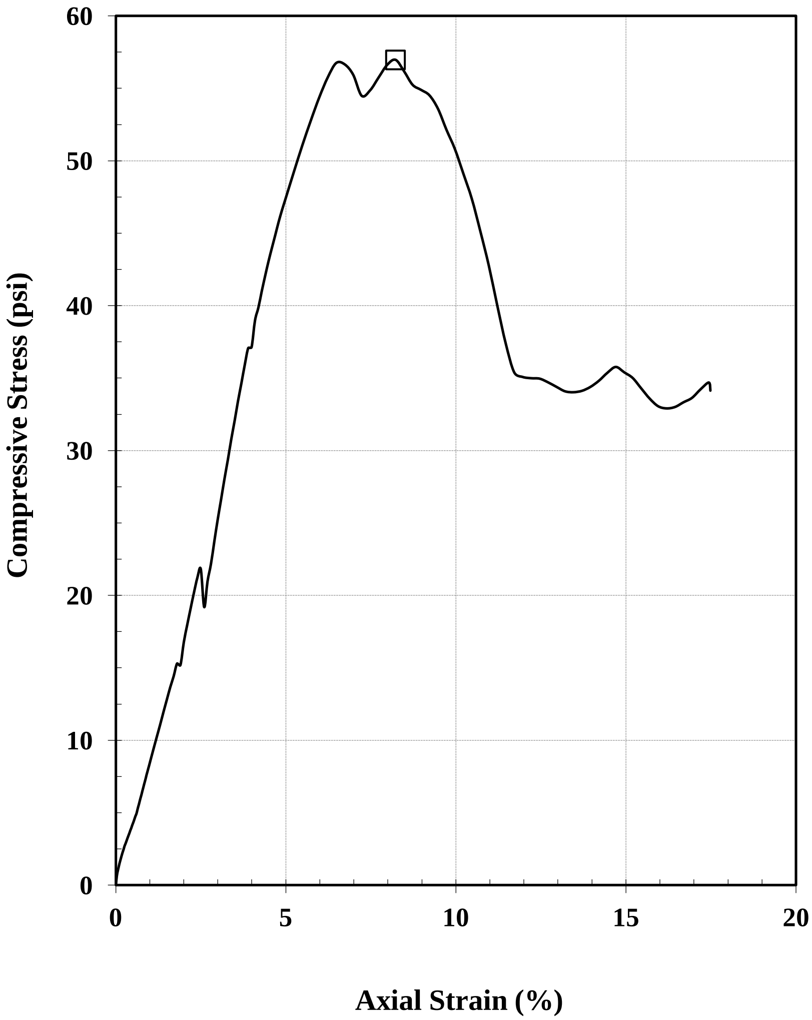
Specimen Image

Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021
Analysis & Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Unconfined Compression Test Report

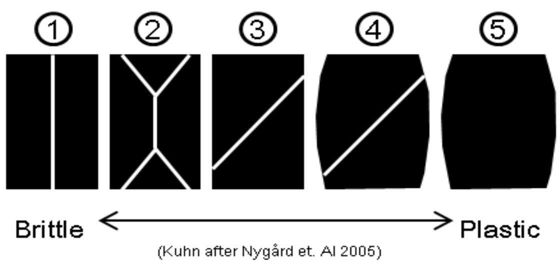
Client:	AECOM	TRI Log No.:	59917.8
Project:	60615067-1.4.14 Plum Creek 2	Type of Specimen:	Intact
Sample ID:	701-20 (23-25) ST-8	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.77
Avg. Height (in)	H_o	5.64
Avg, Water Content (%)	w_o	20.7
Bulk Density (pcf)	γ_{total}	126.3
Dry Density (pcf)	γ_{dry}	104.7
Saturation (%)	S_r	88.6
Void Ratio	e_o	0.64
Assumed Specific Gravity	G_s	2.75

Stresses at Failure	
Unconfined Compressive Strength (psi)	57.0
Axial Strain at Failure (%)	8.2
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	57.0
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	28.5

Failure Mode	3



Jeffrey A. Kuhn, Ph.D., P.E., 3/22/21
Quality Review/Date

702-20

Client: AECOM
TRI Log #: 59914
Project: 60615067-1.4.14 Plum Creek 2

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	702-20 (0-2) P-1	22.5	-	-	-	-	-
2	702-20 (2-4) ST-2	-	-	-	66	22	44
3	702-20 (4-6) P-3	18.8	-	-	-	-	-
4	702-20 (6-8) ST-4	12.2	-	-	-	-	-
5	702-20 (8-9.5) SS-5	16.6	-	-	-	-	-
7	702-20 (18-20) P-7	22.9	-	-	-	-	-
8	702-20 (23-25) ST-8	-	-	-	66	22	44
9	702-20 (28-29.5) SS-9	18.7	-	-	-	-	-

Note: NL = No Liquid Limit; NP = No Plastic Limit

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Crumb Test for Dispersibility of Clayey Soils

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 59914
Test Method: ASTM D6572-B

	Sample Identification	Moisture Content (%)		Temp. (°C)			Grade			Dispersive Classification (1 hr)
		Initial	Adjusted	2 min	1 hr	6 hr	2 min	1 hr	6 hr	
2	702-20 (2-4) ST-2	6.5	45.4	21.8	21.8	22.3	1	1	1	1
6	702-20 (13-15) ST-6	4.1	52.9	21.0	21.8	22.3	1	1	1	1

Grade 1, (Nondispersive): No Reaction; There is no turbid water created by colloids suspended in the water. All particles settle during the first hour.If the cloud is easily visible, assign Grade 3. If the cloud is faintly seen in only small area, assign Grade 1.
Grade 2, (Intermediate): Slight Reaction; A faint, barely visible colloidal suspension causes turbid water near or around the soil crumb surface.
Grade 3, (Dispersive): Moderate Reaction; an easily visible cloud of suspended clay colloids is seen around all of the soil crumb surface. The cloud may extend up to 10 mm (¾ in.) away from the soil crumb mass along the bottom of dish.
Grade 4, (Highly Dispersive): Strong Reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of dish. The soil crumb dispersion is so extensive that it is difficult to determine the interface of the original soil crumb . Often, the colloidal suspension is easily visible on the sides of the dish.

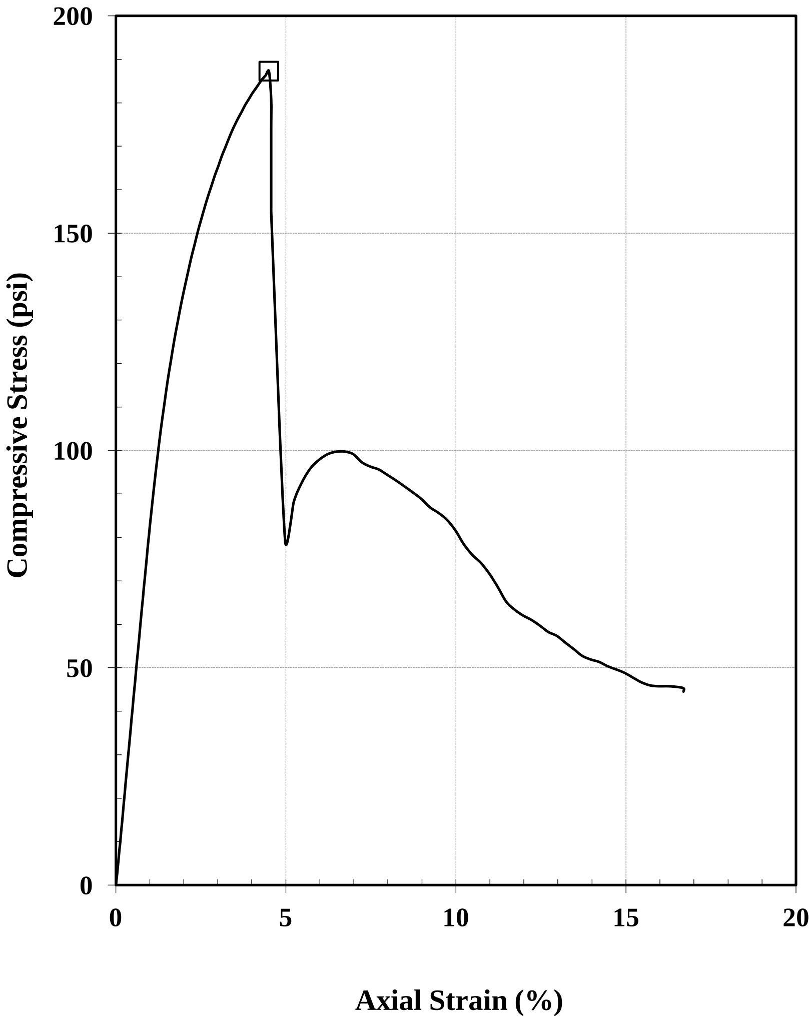
Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

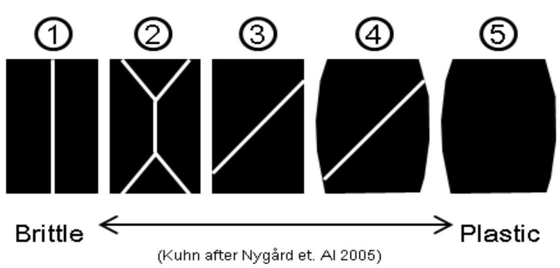
Client:	AECOM	TRI Log No.:	59914.2
Project:	60615067-1.4.14 Plum Creek 2	Type of Specimen:	Intact
Sample ID:	702-20 (2-4) ST-2	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.77
Avg. Height (in)	H_o	5.66
Avg, Water Content (%)	w_o	15.7
Bulk Density (pcf)	γ_{total}	131.3
Dry Density (pcf)	γ_{dry}	113.5
Saturation (%)	S_r	88.7
Void Ratio	e_o	0.51
Assumed Specific Gravity	G_s	2.75

Stresses at Failure	
Unconfined Compressive Strength (psi)	187.3
Axial Strain at Failure (%)	4.5
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	187.3
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	93.6

Failure Mode	3



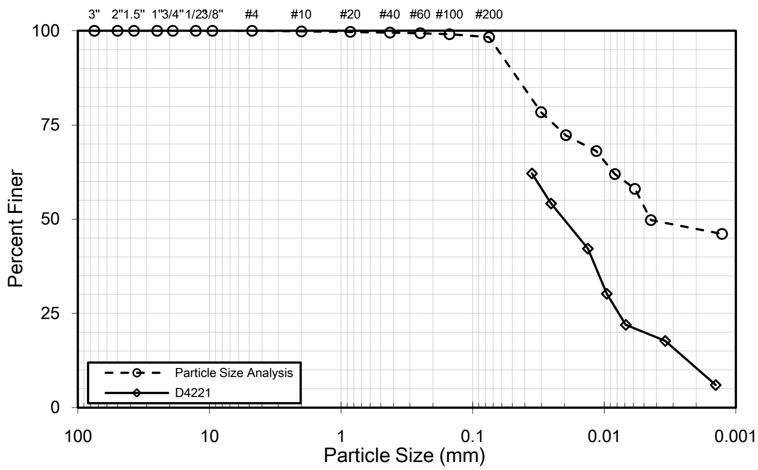
Jeffrey A. Kuhn, Ph.D., P.E., 3/22/21
Quality Review/Date

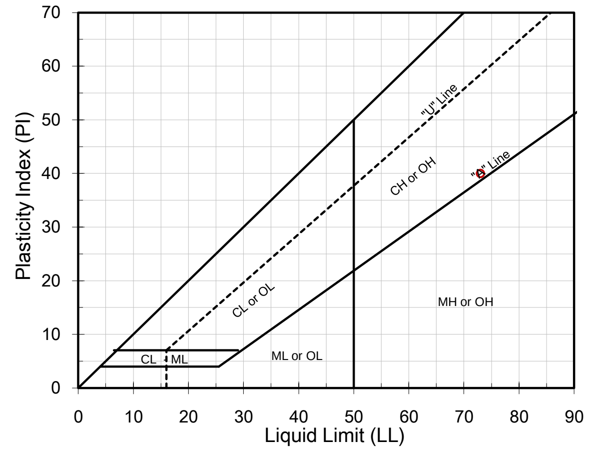
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Particle Size, Atterberg Limit, and USCS Analyses for Soils

Client:	AECOM	TRI Log #:	59914.6
Project:	60615067-1.4.14 Plum Creek 2		
Sample ID:	702-20 (13-15) ST-6		





Mechanical Sieve				Dispersed		Vacuum with Agitation	
ASTM D422-63				ASTM D422-63		ASTM D4221	
Sieve Designation		Percent Passing	Gravel / Sand / Fines	Particle Size	Percent Passing	Particle Size	Percent Passing
-	mm			mm		mm	
3 in.	76.2	100.0	0.0	0.030	78.4	0.035	62.1
2 in.	50.8	100.0		0.020	72.3	0.025	54.2
1.5 in.	38.1	100.0		0.011	68.1	0.013	42.2
1 in.	25.4	100.0		0.008	62.0	0.010	30.2
3/4 in.	19.0	100.0		0.006	58.0	0.007	21.9
1/2 in.	12.7	100.0		0.004	49.8	0.003	17.7
3/8 in.	9.51	100.0		0.001	46.1	0.001	6.0
No. 4	4.76	100.0	1.7	Log-Linear Interpolation			
No. 10	2.00	99.8		Particle Size	Percent Passing	Particle Size	Percent Passing
No. 20	0.841	99.7					
No. 40	0.420	99.5		mm		mm	
No. 60	0.250	99.4		0.005	53.4	0.005	20.0
No. 100	0.149	99.1		0.002	47.4	0.002	10.5
No. 200	0.074	98.3	98.3	N m,2μm,d	47	N m,2μm,nd	11

D_X (mm), Log-Linear Interpolation						Percent Dispersion
10	30	50	60	Cu	Cc	(ASTM D4221)
- -	- -	4.5E-03	7.0E-03	- -	- -	23

USDA	Sand (%)		Silt (%)		Clay (%)	
Clay	(2.0-0.05 mm)	18.9	(0.05-0.002	33.7	(< 0.002 mm)	47.5

Atterberg Limits	
ASTM D4318, Method A : Multipoint, Air Dried	
Liquid Limit	73
Plastic Limit	33
Plastic Index	40
(NL = No Liquid Limit, NP = No Plastic Limit)	

USCS Classification (ASTM D2487)
Elastic silt (MH)

Moisture Content (%)	ASTM D2216	24.1
Organic Content (%)	ASTM D2974-C	- -
Carbonate Content (%)	ASTM D4373	- -

Relative / Index Density		
Minimum (pcf)	ASTM D4254	- -
Maximum, Oven-Dry (pcf)	ASTM D4253-1A	- -
Maximum, Wet (pcf)	ASTM D4253-1B	- -

Jeffrey A. Kuhn, Ph.D, P.E. 3/22/2021

Analysis & Quality Review/Date

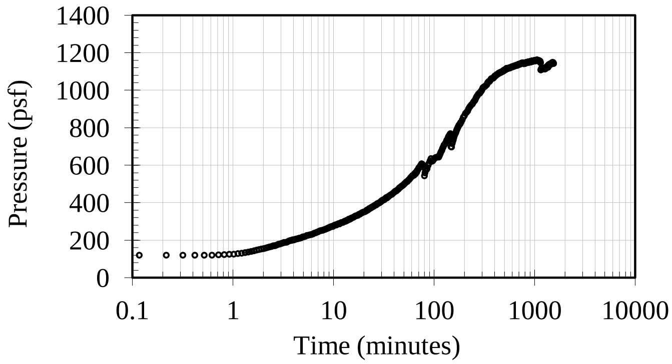
One-Dimensional Consolidation Properties of Soil

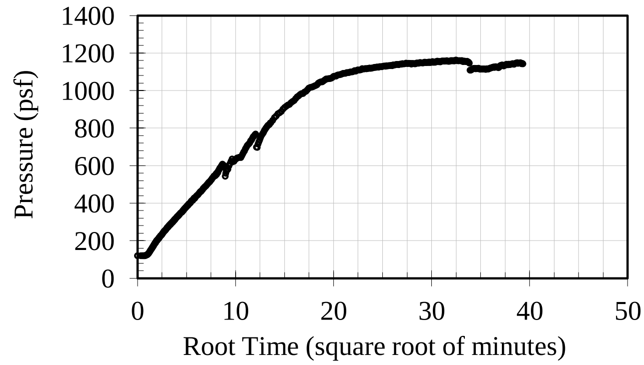
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 702-20 (13-15) ST-6

TRI Log No.: 59914.6
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	23.0
Final Specimen Water Content (%)	25.0
Specimen Diameter (in)	2.486
Initial Specimen Height (in)	1.005
Initial Dry Unit Weight, γ_o lb_f/ft^3	98.2
Specific Gravity (Assumed)	2.75
Initial Void Ratio, e_o	0.683
Initial Degree of Saturation (%)	89.3

Swell Pressure (psf), Maximum Measured	1163





Note: The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. ***A seating stress of 120 psf was utilized for testing.***

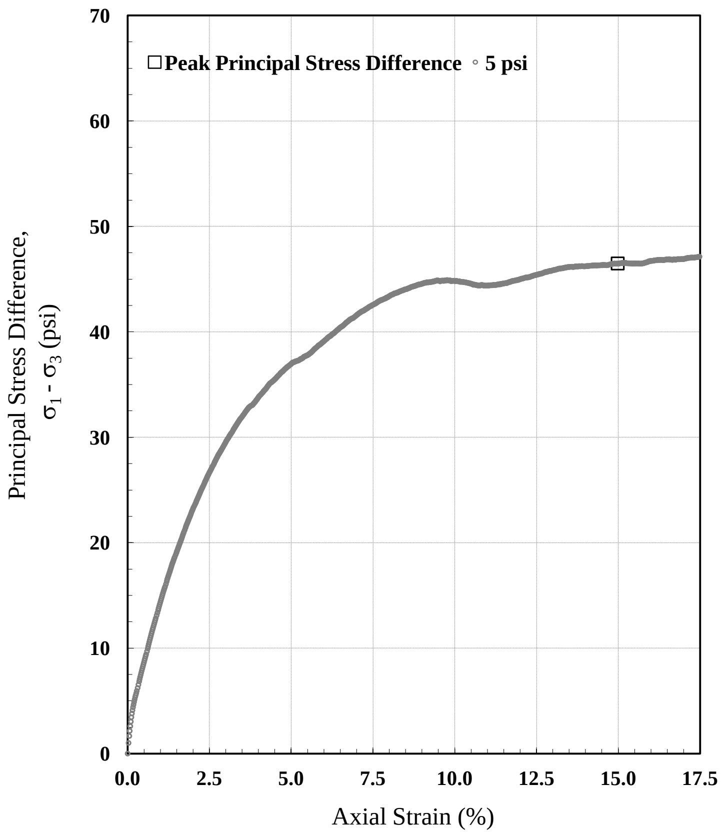
Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Unconsolidated-Undrained (Q) Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 702-20 (13-15) ST-6

TRI Log #: 59914.6
Test Method: ASTM D2850



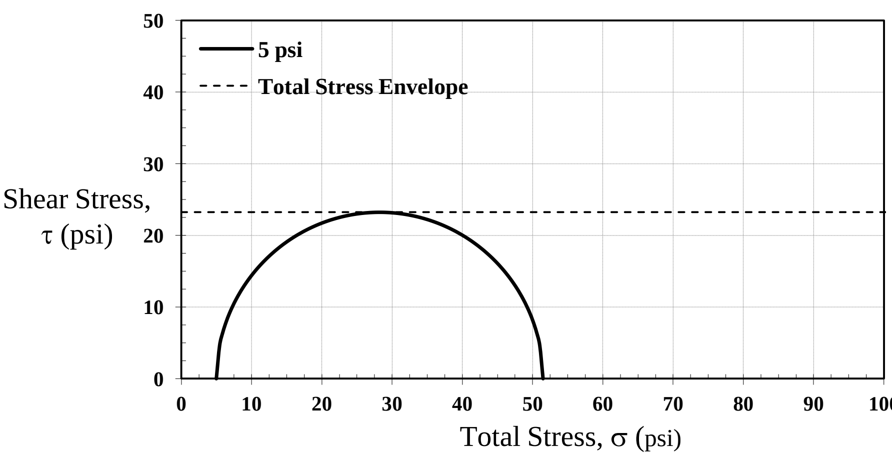
Test Parameters	
Minor Principal Stress (psi)	5.0
Rate of Strain (%/hr)	60

Initial Properties	
Avg. Diameter (in)	2.76
Avg. Height (in)	5.87
Avg. Water Content (%)	23.3
Bulk Density (pcf)	127.7
Dry Density (pcf)	103.6
Saturation (%)	98.7
Void Ratio	0.65
Specific Gravity (Assumed)	2.73

At Failure - Maximum Deviator Stress	
Axial Strain at Failure (%)	15.0
Minor Total Stress (psi)	5.0
Major Total Stress (psi)	51.5
Principal Stress Diff. (psi)	46.5

Total Stress Envelope	
Friction Angle (deg)	0
Undrained Shear Strength, S_u (psi)	23.2
S_u / σ_3	4.6

Note: The calculated value of specimen saturation was approximately 95% or greater. The Mohr failure envelope was taken as a horizontal straight line.



Jeffrey A. Kuhn , Ph.D., P.E., 3/22/2021

Analysis & Quality Review/Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

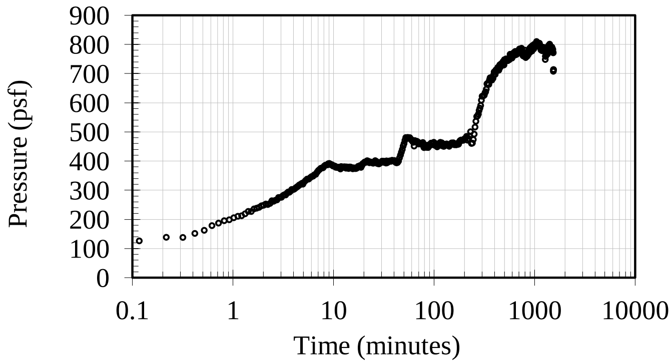
One-Dimensional Consolidation Properties of Soil

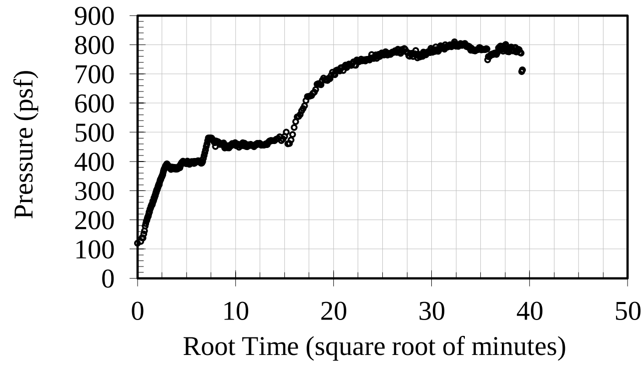
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 702-20 (23-25) ST-8

TRI Log No.: 59914.8
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	19.9
Final Specimen Water Content (%)	20.7
Specimen Diameter (in)	2.499
Initial Specimen Height (in)	1.003
Initial Dry Unit Weight, γ_o lb_f/ft^3	103.9
Specific Gravity (Assumed)	2.75
Initial Void Ratio, e_o	0.591
Initial Degree of Saturation (%)	89.1

Swell Pressure (psf), Maximum Measured	810





Note: The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. ***A seating stress of 120 psf was utilized for testing.***

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

703-20

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2

TRI Log #: 59918

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

COC Line #	Sample Identification	Moisture Content (%)	Dry Unit Weight (pcf)	Fines (%)	Atterberg Limits		
					Liquid Limit	Plastic Limit	Plasticity Index
-	Test Method	ASTM D2216	ASTM D7263	ASTM D1140	ASTM D4318, Method A : Multipoint		
1	703-20 (0-2) P-1	16.9	-	-	-	-	-
2	703-20 (2-3.5) SS-2	16.1	-	-	-	-	-
3	703-20 (3.5-5.5) ST-3	-	-	-	44	18	26
4	703-20 (6-8) P-4	11.8	-	-	-	-	-
5	703-20 (8-10) ST-5	14.3	-	-	-	-	-
6	703-20 (13.5-15) SS-6	22.6	-	-	-	-	-
7	703-20 (18-20) ST-7	-	-	-	61	22	39
8	703-20 (23-25) P-8	21.3	-	-	-	-	-
9	703-20 (27.5-29.5) ST-9	-	-	-	65	23	42

Note: NL = No Liquid Limit; NP = No Plastic Limit

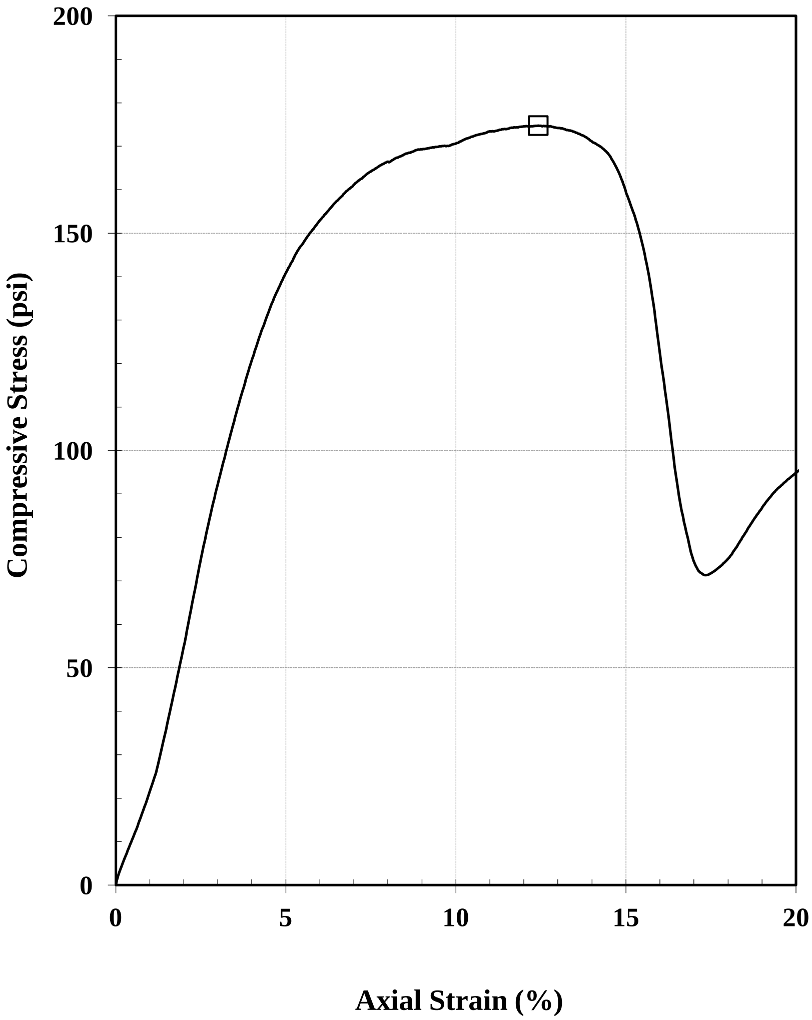
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Unconfined Compression Test Report

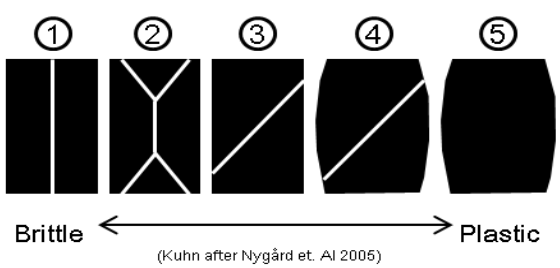
Client:	AECOM	TRI Log No.:	59918.3
Project:	60615067-1.4.14 Plum Creek 2	Type of Specimen:	Intact
Sample ID:	703-20 (3.5-5.5) ST-3	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.76
Avg. Height (in)	H_o	5.59
Avg, Water Content (%)	w_o	15.6
Bulk Density (pcf)	γ_{total}	131.6
Dry Density (pcf)	γ_{dry}	113.8
Saturation (%)	S_r	85.6
Void Ratio	e_o	0.51
Assumed Specific Gravity	G_s	2.75

Stresses at Failure	
Unconfined Compressive Strength (psi)	174.8
Axial Strain at Failure (%)	12.4
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	174.8
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	87.4

Failure Mode	3



Jeffrey A. Kuhn, Ph.D., P.E., 3/22/21

Quality Review/Date

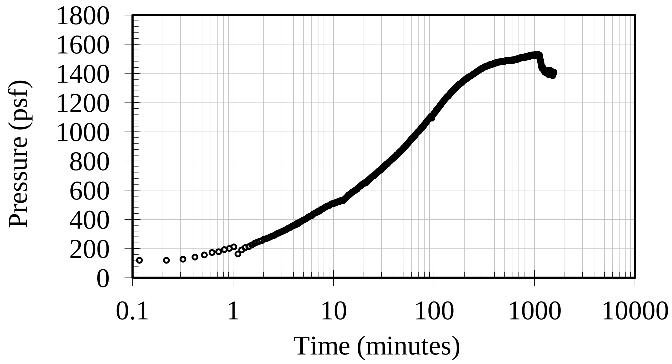
One-Dimensional Consolidation Properties of Soil

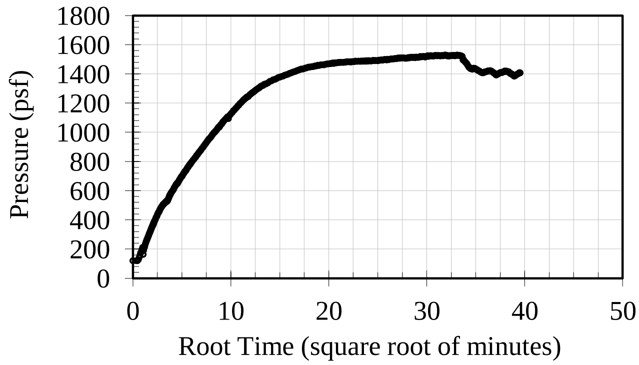
Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Specimen: 703-20 (18-20) ST-7

TRI Log No.: 59918.7
Test Method: ASTM D2435/D4546 Modified

Soil Specimen Properties	
Initial Specimen Water Content (%)	23.8
Final Specimen Water Content (%)	24.8
Specimen Diameter (in)	2.498
Initial Specimen Height (in)	1.002
Initial Dry Unit Weight, γ_o lb_f/ft^3	98.7
Specific Gravity (Assumed)	2.70
Initial Void Ratio, e_o	0.675
Initial Degree of Saturation (%)	93.3

Swell Pressure (psf), Maximum Measured	1530





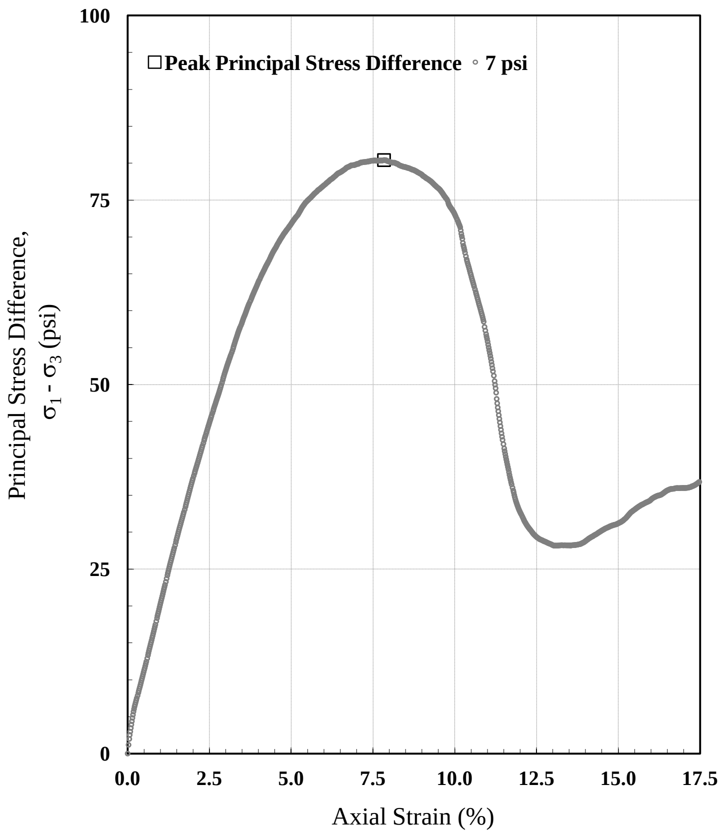
Note: The undisturbed specimen was provided by the client. The specimen was trimmed using a trimming turntable and mounted. The specimen was inundated with tap water during testing. A modified method was performed in which the initial stage of ASTM D2435 testing was performed in which the normal load required to prevent swelling is recorded. This value is being reported as the "Swell Pressure". Please note that alternate methods to determine "Swell Pressure" in an oedometer are presented in ASTM D4546 and thus this modified method could be considered a modification of both methods alike. ***A seating stress of 120 psf was utilized for testing.***

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021
Quality Review/Date

Unconsolidated-Undrained (Q) Triaxial Compression

Client: AECOM
Project: 60615067-1.4.14 Plum Creek 2
Sample: 703-20 (18-20) ST-7

TRI Log #: 59918.7
Test Method: ASTM D2850



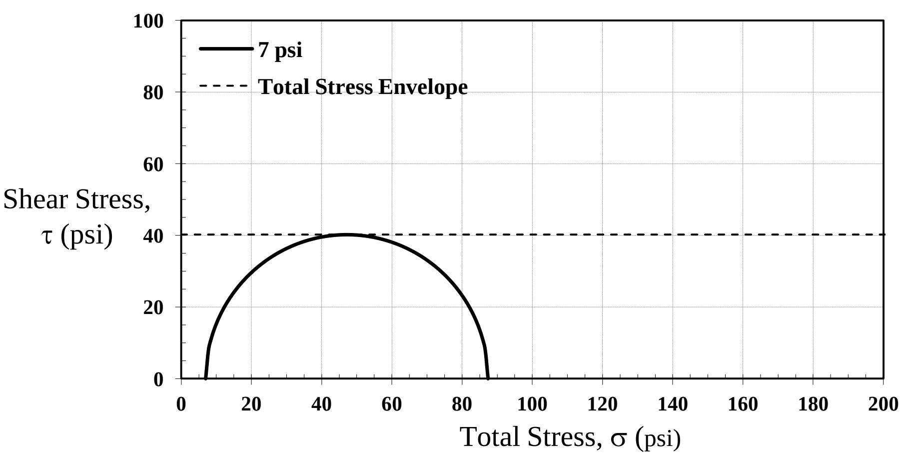
Test Parameters	
Minor Principal Stress (psi)	7.0
Rate of Strain (%/hr)	60

Initial Properties	
Avg. Diameter (in)	2.76
Avg. Height (in)	5.69
Avg. Water Content (%)	23.9
Bulk Density (pcf)	125.6
Dry Density (pcf)	101.4
Saturation (%)	94.7
Void Ratio	0.69
Specific Gravity (Assumed)	2.75

At Failure - Maximum Deviator Stress	
Axial Strain at Failure (%)	7.8
Minor Total Stress (psi)	7.0
Major Total Stress (psi)	87.4
Principal Stress Diff. (psi)	80.4

Total Stress Envelope	
Friction Angle (deg)	0
Undrained Shear Strength, S_u (psi)	40.2
S_u / σ_3	5.7

Note: The calculated value of specimen saturation was less than 95%. The Mohr failure envelope was taken as a horizontal straight line, but noting that the calculated value of saturation indicates a partially saturated specimen.



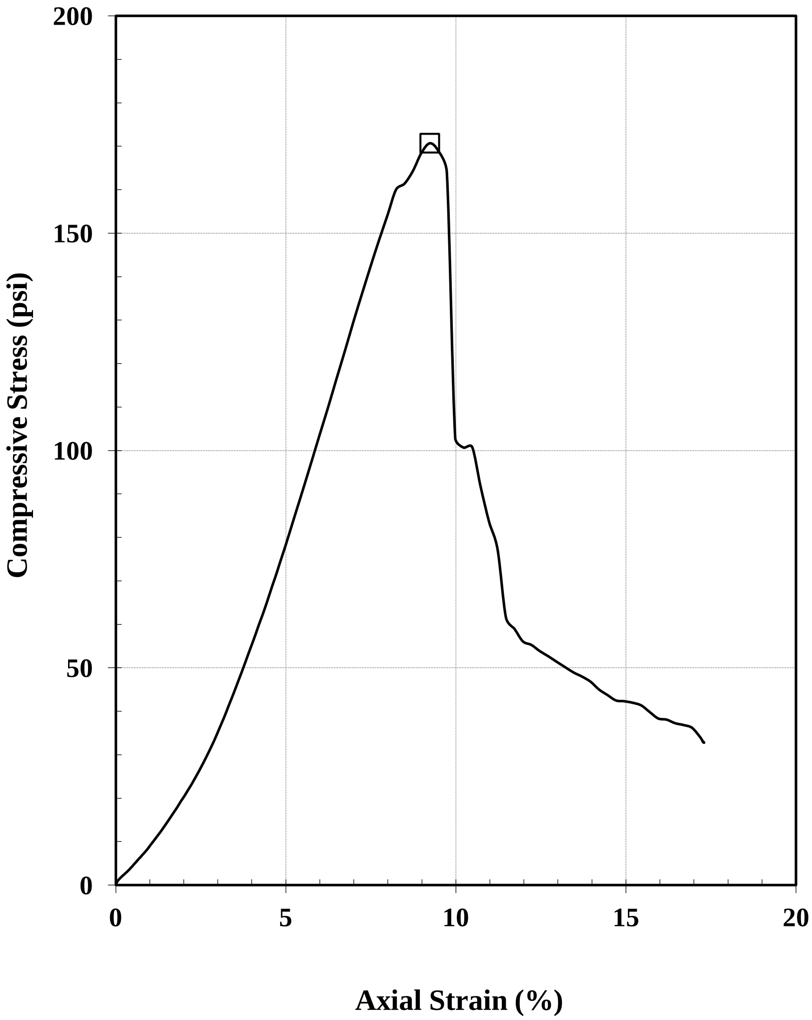
Jeffrey A. Kuhn , Ph.D., P.E., 3/22/2021
Analysis & Quality Review/Date

Unconfined Compression Test Report

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

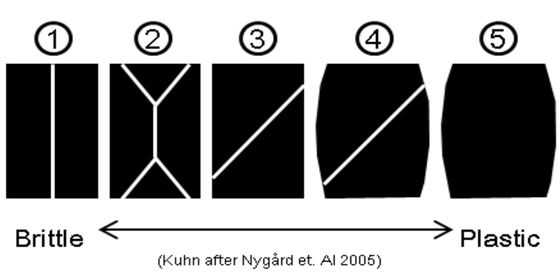
Client:	AECOM	TRI Log No.:	59918.9
Project:	60615067-1.4.14 Plum Creek 2	Type of Specimen:	Intact
Sample ID:	703-20 (27.5-29.5) ST-9	Test Method:	ASTM D2166
		Strain Rate (%/min):	1.0 % / min



Specimen Condition at Time of Test		
Specimen No.		1
Avg. Diameter (in)	D_o	2.80
Avg. Height (in)	H_o	5.65
Avg, Water Content (%)	w_o	18.5
Bulk Density (pcf)	γ_{total}	127.5
Dry Density (pcf)	γ_{dry}	107.6
Saturation (%)	S_r	85.1
Void Ratio	e_o	0.60
Assumed Specific Gravity	G_s	2.75

Stresses at Failure	
Unconfined Compressive Strength (psi)	170.7
Axial Strain at Failure (%)	9.2
Total Stresses at Failure	
Major Principal Stress, σ_1 (psi)	170.7
Minor Principal Stress, σ_3 (psi)	0.0
Undrained Shear Strength, S_u (psi)	85.4

Failure Mode	1



Jeffrey A. Kuhn, Ph.D., P.E., 3/22/21

Quality Review/Date

Appendix B Material Properties Analysis

OBJECTIVES:

1. Analyze laboratory test results;
2. Use published correlations with field and laboratory index/strength tests to supplement advanced laboratory test results;
3. Consider published ranges of values for similar soil types; and
4. Select estimated soil parameters for each geologic unit to be used in geotechnical analysis.

REFERENCES:

External references:
1. NRCS. "210-VI-TR60, Earth Dams and Reservoirs." March, 2019.
2. USACE. 1994. EM 1110-1-2908, Rock Foundations. November 30.
3. Berney, E.S. and Smith, D.M. 2008. *Mechanical and Physical Properties of ASTM C33 Sand.* USACE-ERDC/GSL TR-08-2. February.
4. Casagrande. 1936. *The determination of the preconsolidation load and its practical significance*. In Proceedings of the First International Conference on Soil Mechanics and Foundation Engineering, Cambridge, Mass., 22-26 June. Harvard Printing Office, Cambridge, Mass. Vol. 3, pp. 60-64.
5. Federal Highway Administration (FHWA). 2017. *Geotechnical Engineering Circular No. 5 - Geotechnical Site Characterization*, Publication No. FHWA NHI-16-072.
6. Daniel et al. 2003. *A Method for Correlating Large Penetration Test (LPT) to Standard Penetration Test (SPT) Blow Counts.* Canadian Geotechnical Journal, Vol. 40, pp 66 – 77.
7. CALTRANS. 2003. *Bridge Design Specifications.* Section 4, Shallow Foundations.

Project-specific references:
1. AECOM. 2020. Draft Geologic Investigation Report (GIR).
2. AECOM. 2020. Draft Soil Mechanics Report (SMR).
3. USDA-SCS. 1983. Geologic Investigation Report (SMR).
4. USDA-SCS. 1984. Soil Mechanics Report (SMR).
5. USDA-SCS. 1984. As-Built Drawings.
6. NRCS. 2011. Geophysical Report.
7. NRCS. 2011. Field Repair Drawings, Specs, and Design Report.

PROJECT DESCRIPTION

Proposed dam improvements are intended to mitigate identified dam safety deficiencies associated with the dam's reclassification as a high hazard dam. The proposed modifications to the dam include the following major components:

- Abandoning the existing principal spillway inlet and 24-inch diameter conduit;
- Replacing the existing principal spillway with a new 48-inch diameter conduit, inlet riser, and impact basin;
- Installing rock riprap wave protection on the upstream embankment slope;
- Maintaining the existing embankment crest elevation of El. 662.8 with nominal raise in areas that have experienced settling (maximum fill height of about 1 foot);

- Raising the vegetated auxiliary spillway crest to El. 659.8 feet (about +1.15 feet) and widening the channel from 150 to 250 feet;
- Constructing a new 200-foot-wide overtopping roller-compacted concrete (RCC) spillway with crest at El. 658.6;

Refer to the GIR and SMR report and the “Stability Analysis” and “Seepage Analysis” calculation packages for additional project details.

MATERIAL CHARACTERIZATION

Stratigraphy

Site stratigraphy is described in detail in the Geologic Investigation Report and Soil Mechanic Report, and are summarized briefly as follows:

- Embankment Fill: This material was primarily classified as very stiff to hard lean to fat clay (CL, CH) with some intervals of lean clay (CL) and some sandy intervals (3 to 28% sand). While the as-built drawings indicate embankment zoning with distinct core and shell zones, borings and laboratory testing indicate the shell and core zones are comprised by similar materials. This unit is expected to experience slow drainage due to high fines and clay contents.

- Downstream Fill: The suspected fill material was primarily classified as medium stiff to hard lean to fat clay (CL, CH). The fill designation was due to a somewhat lower consistency of this material. However, the visual similarity of the fill to overburden material suggests that this unit is likely reworked residuum/alluvium. This material was assumed to exhibit slow drainage due to clayey fines.

- Alluvium: This unit consisted of dark brown, medium stiff to hard fat clays (CH) with minor proportion of sand and/or gravel ranging from 0 to 20%. This material was assumed to exhibit slow drainage due to clayey fines.

- Residuum: This unit consisted of light gray to tan, medium stiff to hard lean to fat clays (CL, CH) with some clayey sand (SC) and silty clay (CL-ML) layers. Characterization of this material in the GIR and SMR was subdivided into a calacareous and friable Low Plasticity Residuum (LPR) consisting mostly of silty CL and some CH with less frequent SC and CL-ML intervals, and a Medium Plasticity Residuum (MPR) consisting of consisting of CH with some CL intervals. For engineering analysis, this material was generally considered as a single “Residuum”. It was assumed to exhibit slow drainage due to clayey fines.

- Bedrock: This unit consisted of extremely weak to weak calcareous shale with occasional chalky marl layers. The weathering ranged from moderately to highly weathered. This material was judged to exhibit slow drainage.

Proposed fill materials include fine and coarse filter/drain fill, RCC, and new embankment fill. These materials are described below.

- Drain Fill: This material will consist of a compacted fine filter (modified ASTM C-33 Fine Aggregate) and a coarse filter (ASTM C-33 No. 89 aggregate). These materials will be placed under the RCC spillway and around the new and existing PSW conduits. These materials are free-draining and will exhibit only drained strength behavior.

- RCC: This material will consist of low-slump concrete compacted in lifts that will be used to construct the RCC spillway. The material was treated as relatively low permeability, and will exhibit only drained strength behavior.

- New Embankment Fill: The proposed embankment fill will be constructed of moisture-conditioned and recompacted clayey soils from on-site and/or imported borrow sources. Selective placement of imported low-plasticity (PI=7-15) lean clay (CL) or clayey sand (SC) is planned for under and adjacent to the RCC spillway to reduce swelling potential. The exterior zones of planned embankment fill (crest re-shaping and embankment reconstruction at new PSW) will be low-plasticity clay/clayey sand (CL, SC) with LL<50 and PI=10-30. Interior zones of planned embankment fill for reconstruction at new PSW will consist of medium- to high-plasticity clays (CL, CH) with LL<60 and PI=10-35. Considering the clayey composition of proposed embankment fill, this material was considered to exhibit both undrained and drained strength behavior.

A summary of field and laboratory index test results by stratum are provided in **Table 2**. An Atterberg Limits plot illustrating the range in laboratory index test results of each stratum is provided in **Attachment 1**.

Groundwater

The majority of borings completed in both 2019 and 2020 were dry during drilling. However, static groundwater was observed after drilling in one boring. A stabilized phreatic surface was also measured in piezometers 009-19 and 011-19 installed in 2020. Note that 008-19 is offset several hundred feet to the north of the analysis sections, and the observed groundwater levels in this boring are considered to be less representative than 009-19 or 011-19. Observations are summarized in Table 1.

The static groundwater level downstream of the dam is estimated approximately El. 618 to El.623 based on the visual field observation.

Table 1. Groundwater Observations

Boring ID	Location	Boring Top Elev. (ft)	Reading Date	GW Depth (ft)	GW Elev. (ft)	Measurement Type
008-19	Embankment Crest STA. 11+00	662.2	01/09/2020	28.1	634.1	End of Drilling (<24 hr)
009-19	Embankment Crest STA. 16+40	662.4	01/30/2020	16.3	646.1	Piezometer
			03/26/2020	32.8	629.6	Piezometer
			08/26/2020	14.9	647.5	Piezometer
			10/08/2020	31.5	630.9	Piezometer
011-19	Embankment Crest STA. 23+80	661.2	12/17/2019	27.5	633.7	End of Drilling (>24 hr)
			01/30/2020	46.1	615.1	Piezometer
			02/13/2020	43.6	617.1	Piezometer
			03/26/2020	38.8	622.4	Piezometer
			08/26/2020	33.8	627.4	Piezometer
			10/08/2020	31.0	630.3	Piezometer
702-20	Downstream Toe STA. 17+50	647.8	10/05/2020	Dry	Dry	End of Drilling
			10/08/2020	27.5	620.3	Piezometer
			-	-	-	Piezometer

- *Note: Groundwater not observed in other borings*

*Table 2. Range of Measured Soil Properties**

Stratum	USCS	SPT N (bpf)	PP (tsf)	MC (%)	DD (pcf)	TD (pcf)	LL	PI	LI	Gravel (%)	Sand (%)	Fines (%)	Clay (%)
Embankment (Zone 1 Core)	CH, CL	8 - 25 (16)	1.0 - 4.5+ (3.9)	2.3 - 27.4 (17.6)	97.9 - 117.3 (107.3)	116.1 - 129.8 (125.1)	34 - 74 (58)	20 - 50 (36)	-0.52 to 0.03 (-0.18)	0 - 4.3 (2.5)	6.0 - 27.6 (15.4)	68.1 - 97.5 (85.5)	29.0 - 58.1 (45.5)
Embankment (Zone 2 Shell)	CH, CL	8 - 10	1.5 - 4.5+ (2.8)	9.3 - 27.4 (19.2)	93.9 - 105.2 (97.6)	116.2 - 122.9 (119.5)	34 - 76 (58)	19-55 (38)	-0.65 to 0.05 (-0.10)	0 - 0.8 (0.3)	2.9 - 10.5 (6.3)	89.1 - 98.0 (93.3)	42.9 - 66.2 (56.3)
Downstream Fill	CH, CL	34	4.5+	5.1 - 17.2 (12.7)	107.5 - 114.2	126.0 - 132.4	48 - 71	27 - 48	-0.19 to -0.12	1.1	6.4	89.4 - 92.5	56.8
Alluvium	CH	12 - 26 (18)	3.0 - 4.5 (3.9)	8.4 - 24.3 (17.4)	96.0 - 113.5 (104.3)	112.9 - 132.4 (124.4)	52 - 82 (70)	35 - 62 (48)	-0.33 to 0.08 (-0.04)	0.0 - 19.5 (4.2)	4.3 - 11.7 (8.0)	76.2 - 97.5 (90.1)	53.1 - 64.3 (57.1)
Residuum (LPR)	CL, CH	15 - 44 (24)	All 4.5+ (4.5+)	10.3 - 21.7 (16.2)	99.0 - 124.8 (111.0)	120.5 - 138.8 (129.1)	31 - 77 (57)	15 - 54 (36)	-0.36 to 0.02 (-0.14)	0 - 0	1.5 - 19.8	80.2 - 98.5 (92.7)	38.1 - 66.2
Residuum (MPR)	CH, CL	13 - 70 (25)	2.5-4.5+ 4.2	9.8 - 25.4 (20.0)	99.1 - 115.5 (104.6)	119.2 - 134.9 (126.3)	29-75 (63)	14-52 (41)	-0.24 to 0.38 (-0.02)	0 - 0 (0)	1.7 - 4.2 (2.7)	68.8 - 99.2 (92.8)	47.4 - 68.1 (54.7)
Shale	CH	36 - 100 (85.6)	4.5 - 4.5 (4.5)	1.1 - 21.3 (10.6)	104.6 - 140.1 (117.4)	126.3 - 147.9 (133.9)	65 - 96 (76)	42 - 69 (52)	-0.33 to -0.03 (-0.16)	0.5	30.2	69.3	---
Proposed Embankment 1 (Borrow Layer B)	CL, CH	---	---	OMC: 14.4	Proctor MDD: 115.5	---	32 - 69 (47)	19 - 46 (29)	---	3.4 - 3.8	21 - 21	18.7 - 95.7 (65.3)	42.6 - 43.0
Proposed Embankment 2 (other sources)	CH, CL	---	---	OMC: 22.0 - 24.4 (22.9)	Proctor MDD: 93.9 - 99.0 (22.9)	---	40 - 90	21 - 63	---	0.9 - 19.5	4.3 - 20.3	76.2 - 98.7	36.6 - 64.3

Notes:

1. Reporting format is Minimum – Maximum (Average).
2. Average not provided where 2 test values or fewer are available.
3. Abbreviations:
   a. SPT N – Uncorrected field blow counts; average calculated based on capping refusal values at N=50 bpf
   b. PP – Pocket penetrometer
   c. MC – Natural moisture content
   d. DD – Natural dry unit weight
   e. TD – Natural moist unit weight
   f. LL – Liquid Limit
   g. PI – Plasticity Limit
   h. LI – Liquidity Index
   i. Gravel – Percent coarser than the #4 sieve by weight
   j. Sand – Percent finer than #4 sieve and coarser than #200 sieve
   k. Fines – Percent finer than the #200 sieve by weight
   l. Clay – Percent finer than 0.002 mm by weight
   m. OMC – Optimum Moisture Content per ASTM D698
   n. MDD – Maximum Dry Density per ASTM D698j

**Reported test results only for borings drilled on or adjacent to the dam embankment (000-, 300-, 600-, 700-, 1300-, and 1700-series borings).*

UNIT WEIGHT

Selected unit weights of the various geologic units were based on the results of natural moisture and unit weight tests performed on relatively undisturbed soil samples (Shelby tubes). Standard proctor compaction testing was also performed on bulk samples of on-site borrow material, and unit weights of proposed embankment fill were estimated based on typical compaction moisture/density specifications from this data (i.e., minimum 95% of maximum dry density [MDD] at above-optimum moisture content). Unit weight of granular drain fill material was based on published values. A summary of selected values for analysis is provided in **Table 3**.

Table 3. Selected Unit weights for various geologic units

Material	Unit Weight (pcf)
Existing Embankment Fill – Zone I (Core)	125
Existing Embankment Fill – Zone II (Shell)	125
Proposed Embankment Fill	125
Alluvium	123
Residuum	126
Marl/Shale	130
Filter Drain	120
Rock Riprap	110
RCC	145

SHEAR STRENGTH PARAMETERS

Shear strength parameters have been developed for use in geotechnical calculations including embankment slope stability, bearing capacity, lateral earth pressures, and foundation sliding. The selected shear strength is specific to loading condition, and include unconsolidated-undrained (UU), consolidated-undrained (CU), and consolidated-drained (CD) shear strengths. Selection of these parameters for design is discussed in the following sections.

Total Stress Unconsolidated-Undrained (UU) Strength

The UU shear strength of slow-draining, fine-grained cohesive soils (also referred to as the undrained shear strength, Su), is generally defined as one-half the unconfined compressive strength (qu/2). The UU strengths do not apply to free-draining materials. A summary of laboratory tests and correlations used to estimate the Su of various soil materials is discussed below.

Correlation with Standard Penetration Tests

Crude estimates of Su can obtained from the field Standard Penetration Test (SPT) N-value according to the following equation (FHWA 2017, Section 7, Equation 7.19):

$$Su = f_1 * N_{60} * Pa/100$$

where N_{60} = the field N-value corrected to 60% hammer efficiency, Pa = atmospheric pressure equal to 2,116 psf; and f_1 = empirical coefficient ranging from 4.5 to 5.5 depending on soil plasticity. The more conservative f_1 = 4.5 was used for analysis. SPT hammer energy calibrations were available for the drill rigs used in the field investigation, which had hammer efficiency (Eh) values of 82%. Consequently, the field N-values were multiplied by correction factor of 1.37 (i.e., 80% / 60%) to obtain estimated N_{60} values. A plot of the correlated Su values is provided in **Attachment 2**.

Correlation with Pocket Penetrometer Tests

Crude estimates of unconfined compressive strength (UCS) can be obtained from field pocket penetrometer (PP) testing on the exposed ends of relatively undisturbed Shelby tube samples. The value of Su can be estimated as UCS/2. The PP testing on various soil materials ranged from 1.0 to 4.5+ tsf, corresponding to approximately Su = 1,000 to more than 4,500 psf. A plot of the correlated Su values is provided in **Attachment 2**.

Laboratory Shear Strength Tests

Laboratory Unconfined Compression (UC) and Triaxial Unconsolidated Undrained (UU) tests were performed on relatively undisturbed samples, and remolded samples of proposed fill compacted to 95% of MDD. Test results indicate peak Su = 1,700 to >13,000 psf for undisturbed samples. A plot of the correlated Su values is provided in **Attachment 2**. The Su value for remolded samples was highly dependent on compaction moisture content, ranging from 1,771 to 2,160 psf for samples at optimum moisture content (OMC) and 634 to 1,123 psf for samples compacted at +4% OMC.

Selected UU Strength Parameters

Selected values of UU strengths are summarized in **Table 4**. Conservative lower-bound Su values were selected for existing materials to account for potential softening and/or secondary features (e.g. fissures). The selected Su for proposed fill was based on estimated low-average value of the compaction spec range (e.g., 95-100% of MDD at 0% to +4% OMC).

Table 4. Selected UU Strength Parameters for Design

Material	Undrained Shear Strength, Su (psf)
Existing Embankment Fill – Zone I (Core)	1,200
Existing Embankment Fill – Zone II (Shell)	1,200
Proposed Embankment Fill	1,200
Alluvium	1,500
Residuum	1,500
Marl/Shale	3,000
Filter Drain	---
Rock Riprap	---
RCC	---

Effective Stress Consolidated-Drained (CD) Strength

The effective stress consolidated-drained (CD) shear strength is considered to represent the shear strength of coarse-grained soils which drain freely, as well as the long-term shear strength in slow-draining fine-grained soils which are consolidated and subject to drained loading. The CD strength is typically represented as an envelope defined by an effective cohesion (c') intercept and effective angle of internal friction (φ') based on effective normal stresses. A summary of laboratory tests and correlations used to estimate CD strength of various soil materials is discussed below.

Laboratory Shear Strength Tests

Laboratory testing for effective stress strengths included isotopically consolidated-undrained triaxial shear testing with pore pressure measurements (CIU') on both relatively undisturbed soil samples and remolded samples of prospective borrow material. Consolidated-drained direct shear (CDDS) testing was also performed on undisturbed samples where sample quantity was limited and/or materials were brittle and difficult to trim. Test results for CIU' and CDDS are summarized in **Table 5** and **Table 6**, respectively.

Correlations with Index Properties

Available effective stress strength correlations for cohesive soils include plasticity index (PI) based estimates of peak drained friction angle, ϕ'_{peak}. The estimated ϕ'_{peak} can be calculated based on the following equation by (Mitchell, 1976 published in Terzaghi, Peck, and Mesri, 1996):

$$\phi'_{peak} = \sin^{-1}(0.8 - 0.094*\ln[PI])$$

The estimated ϕ'_{peak} ranges from about 23 degrees to 34 degrees for the various materials near the dam embankment. Results are plotted versus liquid limit in **Attachment 2**. Additionally, the fully softened friction angle (ϕ'_{FSS}) correlations based on liquid limit and clay fraction (Stark et. al, 2005, 2013, 2016) were also evaluated to consider the potential long-term shear strength of high-plasticity clays, which gave typical ϕ'_{FSS} of about 23 to 27 degrees for most on-site clays. A plot is provided in **Attachment 2**.

Cohesionless soils at the site were limited to existing and proposed internal drainage layers, in which case published values for ASTM C33 aggregates were examined. A value of 33 degrees was selected based on publication in **Attachment 2**.

Selected CD Strength Parameters

Selected CD strength values were based on the preceding data and are summarized in **Table 7**.

Initial values were checked for reasonability through trial slope stability analyses of the existing dam section to calibrate the parameters to historic dam performance (see "Slope Stability Analysis" calculations), with consideration of previous analyses and original design criteria. Once analysis results were judged to be reasonable, the parameters were then employed in analysis of proposed conditions. The parameters shown herein are the final values resulting from those calibration evaluations.

Total Stress Consolidated-Undrained (CU) Strength

The total stress consolidated-undrained (CU) shear strength represents the short-term strength in slow-draining, fine-grained soils which are consolidated and then subjected to undrained loading. The CU strength is typically represented as an envelope defined by a total cohesion (c_u) intercept and total angle of internal friction (φ_u) based on total normal stresses. A summary of laboratory tests and correlations used to estimate CU strength of various soil materials is discussed below.

Laboratory Shear Strength Tests

Laboratory CIU' testing on both relatively undisturbed soil samples and remolded samples of prospective borrow material were used to evaluate the CU strengths. The testing laboratory's interpretation of individual shear test results are summarized in **Table 5**.

Selected CU Strength Parameters

Selected CU strength values were based on the preceding data and are summarized in **Table 7**.

NRCS Bilinear Strength Envelopes for Specific Slope Stability Analysis Loading Cases

The NRCS TR-60 specifies that slow-draining material zones be assigned a bi-linear strength envelope corresponding to the lower of the CU and CD strength envelopes for certain loading cases in slope stability analysis (i.e., Rapid Drawdown and Flood Surcharge cases). These bilinear strength envelopes are defined by the intersection point of the selected CU and CD design shear strength envelopes and are summarized in **Table 8**.

Table 5. Summary of Laboratory CIU' Triaxial Shear Test Results (Current Study)

Boring ID	Depth (ft)		Stratum	Test Type [see notes]	USCS	Avg. WC (%)	Avg. DD (pcf)	LL	PI	Pass #200 (%)	Peak Principal Stress Difference $(\sigma_1-\sigma_3)_{max}$				Peak Principal Stress Raio $(\sigma_1/\sigma_3)_{max}$			
											Total Stress (CU-Envelope)		Effective Stress (CD-Envelope)		Total Stress (CU-Envelope)		Effective Stress (CD-Envelope)	
	Top	Bottom									Cohesion, C_u (psf)	Friction Angle, φ_u (deg)	Cohesion, C' (psf)	Friction Angle, φ' (deg)	Cohesion, C_u (psf)	Friction Angle, φ_u (deg)	Cohesion, C' (psf)	Friction Angle, φ' (deg)
11-19	18	20	Embankment Core	U, C	CH	18.2	116.8	55	36	82.8	1,166	12.5	821	16.9	547	15.8	662	18.3
305-19	18	20	MPR	U, C	CH	19.8	105.6	60	35	95.5	778	30.2	0	26 to 41	86	27.8	0	28 to 49
COMP-100B	5 to 6	7.5 to 10	Borrow-Layer B (LPR)	R, C	CL	17.4	109.0	43	26	75.2	835	16.7	432	24.4	533	15.6	634	23.3

Notes:
1) U – Relatively undisturbed sample (10helby tube) at nature density and moisture content.
2) N – Remolded to natural density at natural moisture content.
3) R – Remolded to 95% maximum dry density at moisture content +3% of optimum per ASTM D698.
4) C – Multi-stage shear testing on single specimen. Shearing at lower normal stresses limited to ~3% strain. Sheared to failure at highest tested normal stress.
5) MS – Multi-specimen shear test. Each specimen sheared to failure at one confining stress value.
6) For sample 305-19, the drained strength envelope is reported as the secant friction angle for each of the 3 specimens due to variable shear behavior and poor fit of linear regression of Mohr-Coulomb envelope.

Table 6. Summary of Laboratory CDDS Test Results (Current Study)

Boring ID	Top Depth (ft)	Bottom Depth (ft)	Stratum	Test Type [see notes]	USCS	WC (%)	DD (pcf)	LL	PI	Pass #200 (%)	Peak Envelope		Post-Peak Envelope	
											Cohesion, C (psf)	Friction Angle, φ (deg)	Cohesion, C (psf)	Friction Angle, φ (deg)
304-19	6	8	Embankment	U	CH	24.3	98.9	76	55	91	662	16.8	619	15.2
304-19	18	20	Alluvium	U	CH	20	101.3	80	59	97.5	374	23	173	22.3

Notes:
1) U – Relatively undisturbed sample (Shelby tube) at natural density and moisture content.
2) N – Remolded to natural density at natural moisture content.
2) R – Remolded to 95% maximum dry density at moisture content +3% of optimum per ASTM D698.
3) Post-peak envelope corresponds to 0.25" shear displacement.

Table 7. Selected Unit Weights and CU & CD Shear Strength Parameters for Design

Material	USCS	Total Unit Weight (pcf)	Effective Stress (CD Envelope)		Total Stress (CU Envelope)	
			c′ (psf)	φ ′ (deg)	c_u (psf)	$φ_u$ (deg)
Existing Embankment Fill – Zone I (Core)	CL, CH	130	100	23	400	15
Existing Embankment Fill – Zone II (Shell)	CL, CH	130	100	23	400	15
Proposed Embankment Fill	CL, CH	130	100	23	400	15
Alluvium	CH	123	100	23	400	15
Residuum	CL, CH	126	100	23	400	15
Marl (Bedrock)	CH	140	300	23	400	15
Filter Drain	SP, GP	120	0	30	---	---
Rock Riprap	---	110	0	35	---	---
RCC	---	145	100	45	---	---

Notes:

1. Strength envelopes evaluated over range of 0 – 3,000 psf effective normal stress based on examination of stresses acting on the base of critical slip surfaces from preliminary and final stability analyses.
2. Based on similarity of index properties and field strength tests, the suspected downstream fill materials were considered equivalent to the residuum / alluvium materials for the purposes of slope stability analyses.

Table 8. NRCS Bi-Linear Shear Strength Envelopes for Saturated Materials (Below Phreatic Surface)

Material	Initial Envelope		Bi-Linear Envelop for Flood Surcharge		Bi-Linear Envelope for Rapid Drawdown	
	c (psf)	$φ_1$ (deg)	$σ_n$ (psf)	$φ_{2\text{-FBH}}$ (deg)	$σ_n$ (psf)	$φ_{2\text{-RDD}}$ (deg)
Existing Embankment Fill – Zone I (Core)	100	23	1,917	15	1,917	15
Existing Embankment Fill – Zone II (Shell)	100	23	1,917	15	1,917	15
Proposed Embankment Fill	100	23	1,917	15	1,917	15
Alluvium	100	23	1,917	15	1,917	15
Residuum	100	23	1,917	15	1,917	15
Marl (Bedrock)	300	23	639	15	639	15
Filter Drain	0	33	---	---	---	---
Rock Riprap	0	35	---	---	---	---
RCC	100	45	---	---	---	---

HYDRAULIC CONDUCTIVITY PARAMETERS

Hydraulic conductivity parameters were developed for the purposes of seepage analysis calculations. Discussion regarding selection of hydraulic conductivity parameters is provided in the following sections.

Saturated Hydraulic Conductivity

Hydraulic conductivity laboratory testing was performed on 3 residuum samples and are summarized on Table 9. Limited laboratory hydraulic testing could be performed due to the difficulty in obtaining testable samples. Selection of hydraulic conductivity parameters for the subsurface materials were based on published values and correlations based on soil types and index properties, experience with similar materials. Initial properties were modified during seepage analysis model calibration trials based on known groundwater levels (see Seepage Analysis calculation package).

Table 9. Laboratory Test Results for Hydraulic Conductivity

Boring ID	Top Depth (ft)	Bottom Depth (ft)	Stratum	USCS	Effective Confining Pressure (psf)	Vertical Hydraulic Conductivity Kv (cm/s)
11-19	38	40	MPR	CH	720	7.8E-09
701-20	6	8	LPR	CH	432	1.2E-06
304-19	28	30	LPR	CH	1872	1.9E-09

A summary of referenced correlations, published values, and selected seepage parameters are provided in **Attachment 3**. Final seepage parameters used for design are provided in **Table 10**.

Anisotropy Ratio

Anisotropy ratio is defined as the ratio of hydraulic conductivities in the horizontal direction (k_h) to the vertical direction (k_v), or k_h/k_v. Selection of kh/kv values was based on the USBR publication "Design of Small Dams" and experience with similar soils.

Unsaturated Conductivity Functions

For materials that are partially saturated and/or will not remain saturated, the "saturated / unsaturated" model should be used for seepage modelling. The "saturated only" model should only be used for soils that will always remain below the phreatic surface (Geo Slope, 2021). The saturated/unsaturated model require 2 functions: hydraulic conductivity function and volumetric water content function.

The hydraulic conductivity function describes how the hydraulic conductivity varies with changes in suction (i.e. negative pore-water pressure) present in unsaturated soils. The volumetric water content function describes how the suction varies with changes in water content in the soil.

Unsaturated functions for hydraulic conductivity and volumetric water content were based on SEEP/W default relationships and are presented in **Attachment 3**.

Table 10. Design Hydraulic Parameters for Seepage Analysis

Material Properties				SEEP/W Input Parameters						
Material	Kv (cm/s)	Ratio Kh/Kv	Kh (cm/s)	Model Type	Ksat = Kh (feet/day)	Ratio Kv/Kh	Mv (psf/psf)[(2)]	Θw-sat [(1)]	K-Function	VWC-Function
Existing Fill - Zone I	2.01E-08	5	1.01E-07	Sat. / Unsat.	3.30E-09	0.2	1.00E-06	0.50	Clay	Clay
Embankment Fill - Zone II	2.01E-07	5	1.01E-06	Sat. / Unsat.	3.30E-08	0.2	1.00E-06	0.50	Clay	Clay
Proposed Embankment Fill	1.38E-07	4	5.53E-07	Sat. / Unsat.	1.815E-08	0.25	1.00E-06	0.50	Clay	Clay
Alluvium	5.03E-06	2	1.01E-05	Sat. / Unsat.	3.30E-07	0.5	1.00E-06	0.50	Clay	Clay
Marl	2.01E-07	5	1.01E-06	Sat. Only	3.30E-08	0.2	1.00E-06	0.50	---	---
RipRap	1.11E+00	1	1.11E+00	Sat. / Unsat.	3.65E-02	1	1.00E-03	0.25	Gravel	Gravel
Filter Drain	1.00E-03	2	5.03E-03	Sat. / Unsat.	1.65E-04	0.5	5.00E-06	0.35	Sand	Sand
RCC	1.00E-01	1	1.01E-07	Sat. / Unsat.	3.3E-09	1	1.00E-06	0.10	Sand	Sand

Notes:

1. θw = Volumetric Water Content at Saturation (= Porosity x Degree of Saturation)
2. M_v = Coefficient of Volume Compressibility = I / Modulus of Elasticity
3. Unsaturated functions for volumetric water content (VWC) and hydraulic conductivity (K) based on default SEEP/W relationships.
4. Due to similarties in index properties and consistency, the suspected downstream fill(?) materials were considered equivalent to the residuum/alluvium for the purposes of seepage analysis.

COMPRESSIBILITY PARAMETERS

Stress History

The stress history of the soil is evaluated on the basis of the preconsolidation pressure (p'c) and the overconsolidation ratio (OCR). These parameters are typically evaluated from laboratory consolidation tests. Published correlations with field and laboratory testing data can also be used to develop estimates of soil stress history parameters. The correlation estimates were used to supplement laboratory consolidation test data, evaluate potential material variability, and to identify trends in consolidation parameters versus depth/elevation for each soil unit. Correlations used in the analysis are described in sections below.

Correlation with Undrained Shear Strength – Laboratory Tests

Undrained shear strength (Su) can be related to soil stress history according to the following equation (FHWA 2017, Section 7, Equation 7.6):

$$Su/\sigma'v = S*OCR^m$$

where σ'v = the effective in-situ overburden pressure and S and m are empirical coefficient related to soil type. Selected values of S=0.23 and m=0.9 were considered reasonable for homogenous clays of low sensitivity based on FHWA (2017) and were used for analysis. The equation can be re-arranged to calculate OCR. The resulting estimate of OCR can then be used to calculate p'c = OCR * σ'v.

Correlation results are plotted in **Attachment 4**.

Correlation with Undrained Shear Strength – Pocket Penetrometer Tests

Crude estimates of unconfined compressive strength (UCS) can be obtained from field pocket penetrometer (PP) testing on the exposed ends of relatively undisturbed Shelby tube samples. The value of Su can be estimated as UCS/2.

The PP testing on various embankment materials ranged from 1.0 to 4.5+ tsf, corresponding to approximately Su = 1,000 to more than 4,500 psf. Crude estimates of Su from the field pocket penetrometer tests were used to provide rough estimates of stress history versus elevation/depth according to the FHWA (2017) correlation equations presented above relating Su to OCR and p'c. Plots of the resulting estimated are provided in **Attachment 4**.

Correlation with Undrained Shear Strength – Standard Penetration Tests

The estimated Su values based on N_{60} were used to develop crude estimates of the stress history parameter OCR and p'c based on the FHWA (2017) correlation presented earlier. The resulting values of OCR and p'c were capped at 20 and 20,000 psf, respectively, for the purposes of plotting, which are presented in **Attachment 4**.

Laboratory Consolidation Tests

Results from the laboratory consolidation testing are summarized in **Table 11**, which indicate the soils are moderately to highly overconsolidated. The estimated maximum past pressure (p'c) and overconsolidation (OCR) values obtained from six (6) laboratory consolidation tests are plotted versus depth in **Attachment 4**. The p'c values range from 8,700 to 19,700 psf in the existing embankment and residuum materials, and p'c is relatively independent of depth/elevation. The estimated OCR ranges from about 11 to 36 in samples collected from depths between 3.5 and 15 feet bgs, with a lower OCR of 3.5 in a sample of residuum collected at depth of 23-25 feet bgs.

Table 11. Summary of Consolidation Test Results

Boring ID	Depth (ft)		Stratum	USCS	LL	PI	Cc	Cr	σ'v (psf) (2)	P'c (psf)	OCR	e_0	Cv (ft^2/day)	
	Top	Bottom											Min.	Max.
9-19	8	10	Embankment Core	CH	74	50	0.083	0.027	1,125	13,700	12.2	0.588	3.5E-04	2.8E-02
9-19	23	25	MPR	CH	50	29	0.122	0.036	2,500	8,700	3.5	0.658	1.1E-02	2.0E-02
13-20	6	8	Embankment Core	CH	61	41	0.145	0.027	875	11,400	13.0	0.601	1.9E-03	2.1E-03
601-19	3.5	5.5	LPR	CH	64	35	0.163	0.011	540	19,700	36.0	0.633	2.0E-03	6.4E-03
601-19	13	15	LPR	CH	67	44	0.124	0.025	1,536	17,900	11.7	0.670	1.2E-02	3.5E-02
603-19	8	10	MPR	CH	62	40	0.129	0.036	1,125	16,200	14.4	0.624	1.1E-02	4.7E-02

Notes:
1) Abbreviations:
   a) Cc – Compression index (void ratio basis)
   b) Cr – Recompression index (void ratio basis)
   c) σ'v – Estimated in-situ effective overburden pressures at mid-layer depth based on estimated long-term groundwater levels
   d) P'c – Estimated preconsolidation pressure
   e) CG – Casagrande method
   f) OCR – Estimated overconsolidation ratio
   g) e0 – Initial void ratio
   h) LL – Liquid Limit
   i) PI – Plasticity Index
   j) Cv – Coefficient of consolidation

Calculated at average sample depth assuming static groundwater at 15.4, 11.0, 11.7, and 14.9 feet bgs in borings 9-19, 13-20, 601-19, and 603-19, respectively, with average unit weight of 125 pcf.

Comparison of Stress History Estimation Methods and Selected Parameters

A summary of selected consolidation parameters is provided in **Table 12.** Based on the correlations and laboratory consolidation tests, a minimum p'c=4,000 psf was assigned to the existing materials to account for overconsolidation near the ground surface. A minimum OCR=2.0 was conservatively selected to account for overconsolidation at depth.

While no consolidation tests were performed on remolded samples of proposed embankment fill, experience on other dam projects in the Plum and Elm Creek watersheds in Central Texas indicates laboratory consolidation tests performed on medium- to high-plasticity clays remolded to at least 95% MDD (Standard Proctor) at typical compaction moisture contents (0 to +4% OMC) typically yield p'c of at least 3,000 psf. Thus, p'c=3,000 psf was selected for design.

Table 12. Selected Consolidation Parameters for Settlement Analysis

Material	γ (pcf)	e0	Min. OCR	Minimum P'c (psf)	Cc	Cr	Es (ksf)	Cv (ft^2/day)
Embankment Fill	125	0.60	2.0	4,000	0.2	0.03	--	1E-03
Alluvium	123	0.65	2.0	4,000	0.2	0.03	--	1E-02
Residuum	126	0.60	2.0	4,000	0.2	0.03	--	1E-02
Shale	130	0.50	--	--	--	--	--	--
Proposed Embankment Fill	125	0.70	2.0	3,000	0.2	0.03	--	1E-03

Notes:
1. Abbreviations legend:
a) γ – Total Moist Unit Weight
b) e_0 – Initial Void Ratio;
c) OCR – Overconsolidation Ratio (applies to zones where the P'c is greater than minimum value);
d) P'_c – Maximum Past Pressure (minimum value accounts for near-surface desiccated "crust");
e) C_c – Compression Index from e-log(p) curve;
f) C_r – Recompression Index from e-log(p) curve
g) E_s – Elastic Modulus; refer to text
h) Cv – Coefficient of consolidation

Compressibility Indices

Values of compression index (Cc) and recompression index (Cr) were reported by TRI Environmental on the lab data sheets. AECOM reviewed the data and agree with the estimated values. The Cc and Cr values are summarized in T**able 11**.

Coefficient of Consolidation

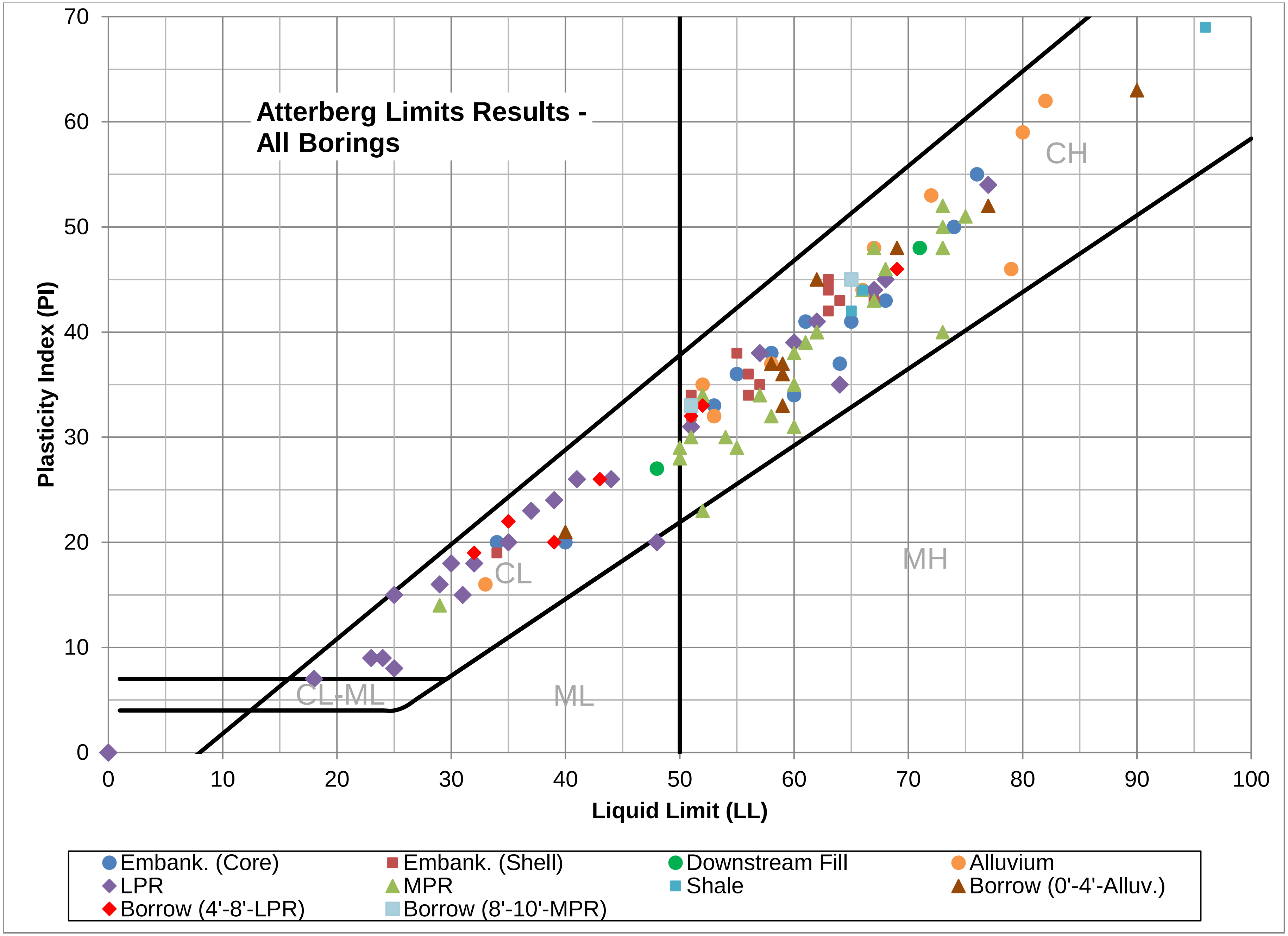
The coefficient of consolidation (Cv) is used to evaluate the time rate of consolidation, and to estimate the period of time required for primary consolidation to be complete following loading. The Cv values estimated by TRI Environmental using the Log-Time and Root-Time methods at each incremental loading step are plotted against corresponding sample void ratio on the laboratory test data sheets. The resulting range of minimum and maximum Cv values are summarized in **Table 11**. Selected values for design are provided in **Table 12**.

Initial Void Ratio

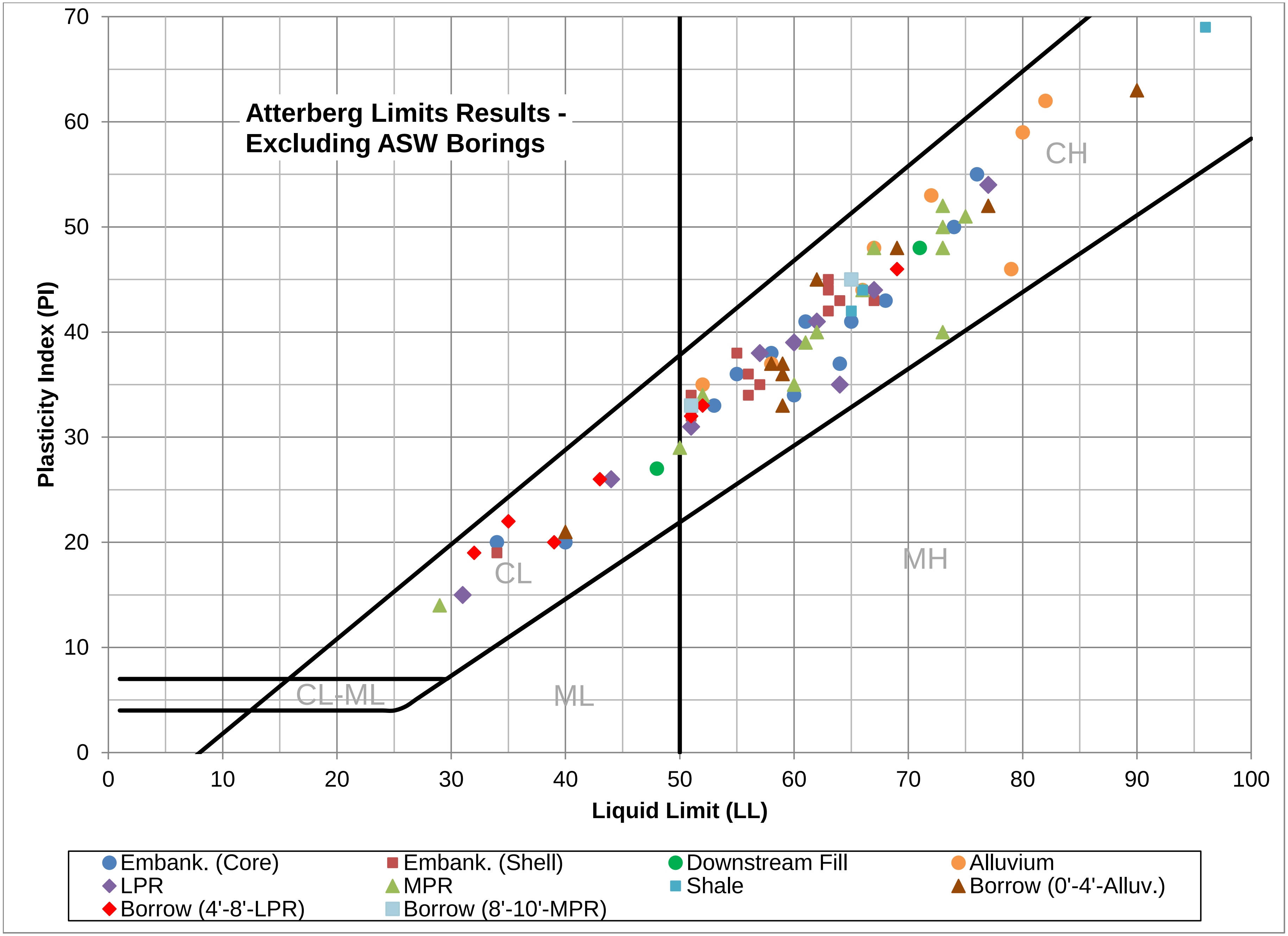
The initial void ratio (e_0) of various geologic units was based on reported results of the consolidation tests and other intact/remolded laboratory tests, and as calculated from dry unit weight measurements on relatively undisturbed Shelby tube samples assuming a specific gravity (Gs) of 2.7 according to manipulation of the equation below. The selected values are provided in **Table 11**.

$$\gamma_d = \frac{G_s \gamma_w}{1 + e}$$

ATTACHMENT 1
Atterberg Limits Plot



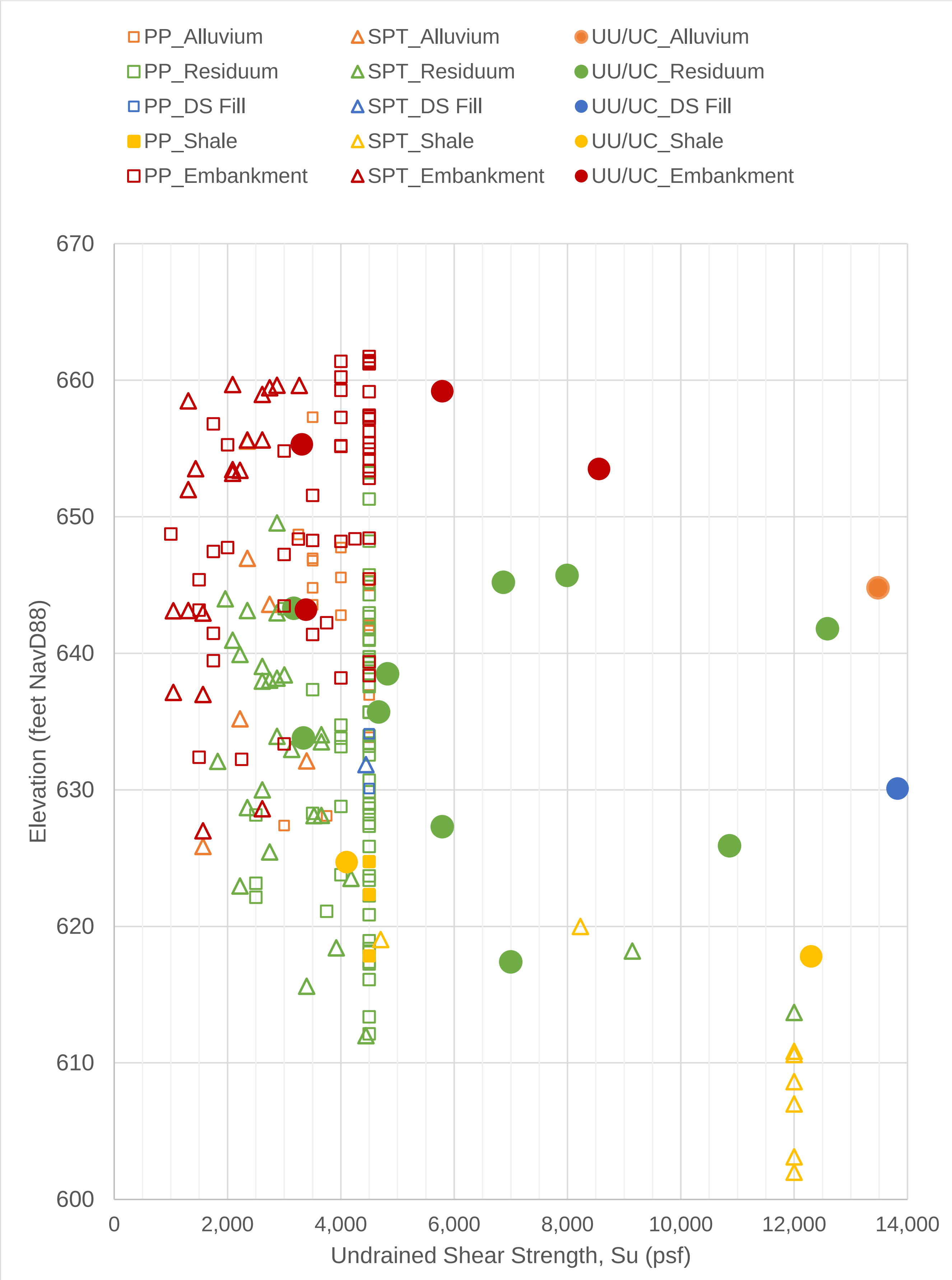
Atterberg Limits Results -
All Borings
Plasticity Index (PI)
Liquid Limit (LL)
CH
CL
MH
CL-ML
ML
0
10
20
30
40
50
60
70
0
10
20
30
40
50
60
70
80
90
100
Embank. (Core)
Embank. (Shell)
Downstream Fill
Alluvium
LPR
MPR
Shale
Borrow (0'-4'-Alluv.)
Borrow (4'-8'-LPR)
Borrow (8'-10'-MPR)



Atterberg Limits Results -
Excluding ASW Borings
Plasticity Index (PI)
Liquid Limit (LL)
0
10
20
30
40
50
60
70
0
10
20
30
40
50
60
70
80
90
100
CH
CL
MH
CL-ML
ML
Embank. (Core)
Embank. (Shell)
Downstream Fill
Alluvium
LPR
MPR
Shale
Borrow (0'-4'-Alluv.)
Borrow (4'-8'-LPR)
Borrow (8'-10'-MPR)

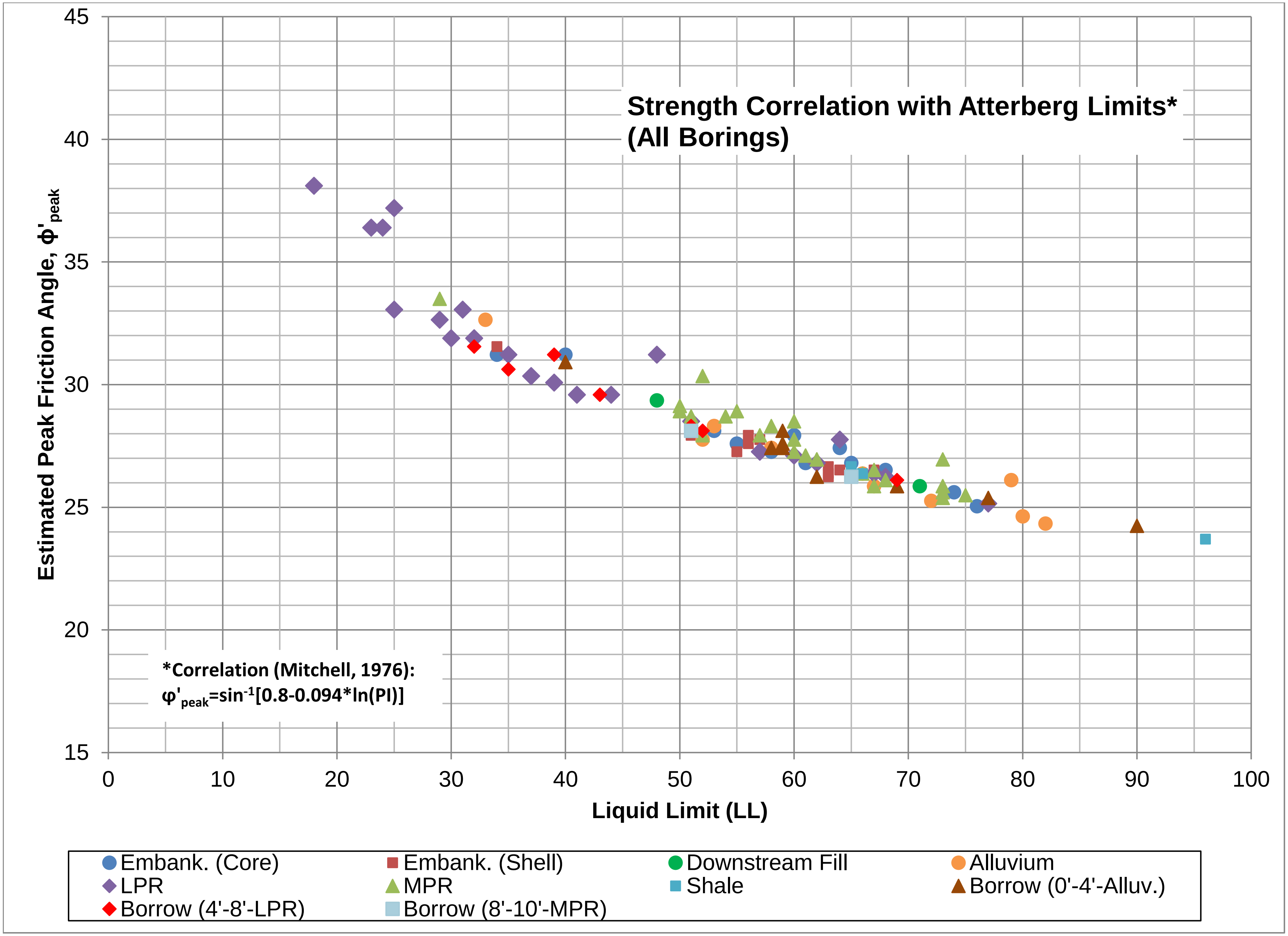
ATTACHMENT 2
Shear Strength Analysis

Undrained Strength (UU) Analysis

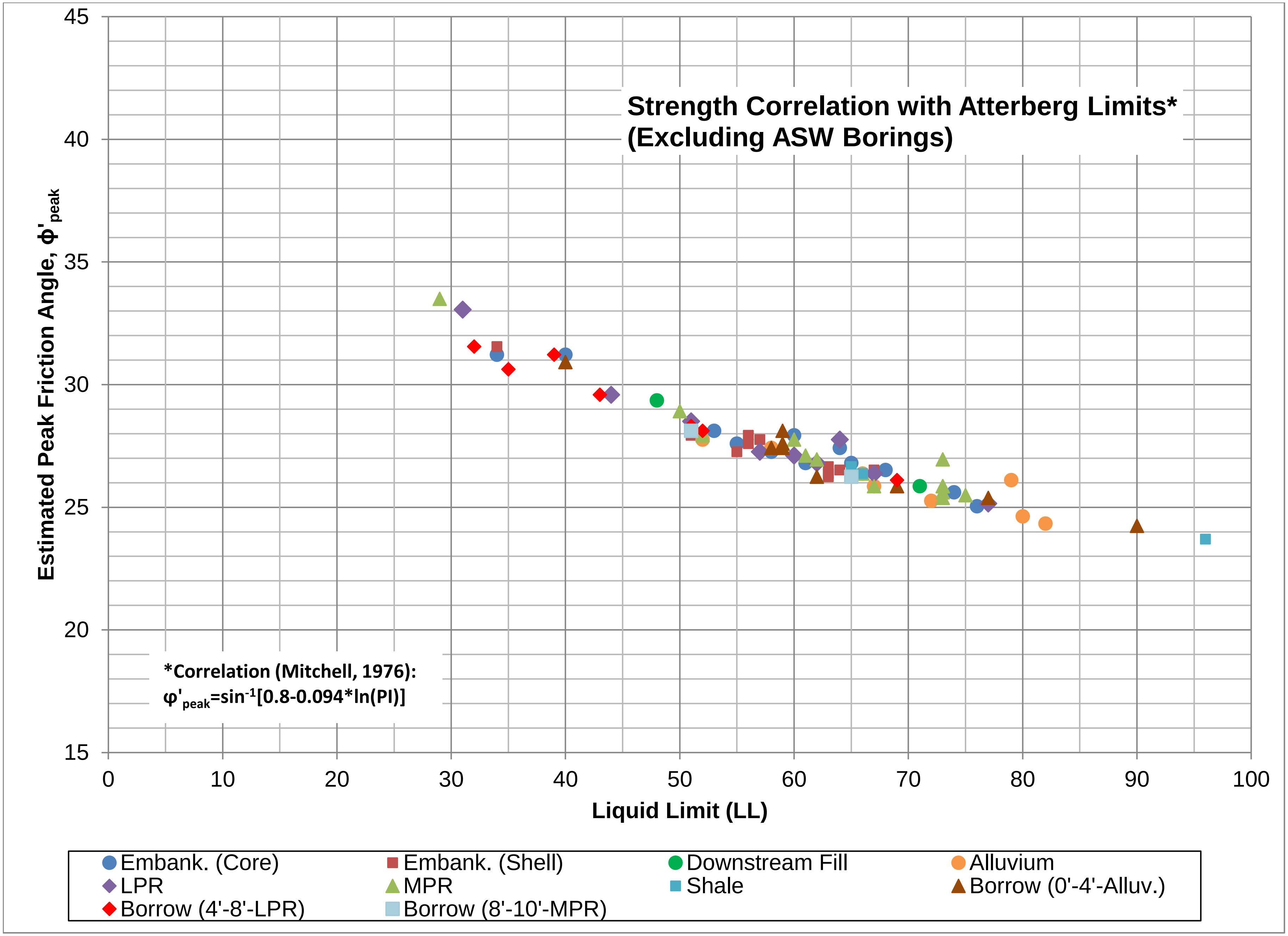


PP_Alluvium
SPT_Alluvium
UU/UC_Alluvium
PP_Residuum
SPT_Residuum
UU/UC_Residuum
PP_DS Fill
SPT_DS Fill
UU/UC_DS Fill
PP_Shale
SPT_Shale
UU/UC_Shale
PP_Embankment
SPT_Embankment
UU/UC_Embankment
670
660
650
640
630
620
610
600
Elevation (feet NavD88)
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
Undrained Shear Strength, Su (psf)

Effective Stress (CD) Strength Analysis



Strength Correlation with Atterberg Limits*
(All Borings)
Estimated Peak Friction Angle, φ'peak
Liquid Limit (LL)
45
40
35
30
25
20
15
0
10
20
30
40
50
60
70
80
90
100
*Correlation (Mitchell, 1976):
φ'peak=sin-1[0.8-0.094*ln(PI)]
Embank. (Core)
Embank. (Shell)
Downstream Fill
Alluvium
LPR
MPR
Shale
Borrow (0'-4'-Alluv.)
Borrow (4'-8'-LPR)
Borrow (8'-10'-MPR)


Strength Correlation with Atterberg Limits*
(Excluding ASW Borings)
*Correlation (Mitchell, 1976):
φ'peak=sin-1[0.8-0.094*ln(PI)]
Estimated Peak Friction Angle, Φ'peak
Liquid Limit (LL)
45
40
35
30
25
20
15
0
10
20
30
40
50
60
70
80
90
100
Embank. (Core)
Embank. (Shell)
Downstream Fill
Alluvium
LPR
MPR
Shale
Borrow (0'-4'-Alluv.)
Borrow (4'-8'-LPR)
Borrow (8'-10'-MPR)

fully softened strength correlation suggested by Stark et al. (2005) provides a reliable estimate of ϕ'_{fs} for use in preliminary design, verification of laboratory test results, and confirmation of back-analysis of first-time slides.

The fully softened strength empirical correlation uses three different CF groups, i.e., CF $\leq 20\%$, $25\% \leq$ CF $\leq 45\%$, and CF $\geq 50\%$, which is similar to the residual strength correlation and accounts for the effect of CF and σ'_n on ϕ'_{fs} values. Furthermore, the empirical correlation uses values of LL and CF measured using disaggregated samples to make it similar to the empirical correlation for drained residual secant friction angle shown in Fig. 2.

The current study suggests a separate mathematical expression for each trend line of the correlation in Fig. 4 that can be used to estimate values of ϕ'_{fs} and a stress-dependent strength envelope using values of LL and CF measured using disaggregated samples.

Equations for Updated Empirical Correlations for Drained Fully Softened Secant Friction Angle

Stark and Eid (1997) and Stark et al. (2005) presented a relationship between LL and drained fully softened secant friction angle in graphic form, with separate trend lines for each effective normal stress for three different CF groups. The current study considered each CF group separately while developing an equation for each trend line for the three effective normal stresses considered, i.e., 50, 100, and 400 kPa. The empirical correlation for fully softened secant friction angle in Stark et al. (2005) and Fig. 4 already includes an effective normal stress of 50 kPa, so this trend line did not have to be added during this study but was an impetus for adding this effective normal stress to the residual strength correlation. Stark et al. (2005) adjusted the ring shear fully softened strength by adding 2.5 degrees to the measured values to make these comparable to the values obtained using a triaxial compression test and, more importantly, first-time landslides (Skempton 1970). This adjustment was deemed necessary by Stark and Eid (1997) and Stark et al. (2005) because first-time landslides usually do not involve a horizontal failure surface as is present in the ring shear device. The failure surface in first-time slides is closer to the orientation of the failure surface in a triaxial compression test, so the existing and new values of ϕ'_{fs} were increased by 2.5 degrees to reflect the triaxial mode of shear. New data for three natural soils tested herein was added to the existing database with this adjustment of 2.5 degrees and the updated correlation is shown in Fig. 4.

A set of three equations for the empirical correlation for drained fully softened secant friction angles of CF Group No. 1 and for LL values ranging from 30% to less than 80% ($30\% \leq$ LL $< 80\%$) was developed during the current study. These equations are given as Eqs. (5*a*) to (5*c*). The LL range of 30% to 80% is specified because the ring shear data are available only for this LL range. A second-degree polynomial can be used to represent the trend lines for CF Group No. 1 and for all three effective normal stresses

$$(\phi'_{fs})_{\sigma'_n = 50\,\mathrm{kPa}} = 34.85 - 0.0709\,(\mathrm{LL}) + 2.35 \times 10^{-4}(\mathrm{LL})^2 \quad (5a)$$

$$(\phi'_{fs})_{\sigma'_n = 100\,\mathrm{kPa}} = 34.39 - 0.0863\,(\mathrm{LL}) + 2.66 \times 10^{-4}(\mathrm{LL})^2 \quad (5b)$$

$$(\phi'_{fs})_{\sigma'_n = 400\,\mathrm{kPa}} = 34.76 - 0.13\,(\mathrm{LL}) + 4.71 \times 10^{-4}(\mathrm{LL})^2 \quad (5c)$$

A set of three equations was also developed herein for CF Group No. 2 and LL values ranging from 30% to 130% ($30\% \leq$ LL $\leq 130\%$), and is given as Eqs. (6*a*)–(6*c*). A second-degree polynomial was also used to represent the trend lines for CF Group No. 2 and for all three effective normal stresses

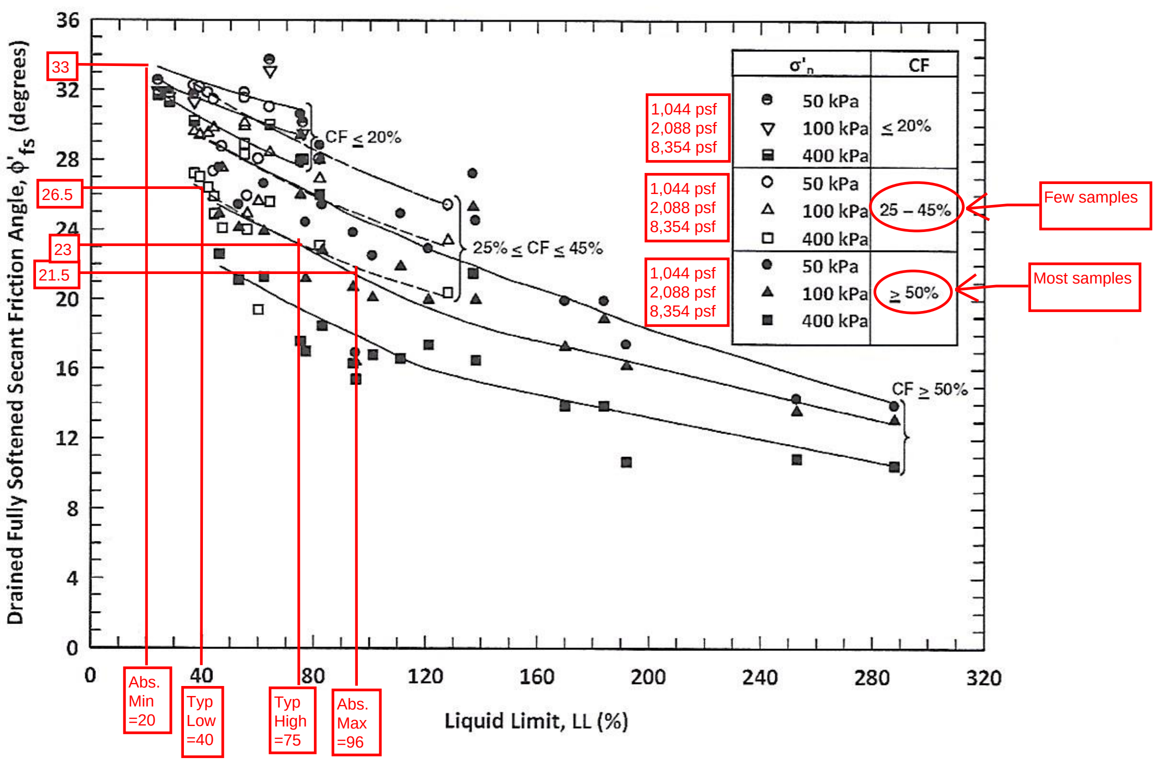


Fig. 4. Updated empirical correlation for drained fully softened secant friction angle based on LL, CF, and σ'_n for 39 natural soils

ERDC/GSL TR-08-2

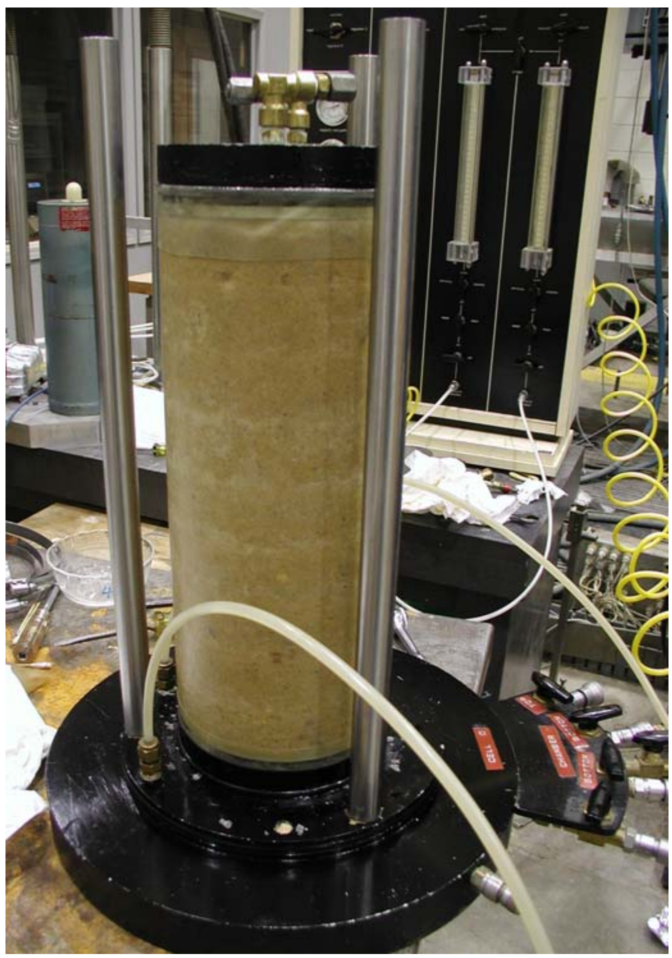
Geotechnical and Structures Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

Mechanical and Physical Properties of ASTM C33 Sand

Ernest S. Berney IV and Donald M. Smith

February 2008



4 Summary and Conclusions

Summary of concrete sand properties

The data summarized below provide the means to determine a wide variety of material properties for use in modeling and validation of indirect physical testing of concrete sand. The following tabulations represent the mechanical properties determined from the laboratory investigations described in Chapters 1–3.

Classification:

USCS: SP – Poorly Graded Sand (nonplastic)
AASHTO: A-3
% Gravel: 6.3%
% Sand: 91.3%
% Fines: 2.4%
Specific Gravity: 2.66

Elastic properties:

Effective Stress Shear Modulus: $G = 469.24\ \sigma'_m{}^{0.6736}$ psi
Effective Stress Young's Modulus: $E = 1173.1\ \sigma'_m{}^{0.6736}$ psi
Poisson's Ratio: 0.25
Correlation between strength and Young's modulus:
$E = 1500 * \text{CBR}$

Effective stress strength properties:

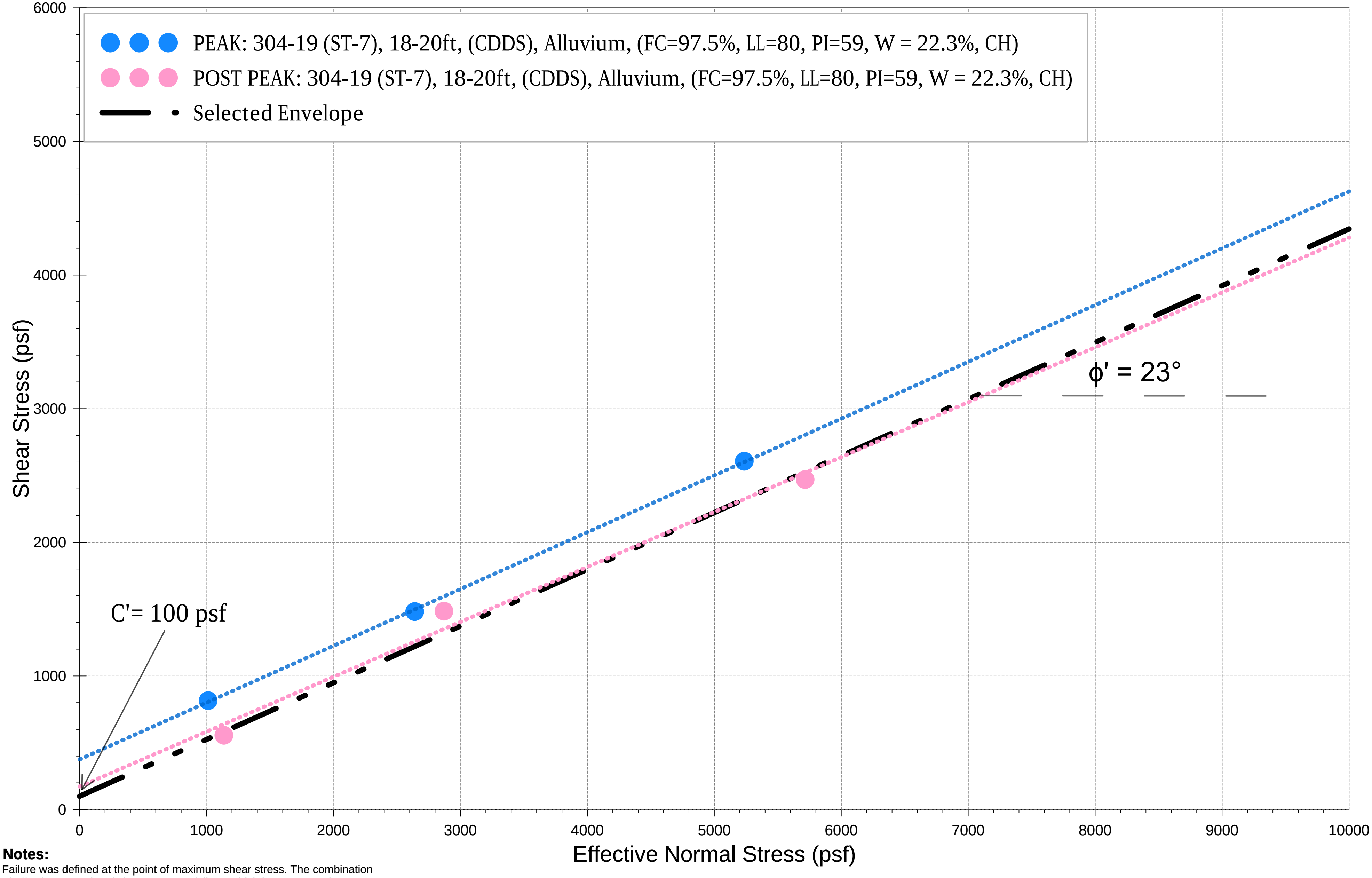
Peak friction angle: 40°
Minimum friction angle: 32.8°
Average friction angle: 36.5°
Cohesion: 0 psi
Coefficient of consolidation, C_c: 0.03 (measured), 0.156 (Lee 1965)
Coefficient of reconsolidation, C_s: 0.01 (est. from isotropic data)
Undrained compressive strength at 10 psi confinement: 39.9 psi

Construction properties:

Maximum relative density: 114.1 pcf
Minimum relative density: 63.9 pcf
Maximum dry density (modified Proctor): 112.5 pcf
Optimum moisture content (modified Proctor): 2%
CBR at optimum conditions (dry): 38 (53 max)
Maximum dry density (standard Proctor): 111 pcf
Optimum moisture content (standard Proctor): 3% and 8%
CBR at optimum conditions (dry): 25 (at 3%), 16 (at 8%)

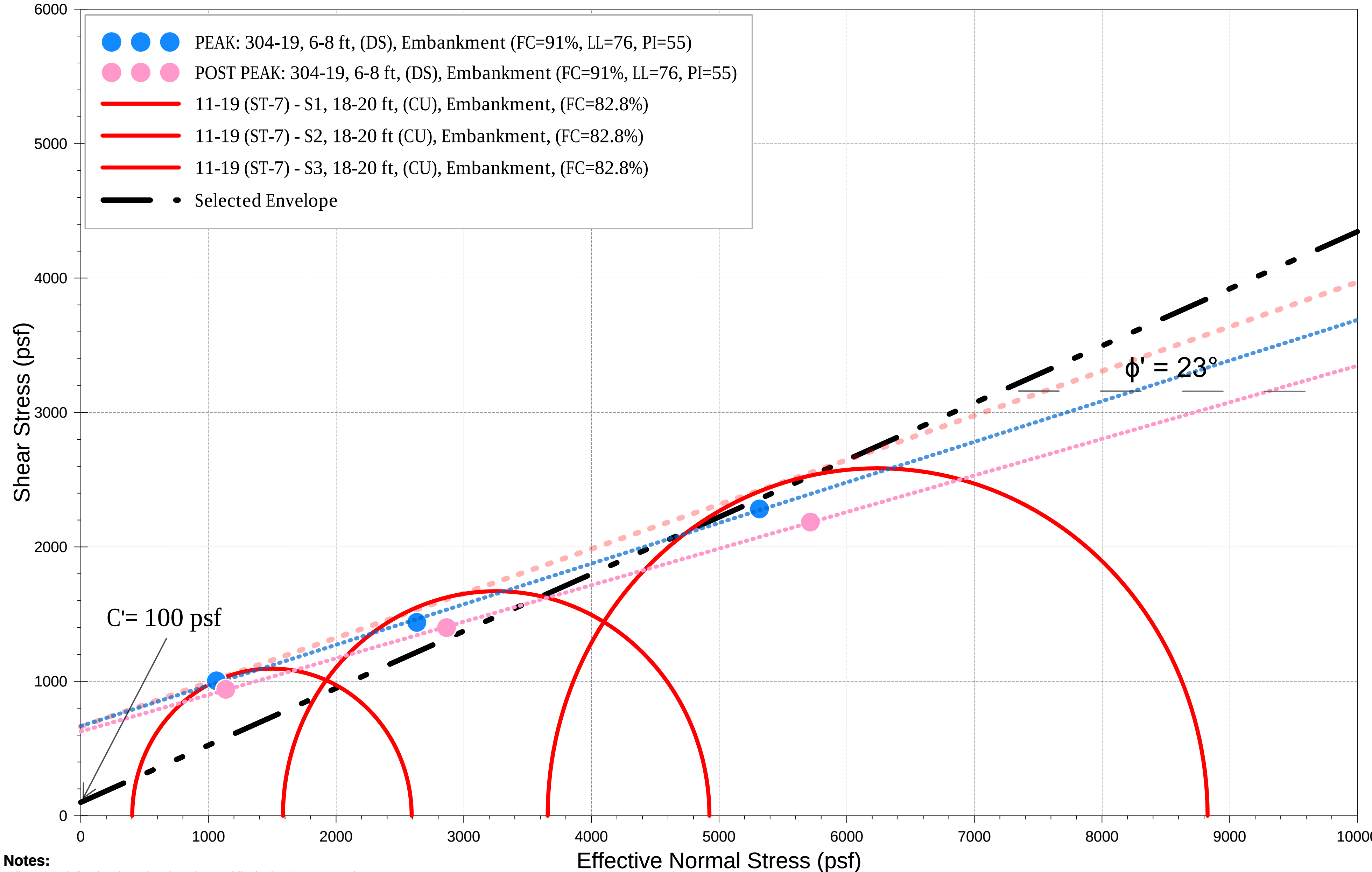
Recommendations

Determination of consolidation properties for granular materials is difficult because of the large pressures required to achieve steady-state deformation. Therefore, it is recommended that the coefficients of consolidation and reconsolidation be used with caution, with emphasis placed on the value determined by Lee that was obtained under pressures much greater than those used in this laboratory investigation.



Notes:
Failure was defined at the point of maximum shear stress. The combination of effective normal and shear stress at failure, which is tangent to the failure line for a given soil, was defined at a point on Mohr's effective stress circle based on consolidated drained direct shear test results.

PROJECT NO. 60615067	ELM & PLUM CREEK DAM REHABILITATION	PLUM #2 REHABILITATION ALLUVIUM SHEAR STRENGTH EFFECTIVE PEAK DRAINED	FIGURE
AECOM	FALLS COUNTY, TX		

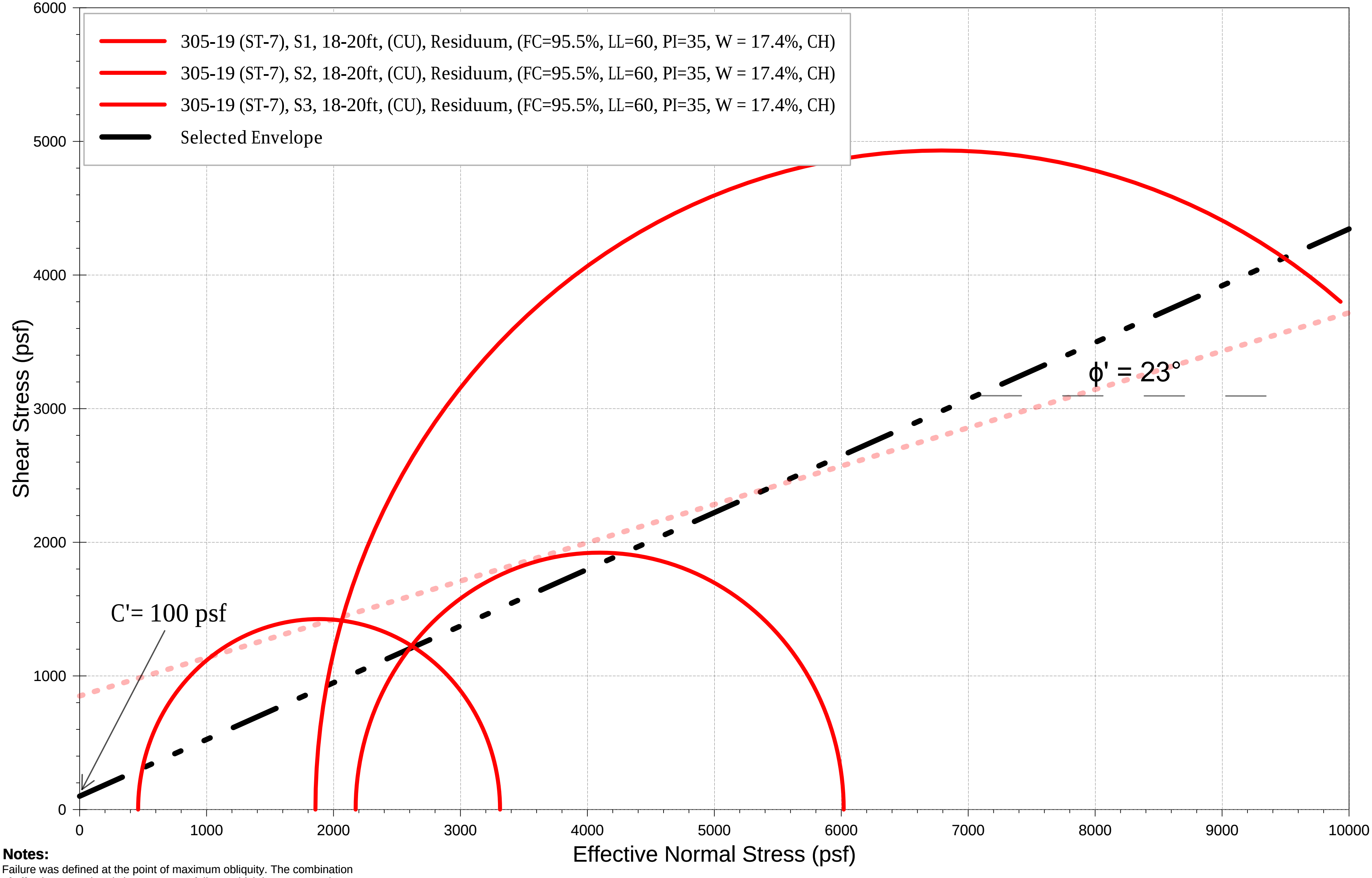


Notes:
Failure was defined at the point of maximum obliquity for CIU' tests and the point of maximum shear for direct shear tests. The combination of effective normal and shear stress at failure, which is tangent to the failure line for a given soil, was defined at a point on Mohr's effective stress circle based on triaxial shear test results.

PROJECT NO. 60615067	ELM & PLUM CREEK DAM REHABILITATION	PLUM #2 REHABILITATION	FIGURE
AECOM	FALLS COUNTY, TX	EXISTING EMBANKMENT SHEAR STRENGTH EFFECTIVE PEAK DRAINED	

04/16/2021 4:02:56

C:\Users\Braden.Erron\Desktop\Scratch\Plum 2\Mohr Shear Circles\Drained- Effective Stress Shear Strength parameters-Embankment.grf



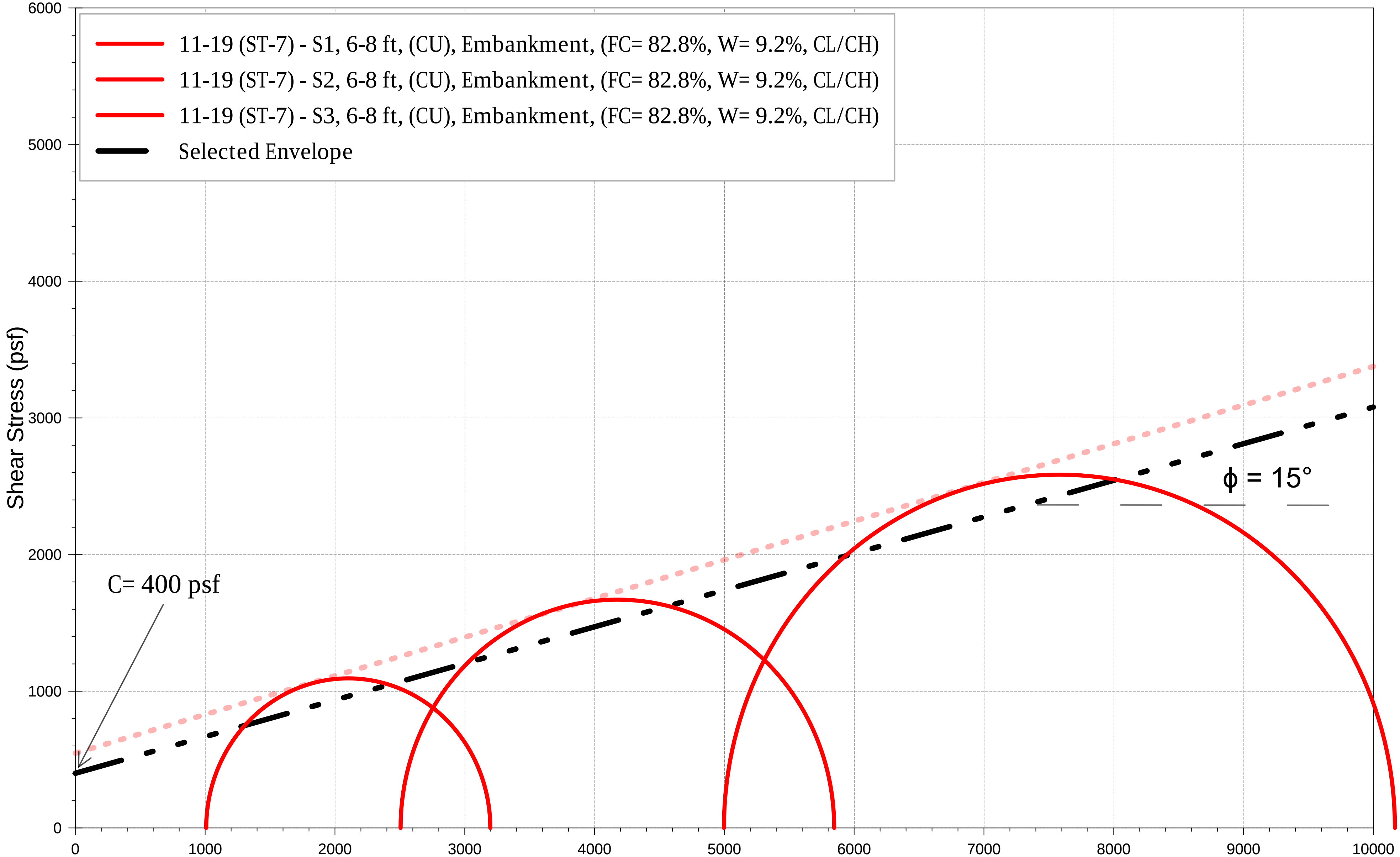
Notes:
Failure was defined at the point of maximum obliquity. The combination of effective normal and shear stress at failure, which is tangent to the failure line for a given soil, was defined at a point on Mohr's effective stress circle based on triaxial shear test results.

PROJECT NO. 60615067	ELM & PLUM CREEK DAM REHABILITATION	PLUM #2 REHABILITATION RESIDUUM SHEAR STRENGTH EFFECTIVE PEAK DRAINED	FIGURE
AECOM	FALLS COUNTY, TX		

04/16/2021 4:03:16

C:\Users\Braden.Erron\Desktop\Scratch\Plum 2\Mohr Shear Circles\Drained - Effective Stress Shear Strength Parameters - Residuum.grf

Total Stress (CU) Strength Analysis

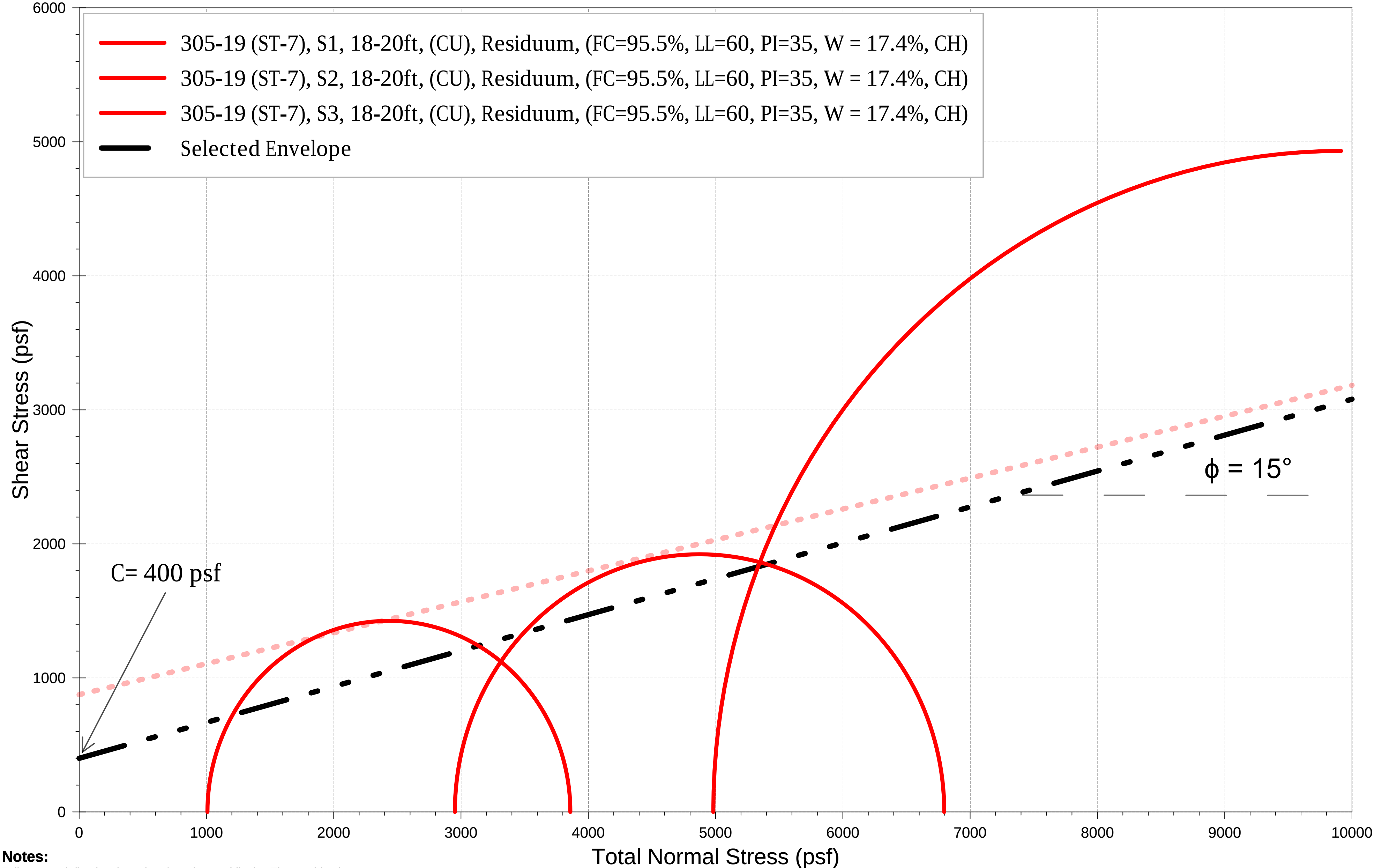


Notes:
Failure was defined at the point of maximum obliquity. The combination of effective normal and shear stress at failure, which is tangent to the failure line for a given soil, was defined at a point on Mohr's effective stress circle based on triaxial shear test results.

04/16/2021 4:03:36

C:\Users\Braden.Erron\Desktop\Scratch\Plum 2\Mohr Shear Circles\Undrained - Total Stress Shear Strength Parameters - Embankment.grf

PROJECT NO. 60615067	ELM & PLUM CREEK DAM REHABILITATION	PLUM #2 REHABILITATION EXISTING EMBANKMENT SHEAR STRENGTH TOTAL PEAK UNDRAINED	FIGURE
AECOM	FALLS COUNTY, TX		



Notes:
Failure was defined at the point of maximum obliquity. The combination of effective normal and shear stress at failure, which is tangent to the failure line for a given soil, was defined at a point on Mohr's effective stress circle based on triaxial shear test results.

PROJECT NO. 60615067	ELM & PLUM CREEK DAM REHABILITATION	PLUM #2 REHABILITATION RESIDUUM SHEAR STRENGTH TOTAL PEAK UNDRAINED	FIGURE
AECOM	FALLS COUNTY, TX		

ATTACHMENT 3
Hydraulic Properties Analysis

Published Values

NAVFAC DM-7 Published Typical Values (conversion factor = 0.508 cm/s from ft/min)

- GW = 5E-02 ft/min = 3E-02 cm/s
- SP = 1E-03 ft/min = 5E-04 cm/s
- SM = 5E-05 ft/min = 3E-05 cm/s
- SC = 5E-07 ft/min = 3E-07 cm/s
- ML = 1E-05 ft/min = 5E-06 cm/s
- CL = 1E-07 ft/min = 5E-08 cm/s
- CH = 1E-07 ft/min = 5E-08 cm/s

UFC, 2004 (after USACE)

- Very Fine to Medium Sand = 1E-03 – 1E-01 cm/s
- Silty Sands to Silty Clays = 1E-04 – 1E-06 cm/s
- “Impervious” Clays = 1E-07 – 1E-09 cm/s

Cedergren, 1977 – Relationship between Hydraulic Conductivity and Dry Unit Weight

- Sandy Silt-1 (ML) = 4E-08 – 6E-07 cm/s (102 to 92 pcf)
- Sandy Silt-2 (ML) = 1E-06 – 2E-06 cm/s (125 to 110 pcf)
- Clayey Sand (SC) = 7E-08 – 1E-06 cm/s (128 to 115 pcf)
- Silty Sand-1 (SM) = 3E-07 – 2E-06 cm/s (115 to 101 pcf)
- Silty Sand-2 (SM) = 3E-05 – 2E-04 cm/s (100 to 91 pcf)

USBR Design of Small Dams (1987)

- SM → k = 1E-03 – 1E-08 cm/s (9E-05 avg)
- SC → k = 1E-05 – 6E-08 cm/s (1E-06 avg)
- ML → K = 4E-05 – 1E-08 cm/s (7E-06 avg)
- CL → k = 1E-05 – 1E-08 cm/s (8E-07 avg)

USBR Embankment Dams, Chapter 8 Seepage, DS-13(8-4), 2011

Permeability k_H of Unconsolidated Natural Soils (k_H inversely related to % finer grains)

(x9.66514E-07 to cm/s)

Soil	k_H Range (ft/yr or 10^{-6} cm/s)	
Gravel, open-work	>2,000,000	
Gravel (GP)	200,000 to 2,000,000	
Gravel (GW)	10,000 to 1,000,000	
Sand, coarse (SP)	10,000 to 500,000	
Sand, medium (SP)	1,000 to 100,000	
Sand, fine (SP)	500 to 50,000	
Sand (SW)	100 to 50,000	
Sand, silty (SM)	100 to 10,000	1E-04 to 1E-02
Sand, clayey (SC)	1 to 1,000	1E-06 to 1E-04
Silt (ML)	1 to 1,000	1E-06 to 1E-04
Clay (CL)	~0 to 3	< 3E-06

References: [15], [18], [22-29], [33-36]

Anisotropy of Natural Soil and Rock

Formation	k_H/k_V
Stratified deposits	10 to 1,000
Massive soil or rock	1 to 3
Fractured rock	0.1 to 10
Eolian soil (loess and dune)	0.02 to 2

References: [3], [15], [17], [19-21], [24], [30-31], [35-42]

Permeability (k_V) of Embankment Core Materials (k_V inversely related to % fines)

(x9.66514E-07 to cm/s)

Unified Soil Classification	k_V Range (ft/yr or $x10^{-6}$ cm/s)*	
GM-SM	0.0 to 10.0	
GM or GC	0.0 to 10.0	
SP-SM	0.0 to 10.0	
SM	0.0 to 10.0	
SM-SC	0.0 to 3.0	
SM-ML	0.0 to 10.0	
SC	0.0 to 3.0	
ML	0.0 to 10.0	
ML-CL	0.0 to 1.0	
CL	0.0 to 1.0	< 1E-06
MH	0.0 to 0.1	

References: [31-32], [34], [44-45]
* Based primarily on Reclamation laboratory test data

Typical unsaturated functions

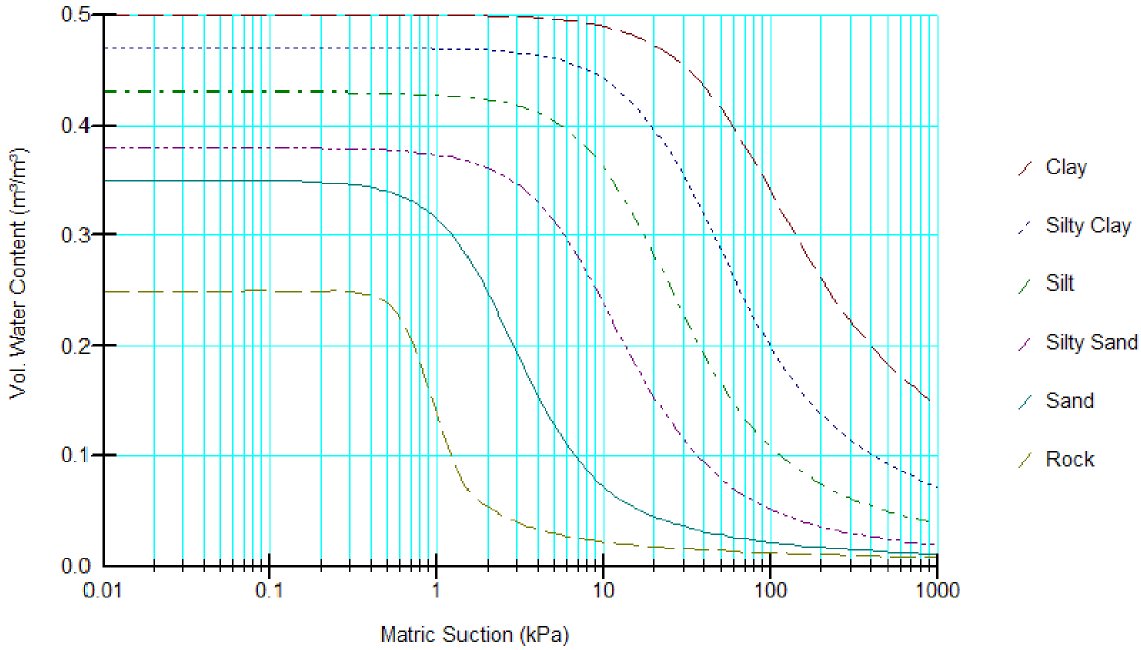
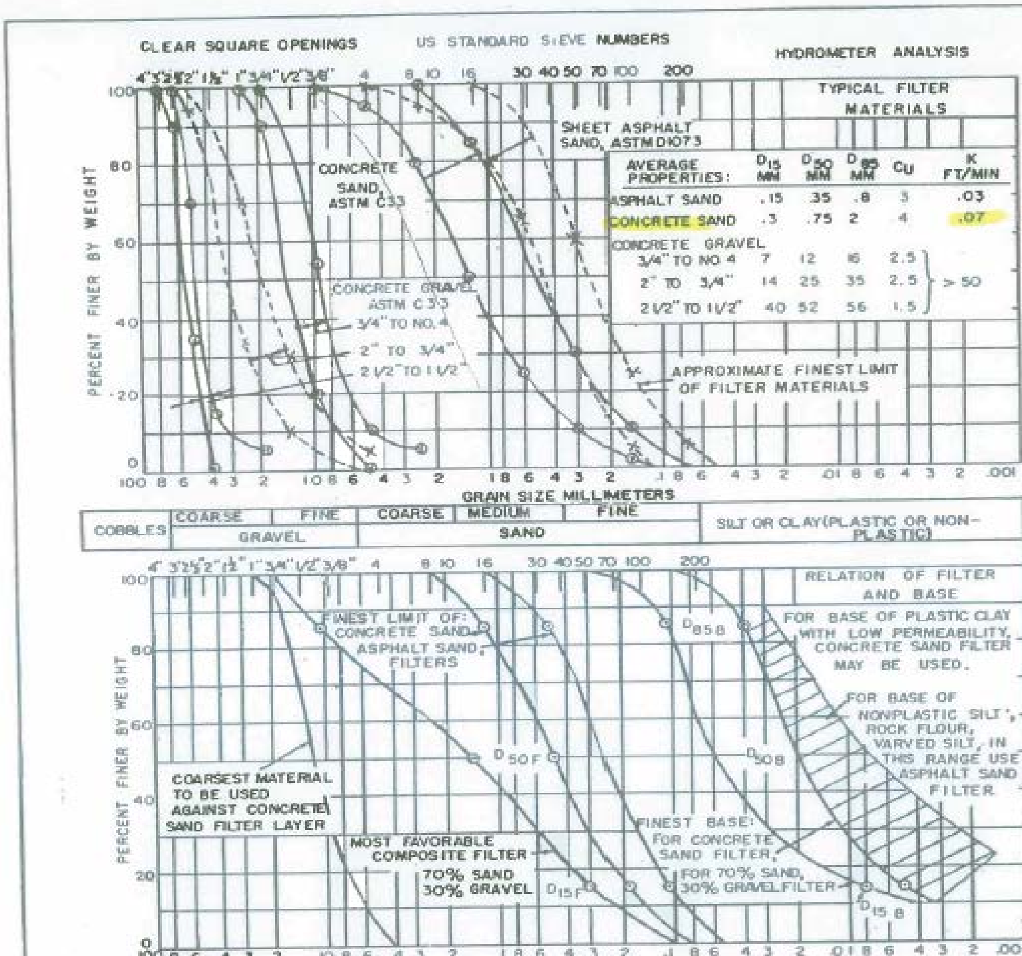


Figure 4-3 Sample Functions in GeoStudio



≈ 101 ft/day

General requirements:

1. To avoid head loss in filter: $\frac{D_{15F}}{D_{15B}} > 4$, and permeability of filter must be large enough to suffice for the particular drainage system.
2. To avoid movement of particles from base: $\frac{D_{15F}}{D_{85B}} < 5$, $\frac{D_{50F}}{D_{50B}} < 25$, $\frac{D_{15F}}{D_{15B}} < 20$

   For very uniform base material ($C_u < 1.5$): D_{15F}/D_{85D} may be increased to 6

   For broadly graded base material ($C_u > 4$): D_{15F}/D_{15B} may be increased to 40
3. To avoid movement of filter in drain pipe perforations or joints:

   D_{85F}/slot width > (1.2 to 1.4) D_{85F}/hole diameter > (1.0 to 1.2)
4. To avoid segregation filter should contain no sizes larger than 3".
5. To avoid internal movement of fines, filter should have no more than 5% passing No. 200 sieve.

FIGURE 8-8
Design Criteria for Protective Filters

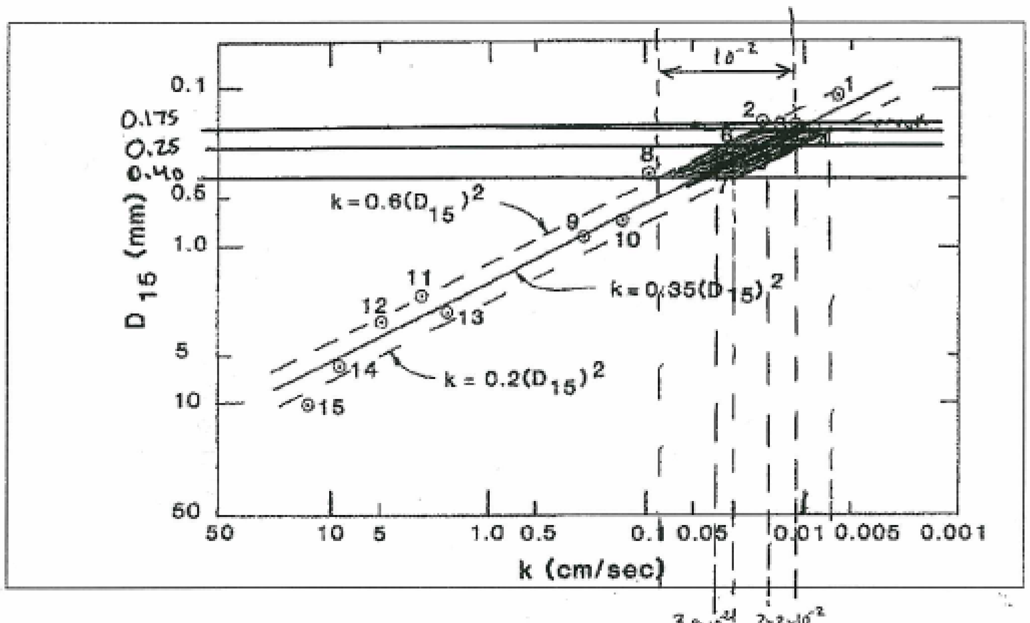
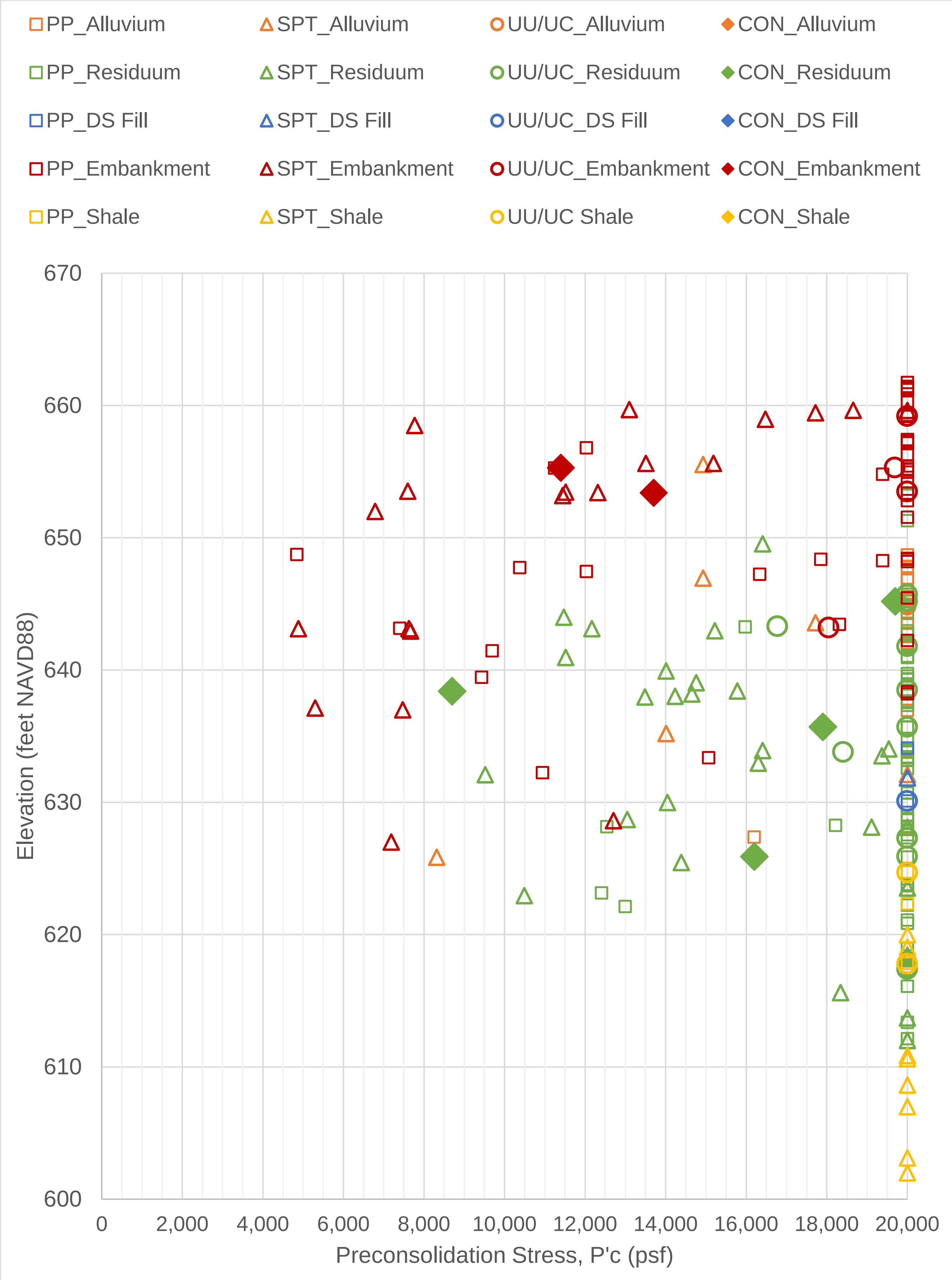


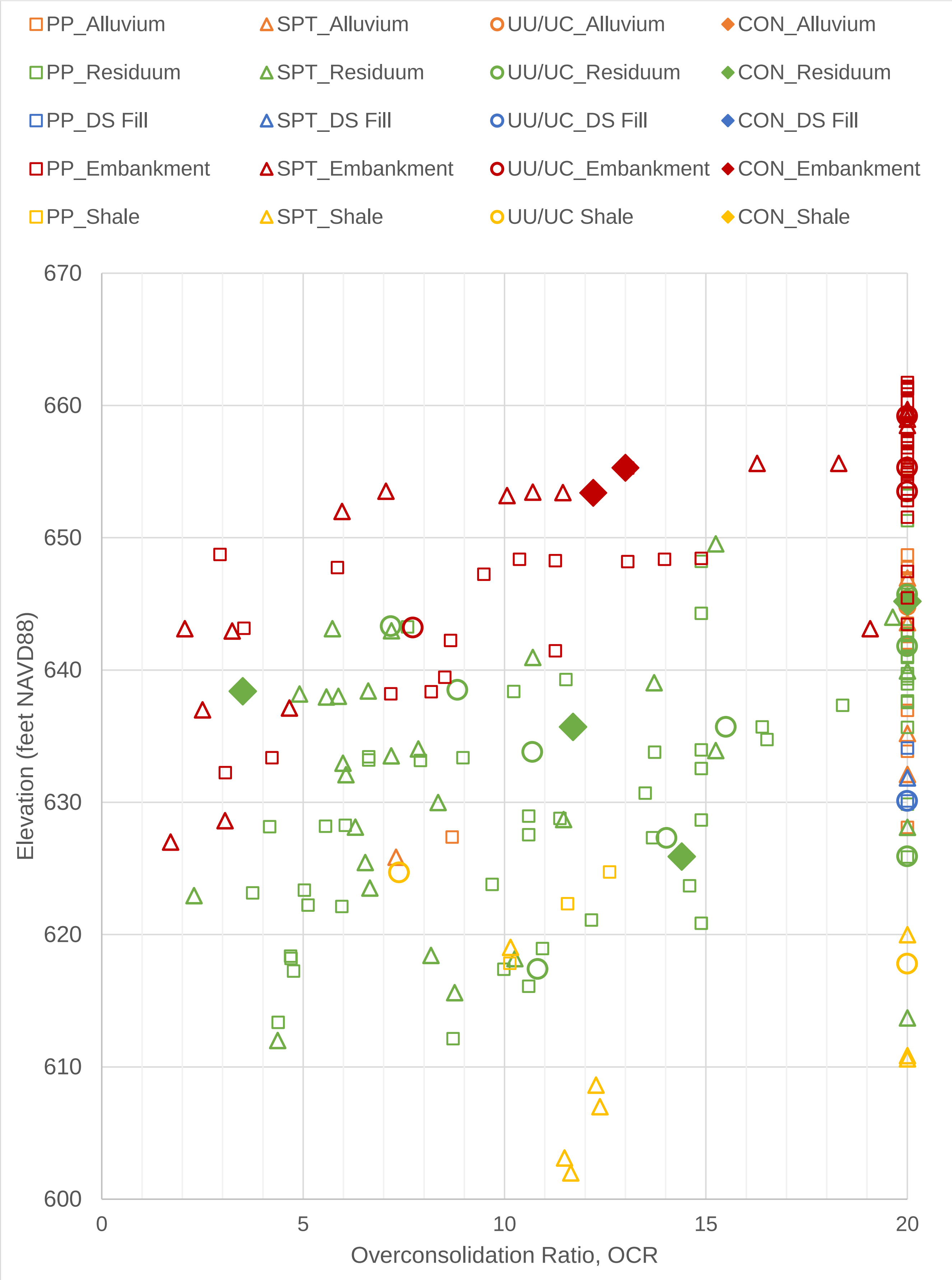
Figure B-1. Illustration from Sherard article on Sand and Gravel filters.

ATTACHMENT 4
Compressibility Analysis

Plots of Consolidation Test Results and Correlated Parameters



PP_Alluvium
SPT_Alluvium
UU/UC_Alluvium
CON_Alluvium
PP_Residuum
SPT_Residuum
UU/UC_Residuum
CON_Residuum
PP_DS Fill
SPT_DS Fill
UU/UC_DS Fill
CON_DS Fill
PP_Embankment
SPT_Embankment
UU/UC_Embankment
CON_Embankment
PP_Shale
SPT_Shale
UU/UC Shale
CON_Shale
670
660
650
640
630
620
610
600
Elevation (feet NAVD88)
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
Preconsolidation Stress, P'c (psf)


PP_Alluvium
SPT_Alluvium
UU/UC_Alluvium
CON_Alluvium
PP_Residuum
SPT_Residuum
UU/UC_Residuum
CON_Residuum
PP_DS Fill
SPT_DS Fill
UU/UC_DS Fill
CON_DS Fill
PP_Embankment
SPT_Embankment
UU/UC_Embankment
CON_Embankment
PP_Shale
SPT_Shale
UU/UC Shale
CON_Shale
670
660
650
640
630
620
610
600
Elevation (feet NAVD88)
0
5
10
15
20
Overconsolidation Ratio, OCR

Appendix C Seepage Analysis

OBJECTIVES:

1. Calculate design hydraulic conductivity for various geologic materials through analysis sections.
2. Perform seepage analysis using computer program SEEP/W to calculate the location of the phreatic surface for use in slope stability calculations
3. Use SEEP/W results to estimate flow rate through the internal drains.
4. Size internal drains based on estimated flow rates.

REFERENCES:

1. GeoStudio. "Seep/W User Manual".
2. NRCS. "210-VI-TR60, Earth Dams and Reservoirs." March, 2019.
3. AECOM. "TSSWCB Plum 2, Geologic Investigation Report." 2021.
4. AECOM. "TSSWCB Plum 2, Soil Mechanics Report." 2021.

BACKGROUND

Project Description

The purpose of the project is to upgrade the dam to meet design criteria for high-hazard dams. The dam classification has changed to high hazard as a result of downstream development since original construction.

The dam rehabilitation involves re-shaping, widening, and/or raising the existing embankment; widening the existing vegetated auxiliary spillway (ASW); abandoning in-place the existing principal spillway (PSW); constructing a new PSW inlet riser, conduit pipe, and impact basin; and constructing a new overtopping roller compacted concrete (RCC) spillway serving as a secondary ASW. The RCC spillway will consist of a crest structure, chute structure, and stilling basin. The foundation for the RCC crest structure will be cut down below the top of the existing embankment crest. Relevant elevations for existing and proposed conditions are listed below in Table 1.

Table 1. Summary of Existing and Proposed Elevations for Various Dam Features

Dam Feature	Existing	Proposed	Change
Earthen Embankment Crest	El. 662.8	El. 663.8	+1.0 feet
Principal Spillway Crest	El. 649.1	El. 645.5	-3.6 feet
Auxiliary Spillway Crest	El. 658.9	El. 659.8	+0.9 feet
Foundation for New Overtopping RCC Spillway Crest Structure	---	El. 658.7 (top of slab) / El. 655.7 (bottom of slab)	-4.1 feet from existing grade to top of slab*
Foundation for New Overtopping RCC Spillway Stilling Basin	---	El. 641.7 (top of slab) / El. 638.7 (bottom of slab)	-5.8 feet from existing grade to top of slab**
**Based on El. 662.8 at crest of existing dam.* ***Based on El. 647.5 at toe of existing dam.*			

Upstream and downstream embankment slopes will be maintained at existing slope angles, which vary from about 2.7H:1V to 3H:1V based on topographic survey (flatter than the specified 2.5H:1V upstream and downstream slopes indicated in the as-built drawings). A new small fill (ranging from <1 to about 2 feet thick) will be placed near the top of the embankment at a 2H:1V slope to widen and raise the embankment crest slightly. A new fill layer at downstream will be placed at 3H:1V slope near the proposed new Principal Spillway section (about Station 24+30).

SEEPAGE DESIGN CRITERIA

The current version of NRCS TR-210-60 requires that the effects of seepage be evaluated for all dams. This evaluation must consider potential embankment and foundation seepage-related failure modes that includes the potential for internal erosion, erosive flow along with defects, internal instability, and uplift pressures to damage the embankment, its foundation, and appurtenant structures. The TR-210-60 provides the following design criteria related to seepage:

1. Design seepage reduction measures to limit seepage and embankment saturation as necessary to address seepage failure modes, provide adequate static and dynamic stability, and limit water loss to the extent required by project function.
2. Minimum factor of safety (FOS) = 4.0 for vertical exit gradients at sites with cohesionless soils at the downstream toe;
3. Minimum FOS = 3.0 for a blanket-aquifer condition in soil using effective stress methods;
4. Include a filter diaphragm around any structure extending through the embankment to the downstream slope (e.g., conduit pipes);
5. Include filtration and drainage features for all significant and high hazard embankment dams unless the designers establish the rationale for less filter and drain protection for the rehabilitation of existing embankments; and
6. Provide seepage integrity for all reservoir stages up to the Texas Commission on Environmental Quality (TCEQ) 75% Probable Maximum Flood (PMF) water surface.

Criteria #2 and #3 only apply to sections where the gravelly/sandy soils are present and covered by relatively thin impervious blanket materials, and do not apply to this project. To satisfy Criteria #4 and #5, this project will require a filter diaphragm around the existing PSW conduit to be abandoned and the proposed new PSW conduit and internal drainage layers, respectively. Criteria #1 and #6 are inherent to the seepage and stability evaluations described in the following sections of this report. Depending on structure complexity, the TR-210-60 allows the use of qualitative methods, analytical methods, graphical methods, and/or numerical methods to evaluate seepage effects.

The critical exit gradient was calculated using the following formula:

$$i_{cr} = \frac{\gamma - \gamma_w}{\gamma_w} = \frac{123 - 62.4}{62.4} = 0.97$$

Where:

$i_{cr} = critical\ exit\ gradient$

$\gamma = unit\ weight\ of\ soil\ at\ the\ toe\ where\ the\ exit\ gradient\ is\ highest\ (Alluvium\ layer)$

$\gamma_w = unit\ weight\ of\ water$

The FOS against uplift is then calculated as follows: $FOS = \frac{i}{i_{cr}}$

Where: $i = calculated\ exit\ gradient = \frac{\Delta H}{L} = \frac{H_{\cdot bottom} - H_{\cdot top}}{Z_{\cdot top} - Z_{\cdot bottom}}$

H_i = Total head at top and bottom of blanket layer

L = Length of seepage flow path (i.e., layer thickness)

Z_i = Elevation at top or bottom of blanket layer

ANALYSIS SECTION AND DRAINAGE FEATURES

Geologic Stratigraphy

Site stratigraphy is described in detail in the Geologic Investigation Report and Soil Mechanic Report, and are summarized briefly as follows:

- Embankment Fill: This material was primarily classified as very stiff to hard lean to fat clay (CL, CH) with some intervals of lean clay (CL) and some sandy intervals (3 to 28% sand). While the as-built drawings indicate embankment zoning with distinct core and shell zones, borings and laboratory testing indicate the shell and core zones are comprised by similar materials. This unit is expected to experience slow drainage due to high fines and clay contents.

- Downstream Fill: The suspected fill material was preliminary classified as medium stiff to hard lean to fat clay (CL, CH). The fill designation was due to a somewhat lower consistency of this material. However, the visual similarity of the fill to overburden materials suggest that this unit is likely reworked residuum/alluvium. This material was assumed to exhibit slow drainage due to clayey fines.

- Alluvium: This unit consisted of dark brown, medium stiff to hard fat clays (CH) with minor proportion of sand and/or gravel ranging from 0 to 20%. This material was assumed to exhibit slow drainage due to clayey fines.

- Residuum: This unit consisted of light gray to tan, medium stiff to hard lean to fat clays (CL, CH) with some clayey sand (SC) and silty clay (CL-ML) layers. Characterization of this material in the GIR and SMR was subdivided into a calcareous and friable Low Plasticity Residuum (LPR) consisting mostly of silty CL and some CH with less frequent SC and CL-ML intervals, and a Medium Plasticity Residuum (MPR) consisting of consisting of CH with some CL intervals. For engineering analysis, this material was generally considered as a single "Residuum". It was assumed to exhibit slow drainage due to clayey fines.

- Bedrock: This unit consisted of extremely weak to weak calcareous shale with occasional chalky marl layers. The weathering ranged from moderately to highly weathered. This material was judged to exhibit slow drainage.

Proposed fill materials include fine and coarse filter/drain fill, RCC, and new embankment fill. These materials are described below.

- Drain Fill: This material will consist of a compacted fine filter (modified ASTM C-33 Fine Aggregate) and a coarse filter (ASTM C-33 No. 89 aggregate). These materials will be placed under the RCC spillway and around the new and existing PSW conduits. These materials are free-draining.

- RCC: This material will consist of low-slump concrete compacted in lifts that will be used to construct the RCC spillway. The material was treated as relatively low permeability..

- New Embankment Fill: The proposed embankment fill will be constructed of moisture-conditioned and recompacted clayey soils from on-site and/or imported borrow sources. Selective placement of imported low-plasticity (PI=7-15) lean clay (CL) or clayey sand (SC) is planned for under and adjacent to the RCC spillway to reduce swelling potential. The exterior zones of planned embankment fill (crest re-shaping and embankment reconstruction at new PSW) will be low-plasticity clay/clayey sand (CL, SC) with LL<50 and PI=10-30. Interior zones of planned embankment fill for reconstruction at new PSW will consist of medium- to high-plasticity clays (CL, CH) with LL<60 and PI=10-35. Considering the clayey composition of proposed embankment fill, this material was considered to exhibit both undrained and drained strength behavior.

Analysis Cross-Sections

Two embankment sections were selected for seepage analysis as follows:

1. STA 23+50: This selected analysis cross-section is located at approximately the maximum dam height and original creek centerline alignment according to information digitized from as-built drawings and 30% design drawings (see Figure 1). The pre-construction ground surface at the analysis section was El. 628.5, the bottom of the cutoff trench is El. 621. A hybrid of the topographic conditions at STA. 23+50 and the existing PSW outlet channel at STA. 24+30 was used to evaluate existing conditions and the proposed embankment crest modification. This section geometry was also used to model the nearby proposed embankment reconstruction following open-cut construction of the new PSW conduit (STA. 25+00).

2. STA 18+50: This selected analysis cross-section corresponds to the right side of the proposed RCC overtopping spillway (i.e., the tallest portion of the embankment near the RCC spillway). The pre-construction ground surface at the analysis section was El. 647.5, the bottom of the cutoff trench is El. 640 (see Figure 1). This section was used to analyze existing conditions, the proposed embankment crest modification on right side of the RCC spillway, and the proposed RCC spillway section.

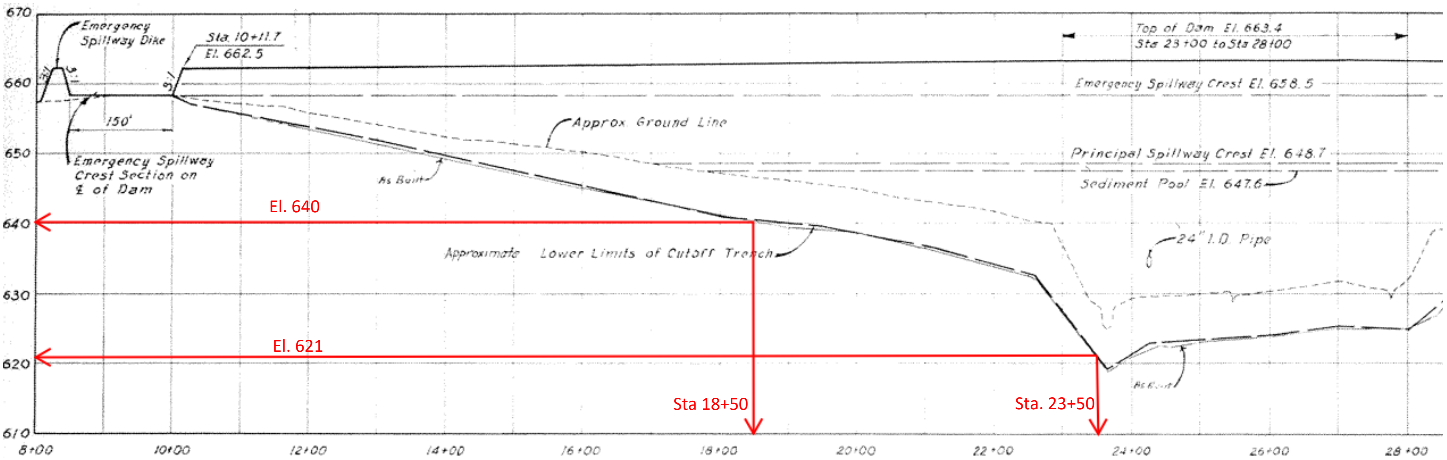


Figure 1. Pre-Construction Ground Surface and Cutoff Trench Bottom Elevations (Looking downstream)

Existing Dam Drainage Features

The existing embankment has no internal drainage system.

Proposed Dam Drainage Features

Overtopping Spillway Section

The proposed overtopping RCC spillway section will have an upstream partial seepage cutoff wall extending 3 feet below the bottom of the crest weir foundation slab. The RCC crest structure slab will bear partially on clayey embankment soils and partially on the underdrain system. The 2 feet thick underdrain will be installed on the downstream slope of the dam underlying the proposed RCC chute structure and RCC stilling basin. The underdrain sand will drain into slotted PVC drain pipes located at El. 652.7 and El. 641.5. The underdrain system consists of fine to coarse aggregate with 6 inches diameter slotted PVC drain pipes surrounded by a coarse aggregate filter (see Figure 2).

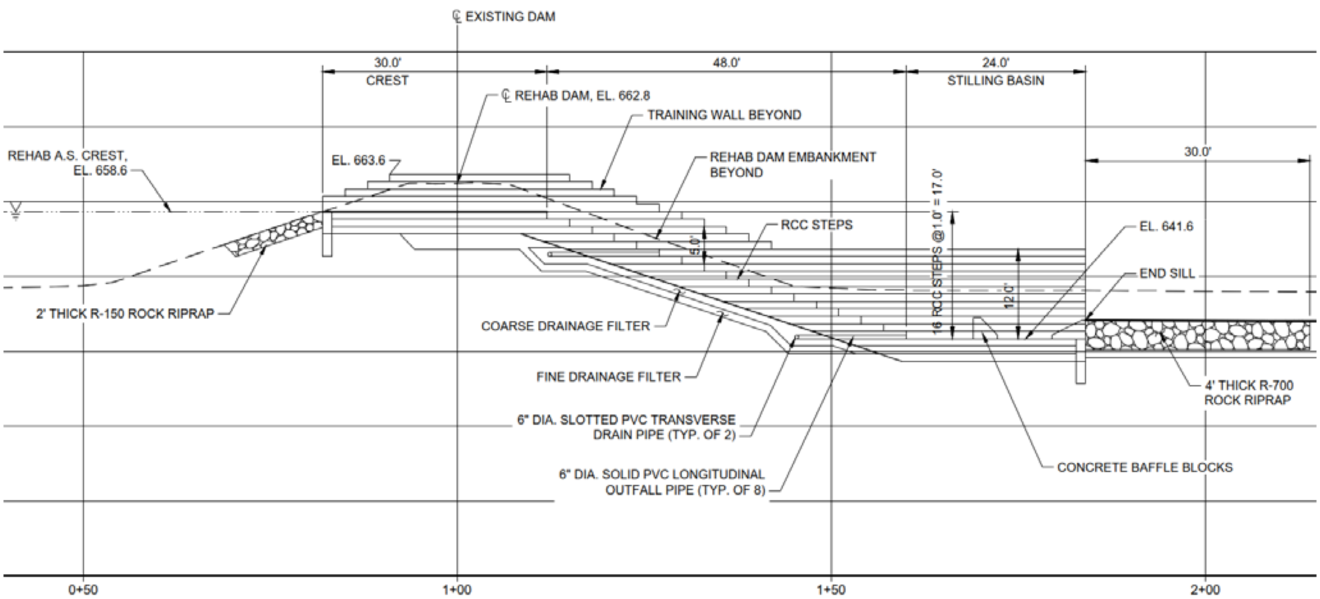


Figure 2. Proposed Internal Drainage System for proposed Overtopping Spillway Section

GROUNDWATER CONDITIONS

Groundwater and Seepage Measurements

The majority of borings completed in both 2019 and 2020 were dry during drilling. However, static groundwater was observed after drilling in one boring, and static groundwater was measured in three piezometers installed and monitored in 2020. Refer to the "Material Properties Calculation Package" for groundwater information.

SEEPAGE ANALYSIS

Methodology

Steady-state seepage analyses were performed using numerical methods to estimate the phreatic conditions within the embankment and internal pore water pressures for use in slope stability computations. Depending on each analysis case, both phreatic surface and pore pressure or only phreatic surface from seepage analysis were used in the slope stability analysis. Additionally, the seepage analyses were conducted to estimate seepage flow volumes for the sizing of the internal drainage system(s).

Potential for through-seepage was examined based on the position of the calculated phreatic surface. Under-seepage was evaluated on the basis of exit gradients.

The general analysis conditions that were considered are described as follows:

- Existing conditions (Calibration): A steady-state seepage analysis was performed for existing conditions at Station 23+50 section to calibrate the material parameters using known reservoir elevation and limited piezometer readings at various points in time. This analysis considered a reservoir surface equal to the existing normal pool (El. 640) and a downstream water level based visual filed observation at El. 618. The material parameters (i.e. hydraulic conductivity, anisotropy, were iteratively adjusted until the elevation of the phreatic surface at the embankment centerline approximated by the model was similar to the groundwater levels measured in piezometer 011-19 (El. 622.4 close to the downstream portion of the embankment crest).

- Proposed Normal Pool: A steady-state seepage analysis was performed for the proposed embankment raise section, including the proposed internal drainage elements (i.e., chimney drain and toe drain for RCC chute for overtopping ASW section), with the reservoir at the proposed PSW crest elevation (El. 645.5). This analysis was used to establish the design phreatic surface and pore water pressure for steady-state slope stability analyses and design phreatic surface for post-drawdown surface for rapid drawdown analyses.

- Proposed Flood Pool: A steady-state seepage analysis was performed for the proposed embankment raise section, including the proposed internal drainage elements, with the reservoir at the proposed ASW crest elevation (El. 659.8). This conservative case was analyzed primarily for drain sizing, and to evaluate the potential for seepage issues during an extended flood pool condition. This resulting phreatic surface was also considered in rapid drawdown slope stability analyses.

- Proposed TCEQ 75% PMF Pool: A steady-state seepage analysis was performed for the proposed embankment raise section, including the proposed internal drainage elements, with the reservoir at the proposed TCEQ 75% PMF pool level (El. 660.8). The 75% PMF pool was taken to be similar to the flood surcharge condition described in NRCS TR-210-60 which requires use of the Freeboard Hydrograph (FBH) for analysis. Thus, for geotechnical purposes, the 75% PMF is referred to as the FBH reservoir level. This very conservative case was used primarily for drain sizing, and the resulting hypothetical phreatic surface was also considered as a simulated uplift pressure applied to saturated material zones for the flood surcharge slope stability analyses.

Seepage Model and Boundary Conditions

The computer program SEEP/W by Geo-Slope International (GeoStudio 2020, Version 10.2.2.20559) was used to perform the steady-state seepage analyses. SEEP/W utilizes a two-dimensional finite element method to compute seepage flow and piezometric head.

Mesh Generation and Boundary Conditions for Steady-State Seepage

A finite element mesh was generated for the proposed embankment and existing foundation considering element sizes of 1.5 ft to 3 ft within the embankment and near-surface materials, and 5 to 10 feet size in other areas of the model.

In order to limit boundary effects, the modelled foundation materials were extended horizontally approximately 1,000 feet upstream of the dam centerline, and about 300 feet downstream of the dam centerline. The analysis assumed the foundation overburden soils were laterally continuous throughout the reservoir, but this assumption could not be confirmed from available data. The shale stratum included in the model was extended down to El. 570 for the section at station 23+50 (i.e., approximately 48 feet thick) and to El. 600 for the section at station 18+50 (i.e., approximately 23 feet thick).

On the upstream ground surface of the model, a total head boundary condition equal to the elevation of the corresponding reservoir level was applied. Similarly, a total head boundary condition was applied to the downstream vertical edge of the model equal to the assumed far-field groundwater level (El. 618 for the 23+50 section and 623 for the 18+50 section). A no-flow boundary was applied to the left vertical edge and bottom of the model. A potential seepage face was applied to the downstream slope of the embankment and ground surface (where it is above the downstream water level). In analyses with the proposed toe drain, an outlet pipe was modeled as a point at the location of the toe drain pipe with a zero-pressure-head boundary condition (El. 641.5). The boundary conditions assigned to the analysis section model shown below in **Table 2**.

Table 2. Summary of Modeled Boundary Conditions for Steady-State Seepage

Boundary Location	Design Boundary Condition	Notes
U/S Ground Surface	Total Head	Set equal to the reservoir elevation being considered in each analysis.
D/S Ground Surface	Potential Seepage Face (Total Flux=0)	Ponding of seepage water was allowed. Seepage through the stilling basin slab/walls and RCC chute was not prohibited from occurring.
U/S Vertical Edge	No flow boundary	Assumes vertical infiltration from reservoir. Set boundary ~1,000 feet U/S of the dam crest centerline to minimize boundary influence effects.
D/S Vertical Edge	Total Head = El. 618 and El.623 (Sta. 23+50 and 18+50, respectively)	Estimated far-field groundwater elevation. Set boundary ~300 feet D/S of dam crest centerline to minimize boundary influence effects.
Bottom of Model	No Flow	Bottom of model extended approximately 23 to 48 feet into bedrock to minimize boundary influence effects.
Internal Drains	Pressure Head = 0	A node at the vertical center of the lowest internal drain was assigned a pressure head equal to zero (i.e., atmospheric pressure) for the proposed RCC overtopping spillway section = El. 641.5
RCC/Concrete Structures	No Flow	Set around perimeter of proposed foundation elements as follows (i.e. assumed as impermeable with waterstops): • Crest structure slab on embankment crest (El. 655.7) • Crest structure slab upstream cutoff wall (El. 652.7 to El. 655.7)

Limited data was available at the time of preparation of this report regarding the static groundwater elevations at the downstream toe of the dam at both analysis section. The groundwater level was selected at El. 618 for section 23+50, and at El. 623 for section 18+50, as these were considered a reasonably conservative approximation for the downstream boundary condition. Piezometer 702-20 at the proposed RCC stilling basin was measured in October 2020 several days after construction and encountered groundwater at El. 620.3, confirming the selected water level for analysis was reasonably representative.

Model Calibration

The model calibration was performed for section 23+50 only because the piezometer reading for the borehole 009-19 near STA 18+50 shows considerable variation in the groundwater level. The groundwater fluctuation at this location could be due to the presence of perched water. However, a definite reason for this fluctuation could not be established based on the currently available data.

Steady-state seepage modeling was conducted for existing conditions to calibrate the modeled parameters to actual groundwater observations. Seepage analysis trials were conducted at section 23+50 using estimated seepage parameters (hydraulic conductivity, anisotropy ratio, unsaturated conductivity functions, etc.). The boundary conditions for the existing normal pool reservoir level (El. 640) and the downstream water level (El. 618) were estimated based on field observation on the same day as the piezometer reading (03/26/2020) which was used for the calibration.

The seepage parameters were varied, within a reasonable range for each material based on the published data, until the resulting phreatic surface resembled groundwater observations. However, the calculated phreatic surface showed a relative insensitivity to the permeability parameters. The phreatic surface is about 12 ft higher than the relevant piezometer reading. The material properties could be changed drastically to have a good match between the piezometer reading and the calibration analysis. However, that would push the permeability parameters for each material well outside the published range for similar materials. Hence, it was decided to use the initial calibration which results in a higher phreatic surface (more conservative for slope stability) . The following sections describe the final model input parameters resulting from the calibration phase.

Material Parameters

Saturated Hydraulic Conductivity and Anisotropy

Saturated hydraulic conductivity and anisotropy ratio properties were based on field observations, rate of groundwater recharge in borings/piezometers, published values and correlations based on soil types and index properties, and experience with similar materials. Final seepage parameters were updated based on the results of model calibration trials, and values used for design are provided in **Table 3**.

Unsaturated Soil Functions

For materials that are partially saturated and/or will not remain saturated, the “saturated/unsaturated” model should be used for seepage modeling. The “saturated only” model should only be used for soils that will always remain below the phreatic surface (Geo Slope, 2021). The saturated/unsaturated model requires 2 functions: hydraulic conductivity function and volumetric water content function.

The hydraulic conductivity function describes how the hydraulic conductivity varies with changes in suction (i.e. negative pore-water pressure) present in unsaturated soils. The volumetric water content function describes how the suction varies with changes in water content in the soil. Unsaturated functions for hydraulic conductivity and volumetric water content were based on SEEP/W default relationships and are presented in **Attachment 1**.

Table 3. Design Hydraulic Parameters for Seepage Analysis

Material Properties				SEEP/W Input Parameters						
Material	**Kv (cm/s)**	**Ratio Kh/Kv**	**Kh (cm/s)**	**Model Type**	**Ksat = Kh (feet/s)**	**Ratio Kv/Kh**	**Mv (psf/psf)(2)**	**Θw-sat (1)**	**K-Function(3)**	**VWC-Function(3)**
Existing Fill - Zone I	2.01E-08	5	1.01E-07	Sat. / Unsat.	3.30E-09	0.2	1.00E-06	0.50	Clay	Clay
Embankment Fill - Zone II	2.01E-07	5	1.01E-06	Sat. / Unsat.	3.30E-08	0.2	1.00E-06	0.50	Clay	Clay
Proposed Embankment Fill	1.38E-07	4	5.53E-07	Sat. / Unsat.	1.815E-08	0.25	1.00E-06	0.50	Clay	Clay
Alluvium	5.03E-06	2	1.01E-05	Sat. / Unsat.	3.30E-07	0.5	1.00E-06	0.50	Clay	Clay
Residuum	1.51E-06	3.33	5.03E-06	Sat. / Unsat.	1.65E-07	0.3	1.00E-06	0.50	Clay	Clay
Marl	2.01E-07	5	1.01E-06	Sat. Only	3.30E-08	0.2	1.00E-06	0.50	---	---
RipRap	1.11E+00	1	1.11E+00	Sat. / Unsat.	3.65E-02	1	1.00E-03	0.25	Gravel	Gravel
Filter Drain	1.00E-03	2	5.03E-03	Sat. / Unsat.	1.65E-04	0.5	5.00E-06	0.35	Sand	Sand
RCC	1.00E-01	1	1.01E-07	Sat. / Unsat.	3.3E-09	1	1.00E-06	0.10	Sand	Sand

Notes:
1. θw = Volumetric Water Content at Saturation (= Porosity x Degree of Saturation)
2. M_v = Coefficient of Volume Compressibility = I / Modulus of Elasticity
3. Unsaturated functions for volumetric water content (VWC) and hydraulic conductivity (K) based on default SEEP/W relationships.

STEADY-STATE SEEPAGE ANALYSIS RESULTS
Phreatic Surface and Seepage Risks

Results of the seepage analysis including calculated exit gradients and FOS for heave are provided below in **Table 4**. Note that the seepage occurs almost entirely in cohesive materials (except for the underdrain materials confined under the RCC slab), and the NRCS TR-210-60 criteria for critical exit gradients (FOS>4 in cohesionless soils at the toe and FOS>3 in blanket-aquifer condition) are not applicable. Nonetheless, exit gradient and FOS were calculated for each analysis case to examine anticipated seepage performance at the downstream toe. The exit gradient/FOS was calculated at the downstream toe of the embankment across the full thickness of the surficial Alluvium layer, except for the proposed RCC spillway section at STA 18+50 where the exit/gradient heave was calculated at the downstream edge of the stilling basin across the thickness of Residuum/Proposed Fill between the bottom of RCC slab (El. 638.5) and bottom of proposed riprap armoring layer (El. 640). Graphical output is provided in **Attachment 2**.

Steady-state seepage results indicate that exit gradients are acceptable (<0.5 based on common engineering practice) and FOS >3 for both existing and proposed conditions for even the conservative 75% PMF steady-state phreatic surface. The phreatic surface does not daylight above the embankment toe for the PSW steady-state phreatic surface, and daylights within the lower 1 foot of the downstream slope for the conservative steady-state ASW and 75% PMF flood pools. Phreatic surfaces obtained from the analyses were used for slope stability analyses (addressed under separate cover).

Maximum seepage uplift pressure on the bottom of the proposed RCC slab at STA 18+50 is approximately 200 psf during the ASW and 75% PMF flood pool as shown below in Figure 3. Given the approximate unit weight of the RCC spillway slab (145 pcf) and slab thickness (3 feet), the FOS against seepage uplift for the RCC spillway is calculated as follows:

$$FOS = \frac{(145pcf)x(3ft)}{200psf} = 2.18 > 2.0 \rightarrow \text{OK}$$

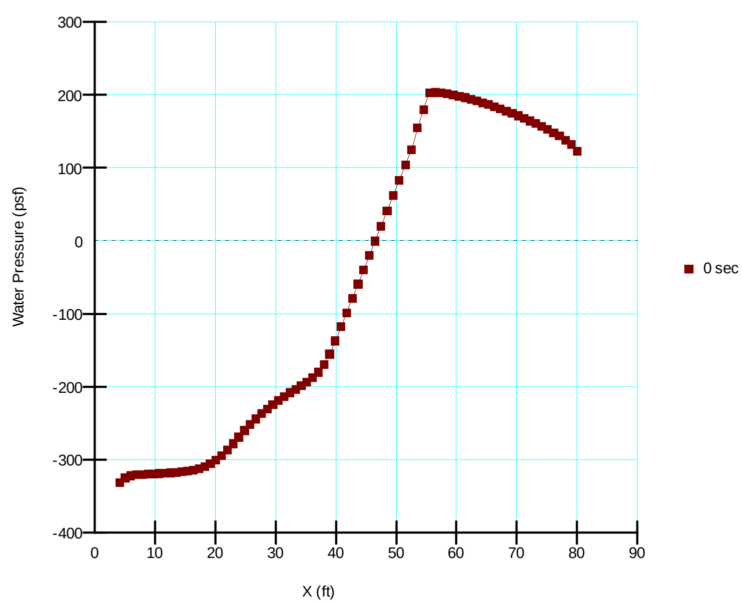


Figure 3. Seepage Pressure on Bottom of RCC Spillway Chute and Stilling Basin (x=0 is embankment crest).

Table 4. Seepage Stability Results

Analysis Section	Condition	Reservoir Level	Location of Gradient Measurement	EL (Y) (feet.)		Total Head		i=ΔH/ΔL	FoS = icr/i
				Top of Stratum Elevation (feet.)	Bottom of Stratum Elevation (feet.)	Top of Stratum, TH (feet.)	Bottom of Stratum, TH (feet.)		
18+50	Existing	PSW	Downstream Toe	647.5	642.5	647.5	648.1	**0.11**	**8.9**
		ASW	Downstream Toe	647.5	642.5	640.9	640.9	**0.00**	**>100**
	Proposed Embankment Crest Mod	PSW	Downstream Toe	647.5	642.5	640.9	640.9	**0.00**	**>100**
		ASW	Downstream Toe	647.5	642.5	647.5	648.1	**0.11**	**8.9**
		75% PMF	Downstream Toe	647.5	642.5	647.5	648.1	**0.12**	**7.9**
	Proposed RCC Overtopping Spillway	PSW	Downstream Toe	640.0	638.5	639.0	639.1	**0.06**	**16.0**
		ASW	Downstream Toe	640.0	638.5	640.1	640.5	**0.21**	**4.5**
		75% PMF	Downstream Toe	640.0	638.5	640.2	640.6	**0.21**	**4.6**
23+50	Existing	PSW	Downstream Toe	628.5	626.5	628.5	628.7	**0.10**	**9.6**
		ASW	Downstream Toe	628.5	626.5	628.5	629.0	**0.23**	**4.2**
	Proposed Embankment Crest Mod	PSW	Downstream Toe	628.5	626.5	628.5	628.7	**0.10**	**9.6**
		ASW	Downstream Toe	628.5	626.5	628.5	629.0	**0.23**	**4.2**
		75% PMF	Downstream Toe	628.5	626.5	628.5	629.0	**0.24**	**4.1**
	Proposed Embankment Reconstruct at New PSW	PSW	Downstream Toe	628.5	626.5	628.5	628.7	**0.10**	**9.7**
		ASW	Downstream Toe	628.5	626.5	628.5	629.0	**0.25**	**3.8**
		75% PMF	Downstream Toe	628.5	626.5	628.5	629.1	**0.27**	**3.6**

Estimated Seepage Flow Rates

Seepage analyses indicate the following flow rates (unit flux) into the various internal drainage elements of the dam for the various conditions considered is provided below in Table 6.

Table 5. Summary of Calculated Seepage Flows into Internal Drains

Analysis Section	Reservoir Level	Prop. RCC Underdrain (1)	
		Unit Flux (CF/day/LF)	Total Flow (gpm) (2)
Overtopping Spillway at STA. 18+50	El. 645.5 (PSW)	---	---
	El. 659.8 (ASW)	0.0472	0.0525
	El. 660.8 (75% PMF)	0.0511	0.0567

Notes:
1. Length of proposed RCC underdrain is 214 LF along dam axis.
2. Conversion 7.48 gal = 1 CF. Conversion from 1 gpm = 192.5134 CF/day.

Capacity Sizing of New Drain Pipes

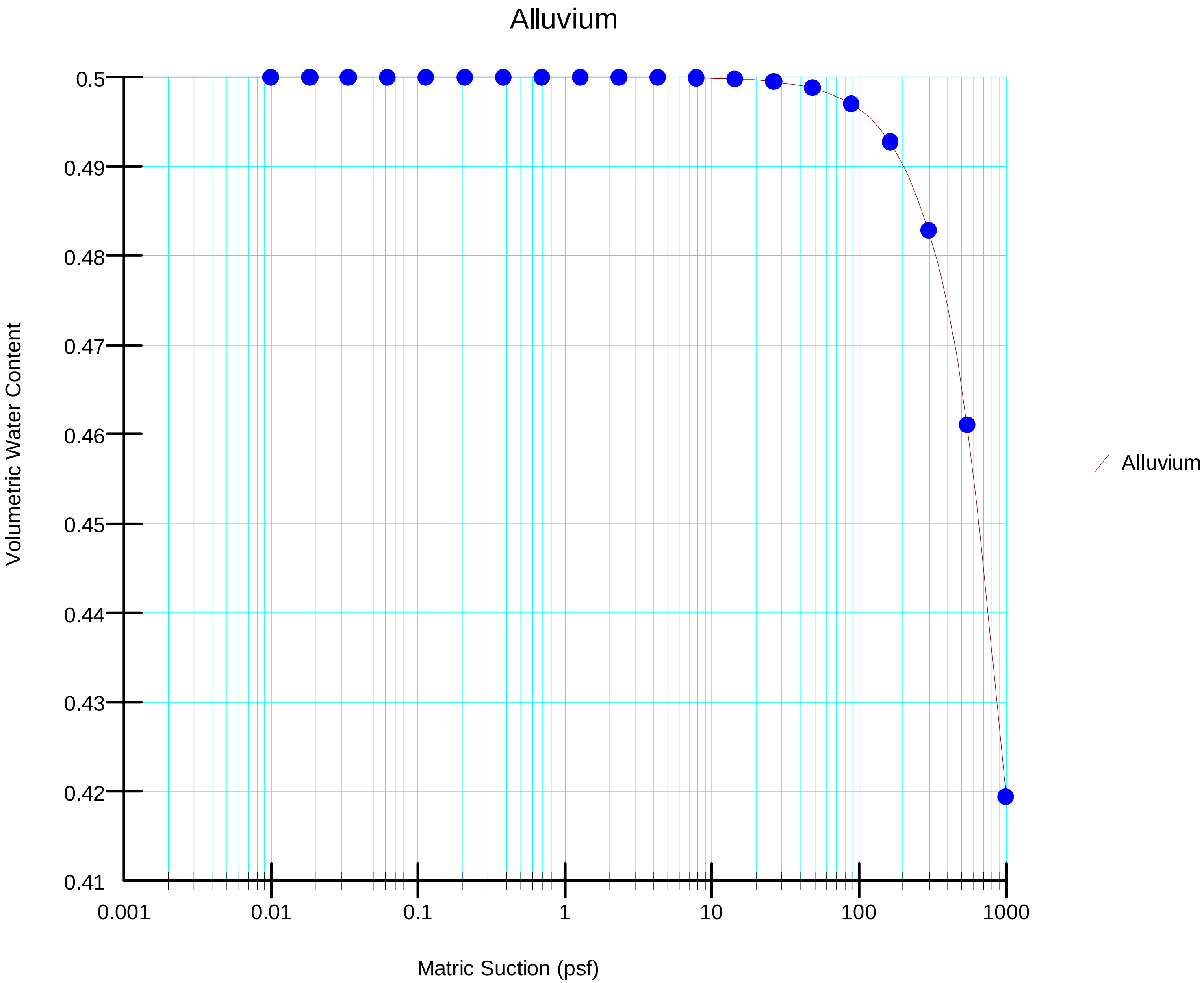
Capacity sizing of new drains was performed considering the estimated flow volumes from the seepage analysis. A factor of safety of 10 was applied to the estimated seepage volumes for the worst case flow estimate (i.e., 75% PMF pool level seepage volumes). The resulting design flow capacity values are as follows:

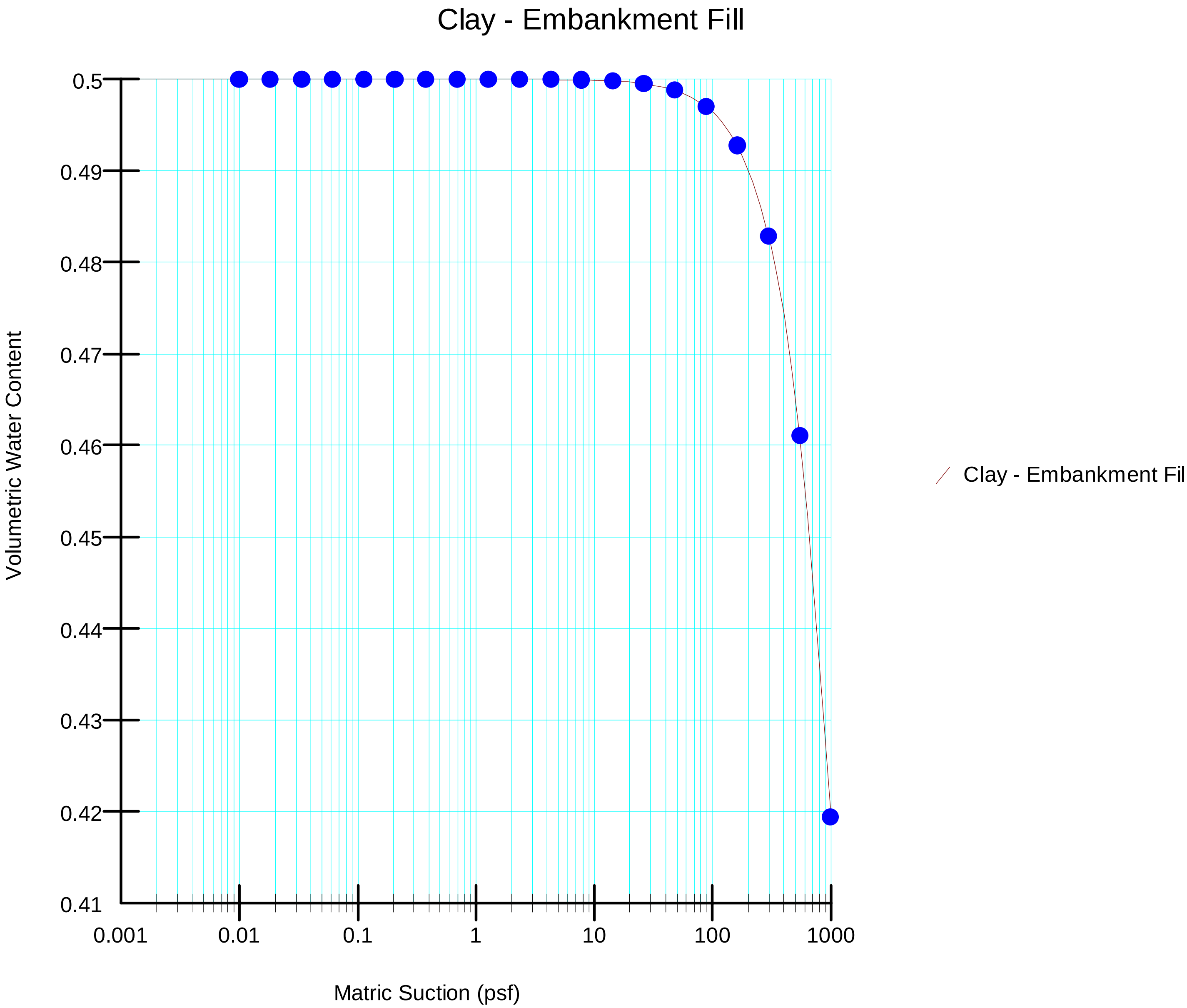
- Proposed RCC Underdrain: (0.0567 gpm)*(10) = 0.57 gpm (0.0013 cfs)

Calculations were performed to estimate the required pipe size to handle estimated seepage flows based on hydraulic capacity according to Manning's equation. The hydraulic calculations assumed a manning's coefficient, n=0.012 for PVC pipe, and a 1% slope on the toe drain outlet pipe. The required pipe diameter was checked for two cases: 1) pipe flowing 25% full; and 2) pipe flowing 50% full, using the hydraulic radius to pipe diameter ratio contained in Table B.3 of USBR (1987) *Design of Small Dams.* Calculations are provided in **Attachment 3**.

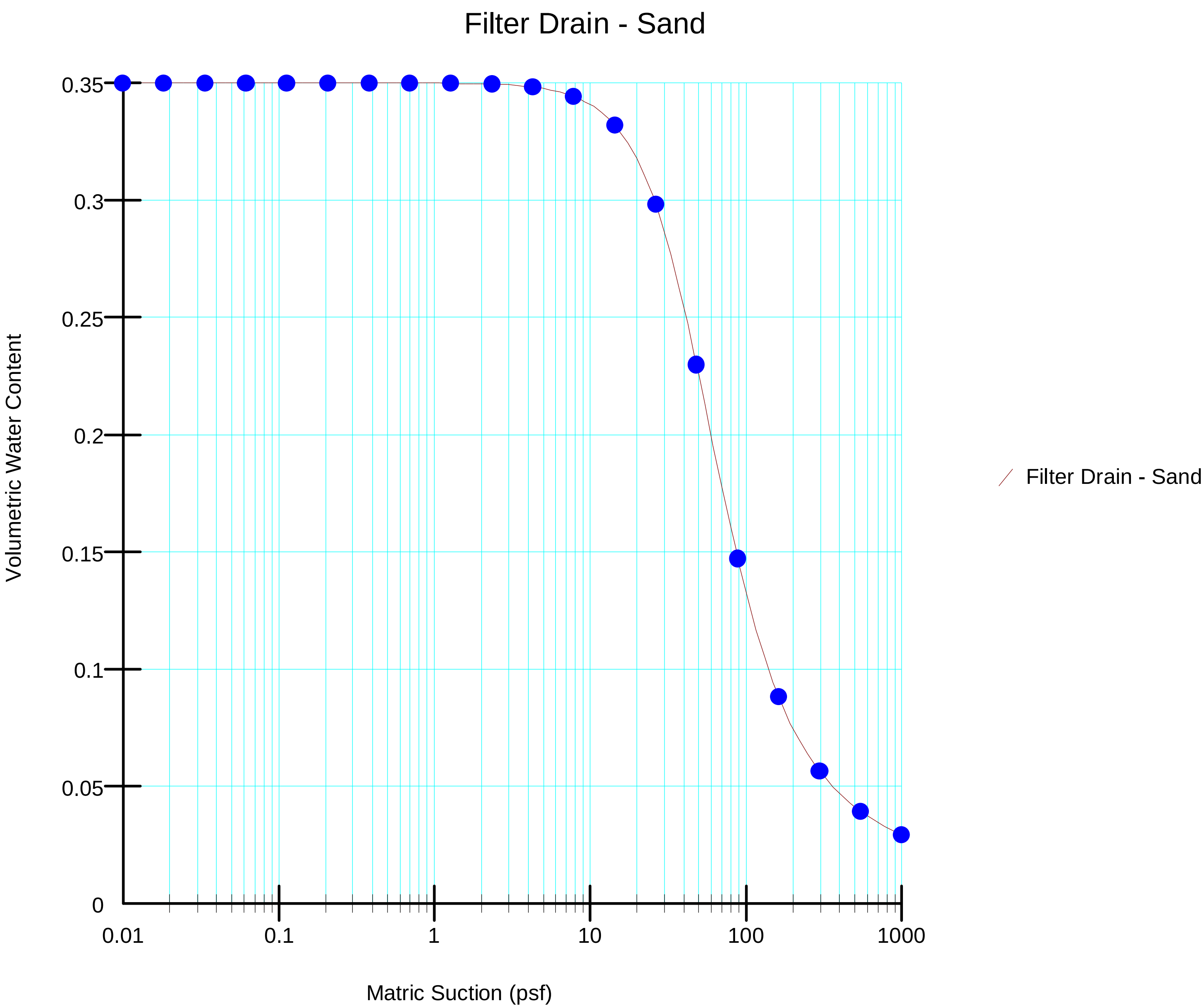
The results indicate that a 6-inch diameter PVC drain pipe will be substantially larger than required to adequately convey the anticipated seepage flow volumes when flowing at less than 25% full. For constructability reasons, a 6-inch diameter drain pipe is recommended for all new internal drains. Based on the excess hydraulic capacity of a 6-inch pipe, further analysis to evaluate minimum pipe flow velocity was judged to be unnecessary.

ATTACHMENT 1
SEEP/W Functions

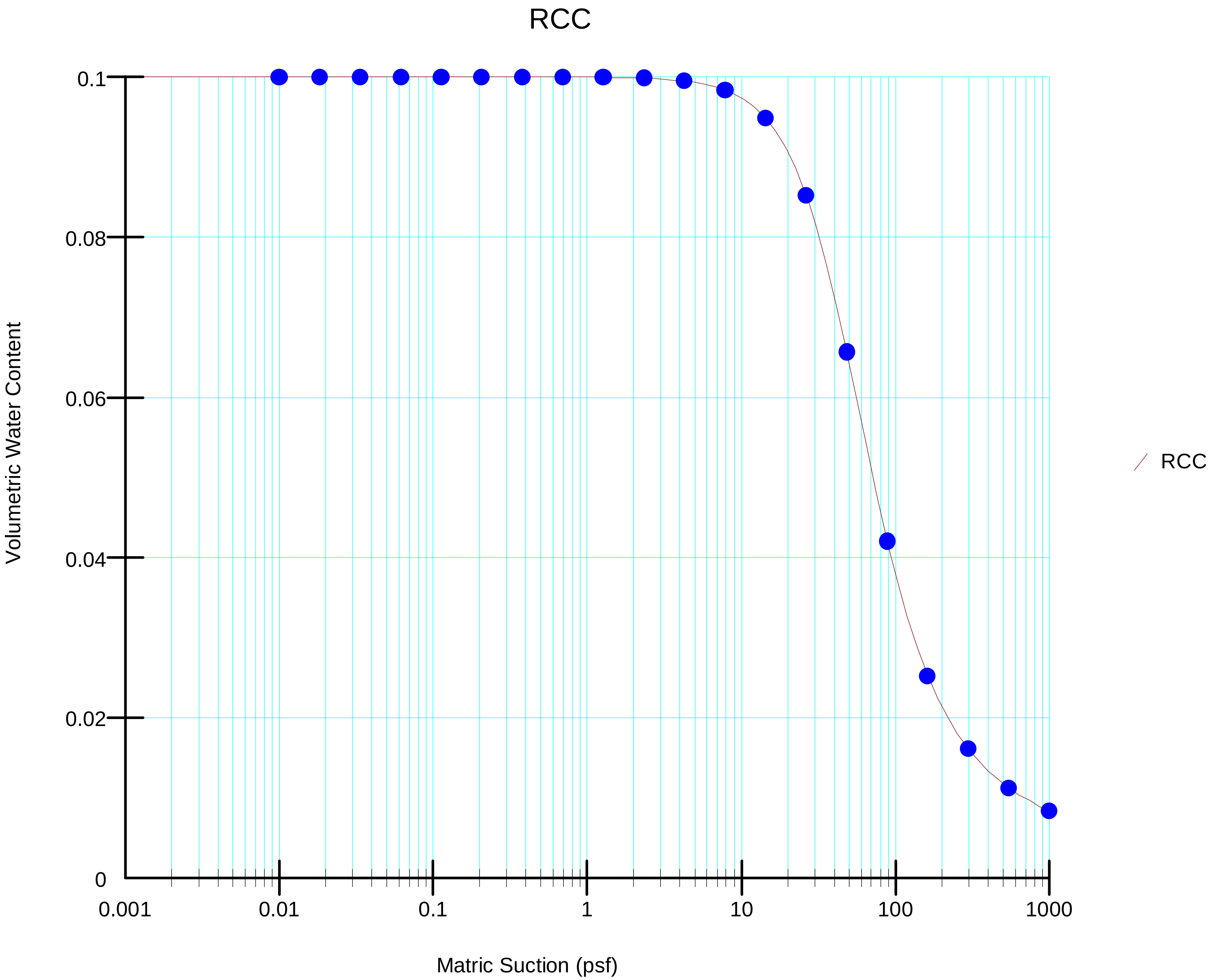

Alluvium
Volumetric Water Content
0.5
0.49
0.48
0.47
0.46
0.45
0.44
0.43
0.42
0.41
0.001
0.01
0.1
1
10
100
1000
Matric Suction (psf)
Alluvium



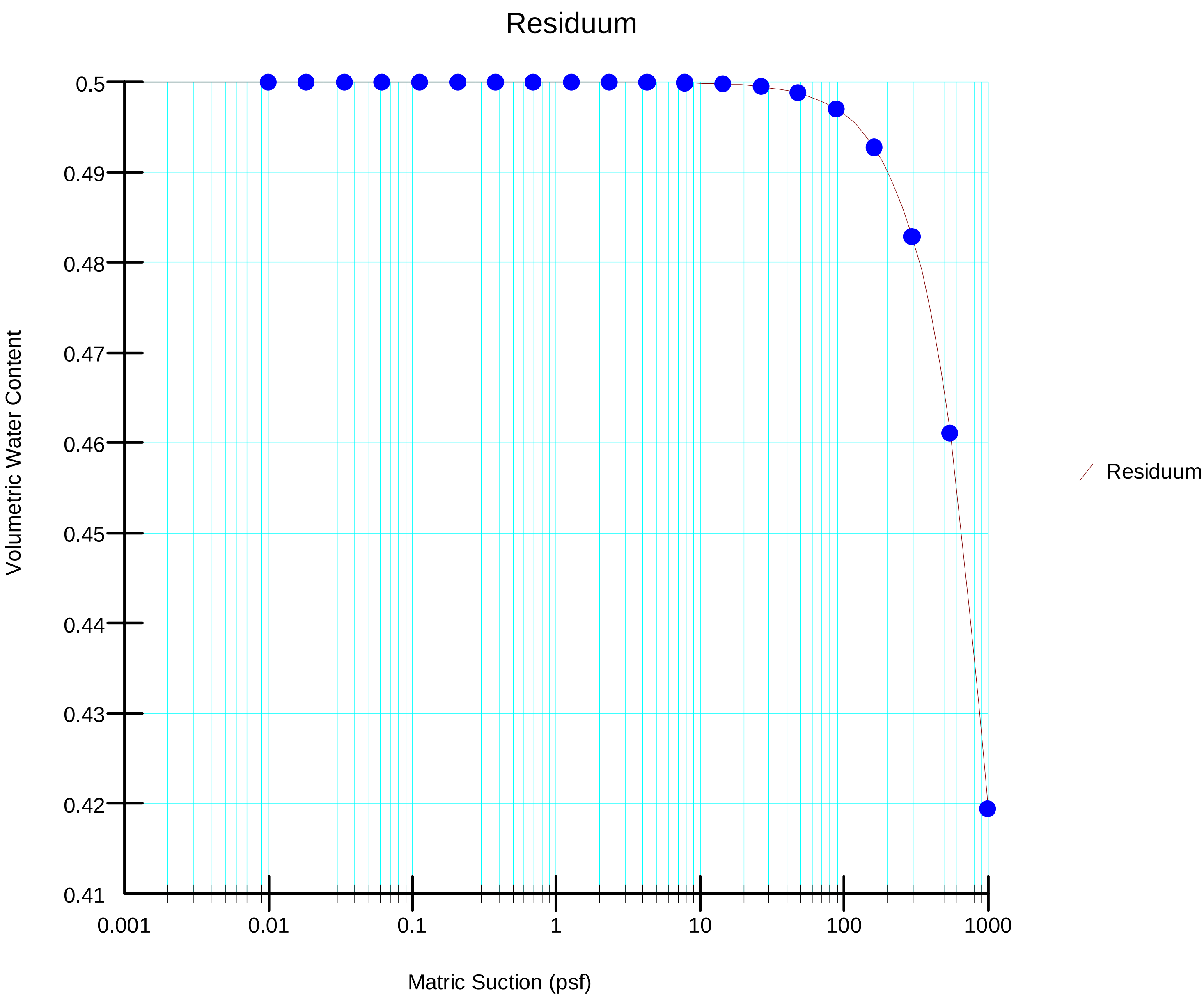
Clay - Embankment Fill
Volumetric Water Content
0.5
0.49
0.48
0.47
0.46
0.45
0.44
0.43
0.42
0.41
0.001
0.01
0.1
1
10
100
1000
Matric Suction (psf)
Clay - Embankment Fill

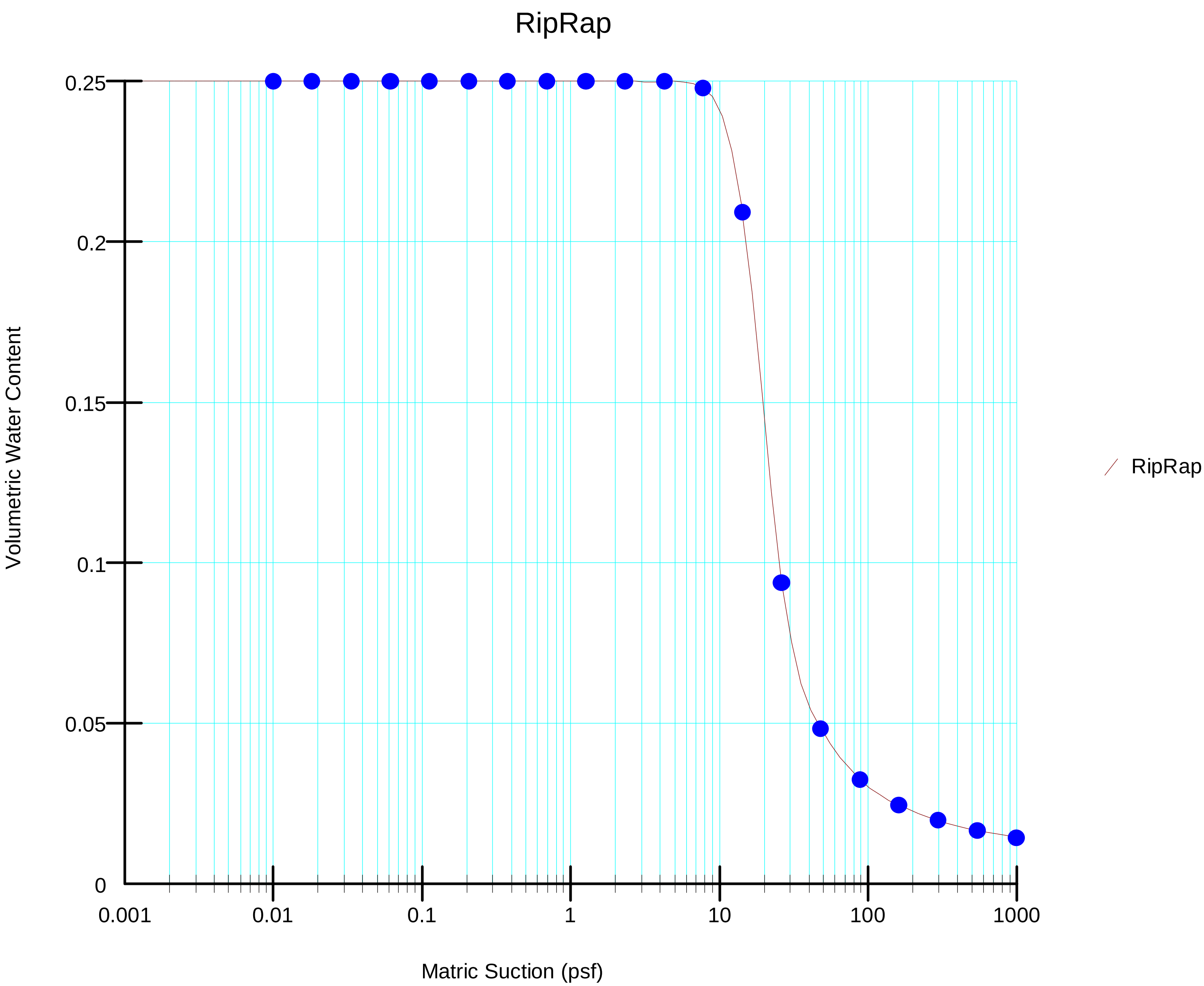


Filter Drain - Sand
Volumetric Water Content
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.01
0.1
1
10
100
1000
Matric Suction (psf)
Filter Drain - Sand

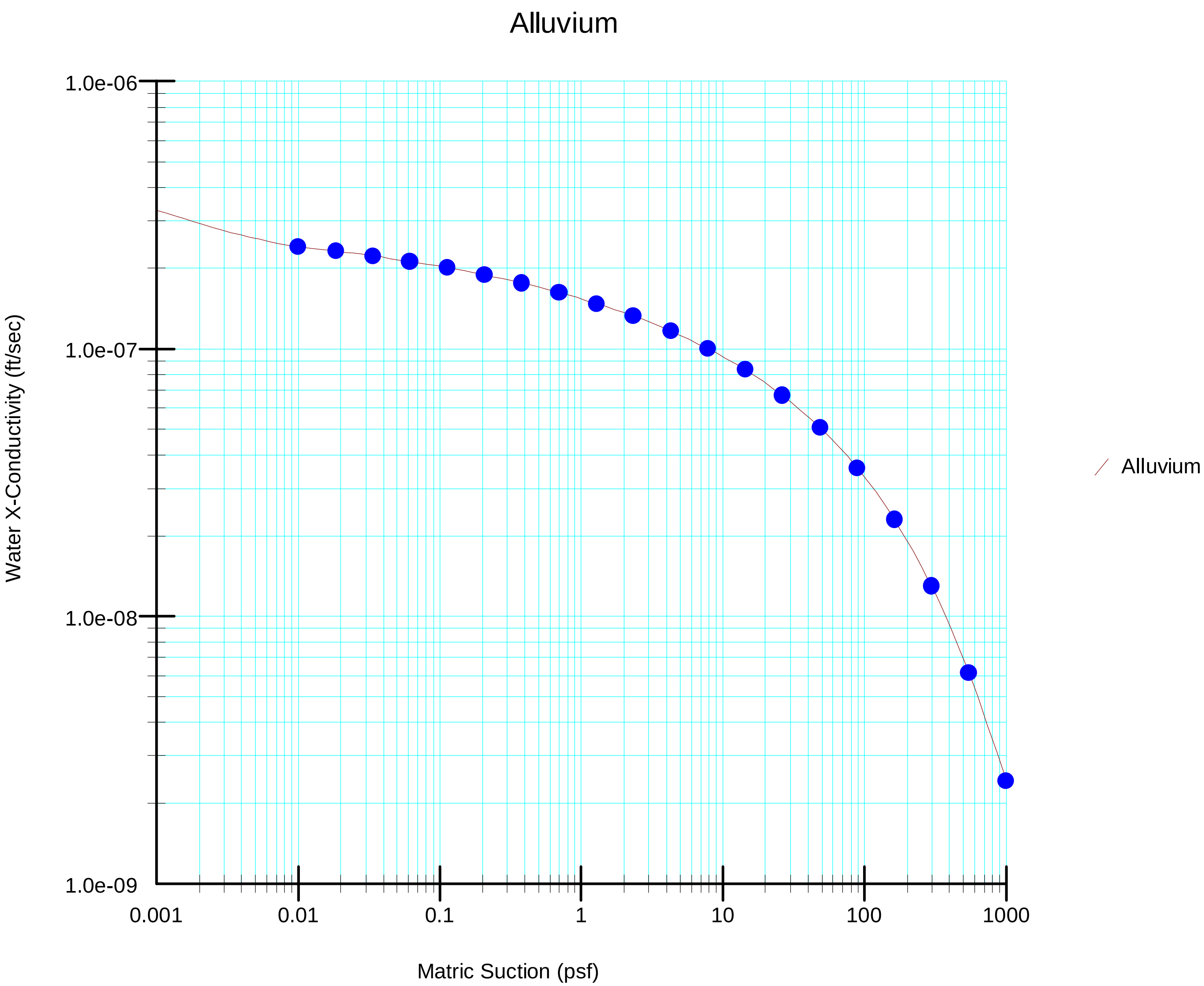


RCC
Volumetric Water Content
0.1
0.08
0.06
0.04
0.02
0
0.001
0.01
0.1
1
10
100
1000
Matric Suction (psf)
RCC

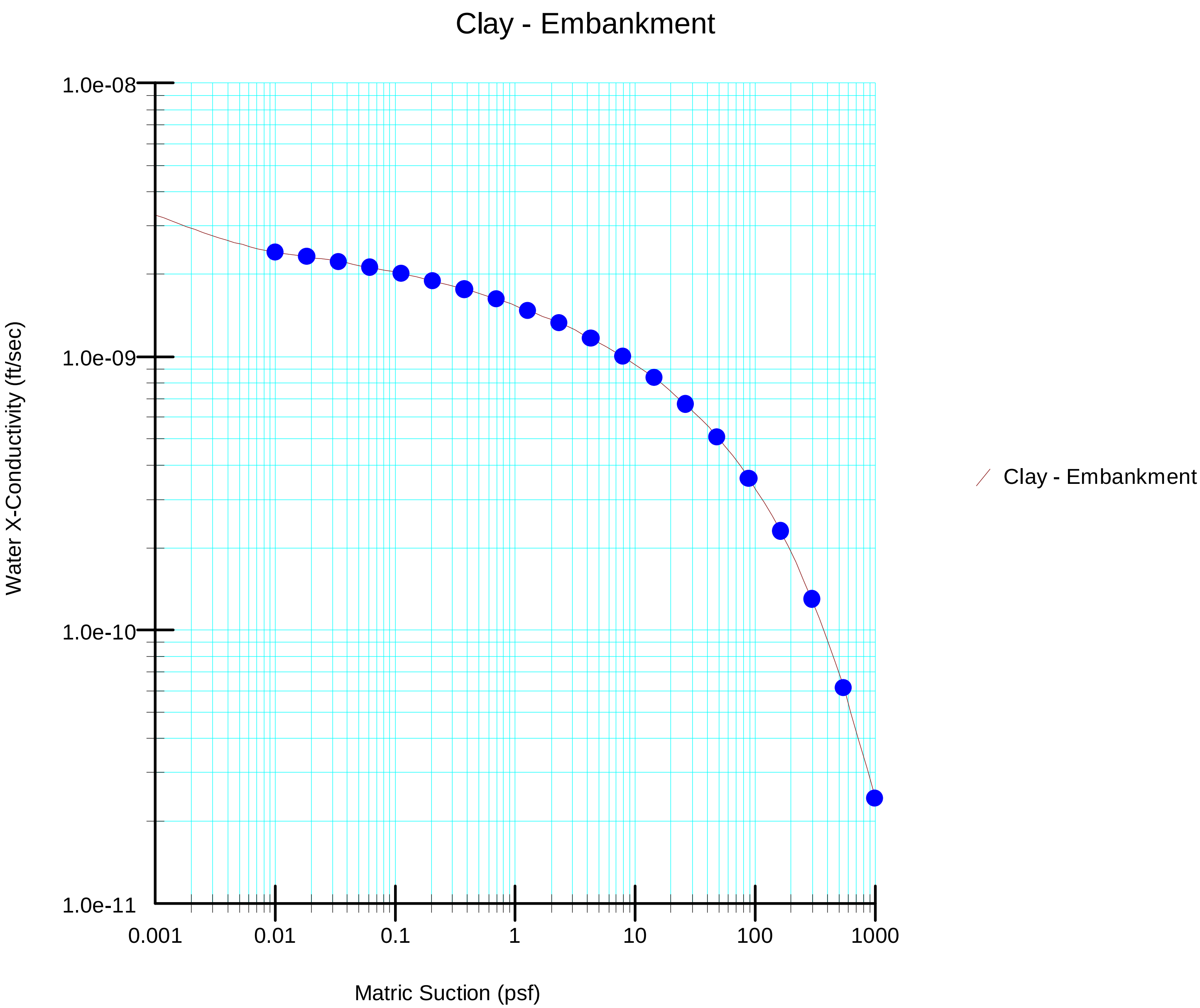

Residuum
Volumetric Water Content
0.5
0.49
0.48
0.47
0.46
0.45
0.44
0.43
0.42
0.41
0.001
0.01
0.1
1
10
100
1000
Matric Suction (psf)
Residuum

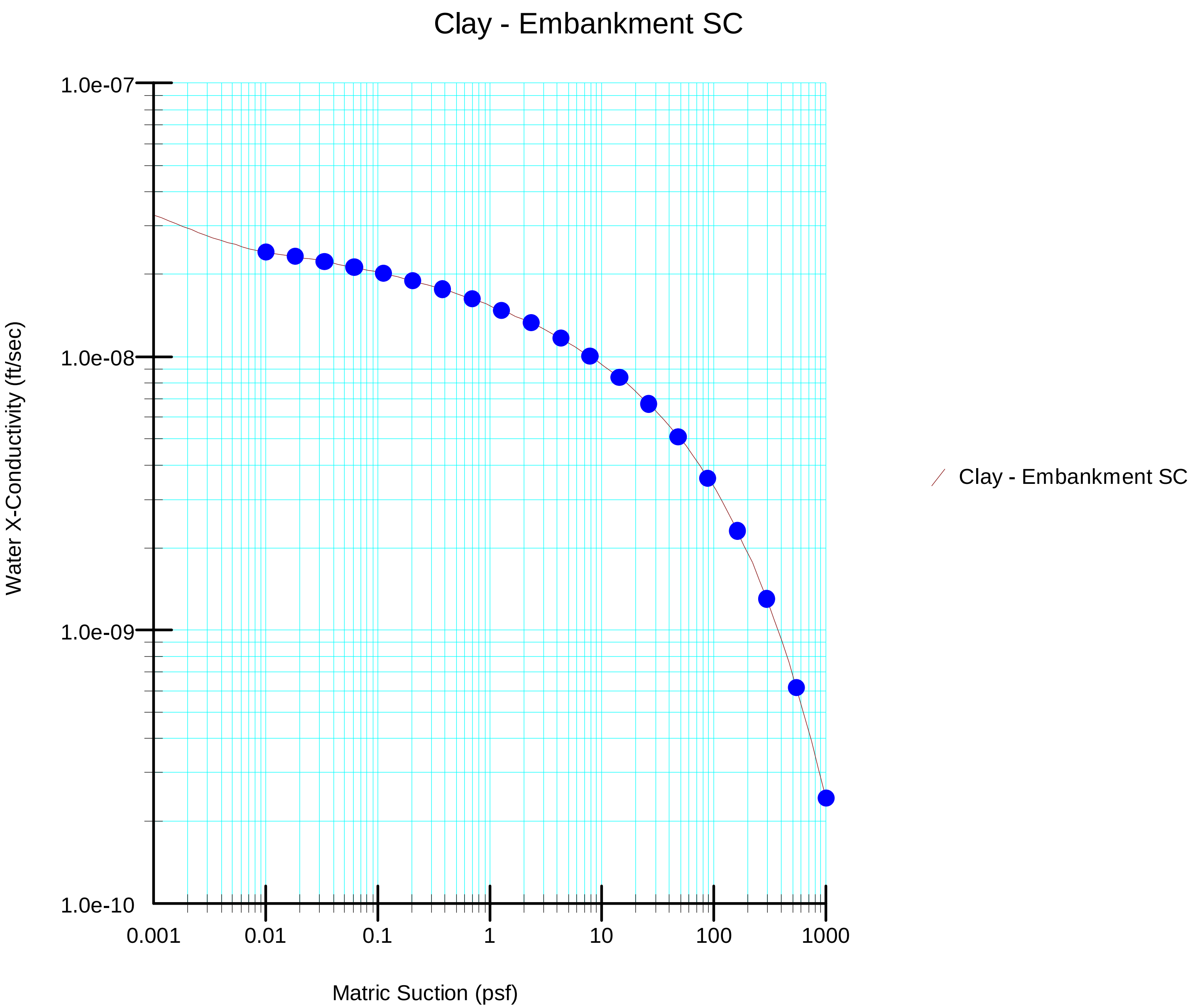


RipRap
Volumetric Water Content
0.25
0.2
0.15
0.1
0.05
0
0.001
0.01
0.1
1
10
100
1000
Matric Suction (psf)
RipRap

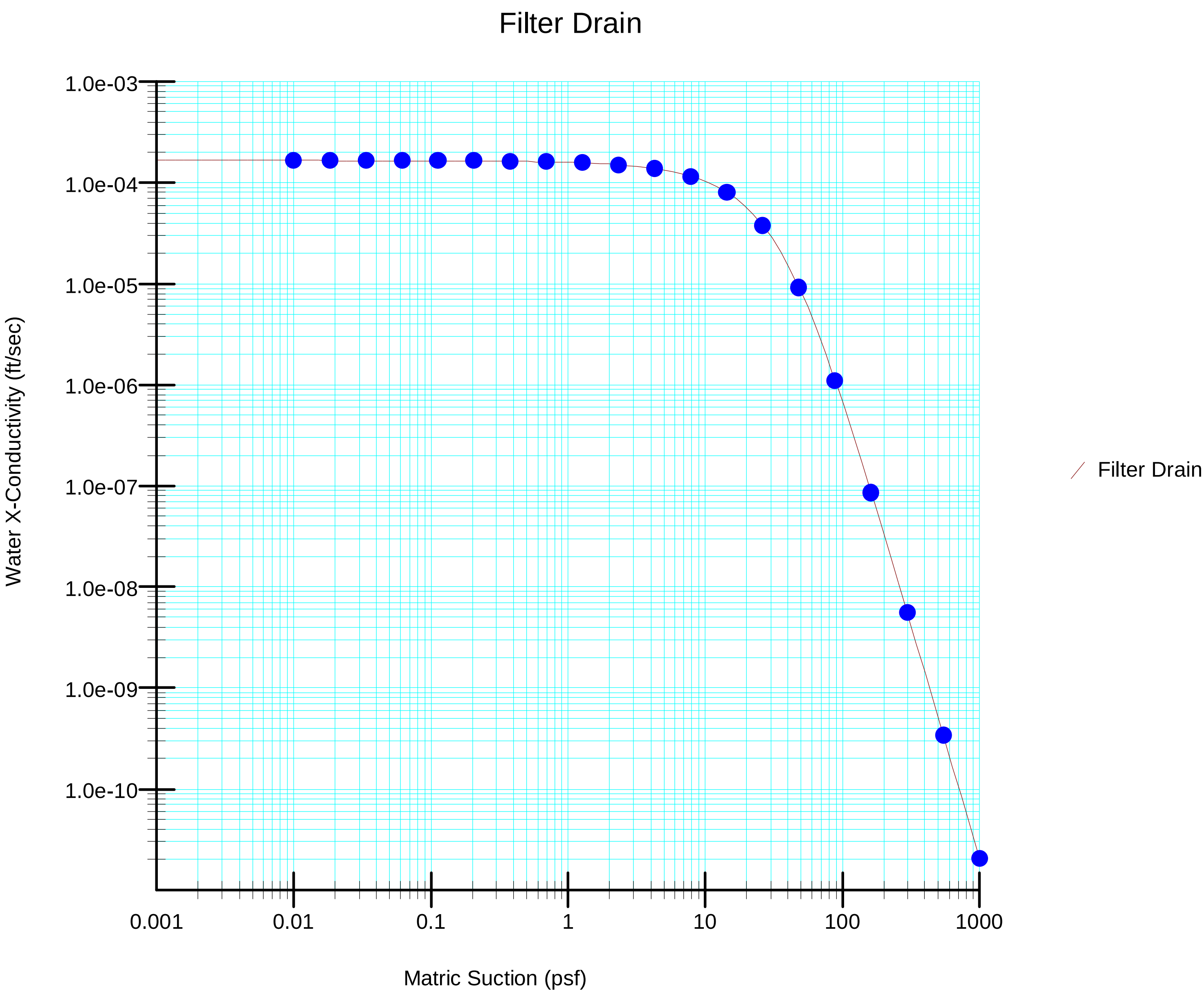


Alluvium
1.0e-06
1.0e-07
1.0e-08
1.0e-09
Water X-Conductivity (ft/sec)
0.001
0.01
0.1
1
10
100
1000
Matric Suction (psf)
Alluvium

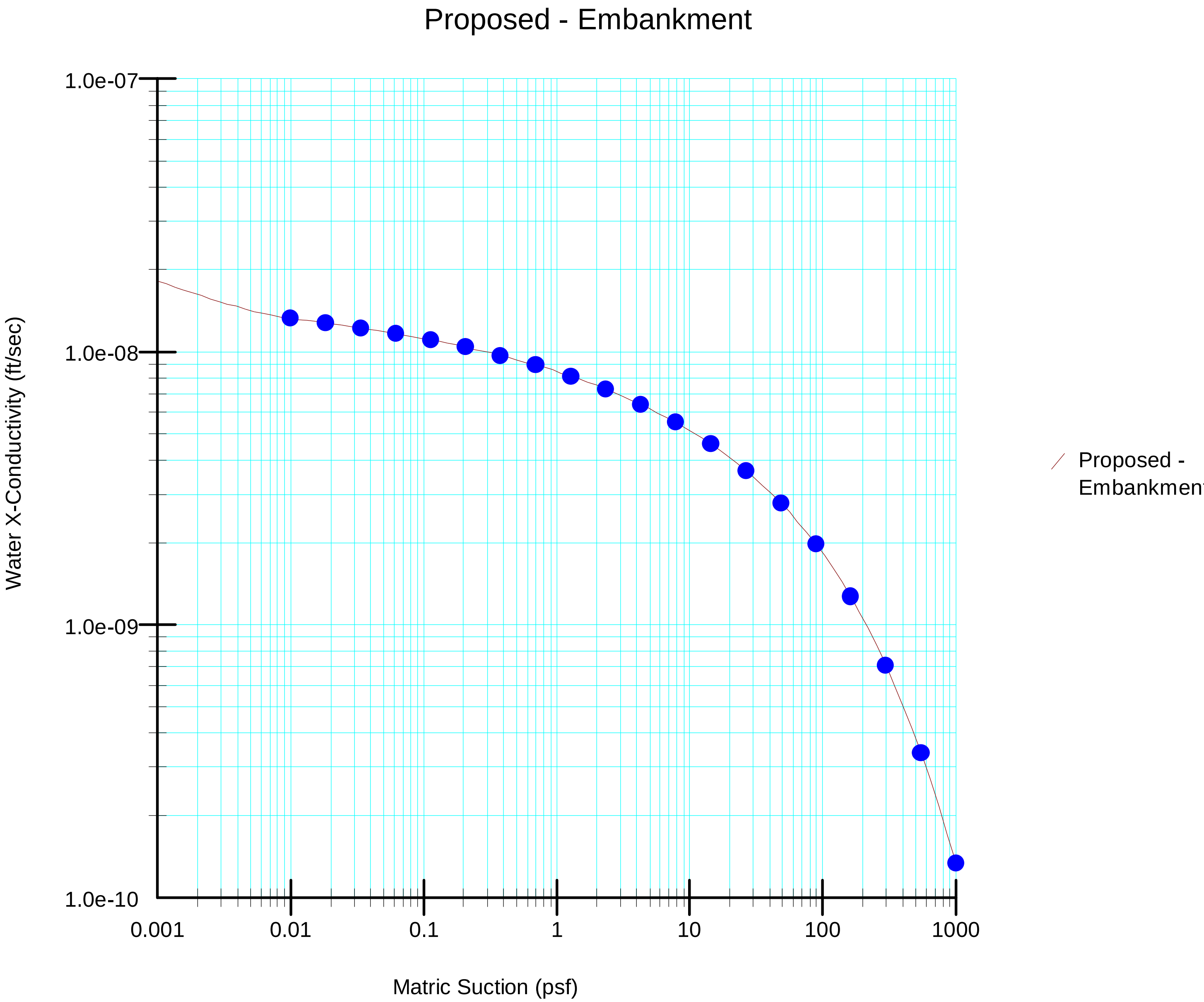

Clay - Embankment
Water X-Conductivity (ft/sec)
1.0e-08
1.0e-09
1.0e-10
1.0e-11
0.001
0.01
0.1
1
10
100
1000
Matric Suction (psf)
Clay - Embankment



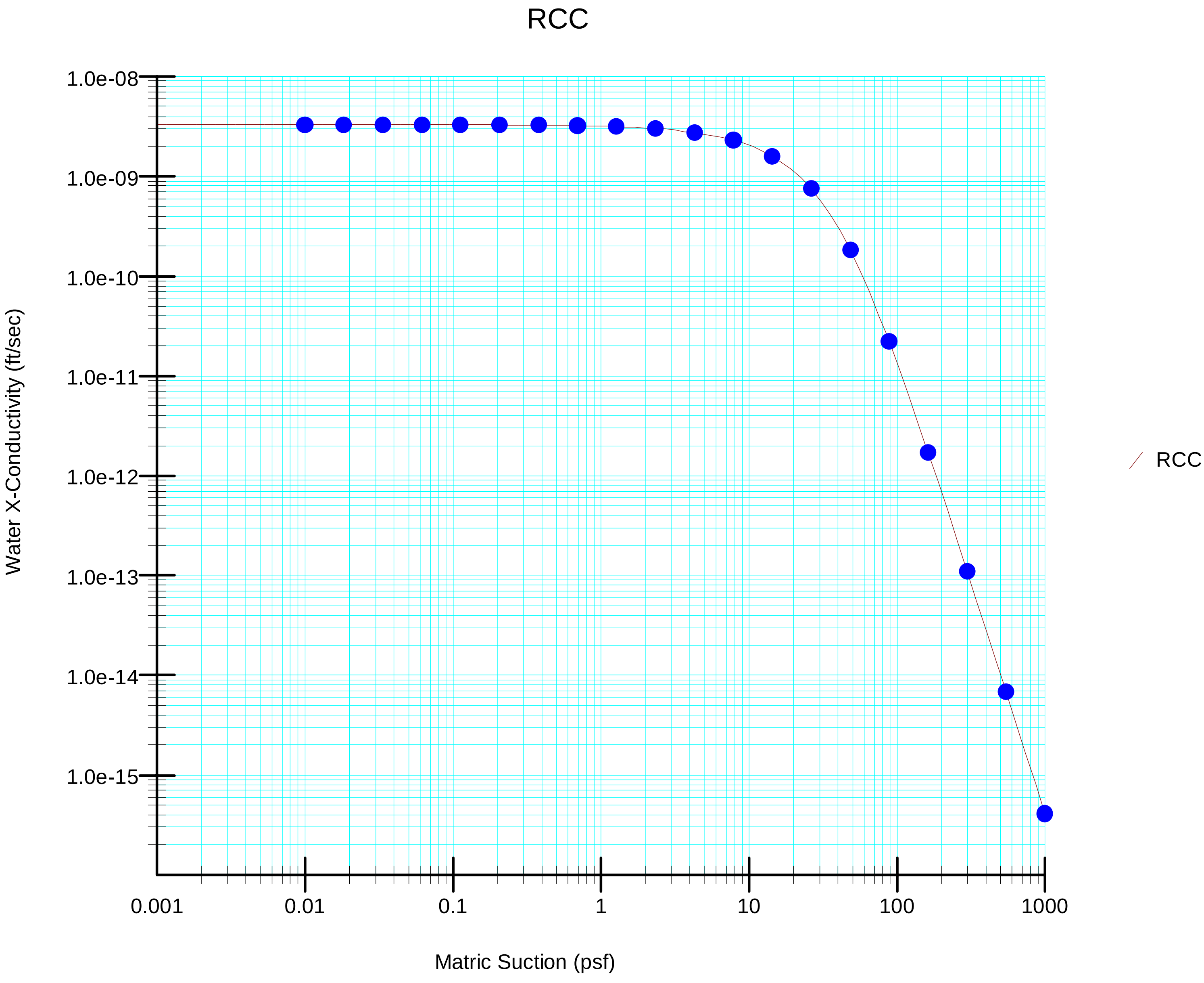
Clay - Embankment SC
1.0e-07
1.0e-08
1.0e-09
1.0e-10
Water X-Conductivity (ft/sec)
0.001
0.01
0.1
1
10
100
1000
Matric Suction (psf)
Clay - Embankment SC

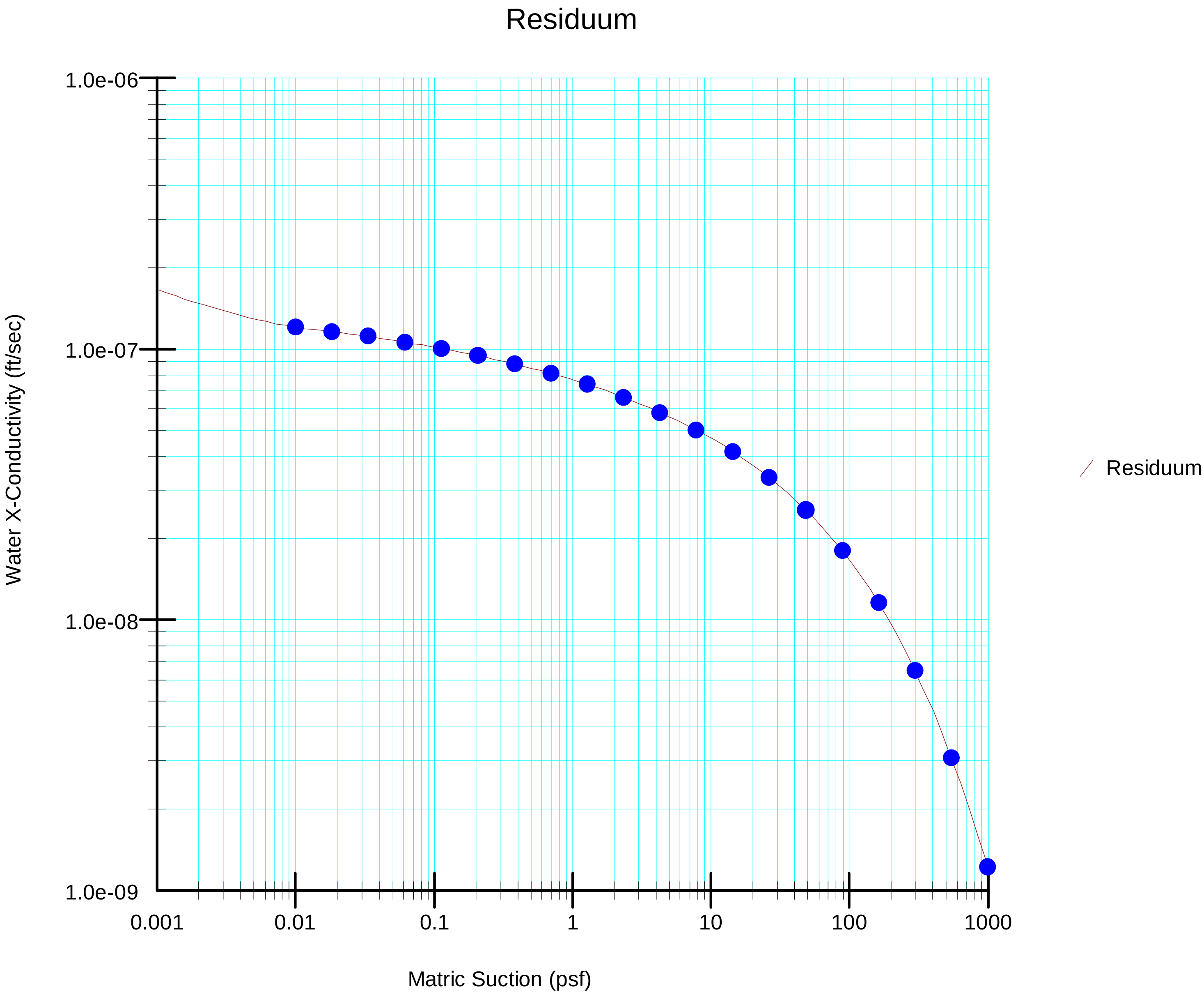


Filter Drain
1.0e-03
1.0e-04
1.0e-05
1.0e-06
1.0e-07
1.0e-08
1.0e-09
1.0e-10
Water X-Conductivity (ft/sec)
0.001
0.01
0.1
1
10
100
1000
Matric Suction (psf)
Filter Drain

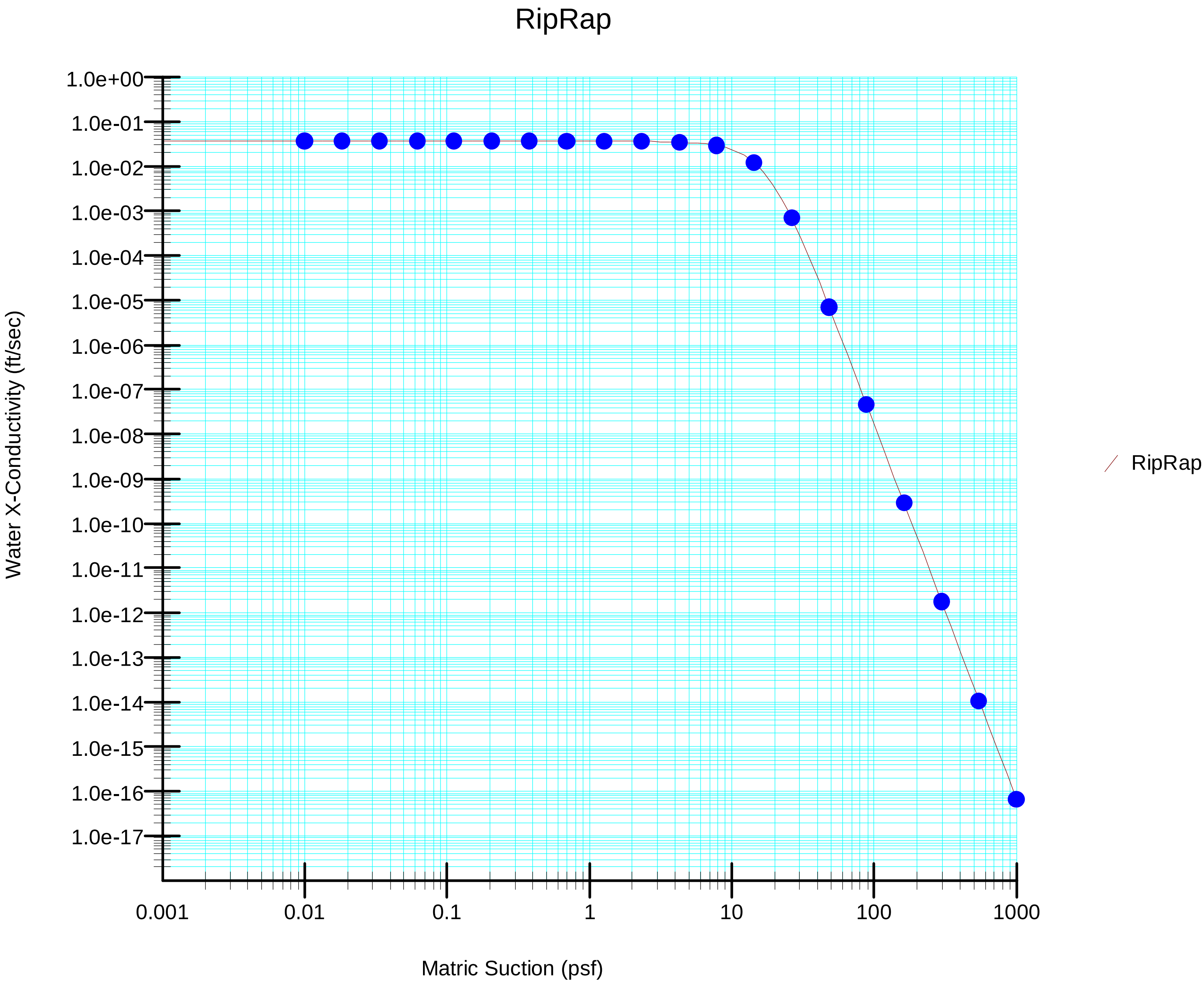


Proposed - Embankment
1.0e-07
1.0e-08
1.0e-09
1.0e-10
Water X-Conductivity (ft/sec)
0.001
0.01
0.1
1
10
100
1000
Matric Suction (psf)
Proposed - Embankment


RCC
1.0e-08
1.0e-09
1.0e-10
1.0e-11
1.0e-12
1.0e-13
1.0e-14
1.0e-15
Water X-Conductivity (ft/sec)
0.001
0.01
0.1
1
10
100
1000
Matric Suction (psf)
RCC



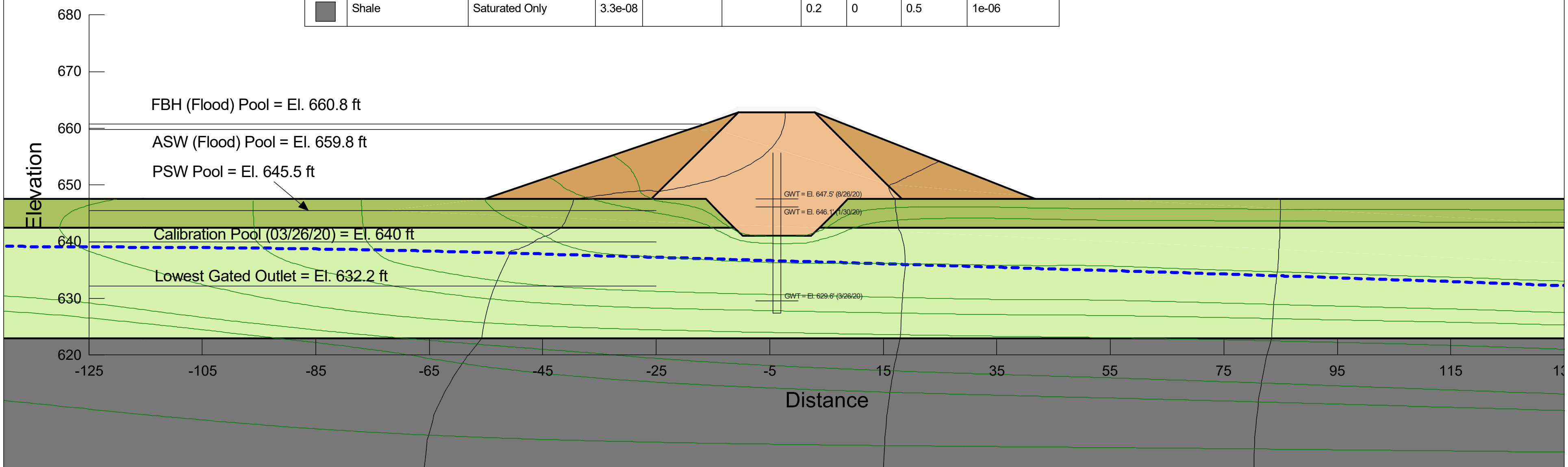
Residuum
1.0e-06
1.0e-07
1.0e-08
1.0e-09
0.001
0.01
0.1
1
10
100
1000
Matric Suction (psf)
Water X-Conductivity (ft/sec)
Residuum


RipRap
1.0e+00
1.0e-01
1.0e-02
1.0e-03
1.0e-04
1.0e-05
1.0e-06
1.0e-07
1.0e-08
1.0e-09
1.0e-10
1.0e-11
1.0e-12
1.0e-13
1.0e-14
1.0e-15
1.0e-16
1.0e-17
Water X-Conductivity (ft/sec)
0.001
0.01
0.1
1
10
100
1000
Matric Suction (psf)
RipRap

ATTACHMENT 2
SEEP/W Output

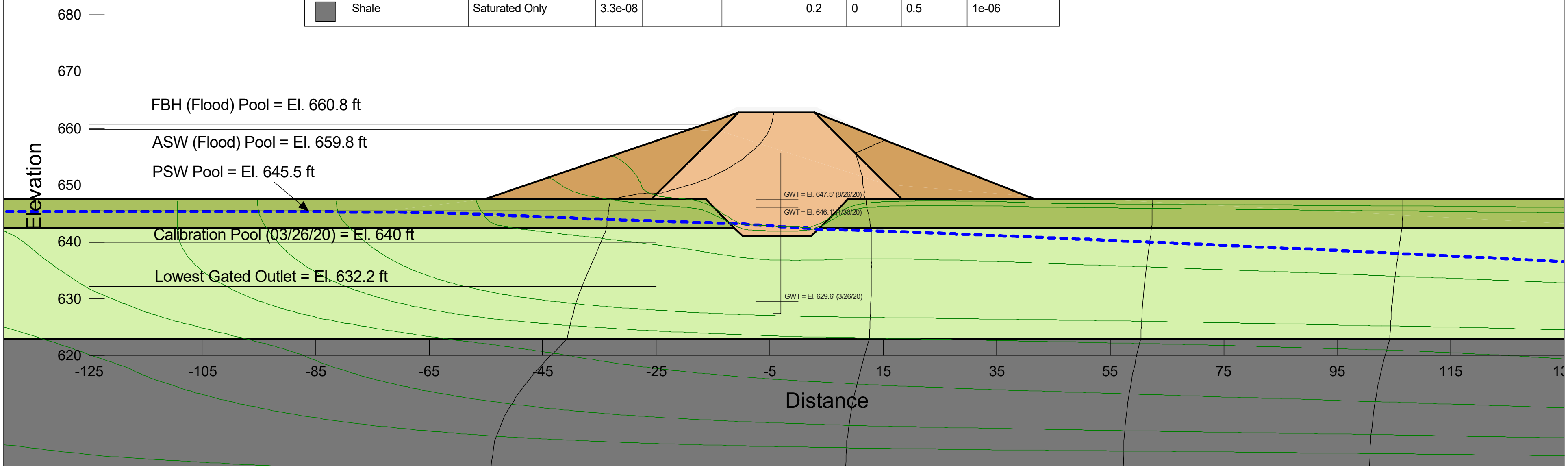
Section 18+50 (Proposed Embankment Crest Modification)

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Existing Embankment Fill - Zone II (SC)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment SC	0.2	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



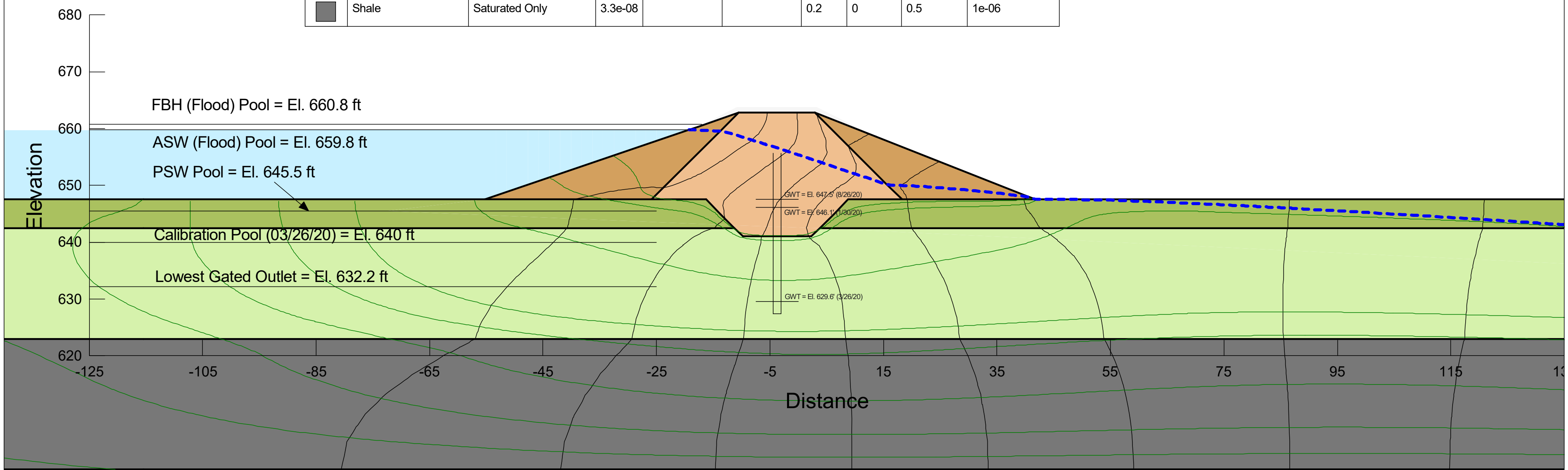
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_Embank_Seep_Exist_Emb_Calibration(El. 640 ft)
Method: Steady-State
Tool Version: 10.2.2.20559

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Existing Embankment Fill - Zone II (SC)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment SC	0.2	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



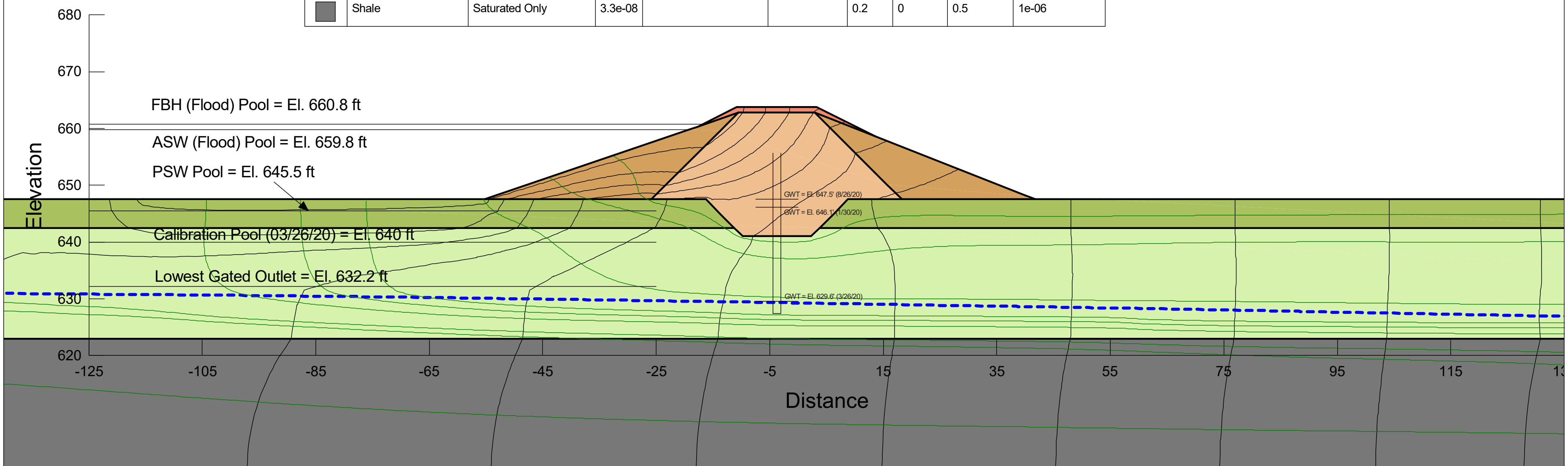
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_Embank_Seep_Exist_Emb_PSW
Method: Steady-State
Tool Version: 10.2.2.20559

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Existing Embankment Fill - Zone II (SC)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment SC	0.2	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



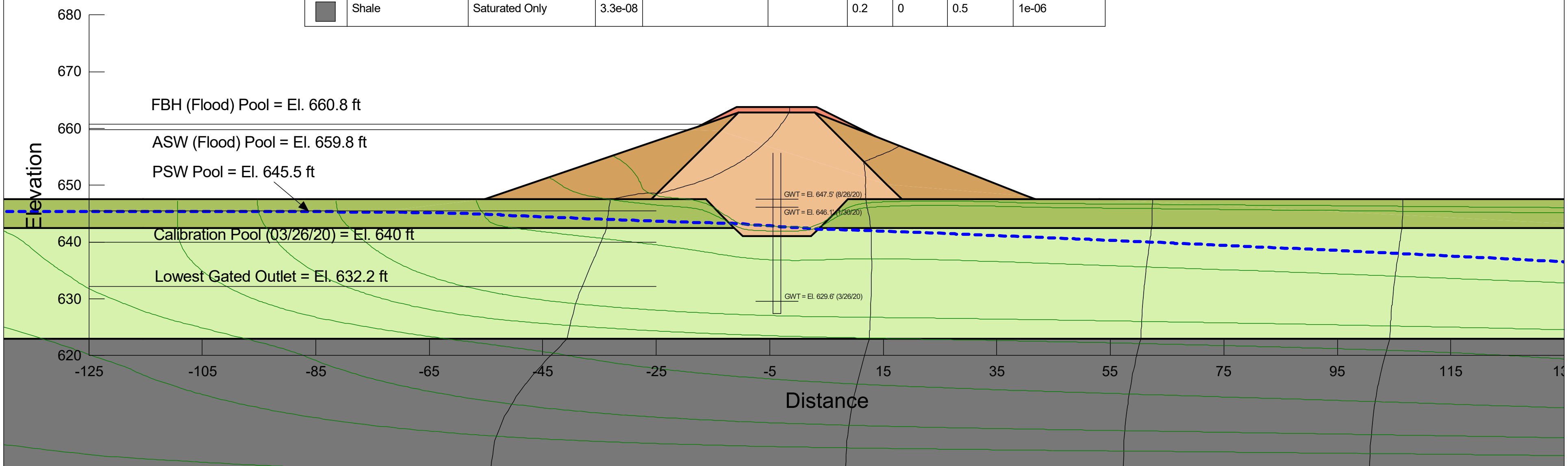
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_Embank_Seep_Exist_Emb_ASW
Method: Steady-State
Tool Version: 10.2.2.20559

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Existing Embankment Fill - Zone II (SC)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment SC	0.2	0		
	Proposed Embankment Fill	Saturated / Unsaturated		Clay - Embankment Fill	Proposed - Embankment	0.25	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



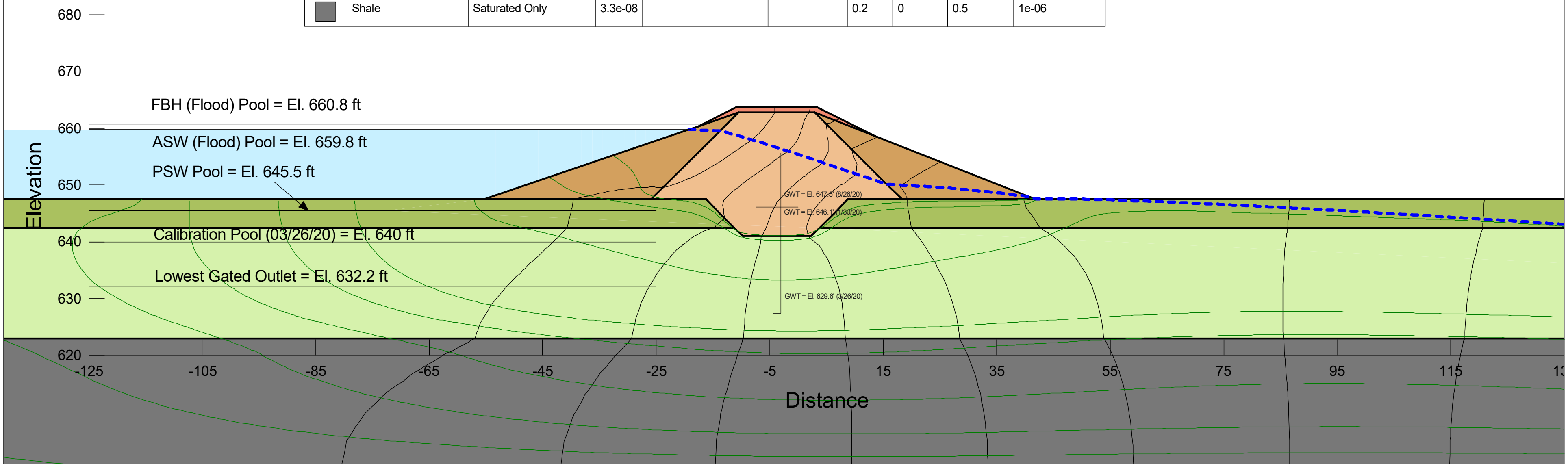
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_Embank_Seep_Prop_Emb_Lowest Gated
Method: Steady-State
Tool Version: 10.2.2.20559

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Existing Embankment Fill - Zone II (SC)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment SC	0.2	0		
	Proposed Embankment Fill	Saturated / Unsaturated		Clay - Embankment Fill	Proposed - Embankment	0.25	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



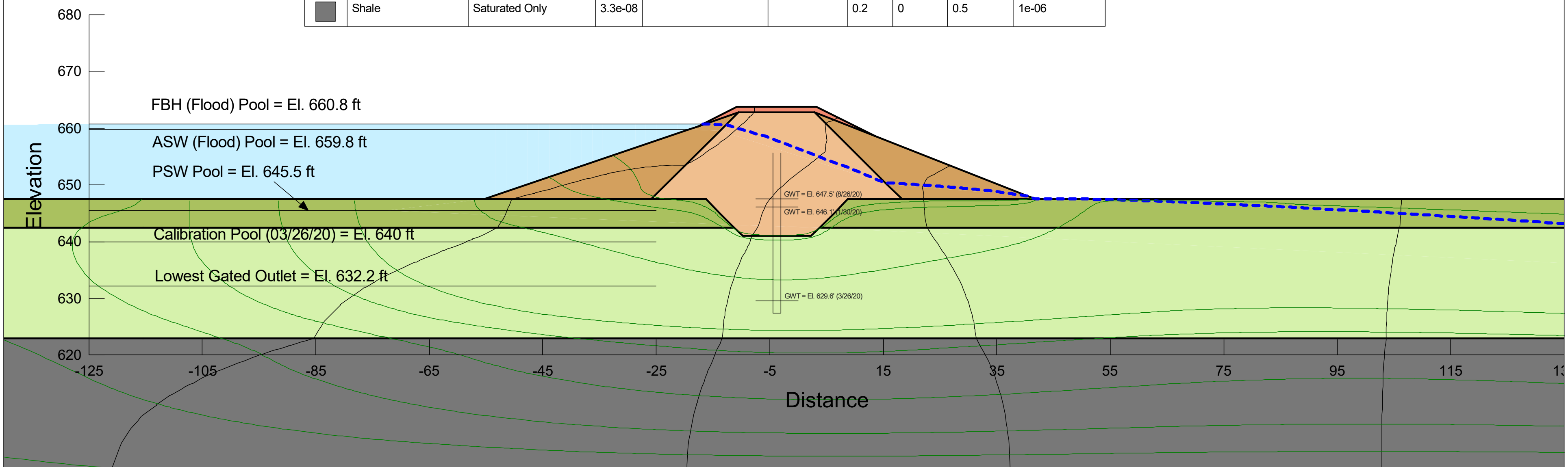
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_Embank_Seep_Prop_Emb_PSW
Method: Steady-State
Tool Version: 10.2.2.20559

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Existing Embankment Fill - Zone II (SC)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment SC	0.2	0		
	Proposed Embankment Fill	Saturated / Unsaturated		Clay - Embankment Fill	Proposed - Embankment	0.25	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_Embank_Seep_Prop_Emb_ASW
Method: Steady-State
Tool Version: 10.2.2.20559

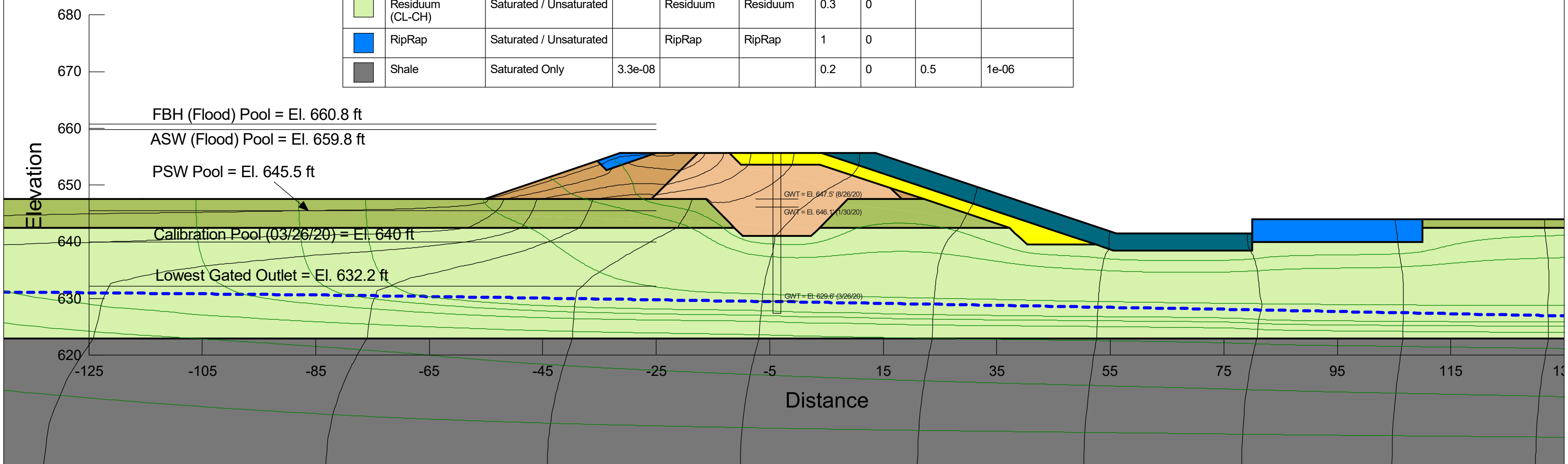
Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Existing Embankment Fill - Zone II (SC)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment SC	0.2	0		
	Proposed Embankment Fill	Saturated / Unsaturated		Clay - Embankment Fill	Proposed - Embankment	0.25	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_Embank_Seep_Prop_Emb_FBH
Method: Steady-State
Tool Version: 10.2.2.20559

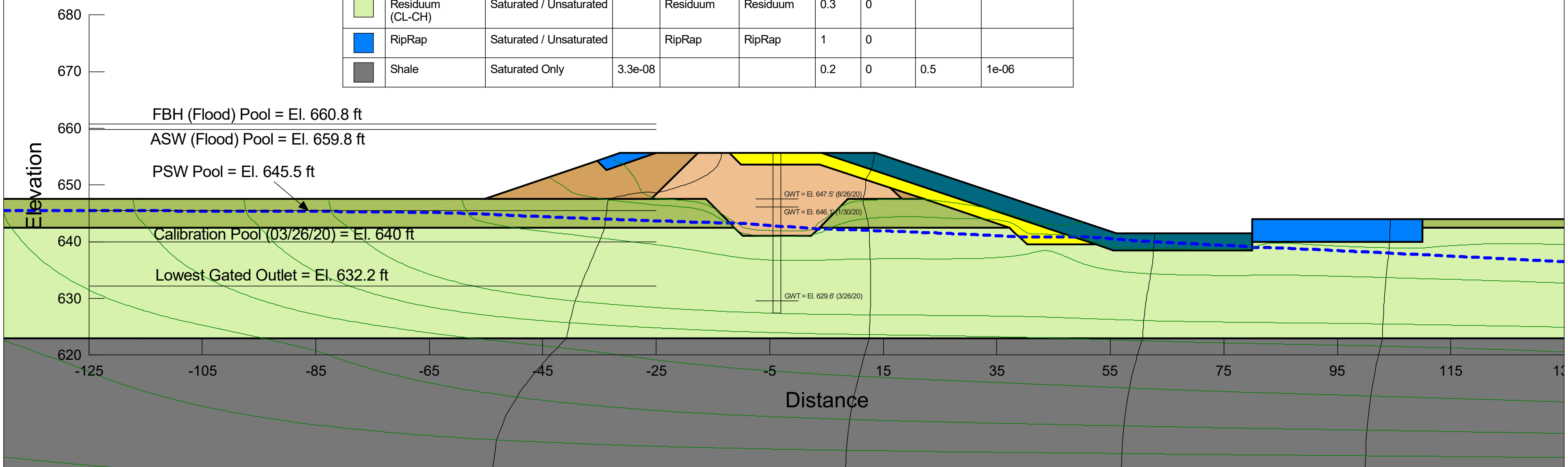
Section 18+50 (Proposed RCC Overtopping Spillway)

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Existing Embankment Fill - Zone II (SC)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment SC	0.2	0		
	Filter Drain	Saturated / Unsaturated		Filter Drain - Sand	Filter Drain	0.5	0		
	RCC	Saturated / Unsaturated		RCC	RCC	1	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	RipRap	Saturated / Unsaturated		RipRap	RipRap	1	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



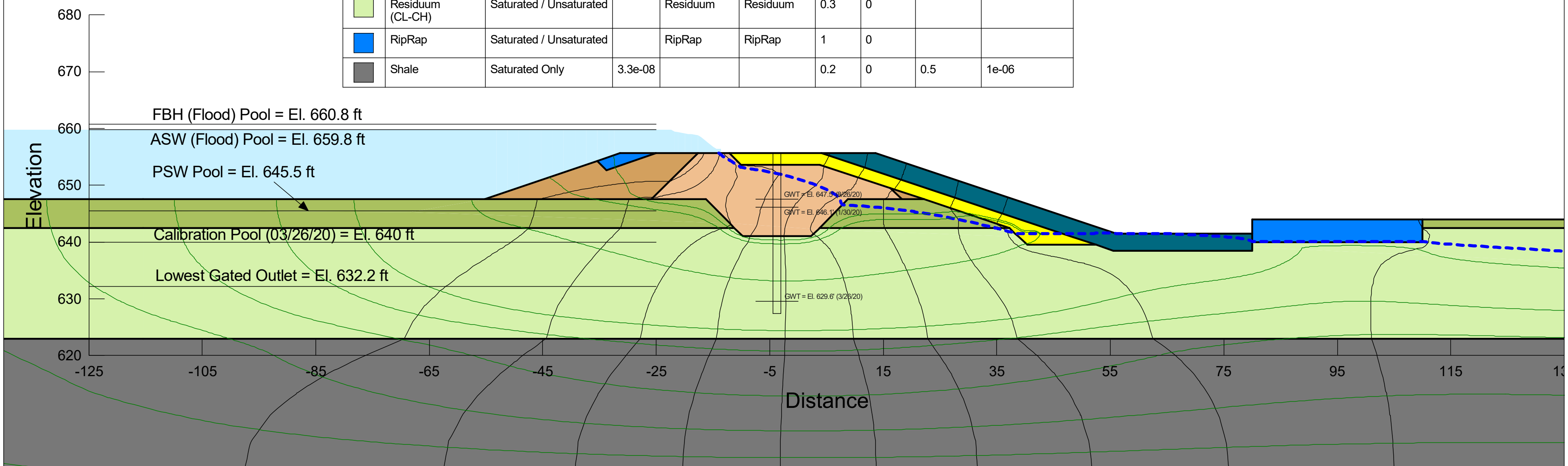
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_RCC_Seep_Prop_Emb_Lowest_Gated
Method: Steady-State
Tool Version: 10.2.2.20559

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Existing Embankment Fill - Zone II (SC)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment SC	0.2	0		
	Filter Drain	Saturated / Unsaturated		Filter Drain - Sand	Filter Drain	0.5	0		
	RCC	Saturated / Unsaturated		RCC	RCC	1	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	RipRap	Saturated / Unsaturated		RipRap	RipRap	1	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



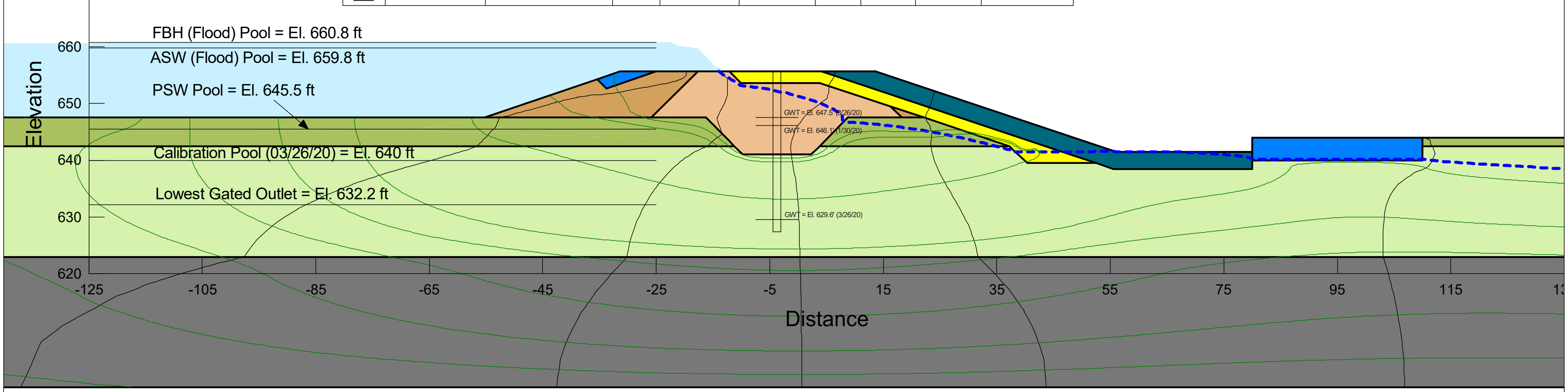
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_RCC_Seep_Prop_Emb_PSW
Method: Steady-State
Tool Version: 10.2.2.20559

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Existing Embankment Fill - Zone II (SC)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment SC	0.2	0		
	Filter Drain	Saturated / Unsaturated		Filter Drain - Sand	Filter Drain	0.5	0		
	RCC	Saturated / Unsaturated		RCC	RCC	1	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	RipRap	Saturated / Unsaturated		RipRap	RipRap	1	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_RCC_Seep_Prop_Emb_ASW
Method: Steady-State
Tool Version: 10.2.2.20559

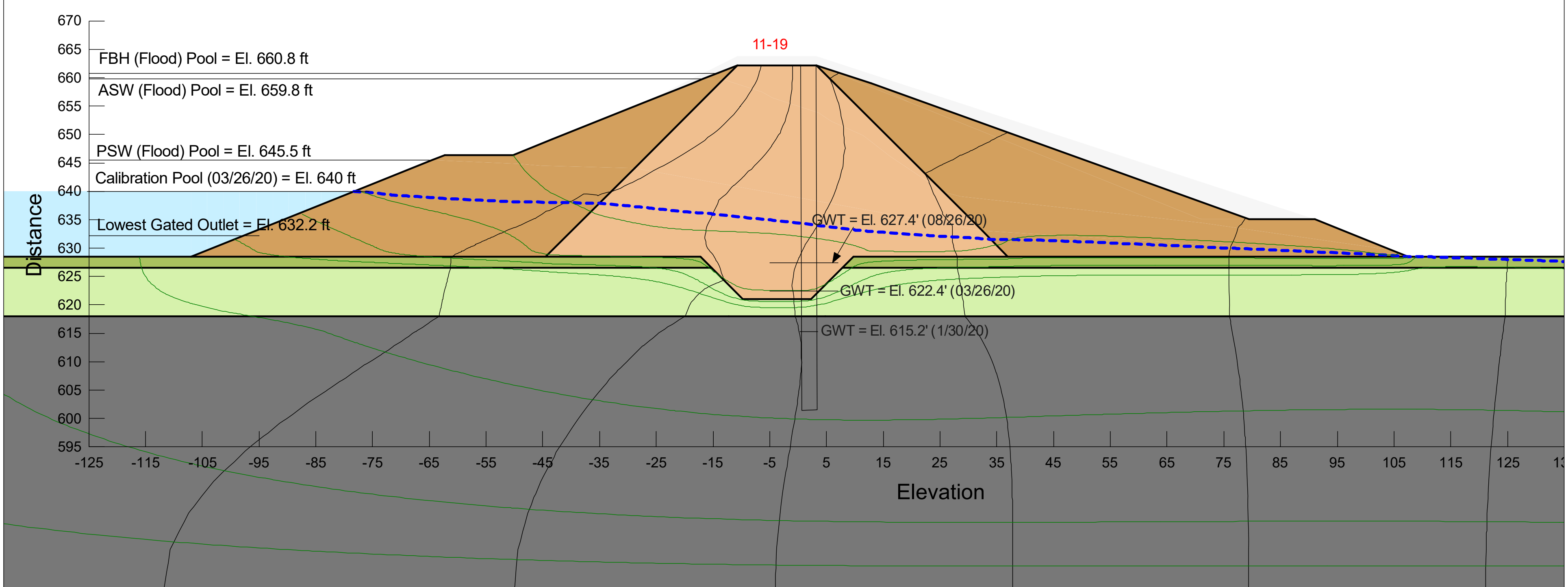
Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Existing Embankment Fill - Zone II (SC)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment SC	0.2	0		
	Filter Drain	Saturated / Unsaturated		Filter Drain - Sand	Filter Drain	0.5	0		
	RCC	Saturated / Unsaturated		RCC	RCC	1	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	RipRap	Saturated / Unsaturated		RipRap	RipRap	1	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_RCC_Seep_Prop_Emb_FBH
Method: Steady-State
Tool Version: 10.2.2.20559

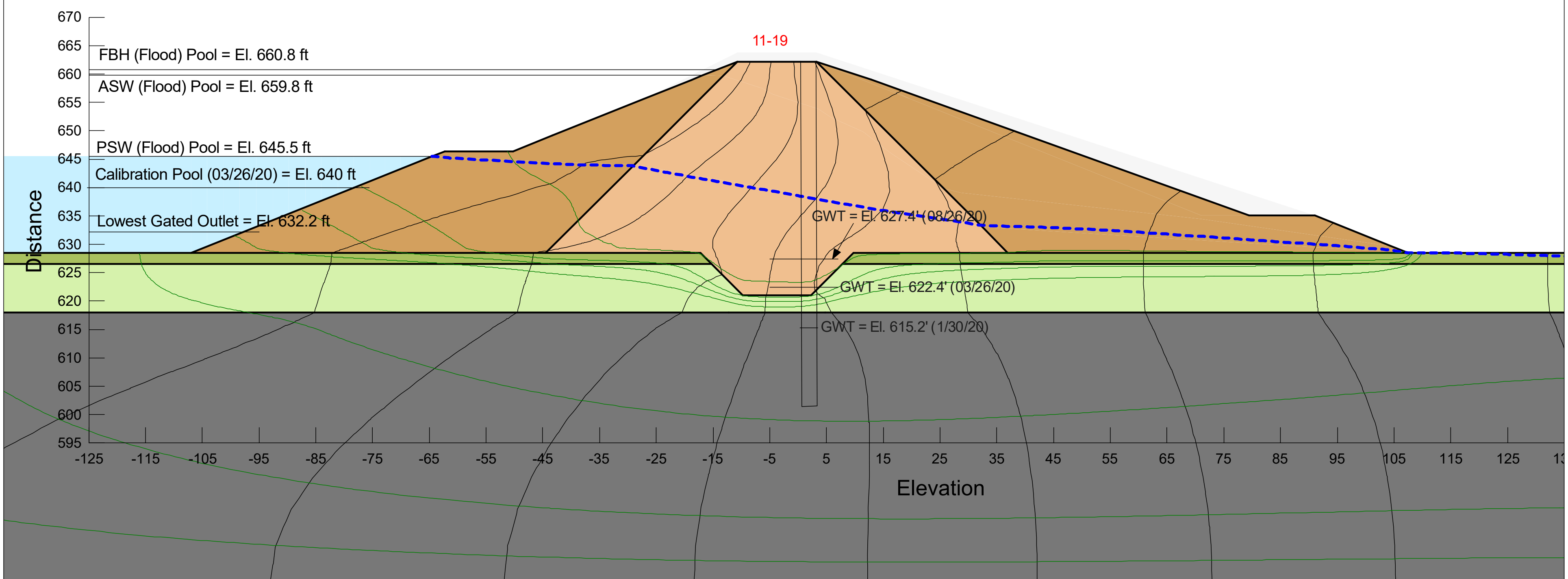
Station 23+50 (Proposed Embankment Crest Modification)

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Existing Embankment Fill - Zone II (SC)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment SC	0.2	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



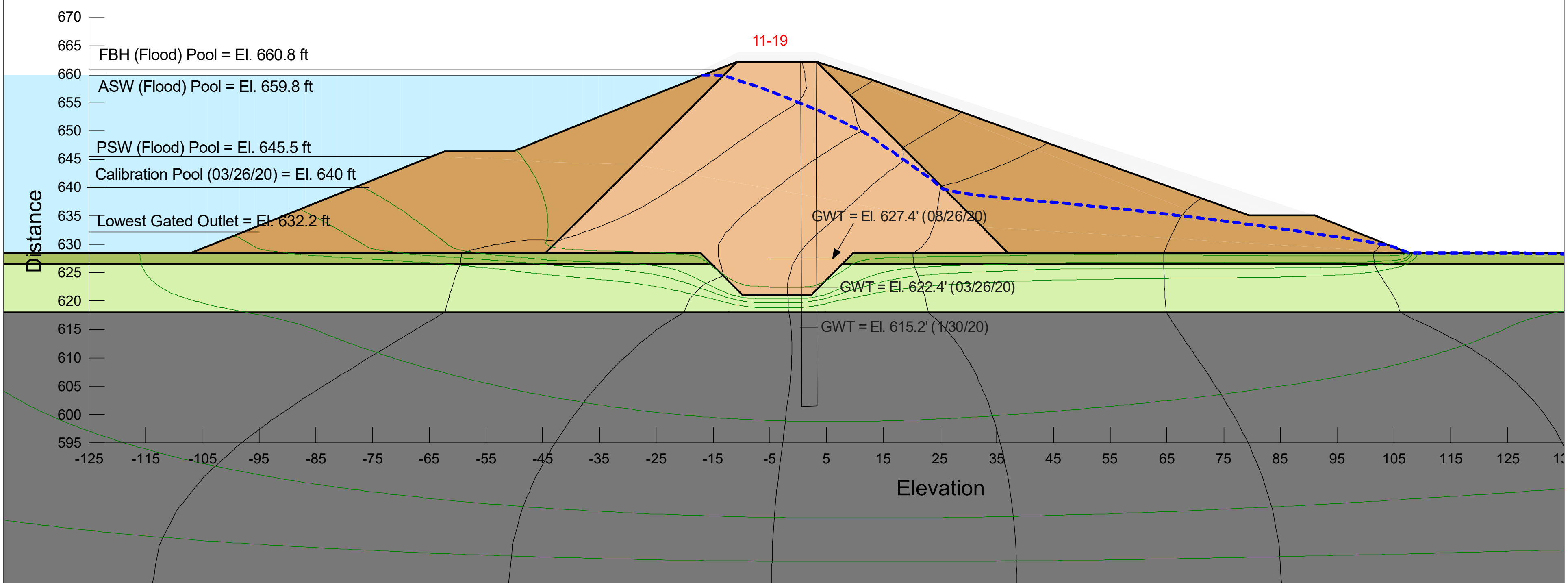
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_Seep_Exist_Emb_Caliberation (El. 640 ft)
Method: Steady-State
Tool Version: 10.2.2.20559

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Existing Embankment Fill - Zone II (SC)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment SC	0.2	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



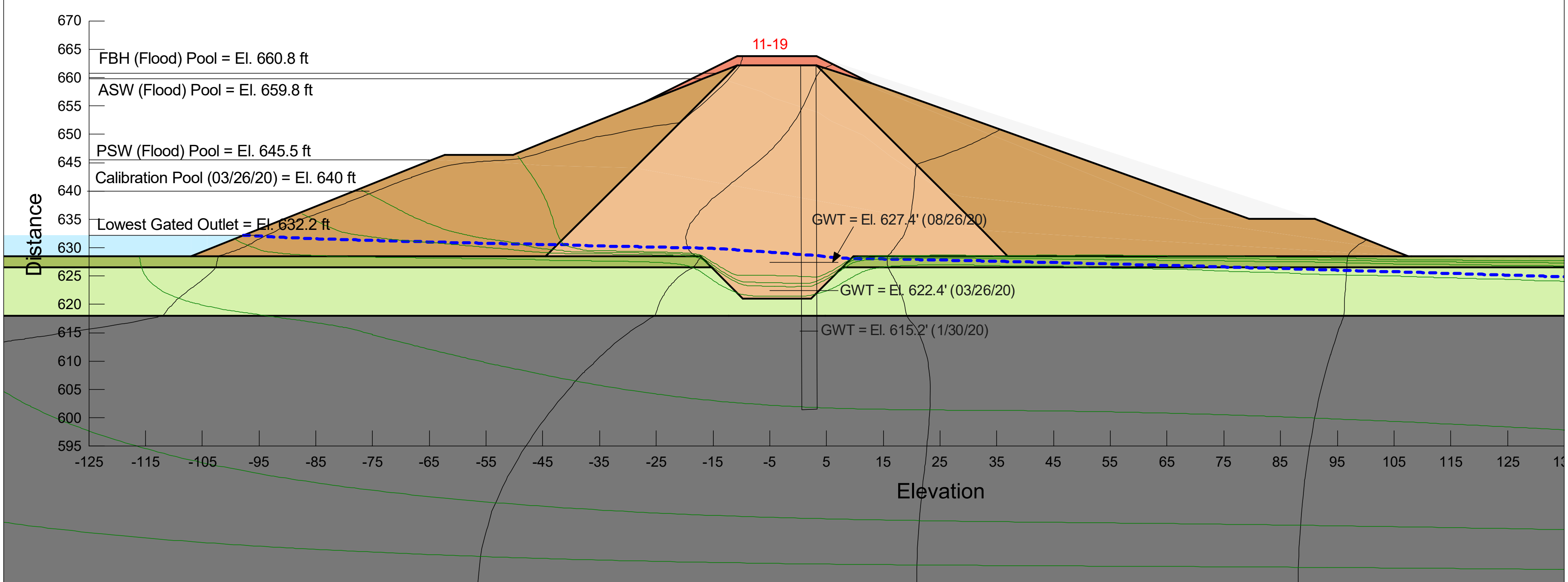
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_Seep_Exist_Emb_PSW (El. 645.5 ft)
Method: Steady-State
Tool Version: 10.2.2.20559

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Existing Embankment Fill - Zone II (SC)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment SC	0.2	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



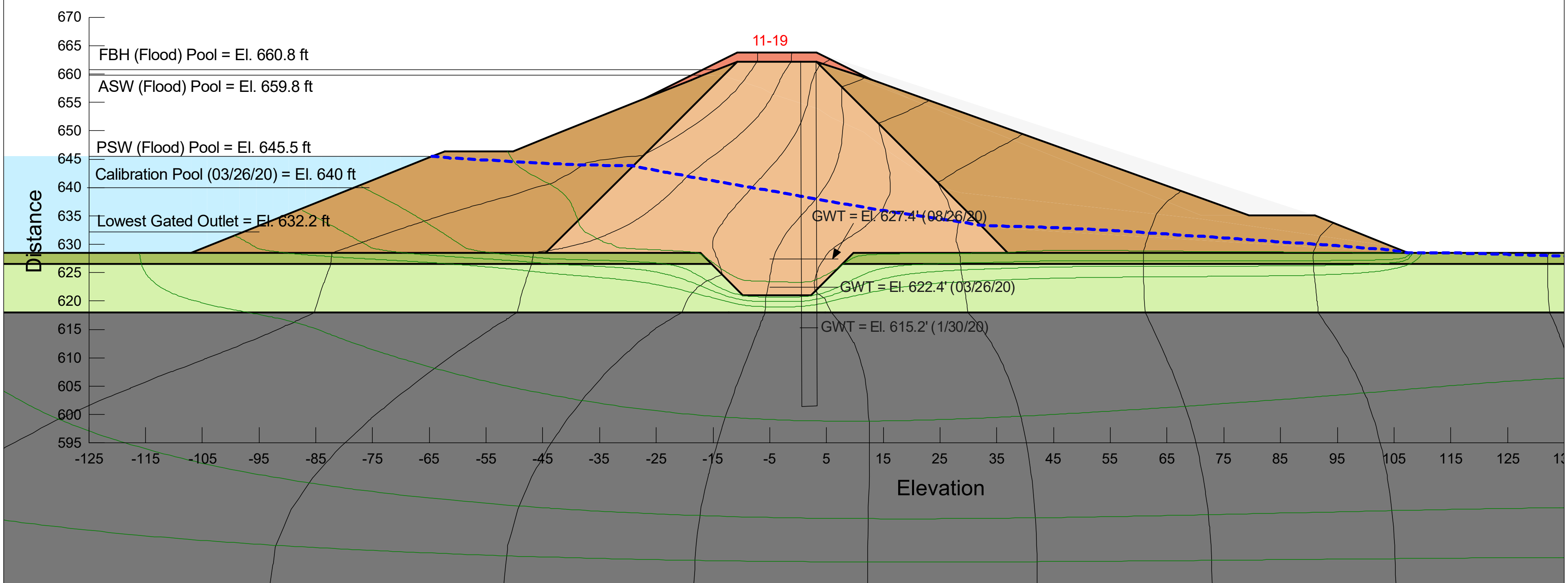
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_Seep_Exist_Emb_ASW (El. 659.8 ft)
Method: Steady-State
Tool Version: 10.2.2.20559

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Existing Embankment Fill - Zone II (SC)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment SC	0.2	0		
	Proposed Embankment Fill	Saturated / Unsaturated		Clay - Embankment Fill	Proposed - Embankment	0.25	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



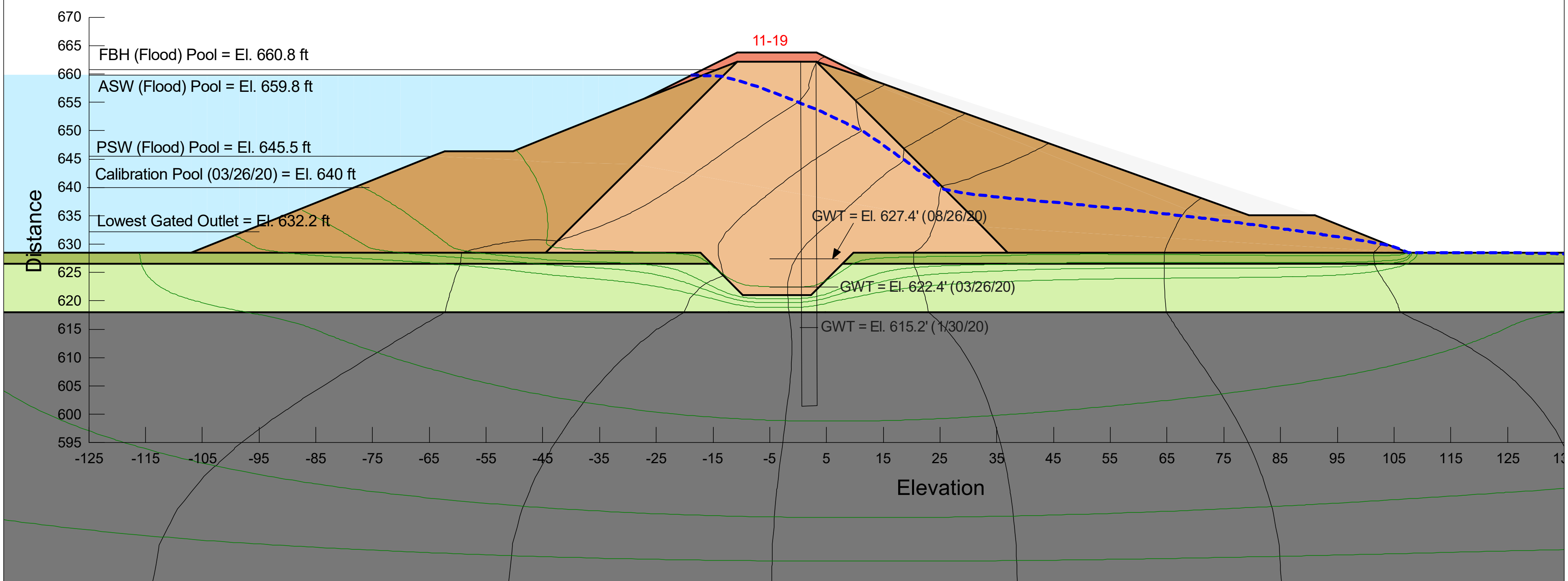
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_Seep_Prop_Emb_Lowest Gated (El. 632.2 ft)
Method: Steady-State
Tool Version: 10.2.2.20559

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Existing Embankment Fill - Zone II (SC)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment SC	0.2	0		
	Proposed Embankment Fill	Saturated / Unsaturated		Clay - Embankment Fill	Proposed - Embankment	0.25	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



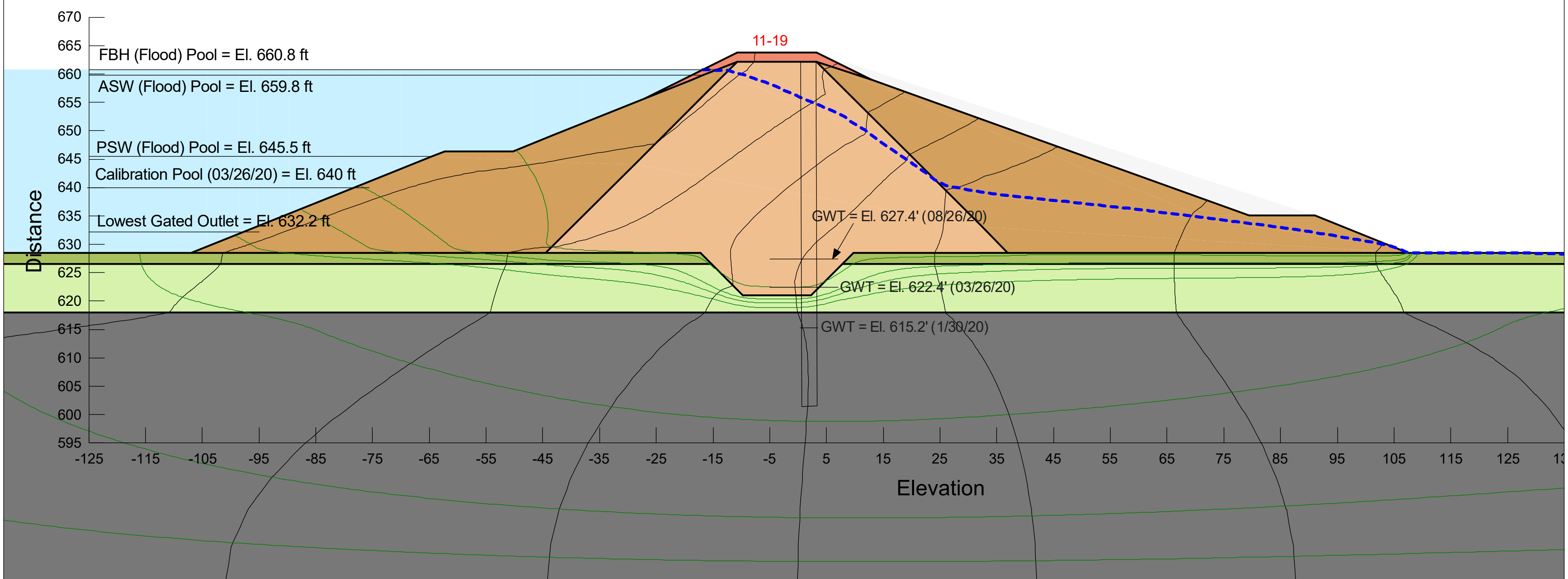
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_Seep_Prop_Emb_PSW (El. 645.5 ft)
Method: Steady-State
Tool Version: 10.2.2.20559

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Existing Embankment Fill - Zone II (SC)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment SC	0.2	0		
	Proposed Embankment Fill	Saturated / Unsaturated		Clay - Embankment Fill	Proposed - Embankment	0.25	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_Seep_Prop_Emb_ASW (El. 659.8 ft)
Method: Steady-State
Tool Version: 10.2.2.20559

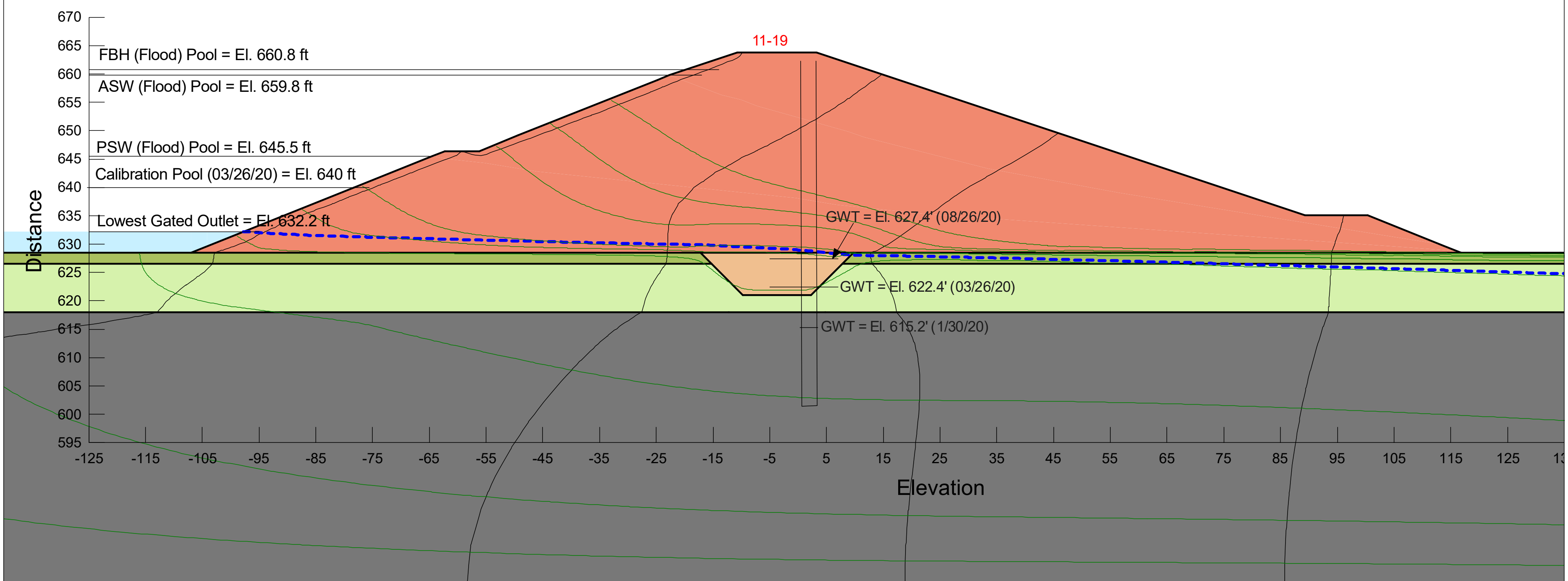
Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Existing Embankment Fill - Zone II (SC)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment SC	0.2	0		
	Proposed Embankment Fill	Saturated / Unsaturated		Clay - Embankment Fill	Proposed - Embankment	0.25	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_Seep_Prop_Emb_FBH (El. 660.8 ft)
Method: Steady-State
Tool Version: 10.2.2.20559

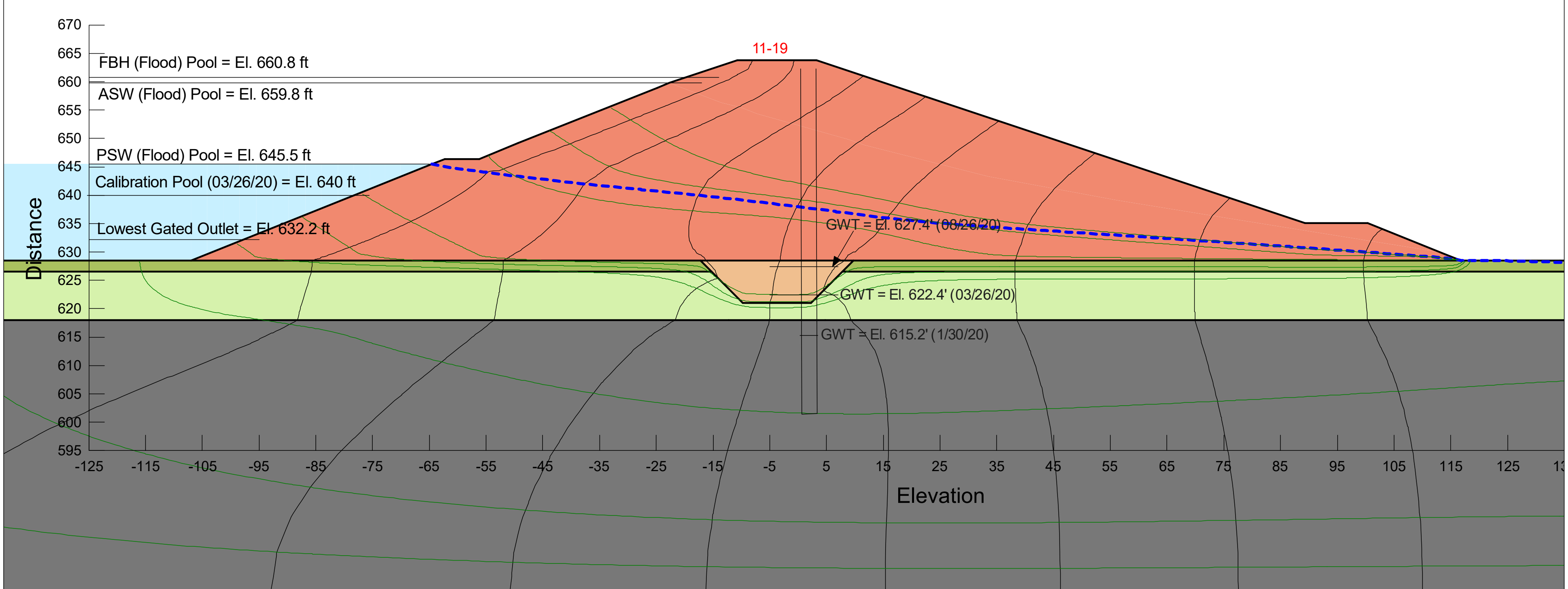
Station 23+50 (Proposed Embankment Reconstruction at New PSW)

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Proposed Embankment Fill	Saturated / Unsaturated		Clay - Embankment Fill	Proposed - Embankment	0.25	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



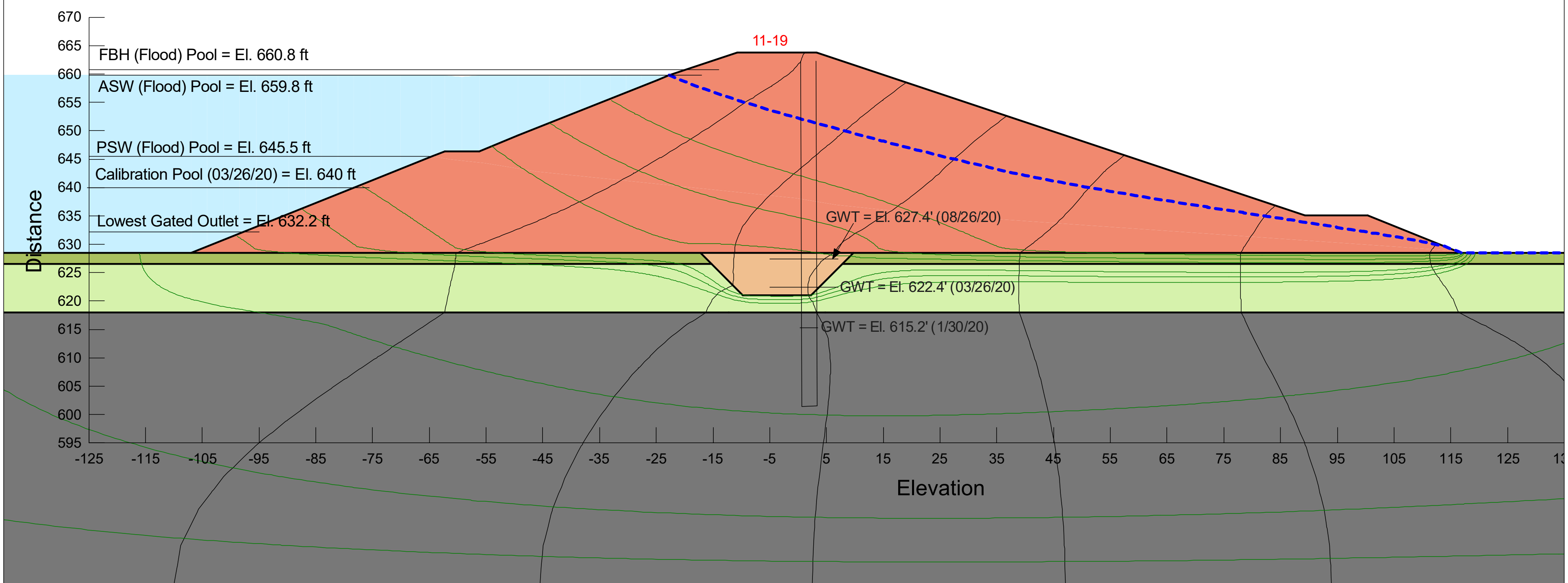
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_new_Seep_Prop_Emb_Lowest Gated (El. 632.2 ft) (2)
Method: Steady-State
Tool Version: 10.2.2.20559

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Proposed Embankment Fill	Saturated / Unsaturated		Clay - Embankment Fill	Proposed - Embankment	0.25	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



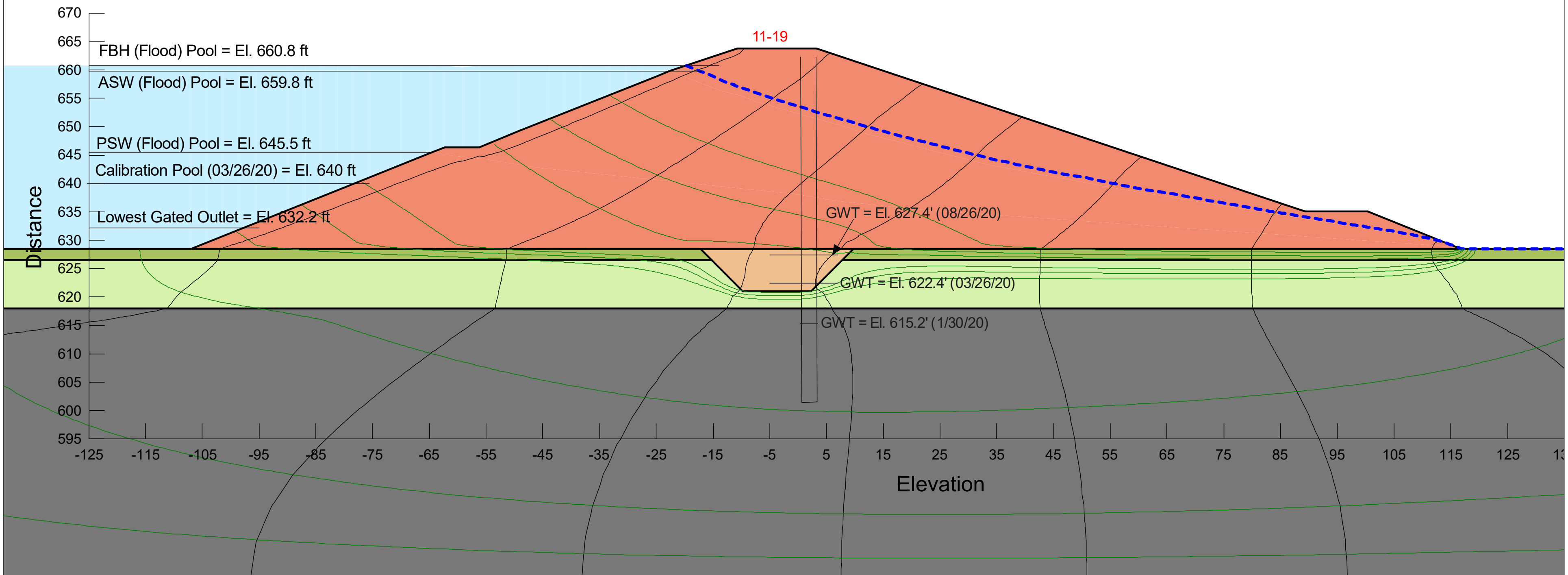
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_new_Seep_Prop_Emb_PSW (El. 645.5 ft) (2)
Method: Steady-State
Tool Version: 10.2.2.20559

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Proposed Embankment Fill	Saturated / Unsaturated		Clay - Embankment Fill	Proposed - Embankment	0.25	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_new_Seep_Prop_Emb_ASW (El. 659.8 ft) (2)
Method: Steady-State
Tool Version: 10.2.2.20559

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)	Volumetric Water Content	Compressibility (/psf)
	Alluvium (CH)	Saturated / Unsaturated		Alluvium	Alluvium	0.5	0		
	Existing Embankment Fill - Zone I (CH)	Saturated / Unsaturated		Clay - Embankment Fill	Clay - Embankment	0.2	0		
	Proposed Embankment Fill	Saturated / Unsaturated		Clay - Embankment Fill	Proposed - Embankment	0.25	0		
	Residuum (CL-CH)	Saturated / Unsaturated		Residuum	Residuum	0.3	0		
	Shale	Saturated Only	3.3e-08			0.2	0	0.5	1e-06



Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_new_Seep_Prop_Emb_FBH (El. 660.8 ft) (2)
Method: Steady-State
Tool Version: 10.2.2.20559

ATTACHMENT 3

Drain Sizing

Project: Plum #2 underdrain RCC
Project No.: 60546729
Date: 10/23/2020
Engineer: EG

SIZING OF TOE DRAIN PIPE

Manning's Equation: $$Q = \frac{1.49}{n} r^{2/3} s^{1/2} A$$

Q = Design Discharge through Pipe (ft^3/sec)
n = Manning's Roughness Coefficient
r = Hydraulic Radius (ft)
s = Slope of Channel Bottom (ft/ft)
A = Area of Flow (ft^2)

****Restrictions: Limit flow depth to 50% of pipe's diameter.*

Length of Pipe, L =	214	ft	(approximate length of embankment dam)
Seepage Flow at Max Embankment Section, q =	5.5E-07	ft^3/sec/ft	(refer to Seepage Analysis results; q=0.20054 CF/day/LF)
Apply Factor of Safety, FS =	10		(accounts for variability and uncertainity in hydraulic conductivities)
Design Discharge through Pipe, Q = FS(qL) =	**0.0012**	ft^3/sec	(required pipe capacity)
Manning's Roughness Coefficient, n =	0.012		(for perforated PVC pipe with smooth interior)
Slope of Channel Bottom, s =	0.01	ft/ft	(slope of toe drain outlet pipe; assume 1%)
For a pipe flowing 50% full: A/D^2 =	0.3927		(from Table B-3 in USBR, 1987)
r/D =	0.2500		(from Table B-3 in USBR, 1987)
D =	Diameter of Pipe		
Area of Flow, A =	$0.3927D^2$	ft^2	
Hydraulic Radius, r =	0.2500D	ft	

Manning's Equation Becomes: $$Q = \frac{1.49}{n}(0.2500D)^{2/3} s^{1/2}(0.3927D^2)$$ **--- Solve for D**

Trial Diameter of Pipe, D >=	0.50	ft	(consider minimum 6-inch pipe)
	6.00	in	
Q_{Design} =	**0.305**	**ft^3/sec**	(adjust pipe diameter until Qdesign >= Q from above)
Check capacity =	**OK**		

Selected drain pipe diameter (inches):	**6**

Maximum Discharge for
Selected Pipe Flowing 50% Full, Q_{max} = **0.305** **ft^3/sec**

Project: Plum #2 underdrain RCC
Project No.: 60546729
Date: 10/23/2020
Engineer: EG

SIZING OF TOE DRAIN PIPE

Manning's Equation: $Q = \frac{1.49}{n} r^{2/3} s^{1/2} A$

Q = Design Discharge through Pipe (ft^3/sec)
n = Manning's Roughness Coefficient
r = Hydraulic Radius (ft)
s = Slope of Channel Bottom (ft/ft)
A = Area of Flow (ft^2)

****Restrictions: Limit flow depth to 25% of pipe's diameter.*

Length of Pipe, L =	214	ft	(approximate length of embankment dam)
Seepage Flow at Max Embankment Section, q =	5.5E-07	ft^3/sec/ft	(refer to Seepage Analysis results; q=0.20054 CF/day/LF)
Apply Factor of Safety, FS =	10		(accounts for variability and uncertainity in hydraulic conductivities)
Design Discharge through Pipe, Q = FS(qL) =	**0.0012**	ft^3/sec	(required pipe capacity)
Manning's Roughness Coefficient, n =	0.012		(for perforated PVC pipe with smooth interior)
Slope of Channel Bottom, s =	0.01	ft/ft	(slope of toe drain outlet pipe; assume 1%)
For a pipe flowing 25% full: A/D^2 =	0.1535		(from Table B-3 in USBR, 1987)
r/D =	0.1466		(from Table B-3 in USBR, 1987)
D =	Diameter of Pipe		
Area of Flow, A =	$0.1535D^2$	ft^2	
Hydraulic Radius, r =	0.1466D	ft	

Manning's Equation Becomes: $Q = \frac{1.49}{n}(0.1466D)^{2/3} s^{1/2} (0.1535D^2)$ **--- Solve for D**

Trial Diameter of Pipe, D >=	0.50	ft	(consider minimum 6-inch pipe)
	6.00	in	
Q_{Design} =	**0.083**	**ft^3/sec**	(adjust pipe diameter until Qdesign >= Q from above)
Check capacity =	**OK**		

Selected drain pipe diameter (inches): 6

Maximum Discharge for Selected Pipe Flowing 25% Full, Q_{max} = **0.083** **ft^3/sec**

Appendix D Slope Stability Analysis

OBJECTIVE:

1. Present background information and NRCS criteria for slope stability and design strength envelopes
2. Analyze existing conditions to calibrate soil strength parameters.
3. Using calibrated parameters, analyze proposed conditions to verify minimum factors of safety per NRCS.

REFERENCES:

1. GeoStudio User's Manual. "Slope/W".
2. AECOM. "TSSWCB Plum 2, Soil Mechanics Report." 2021.
3. AECOM. "TSSWCB Plum 2, Geologic Investigation Report." 2021.
4. USACE. "EM 1110-2-1902, Appendix G."

PROJECT DESCRIPTION

The purpose of the project is to upgrade the dam to meet design criteria for high-hazard dams. The dam classification has changed to high hazard as a result of downstream development since original construction.

The dam rehabilitation involves re-shaping, widening, and/or raising the existing embankment; widening the existing vegetated auxiliary spillway (ASW); abandoning in-place the existing principal spillway (PSW); constructing a new PSW inlet riser, conduit pipe, and impact basin; and constructing a new overtopping roller compacted concrete (RCC) spillway serving as a secondary ASW. The RCC spillway will consist of a crest structure, chute structure, and stilling basin. The foundation for the RCC crest structure will be cut down below the top of the existing embankment crest. Relevant elevations for existing and proposed conditions are listed below in Table 1.

Table 1.Summary of Existing and Proposed Elevations for Various Dam Features

Dam Feature	Existing	Proposed	Change
Earthen Embankment Crest	El. 662.8	El. 663.8	+1.0 feet
Principal Spillway Crest	El. 649.1	El. 645.5	-3.6 feet
Auxiliary Spillway Crest	El. 658.9	El. 659.8	+0.9 feet
Foundation for New Overtopping RCC Spillway Crest Structure	---	El. 658.7 (top of slab) / El. 655.7 (bottom of slab)	-4.1 feet from existing grade to top of slab*
Foundation for New Overtopping RCC Spillway Stilling Basin	---	El. 641.7 (top of slab) / El. 638.7 (bottom of slab)	-5.8 feet from existing grade to top of slab**
**Based on El. 662.8 at crest of existing dam.* ***Based on El. 647.5 at toe of existing dam.*			

Upstream and downstream embankment slopes will be maintained at existing slope angles, which vary from about 2.7H:1V to 3H:1V based on topographic survey (flatter than the specified 2.5H:1V upstream and downstream slopes indicated in the as-built drawings). A new small fill (ranging from <1 to about 2 feet thick) will be placed near the top of the embankment at a 2H:1V slope to widen and raise the embankment crest slightly. A new fill layer at downstream will be placed at 3H:1V slope near the proposed new PSW section (about Station 24+30). Embankment cross-sections at 100-foot intervals illustrating existing and proposed grades are shown in **Attachment 1**.

SLOPE STABILITY DESIGN CRITERIA

Design criteria for slope stability are provided in the current 2019 version of the NRCS TR-210-60. The criteria require analysis of the following loading conditions for the proposed dam modification:

- End of Construction;
- Steady-State Seepage;
- Flood Surcharge;
- Rapid Drawdown; and
- Dynamic stability (if applicable).

The required shear strengths, pore water pressures, and required minimum factors of safety are listed in Table 2. Note that the TR-210-60 only requires numerical analysis of dynamic stability for sites with potential for significant loss of strength under earthquake loading (e.g., liquefaction and/or cyclic softening), design PGA>0.2g, and/or sites with limited loss of strength under earthquake loading that do not meet the criteria for “well-built” dams. The TR-210-60 recommends that seismic stability begins with the simplest and most conservative method (i.e., typically pseudostatic analysis based on AECOM’s experience), and progressively more detailed and complex evaluations if unsatisfactory performance is predicted. The TR-210-60 requires a minimum FOS=1.2 for post-earthquake stability but does not provide specific criteria for seismic analysis procedures or input shear strengths.

Table 2. NRCS Slope Stability Design Criteria

Design Condition	NRCS Design Shear Strengths	NRCS Pore Water Pressures	NRCS Minimum Factor of Safety
End of Construction (D/S and U/S slopes)	• UU strengths for low-perm soils • CD strengths for free-draining soils	Phreatic surface at the time of construction.	1.4 (into foundation) 1.3 (in embankment)
Rapid Drawdown (U/S slopes)	• Bi-linear composite envelope from lowest of CU and CD envelopes for low-perm soil • CD strengths for free-draining soils	Drawdown from highest normal pool to lowest ungated outlet.	1.2 1.1 (infinite slope)
Steady-State Seepage (D/S slope)	• CD strengths for all soils	Phreatic surface developed from highest normal pool.	1.5 1.3 (infinite slope)
Flood Surcharge	• Bi-linear composite envelope from lowest of CU and CD envelopes for low-perm soil • CD strengths for free-draining soils	Reservoir level at the Freeboard Hydrograph (FBH) elevation.	1.4 1.2 (infinite slope)
Dynamic Stability (if applicable)	• See text	Phreatic surface developed from highest normal pool.	1.2 (post-earthquake)

Notes:
1. UU – Unconsolidated Undrained
2. CU – Consolidated Undrained
3. CD – Consolidated Drained

SEISMIC DESIGN

NRCS Screening Procedure

Seismic site characterization was performed according to the guidance in the most recent NRCS TR-210-60 (2019). The document specifies that conventional seismic analysis be evaluated for sites with Peak Ground Acceleration (PGA) equal to or greater than 0.07g for the seismic event associated with the dam's hazard class and consequences of failure. Based on the dam's re-classification as high hazard, AECOM believes that a "high consequence" designation for potential seismic failure is appropriate for this project, corresponding to the 0.5% in 50 year earthquake event (10,000-year return period) is recommended for design-level evaluations per Table 4-1 of the TR-210-60.

A de-aggregation of seismic hazard for the project site was conducted using the online USGS National Seismic Hazards Mapping Tool and the 2014 Conterminous U.S. data set. The deaggregation output indicates the PGA for a site underlain by "rock" (i.e., B-C boundary) is 0.055g for the 0.5% in 50 year earthquake event (10,000-year return period) at the project site. The PGA was adjusted for site class assuming Site Class D based on SPT N-values in the upper 100 feet of below the dam and corresponding site coefficient FPGA of 1.6 (sites with top of rock PGA less than 0.1, per ASCE 7-10), which yields a design PGA_{Design} = PGA x F_{PGA} = 0.088g.

While the PGA_{Design} exceeds the referenced 0.07g cited in the TR-210-60, the document also has a provision that waives the requirement for seismic analysis of "well-built" embankment dams with a limited potential loss of strength at sites with PGA_{Design} less than 0.2g. The TR-210-60 defines "well-built" embankments as those with the following features:

1. constructed from well-compacted earth or rock fill;
2. founded on rock or dense soil (particularly clay) foundations;
3. adequate static factors of safety;
4. seepage control and freeboard; and
5. constructed under controlled conditions.

Based on a review of historical design information, the results of this field investigation, and the geotechnical analyses contained herein, AECOM believes that the dam meets the criteria for well-built embankment dams, in which case further seismic evaluation is not required.

Texas Commission on Environmental Quality (TCEQ) Screening Procedure

Site seismicity was also evaluated with respect to guidelines provided by Texas Commission on Environmental Quality, Design & Construction Guidelines for Dams in Texas (2009). The guidance states that seismic evaluations of dam stability must be conducted for high- and significant-hazard dams near "seismically active" faults, which are defined as faults recognized by and included in the USGS Quaternary Fault and Fold Database. Based on AECOM's review of the USGS database, the nearest active fault zone is the Gulf-margin normal faults system located more than 45 miles east of the site. This system is considered as the "latest Quaternary" (active within the last 15,000 years) and consists of a compilation of numerous individual unmapped faults. The faults are decoupled from the underlying crust and assigned as Class B structures due to their low seismicity (Wheeler, 1999). Based on this information and the discussion in the previous section, AECOM judges that seismic stability is not required per TCEQ screening guidelines. Kyle fault and San Marcos springs fault in close proximity to the site.

Seismic Loading

Based on the foregoing, dynamic slope stability (seismic loading) does not need to be analyzed. Therefore, pseudostatic stability and/or post-earthquake stability cases were not performed herein.

Given the relatively low seismicity of the site and distance from mapped faults and faults systems, and the relative stiffness and cohesive nature of site soils, the risks of seismic hazards such as liquefaction, cyclic strain softening, and fault-rupture are considered to be negligible. Therefore, earthquake-induced strength loss is not expected and was not considered in the design shear strength values.

ANALYSIS SECTION

Geologic Stratigraphy

Site stratigraphy is described in detail in the Geologic Investigation Report and Soil Mechanic Report, and are summarized briefly as follows:

- Embankment Fill: This material was primarily classified as very stiff to hard lean to fat clay (CL, CH) with some intervals of lean clay (CL) and some sandy intervals (3 to 28% sand). While the as-built drawings indicate embankment zoning with distinct core and shell zones, borings and laboratory testing indicate the shell and core zones are comprised by similar materials. This unit is expected to experience slow drainage due to high fines and clay contents.

- Downstream Fill: The suspected fill material was preliminary classified as medium stiff to hard lean to fat clay (CL, CH). The fill designation was due to a somewhat lower consistency of this material. However, the visual similarity of the fill to overburden material suggests that this unit is likely reworked residuum/alluvium. This material was assumed to exhibit slow drainage due to clayey fines.

- Alluvium: This unit consisted of dark brown, medium stiff to hard fat clays (CH) with minor proportion of sand and/or gravel ranging from 0 to 20%. This material was assumed to exhibit slow drainage due to clayey fines.

- Residuum: This unit consisted of light gray to tan, medium stiff to hard lean to fat clays (CL, CH) with some clayey sand (SC) and silty clay (CL-ML) layers. Characterization of this material in the GIR and SMR was subdivided into a calacareous and friable Low Plasticity Residuum (LPR) consisting mostly of silty CL and some CH with less frequent SC and CL-ML intervals, and a Medium Plasticity Residuum (MPR) consisting of consisting of CH with some CL intervals. For engineering analysis, this material was generally considered as a single “Residuum”. It was assumed to exhibit slow drainage due to clayey fines.

- Bedrock: This unit consisted of extremely weak to weak calcareous shale with occasional chalky marl layers. The weathering ranged from moderately to highly weathered. . This material was judged to exhibit slow drainage

Proposed fill materials include fine and coarse filter/drain fill, RCC, and new embankment fill. These materials are described below.

- Drain Fill: This material will consist of a compacted fine filter (modified ASTM C-33 Fine Aggregate) and a coarse filter (ASTM C-33 No. 89 aggregate). These materials will be placed under the RCC spillway and around the new and existing PSW conduits. These materials are free-draining.

- RCC: This material will consist of low-slump concrete compacted in lifts that will be used to construct the RCC spillway. The material was treated as relatively low permeability with high frictional resistance.

- New Embankment Fill: The proposed embankment fill will be constructed of moisture-conditioned and recompacted clayey soils from on-site and/or imported borrow sources. Selective placement of imported low-plasticity (PI=7-15) lean clay (CL) or clayey sand (SC) is planned for under and adjacent to the RCC spillway to reduce swelling potential. The exterior zones of planned embankment fill (crest re-shaping and embankment reconstruction at new PSW) will be low-plasticity clay/clayey sand (CL, SC) with LL<50 and PI=10-30. Interior zones of planned embankment fill for reconstruction at new PSW will consist of medium- to high-plasticity clays (CL, CH) with LL<60 and PI=10-35. Considering the clayey composition of proposed embankment fill, this material was considered to exhibit both undrained and drained strength behavior.

Groundwater

Groundwater conditions and corresponding pore-water pressures were based on the seepage analysis results. Depending on the analysis case either both phreatic surface and pore-water pressure or only phreatic surface were used in the slope stability analysis (see Seepage Analysis Calculation Package) and TR-210-60 loading conditions for slope stability analysis described in the following sections herein.

Analysis Cross-Section Geometry

As discussed in the “Seepage Analysis Calculation Package”, the selected analysis cross-sections are:

1. STA. 23+50: This selected analysis cross-section is is located at approximately the maximum dam height and original creek centerline alignment. A hybrid of the topographic conditions at STA. 23+50 and the existing PSW outlet channel at STA. 24+30 was used to evaluate existing conditions and the proposed embankment crest modification. This section geometry was also used to model the nearby proposed embankment reconstruction following open-cut construction of the new PSW conduit (STA. 25+00). The downstream slope was modeled as approximately 2.8H:1V (approximate average of as-built 2.5H:1V and 2020 topographic survey of 3H:1V) to better match existing and proposed conditions, and the upstream slope was conservatively modeled as 2.5H:1V per as-builts (although 3H:1V is indicated by topo survey). The existing upstream and downstream berms associated with the PSW were included in the model.

2. STA 18+50: This selected analysis cross-section corresponds to the right side of the proposed RCC overtopping spillway (i.e., the tallest portion of the embankment near the RCC spillway). The pre-construction ground surface at the analysis section was El. 647.5, the bottom of the cutoff trench is El. 640 (see Figure 1). This section was used to analyze existing conditions, the proposed embankment crest modification on right side of the RCC spillway, and the proposed RCC spillway section. The upstream and downstream slopes were conservatively modeled as 2.5H:1V per

the as-builts, although 2020 topo survey indicates approximately 2.7H:1V and 3H:1V slopes for the downstream and upstream slopes, respectively.

The cross-section geometry, including internal drainage features and estimated phreatic surfaces for slope stability analysis, are documented in the “Seepage Analysis Calculation Package”.

Existing Structures and External Loading

No existing structures are present that will have an appreciable effect on slope stability. The dam is not subject to significant external dead loads or live loads.

Proposed Structures and External Loading

For the proposed Embankment Crest Modification Sections, no new structures are planned, and no significant external loads are anticipated that would affect embankment slope stability.

For the proposed RCC Overtopping Spillway Section, associated structures that will be founded on or near the dam embankment include the crest structure (RCC slab and RCC walls), chute structure (RCC stepped chute slab and RCC walls), and stilling basin (RCC slab and RCC walls). In all cases, the spillway invert will be excavated below the existing ground surface, and gravity RCC retaining walls will be provided along the each side of the spillway to retain adjacent embankment fill and backfill. Plan and profile drawings of the spillway can be viewed on the 90% drawings.

- Crest Structure. The crest structure is located on top of the existing embankment. It consists of a 3-foot thick RCC mat foundation slab serving as the flow weir, and 8-ft tall retraining walls along both outside edges (parallel to flow direction). Design drawings show retaining wall footings have an effective 11.33-ft wide footing base. Based on experience with similar projects, we have assumed an estimated maximum gross pressure of 1,500 psf due to overturning eccentricity forces. The gross footing pressure on the remaining interior portion of the spillway is about 450 psf during the dry condition (self-weight only) and an estimated 500 psf during flood conditions (assuming nominal flow depth of ~1 foot).

- Chute Structure. The chute structure is located on the downstream slope of the dam. It consists of 3-ft thick RCC steps (vertical dimension) in the interior portion, and about 10-ft tall training walls along both outside edges (parallel to flow direction) to form the spillway chute. Design drawings show retaining wall footings have an effective 11.33-ft wide footing base. Based on experience with similar projects, we have assumed an estimated maximum gross pressure of 1,800 psf due to overturning eccentricity forces. The gross footing pressure on the remaining interior portion of the spillway is about 450 psf during the dry condition (self-weight only) and an estimated 500 psf during flood conditions (assuming nominal flow depth of ~1 foot).

- Stilling Basin. The stilling basin structure is located near the downstream toe of the dam. It consists of a 3-ft thick RCC slab with baffle blocks in the interior portion, and 15-ft tall retaining walls along both outside edges (parallel to the flow direction). Design drawings show retaining wall footings have an effective 11.33-ft wide footing base. Based on experience with similar projects, we have assumed an estimated maximum gross pressure of 2,500 psf due to overturning forces. The gross footing pressure on the remaining interior portion of the spillway is about 450 psf during the dry condition (self-weight only) and an estimated 500 psf during flood conditions (assuming nominal flow depth of ~1 foot).

Based on the above discussion, the structural loading imparted by the exterior RCC training walls is much higher than the interior RCC slab. When considering the weighted average of bearing stresses over the full spillway width (transverse to flow direction), the average bearing pressure is substantially lower than the estimated maximum bearing pressure at the toe of the training walls. A summary of bearing stresses, and calculated weighted averages, are provided below in Table 3.

For slope stability modeling purposes, the maximum allowable external structure loadings from the RCC Spillway used in slope stability calculations were iteratively estimated as the maximum load that could satisfy the minimum required factor of safety of 1.5 for the steady state analysis case. The loading was modeled as a uniform vertical surcharge pressure applied to the upper portion of the embankment at the proposed bearing elevation of the crest structure foundation. Note that although localized higher bearing pressures will occur at the toe of each wall due to RCC self-weight and overturning eccentricity loads, the weighted-average loads discussed above are believed to provide a more accurate representation of slope stability performance on top of the embankment versus the use of maximum bearing values which occur over a relatively small area. This approach also accommodates the 2-D limitations of the limit-equilibrium modeling software. The localized higher bearing pressures at the wall toes were evaluated on the basis of conventional bearing capacity (see “Bearing Capacity Calculation Package”) and settlement analysis (see “Foundation Settlement Calculation Package”) to confirm acceptable performance of the subgrade soils from a shear strength and deformation perspective. Further discussion regarding the modeling of external loads is provided in the “Analysis” section of this report.

Table 3. Summary of Spillway Structure Dimensions and Static Bearing Pressures

Location	Spillway Structure Widths (feet)			Static External Bearing Pressure by Location (psf)					
	Wall Footings(1)	Chute Interior(1)	Total Width(1)	Wall Heel	Wall Toe	Spillway Interior (Dry)	Spillway Interior (Flowing)	**Weighted Average (Dry)**	**Weighted Average (Flowing)**
Crest Structure	11.33 (each)	190	212.7	TBD	1,500(2)	450	500(2)	**562**	**606**
Chute Structure	11.33 (each)	190	212.7	TBD	1,800(2)	450	500(2)	**594**	**638**
Stilling Basin	11.33 (each)	190	212.7	TBD	2,500(2)	450	500(2)	**668**	**713**

Notes:
1- Perpendicular to flow direction
2- Estimated

MATERIAL PARAMETERS

Input parameters for slope stability analysis were taken from the "Material Properties Calculation Package" and were based on the laboratory test results, in-situ field testing, correlations with index test results, and engineering judgment for each of the proposed loading cases and analysis conditions. Input parameters include

- Total unit weight, γ_t;
- Unconsolidated-undrained (UU) shear strength envelope (also known as Undrained Shear Strength, S_u);
- Consolidated-drained (CD) shear strength envelope ("effective stress envelope"); and
- Consolidated-undrained (CU) shear strength envelope ("total stress envelope").

Initial steady-state seepage slope stability analyses were performed for the existing dam section using trial values to calibrate the model to historic dam performance, with consideration of previous analyses and original design criteria. Once results were judged to be reasonable, the parameters were then employed in the analysis of proposed conditions. A summary of the design parameters selected for the final design of the various loading conditions is provided in Table 4.

Table 4. Selected Unit Weights and Design Shear Strength Parameters

Material	**USCS**	**Total Unit Weight (pcf)[1]**	**UU Strengths**	**Effective Stress (CD Envelope)**		**Total Stress (CU Envelope)**	
			S_u (psf)[2]	**c' (psf)**	**φ ' (deg)**	**c_u (psf)**	**$φ_u$ (deg)**
Existing Embankment Fill – Zone I (Core)	CL, CH	125	1,200	100	23	400	15
Existing Embankment Fill – Zone II (Shell)	CL, CH	125	1,200	100	23	400	15
Proposed Embankment Fill	CL, CH	125	1,200	100	23	400	15
Alluvium	CH	123	1,500	100	23	400	15
Residuum	CL, CH	126	1,500	100	23	400	15
Shale	CH	130	3,000	300	23	400	15
Filter Drain	SP, GP	120	---	0	30	---	---
Rock Riprap	---	110	---	0	35	---	---
RCC	---	145	---	100	45	---	---

Notes:

1. Moist unit weight for materials above phreatic surface was assumed to be equal to saturated unit weights which will result in more conservative analysis.
2. Based on as-built information and/or AECOM investigation data

For several of the required NRCS loading conditions for slope stability analyses, the use of bi-linear composite strength envelopes may be required. For both the Flood Surcharge and NRCS Rapid Drawdown analysis cases, slow-draining material zones are assigned a bi-linear strength envelope corresponding to the lower of the CD and CU strength envelopes. The bilinear envelope is defined using the normal stress at which the CD and CU envelopes intersect on the plot of shear stress vs. normal stress. Free-draining soil zones are modeled with CD strengths only. The bi-linear envelopes are defined in Table 5 below and shown graphically in Attachment 1. Further description of analysis shear strengths for Rapid Drawdown is provided below:

- Rapid Drawdown (NRCS Procedure): Rapid drawdown analyses were conducted according to the NRCS procedure using a 1-stage analysis. In that analysis, slow-draining saturated material zones are assigned a bi-linear strength envelope corresponding to the lower of the CU and CD strength envelopes per TR-210-60 guidance. Free-draining materials, and materials above the phreatic surface, are assigned CD strength parameters.

- Rapid Drawdown (Alternate 3-Stage Procedure): Rapid drawdown analysis was also performed according to the 3-stage procedure proposed by Duncan, Wright and Wong (1990) and presented in USACE EM 1110-2-1902. Duncan, Wright and Wong (1990) have shown that the three-stage procedure reasonably predicts slope instability for several case histories, and that one-step and two-step procedures similar to the NRCS method are usually conservative and can over-predict slope instability. The 3-stage procedure was performed to provide improved confidence in the results of the NRCS method. In this procedure, the effective stress strength parameters are used in the first stage of stability computations. For second stage computations, the undrained shear strengths are used and are based on effective consolidation pressure estimated from the first stage analysis. The undrained strength relationship from the CU' laboratory triaxial tests is given by the major and minor principal stresses at consolidation being equal (i.e. for K_c=1), but the undrained strength used in the analysis is determined by interpolation between this relationship and the higher effective stress envelope (K_c=$K_{failure}$, i.e. the principal stress ratio at failure). The interpolated strength is selected based on the effective normal stress and the K_c ratio computed at the base of the slice during first stage computations. Thus, at the base of a slice where K_c>1.0 the undrained strength will be higher than if K_c is assumed to equal to 1.0 as in the NRCS two step procedure. For materials having a permeability greater than about 1E-03 cm/sec the drained strength is used, rather than the undrained strength. A third stage calculation is performed to compare the undrained strengths to the drained strength at the base of each slice. If the drained strength is lower it is used in the stability calculation. It is noted that the NRCS bi-linear envelopes are not used in this analysis; interpolation is automatically performed by the program using the CU and CD envelopes.

Pore water pressure assumptions used in the various loading cases are described in the "Analysis" section.

Table 5. NRCS Bi-Linear Shear Strength Envelopes for Saturated Materials (Below Phreatic Surface)

Material	**Initial Envelope**		**Bi-Linear Envelop for Rapid Drawdown**		**Bi-Linear Envelope for Flood Surcharge**	
	c (psf)	**φ_1 (deg)**	**σ_n (psf)**	**$\varphi_{2\text{-RDD}}$ (deg)**	**σ_n (psf)**	**$\varphi_{2\text{-FBH}}$ (deg)**
Existing Embankment Fill – Zone I (Core)	100	23	1,917	15	1,917	15
Existing Embankment Fill – Zone II (Shell)	100	23	1,917	15	1,917	15
Proposed Embankment Fill	100	23	1,917	15	1,917	15
Alluvium	100	23	1,917	15	1,917	15
Residuum	100	23	1,917	15	1,917	15
Shale	300	23	639	15	639	15
Filter Drain	0	33	---	---	---	---
Rock Riprap	0	35	---	---	---	---
RCC	100	45	---	---	---	---

SLOPE STABILITY ANALYSIS

Methodology

Slope stability analyses were conducted using the software SLOPE/W by Geo-Slope International (Geostudio 2020, Version 10.2.2.20559). The limit-equilibrium program employs an iterative search algorithm to locate the critical shear surface for each design condition and the corresponding factor of safety. Spencer's Method was used because it satisfies both force and moment equilibrium.

Pore Water Pressures

The analyzed piezometric surface is unique to each design condition. Based on the understanding of proposed construction sequencing and long-term proposed improvements, the design piezometric levels used for slope stability are summarized in Table 6 (next page). Some additional discussion is provided as follows:

- Existing Conditions (Calibration): As discussed in the Seepage Analysis, a steady-state analysis of existing conditions using known groundwater levels (from borings and piezometers) and estimated reservoir level was performed to calibrate the seepage material properties to reflect observed conditions. Reservoir pool level of El. 640 was used, which corresponded to approximate pool level readings on 03/26/2020 when piezometer readings were collected.

- Steady-State Seepage: A phreatic surface associated with principal spillway (PSW) crest elevation El. 645.5 (i.e., highest normal pool) was used in these analyses.

- End of Construction: Limited reservoir drawdown is anticipated to take place during construction. Conservatively, the phreatic surface associated with the existing normal pool conditions was used for both proposed embankment raise and overtopping spillways sections. For end of construction cases, a tension crack line is considered passing through clayey materials in order to eliminate negative effective normal stresses on the shear surfaces. The required depth of this line is determined by trial and error.

- Flood Surcharge: The current 2019 version of the TR-210-60 is somewhat vague regarding pore-water pressures to be used for this case, but states that potential seepage effects associated with embankment material properties and defects resulting from a phreatic surface developed from the freeboard hydrograph (FBH) level should be considered (Note that TCEQ 75% Probable Maximum Flood (PMF) is the controlling hydrologic event for the design of this project, and thus the 75% PMF pool level has been adopted in lieu of FBH for geotechnical analysis). Additionally, the TR-210-60 states that a potential increase in pore pressures in the normally saturated portion of the embankment resulting from the FBH (i.e., 75% PMF for this project) level should be evaluated. Consequently, AECOM adopted an approach similar to the steady-state seepage case in the prior (2005) version of the TR-210-60 modified for the flood surcharge condition. For flood surcharge conditions, first, the embankment and foundation materials were divided into saturated and unsaturated zones based on an estimated steady-state phreatic surface corresponding to the proposed normal pool level (El. 645.5). In this modified approach, saturated materials were subjected to pore pressures associated with a hypothetical steady-state phreatic surface developed at the proposed 75% PMF pool level (El. 660.8) to simulate uplift pressures associated with the highest possible flood pool level. The 75% PMF phreatic surface was not applied to unsaturated material zones (i.e. above the normal pool phreatic surface), due to the unlikelihood that an elevated phreatic surface could develop over the relatively short duration of a flood event. This approach is conservative, because while desiccated near-surface soils on the upstream slope may become saturated during such an event, the limited duration of elevated pool level is unlikely to produce a wetting front that penetrates a significant distance into the embankment. This is particularly likely given that this embankment dam consists of compacted, moderate- to high-plasticity clay with modest slopes and no evident embankment cracking. Consequently, there is expected to be no appreciable effect on embankment saturation associated with the 75% PMF flood pool.

- Rapid Drawdown (NRCS procedure): The current NRCS TR-210-60 requires rapid drawdown be assessed from the highest normal pool level to the lowest gated or ungated outlet. For this site, the highest normal pool will be the proposed PSW inlet riser crest elevation (El. 645.5), and the lowest outlet is the proposed PSW conduit with invert El. 632.2 at the inlet riser. Given the limited amount of drawdown (e.g. 13.3 feet), a more conservative case was analyzed to check rapid drawdown conditions associated with a reservoir drawdown from the proposed ASW pool level (El. 659.8) to the normal pool level (El. 645.5). This 1-stage analysis procedure considers a single piezometric line developed at the initial pre-drawdown steady-state analysis, but modified to instantaneously lower the reservoir to the post-drawdown level; this removes the beneficial weight of impounded water above the post-drawdown level, while maintaining the elevated pre-drawdown phreatic surface within the embankment (i.e., piezometric line is coincident with upstream slope ground surface between the pre-drawdown and post-drawdown pool levels).

- Rapid Drawdown (Alternate 3-Stage Procedure): This procedure follows the 3-stage analysis method (Duncan, Wright, and Wong, 1990) and incorporates 2 piezometric lines: pre-drawdown and post-drawdown. The pre-drawdown line is the steady-state phreatic surface developed at the pre-drawdown reservoir pool level. The post-drawdown line is the steady-state phreatic surface developed at the post-drawdown reservoir pool level. The pre-drawdown surface is used to calculate pore pressures and effective consolidation stresses, which are used to estimate undrained shear strengths used in stability calculations. Similar to the NRCS procedure, two separate drawdown analyses were conducted: 1) drawdown from the PSW inlet riser crest elevation to the lowest gated/ungated outlet; and 2) drawdown from the ASW crest to the PSW inlet riser crest.

Table 6. Summary of Modeled Water Levels for Seepage Analyses

Analysis Case	Upstream Reservoir Level	Phreatic Surface	Downstream Channel
End of Construction	Existing PSW (El. 645.5)	Existing PSW phreatic surface from seepage analysis. Assumes reservoir will not be drawn down during construction.	El. 618 (STA 23+50) El. 623 (STA 18+50) (estimated GW)
Steady-State Seepage	Proposed PSW (El. 645.5)	Proposed PSW phreatic surface. No simulated uplift.	El. 618 (STA 23+50) El. 623 (STA 18+50) (estimated GW)
Flood Surcharge	Proposed PSW (El. 764.5)	Proposed PSW phreatic surface from seepage analysis to delineate moist and saturated embankment zones. A simulated uplift pressure is applied to saturated zones, accomplished by a phreatic surface originating from a reservoir pool at proposed 75% PMF level (El. 660.8).	El. 618 (STA 23+50) El. 623 (STA 18+50) (estimated GW)
Rapid Drawdown (NRCS Method)	Drawdown from PSW to Lowest Outlet (El. 645.5 to 632.2)	Proposed PSW phreatic surface within the embankment, phreatic surface coincident with ground surface on upstream side of embankment, and pool level at lowest outlet.	El. 618 (STA 23+50) El. 623 (STA 18+50) (estimated GW)
	Drawdown from ASW to PSW (El. 659.8 to 645.5)	Proposed ASW phreatic surface within the embankment, phreatic surface coincident with ground surface on upstream side of embankment, and pool level at PSW.	El. 618 (STA 23+50) El. 623 (STA 18+50) (estimated GW)
Rapid Drawdown (3-stage Method)	Drawdown from PSW to Lowest Outlet (El. 645.5 to 632.2)	Stage 1 equal to the proposed PSW phreatic surface, and Stage 2 equal to the phreatic surface developed from pool level at lowest outlet.	n/a
	Drawdown from ASW to PSW (El. 659.8 to 645.5)	Stage 1 equal to the proposed ASW phreatic surface, and Stage 2 equal to the proposed PSW phreatic surface.	n/a

Existing Conditions Analysis

Steady-state seepage was analyzed for existing conditions according to procedures described previously. The purpose was to calibrate the input stability parameters to observed dam performance (i.e., lack of known slope instability) considering the results of field and laboratory data, construction records, and original design criteria. Once calculated factors of safety were judged to be reasonable and strength parameters were judged to be consistent with the field and laboratory, values were then used for stability analysis for proposed conditions.

Proposed Conditions Analysis and Structure Loading

A suite of stability analyses was performed for both the proposed embankment raise section and overtopping spillway section to check that the calculated factors of safety were acceptable.

For the overtopping spillway section, the external structure loads were modeled as follows:

- Crest Structure: The foundation bearing pressure imparted by the crest structure at the top of the embankment is modeled as a uniform surcharge pressure acting over the entire foundation width. The foundation was not modeled as a material layer for simplicity, since the gross bearing pressures provided by the structural engineer include the self-weight of the foundation. This approach was also considered to be conservative because it neglects the strength contribution of the concrete at the top of the slip surface, which would likely require modeling a tension crack. Hence, the top of the embankment for this section is modeled at El. 655.7 (bottom of foundation slab). As described previously, the loads used in the slope stability analyses is a 1,530 psf uniform surcharge based on iteration.

- Chute Structure: The RCC stepped spillway chute is modeled as a material layer. Firstly, it was judged too conservative to neglect the strength contribution of this layer, and the nominal cohesive strength of the RCC layer also helps to remove inconsequential infinite-slope failure surfaces from the model output. Secondly, for normal pool conditions, there will be no water flow in the RCC spillway chute, resulting in typical long-term loads restricted to the self-weight of the 3-ft thick RCC slab. Initial stability trials were performed considering the additional pressure imparted during spillway flow events and higher stresses at retaining walls, but it was found that the increase in effective stress on the slope increased the factor of safety, and thus was neglected in the final analyses to be conservative.

- Stilling Basin: The stilling basin foundation slab is also modeled as a material layer, for similar reasons as the RCC stepped chute. External foundation loads associated with this structure were conservatively ignored since these loads would serve to increase resisting forces on the critical slip surface. However, ponded water generated by the seepage model output was allowed to occur in the stilling basin for slope stability modeling since the estimated groundwater level is above the bottom of the stilling basin.

SLOPE STABILITY RESULTS

General

Graphical model output for the analyses described in this calculation is provided in **Attachment 2**. A summary and discussion of the results is provided in the following sections.

Existing Conditions

The results of the slope stability analysis for the analyzed existing conditions are summarized in Table 7. Stability results indicate that minimum factors of safety for steady-state conditions are met for both cross-sections.

Table 7. Slope Stability Results for Existing Conditions

Station	Loading Case	Calculated FOS[1]		Minimum FOS
		Downstream Slope	Upstream Slope	
18+50	Steady-State Seepage (PSW pool)	1.8	---	1.5
23+50	Steady-State Seepage (PSW pool)	1.5	---	1.5

Proposed Embankment Crest Modification Sections

The results of the slope stability analysis for the proposeds embankment crest modifications are summarized in Table 8. Stability results indicate that minimum factors of safety are met for required analysis conditions at both cross-sections, except that for STA 23+50 the NRCS rapid drawdown condition gives a factor of safety of 1.1 which lower than the minimum value (1.2). As noted previously, the NRCS 1-stage procedure is conservative, and the more common alternate 3-stage rapid drawdown procedure yields factors of safety ranging from 1.3 to 1.5 which exceed the minimum value. Further, it is noted that the actual upstream slope angle based on 2020 survey (3H:1V) is flatter than the analyzed 2.5H:1V slope based on as-built drawings. Consequently, the embankment is anticipated to perform adequately during rapid drawdown conditions and no mitigation measures or modifications are recommended to improve rapid drawdown stability.

Table 8. Slope Stability Results for Proposed Embankment Crest Modification Section

Station	Loading Case	Calculated FOS[1]		Minimum FOS
		Downstream Slope	Upstream Slope	
18+50 (Embank. Crest Mod.)	End of Construction (shallow) (2)	5.3	5.6	1.3
	End of Construction (deep)	4.2	4.3	1.4
	Steady-State Seepage (PSW pool)	1.7	---	1.5
	Rapid Drawdown – ASW to PSW (NRCS Method)	---	1.2	1.2
	Rapid Drawdown – ASW to PSW (3-Stage Method)	---	1.9	1.2
	Rapid Drawdown – PSW to Lowest Gated Outlet (NRCS Method)	---	1.9	1.2
	Rapid Drawdown – PSW to Lowest Gated Outlet (3-Stage Method)	---	1.9	1.2
	Flood Surcharge (75% PMF)	1.7	---	1.4
23+50 (Embank. Crest Mod.)	End of Construction (shallow) (2)	3.2	3.1	1.3
	End of Construction (deep)	2.5	3.0	1.4
	Steady-State Seepage (PSW pool)	1.5	---	1.5
	Rapid Drawdown – ASW to PSW (NRCS Method)	---	1.1*	1.2
	Rapid Drawdown – ASW to PSW (3-Stage Method)	---	1.5	1.2
	Rapid Drawdown – PSW to Lowest Gated Outlet (NRCS Method)	---	1.1*	1.2
	Rapid Drawdown – PSW to Lowest Gated Outlet (3-Stage Method)	---	1.4	1.2
	Flood Surcharge (75% PMF)	1.4	---	1.4
23+50 (Embank. Reconstruct at New PSW)	End of Construction (shallow) (2)	3.2	2.9	1.3
	End of Construction (deep)	2.6	2.8	1.4
	Steady-State Seepage (PSW pool)	1.6	---	1.5
	Rapid Drawdown – ASW to PSW (NRCS Method)	---	1.1*	1.2
	Rapid Drawdown – ASW to PSW (3-Stage Method)	---	1.4	1.2
	Rapid Drawdown – PSW to Lowest Gated Outlet (NRCS Method)	---	1.1*	1.2
	Rapid Drawdown – PSW to Lowest Gated Outlet (3-Stage Method)	---	1.3	1.2
	Flood Surcharge (75% PMF)	1.4	---	1.4

Notes:

1. The reported FOS for each loading case corresponds to the lowest value obtained from various slip surface search methods.
2. The slip surface search boundaries were limited to produce shallow slope failure confined to the embankment.
3. * - See text discussion in “Slope Stability Results” associated with each cross-section.

Proposed RCC Overtopping Spillway

The slope stability results for the proposed RCC overtopping spillway analysis section are summarized in Table 9. Stability results indicate that minimum factors of safety are met for required analysis conditions for the proposed overtopping spillway section.

The RCC spillway crest structure applied bearing pressure was increased incrementally to reach a minimum FOS=1.5 for the steady state stability case. The required minimum factor of safety for this case was satisfied for the pressure up to

1,530 psf, which is significantly higher than the weighted average bearing pressure across the spillway of ~700 psf and slightly higher than the localized maximum bearing pressure at the toe of training wall foundations estimated as about 1,500 psf. Therefore, all the other slope stability cases were also analyzed for the 1,530 psf pressure.

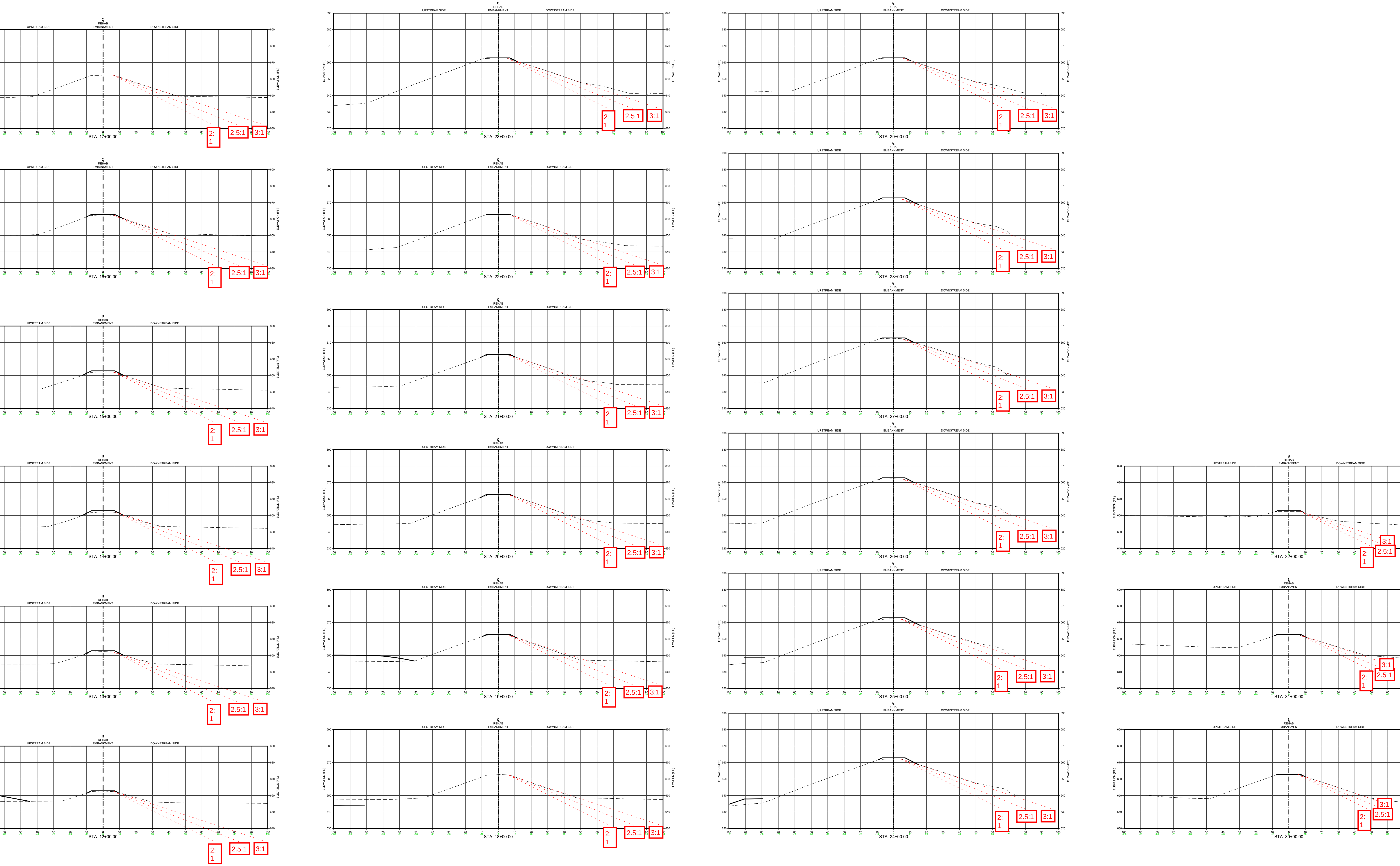
For the 3-stage rapid drawdown method, a minimum factor of safety of 1.6 was achieved using the maximum concentrated bearing pressure of 1,530 psf, well in excess of the minimum 1.2. For the NRCS rapid drawdown method, a factor of safety of at least 1.2 was achieved for bearing pressures up to 1,530 psf. Consequently, both analysis methods indicate the slope should be stable for rapid drawdown conditions. Each of the slope stability analysis cases satisfy the minimum factor of safety for the conservative pressure of 1,530 psf which is more than the weighted average and maximum pressure that was estimated for the proposed structure.

Note that generalized bearing capacity calculations and settlement analyses, prepared under separate cover, also govern the design footing pressures for the spillway structures.

Table 9. Slope Stability Results for Proposed Overtopping Spillway Section

Loading Case	**Avg. Crest Structure Bearing Pressure, q_{max} (psf)**	**Calculated FOS**		**Minimum FOS**
		Downstream Slope	**Upstream Slope**	
End of Construction (shallow)	1,530	1.9	3.7	1.3
End of Construction (deep)	1,530	2.5	3.2	1.4
Steady-State Seepage (PSW pool)	1,530	1.5	---	1.5
Rapid Drawdown- ASW to PSW (NRCS Method)	1,530	---	1.2	1.2
Rapid Drawdown-ASW to PSW (3-Stage Method)	1,530	---	1.6	1.2
Rapid Drawdown-PSW to Lowest Gated Outlet (NRCS Method)	1,530	---	1.7	1.2
Rapid Drawdown-PSW to Lowest Gated Outlet (3-Stage Method)	1,530	---	1.7	1.2
Flood Surcharge (75% PMF)	1,530	1.5	---	1.4

ATTACHMENT 1
EMBANKMENT CROSS-SECTIONS


UPSTREAM SIDE
℄ REHAB EMBANKMENT
DOWNSTREAM SIDE
ELEVATION (FT.)
STA. 17+00.00
STA. 16+00.00
STA. 15+00.00
STA. 14+00.00
STA. 13+00.00
STA. 12+00.00
STA. 23+00.00
STA. 22+00.00
STA. 21+00.00
STA. 20+00.00
STA. 19+00.00
STA. 18+00.00
STA. 29+00.00
STA. 28+00.00
STA. 27+00.00
STA. 26+00.00
STA. 25+00.00
STA. 24+00.00
STA. 32+00.00
STA. 31+00.00
STA. 30+00.00
2:1
2.5:1
3:1

ATTACHMENT 2

Bi-Linear Strength Envelopes

Non-Linear Envelope Calculation for SLOPE/W:
Input for Upstream Rapid Drawdown (RDD) and Flood Surcharge (FBH) Conditions

Embankment

Effective Stress ϕ'	23.0	deg
Effective Stress c'	100	psf
Total Stress ϕ	15.0	deg
Total Stress c	400	psf

Bilinear for RDD/FBH	
Cohesion (psf)	100
ϕ-1 (deg)	23.0
ϕ-2 (deg)	15.0
σn @ intersect (psf)	1917

Alluvium/Residuum

Effective Stress ϕ'	23.0	deg
Effective Stress c'	100	psf
Total Stress ϕ	15.0	deg
Total Stress c	400	psf

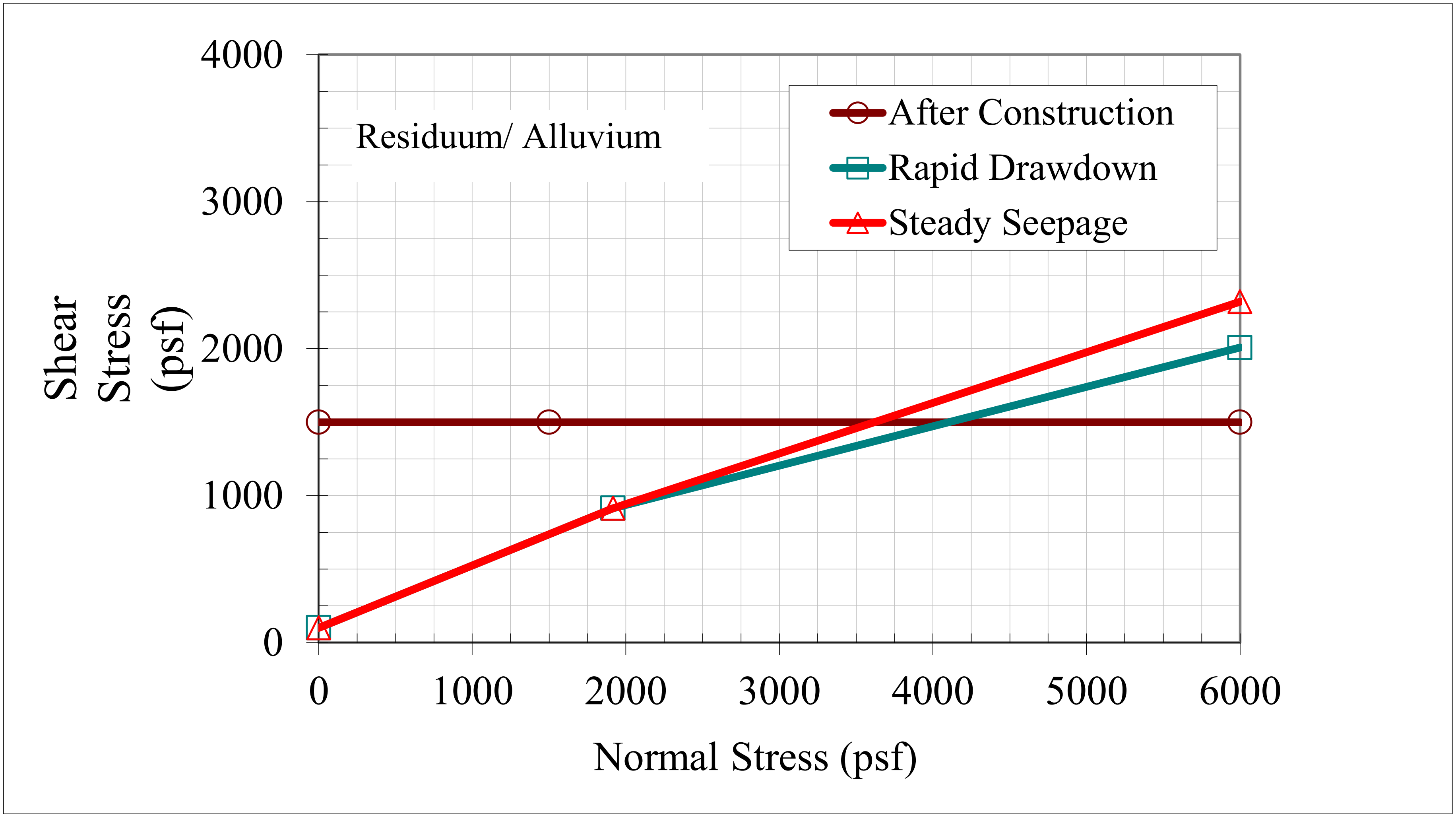
Bilinear for RDD/FBH	
Cohesion (psf)	100
ϕ-1 (deg)	23.0
ϕ-2 (deg)	15.0
σn @ intersect (psf)	1917

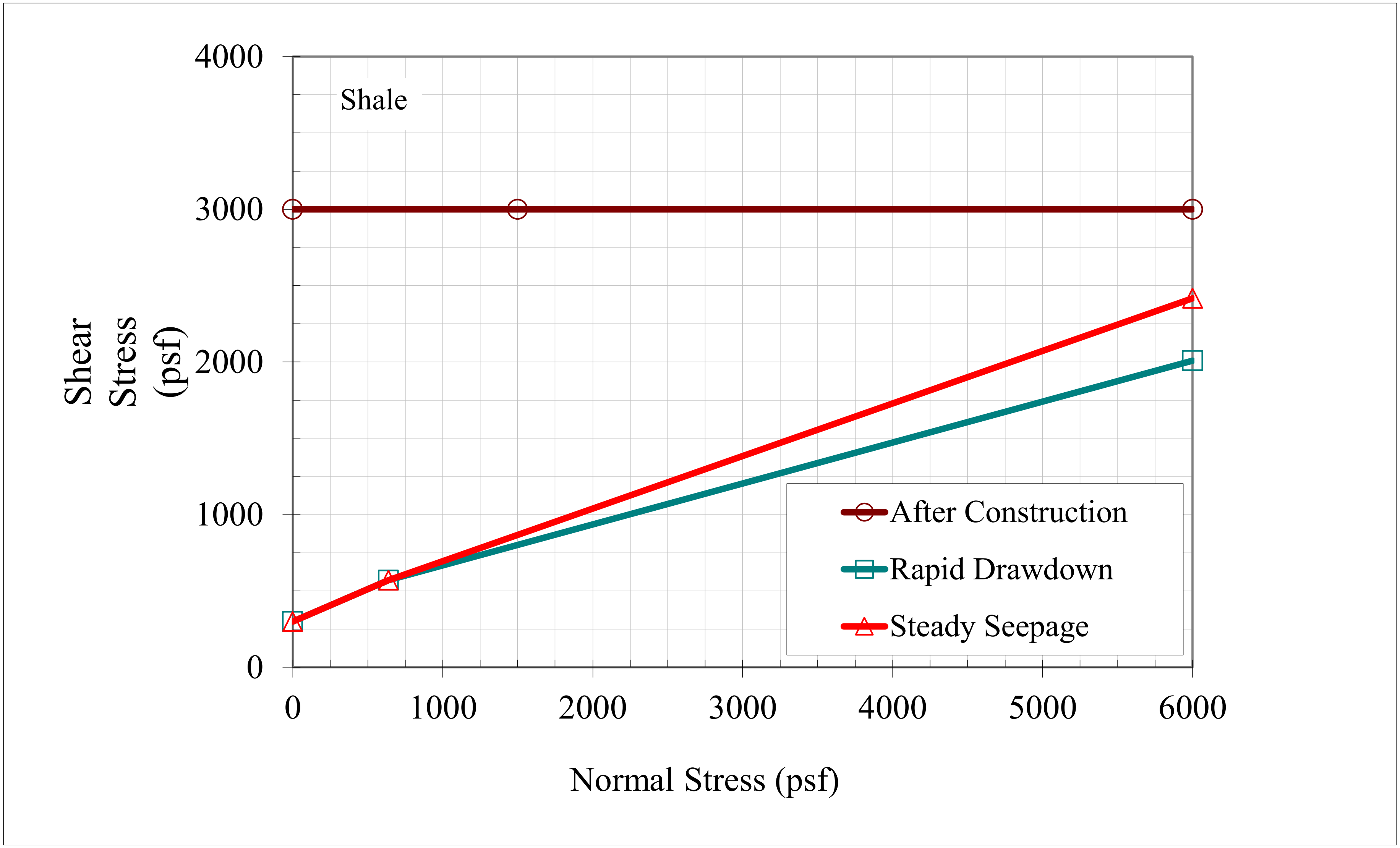
Shale

Effective Stress ϕ'	23.0	deg
Effective Stress c'	300	psf
Total Stress ϕ	15.0	deg
Total Stress c	400	psf

Bilinear for RDD/FBH	
Cohesion (psf)	300
ϕ-1 (deg)	23.0
ϕ-2 (deg)	15.0
σn @ intersect (psf)	639

Embankment
After Construction
Rapid Drawdown
Steady Seepage
Shear Stress (psf)
Normal Stress (psf)
0
1000
2000
3000
4000
5000
6000

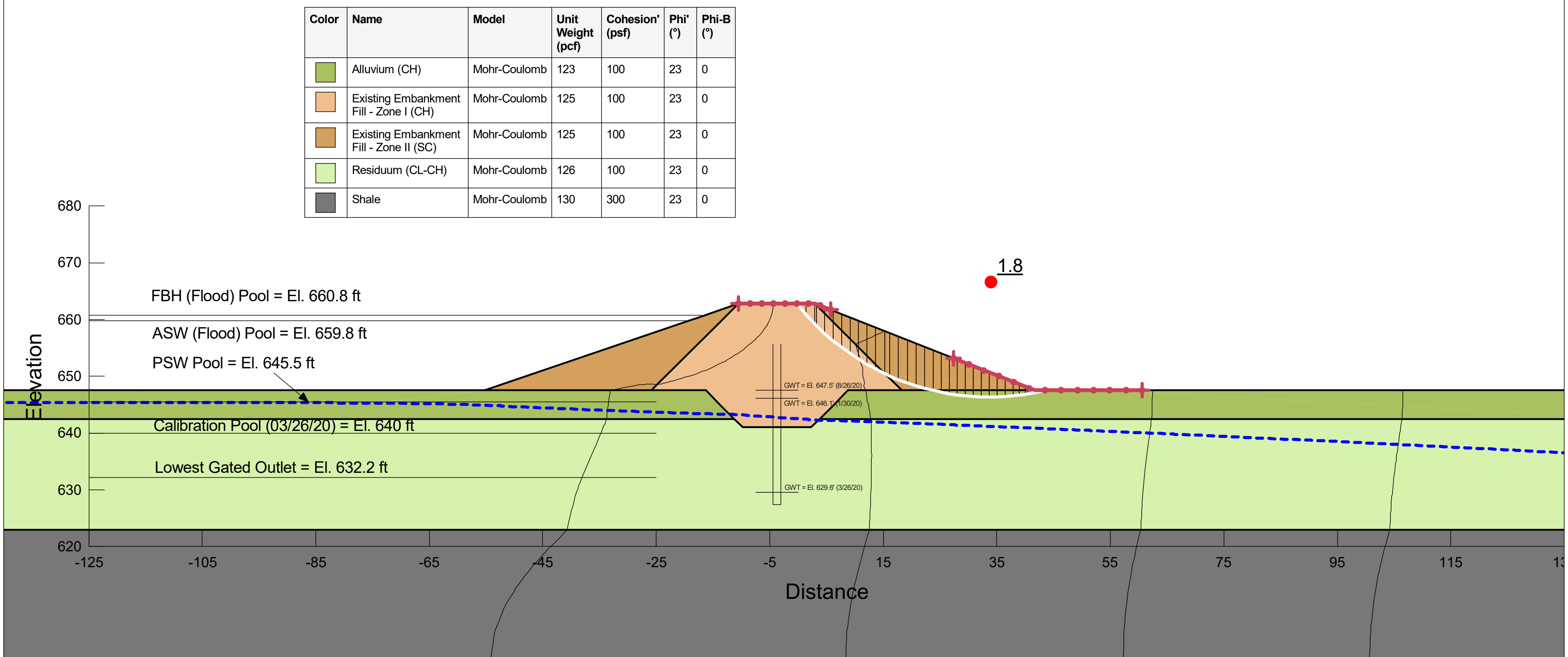

Residuum/ Alluvium
After Construction
Rapid Drawdown
Steady Seepage
Shear Stress (psf)
Normal Stress (psf)
0
1000
2000
3000
4000
5000
6000



Shale
Shear Stress (psf)
Normal Stress (psf)
4000
3000
2000
1000
0
0
1000
2000
3000
4000
5000
6000
After Construction
Rapid Drawdown
Steady Seepage

ATTACHMENT 3
SLOPE/W Model Output

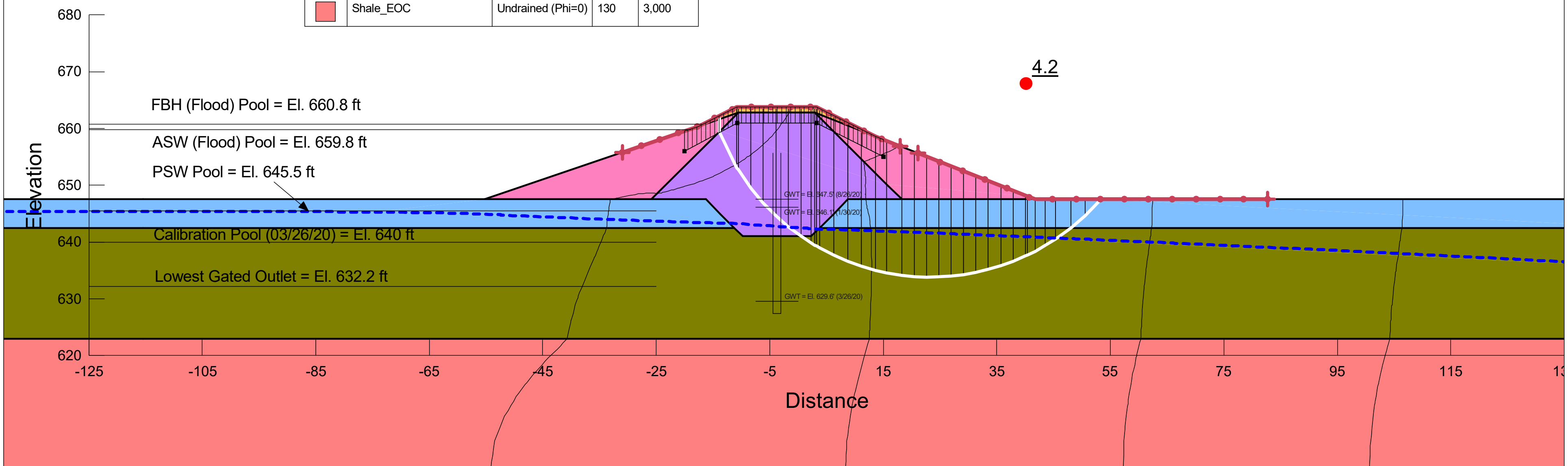
Station 18+50 (Proposed Embankment Crest Modification)



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Alluvium (CH)	Mohr-Coulomb	123	100	23	0
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100	23	0
	Existing Embankment Fill - Zone II (SC)	Mohr-Coulomb	125	100	23	0
	Residuum (CL-CH)	Mohr-Coulomb	126	100	23	0
	Shale	Mohr-Coulomb	130	300	23	0

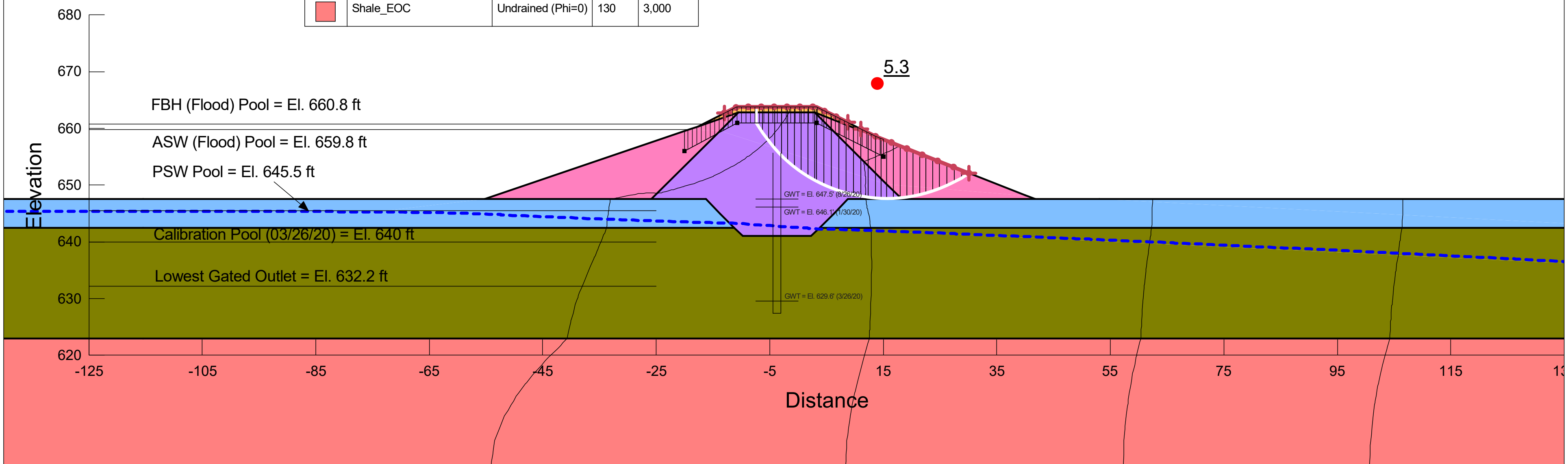
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_Embank_Slope_Exist_Emb_PSW
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)
	Alluvium (CH)_EOC	Undrained (Phi=0)	123	1,500
	Existing Embankment Fill - Zone I (CH)_EOC	Undrained (Phi=0)	125	1,200
	Existing Embankment Fill - Zone II (SC)_EOC	Undrained (Phi=0)	125	1,200
	Proposed Embankment Fill_EOC	Undrained (Phi=0)	125	1,200
	Residuum (CL-CH)_EOC	Undrained (Phi=0)	126	1,500
	Shale_EOC	Undrained (Phi=0)	130	3,000



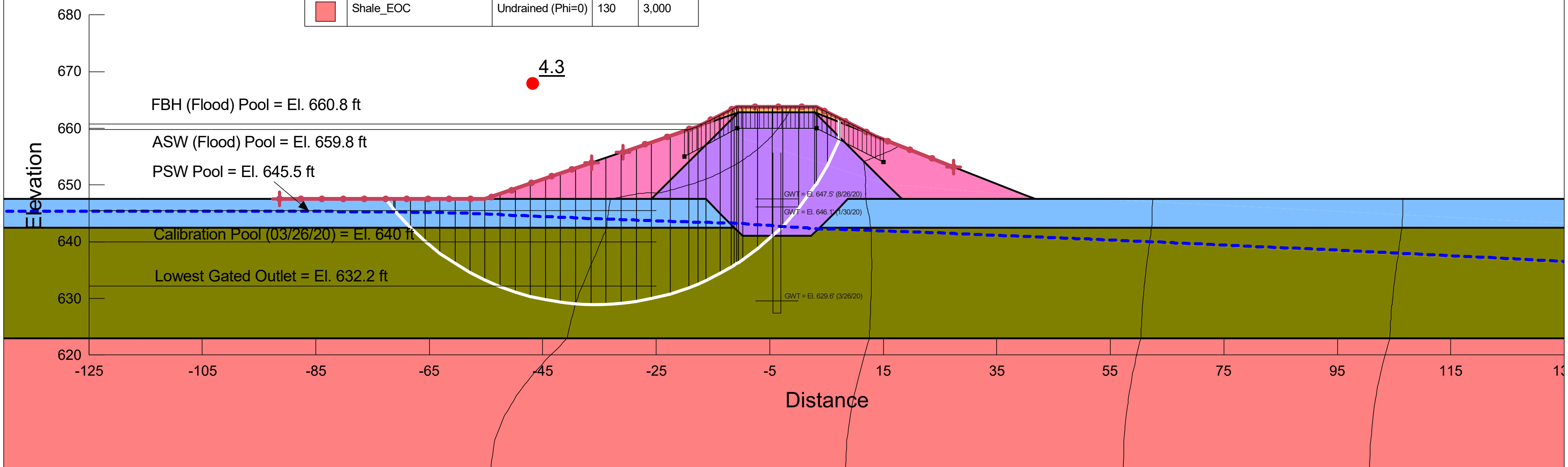
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_Embank_Slope_Prop_Emb_PSW_EOC_DS_Deep_Failure
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)
	Alluvium (CH)_EOC	Undrained (Phi=0)	123	1,500
	Existing Embankment Fill - Zone I (CH)_EOC	Undrained (Phi=0)	125	1,200
	Existing Embankment Fill - Zone II (SC)_EOC	Undrained (Phi=0)	125	1,200
	Proposed Embankment Fill_EOC	Undrained (Phi=0)	125	1,200
	Residuum (CL-CH)_EOC	Undrained (Phi=0)	126	1,500
	Shale_EOC	Undrained (Phi=0)	130	3,000



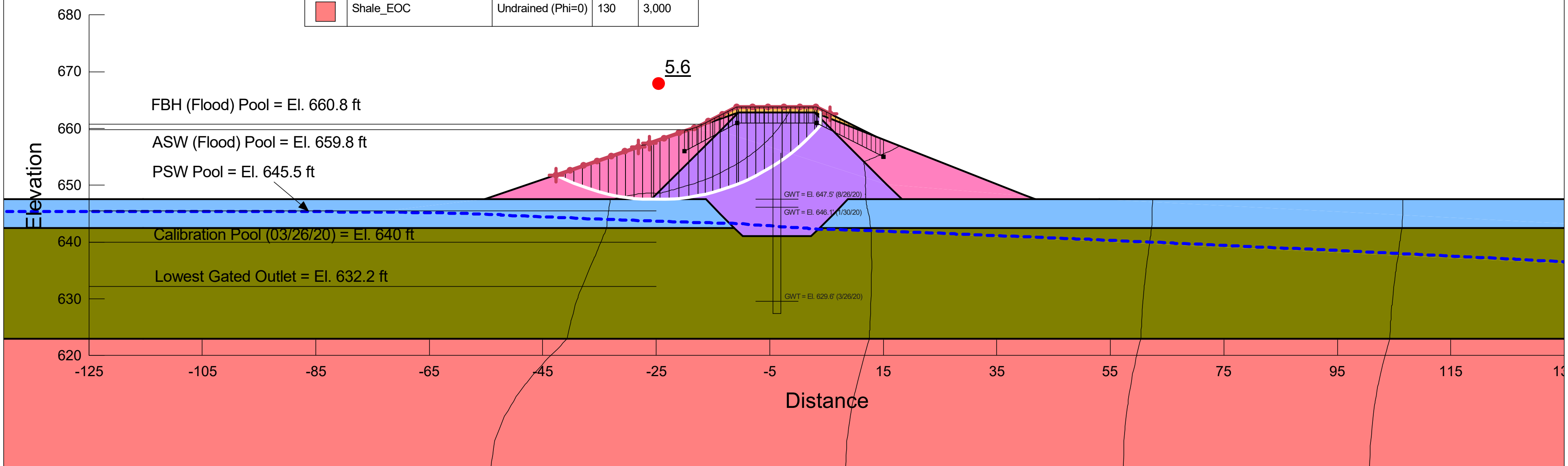
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_Embank_Slope_Prop_Emb_PSW_EOC_DS_Shallow_Failure
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)
	Alluvium (CH)_EOC	Undrained (Phi=0)	123	1,500
	Existing Embankment Fill - Zone I (CH)_EOC	Undrained (Phi=0)	125	1,200
	Existing Embankment Fill - Zone II (SC)_EOC	Undrained (Phi=0)	125	1,200
	Proposed Embankment Fill_EOC	Undrained (Phi=0)	125	1,200
	Residuum (CL-CH)_EOC	Undrained (Phi=0)	126	1,500
	Shale_EOC	Undrained (Phi=0)	130	3,000



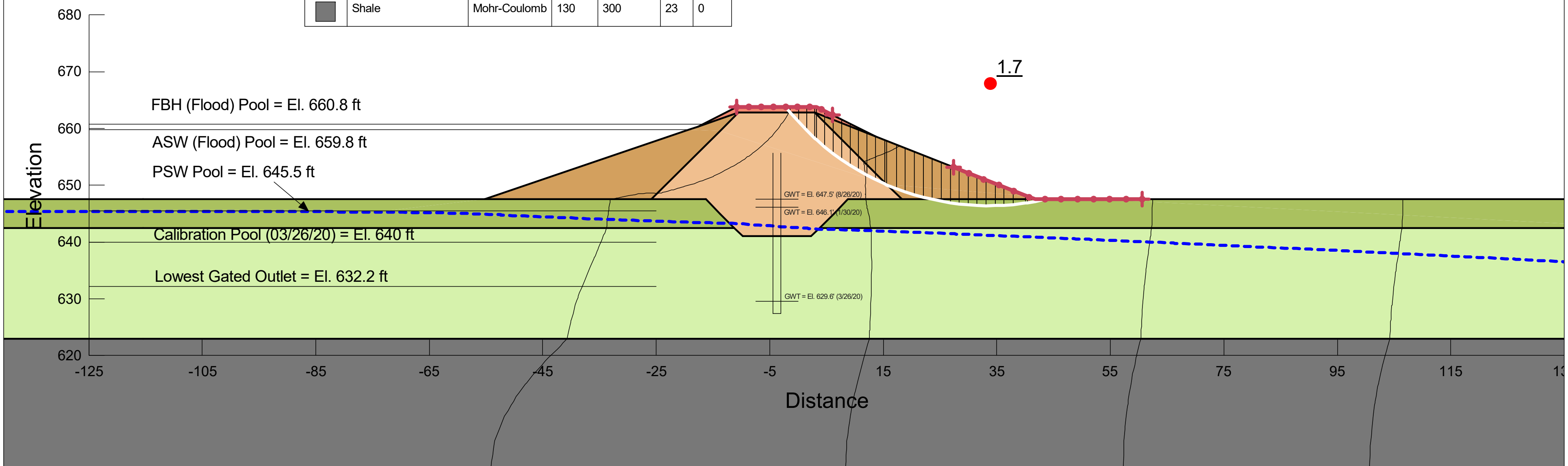
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_Embank_Slope_Prop_Emb_PSW_EOC_US_Deep_Failure
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)
	Alluvium (CH)_EOC	Undrained (Phi=0)	123	1,500
	Existing Embankment Fill - Zone I (CH)_EOC	Undrained (Phi=0)	125	1,200
	Existing Embankment Fill - Zone II (SC)_EOC	Undrained (Phi=0)	125	1,200
	Proposed Embankment Fill_EOC	Undrained (Phi=0)	125	1,200
	Residuum (CL-CH)_EOC	Undrained (Phi=0)	126	1,500
	Shale_EOC	Undrained (Phi=0)	130	3,000



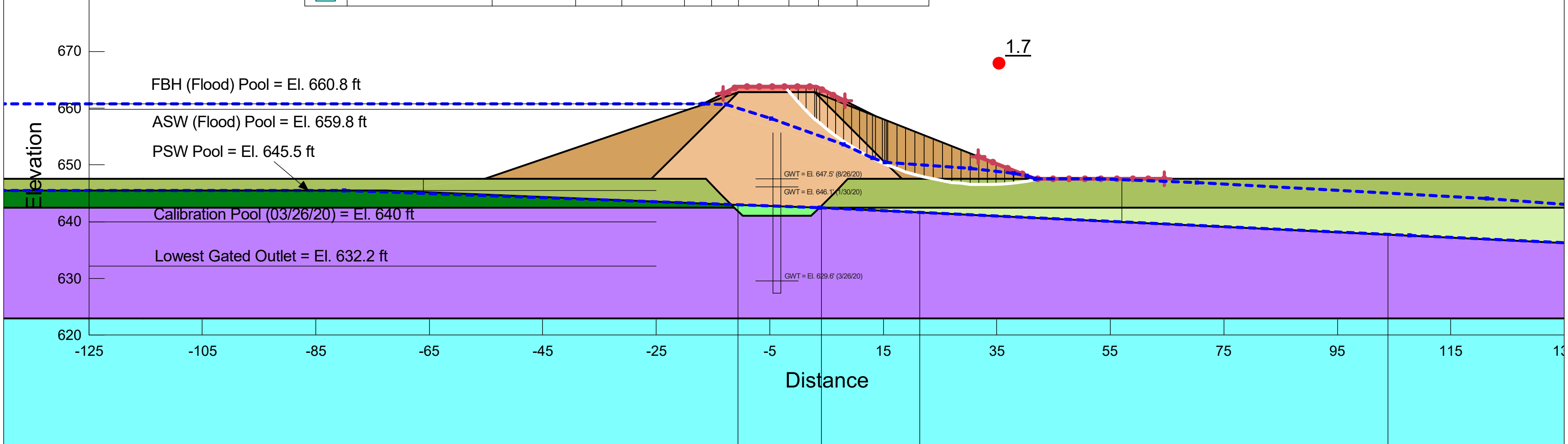
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_Embank_Slope_Prop_Emb_PSW_EOC_US_Shallow_Failure
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Alluvium (CH)	Mohr-Coulomb	123	100	23	0
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100	23	0
	Existing Embankment Fill - Zone II (SC)	Mohr-Coulomb	125	100	23	0
	Proposed Embankment Fill	Mohr-Coulomb	125	100	23	0
	Residuum (CL-CH)	Mohr-Coulomb	126	100	23	0
	Shale	Mohr-Coulomb	130	300	23	0



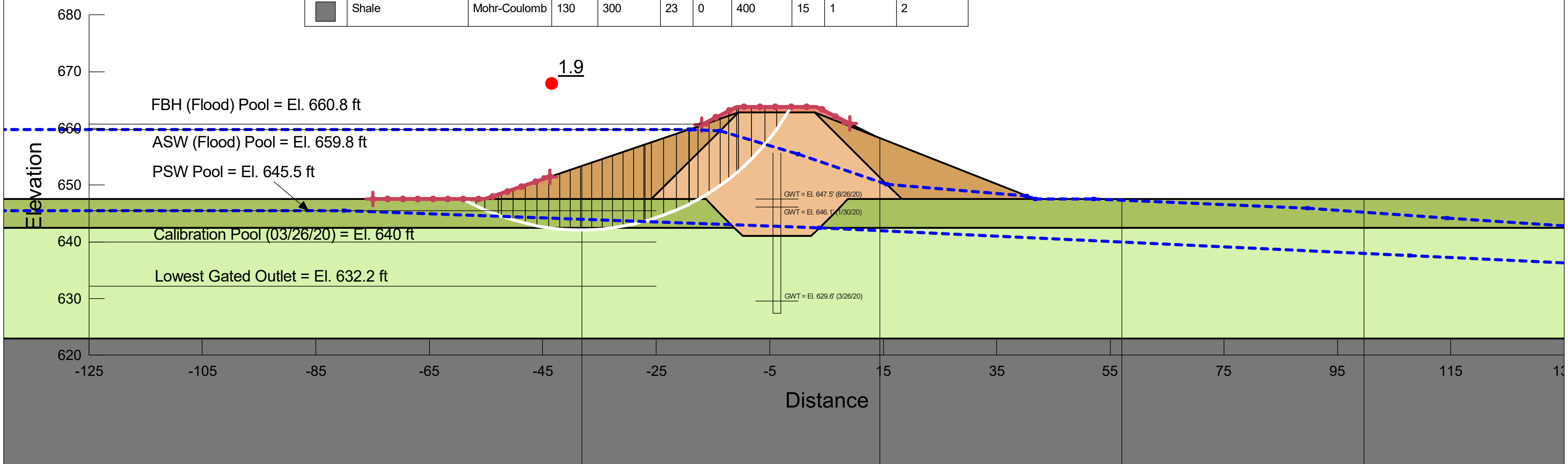
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_Embank_Slope_Prop_Emb_PSW
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi 1 (°)	Phi 2 (°)	Bilinear Normal (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	Alluvium (CH)	Mohr-Coulomb	123	100				23	0	1
	Alluvium (CH)_Bilinear	Bilinear	123	100	23	15	1,917		0	2
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100				23	0	1
	Existing Embankment Fill - Zone I (CH)_Bilinear	Bilinear	125	100	23	15	1,917		0	2
	Existing Embankment Fill - Zone II (SC)	Mohr-Coulomb	125	100				23	0	1
	Proposed Embankment Fill	Mohr-Coulomb	125	100				23	0	1
	Residuum (CL-CH)	Mohr-Coulomb	126	100				23	0	1
	Residuum (CL-CH)_Bilinear	Bilinear	126	100	23	15	1,917		0	2
	Shale_Bilinear	Bilinear	130	300	23	15	639		0	2



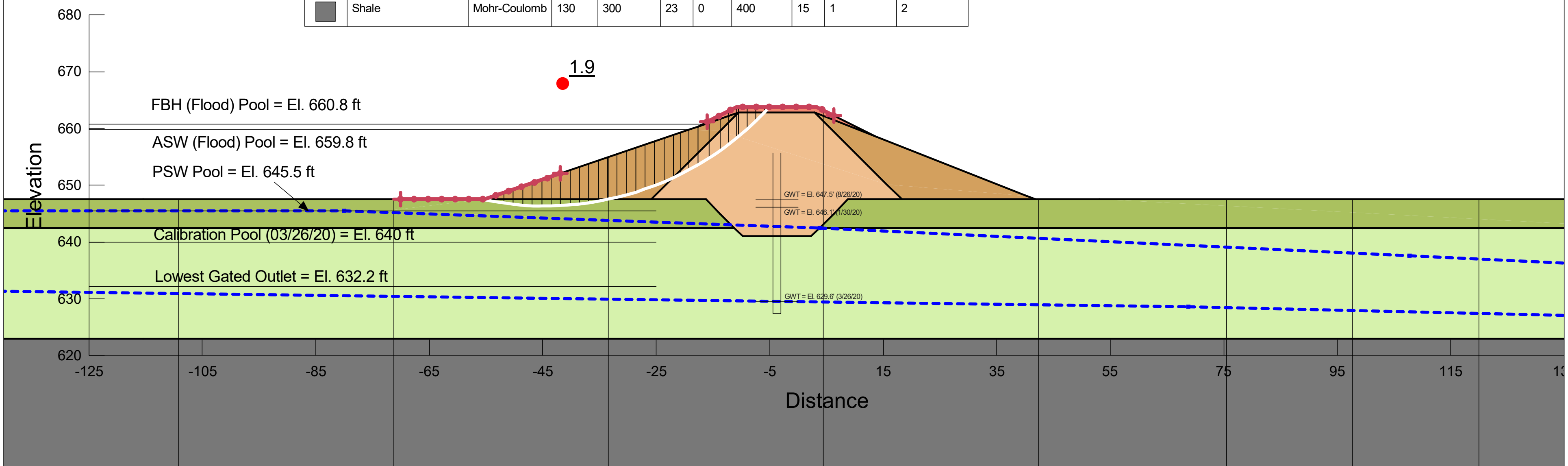
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_Embank_Slope_Prop_Emb_FBH
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	Alluvium (CH)	Mohr-Coulomb	123	100	23	0	400	15	1	2
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100	23	0	400	15	1	2
	Existing Embankment Fill - Zone II (SC)	Mohr-Coulomb	125	100	23	0	400	15	1	2
	Proposed Embankment Fill	Mohr-Coulomb	125	100	23	0	400	15	1	2
	Residuum (CL-CH)	Mohr-Coulomb	126	100	23	0	400	15	1	2
	Shale	Mohr-Coulomb	130	300	23	0	400	15	1	2



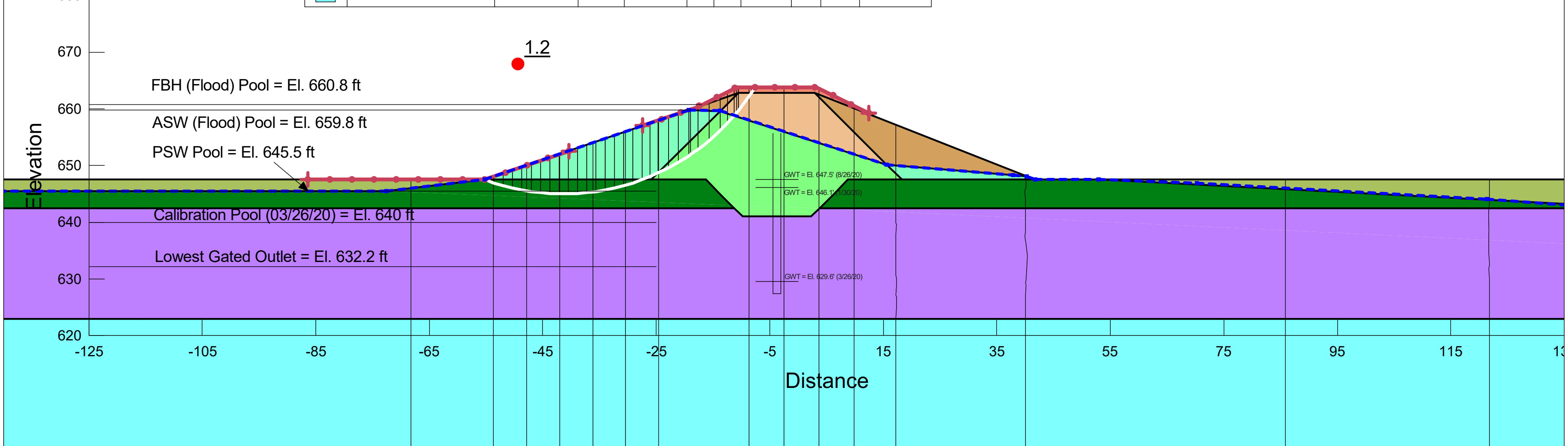
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_Embank_Slope_Prop_Emb_3 Stages_RDD_ASW to PSW
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	Alluvium (CH)	Mohr-Coulomb	123	100	23	0	400	15	1	2
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100	23	0	400	15	1	2
	Existing Embankment Fill - Zone II (SC)	Mohr-Coulomb	125	100	23	0	400	15	1	2
	Proposed Embankment Fill	Mohr-Coulomb	125	100	23	0	400	15	1	2
	Residuum (CL-CH)	Mohr-Coulomb	126	100	23	0	400	15	1	2
	Shale	Mohr-Coulomb	130	300	23	0	400	15	1	2



Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_Embank_Slope_Prop_Emb_3 Stages_RDD_PSW to Lowest Gated
Method: Spencer
Tool Version: 10.2.2.20559

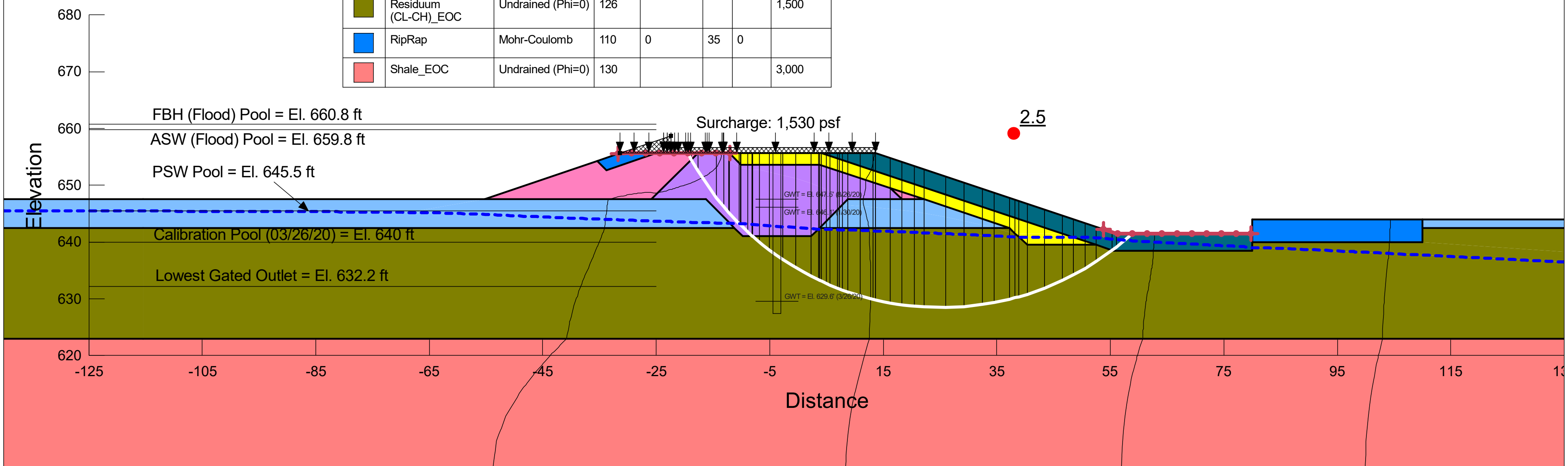
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi 1 (°)	Phi 2 (°)	Bilinear Normal (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	Alluvium (CH)	Mohr-Coulomb	123	100				23	0	1
	Alluvium (CH)_Bilinear	Bilinear	123	100	23	15	1,917		0	1
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100				23	0	1
	Existing Embankment Fill - Zone I (CH)_Bilinear	Bilinear	125	100	23	15	1,917		0	1
	Existing Embankment Fill - Zone II (SC)	Mohr-Coulomb	125	100				23	0	1
	Existing Embankment Fill - Zone II (SC)_Bilinear	Bilinear	125	100	23	15	1,917		0	1
	Proposed Embankment Fill	Mohr-Coulomb	125	100				23	0	1
	Residuum (CL-CH)	Mohr-Coulomb	126	100				23	0	1
	Residuum (CL-CH)_Bilinear	Bilinear	126	100	23	15	1,917		0	1
	Shale_Bilinear	Bilinear	130	300	23	15	639		0	1



Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_Embank_Slope_Prop_Emb_NRCS_RDD_ASW to PSW
Method: Spencer
Tool Version: 10.2.2.20559

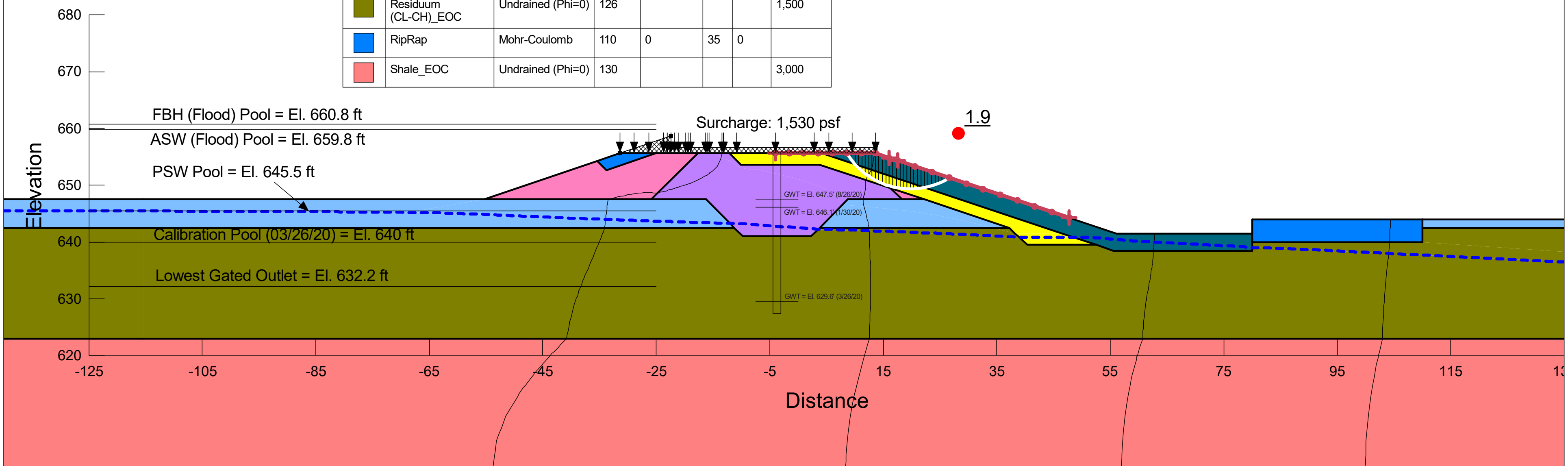
Station 18+50 (Proposed RCC Overtopping Spillway)

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion (psf)
	Alluvium (CH)_EOC	Undrained (Phi=0)	123				1,500
	Existing Embankment Fill - Zone I (CH)_EOC	Undrained (Phi=0)	125				1,200
	Existing Embankment Fill - Zone II (SC)_EOC	Undrained (Phi=0)	125				1,200
	Filter Drain	Mohr-Coulomb	120	0	33	0	
	RCC	Mohr-Coulomb	145	100	45	0	
	Residuum (CL-CH)_EOC	Undrained (Phi=0)	126				1,500
	RipRap	Mohr-Coulomb	110	0	35	0	
	Shale_EOC	Undrained (Phi=0)	130				3,000



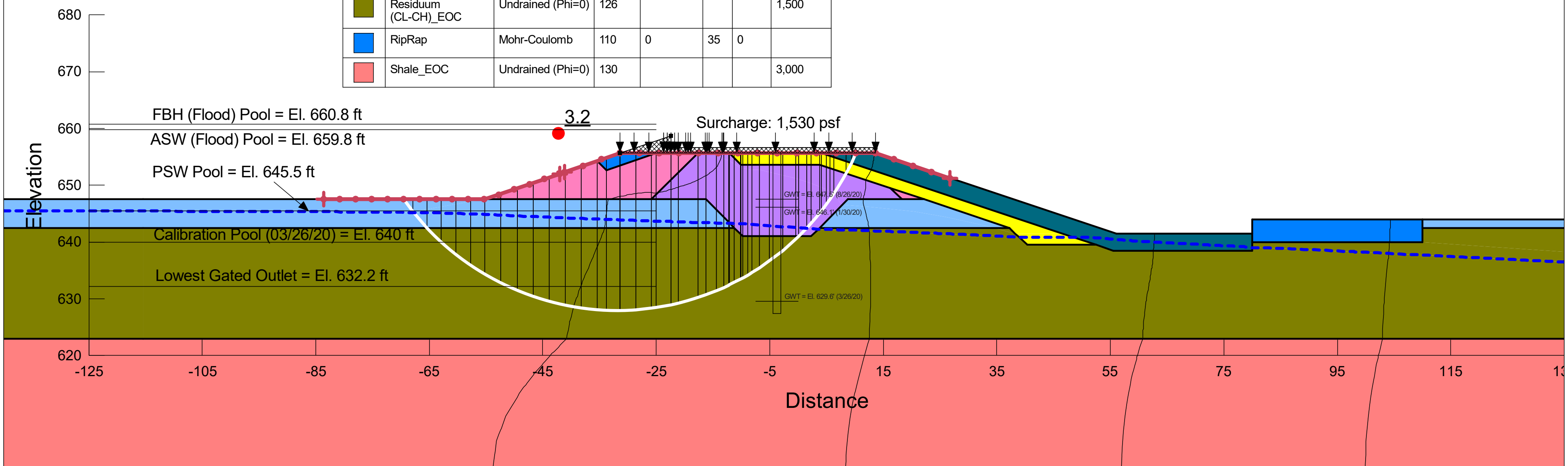
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_RCC_Slope_Prop_Emb_PSW_EOC_DS_Deep_Failure
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion (psf)
	Alluvium (CH)_EOC	Undrained (Phi=0)	123				1,500
	Existing Embankment Fill - Zone I (CH)_EOC	Undrained (Phi=0)	125				1,200
	Existing Embankment Fill - Zone II (SC)_EOC	Undrained (Phi=0)	125				1,200
	Filter Drain	Mohr-Coulomb	120	0	33	0	
	RCC	Mohr-Coulomb	145	100	45	0	
	Residuum (CL-CH)_EOC	Undrained (Phi=0)	126				1,500
	RipRap	Mohr-Coulomb	110	0	35	0	
	Shale_EOC	Undrained (Phi=0)	130				3,000



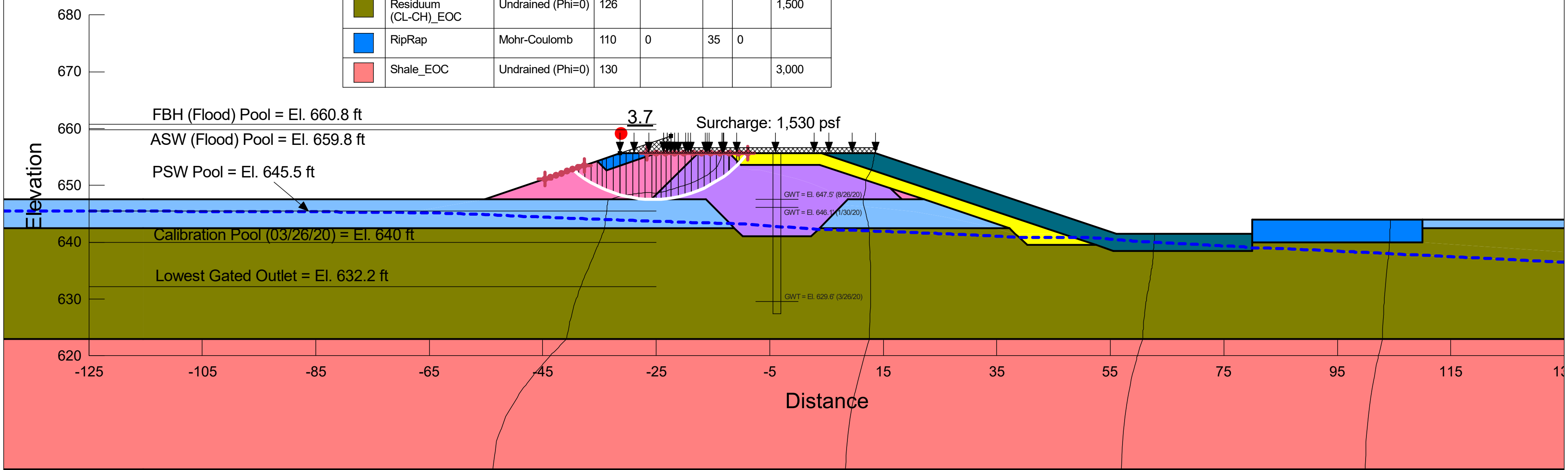
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_RCC_Slope_Prop_Emb_PSW_EOC_DS_Shallow_Failure
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion (psf)
	Alluvium (CH)_EOC	Undrained (Phi=0)	123				1,500
	Existing Embankment Fill - Zone I (CH)_EOC	Undrained (Phi=0)	125				1,200
	Existing Embankment Fill - Zone II (SC)_EOC	Undrained (Phi=0)	125				1,200
	Filter Drain	Mohr-Coulomb	120	0	33	0	
	RCC	Mohr-Coulomb	145	100	45	0	
	Residuum (CL-CH)_EOC	Undrained (Phi=0)	126				1,500
	RipRap	Mohr-Coulomb	110	0	35	0	
	Shale_EOC	Undrained (Phi=0)	130				3,000



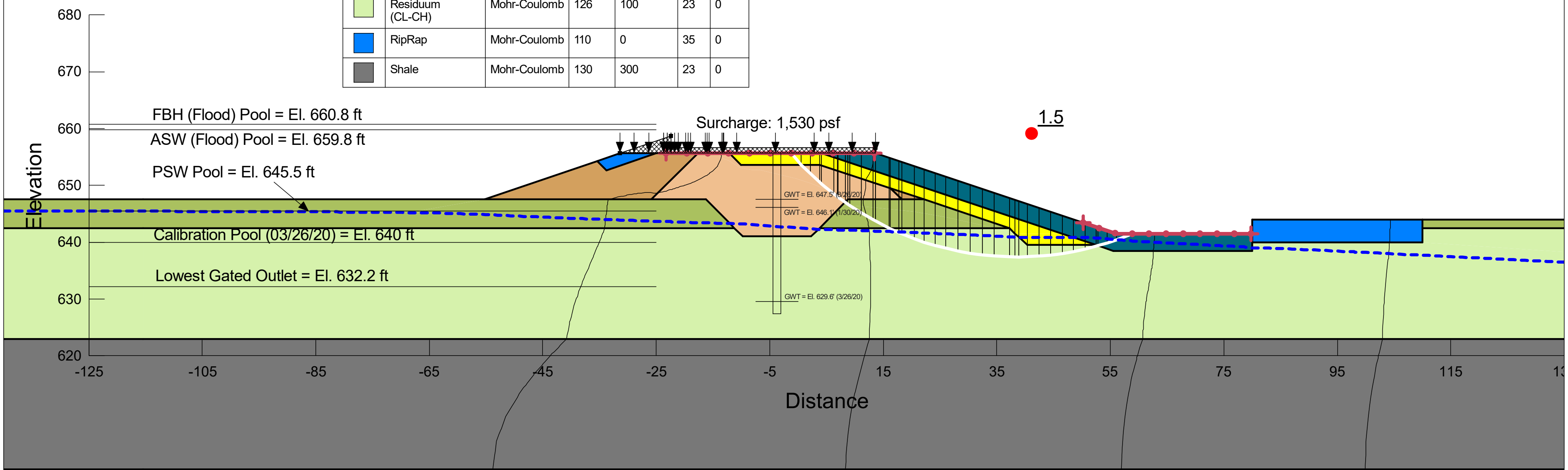
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_RCC_Slope_Prop_Emb_PSW_EOC_US_Deep_Failure
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion (psf)
	Alluvium (CH)_EOC	Undrained (Phi=0)	123				1,500
	Existing Embankment Fill - Zone I (CH)_EOC	Undrained (Phi=0)	125				1,200
	Existing Embankment Fill - Zone II (SC)_EOC	Undrained (Phi=0)	125				1,200
	Filter Drain	Mohr-Coulomb	120	0	33	0	
	RCC	Mohr-Coulomb	145	100	45	0	
	Residuum (CL-CH)_EOC	Undrained (Phi=0)	126				1,500
	RipRap	Mohr-Coulomb	110	0	35	0	
	Shale_EOC	Undrained (Phi=0)	130				3,000



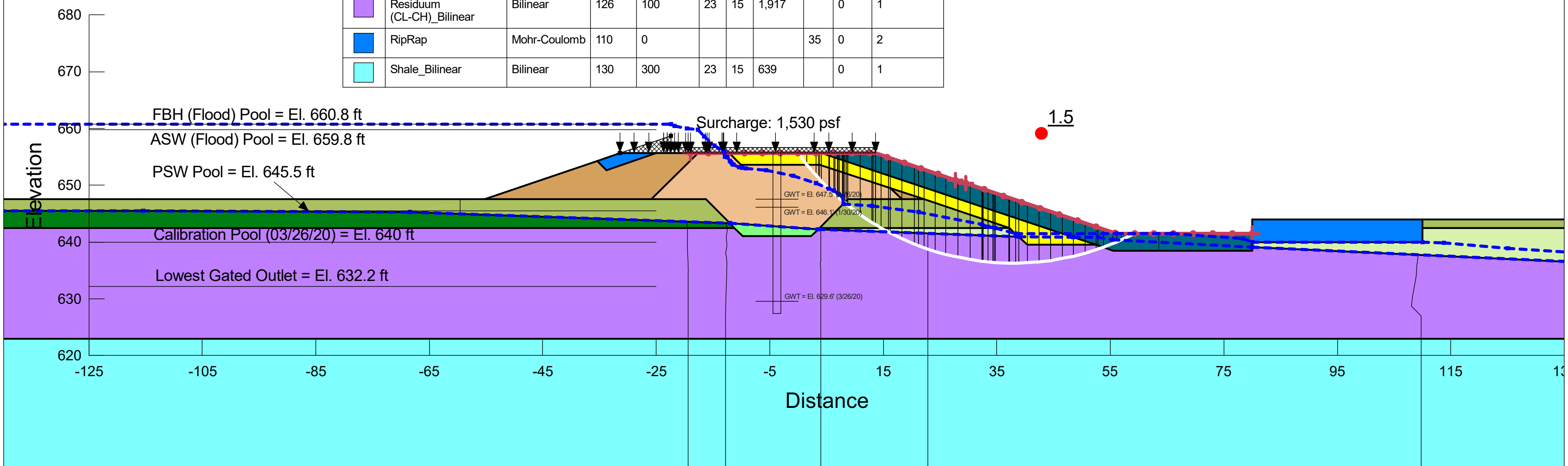
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_RCC_Slope_Prop_Emb_PSW_EOC_US_Shallow_Failure
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Alluvium (CH)	Mohr-Coulomb	123	100	23	0
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100	23	0
	Existing Embankment Fill - Zone II (SC)	Mohr-Coulomb	125	100	23	0
	Filter Drain	Mohr-Coulomb	120	0	33	0
	RCC	Mohr-Coulomb	145	100	45	0
	Residuum (CL-CH)	Mohr-Coulomb	126	100	23	0
	RipRap	Mohr-Coulomb	110	0	35	0
	Shale	Mohr-Coulomb	130	300	23	0



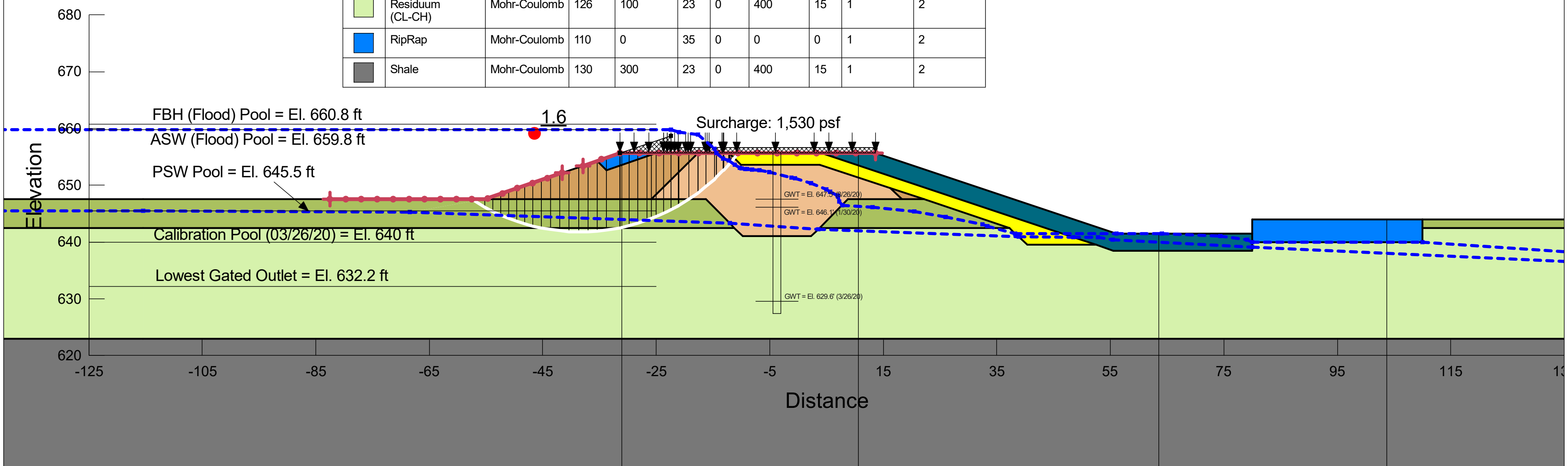
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_RCC_Slope_Prop_Emb_PSW
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi 1 (°)	Phi 2 (°)	Bilinear Normal (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	Alluvium (CH)	Mohr-Coulomb	123	100				23	0	2
	Alluvium (CH)_Bilinear	Bilinear	123	100	23	15	1,917		0	1
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100				23	0	2
	Existing Embankment Fill - Zone I (CH)_Bilinear	Bilinear	125	100	23	15	1,917		0	1
	Existing Embankment Fill - Zone II (SC)	Mohr-Coulomb	125	100				23	0	2
	Filter Drain	Mohr-Coulomb	120	0				33	0	2
	RCC	Mohr-Coulomb	145	100				45	0	2
	Residuum (CL-CH)	Mohr-Coulomb	126	100				23	0	2
	Residuum (CL-CH)_Bilinear	Bilinear	126	100	23	15	1,917		0	1
	RipRap	Mohr-Coulomb	110	0				35	0	2
	Shale_Bilinear	Bilinear	130	300	23	15	639		0	1



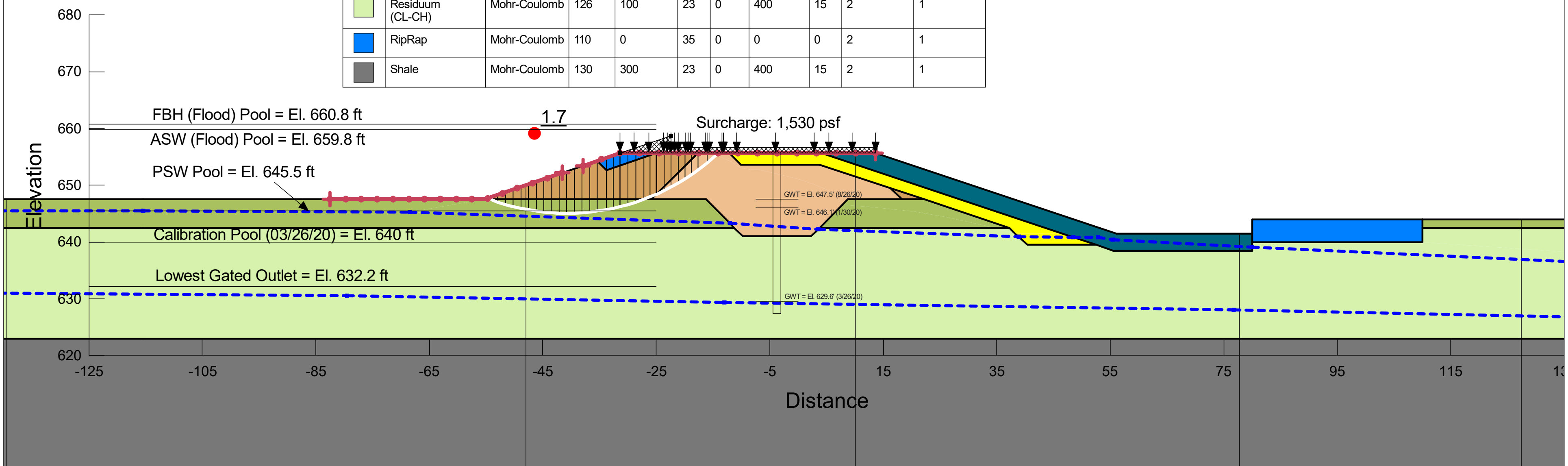
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_RCC_Slope_Prop_Emb_FBH
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	Alluvium (CH)	Mohr-Coulomb	123	100	23	0	400	15	1	2
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100	23	0	400	15	1	2
	Existing Embankment Fill - Zone II (SC)	Mohr-Coulomb	125	100	23	0	400	15	1	2
	Filter Drain	Mohr-Coulomb	120	0	33	0	0	0	1	2
	RCC	Mohr-Coulomb	145	100	45	0	0	0	1	2
	Residuum (CL-CH)	Mohr-Coulomb	126	100	23	0	400	15	1	2
	RipRap	Mohr-Coulomb	110	0	35	0	0	0	1	2
	Shale	Mohr-Coulomb	130	300	23	0	400	15	1	2



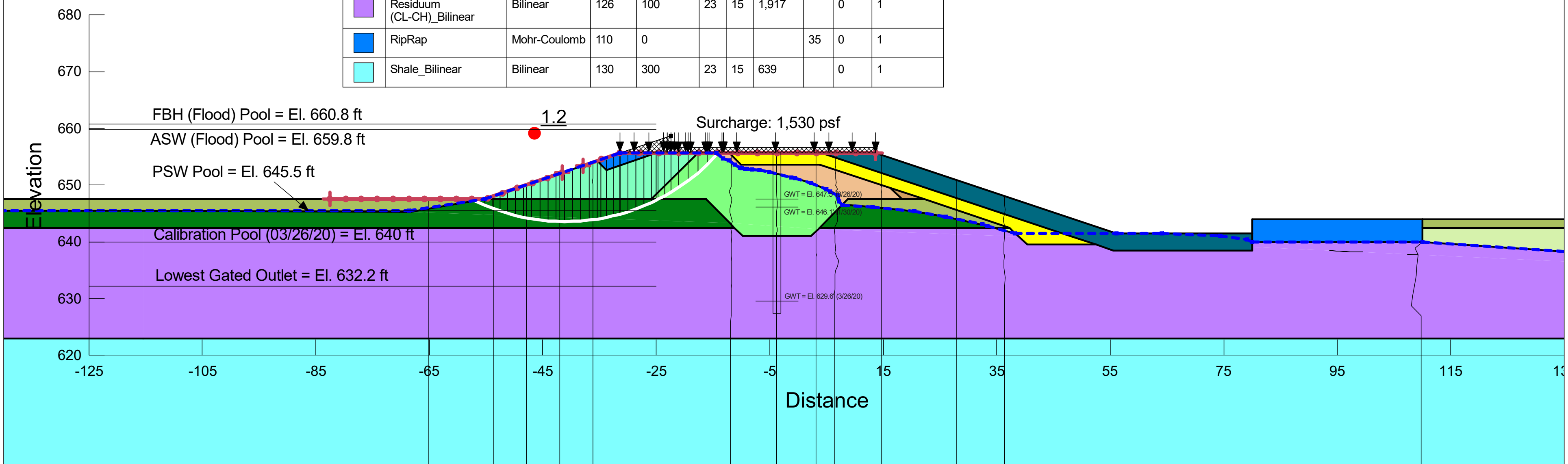
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_RCC_Slope_Prop_Emb_3 Stages_RDD_ASW to PSW
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	Alluvium (CH)	Mohr-Coulomb	123	100	23	0	400	15	2	1
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100	23	0	400	15	2	1
	Existing Embankment Fill - Zone II (SC)	Mohr-Coulomb	125	100	23	0	400	15	2	1
	Filter Drain	Mohr-Coulomb	120	0	33	0	0	0	2	1
	RCC	Mohr-Coulomb	145	100	45	0	0	0	2	1
	Residuum (CL-CH)	Mohr-Coulomb	126	100	23	0	400	15	2	1
	RipRap	Mohr-Coulomb	110	0	35	0	0	0	2	1
	Shale	Mohr-Coulomb	130	300	23	0	400	15	2	1



Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_RCC_Slope_Prop_Emb_3 Stages_RDD_PSW to Lowest Gated
Method: Spencer
Tool Version: 10.2.2.20559

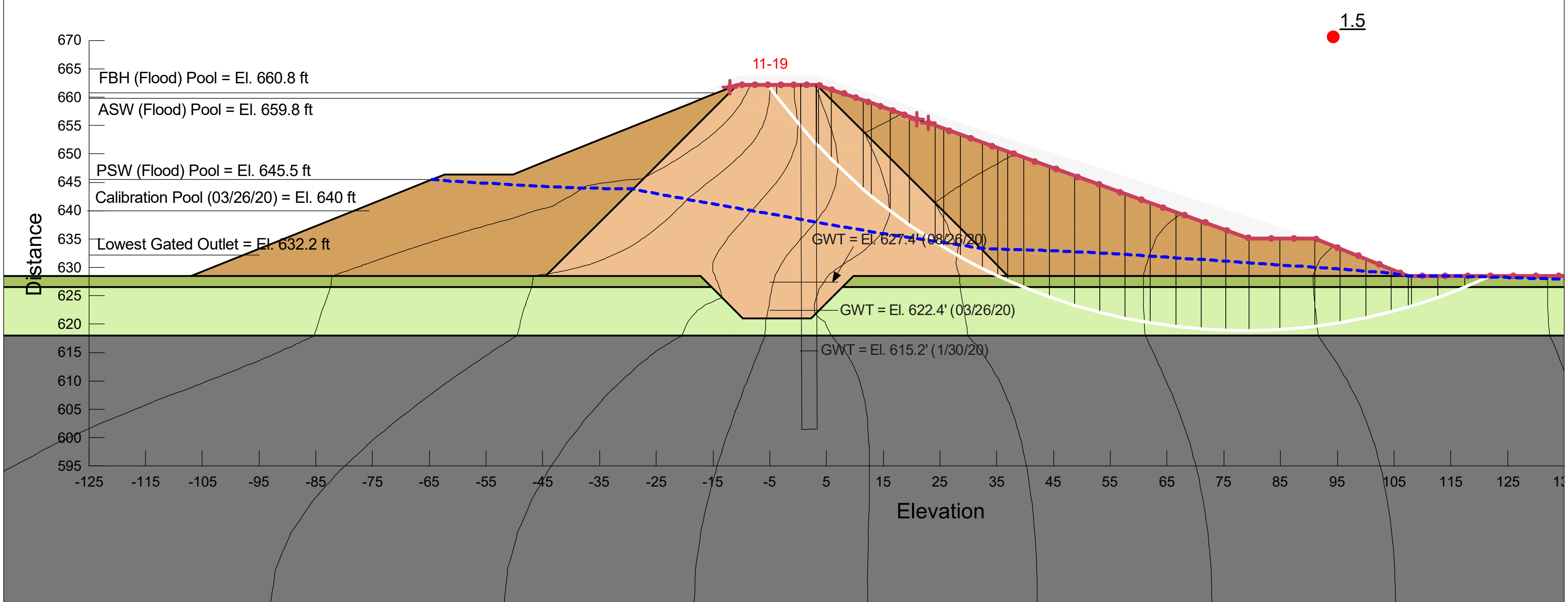
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi 1 (°)	Phi 2 (°)	Bilinear Normal (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	Alluvium (CH)	Mohr-Coulomb	123	100				23	0	1
	Alluvium (CH)_Bilinear	Bilinear	123	100	23	15	1,917		0	1
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100				23	0	1
	Existing Embankment Fill - Zone I (CH)_Bilinear	Bilinear	125	100	23	15	1,917		0	1
	Existing Embankment Fill - Zone II (SC)	Mohr-Coulomb	125	100				23	0	1
	Existing Embankment Fill - Zone II (SC)_Bilinear	Bilinear	125	100	23	15	1,917		0	1
	Filter Drain	Mohr-Coulomb	120	0				33	0	1
	RCC	Mohr-Coulomb	145	100				45	0	1
	Residuum (CL-CH)	Mohr-Coulomb	126	100				23	0	1
	Residuum (CL-CH)_Bilinear	Bilinear	126	100	23	15	1,917		0	1
	RipRap	Mohr-Coulomb	110	0				35	0	1
	Shale_Bilinear	Bilinear	130	300	23	15	639		0	1



Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_18+50_RCC_Slope_Prop_Emb_NRCS_RDD_ASW to PSW
Method: Spencer
Tool Version: 10.2.2.20559

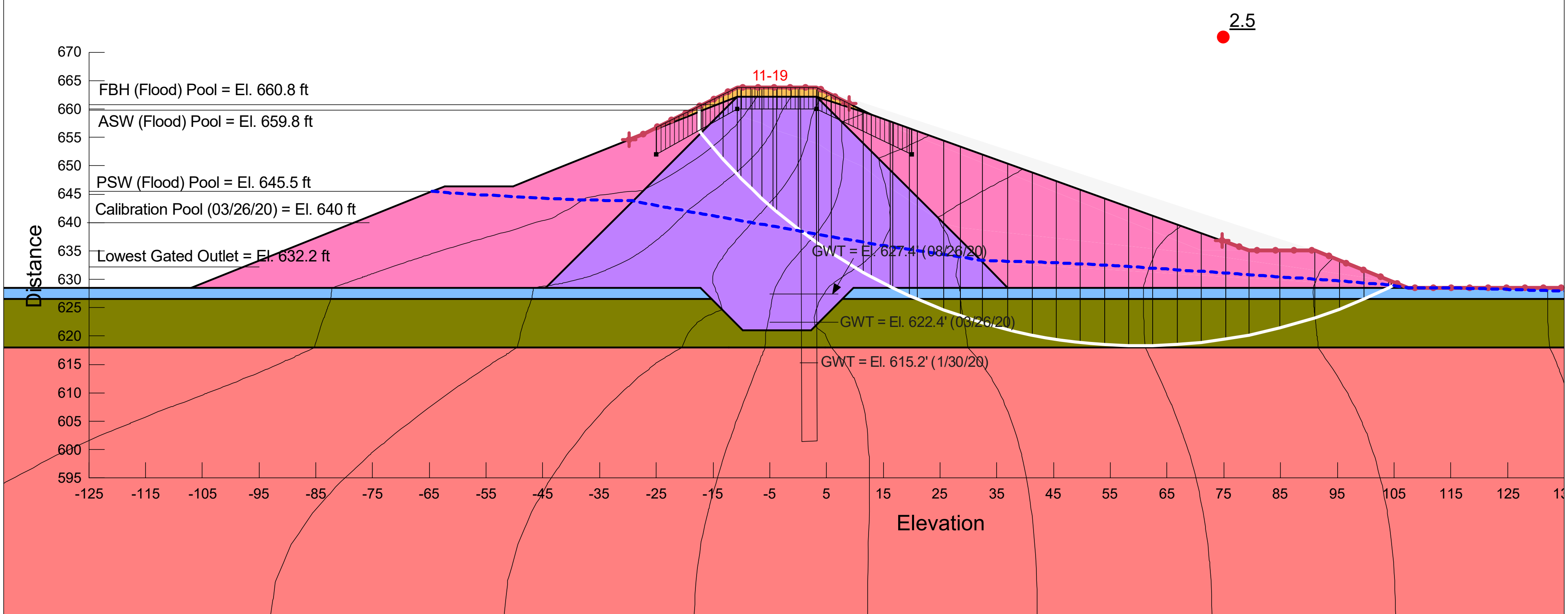
Station 23+50 (Proposed Embankment Crest Modification)

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Alluvium (CH)	Mohr-Coulomb	123	100	23	0
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100	23	0
	Existing Embankment Fill - Zone II (SC)	Mohr-Coulomb	125	100	23	0
	Residuum (CL-CH)	Mohr-Coulomb	126	100	23	0
	Shale	Mohr-Coulomb	130	300	23	0



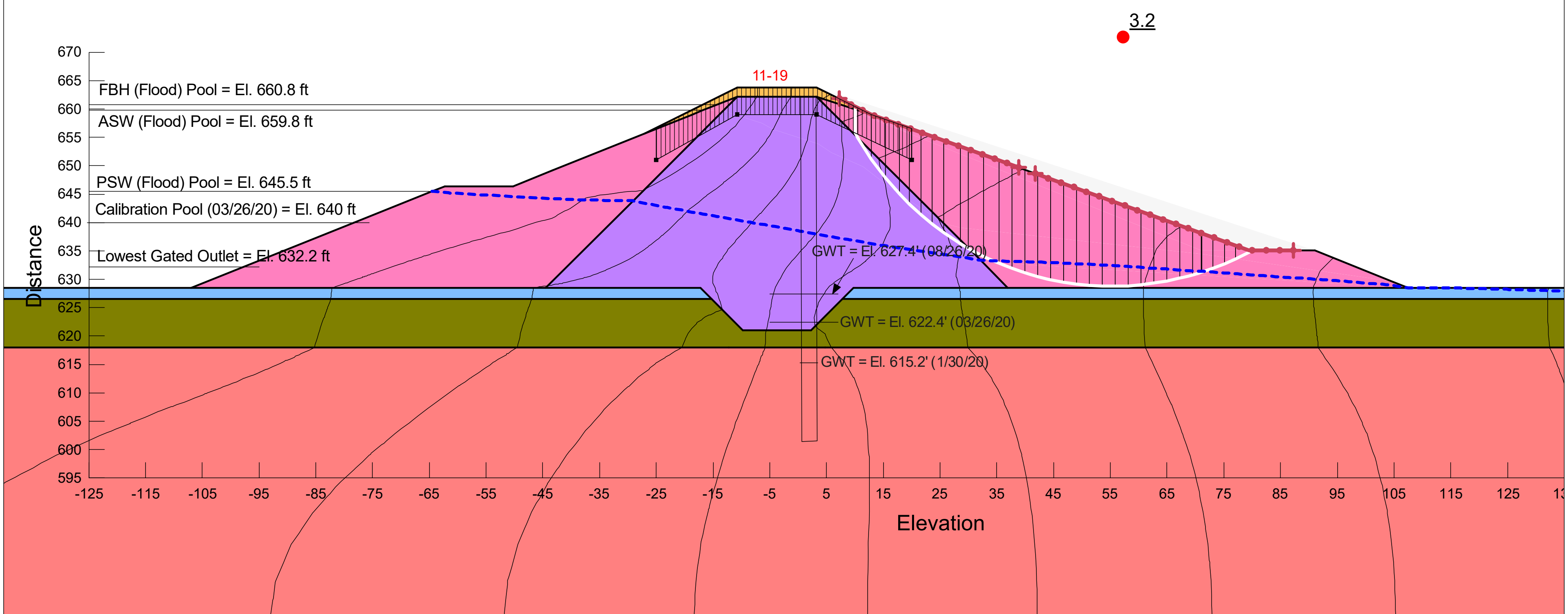
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_Slope_Exist_Emb_PSW (EL. 645.5)
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)
	Alluvium (CH)_EOC	Undrained (Phi=0)	123	1,500
	Existing Embankment Fill - Zone I (CH)_EOC	Undrained (Phi=0)	125	1,200
	Existing Embankment Fill - Zone II (SC)_EOC	Undrained (Phi=0)	125	1,200
	Proposed Embankment Fill_EOC	Undrained (Phi=0)	125	1,200
	Residuum (CL-CH)_EOC	Undrained (Phi=0)	126	1,500
	Shale_EOC	Undrained (Phi=0)	130	3,000



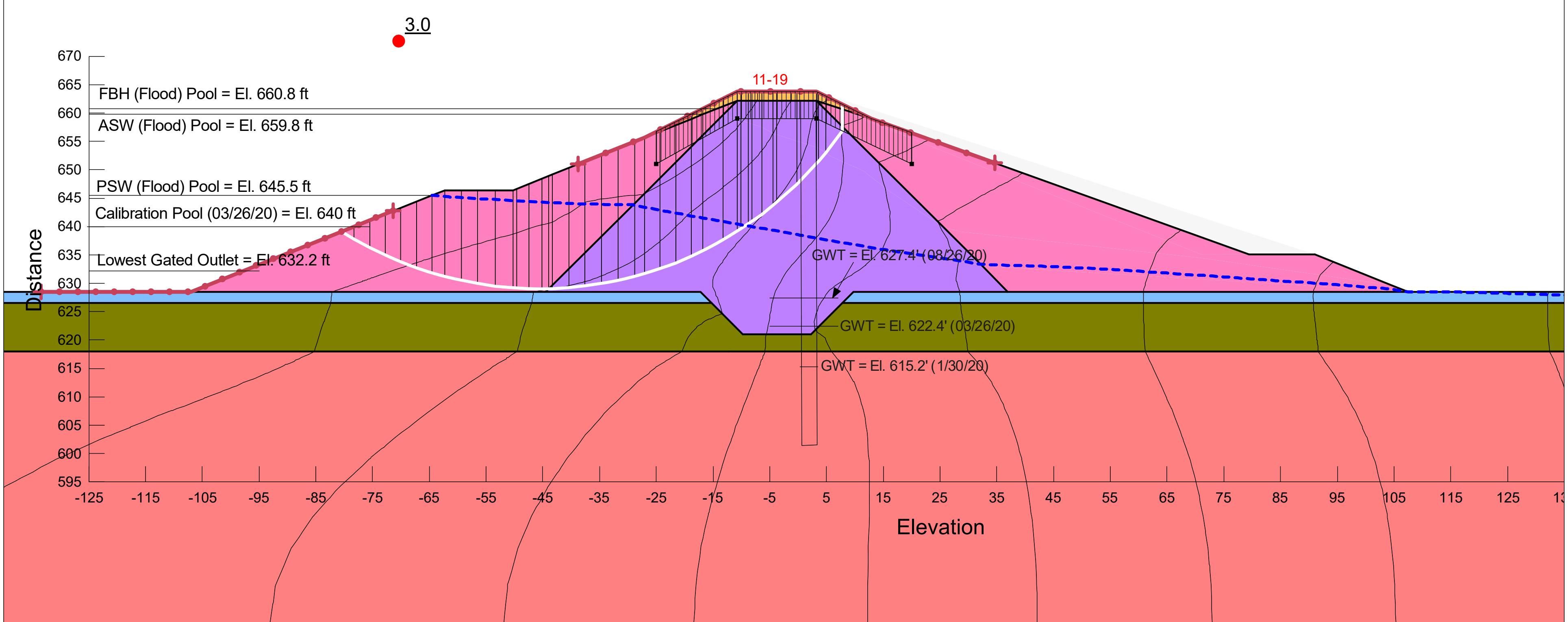
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_Slope_Prop_Emb_PSW_EOC_DS_Deep_Failure (EL. 645.5)
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)
	Alluvium (CH)_EOC	Undrained (Phi=0)	123	1,500
	Existing Embankment Fill - Zone I (CH)_EOC	Undrained (Phi=0)	125	1,200
	Existing Embankment Fill - Zone II (SC)_EOC	Undrained (Phi=0)	125	1,200
	Proposed Embankment Fill_EOC	Undrained (Phi=0)	125	1,200
	Residuum (CL-CH)_EOC	Undrained (Phi=0)	126	1,500
	Shale_EOC	Undrained (Phi=0)	130	3,000



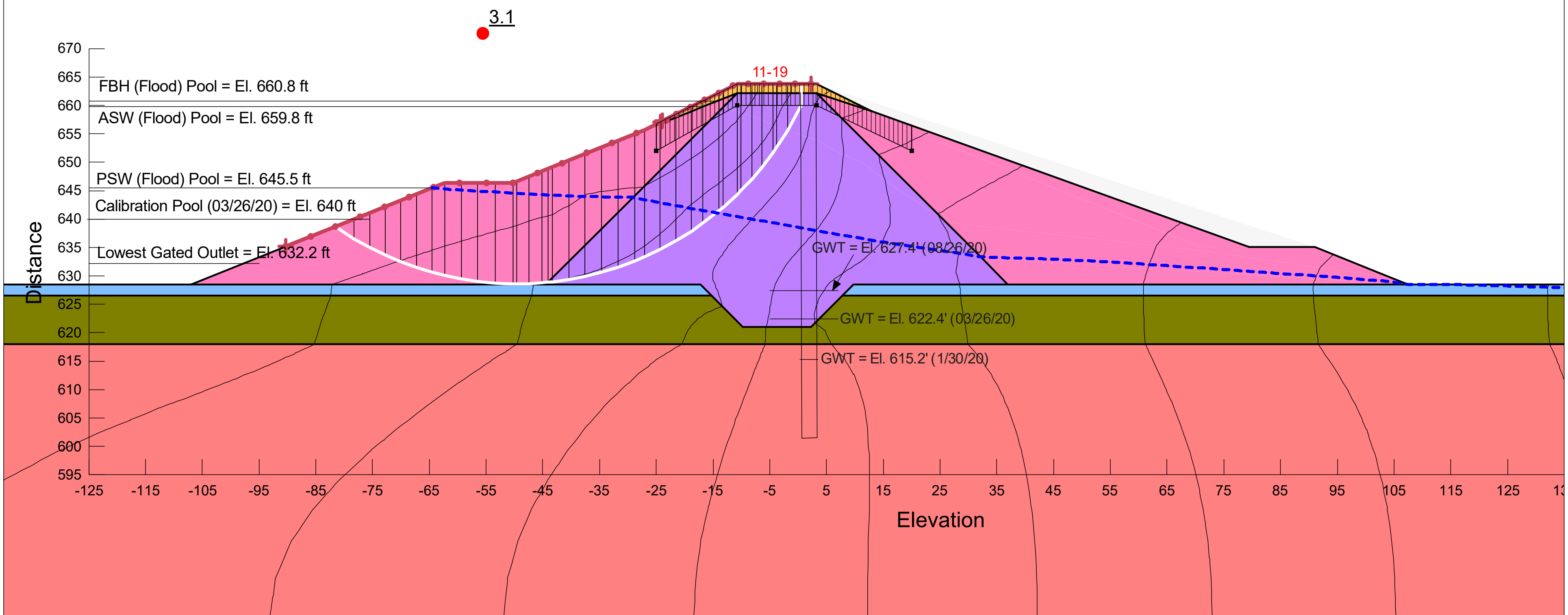
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_Slope_Prop_Emb_PSW_EOC_DS_Shallow_Failure (EL. 645.5)
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)
	Alluvium (CH)_EOC	Undrained (Phi=0)	123	1,500
	Existing Embankment Fill - Zone I (CH)_EOC	Undrained (Phi=0)	125	1,200
	Existing Embankment Fill - Zone II (SC)_EOC	Undrained (Phi=0)	125	1,200
	Proposed Embankment Fill_EOC	Undrained (Phi=0)	125	1,200
	Residuum (CL-CH)_EOC	Undrained (Phi=0)	126	1,500
	Shale_EOC	Undrained (Phi=0)	130	3,000



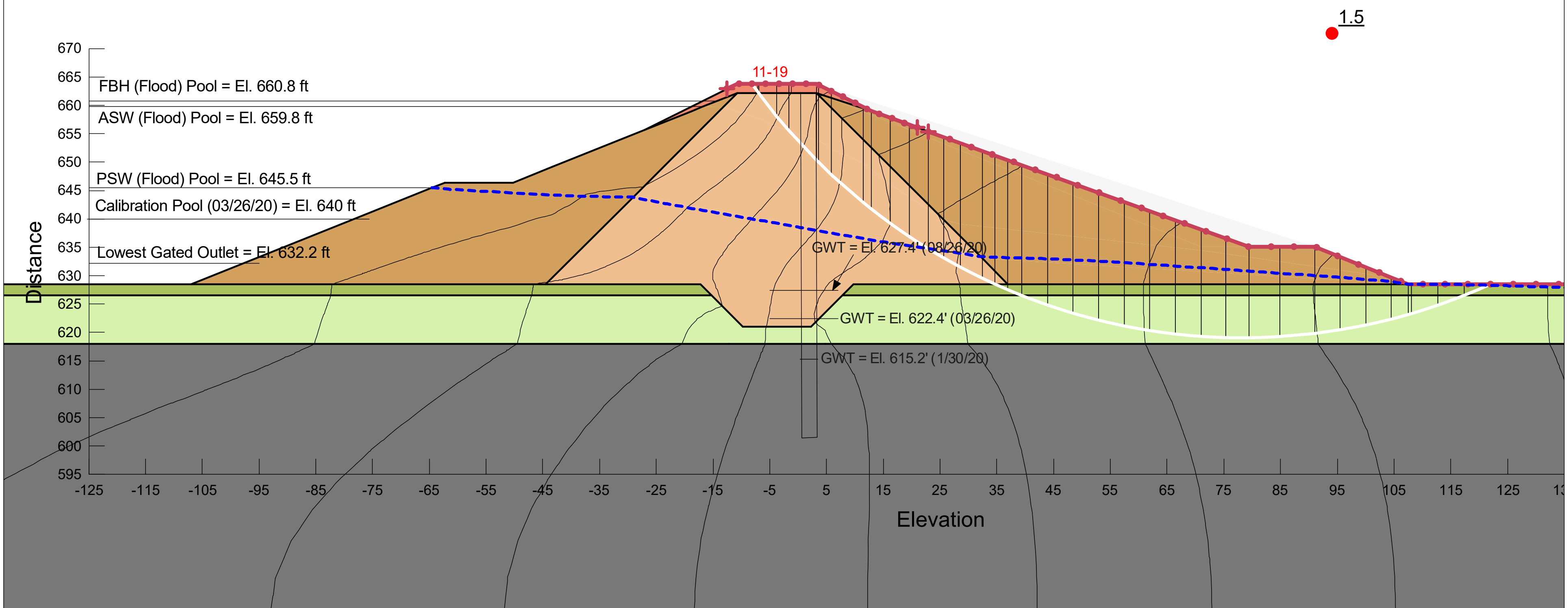
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_Slope_Prop_Emb_PSW_EOC_US_Deep_Failure (EL. 645.5)
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)
	Alluvium (CH)_EOC	Undrained (Phi=0)	123	1,500
	Existing Embankment Fill - Zone I (CH)_EOC	Undrained (Phi=0)	125	1,200
	Existing Embankment Fill - Zone II (SC)_EOC	Undrained (Phi=0)	125	1,200
	Proposed Embankment Fill_EOC	Undrained (Phi=0)	125	1,200
	Residuum (CL-CH)_EOC	Undrained (Phi=0)	126	1,500
	Shale_EOC	Undrained (Phi=0)	130	3,000



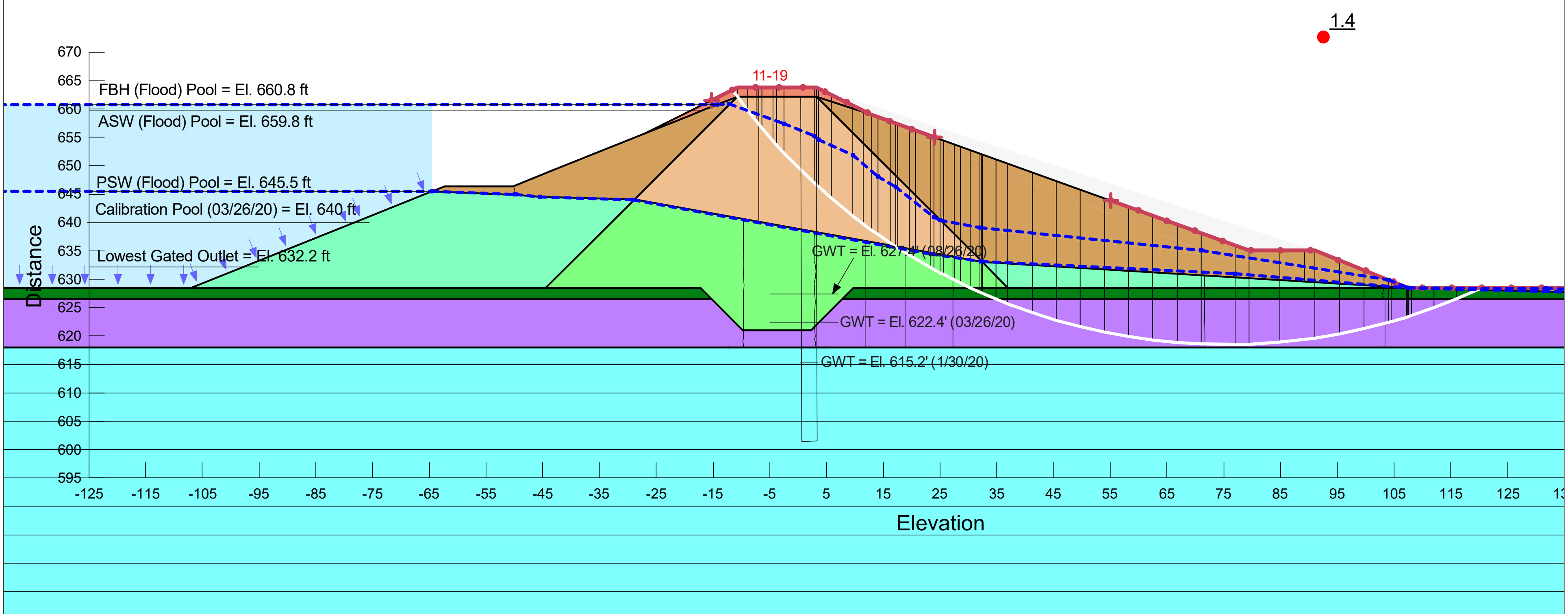
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_Slope_Prop_Emb_PSW_EOC_US_Shallow_Failure (EL. 645.5)
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Alluvium (CH)	Mohr-Coulomb	123	100	23	0
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100	23	0
	Existing Embankment Fill - Zone II (SC)	Mohr-Coulomb	125	100	23	0
	Proposed Embankment Fill	Mohr-Coulomb	125	100	23	0
	Residuum (CL-CH)	Mohr-Coulomb	126	100	23	0
	Shale	Mohr-Coulomb	130	300	23	0



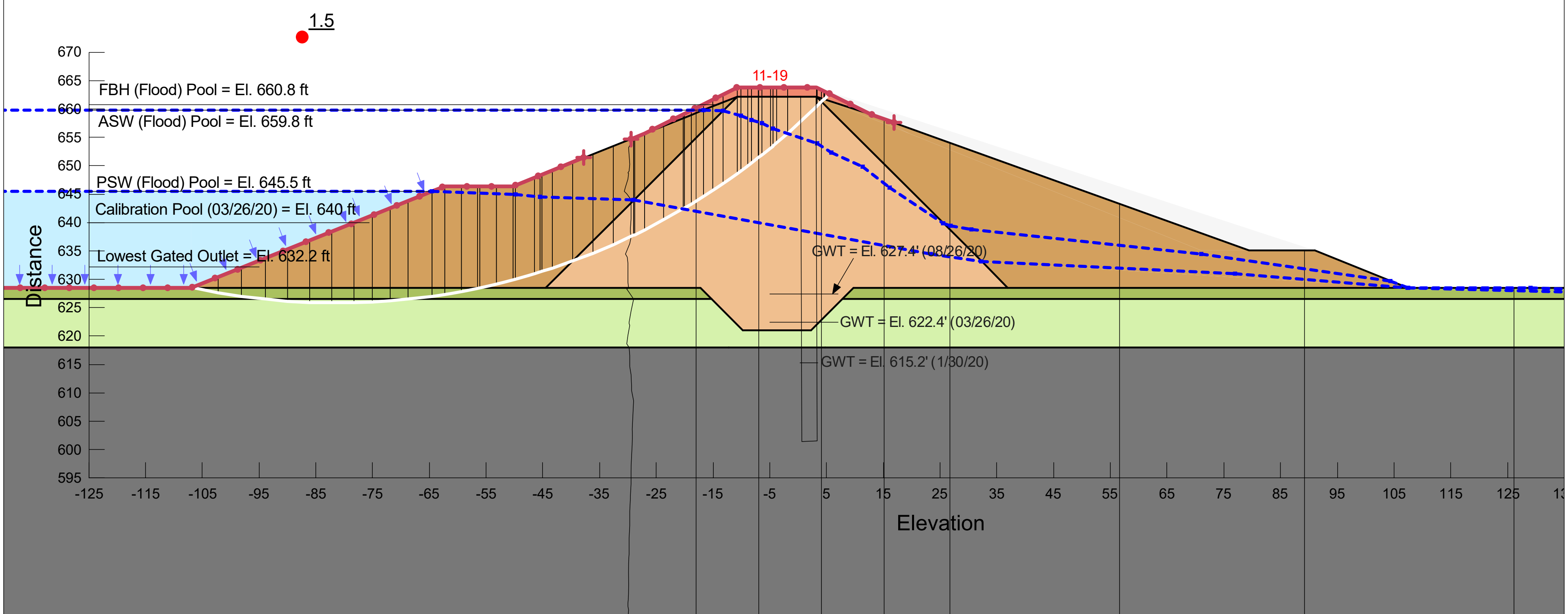
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_Slope_Prop_Emb_PSW (EL. 645.5)
Method: Spencer
Tool Version: 10.2.2.20559

	Alluvium (CH)	Mohr-Coulomb	123	100				23	0	1
	Alluvium (CH)_Bilinear	Bilinear	123	100	23	15	1,917		0	2
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100				23	0	1
	Existing Embankment Fill - Zone I (CH)_Bilinear	Bilinear	125	100	23	15	1,917		0	2
	Existing Embankment Fill - Zone II (SC)	Mohr-Coulomb	125	100				23	0	1
	Existing Embankment Fill - Zone II (SC)_Bilinear	Bilinear	125	100	23	15	1,917		0	2
	Proposed Embankment Fill	Mohr-Coulomb	125	100				23	0	1
	Residuum (CL-CH)	Mohr-Coulomb	126	100				23	0	1
	Residuum (CL-CH)_Bilinear	Bilinear	126	100	23	15	1,917		0	2
	Shale_Bilinear	Bilinear	130	300	23	15	639		0	



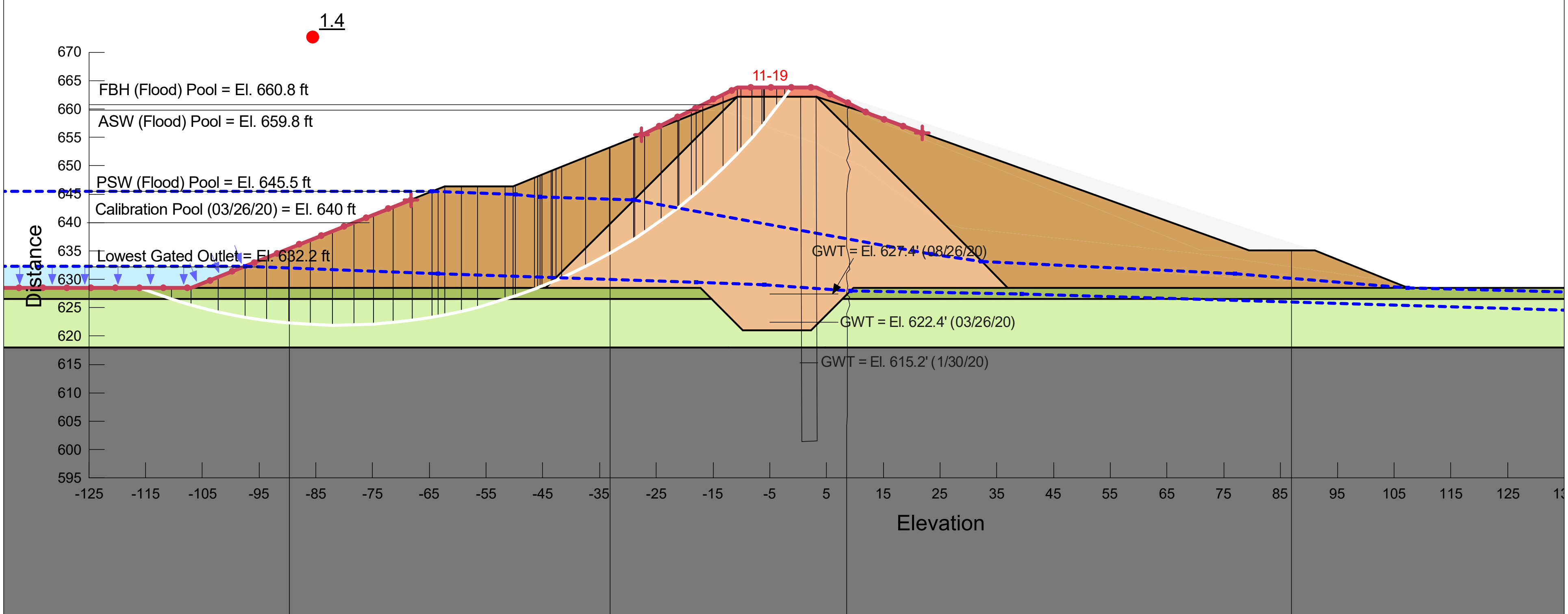
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_Slope_Prop_Emb_FBH (EL. 645.5-660.8)
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	Alluvium (CH)	Mohr-Coulomb	123	100	23	0	400	15	1	2
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100	23	0	400	15	1	2
	Existing Embankment Fill - Zone II (SC)	Mohr-Coulomb	125	100	23	0	400	15	1	2
	Proposed Embankment Fill	Mohr-Coulomb	125	100	23	0	400	15	1	2
	Residuum (CL-CH)	Mohr-Coulomb	126	100	23	0	400	15	1	2
	Shale	Mohr-Coulomb	130	300	23	0	400	15	1	2



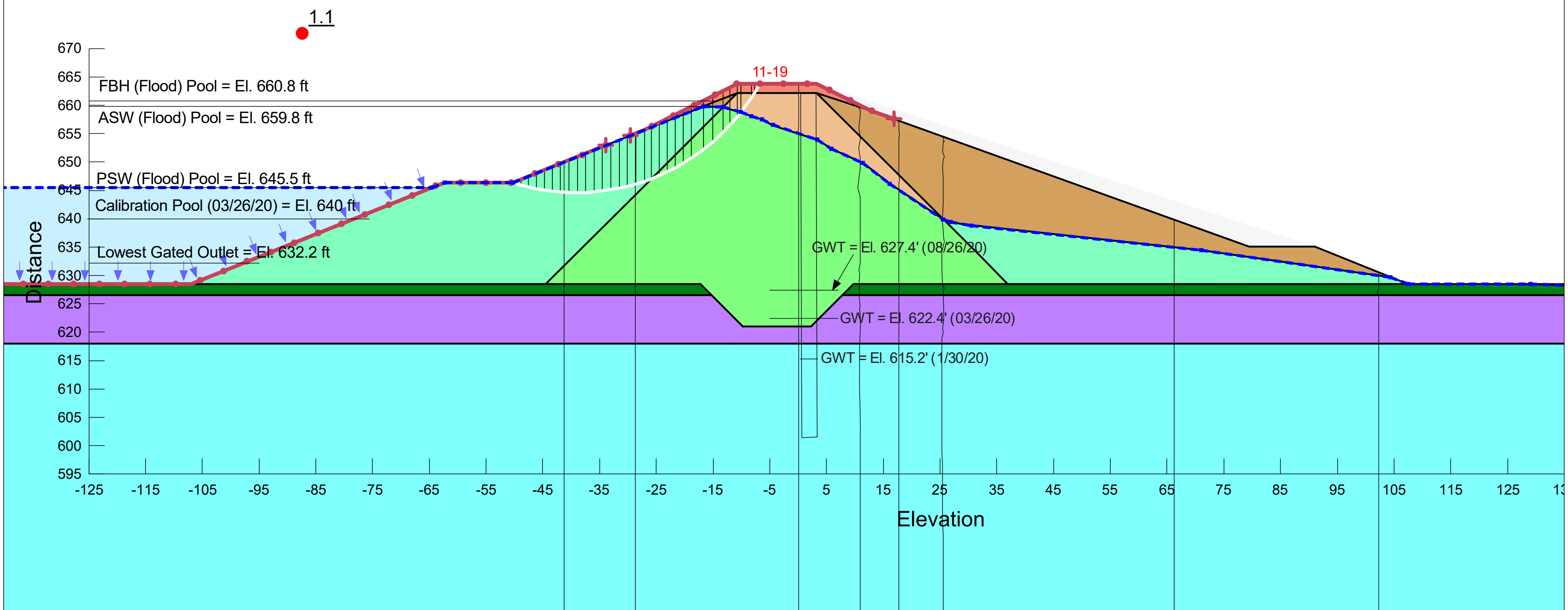
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_Slope_Prop_Emb_3 Stages_RDD_ASW to PSW (EL. 645.5-659.8)
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	Alluvium (CH)	Mohr-Coulomb	123	100	23	0	400	15	1	2
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100	23	0	400	15	1	2
	Existing Embankment Fill - Zone II (SC)	Mohr-Coulomb	125	100	23	0	400	15	1	2
	Proposed Embankment Fill	Mohr-Coulomb	125	100	23	0	400	15	1	2
	Residuum (CL-CH)	Mohr-Coulomb	126	100	23	0	400	15	1	2
	Shale	Mohr-Coulomb	130	300	23	0	400	15	1	2



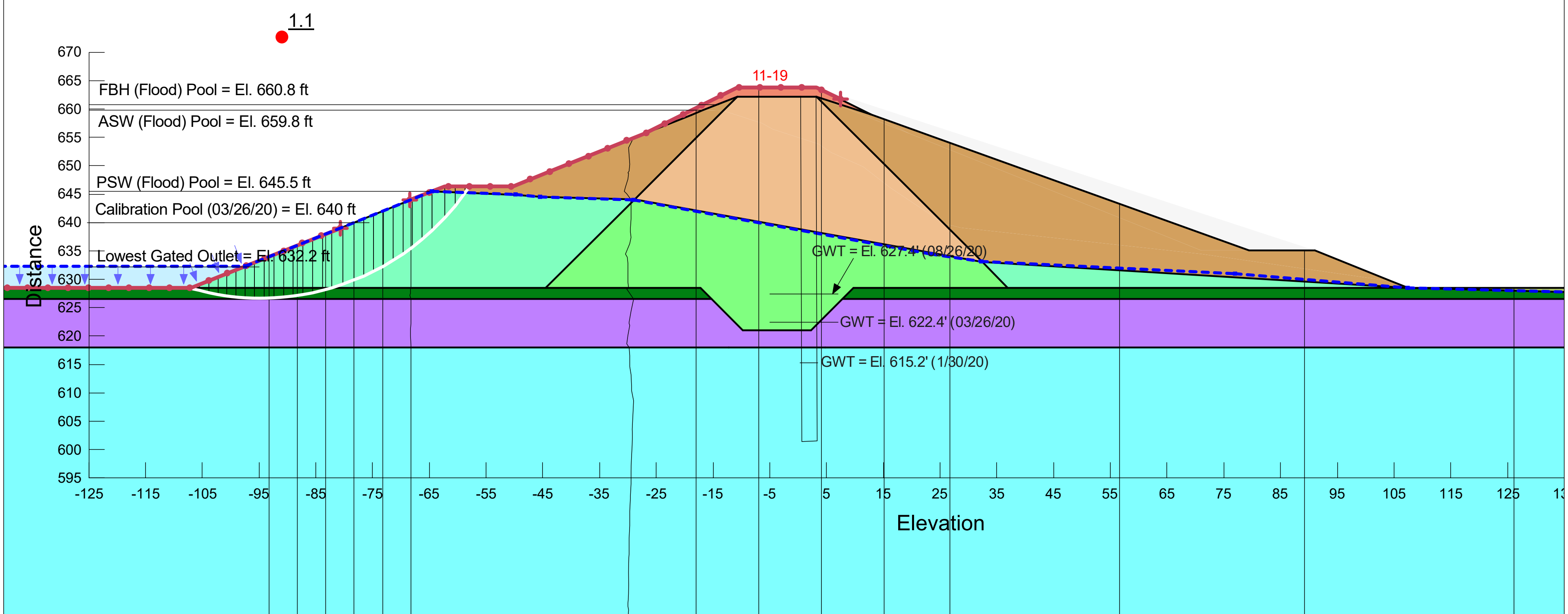
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_Slope_Prop_Emb_3 Stages_RDD_PSW to Lowest Gated(EL. 645.5-632.2)
Method: Spencer
Tool Version: 10.2.2.20559

	Alluvium (CH)	Mohr-Coulomb	123	100				23	0	1
	Alluvium (CH)_Bilinear	Bilinear	123	100	23	15	1,917		0	1
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100				23	0	1
	Existing Embankment Fill - Zone I (CH)_Bilinear	Bilinear	125	100	23	15	1,917		0	1
	Existing Embankment Fill - Zone II (SC)	Mohr-Coulomb	125	100				23	0	1
	Existing Embankment Fill - Zone II (SC)_Bilinear	Bilinear	125	100	23	15	1,917		0	1
	Proposed Embankment Fill	Mohr-Coulomb	125	100				23	0	1
	Residuum (CL-CH)	Mohr-Coulomb	126	100				23	0	1
	Residuum (CL-CH)_Bilinear	Bilinear	126	100	23	15	1,917		0	1
	Shale_Bilinear	Bilinear	130	300	23	15	639		0	1



Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_Slope_Prop_Emb_NRCS_RDD_ASW to PSW (EL. 645.5-659.8)
Method: Spencer
Tool Version: 10.2.2.20559

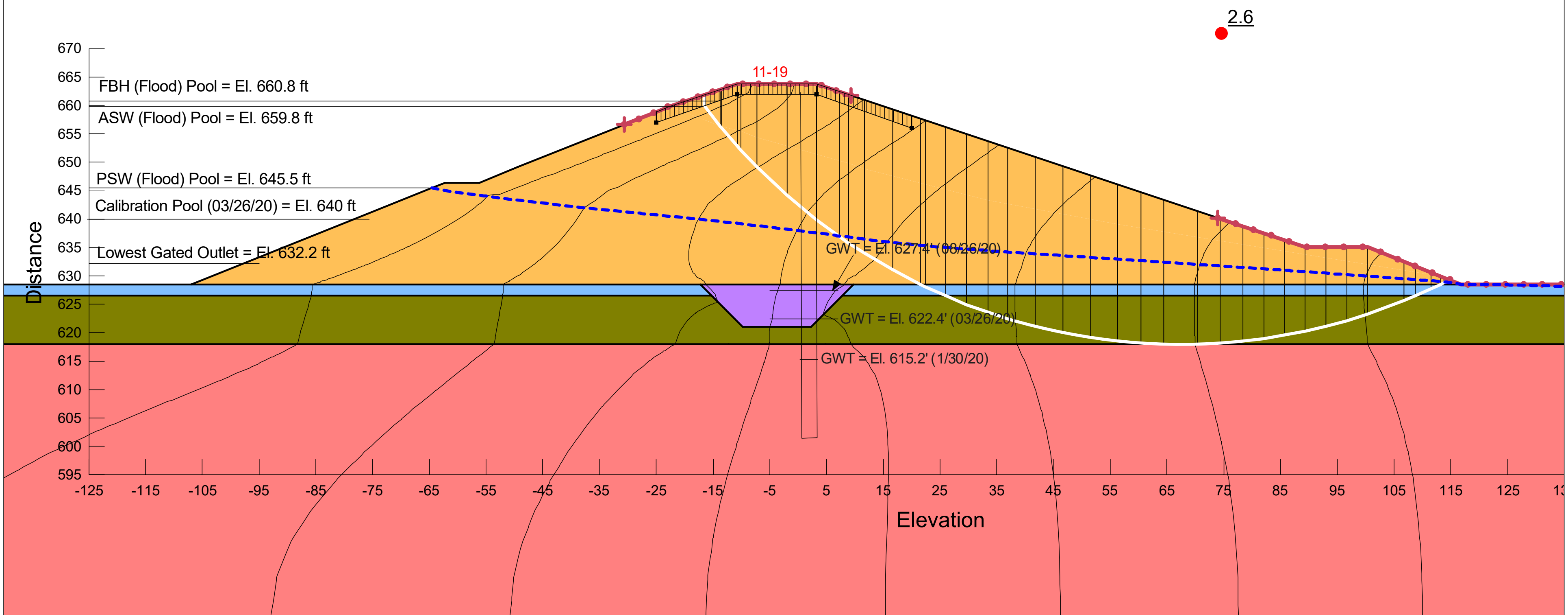
	Alluvium (CH)	Mohr-Coulomb	123	100				23	0	1
	Alluvium (CH)_Bilinear	Bilinear	123	100	23	15	1,917		0	1
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100				23	0	1
	Existing Embankment Fill - Zone I (CH)_Bilinear	Bilinear	125	100	23	15	1,917		0	1
	Existing Embankment Fill - Zone II (SC)	Mohr-Coulomb	125	100				23	0	1
	Existing Embankment Fill - Zone II (SC)_Bilinear	Bilinear	125	100	23	15	1,917		0	1
	Proposed Embankment Fill	Mohr-Coulomb	125	100				23	0	1
	Residuum (CL-CH)	Mohr-Coulomb	126	100				23	0	1
	Residuum (CL-CH)_Bilinear	Bilinear	126	100	23	15	1,917		0	1
	Shale_Bilinear	Bilinear	130	300	23	15	639		0	1



Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_Slope_Prop_Emb_NRCS_RDD_PSW to Lowest Gated(EL. 645.5-632.2)
Method: Spencer
Tool Version: 10.2.2.20559

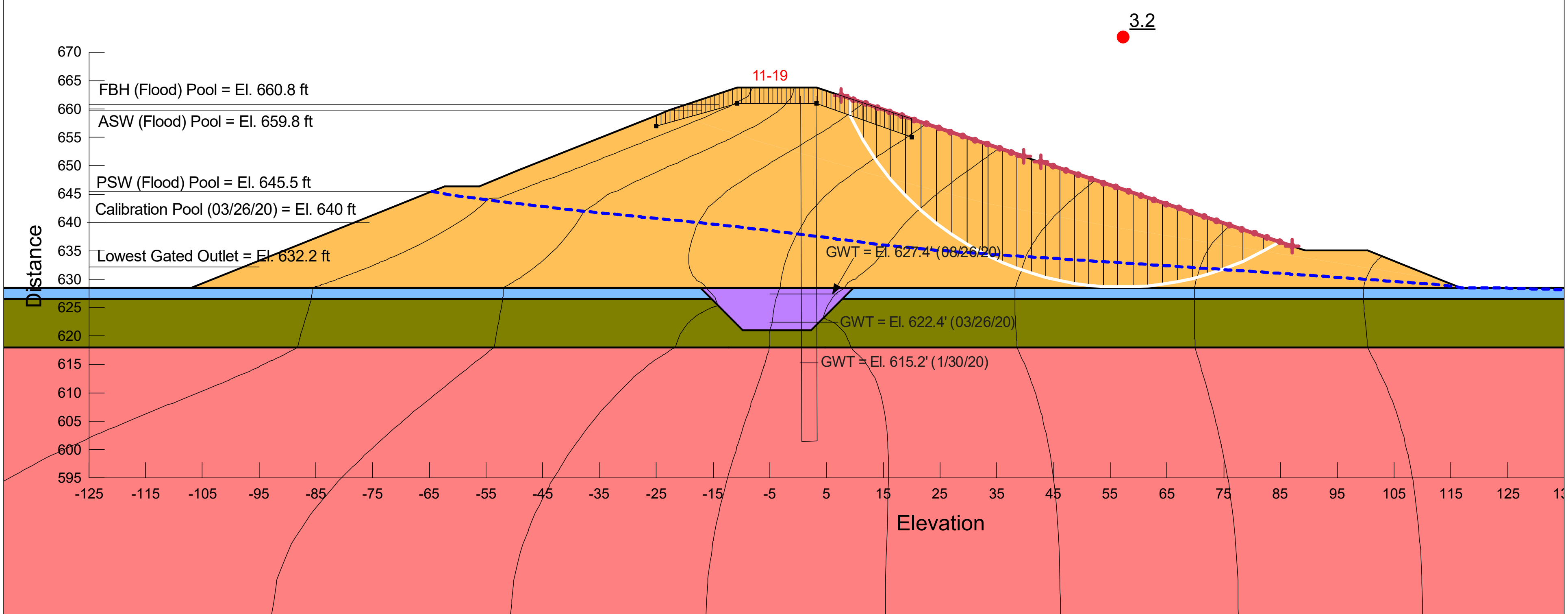
Station 23+50 (Proposed Embankment Reconstruction at New PSW)

Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)
	Alluvium (CH)_EOC	Undrained (Phi=0)	123	1,500
	Existing Embankment Fill - Zone I (CH)_EOC	Undrained (Phi=0)	125	1,200
	Proposed Embankment Fill_EOC	Undrained (Phi=0)	125	1,200
	Residuum (CL-CH)_EOC	Undrained (Phi=0)	126	1,500
	Shale_EOC	Undrained (Phi=0)	130	3,000



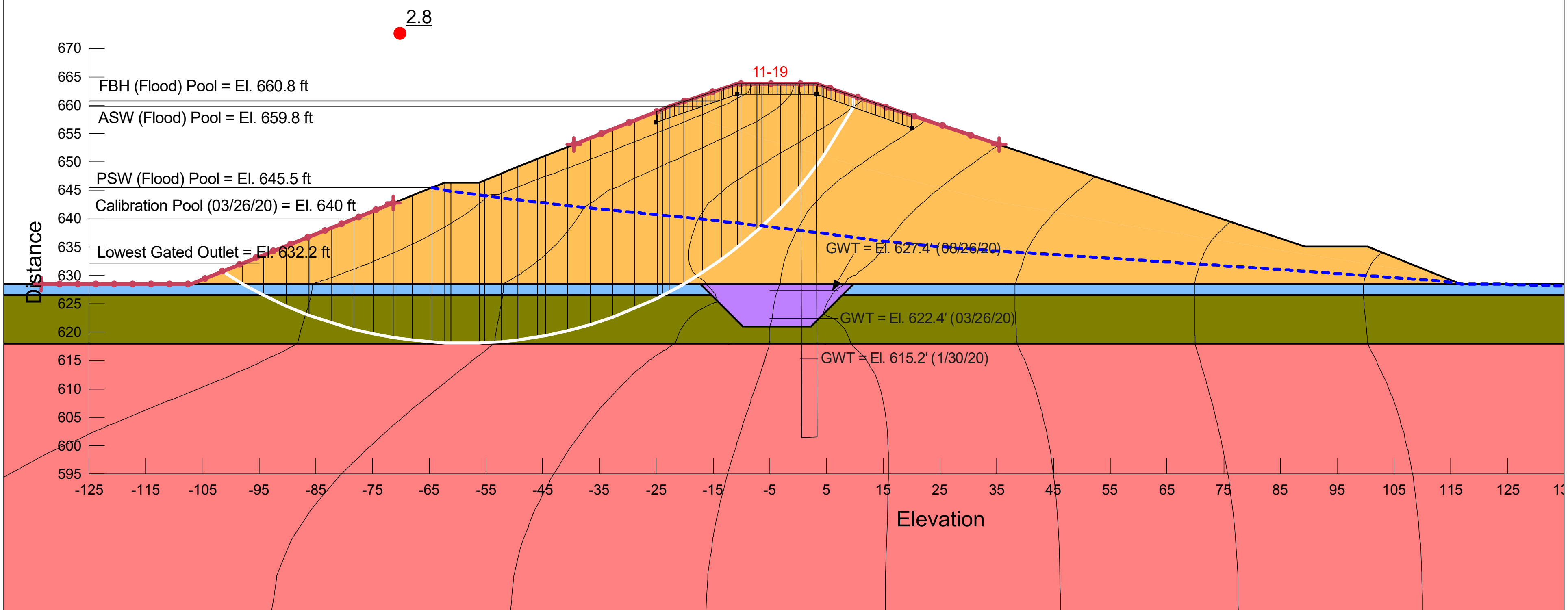
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_new_Slope_Prop_Emb_PSW_EOC_DS_Deep_Failure (EL. 645.5) (2)
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)
	Alluvium (CH)_EOC	Undrained (Phi=0)	123	1,500
	Existing Embankment Fill - Zone I (CH)_EOC	Undrained (Phi=0)	125	1,200
	Proposed Embankment Fill_EOC	Undrained (Phi=0)	125	1,200
	Residuum (CL-CH)_EOC	Undrained (Phi=0)	126	1,500
	Shale_EOC	Undrained (Phi=0)	130	3,000



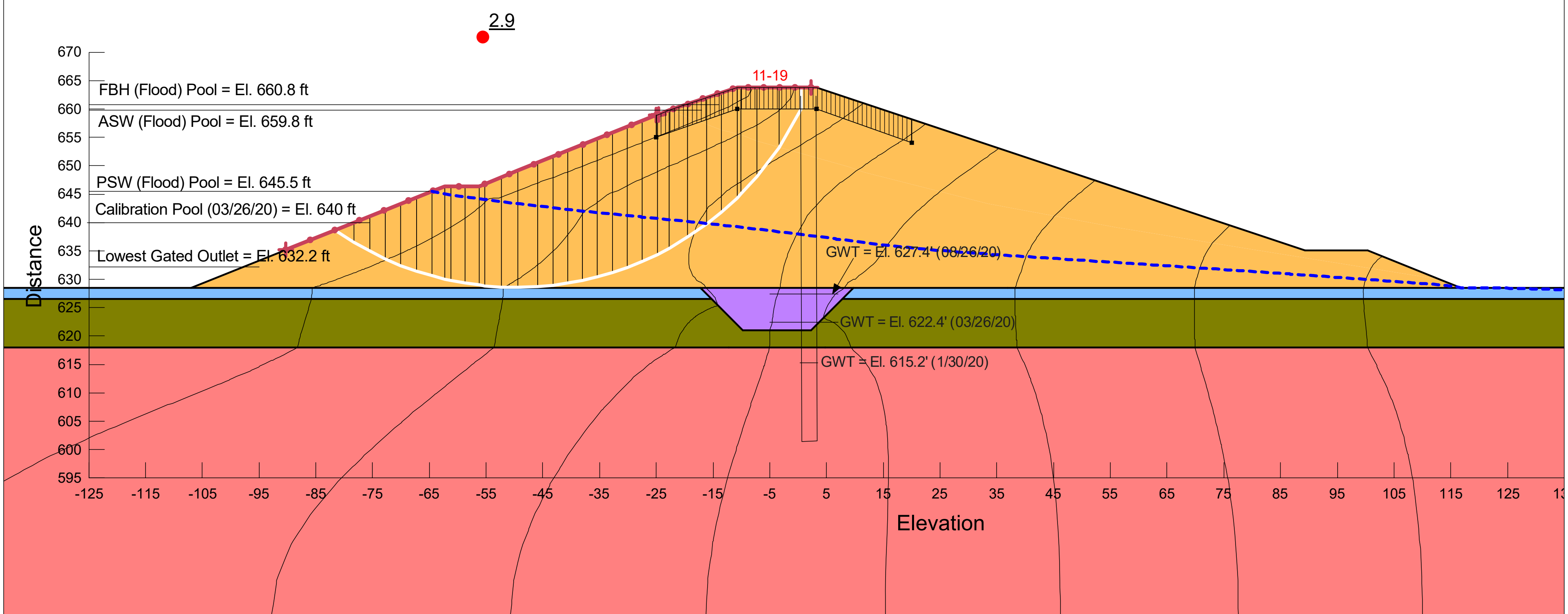
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_new_Slope_Prop_Emb_PSW_EOC_DS_Shallow_Failure (EL. 645.5) (2)
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)
	Alluvium (CH)_EOC	Undrained (Phi=0)	123	1,500
	Existing Embankment Fill - Zone I (CH)_EOC	Undrained (Phi=0)	125	1,200
	Proposed Embankment Fill_EOC	Undrained (Phi=0)	125	1,200
	Residuum (CL-CH)_EOC	Undrained (Phi=0)	126	1,500
	Shale_EOC	Undrained (Phi=0)	130	3,000



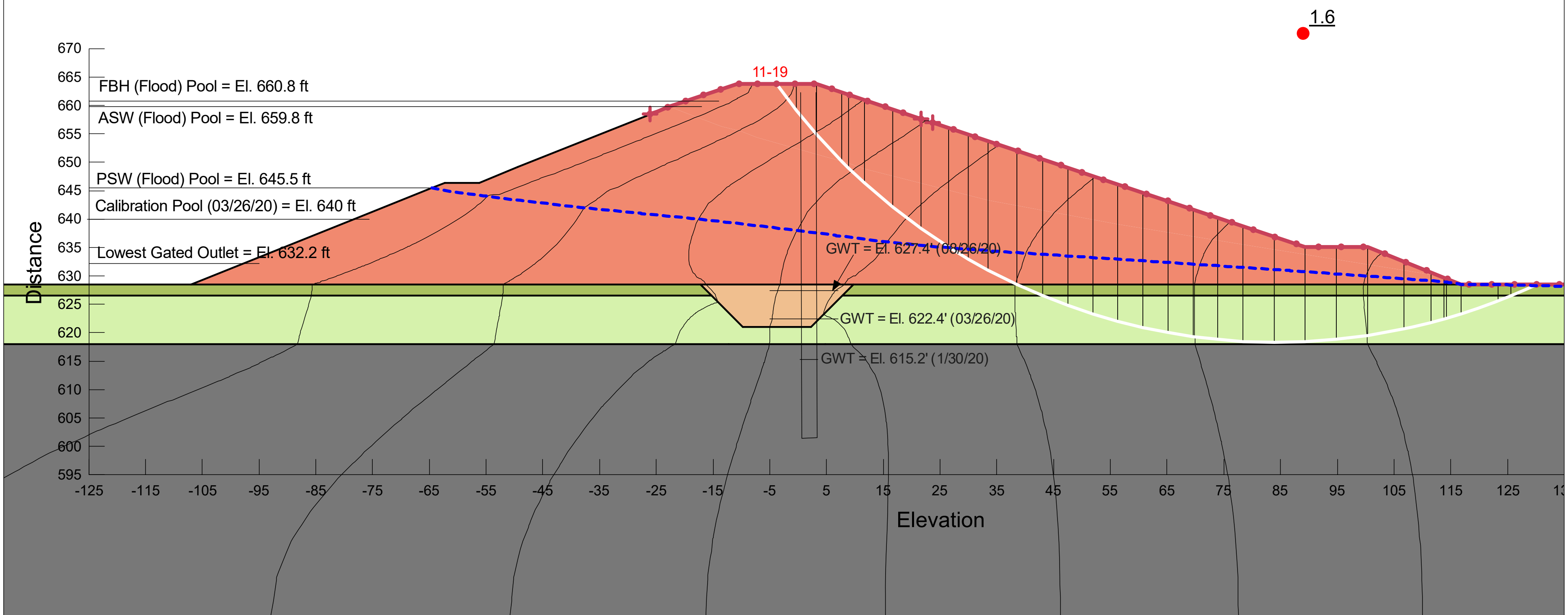
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_new_Slope_Prop_Emb_PSW_EOC_US_Deep_Failure (EL. 645.5) (2)
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)
	Alluvium (CH)_EOC	Undrained (Phi=0)	123	1,500
	Existing Embankment Fill - Zone I (CH)_EOC	Undrained (Phi=0)	125	1,200
	Proposed Embankment Fill_EOC	Undrained (Phi=0)	125	1,200
	Residuum (CL-CH)_EOC	Undrained (Phi=0)	126	1,500
	Shale_EOC	Undrained (Phi=0)	130	3,000



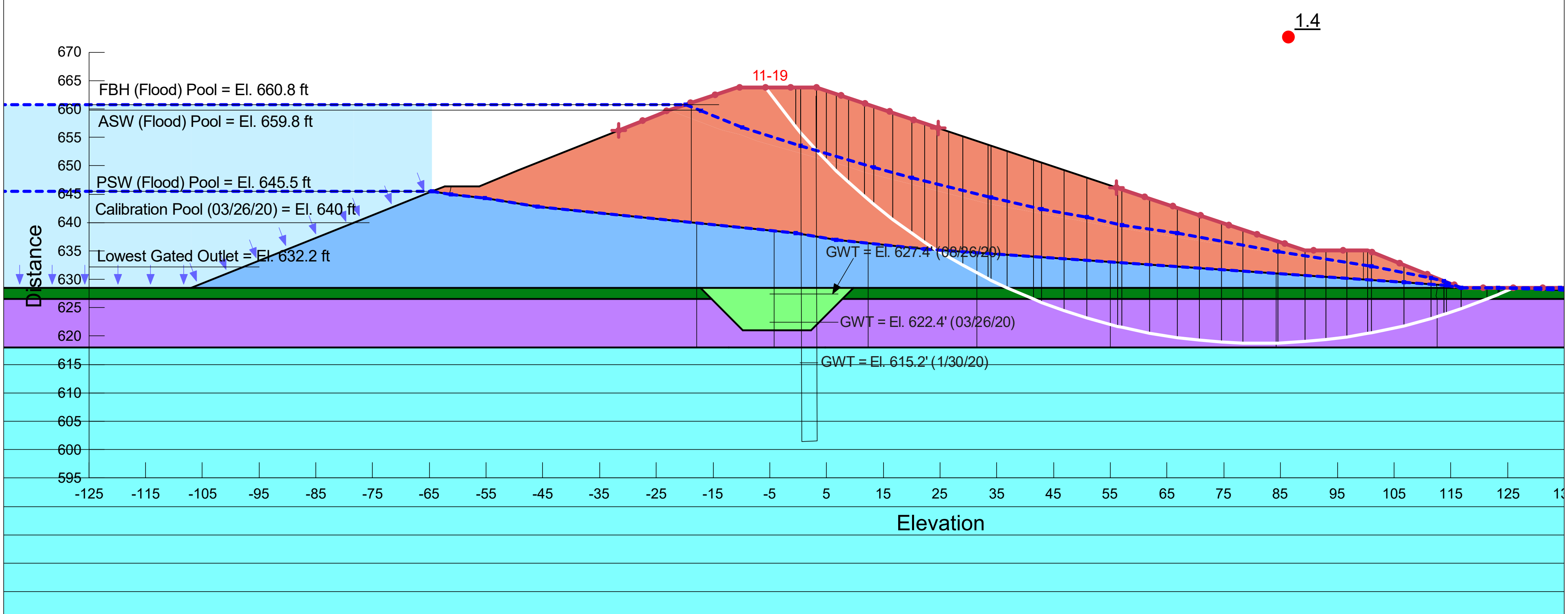
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_new_Slope_Prop_Emb_PSW_EOC_US_Shallow_Failure (EL. 645.5) (2)
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Alluvium (CH)	Mohr-Coulomb	123	100	23	0
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100	23	0
	Proposed Embankment Fill	Mohr-Coulomb	125	100	23	0
	Residuum (CL-CH)	Mohr-Coulomb	126	100	23	0
	Shale	Mohr-Coulomb	130	300	23	0



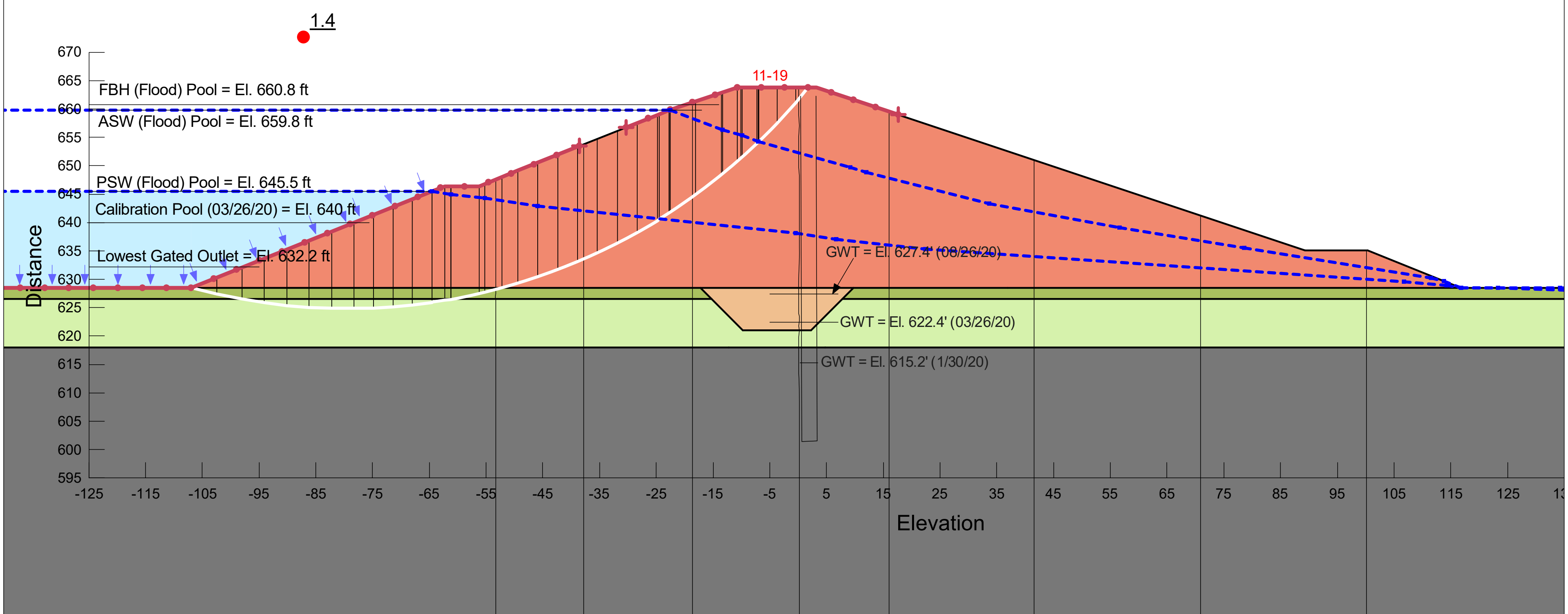
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_new_Slope_Prop_Emb_PSW (EL. 645.5) (2)
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi 1 (°)	Phi 2 (°)	Bilinear Normal (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	Alluvium (CH)	Mohr-Coulomb	123	100				23	0	1
	Alluvium (CH)_Bilinear	Bilinear	123	100	23	15	1,917		0	2
	Existing Embankment Fill - Zone I (CH)_Bilinear	Bilinear	125	100	23	15	1,917		0	2
	Proposed Embankment Fill	Mohr-Coulomb	125	100				23	0	1
	Proposed Embankment Fill_Bilinear	Bilinear	125	100	23	15	1,917		0	2
	Residuum (CL-CH)	Mohr-Coulomb	126	100				23	0	1
	Residuum (CL-CH)_Bilinear	Bilinear	126	100	23	15	1,917		0	2
	Shale_Bilinear	Bilinear	130	300	23	15	639		0	



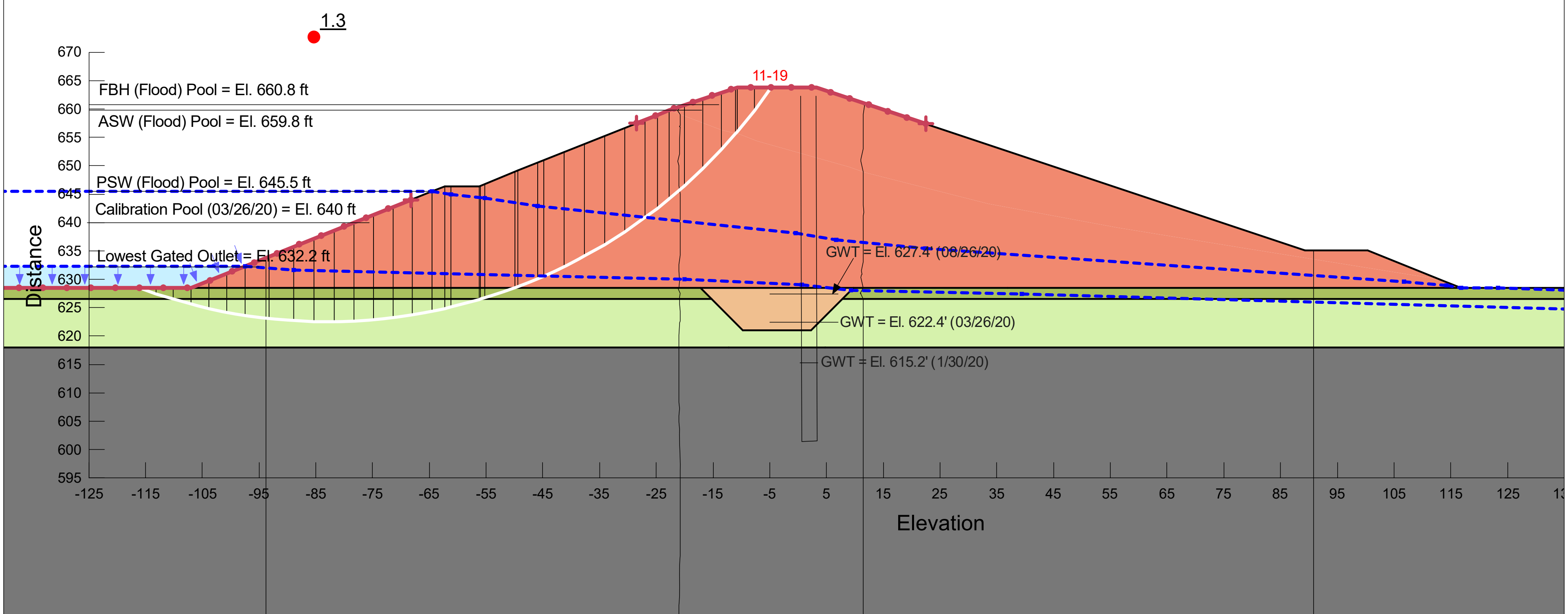
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_new_Slope_Prop_Emb_FBH (EL. 645.5-660.8) (2)
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	Alluvium (CH)	Mohr-Coulomb	123	100	23	0	400	15	1	2
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100	23	0	400	15	1	2
	Proposed Embankment Fill	Mohr-Coulomb	125	100	23	0	400	15	1	2
	Residuum (CL-CH)	Mohr-Coulomb	126	100	23	0	400	15	1	2
	Shale	Mohr-Coulomb	130	300	23	0	400	15	1	2



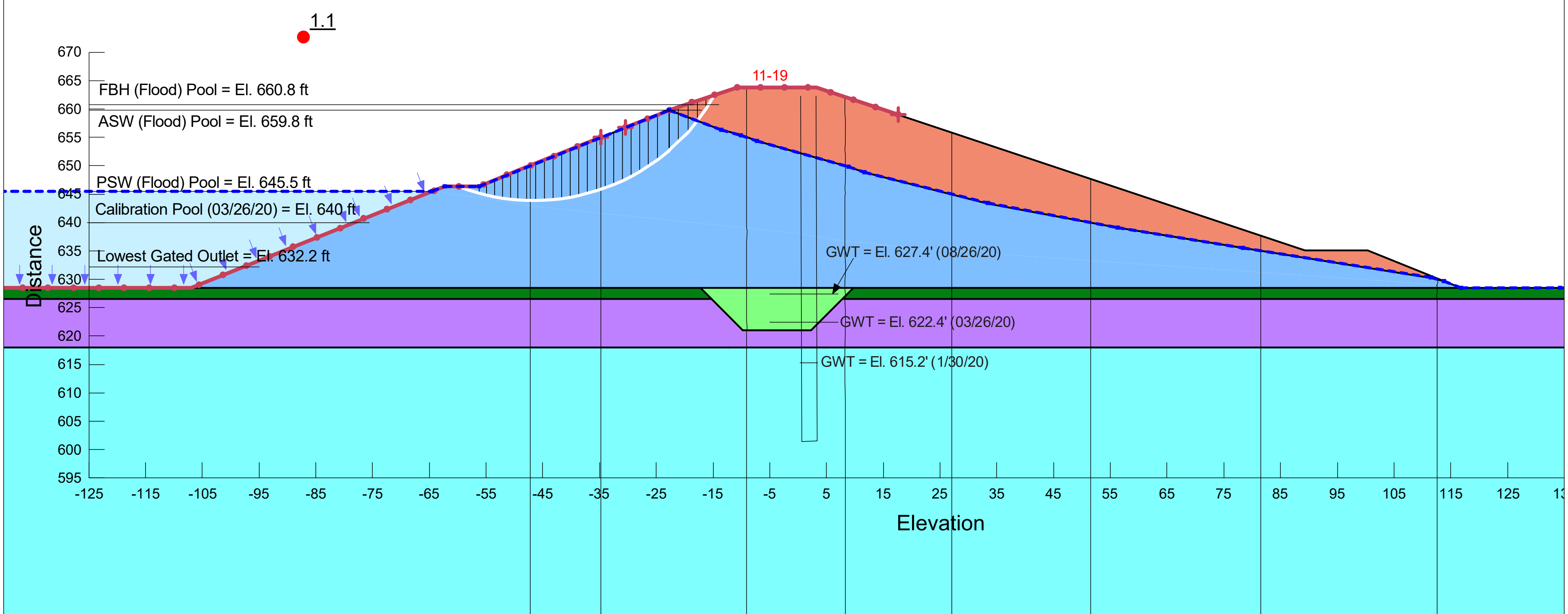
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_new_Slope_Prop_Emb_3 Stages_RDD_ASW to PSW (EL. 645.5-659.8) (2)
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	Alluvium (CH)	Mohr-Coulomb	123	100	23	0	400	15	1	2
	Existing Embankment Fill - Zone I (CH)	Mohr-Coulomb	125	100	23	0	400	15	1	2
	Proposed Embankment Fill	Mohr-Coulomb	125	100	23	0	400	15	1	2
	Residuum (CL-CH)	Mohr-Coulomb	126	100	23	0	400	15	1	2
	Shale	Mohr-Coulomb	130	300	23	0	400	15	1	2



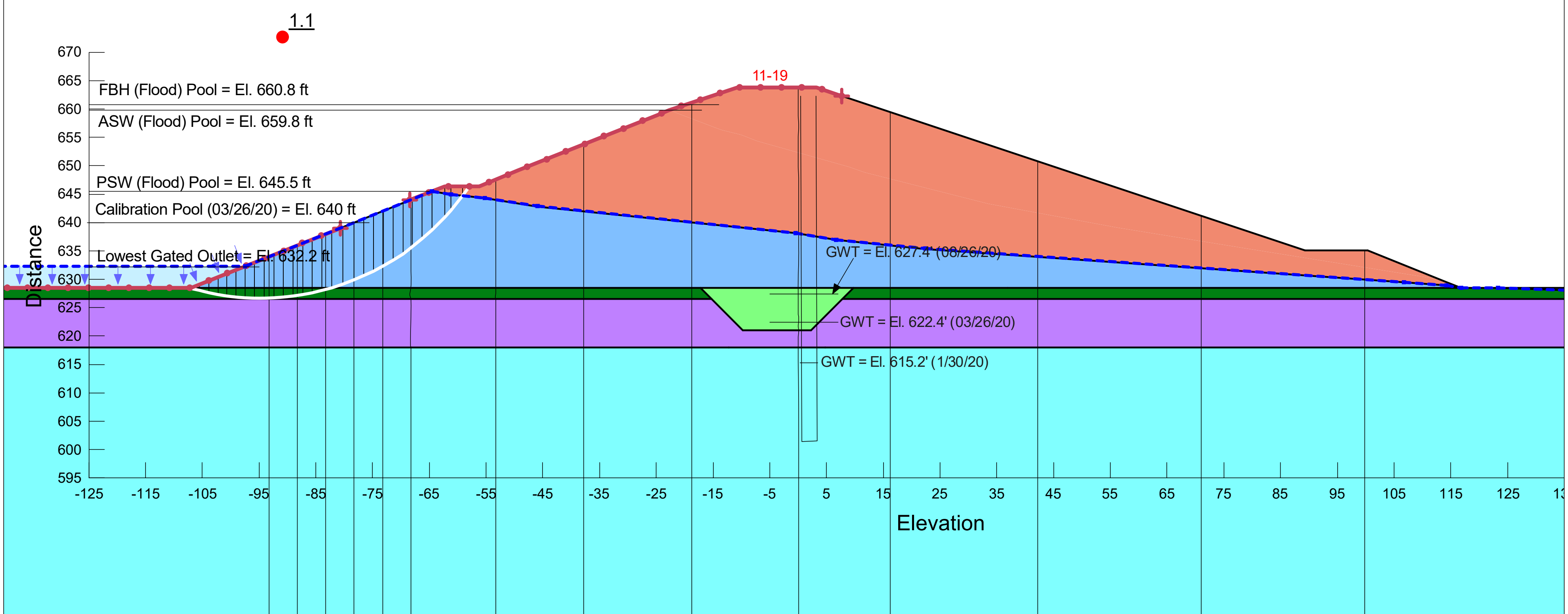
Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_new_Slope_Prop_Emb_3 Stages_RDD_PSW to Lowest Gated(EL. 645.5-632.2) (2)
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi 1 (°)	Phi 2 (°)	Bilinear Normal (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	Alluvium (CH)	Mohr-Coulomb	123	100				23	0	1
	Alluvium (CH)_Bilinear	Bilinear	123	100	23	15	1,917		0	1
	Existing Embankment Fill - Zone I (CH)_Bilinear	Bilinear	125	100	23	15	1,917		0	1
	Proposed Embankment Fill	Mohr-Coulomb	125	100				23	0	1
	Proposed Embankment Fill_Bilinear	Bilinear	125	100	23	15	1,917		0	1
	Residuum (CL-CH)	Mohr-Coulomb	126	100				23	0	1
	Residuum (CL-CH)_Bilinear	Bilinear	126	100	23	15	1,917		0	1
	Shale_Bilinear	Bilinear	130	300	23	15	639		0	1



Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_new_Slope_Prop_Emb_NRCS_RDD_ASW to PSW (EL. 645.5-659.8) (2)
Method: Spencer
Tool Version: 10.2.2.20559

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi 1 (°)	Phi 2 (°)	Bilinear Normal (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	Alluvium (CH)	Mohr-Coulomb	123	100				23	0	1
	Alluvium (CH)_Bilinear	Bilinear	123	100	23	15	1,917		0	1
	Existing Embankment Fill - Zone I (CH)_Bilinear	Bilinear	125	100	23	15	1,917		0	1
	Proposed Embankment Fill	Mohr-Coulomb	125	100				23	0	1
	Proposed Embankment Fill_Bilinear	Bilinear	125	100	23	15	1,917		0	1
	Residuum (CL-CH)	Mohr-Coulomb	126	100				23	0	1
	Residuum (CL-CH)_Bilinear	Bilinear	126	100	23	15	1,917		0	1
	Shale_Bilinear	Bilinear	130	300	23	15	639		0	1



Title: TSSWCB Plum FRS No. 2 Rehabilitation
Name: Sta_23+50_new_Slope_Prop_Emb_NRCS_RDD_PSW to Lowest Gated(EL. 645.5-632.2) (2)
Method: Spencer
Tool Version: 10.2.2.20559

Appendix E Embankment Settlement

AECOM

				Calc No.:	4
Job:	Plum Creek FRS No. 2 Rehabilitation	Project No.	60615067	Page:	1 of 8
Description:	Embankment Settlement Analysis	Computed By:	L. Finnefrock	Date:	6/4/2021
		Checked By:	A. Bukkapatnam	Date:	

OBJECTIVES:

1. Develop stratigraphy and consolidation parameters for subgrade soils,
2. Develop surcharge load distribution associated with new embankment fill;
3. Perform calculations to develop estimates of settlement for proposed embankment fill; and
4. Provide design recommendations based on results of settlement analysis.

REFERENCES:

External references:

1. Holtz, R. D., Kovacs, W. D., & Sheahan, T. C. (2010). Chapter 8 Compressibility of Soil and Rock. In *An introduction to geotechnical engineering* (2nd. ed.). Pearson.
2. Holtz, R. D., Kovacs, W. D., & Sheahan, T. C. (2010). Chapter 9.3 Terzaghi's One Dimensional Consolidation Theory. In *An introduction to geotechnical engineering* (2nd. ed.). Pearson.
3. Holtz, R. D., Kovacs, W. D., & Sheahan, T. C. (2010). Chapter 10.3.2 Boussinesq Theory. In *An introduction to geotechnical engineering* (2nd. ed.). Pearson.

Project specific references:
1. USDA-SCS. 1967. Geologic Investigation Report (GIR), Plum Creek Watershed, Site No. 2.
2. USDA-SCS. 1967. Soil Mechanics Report (SMR), Plum Creek Site 2.
3. USDA-SCS. 1969. As-Built Drawings, Plum Creek Watershed Project Floodwater Retarding Dam No. 2.
4. AECOM. 2021. GIR, Plum Creek Watershed FRS No. 2 Rehabilitation Design.
5. AECOM. 2021. SMR, Plum Creek Watershed FRS No. 2 Rehabilitation Design.
6. AECOM. 2020. 90% Design Drawings, Floodwater Retarding Structure Site No. 2 Rehabilitation Caldwell County, Texas.

PROJECT DESCRIPTION

Rehabilitation of the Plum Creek Watershed FRS No. 2 will generally include the following design elements:

- Raising the existing auxiliary spillway (ASW) crest by 1.15 feet to El. 659.8 feet;
- Widening the existing ASW from 150 feet to 250 feet;
- Constructing a new 200-foot-wide roller-compacted concrete (RCC) spillway with crest at El. 658.6 feet;
- Replacing the existing 30-inch principal spillway (PSW) conduit with a new 48-inch diameter conduit, and constructing new PSW impact basin and inlet riser with crest at El. 645.4 feet;
- Adding a new impact basin for the principal spillway outlet; and
- Restoring the crest of the dam to nominal elevation of 662.8 feet.

Refer to the GIR, SMR, and 90% design drawings for additional project details.

MATERIAL CHARACTERIZATION

Site stratigraphy is described in detail in the Geologic Investigation Report and Soil Mechanics Report. Characterization of the various materials with respect to consolidation and settlement behavior are described as follows:

- Embankment Fill: The existing Embankment Fill was generally described on the boring logs as medium stiff to hard fat clay (CH) with minor sand, silt, and/or gravel content. This unit is expected to experience slow drainage and exhibit long-term consolidation characteristics due to high fines and clay contents.

- Downstream Fill: Suspected Downstream Fill materials up to about 8 feet thick were encountered in boring 305-19, which was drilled on the PSW crossing berm at the downstream toe. While boring 603-19 was drilled within these station limits, it appears to have been drilled just downstream of the fill area based on visual characteristics of the material and examination of topographic data. The suspected fill material consisted of medium stiff to hard lean to fat clay (CL, CH). The fill designation was due to a somewhat lower consistency of this material. However, the visual similarity of the fill to natural overburden materials suggests that this unit is likely reworked residuum/alluvium. This unit is expected to experience slow drainage and exhibit long-term consolidation characteristics due to high fines and clay contents.

- Alluvium: This unit consisted of dark brown, medium stiff to hard fat clays (CH) with minor proportion of sand and/or gravel ranging from 0 to 20%. The Alluvium contained trace to abundant organics, trace to some fine to coarse subrounded to subangular gravel, calcareous nodules and inclusions, iron oxidation staining, and trace shell fragments. This unit is expected to experience slow drainage and exhibit long-term consolidation characteristics due to high fines and clay contents.

- Residuum: This unit consisted of light gray to tan, medium stiff to hard lean to fat clays (CL, CH) with some clayey sand (SC) and silty clay (CL-ML) layers. Characterization of this material in the GIR and SMR was subdivided into a calacareous and friable Low Plasticity Residuum (LPR) consisting mostly of silty CL and some CH with less frequent SC and CL-ML intervals, and a Medium Plasticity Residuum (MPR) consisting of consisting of CH with some CL intervals. For engineering analysis, this material was generally considered as a single “Residuum”. This unit is expected to experience slow drainage and exhibit long-term consolidation characteristics due to high fines and clay contents.

- Shale: This unit consisted of extremely weak to weak calcareous shale with occasional chalky marl layers. The weathering ranged from moderately to highly weathered. On the basis of SPT N-values, the shale is considered to be “unyielding” and will not experience consolidation characteristics.

Proposed fill materials include fine and coarse filter/drain fill, RCC, and new embankment fill. These materials are described below.

- Drain Fill: This material will consist of a compacted fine filter and a coarse filter with gradations similar to ASTM C-33 aggregates. These materials will be placed under the RCC spillway and around the new and existing PSW conduits. These materials are free-draining.

- RCC: This material will consist of low-slump concrete compacted in lifts that will be used to construct the RCC spillway. The material was treated as relatively low permeability with high frictional resistance.

- New Embankment Fill: The proposed embankment fill will be constructed of moisture-conditioned and recompacted clayey soils from on-site and/or imported borrow sources. Selective placement of imported low-plasticity (PI=7-15) lean clay (CL) or clayey sand (SC) is planned for under and adjacent to the RCC spillway to reduce swelling potential. The exterior zones of planned embankment fill (crest re-shaping and embankment reconstruction at new PSW) will be low-plasticity clay/clayey sand (CL, SC) with LL<50 and PI=10-30. Interior zones of planned embankment fill for reconstruction at new PSW will consist of medium- to high-plasticity clays (CL, CH) with LL<60 and PI=10-35. Considering the clayey composition of proposed embankment fill, this material was considered to exhibit both undrained and drained strength behavior.

EMBANKMENT SETTLEMENT ANALYSIS

Proposed Embankment Fill Locations and Analysis Sections

- Existing Embankment Modification: The Plum Creek 2 rehabilitation will not include a raise of the embankment crest or flattening of either the upstream or downstream slopes, and thus the embankment prism will remain largely unchanged by the rehabilitation. Except for the areas of the new PSW and RCC spillway, modification of the existing embankment will be limited to minor amounts of new fill to level the embankment crest, and possibly some minor cut/fill grading to smooth the embankment slopes. Consequently, anticipated settlement of the embankment is minor to negligible, and settlement calculations are not required at this location.

- Embankment Reconstruction at Proposed PSW: Construction of the proposed new PSW structures will require a full breach excavation of the dam embankment. Preliminary design grades indicate the excavation will extend to a minimum El. 631, which is approximately 31 feet below the existing embankment crest. Following installation of the PSW, the embankment will be reconstructed back to current grade using embankment fill with no significant change in embankment geometry. Therefore, negligible settlement is expected in the underlying foundation soils, and consolidation settlement calculations are not required. However, self-weight consolidation of the new 31-foot thick clay fill needs to be considered to evaluate the need for overbuild at the crest, and will be discussed later.

- ASW Training Dikes: Design drawings indicate that construction of a new training dike (earthfill berm) will be required to contain flows on the right side of the proposed ASW channel widening. The training dike will have a crest width of about 12 feet and 3H:1V sideslopes. Maximum proposed height is about 7.4 feet at ASW centerline

STA. 10+68. Settlement analysis was performed for the maximum height section (STA. 10+68) to develop an estimate of required overbuild (if necessary) to compensate for fill-induced consolidation of the subgrade soils.

- RCC Spillway Outlet Channel Training Dikes: Design drawings indicate that construction of a new training dike (earthfill berm) will be required to contain flows on the right side of the proposed outlet channel downstream of the RCC spillway stilling basin. The training dike will have a crest width of about 12 feet and 3H:1V sideslopes. Maximum proposed height is about 6.5 feet just downstream of the stilling basin. Settlement analysis was performed for the maximum height section to develop an estimate of required overbuild (if necessary) to compensate for fill-induced consolidation of the subgrade soils.

Consolidation Parameters

Consolidation parameters selected for settlement analysis and foundation design were based on the results of laboratory consolidation testing, correlation with field and laboratory strength tests, and experience at nearby sites and other sites within Central Texas. Development of consolidation parameters is discussed under separate cover in the “Material Properties Calculation Package”. A summary of subgrade stratigraphy and consolidation parameters used for each of the two analysis locations is provided in Tables 1 and 2.

Groundwater Assumptions

Groundwater levels for analysis were estimated based on measured groundwater levels in the borings and piezometers. Groundwater measurement from borings are discussed in the Geologic Investigation Report and the “Material Properties Calculation Package”.

For the purposes of settlement analysis, the following groundwater levels were used.

- ASW Widening Right Training Dike: El. 637 (20 feet below existing grade)
- RCC Spillway Outlet Channel Right Training Dike: El. 638 (8 feet below footing base)

Design Criteria

No specific NRCS criteria exist regarding tolerable settlement for embankments. Design criteria for the embankment raise is to ensure the post-settlement embankment crest elevation meets the minimum design freeboard criteria. AECOM has assumed that embankment overbuild will be required in cases where the estimated total crest settlement exceeds 3 inches.

Methodology

Settlement analyses were conducted according to Terzaghi’s one-dimensional theory of consolidation using a spreadsheet developed by AECOM. The analysis modeled the proposed dike geometry as a non-uniform distributed load of infinite length to estimate consolidation settlement in the underlying foundations soils. The distribution of surface stresses with depth was estimated according to Boussinesq's equations which incorporate the theory of elasticity.

Self-weight consolidation of the proposed fill material was conservatively added to the calculated consolidation settlements in foundation soils. Published literature suggests self-weight compression for embankment fills typically ranges from about 0.5 to 2% of the fill height. AECOM assumed self-weight compression equal to 1% of the fill height for the compacted embankment fill materials, and this was incorporated into the settlement evaluation as applicable.

The estimated self-weight compression of fill and consolidation of foundation materials were conservatively assumed to occur post-construction, although it is likely that some of the settlement will occur during typical construction duration. Time-rate consolidation calculations can be performed if a more accurate estimate of settlement versus time is required based on the estimated coefficient of consolidation (Cv) presented in Tables 1-2.

Table 1. Consolidation Parameters for Settlement Analysis – ASW Training Dikes

Material	Depth Interval (ft bgs)	γ (pcf)	e_0	Min. OCR	Minimum P'_c (psf)	C_c	C_r	E_s (ksf)	Cv (ft^2/day)
Embankment Fill	n/a	125	0.60	2.0	4,000	0.20	0.03	---	0.001
Alluvium	0 – 5	123	0.65	2.0	4,000	0.20	0.03	--	0.01
Residuum	5 – 42	126	0.60	2.0	4,000	0.20	0.03	--	0.01
Shale	42 – 47	130	0.50	---	---	--	--	--	---

Notes:
1. n/a – not applicable to analysis section
2. Abbreviations legend:
   a) γ – Total Moist Unit Weight
   b) e_0 – Initial Void Ratio;
   c) OCR – Overconsolidation Ratio (applies to zones at depth where σ'v is greater than the minimum P'c value);
   d) P'_c – Maximum Past Pressure (minimum value accounts for near-surface desiccated "crust");
   e) C_c – Compression Index from e-log(p) curve;
   f) C_r – Recompression Index from e-log(p) curve
   g) E_s – Elastic Modulus; refer to text
   h) Cv – Coefficient of consolidation

Table 2. Consolidation Parameters for Settlement Analysis – RCC Spillway Outlet Channel Training Dikes

Material	Depth Interval (ft bgs)	γ (pcf)	e_0	Min. OCR	Minimum P'_c (psf)	C_c	C_r	E_s (ksf)	Cv (ft^2/day)
Embankment Fill	n/a	125	0.60	2.0	4,000	0.20	0.03	---	0.001
Alluvium	0 – 6	123	0.65	2.0	4,000	0.20	0.03	--	0.01
Residuum	6 – 28	126	0.60	2.0	4,000	0.20	0.03	--	0.01
Shale	28 – 33	130	0.50	---	---	--	--	--	---

Notes:
1. n/a – not applicable to analysis section.

Table 3. Embankment Fill Geometry and Surcharge Load Model

Analysis Location / Section	Maximum Fill Height (feet)	Assumed Fill Unit Weight (pcf)	Maximum Surcharge Pressure (psf)	Fill Crest Width (feet)	Slope Angle	Left Slope Length (feet)	Right Slope Length (feet)
Existing Embankment Modification	< 2	125	---(1)	14	Varies(3)	Varies(3)	Varies(3)
Embankment Reconstruction for New PSW	31	125	--- (2)	14	3H:1V	93	93
ASW Widening Right Training Dike	7.4	125	925	12	3H:1V	22.2	22.2
RCC Spillway Outlet Channel Training Dike	6.5	125	812.5	12	3H:1V	19.5	19.5

Notes:
1. Consolidation of subgrade materials considered negligible based on limited fill thickness and extent.
2. Consolidation of subgrade materials considered negligible based on similar loading from existing embankment with no significant changes in proposed cross-section geometry.
3. Existing embankment ranges from 2.7H:1V to 3H:1V per 2020 topo survey. Proposed 2H:1V for minor fill to reestablish crest elevation.

ANALYSIS RESULTS AND DISCUSSION

Results of the embankment settlement analysis are presented in **Table 4**. Calculations are provided in **Attachments 1** and **2**. Calculated settlements are relatively minor: approximately 1.5 to 2 inches of subgrade consolidation settlement is estimated for the ASW and RCC spillway outlet training dikes, with less than 1 inch of self-weight fill compression. Self-weight compression is estimated to be approximately 4 inches for the embankment reconstruction at the new PSW location, with negligible subgrade consolidation.

Due to uncertainty regarding time rate of consolidation and critical nature of the dam embankment, a minor crest overbuild of 0.5 feet is recommended for the embankment reconstruction at the new PSW location. No overbuild is recommended for the training dikes due to minor estimated settlement and less critical function for these structures.

Table 4. Summary of Embankment Settlement Analysis Results and Recommendations

Analysis Location / Section	Estimated Consolidation Settlement of Foundation Soils (inches)	Estimated Self-Weight Compression of Fill Materials (inches) (1)	Estimated Total Settlement at Crest of New Fill (inches)	Recommended Fill Crest Overbuild (feet)
Existing Embankment Modification	negligible	negligible	negligible	none
Embankment Reconstruction at New PSW	negligible	3.7	3.7	0.5
ASW Widening Right Training Dike	1.85	0.9	2.8	none
RCC Spillway Outlet Channel Training Dike	1.57	0.8	2.4	none

Notes:
1. Assumes self-weight compression is 1% of fill height.

ATTACHMENT 1
Settlement Calculations – ASW Widening Right Training Dike

One-Dimensional Settlement Analysis

Project Name and #: **Plum #2 Rehab**
Date: **6/4/2021**
Description: **Auxiliary Spillway Training Dike - STA 10+68**
Borings 206-19, 207-19, and 8-19
Computed By: **LTF**

INPUT DATA

Soil Profile Input

Water Table Depth: 20 ft

Enter up to 20 layers

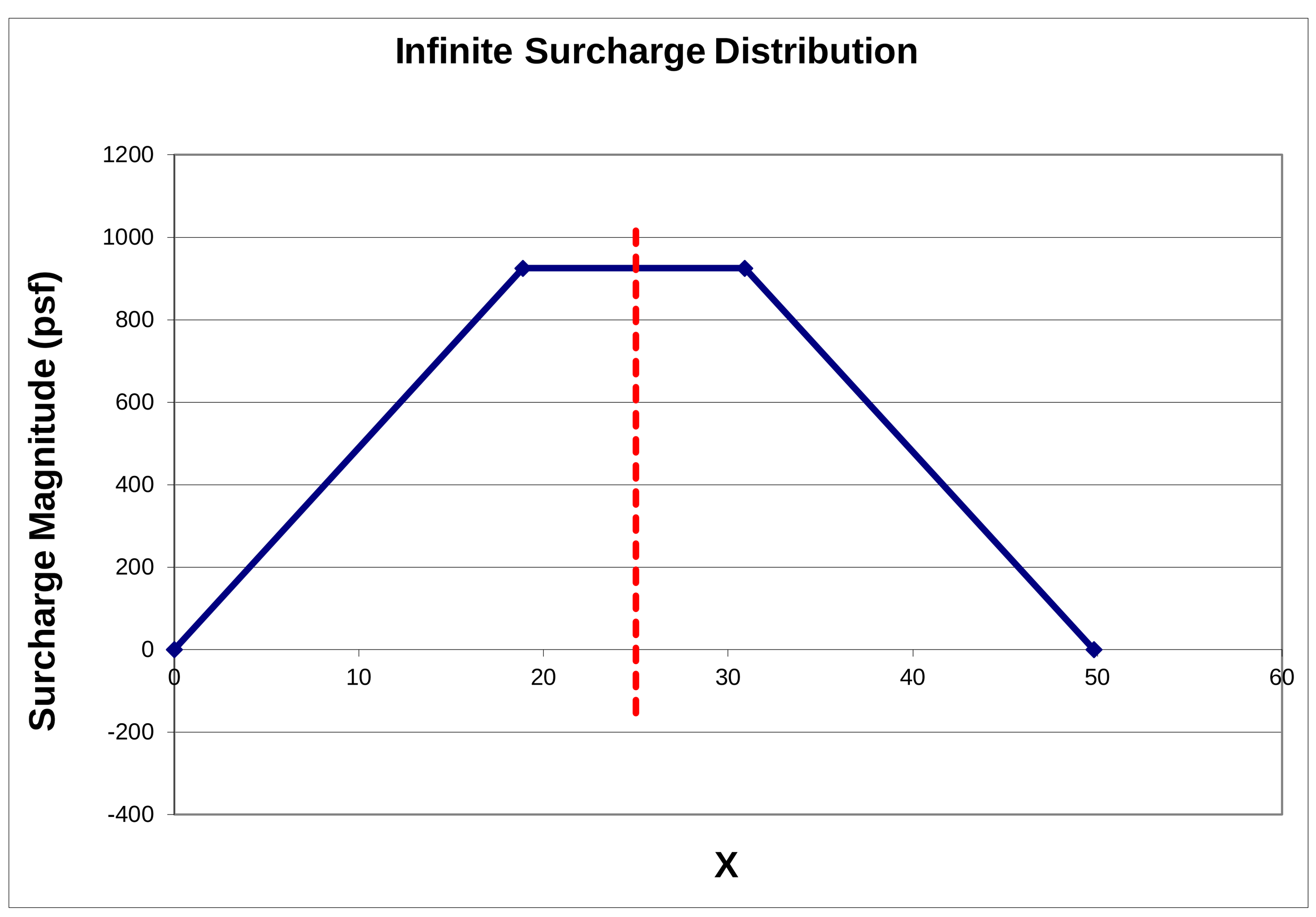
Layer Number	Layer Description	Layer Thickness (ft)	unit wt (pcf)	e_0 at layer	P_c* (psf)	C_r	C_c	Bottom Elev.	Bottom Depth
								GS Elev= 657 ft	
1	Alluvium	1	123	0.65	4,000	0.030	0.20	656	1
2	Alluvium	1	123	0.65	4,000	0.030	0.20	655	2
3	Alluvium	1	123	0.65	4,000	0.030	0.20	654	3
4	Alluvium	1	123	0.65	4,000	0.030	0.20	653	4
5	Alluvium	1	123	0.65	4,000	0.030	0.20	652	5
6	Residuum	2	126	0.60	4,000	0.030	0.20	650	7
7	Residuum	2	126	0.60	4,000	0.030	0.20	648	9
8	Residuum	2	126	0.60	4,000	0.030	0.20	646	11
9	Residuum	2	126	0.60	4,000	0.030	0.20	644	13
10	Residuum	2	126	0.60	4,000	0.030	0.20	642	15
11	Residuum	2	126	0.60	4,000	0.030	0.20	640	17
12	Residuum	4	126	0.60	4,000	0.030	0.20	636	21
13	Residuum	4	126	0.60	4,000	0.030	0.20	632	25
14	Residuum	4	126	0.60	4,000	0.030	0.20	628	29
15	Residuum	4	126	0.60	4,000	0.030	0.20	624	33
16	Residuum	4	126	0.60	4,000	0.030	0.20	620	37
17	Residuum	5	126	0.60	4,000	0.030	0.20	615	42
18	Shale	5	130	0.50	4,000	0.000	0.00	610	47
19									
20									

Surcharge Input

Infinite Surcharge Geometry (Up to 10 Points)

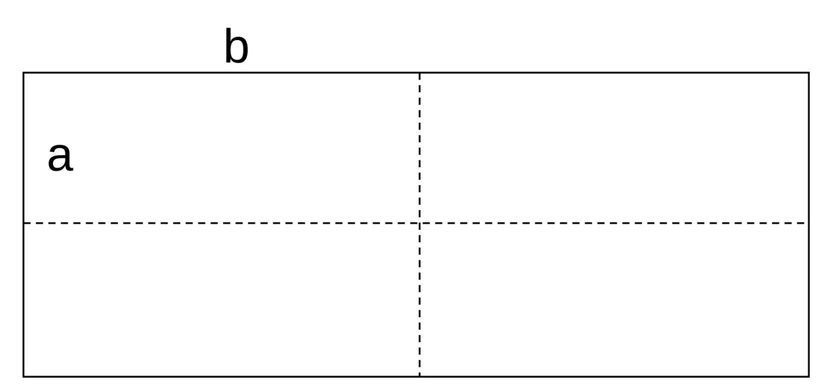
x-Coordinate of Settlement Point: 25

Point Number	x coordinate	surcharge value (psf)
1	0	0
2	18.9	925
3	30.9	925
4	49.8	0
5		
6		
7		
8		
9		
10		



Rectangular Loading

	Load 1	Load 2	Load 3
Include Rectangular Load?	n		
Enter Corner or Center (CO or CE) - Defaults to CE	co	CE	CO
Enter magnitude, q (psf)	0		
Enter Width, a (ft)	10		
Enter Length, b (ft)	10		



Whole width = 2a; Whole length = 2b (for both CE and CO)

One-Dimensional Settlement Analysis

Project Name and #: **Plum #2 Rehab**
Date: **6/4/2021**
Description: **Auxiliary Spillway Training Dike - STA 10+68**
Computed By: **LTF**

Settlement Anaysis Summary

Water Table Depth: 20 ft

Enter up to 20 layers

Layer Number	Layer Description	Layer Thickness (ft)	unit wt (pcf)	e_0 at layer	Overcons? (Y or N)	P_c* (psf)	C_r	C_c	Layer Center Depth (ft)	P_0 at layer Center (psf)	Layer* Surcharge (psf)	P_f at layer center (psf)	Layer Settlement (in)
1	Alluvium	1	123	0.65	Y	4000	0.03	0.2	0.5	61.5	925.0	986.5	0.263
2	Alluvium	1	123	0.65	Y	4000	0.03	0.2	1.5	184.5	924.1	1108.6	0.170
3	Alluvium	1	123	0.65	Y	4000	0.03	0.2	2.5	307.5	921.2	1228.7	0.131
4	Alluvium	1	123	0.65	Y	4000	0.03	0.2	3.5	430.5	915.4	1345.9	0.108
5	Alluvium	1	123	0.65	Y	4000	0.03	0.2	4.5	553.5	906.6	1460.1	0.092
6	Residuum	2	126	0.6	Y	4000	0.03	0.2	6	741	888.4	1629.4	0.154
7	Residuum	2	126	0.6	Y	4000	0.03	0.2	8	993	857.2	1850.2	0.122
8	Residuum	2	126	0.6	Y	4000	0.03	0.2	10	1245	821.3	2066.3	0.099
9	Residuum	2	126	0.6	Y	4000	0.03	0.2	12	1497	783.6	2280.6	0.082
10	Residuum	2	126	0.6	Y	4000	0.03	0.2	14	1749	745.6	2494.6	0.069
11	Residuum	2	126	0.6	Y	4000	0.03	0.2	16	2001	708.5	2709.5	0.059
12	Residuum	4	126	0.6	Y	4000	0.03	0.2	19	2379	655.8	3034.8	0.095
13	Residuum	4	126	0.6	Y	4000	0.03	0.2	23	2695.8	592.4	3288.2	0.078
14	Residuum	4	126	0.6	Y	4000	0.03	0.2	27	2950.2	537.1	3487.3	0.065
15	Residuum	4	126	0.6	Y	4000	0.03	0.2	31	3204.6	489.3	3693.9	0.056
16	Residuum	4	126	0.6	Y	4000	0.03	0.2	35	3459	448.0	3907.0	0.048
17	Residuum	5	126	0.6	Y	4000	0.03	0.2	39.5	3745.2	408.2	4153.4	0.155
18	Shale	5	130	0.5	N	4000	0	0	44.5	4073.2	370.7	4443.9	0.000

TOTAL COMPUTED SETTLEMENT: 1.85 in

0.154 ft

One-Dimensional Settlement Analysis

Project Name and #: **6/4/2021**
Date: **Auxiliary Spillway Training Dike - STA 10+68**
Description: **LTF**

Surcharge Load Summary

All Loadings in pounds per square foot

Layer Number	Layer Description	Center Depth	Rectangular Loading (psf) Load 1	Load 2	Load 3	Infinite Surcharge (psf)	TOTAL SURCHARGE (psf)
1	Alluvium	0.5				925	925
2	Alluvium	1.5				924	924
3	Alluvium	2.5				921	921
4	Alluvium	3.5				915	915
5	Alluvium	4.5				907	907
6	Residuum	6				888	888
7	Residuum	8				857	857
8	Residuum	10				821	821
9	Residuum	12				784	784
10	Residuum	14				746	746
11	Residuum	16				708	708
12	Residuum	19				656	656
13	Residuum	23				592	592
14	Residuum	27				537	537
15	Residuum	31				489	489
16	Residuum	35				448	448
17	Residuum	39.5				408	408
18	Shale	44.5				371	371

ATTACHMENT 2
Settlement Calculations – RCC Spillway Outlet Channel Right Training Dike

One-Dimensional Settlement Analysis

Project Name and #: Plum #2 Rehab
Date: 6/4/2021
Description: RCC Spillway Training Dike (Right Side)
Borings 703-20 & 402-20
Computed By: LTF

INPUT DATA

Soil Profile Input

Water Table Depth: 8 ft

Enter up to 20 layers

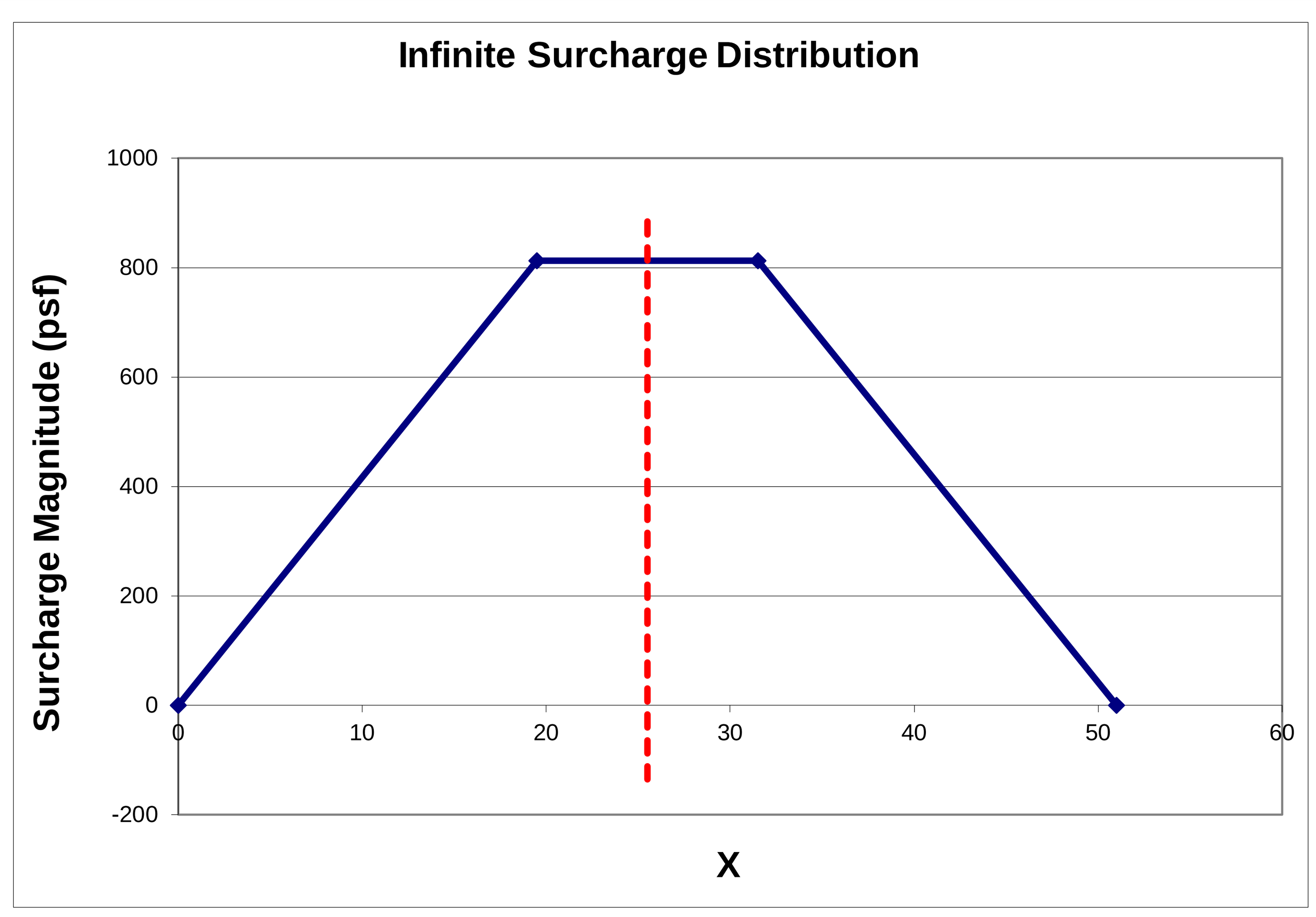
Layer Number	Layer Description	Layer Thickness (ft)	unit wt (pcf)	e_0 at layer	P_c* (psf)	C_r	C_c	GS Elev= 646 ft Bottom Elev.	Bottom Depth
1	Alluvium	1	123	0.65	4,000	0.030	0.20	645	1
2	Alluvium	1	123	0.65	4,000	0.030	0.20	644	2
3	Alluvium	1	123	0.65	4,000	0.030	0.20	643	3
4	Alluvium	1	123	0.65	4,000	0.030	0.20	642	4
5	Alluvium	1	123	0.65	4,000	0.030	0.20	641	5
6	Alluvium	1	123	0.65	4,000	0.030	0.20	640	6
7	Residuum	2	126	0.60	4,000	0.030	0.20	638	8
8	Residuum	2	126	0.60	4,000	0.030	0.20	636	10
9	Residuum	2	126	0.60	4,000	0.030	0.20	634	12
10	Residuum	2	126	0.60	4,000	0.030	0.20	632	14
11	Residuum	2	126	0.60	4,000	0.030	0.20	630	16
12	Residuum	2	126	0.60	4,000	0.030	0.20	628	18
13	Residuum	2	126	0.60	4,000	0.030	0.20	626	20
14	Residuum	2	126	0.60	4,000	0.030	0.20	624	22
15	Residuum	2	126	0.60	4,000	0.030	0.20	622	24
16	Residuum	2	126	0.60	4,000	0.030	0.20	620	26
17	Residuum	2	126	0.60	4,000	0.030	0.20	618	28
18	Shale	5	130	0.50	4,000	0.000	0.00	613	33
19									
20									

Surcharge Input

Infinite Surcharge Geometry (Up to 10 Points)

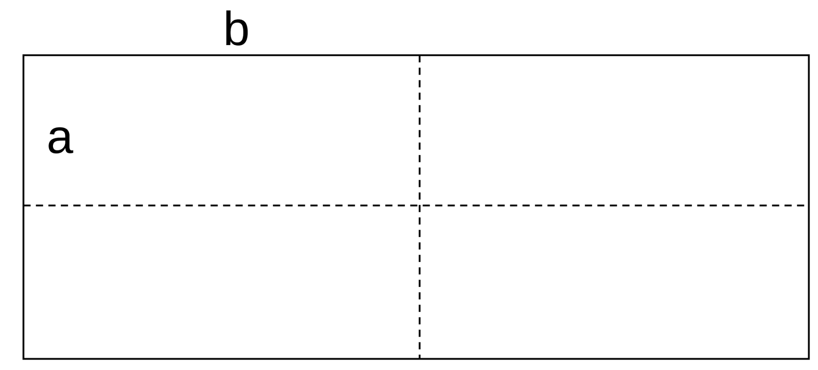
x-Coordinate of Settlement Point: 25.5

Point Number	x coordinate	surcharge value (psf)
1	0	0
2	19.5	812.5
3	31.5	812.5
4	51	0
5		
6		
7		
8		
9		
10		



Rectangular Loading

	Load 1	Load 2	Load 3
Include Rectangular Load?	n		
Enter Corner or Center (CO or CE) - Defaults to CE	co	CE	CO
Enter magnitude, q (psf)	0		
Enter Width, a (ft)	10		
Enter Length, b (ft)	10		



Whole width = 2a; Whole length = 2b (for both CE and CO)

One-Dimensional Settlement Analysis

Project Name and #: **Plum #2 Rehab**
Date: **6/4/2021**
Description: **RCC Spillway Training Dike (Right Side)**
Computed By: **LTF**

Settlement Anaysis Summary

Water Table Depth: 8 ft

Enter up to 20 layers

Layer Number	Layer Description	Layer Thickness (ft)	unit wt (pcf)	e_0 at layer	Overcons? (Y or N)	P_c* (psf)	C_r	C_c	Layer Center Depth (ft)	P_0 at layer Center (psf)	Layer* Surcharge (psf)	P_f at layer center (psf)	Layer Settlement (in)
1	Alluvium	1	123	0.65	Y	4000	0.03	0.2	0.5	61.5	812.5	874.0	0.251
2	Alluvium	1	123	0.65	Y	4000	0.03	0.2	1.5	184.5	811.7	996.2	0.160
3	Alluvium	1	123	0.65	Y	4000	0.03	0.2	2.5	307.5	809.2	1116.7	0.122
4	Alluvium	1	123	0.65	Y	4000	0.03	0.2	3.5	430.5	804.3	1234.8	0.100
5	Alluvium	1	123	0.65	Y	4000	0.03	0.2	4.5	553.5	796.8	1350.3	0.085
6	Alluvium	1	123	0.65	Y	4000	0.03	0.2	5.5	676.5	786.9	1463.4	0.073
7	Residuum	2	126	0.6	Y	4000	0.03	0.2	7	864	768.5	1632.5	0.124
8	Residuum	2	126	0.6	Y	4000	0.03	0.2	9	1053.6	739.4	1793.0	0.104
9	Residuum	2	126	0.6	Y	4000	0.03	0.2	11	1180.8	707.6	1888.4	0.092
10	Residuum	2	126	0.6	Y	4000	0.03	0.2	13	1308	674.8	1982.8	0.081
11	Residuum	2	126	0.6	Y	4000	0.03	0.2	15	1435.2	642.3	2077.5	0.072
12	Residuum	2	126	0.6	Y	4000	0.03	0.2	17	1562.4	610.8	2173.2	0.064
13	Residuum	2	126	0.6	Y	4000	0.03	0.2	19	1689.6	580.7	2270.3	0.058
14	Residuum	2	126	0.6	Y	4000	0.03	0.2	21	1816.8	552.2	2369.0	0.052
15	Residuum	2	126	0.6	Y	4000	0.03	0.2	23	1944	525.5	2469.5	0.047
16	Residuum	2	126	0.6	Y	4000	0.03	0.2	25	2071.2	500.5	2571.7	0.042
17	Residuum	2	126	0.6	Y	4000	0.03	0.2	27	2198.4	477.1	2675.5	0.038
18	Shale	5	130	0.5	Y	4000	0	0	30.5	2431	440.1	2871.1	0.000

TOTAL COMPUTED SETTLEMENT: 1.57 in

0.131 ft

One-Dimensional Settlement Analysis

Project Name and #: **6/4/2021**
Date: **RCC Spillway Training Dike (Right Side)**
Description: **LTF**

Surcharge Load Summary

All Loadings in pounds per square foot

Layer Number	Layer Description	Center Depth	Rectangular Loading (psf)		
			Load 1	*Load 2*	*Load 3*
1	Alluvium	0.5			
2	Alluvium	1.5			
3	Alluvium	2.5			
4	Alluvium	3.5			
5	Alluvium	4.5			
6	Alluvium	5.5			
7	Residuum	7			
8	Residuum	9			
9	Residuum	11			
10	Residuum	13			
11	Residuum	15			
12	Residuum	17			
13	Residuum	19			
14	Residuum	21			
15	Residuum	23			
16	Residuum	25			
17	Residuum	27			
18	Shale	30.5			

Appendix F Swell and Foundation Heave Analysis

CALCULATION OBJECTIVE

Proposed structures associated with the proposed RCC spillway chute, RCC spillway crest, RCC spillway stilling basin, PSW impact basin, and PSW inlet tower structures will be founded on expansive clay or shale. Based on laboratory swell tests results, the bearing material for the proposed structures exhibits expansive soil characteristics and may cause excessive shrink and swell movements under the proposed structures.

The purpose of this calculation package is to 1) analyze laboratory swell data; 2) estimate the magnitude of potential vertical heave on the proposed structures due to expansive soil swelling; and 3) estimate the minimum depth of over-excavation and replacement required to reduce potential vertical heave to tolerable levels.

REFERENCES/INPUTS/FIELD DATA

1. USDA-SCS. 1967. Geologic Investigation Report (GIR), Plum Creek Watershed, Site No. 2.
2. USDA-SCS. 1967. Soil Mechanics Report (SMR), Plum Creek Site 2.
3. USDA-SCS. 1969. As-Built Drawings, Plum Creek Watershed Project Floodwater Retarding Dam No. 2.
4. AECOM. 2021. GIR, Plum Creek Watershed FRS No. 2 Rehabilitation Design.
5. AECOM. 2021. SMR, Plum Creek Watershed FRS No. 2 Rehabilitation Design.
6. AECOM. 2020. 90% Design Drawings, Floodwater Retarding Structure Site No. 2 Rehabilitation Hays County, Texas.

ANALYSIS METHODLOGY

General

Results of constant-volume swell tests with an unloading phase were used to estimate swell pressure and swelling strain index from swell-log (pressure) curves. These results were used to perform heave analyses for each structure.

The heave analyses were performed analogous to a "reverse-consolidation" process, whereby the foundation soils are sub-divided into layers and volume change (swelling) is assumed to occur in the layers where the effective stress is less than the measured swell pressure. The effective stress is a function of the soil self-weight, pore water pressure from groundwater, and the sustained foundation load (the simplified 2:1 load distribution with depth was assumed). Swelling in each soil layer is calculated based on the swelling strain index, defined as the linear slope of the strain vs. log-pressure curve from each swell test. Heave was assumed to only occur within the "active zone" (i.e., zone of seasonal moisture fluctuation), which was assumed to be the upper 15 feet below the lowest surrounding finished grade. In order to capture the variability of the swell test results, each structure was evaluated based on individual swell test result applied to the entire subgrade separately (as opposed to assigning swell properties from each test to specific depth intervals in a single analysis).

Groundwater measurement from borings is discussed in the Geologic Investigation Report (GIR) and the "Material Properties Calculation Package". For heave analyses and effective stress calculation, groundwater level was conservatively assumed to be at the base of the structures. This was due to the possibility of seasonal groundwater level fluctuation and/or changes in groundwater level due to changes in reservoir level.

Heave analysis was performed on the RCC spillway crest walls and slab, RCC spillway chute walls and slab, RCC spillway stilling basin walls and slab, impact basin foundation, and inlet tower foundation. Sustained loading on the RCC structures was assumed to be the self-weight of the RCC (i.e., 150 pcf unit weight multiplied by the thickness of the structural element). Sustained loading on the impact basin and inlet tower was considered to be the maximum unfactored gross bearing pressure of 2,000 psf and 1,500 psf, respectively. Non-expansive fill with a unit weight of 120 pcf was considered for over-excavation and replacement. Analyses were performed to estimate the required over-excavation and replacement to limit foundation heave to either 1 or 1 ½ inches.

Laboratory Data Analysis

Laboratory swell tests results were performed as follows:

- Step 1) An initial seating load of ~100 psf is applied to the sample.
- Step 2) Sample is inundated with water, and the load is added as necessary to prevent swell (i.e., constant-volume swell test).
- Step 3) The maximum load required to prevent swell from occurring is the "swell pressure".
- Step 4) For constant-volume swell tests with an unloading cycle, after reaching the swell pressure the load is incrementally decreased in ½ to ¼ steps and % swell is measured at each unload step.

The procedure to analyze laboratory test data and obtain input parameters for the heave analysis are as follows:

- For each test tabulate applied pressure, initial and final strain at each load step, calculate strain at each load increment, and cumulative strain at end of each load.
- Plot percent strain versus log-pressure for all test
- Calculate swelling strain index: $C_{s\varepsilon} = \frac{(\varepsilon_{\max load} - \varepsilon_{\min. unload})}{\log(P_{\max load}) - \log(P_{min.\ unload})}$
- Obtain swell pressure (SP) as the maximum pressure from raw data during constant-volume phase of test
- Estimate the "free swell" (i.e., swell strain at 20 psf confining pressure as defined in ASTM D4546) based on swell percentage at the lowest confining pressure (typically 100 psf) and $C_{s\varepsilon}$:

$$\%\ Swell_{20\ psf} = [\frac{\%Swell_{100\ psf}}{100} + C_{s\varepsilon}(\log(100\ psf) - \log(20\ psf))] \times 100$$

- Plot SP against liquid limit, plasticity index, and clay fraction to identify potential trends. Repeat the same process for $\%\ Swell_{100\ psf}$.

Results of the laboratory swell data analyses are provided in **Attachment 1**.

Foundation Heave Analysis

Unfactored sustained foundation pressures (q_{max}) and base width (B) are provided below:

Location	Structure Type	Unfactored Foundation Pressure (psf)	Base Width (ft)
RCC Spillway Chute Structure	Walls	1,800	11.33
	Slab	450	48
RCC Spillway Crest Structure	Walls	1,500	11.33
	Slab	450	30
RCC Stilling Basin	Walls	2,000	11.33
	Slab	450	24
Impact Basin	---	2,000	17.7
Inlet Tower	---	1,500	13.5

The procedure to estimate potential vertical heave on proposed structure foundations is as follows:

- Groundwater was assumed to be at the base of foundation at each structure.
- Perform reverse-consolidation analysis to calculate estimated heave:
  - The subgrade is divided into 2 ft thick layers. Heave is only considered in layers below the non-expansive fill below footing.
  - Use 2:1 stress distribution method to estimate stress at the midpoint of each 2 ft layer.
  $$\Delta\sigma_m = (q_{max}) \times (\frac{B}{B + Z_{Midpoint}})$$
  - Calculate total stress at midpoint of layer: $\sigma_t = \Delta\sigma_m + \gamma_F H_F + \sum \gamma_i H_i$
  - Calculate effective stress: $\sigma' = \sigma_t - (62.4\, pcf) \times (h_w)$
  - Calculate % swell in each sublayer: $\%swell = \begin{cases} C_{s\varepsilon} \times (\log(SP) - \log(\sigma')) \times 100, & \sigma' \leq SP \\ 0, & \sigma' > SP \end{cases}$
  - Calculate heave of individual sublayers: $Heave_i = (Layer\ Thickness) \times (\frac{\%Swell}{100})$
  - Calculate total heave on foundation:
  $$Unlimited\ Active\ Zone = \sum Heave_i$$
  $$Active\ Zone\ Limited\ to\ 15\ ft\ below\ base\ of\ footing = \sum Heave_i\ for\ z \leq 15\ ft$$
- Active zone is generally limited to a depth of 15 ft below the lowest surrounding finished grade (except the inlet tower which is assumed as 10 feet). It is assumed material below the active zone does not experience significant changes in moisture content or related shrink/swell movement, and thus will not contribute to heave. Surrounding grade was conservatively assumed to be the top of slab elevation in most cases.

- Adjust thickness of non-expansive fill below proposed footing to limit heave to tolerable levels (1 or 1 ½ inches).

Results of the foundation heave analyses are provided in **Attachment 2**.

Symbol	Definition
$C_{s\varepsilon}$	Swelling strain index
q_{max}	Unfactored foundation pressure
B	Foundation base width
$\varepsilon_{\max load}$	Strain after maximum applied load
$\varepsilon_{\min unload}$	Strain after minimum applied
$P_{\max load}$	Applied maximum load
$P_{\min unload}$	Applied minimum load
SP	Swell pressure
$\Delta\sigma_m$	Stress increase due to foundation load
$Z_{Midpoint}$	the depth below the foundation to the midpoint of a layer
σ_t	Total stress
σ'	Effective stress
h_w	Height of groundwater column above the middle of soil layer
γ_F	unit weight of non-expansive fill
H_F	thickness of non-expansive fill
γ_i	unit weight of subgrade layer
H_i	thickness of subgrade layers
z	Depth

RESULTS AND CONCLUSIONS

A summary of analysis results is shown below in **Table 1**. According to the 90% drawings a 2-foot thick underdrain layer consisting of clean fine and coarse aggregates will be placed below the foundations of the proposed RCC spillway structures to collect/convey seepage and relieve hydrostatic pressure. This 2-foot thick underdrain layer requires will act as non-expansive fill, and the 2-foot overexcavation required to install the underdrain was considered in the base analysis case (i.e., “no additional overexcavation/replacement”) for the RCC spillway heave calculations..

Results are variable for all cases considered due to variability in the results of individual swell tests. For the base analysis cases, the calculated heave for the RCC walls and slab ranged from negligible to over 2 inches (average between about 1 and 2 inches), and calculated heave the PSW structures was between 2 and 3 inches. Therefore, additional overexcavation / replacement is needed to limit heave to tolerable levels.

For the RCC spillway, the required overexcavation/replacement depth ranges from 2 to 9 feet to limit heave to 1 inch, and 2 to 7 feet to limit heave to 1.5 inches.

For the PSW structures, overexcavation / replacement depth ranges from 4 to 8 feet to limit heave to 1 inch, and 2 to 6 feet to limit heave to 1.5 inces.

Table 1. Summary of Foundation Heave Analyses

Location	Structure Type	Total Heave (inch) with No Additional Overexcavation / Replacement (1)	Limit Heave to 1 inch	Limit Heave to 1 ½ inches
			Required Overexcavation / Replacement Depth (feet)	
RCC Spillway Crest Structure	Walls	0.11 to 2.02 (1.09 average)	2.0 to 7.0	2.0 to 3.0
	Slab	0.49 to 2.22 (average 1.82)	2.0 to 7.0	2.0 to 6.0
RCC Spillway Chute Structure	Walls	0.00 to 0.92 (average 0.58)	2.0	2.0
	Slab	0.03 to 2.16 (average 1.45)	2.0 to 7.0	2.0 to 6.0
RCC Stilling Basin Structure	Walls	0.00 to 1.68 (average 0.84)	2.0 to 7.0	2.0 to 4.0
	Slab	0.82 to 2.88 (average 1.85)	2.0 to 9.0	2.0 to 7.0
Impact Basin	---	2.79	8.0	6.0
Inlet Tower	---	2.40	4.0	2.0

Note:

1) Analysis of RCC spillway structure includes 2 ft overexcavation under slab to install underdrain layer.

AECOM

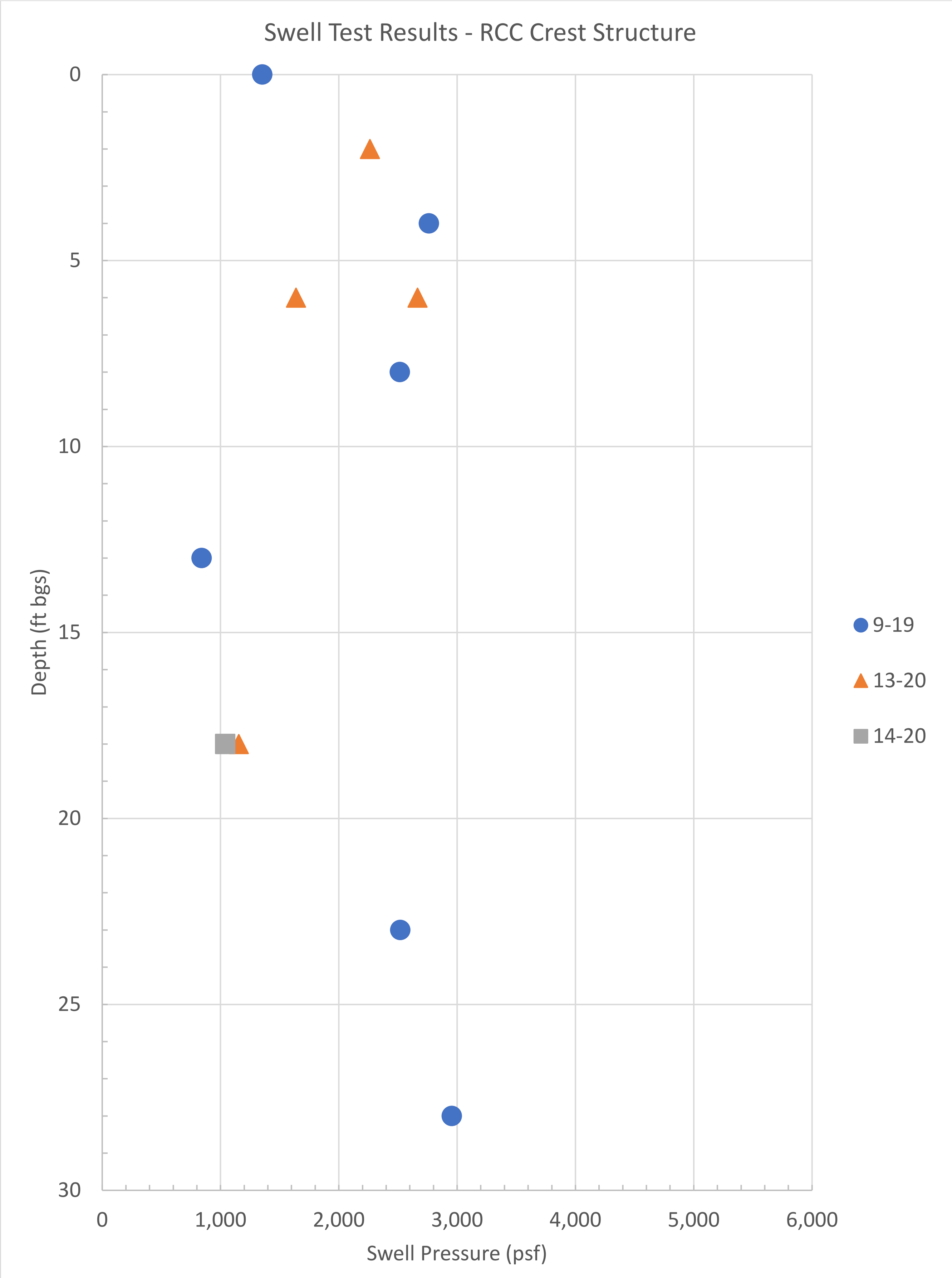
				Calc No.:	7
Job:	Plum Creek FRS No. 2 Dam Rehabilitation	Project No.	60615067	Page:	6 of 7
Description:	Foundation Heave Analyses	Computed By:	O. Novitchkov	Date:	5/25/2021
		Checked By:	L. Finnefrock	Date:	5/29/2021

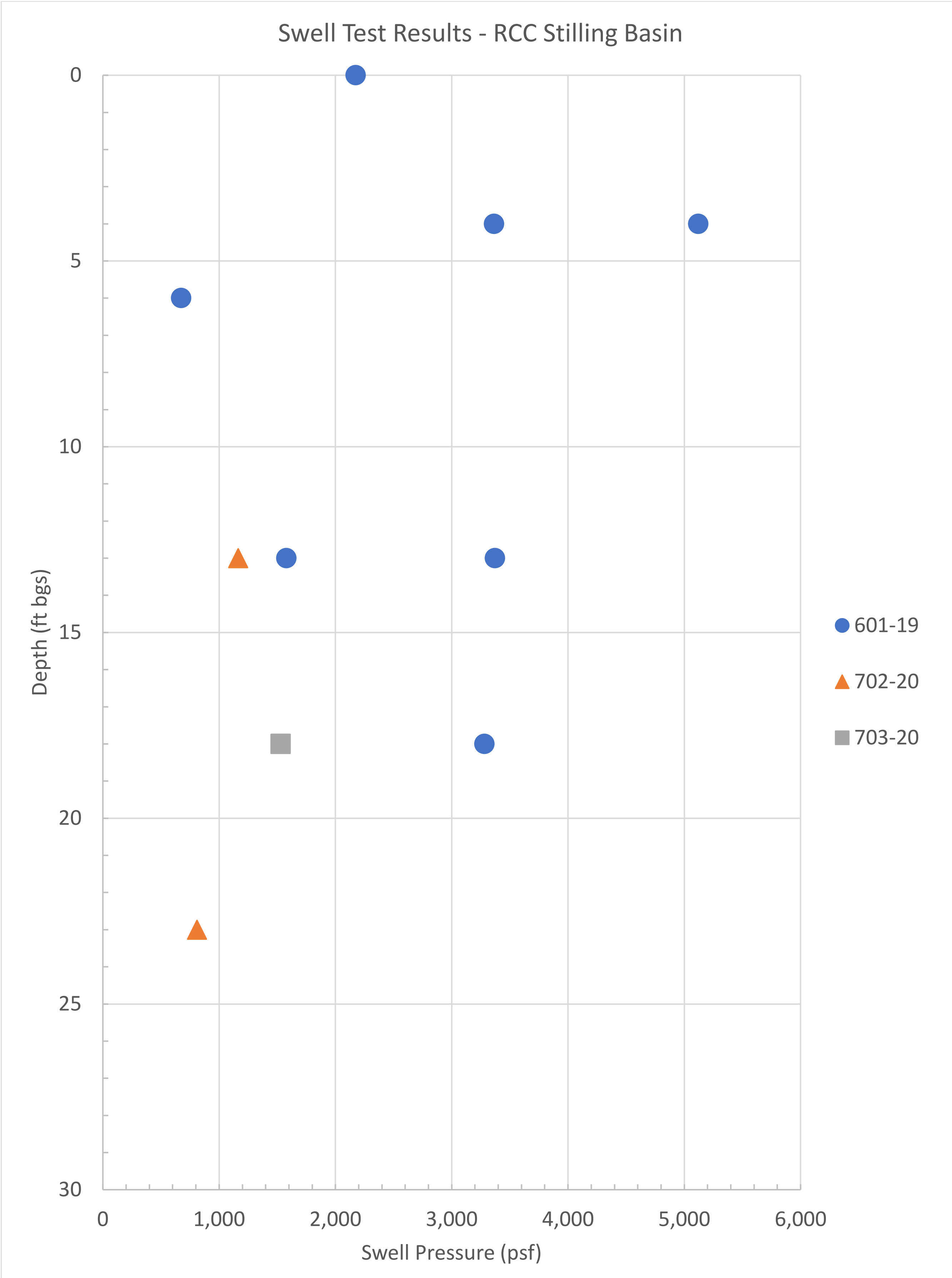
ATTACHMENT 1
Analysis of Swell Test Data

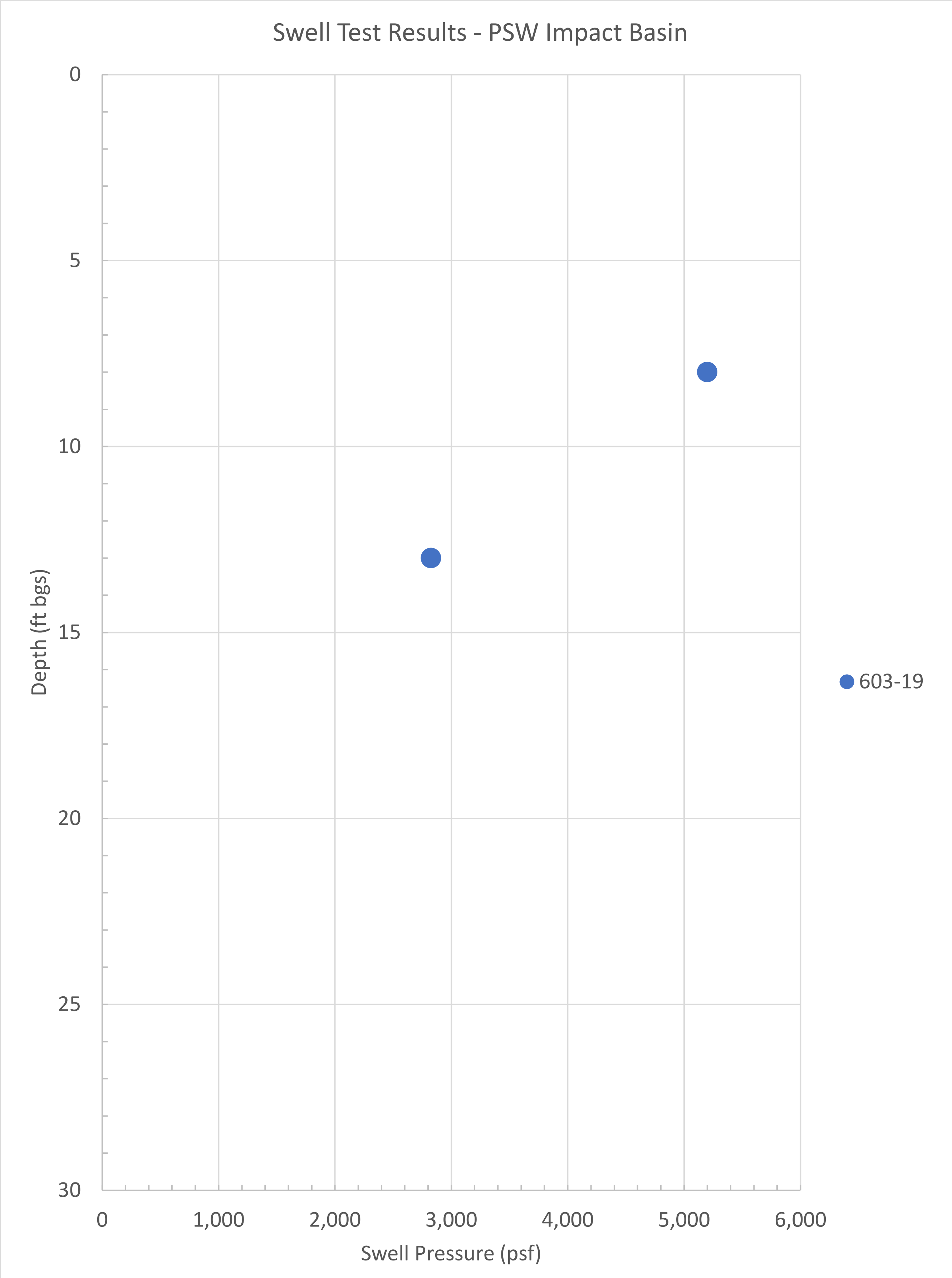
Structure	Boring ID	Top Depth (ft)	Bott. Depth (ft)	Sample ID	Stratum	USCS	Moisture Content (%)	Moisture Content (+/-OMC)	LL	PI	CF (%)	Test Type	Swell Pressure (psf) [1]	%Swell at σ=250 psf (2)	Swelling Strain Index, Csε (3)	Est. Free Swell (%) (4)
RCC Crest Structure (left side)	9-19	0	2	P-1	Embank. Core	CH			65	41	58.1	SP	1,354			
	9-19	4	6	P-3	Embank. Core	CH			68	43	46.4	SP	2,762			
	9-19	8	10	ST-5	Embank. Core	CH			74	50		SPU	2,517	3.67	0.037	7.83
	9-19	8	10	ST-5	Embank. Core	CH			74	50		IC	6,338		0.035	
	9-19	13	15	P-6	Embank. Core	CH			60	34	48.5	SP	841			
	9-19	23	25	ST-8	MPR	CH			50	29		IC	2,521		0.034	
	9-19	28	30	P-9	MPR	CH			73	48	48.5	SP	2,955			
RCC Crest Structure (middle)	13-20	2	4	ST-2	Embank. Core	CH			64	37		SP	2,262			
	13-20	6	8	ST-4	Embank. Core	CH			61	41		SPU	1,637	1.02	0.013	2.44
	13-20	6	8	ST-4	Embank. Core	CH			61	41		IC	2,666		0.034	
	13-20	18	20	ST-7	MPR	CH			52	34		SP	1,154			
RCC Crest Structure (right side)	14-20	18	20	ST-7	Embank. Core	CH			58	38		SP	1,040			
RCC Stilling Basin (left side)	601-19	0	2	P-1	Alluvium	CH			79	46	64.3	SP	2,175			
	601-19	4	6	ST-3	LPR	CH			64	35		SPU	5,121	3.87	0.029	7.02
	601-19	4	6	ST-3	LPR	CH			64	35		IC	3,364			
	601-19	6	8	P-4	LPR	CL			61	15	38.1	SP	674			
	601-19	13	15	ST-6	LPR	CH			67	44		SPU	1,578	1.82	0.023	4.30
	601-19	13	15	ST-6	LPR	CH			67	44		IC	3,373			
	601-19	18	20	P-7	LPR	CH			77	54	66.2	SP	3,282			
PSW Impact Basin	603-19	8	10	ST-5	MPR	CH			62	40		IC	5,200		0.045	
	603-19	13	15	P-6	MPR	CL			29	14	68.1	SP	2,826			
RCC Stilling Basin (middle)	702-20	13	15	ST-6	MPR	CH			73	40	47.4	SP	1,163			
	702-20	23	25	ST-8	MPR	CH			66	44		SP	810			
RCC Stilling Basin (right side)	703-20	18	20	ST-7	MPR	CH			61	39		SP	1,530			
COMP-100A		0	2.5 to 6		Borrow	CH		0.2	58	37	61.3	SP	875			
COMP-100A		0	2.5 to 6		Borrow	CH		4.3	58	37	61.3	SP	346			
COMP-100B		5 to 6	7.5 to 10		Borrow	CL		0	43	26	43	SP	532			
COMP-100B		5 to 6	7.5 to 10		Borrow	CL		2	43	26	43	SP	327			
COMP-100B		5 to 6	7.5 to 10		Borrow	CL		4	43	26	43	SP	184			
COMP-400A		0	5		Borrow	CH		0	59	33	61.5	SP	1,294			
COMP-400A		0	5		Borrow	“		4	“	“	“	SP	614			
COMP-1700A		0	4 to 8		Borrow	CH		0	64	43	42.9	SPU	746	0.99	0.011	3.16

Notes:

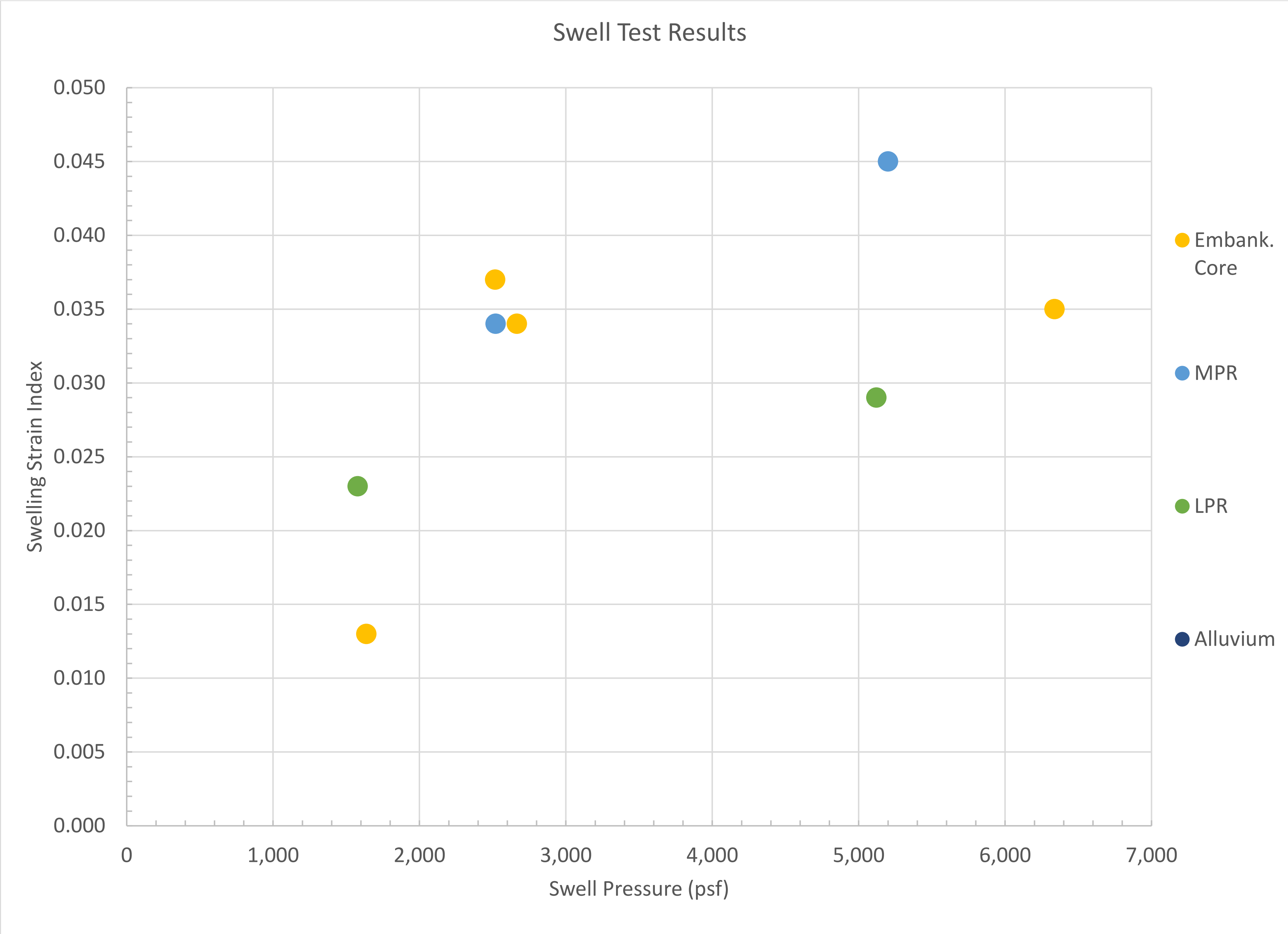
1) Test Type: “IC” = Incremental Consolidation; “SP” = Swell Pressure only; “SPU” = Swell pressure with staged unloading
2) Constant-volume procedure.
3) Maximum swell at 250 psf vertical confining pressure following incremental unloading from swell pressure.
4) Swelling strain index is the slope of the unloading curve, $Cs\varepsilon = (\varepsilon_2 - \varepsilon_1) / \log(p_2/p_1)$
5) Estimated swell at 20 psf vertical confining pressure based on Csε.


Swell Test Results - RCC Crest Structure
Depth (ft bgs)
0
5
10
15
20
25
30
0
1,000
2,000
3,000
4,000
5,000
6,000
Swell Pressure (psf)
9-19
13-20
14-20


Swell Test Results - RCC Stilling Basin
Depth (ft bgs)
0
5
10
15
20
25
30
0
1,000
2,000
3,000
4,000
5,000
6,000
Swell Pressure (psf)
601-19
702-20
703-20

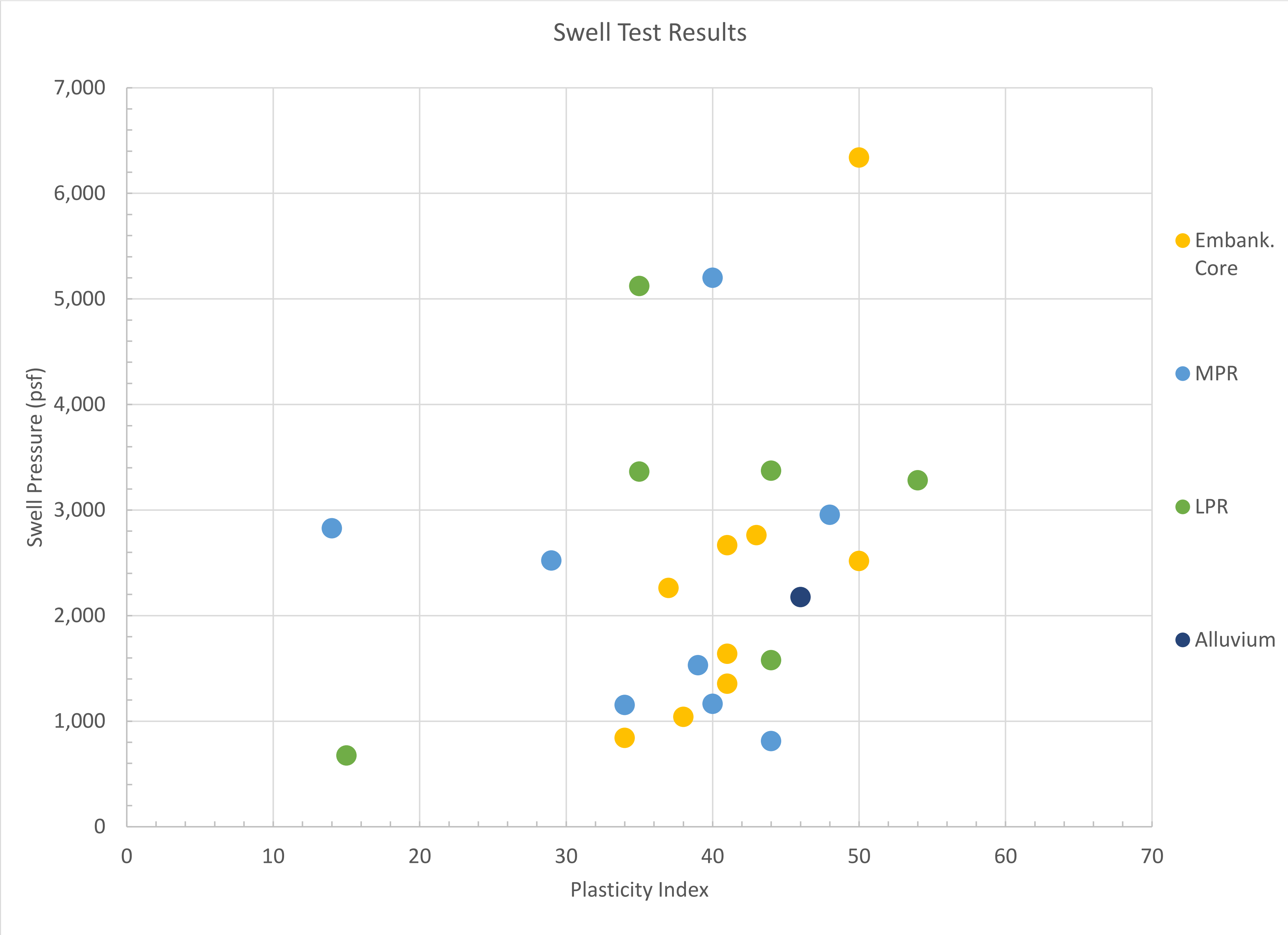


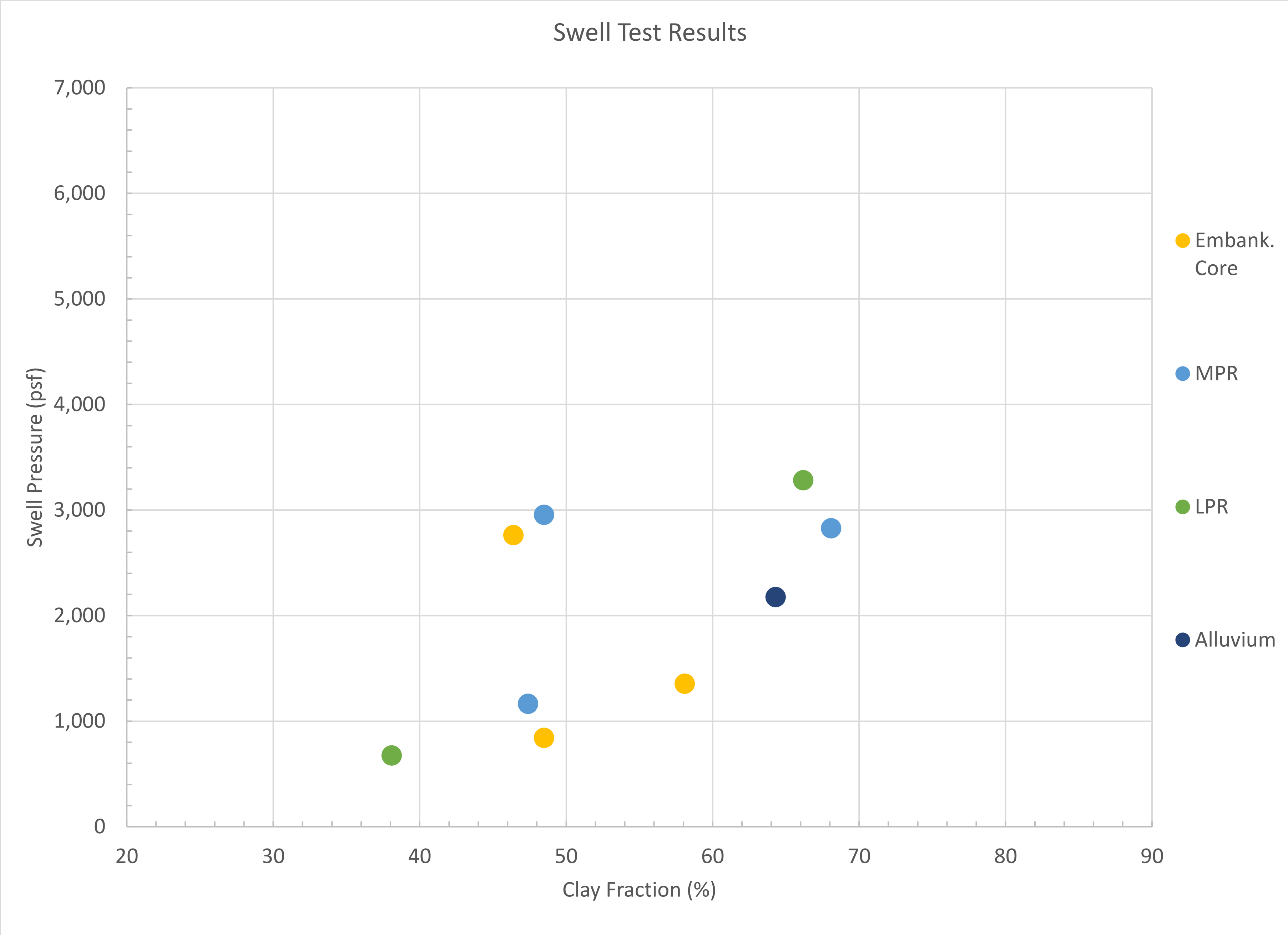
Swell Test Results - PSW Impact Basin
Depth (ft bgs)
0
5
10
15
20
25
30
0
1,000
2,000
3,000
4,000
5,000
6,000
Swell Pressure (psf)
603-19

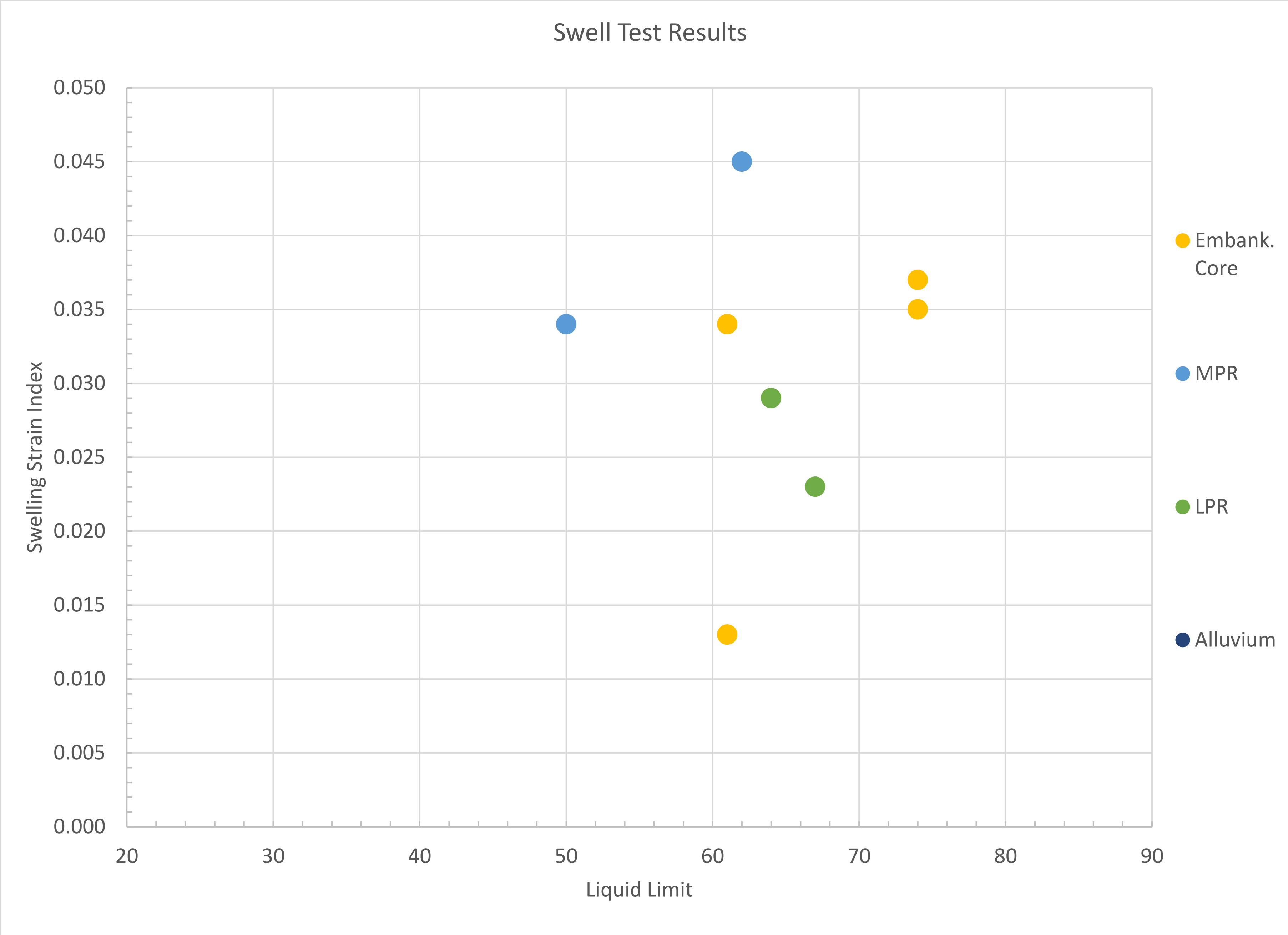


Swell Test Results
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Swelling Strain Index
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
Swell Pressure (psf)
Embank. Core
MPR
LPR
Alluvium

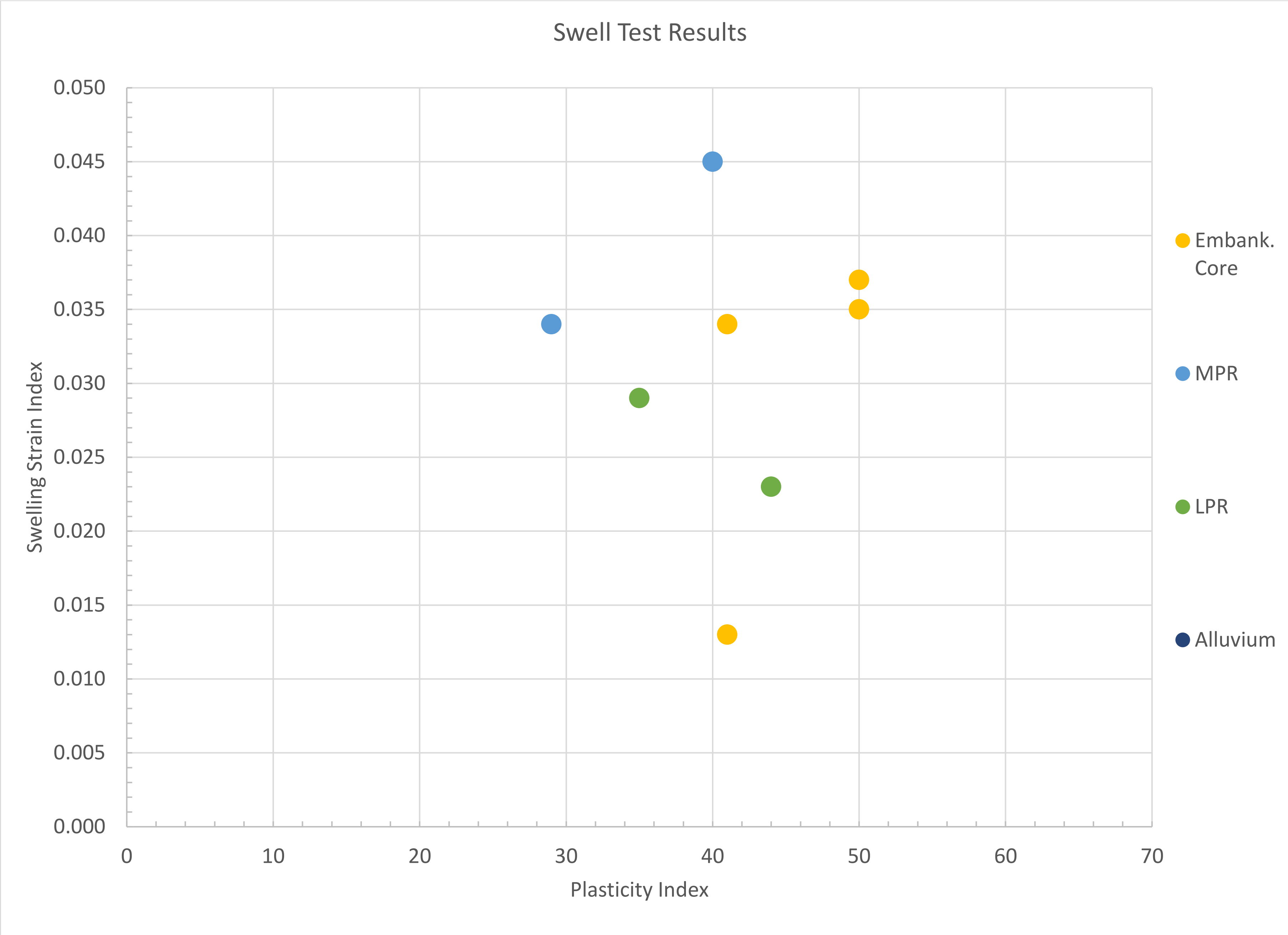
Swell Test Results
Swell Pressure (psf)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
20
30
40
50
60
70
80
90
Liquid Limit
Embank. Core
MPR
LPR
Alluvium

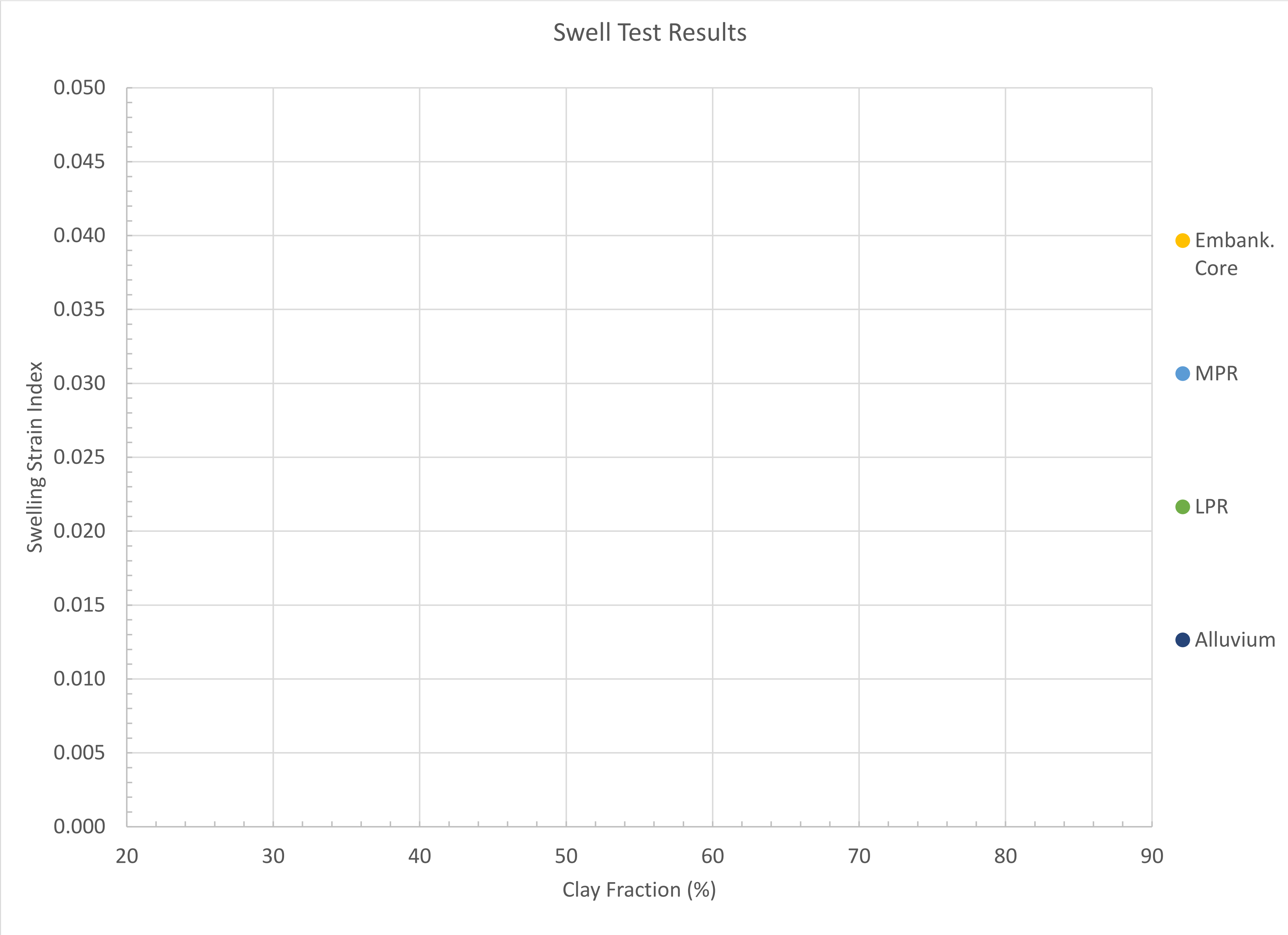

Swell Test Results
Swell Pressure (psf)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0
10
20
30
40
50
60
70
Plasticity Index
Embank. Core
MPR
LPR
Alluvium

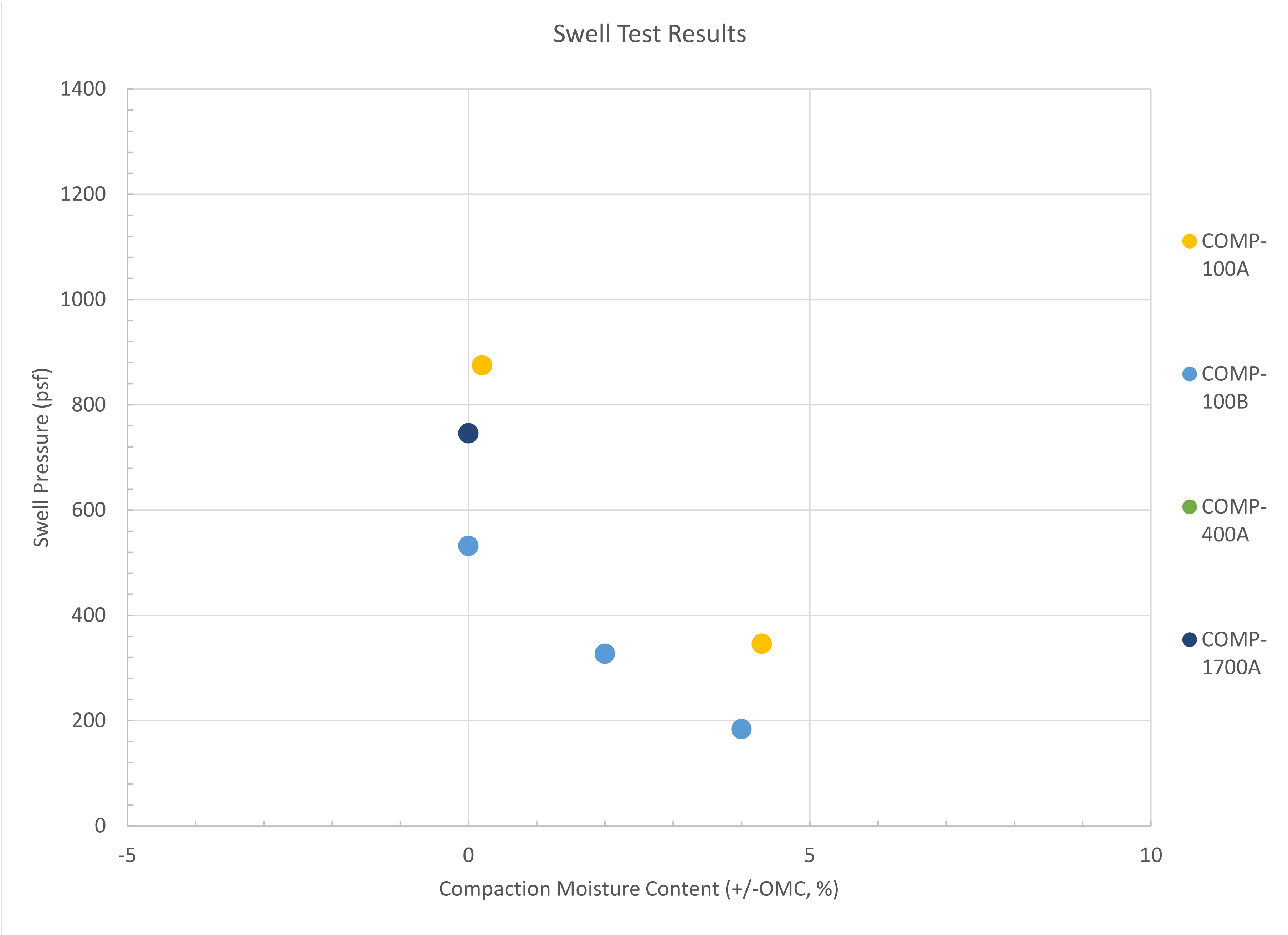

Swell Test Results
Swell Pressure (psf)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
20
30
40
50
60
70
80
90
Clay Fraction (%)
Embank. Core
MPR
LPR
Alluvium



Swell Test Results
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Swelling Strain Index
20
30
40
50
60
70
80
90
Liquid Limit
Embank. Core
MPR
LPR
Alluvium


Swell Test Results
Swelling Strain Index
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0
10
20
30
40
50
60
70
Plasticity Index
Embank. Core
MPR
LPR
Alluvium


Swell Test Results
Swelling Strain Index
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
20
30
40
50
60
70
80
90
Clay Fraction (%)
Embank. Core
MPR
LPR
Alluvium


Swell Test Results
Swell Pressure (psf)
1400
1200
1000
800
600
400
200
0
-5
0
5
10
Compaction Moisture Content (+/-OMC, %)
COMP-100A
COMP-100B
COMP-400A
COMP-1700A

AECOM

				Calc No.:	7
Job:	Plum Creek FRS No. 2 Dam Rehabilitation	Project No.	60615067	Page:	7 of 7
Description:	Foundation Heave Analyses	Computed By:	O. Novitchkov	Date:	5/25/2021
		Checked By:	L. Finnefrock	Date:	5/29/2021

ATTACHMENT 2
Heave Calculations for Proposed Structures

SUMMARY OF SWELL CALCULATIONS FOR PROPOSED STRUCTURES

Analysis Case: Limit heave to 1.0 inch or less

				RCC SPLLWAY - CREST STRUCTURE - WALLS					RCC SPLLWAY - CREST STRUCTURE - SLAB				
				Sustained Foundation Pressure:			1,500 psf		Sustained Foundation Pressure:			450 psf	
				Foundation Base Width:			11.33 feet		Foundation Base Width:			30 feet	
Boring ID	Sample ID	Sample Depth Interval (ft bgs)	Stratum	GWT Depth Below Footing (ft)	Footing Depth Below Existing (ft)	Thickness of Underdrain (ft)	Total Fill Replacement Below Footing (ft)	Potential Vertica Heave (inch)	GWT Depth Below Footing (ft)	Footing Depth Below Existing (ft)	Thickness of Underdrain (ft)	Total Fill Replacement Below Footing (ft)	Potential Vertica Heave (inch)
9-19	ST-5 (SPU)	8-10	Embank. Core	0	3	2	4	0.92	0	3	2	7	0.98
9-19	ST-5 (IC)	8-10	Embank. Core	0	3	2	4	0.92	0	3	2	7	0.98
9-19	ST-8	23-25	MPR	0	3	2	4	0.85	0	3	2	7	0.91
13-20	ST-4 (SPU)	6-8	Embank. Core	0	3	2	2	0.11	0	3	2	2	0.49
13-20	ST-4 (IC)	6-8	Embank. Core	0	3	2	7	0.88	0	3	2	7	0.95
	COMP-1700A	0 to 4/8	Embank. Shell	-	-	-	-	-	-	-	-	-	-
Minimum				---	---	---	---	0.11	---	---	---	---	0.49
Average				---	---	---	---	0.74	---	---	---	---	0.86
Maximum				---	---	---	---	0.92	---	---	---	---	0.98

				RCC SPILLWAY - CHUTE STRUCTURE - WALLS					RCC SPILLWAY - CHUTE STRUCTURE - SLAB				
				Sustained Foundation Pressure:			1,800 psf		Sustained Foundation Pressure:			450 psf	
				Foundation Base Width:			11.33 feet		Foundation Base Width:			48 feet	
Boring ID	Sample ID	Sample Depth Interval (ft bgs)	Stratum	GWT Depth Below Footing (ft)	Footing Depth Below Existing (ft)	Thickness of Underdrain (ft)	Total Fill Replacement Below Footing (ft)	Potential Vertica Heave (inch)	GWT Depth Below Footing (ft)	Footing Depth Below Existing (ft)	Thickness of Underdrain (ft)	Total Fill Replacement Below Footing (ft)	Potential Vertica Heave (inch)
9-19	ST-5 (SPU)	8-10	Embank. Core	0	5	2	2	0.89	0	5	2	7	0.95
9-19	ST-5 (IC)	8-10	Embank. Core	0	5	2	2	0.82	0	5	2	6.5	1.05
9-19	ST-8	23-25	MPR	0	5	2	2	0.82	0	5	2	7	0.87
13-20	ST-4 (SPU)	6-8	Embank. Core	0	5	2	2	0.02	0	5	2	2	0.46
13-20	ST-4 (IC)	6-8	Embank. Core	0	5	2	2	0.92	0	5	2	7	0.92
	COMP-1700A	0 to 4/8	Embank. Shell	0	5	2	2	0.00	0	5	2	2	0.03
Minimum				---	---	---	---	0.00	---	---	---	---	0.03
Average				---	---	---	---	0.58	---	---	---	---	0.71
Maximum				---	---	---	---	0.92	---	---	---	---	1.05

				RCC SPILLWAY - STILLING BASIN - WALLS					RCC SPILLWAY - STILLING BASIN - SLAB				
				Sustained Foundation Pressure:			2,000 psf		Sustained Foundation Pressure:			450 psf	
				Foundation Base Width:			11.33 feet		Foundation Base Width:			24 feet	
Boring ID	Sample ID	Sample Depth Interval (ft bgs)	Stratum	GWT Depth Below Footing (ft)	Footing Depth Below Existing (ft)	Thickness of Underdrain (ft)	Total Fill Replacement Below Footing (ft)	Potential Vertica Heave (inch)	GWT Depth Below Footing (ft)	Footing Depth Below Existing (ft)	Thickness of Underdrain (ft)	Total Fill Replacement Below Footing (ft)	Potential Vertica Heave (inch)
601-19	ST-5 (SPU)	3.5-5.5	LPR	0	10	2	7	0.86	0	10	2	9	0.78
601-19	ST-5 (IC)	13-15	LPR	0	10	2	2	0.00	0	10	2	2	0.82
Minimum				---	---	---	---	0.00	---	---	---	---	0.78
Average				---	---	---	---	0.43	---	---	---	---	0.80
Maximum				---	---	---	---	0.86	---	---	---	---	0.82

				PRINCIPAL SPILLWAY - IMPACT BASIN					PRINCIPAL SPILLWAY - INLET TOWER				
				Sustained Foundation Pressure:			2,000 psf		Sustained Foundation Pressure:			1,500 psf	
				Foundation Base Width:			17.7 feet		Foundation Base Width:			13.5 feet	
Boring ID	Sample ID	Sample Depth Interval (ft bgs)	Stratum	GWT Depth Below Footing (ft)	Footing Depth Below Existing (ft)	Thickness of Underdrain (ft)	Total Fill Replacement Below Footing (ft)	Potential Vertica Heave (inch)	GWT Depth Below Footing (ft)	Footing Depth Below Existing (ft)	Thickness of Underdrain (ft)	Total Fill Replacement Below Footing (ft)	Potential Vertica Heave (inch)
603-19	ST-5	8-10	MPR	0	8.5	0	8	0.96	0	3	0	4.00	0.92
603-19	ST-5	8-10	MPR	0	8.5	0	8	0.96	0	3	0	4.00	0.92
Minimum				---	---	---	---	0.96	---	---	---	---	0.92
Average				---	---	---	---	0.96	---	---	---	---	0.92
Maximum				---	---	---	---	0.96	---	---	---	---	0.92

SWELL CALCULATIONS
PROPOSED PRINCIPAL SPILLWAY
INLET TOWER

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
Inlet Tower	0	3	0	1500	13.5	4	120
Swell parameters from the Impact Basin were extrapolated to Inlet Tower				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			10

Sample ID: ST-5

Boring ID:	603-19	Material:	MPR	Swelling Strain Index, Csε:	0.045
Depth (ft):	8-10	Total Unit Weight (pcf):	129.4	Swell Pressure (psf):	5,200

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
4	5	1	1,125	1,670	281	1,389	2.58	0.31	0.31
5	6	1	1,066	1,740	343	1,397	2.57	0.31	0.31
6	7	1	1,013	1,816	406	1,410	2.55	0.31	0.31
7	8	1	964	1,897	468	1,429	2.52	0.30	0.00
8	9	1	920	1,983	530	1,452	2.49	0.30	0.00
9	10	1	880	2,072	593	1,479	2.46	0.29	0.00
10	12	2	827	2,212	686	1,526	2.40	0.58	0.00
12	14	2	764	2,409	811	1,598	2.31	0.55	0.00
14	16	2	711	2,614	936	1,678	2.21	0.53	0.00
16	26	10	587	3,267	1,310	1,956	1.91	2.29	0.00
							SUM	**5.77**	**0.92**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
Inlet Tower	0	3	0	1500	13.5	4	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			10

Sample ID: **ST-5**

Boring ID:	603-19	Material:	MPR	Swelling Strain Index, Csε:	0.045
Depth (ft):	8-10	Total Unit Weight (pcf):	129.4	Swell Pressure (psf):	5,200

Depth Below Fndtn									
Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
4	5	1	1,125	1,670	281	1,389	2.58	0.31	0.31
5	6	1	1,066	1,740	343	1,397	2.57	0.31	0.31
6	7	1	1,013	1,816	406	1,410	2.55	0.31	0.31
7	8	1	964	1,897	468	1,429	2.52	0.30	0.00
8	9	1	920	1,983	530	1,452	2.49	0.30	0.00
9	10	1	880	2,072	593	1,479	2.46	0.29	0.00
10	12	2	827	2,212	686	1,526	2.40	0.58	0.00
12	14	2	764	2,409	811	1,598	2.31	0.55	0.00
14	16	2	711	2,614	936	1,678	2.21	0.53	0.00
16	26	10	587	3,267	1,310	1,956	1.91	2.29	0.00
							SUM	**5.77**	**0.92**

SWELL CALCULATIONS
PROPOSED PRINCIPAL SPILLWAY
IMPACT BASIN

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
Impact Basin	0	8.5	0	2000	17.7	8	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: **ST-5**

Boring ID:	603-19	Material:	MPR	Swelling Strain Index, Csε:	0.045
Depth (ft):	8-10	Total Unit Weight (pcf):	129.4	Swell Pressure (psf):	5,200

Depth Below Fndtn Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
8	9	1	1,351	2,376	530	1,845	2.02	0.24	0.24
9	10	1	1,301	2,456	593	1,863	2.01	0.24	0.24
10	11	1	1,255	2,539	655	1,884	1.98	0.24	0.24
11	12	1	1,212	2,625	718	1,908	1.96	0.24	0.24
12	13	1	1,172	2,714	780	1,934	1.93	0.23	0.00
13	14	1	1,135	2,806	842	1,964	1.90	0.23	0.00
14	16	2	1,083	2,948	936	2,012	1.86	0.45	0.00
16	18	2	1,020	3,145	1,061	2,084	1.79	0.43	0.00
18	20	2	965	3,348	1,186	2,162	1.71	0.41	0.00
20	30	10	829	3,989	1,560	2,429	1.49	1.79	0.00
							SUM	**4.49**	**0.96**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
Impact Basin	0	8.5	0	2000	17.7	8	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **ST-5**

Boring ID: 603-19 Material: MPR Swelling Strain Index, Csε: 0.045

Depth (ft): 8-10 Total Unit Weight (pcf): 129.4 Swell Pressure (psf): 5,200

Depth Below Fndtn									
Top (ft)	Bottom (ft)	Layer Thicknes s (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
8	9	1	1,351	2,376	530	1,845	2.02	0.24	0.24
9	10	1	1,301	2,456	593	1,863	2.01	0.24	0.24
10	11	1	1,255	2,539	655	1,884	1.98	0.24	0.24
11	12	1	1,212	2,625	718	1,908	1.96	0.24	0.24
12	13	1	1,172	2,714	780	1,934	1.93	0.23	0.00
13	14	1	1,135	2,806	842	1,964	1.90	0.23	0.00
14	16	2	1,083	2,948	936	2,012	1.86	0.45	0.00
16	18	2	1,020	3,145	1,061	2,084	1.79	0.43	0.00
18	20	2	965	3,348	1,186	2,162	1.71	0.41	0.00
20	30	10	829	3,989	1,560	2,429	1.49	1.79	0.00
							SUM	**4.49**	**0.96**

SWELL CALCULATIONS
PROPOSED RCC SPILLWAY
CREST STRUCTURE - WALLS

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Walls	0	3	0	1500	11.33	4	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: ST-5 (SPU)
Boring ID: 9-19 Material: Embank. Core Swelling Strain Index, Cs: 0.037
Depth (ft): 8-10 Total Unit Weight (pcf): 128.3 Swell Pressure (psf): 2,517

Depth Below Fndtn Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
4	5	1	1,074	1,618	281	1,337	1.02	0.12	0.12
5	6	1	1,010	1,682	343	1,339	1.01	0.12	0.12
6	7	1	953	1,754	406	1,348	1.00	0.12	0.12
7	8	1	903	1,832	468	1,364	0.98	0.12	0.12
8	9	1	857	1,914	530	1,384	0.96	0.12	0.12
9	10	1	816	2,002	593	1,409	0.93	0.11	0.11
10	12	2	761	2,139	686	1,453	0.88	0.21	0.21
12	14	2	699	2,333	811	1,522	0.81	0.19	0.00
14	16	2	645	2,537	936	1,601	0.73	0.17	0.00
16	26	10	526	3,187	1,310	1,876	0.47	0.57	0.00
							SUM	1.86	0.92

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Walls	0	3	0	1500	11.33	4	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: ST-5 (IC)
Boring ID: 9-19 Material: Embank. Core Swelling Strain Index, Cs: 0.035
Depth (ft): 8-10 Total Unit Weight (pcf): 128.3 Swell Pressure (psf): 6,338

Depth Below Fndtn Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
4	5	1	1,074	1,618	281	1,337	1.02	0.12	0.12
5	6	1	1,010	1,682	343	1,339	1.01	0.12	0.12
6	7	1	953	1,754	406	1,348	1.00	0.12	0.12
7	8	1	903	1,832	468	1,364	0.98	0.12	0.12
8	9	1	857	1,914	530	1,384	0.96	0.12	0.12
9	10	1	816	2,002	593	1,409	0.93	0.11	0.11
10	12	2	761	2,139	686	1,453	0.88	0.21	0.21
12	14	2	699	2,333	811	1,522	0.81	0.19	0.00
14	16	2	645	2,537	936	1,601	0.73	0.17	0.00
16	26	10	526	3,187	1,310	1,876	0.47	0.57	0.00
							SUM	1.86	0.92

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Walls	0	3	0	1500	11.33	4	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: ST-8
Boring ID: 9-19
Depth (ft): 23-25

Material: MPR
Total Unit Weight (pcf): 128.7

Swelling Strain Index, Csε: 0.034
Swell Pressure (psf): 2,521

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
4	5	1	1,074	1,618	281	1,337	0.94	0.11	0.11
5	6	1	1,010	1,683	343	1,340	0.93	0.11	0.11
6	7	1	953	1,755	406	1,349	0.92	0.11	0.11
7	8	1	903	1,833	468	1,365	0.91	0.11	0.11
8	9	1	857	1,916	530	1,386	0.88	0.11	0.11
9	10	1	816	2,004	593	1,411	0.86	0.10	0.10
10	12	2	761	2,142	686	1,456	0.81	0.19	0.19
12	14	2	699	2,337	811	1,526	0.74	0.18	0.00
14	16	2	645	2,541	936	1,605	0.67	0.16	0.00
16	26	10	526	3,194	1,310	1,883	0.43	0.52	0.00
							SUM	**1.70**	**0.85**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Walls	0	3	0	1500	11.33	2	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: **ST-4 (SPU)**

Boring ID:	13-20	Material:	Embank. Core	Swelling Strain Index, Cs:	0.013
Depth (ft):	6-8	Total Unit Weight (pcf):	129.1	Swell Pressure (psf):	1,637

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,229	1,533	156	1,377	0.10	0.01	0.01
3	4	1	1,146	1,580	218	1,361	0.10	0.01	0.01
4	5	1	1,074	1,636	281	1,356	0.11	0.01	0.01
5	6	1	1,010	1,702	343	1,358	0.11	0.01	0.01
6	7	1	953	1,774	406	1,369	0.10	0.01	0.01
7	8	1	903	1,853	468	1,385	0.09	0.01	0.01
8	10	2	836	1,980	562	1,418	0.08	0.02	0.02
10	12	2	761	2,163	686	1,477	0.06	0.01	0.01
12	14	2	699	2,359	811	1,547	0.03	0.01	0.01
14	24	10	560	2,995	1,186	1,809	0.00	0.00	0.00
							SUM	0.11	0.11

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Walls	0	3	0	1500	11.33	7	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: **ST-4 (IC)**

Boring ID:	13-20	Material:	Embank. Core	Swelling Strain Index, Cs:	0.034
Depth (ft):	6-8	Total Unit Weight (pcf):	129.1	Swell Pressure (psf):	2,666

Depth Below Fndtn									
Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
7	8	1	903	1,807	468	1,339	1.02	0.12	0.12
8	9	1	857	1,891	530	1,360	0.99	0.12	0.12
9	10	1	816	1,979	593	1,386	0.97	0.12	0.12
10	11	1	779	2,070	655	1,415	0.94	0.11	0.11
11	12	1	744	2,165	718	1,448	0.90	0.11	0.11
12	13	1	713	2,263	780	1,483	0.87	0.10	0.10
13	15	2	671	2,415	874	1,541	0.81	0.19	0.19
15	17	2	622	2,624	998	1,625	0.73	0.18	0.00
17	19	2	579	2,840	1,123	1,716	0.65	0.16	0.00
19	29	10	481	3,516	1,498	2,018	0.41	0.49	0.00
							SUM	**1.70**	**0.88**

SWELL CALCULATIONS
PROPOSED RCC SPILLWAY
CREST STRUCTURE - SLAB

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Slab	0	3	0	450	30	7	120

Footing Depth Below Finish (ft bgs): 3
Active Zone Depth (ft bgs): 15

Sample ID: ST-5 (SPU)
Boring ID: 9-19
Depth (ft): 8-10
Material: Embank. Core
Total Unit Weight (pcf): 128.3
Swelling Strain Index, Cs: 0.037
Swell Pressure (psf): 2,517

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
7	8	1	360	1,264	468	796	1.85	0.22	0.22
8	9	1	351	1,383	530	853	1.74	0.21	0.21
9	10	1	342	1,503	593	910	1.64	0.20	0.20
10	11	1	333	1,622	655	967	1.54	0.18	0.18
11	12	1	325	1,743	718	1,025	1.44	0.17	0.17
12	13	1	318	1,863	780	1,083	1.35	0.16	0.00
13	15	2	307	2,045	874	1,171	1.23	0.30	0.00
15	17	2	293	2,288	998	1,290	1.07	0.26	0.00
17	19	2	281	2,533	1,123	1,409	0.93	0.22	0.00
19	29	10	250	3,271	1,498	1,774	0.56	0.68	0.00
							SUM	2.60	0.98

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Slab	0	3	0	450	30	7	120

Footing Depth Below Finish (ft bgs): 3
Active Zone Depth (ft bgs): 15

Sample ID: ST-5 (IC)
Boring ID: 9-19
Depth (ft): 8-10
Material: Embank. Core
Total Unit Weight (pcf): 128.3
Swelling Strain Index, Cs: 0.035
Swell Pressure (psf): 6,338

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
7	8	1	360	1,264	468	796	1.85	0.22	0.22
8	9	1	351	1,383	530	853	1.74	0.21	0.21
9	10	1	342	1,503	593	910	1.64	0.20	0.20
10	11	1	333	1,622	655	967	1.54	0.18	0.18
11	12	1	325	1,743	718	1,025	1.44	0.17	0.17
12	13	1	318	1,863	780	1,083	1.35	0.16	0.00
13	15	2	307	2,045	874	1,171	1.23	0.30	0.00
15	17	2	293	2,288	998	1,290	1.07	0.26	0.00
17	19	2	281	2,533	1,123	1,409	0.93	0.22	0.00
19	29	10	250	3,271	1,498	1,774	0.56	0.68	0.00
							SUM	2.60	0.98

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Slab	0	3	0	450	30	7	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: **ST-8**
Boring ID: 9-19 Material: MPR Swelling Strain Index, Csε: 0.034
Depth (ft): 23-25 Total Unit Weight (pcf): 128.7 Swell Pressure (psf): 2,521

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
7	8	1	360	1,264	468	796	1.70	0.20	0.20
8	9	1	351	1,384	530	853	1.60	0.19	0.19
9	10	1	342	1,504	593	911	1.50	0.18	0.18
10	11	1	333	1,624	655	969	1.41	0.17	0.17
11	12	1	325	1,744	718	1,027	1.33	0.16	0.16
12	13	1	318	1,865	780	1,085	1.24	0.15	0.00
13	15	2	307	2,048	874	1,174	1.13	0.27	0.00
15	17	2	293	2,292	998	1,293	0.99	0.24	0.00
17	19	2	281	2,537	1,123	1,414	0.85	0.20	0.00
19	29	10	250	3,278	1,498	1,780	0.51	0.62	0.00
							SUM	**2.38**	**0.91**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Slab	0	3	0	450	30	2	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: ST-4 (SPU)
Boring ID: 13-20 Material: Embank. Core Swelling Strain Index, Cs%: 0.013
Depth (ft): 6-8 Total Unit Weight (pcf): 129.1 Swell Pressure (psf): 1,637

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	415	720	156	564	0.60	0.07	0.07
3	4	1	403	837	218	618	0.55	0.07	0.07
4	5	1	391	954	281	673	0.50	0.06	0.06
5	6	1	380	1,072	343	729	0.46	0.05	0.05
6	7	1	370	1,191	406	785	0.41	0.05	0.05
7	8	1	360	1,310	468	842	0.38	0.05	0.05
8	10	2	346	1,490	562	928	0.32	0.08	0.08
10	12	2	329	1,731	686	1,045	0.25	0.06	0.06
12	14	2	314	1,974	811	1,163	0.19	0.05	0.00
14	24	10	276	2,710	1,186	1,525	0.04	0.05	0.00
							SUM	**0.58**	**0.49**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Slab	0	3	0	450	30	7	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: **ST-4 (IC)**

Boring ID:	13-20	Material:	Embank. Core	Swelling Strain Index, Cs:	0.034
Depth (ft):	6-8	Total Unit Weight (pcf):	129.1	Swell Pressure (psf):	2,666

Depth Below Fndtn: Top (ft)	Depth Below Fndtn: Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
7	8	1	360	1,265	468	797	1.78	0.21	0.21
8	9	1	351	1,384	530	854	1.68	0.20	0.20
9	10	1	342	1,505	593	912	1.58	0.19	0.19
10	11	1	333	1,625	655	970	1.49	0.18	0.18
11	12	1	325	1,746	718	1,029	1.41	0.17	0.17
12	13	1	318	1,868	780	1,088	1.32	0.16	0.00
13	15	2	307	2,051	874	1,177	1.21	0.29	0.00
15	17	2	293	2,295	998	1,297	1.06	0.26	0.00
17	19	2	281	2,541	1,123	1,418	0.93	0.22	0.00
19	29	10	250	3,285	1,498	1,787	0.59	0.71	0.00
							SUM	**2.59**	**0.95**

SWELL CALCULATIONS
PROPOSED RCC SPILLWAY
CHUTE STRUCTURE - WALLS

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Walls	0	5	0	1800	11.33	2	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: ST-5 (SPU)
Boring ID: 9-19
Depth (ft): 8-10
Material: Embank. Core
Total Unit Weight (pcf): 128.3
Swelling Strain Index, Csε: 0.037
Swell Pressure (psf): 2,517

Depth Below Fndtn Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,475	1,779	156	1,623	0.71	0.08	0.08
3	4	1	1,375	1,808	218	1,589	0.74	0.09	0.09
4	5	1	1,288	1,849	281	1,568	0.76	0.09	0.09
5	6	1	1,212	1,901	343	1,558	0.77	0.09	0.09
6	7	1	1,144	1,961	406	1,556	0.77	0.09	0.09
7	8	1	1,083	2,029	468	1,561	0.77	0.09	0.09
8	10	2	1,003	2,141	562	1,580	0.75	0.18	0.18
10	12	2	913	2,308	686	1,622	0.71	0.17	0.17
12	14	2	838	2,490	811	1,678	0.65	0.16	0.00
14	24	10	672	3,094	1,186	1,908	0.45	0.53	0.00
							SUM	1.58	0.89

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Walls	0	5	0	1800	11.33	2	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: ST-5 (IC)
Boring ID: 9-19
Depth (ft): 8-10
Material: Embank. Core
Total Unit Weight (pcf): 128.3
Swelling Strain Index, Csε: 0.035
Swell Pressure (psf): 6,338

Depth Below Fndtn Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,475	1,779	156	1,623	0.65	0.08	0.08
3	4	1	1,375	1,808	218	1,590	0.68	0.08	0.08
4	5	1	1,288	1,850	281	1,569	0.70	0.08	0.08
5	6	1	1,212	1,902	343	1,559	0.71	0.09	0.09
6	7	1	1,144	1,963	406	1,557	0.71	0.09	0.09
7	8	1	1,083	2,031	468	1,563	0.71	0.08	0.08
8	10	2	1,003	2,144	562	1,582	0.69	0.17	0.17
10	12	2	913	2,312	686	1,625	0.65	0.16	0.16
12	14	2	838	2,494	811	1,683	0.60	0.14	0.00
14	24	10	672	3,100	1,186	1,915	0.41	0.49	0.00
							SUM	1.45	0.82

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Walls	0	5	0	1800	11.33	2	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: **ST-8**

Boring ID:	9-19	Material:	MPR	Swelling Strain Index, Csε:	0.034
Depth (ft):	23-25	Total Unit Weight (pcf):	128.7	Swell Pressure (psf):	2,521

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,475	1,779	156	1,623	0.65	0.08	0.08
3	4	1	1,375	1,808	218	1,590	0.68	0.08	0.08
4	5	1	1,288	1,850	281	1,569	0.70	0.08	0.08
5	6	1	1,212	1,902	343	1,559	0.71	0.09	0.09
6	7	1	1,144	1,963	406	1,557	0.71	0.09	0.09
7	8	1	1,083	2,031	468	1,563	0.71	0.08	0.08
8	10	2	1,003	2,144	562	1,582	0.69	0.17	0.17
10	12	2	913	2,312	686	1,625	0.65	0.16	0.16
12	14	2	838	2,494	811	1,683	0.60	0.14	0.00
14	24	10	672	3,100	1,186	1,915	0.41	0.49	0.00
							SUM	**1.45**	**0.82**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Walls	0	5	0	1800	11.33	2	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **ST-4 (SPU)**

Boring ID:	13-20	Material:	Embank. Core	Swelling Strain Index, Csε:	0.013
Depth (ft):	6-8	Total Unit Weight (pcf):	129.1	Swell Pressure (psf):	1,637

Depth Below Fndtn Top (ft)	Bottom (ft)	Layer Thicknes s (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,475	1,779	156	1,623	0.00	0.00	0.00
3	4	1	1,375	1,809	218	1,590	0.02	0.00	0.00
4	5	1	1,288	1,851	281	1,570	0.02	0.00	0.00
5	6	1	1,212	1,904	343	1,560	0.03	0.00	0.00
6	7	1	1,144	1,965	406	1,559	0.03	0.00	0.00
7	8	1	1,083	2,033	468	1,565	0.03	0.00	0.00
8	10	2	1,003	2,147	562	1,585	0.02	0.00	0.00
10	12	2	913	2,315	686	1,629	0.00	0.00	0.00
12	14	2	838	2,498	811	1,687	0.00	0.00	0.00
14	24	10	672	3,107	1,186	1,922	0.00	0.00	0.00
							SUM	0.02	0.02

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Walls	0	5	0	1800	11.33	2	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: ST-4 (IC)

Boring ID: 13-20 | Material: Embank. Core | Swelling Strain Index, Csε: 0.034

Depth (ft): 6-8 | Total Unit Weight (pcf): 129.1 | Swell Pressure (psf): 2,666

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,475	1,779	156	1,623	0.73	0.09	0.09
3	4	1	1,375	1,809	218	1,590	0.76	0.09	0.09
4	5	1	1,288	1,851	281	1,570	0.78	0.09	0.09
5	6	1	1,212	1,904	343	1,560	0.79	0.09	0.09
6	7	1	1,144	1,965	406	1,559	0.79	0.10	0.10
7	8	1	1,083	2,033	468	1,565	0.79	0.09	0.09
8	10	2	1,003	2,147	562	1,585	0.77	0.18	0.18
10	12	2	913	2,315	686	1,629	0.73	0.17	0.17
12	14	2	838	2,498	811	1,687	0.68	0.16	0.00
14	24	10	672	3,107	1,186	1,922	0.48	0.58	0.00
							SUM	**1.66**	**0.92**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Walls	0	5	0	1800	11.33	2	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: COMP-1700A

Boring ID:	mix	Material:	Embank. Shell	Swelling Strain Index, Csε:	0.011
Depth (ft):	0 to 4,8	Total Unit Weight (pcf):	125.0	Swell Pressure (psf):	746

Depth Below Fndtn Top (ft)	Bottom (ft)	Layer Thicknes s (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,475	1,777	156	1,621	0.00	0.00	0.00
3	4	1	1,375	1,803	218	1,584	0.00	0.00	0.00
4	5	1	1,288	1,841	281	1,560	0.00	0.00	0.00
5	6	1	1,212	1,889	343	1,546	0.00	0.00	0.00
6	7	1	1,144	1,946	406	1,541	0.00	0.00	0.00
7	8	1	1,083	2,011	468	1,543	0.00	0.00	0.00
8	10	2	1,003	2,118	562	1,557	0.00	0.00	0.00
10	12	2	913	2,278	686	1,592	0.00	0.00	0.00
12	14	2	838	2,453	811	1,642	0.00	0.00	0.00
14	24	10	672	3,037	1,186	1,852	0.00	0.00	0.00
							SUM	**0.00**	**0.00**

SWELL CALCULATIONS
PROPOSED RCC SPILLWAY
CHUTE STRUCTURE - SLAB

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Slab	0	5	0	450	48	7	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: ST-5 (SPU)
Boring ID: 9-19 Material: Embank. Core Swelling Strain Index, Cs: 0.037
Depth (ft): 8-10 Total Unit Weight (pcf): 128.3 Swell Pressure (psf): 2,517

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
7	8	1	389	1,293	468	825	1.79	0.22	0.22
8	9	1	382	1,415	530	884	1.68	0.20	0.20
9	10	1	376	1,536	593	944	1.58	0.19	0.19
10	11	1	369	1,658	655	1,003	1.48	0.18	0.18
11	12	1	363	1,780	718	1,063	1.39	0.17	0.17
12	13	1	357	1,903	780	1,123	1.30	0.16	0.00
13	15	2	348	2,086	874	1,213	1.17	0.28	0.00
15	17	2	338	2,332	998	1,334	1.02	0.24	0.00
17	19	2	327	2,579	1,123	1,455	0.88	0.21	0.00
19	29	10	300	3,321	1,498	1,824	0.52	0.62	0.00
							SUM	2.46	0.95

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Slab	0	5	0	450	48	6.5	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: ST-5 (IC)
Boring ID: 9-19 Material: Embank. Core Swelling Strain Index, Cs: 0.035
Depth (ft): 8-10 Total Unit Weight (pcf): 128.3 Swell Pressure (psf): 6,338

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
6.5	7.5	1	393	1,233	437	796	1.70	0.20	0.20
7.5	8.5	1	386	1,354	499	855	1.60	0.19	0.19
8.5	9.5	1	379	1,476	562	915	1.50	0.18	0.18
9.5	10.5	1	372	1,599	624	975	1.40	0.17	0.17
10.5	11.5	1	366	1,721	686	1,035	1.32	0.16	0.16
11.5	12.5	1	360	1,844	749	1,095	1.23	0.15	0.15
12.5	14.5	2	351	2,028	842	1,185	1.11	0.27	0.00
14.5	16.5	2	340	2,274	967	1,307	0.97	0.23	0.00
16.5	18.5	2	330	2,521	1,092	1,429	0.84	0.20	0.00
18.5	28.5	10	302	3,266	1,466	1,799	0.50	0.60	0.00
							SUM	2.35	1.05

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Slab	0	5	0	450	48	7	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: ST-8
Boring ID: 9-19 | Material: MPR | Swelling Strain Index, Cs: 0.034
Depth (ft): 23-25 | Total Unit Weight (pcf): 128.7 | Swell Pressure (psf): 2,521

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
7	8	1	389	1,294	468	826	1.65	0.20	0.20
8	9	1	382	1,415	530	885	1.55	0.19	0.19
9	10	1	376	1,537	593	945	1.45	0.17	0.17
10	11	1	369	1,660	655	1,004	1.36	0.16	0.16
11	12	1	363	1,782	718	1,065	1.27	0.15	0.15
12	13	1	357	1,905	780	1,125	1.19	0.14	0.00
13	15	2	348	2,089	874	1,216	1.08	0.26	0.00
15	17	2	338	2,336	998	1,337	0.94	0.22	0.00
17	19	2	327	2,583	1,123	1,460	0.81	0.19	0.00
19	29	10	300	3,328	1,498	1,830	0.47	0.57	0.00
							SUM	**2.26**	**0.87**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Slab	0	5	0	450	48	2	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: ST-4 (SPU)
Boring ID: 13-20 Material: Embank. Core Swelling Strain Index, Csε: 0.013
Depth (ft): 6-8 Total Unit Weight (pcf): 129.1 Swell Pressure (psf): 1,637

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	428	732	156	576	0.59	0.07	0.07
3	4	1	419	853	218	635	0.53	0.06	0.06
4	5	1	411	974	281	693	0.49	0.06	0.06
5	6	1	404	1,096	343	752	0.44	0.05	0.05
6	7	1	396	1,217	406	812	0.40	0.05	0.05
7	8	1	389	1,339	468	871	0.36	0.04	0.04
8	10	2	379	1,523	562	961	0.30	0.07	0.07
10	12	2	366	1,768	686	1,082	0.23	0.06	0.06
12	14	2	354	2,014	811	1,203	0.17	0.04	0.00
14	24	10	322	2,757	1,186	1,571	0.02	0.03	0.00
							SUM	**0.53**	**0.46**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Slab	0	5	0	450	48	7	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: ST-4 (IC)
Boring ID: 13-20 Material: Embank. Core Swelling Strain Index, $C_{s\varepsilon}$: 0.034
Depth (ft): 6-8 Total Unit Weight (pcf): 129.1 Swell Pressure (psf): 2,666

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
7	8	1	389	1,294	468	826	1.73	0.21	0.21
8	9	1	382	1,416	530	886	1.63	0.20	0.20
9	10	1	376	1,538	593	946	1.53	0.18	0.18
10	11	1	369	1,661	655	1,006	1.44	0.17	0.17
11	12	1	363	1,784	718	1,066	1.35	0.16	0.16
12	13	1	357	1,907	780	1,127	1.27	0.15	0.00
13	15	2	348	2,092	874	1,218	1.16	0.28	0.00
15	17	2	338	2,339	998	1,341	1.01	0.24	0.00
17	19	2	327	2,587	1,123	1,464	0.88	0.21	0.00
19	29	10	300	3,335	1,498	1,837	0.55	0.66	0.00
							SUM	**2.47**	**0.92**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Slab	0	5	0	450	48	2	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: **COMP-1700A**

Boring ID: mix | Material: Embank. Shell | Swelling Strain Index, Cs: 0.011

Depth (ft): 0 to 4,8 | Total Unit Weight (pcf): 125.0 | Swell Pressure (psf): 746

Depth Below Fndtn									
Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	428	730	156	574	0.13	0.02	0.02
3	4	1	419	847	218	629	0.08	0.01	0.01
4	5	1	411	964	281	683	0.04	0.01	0.01
5	6	1	404	1,081	343	738	0.01	0.00	0.00
6	7	1	396	1,199	406	793	0.00	0.00	0.00
7	8	1	389	1,317	468	849	0.00	0.00	0.00
8	10	2	379	1,494	562	932	0.00	0.00	0.00
10	12	2	366	1,731	686	1,045	0.00	0.00	0.00
12	14	2	354	1,969	811	1,158	0.00	0.00	0.00
14	24	10	322	2,687	1,186	1,502	0.00	0.00	0.00
							SUM	0.03	0.03

SWELL CALCULATIONS
PROPOSED RCC SPILLWAY
STILLING BASIN - WALLS

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Stilling Basin - Walls	0	10	0	2000	11.33	7	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **ST-3**

Boring ID: 601-19 Material: LPR Swelling Strain Index, Csε: 0.029

Depth (ft): 3.5-5.5 Total Unit Weight (pcf): 123.6 Swell Pressure (psf): 5,121

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thicknes s (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
7	8	1	1,203	2,105	468	1,637	1.44	0.17	0.17
8	9	1	1,143	2,168	530	1,638	1.44	0.17	0.17
9	10	1	1,088	2,237	593	1,644	1.43	0.17	0.17
10	11	1	1,038	2,311	655	1,655	1.42	0.17	0.17
11	12	1	993	2,389	718	1,671	1.41	0.17	0.17
12	13	1	951	2,471	780	1,691	1.40	0.17	0.00
13	15	2	895	2,600	874	1,726	1.37	0.33	0.00
15	17	2	829	2,782	998	1,783	1.33	0.32	0.00
17	19	2	773	2,972	1,123	1,849	1.28	0.31	0.00
19	29	10	641	3,583	1,498	2,085	1.13	1.36	0.00
							SUM	**3.34**	**0.86**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Stilling Basin - Walls	0	10	0	2000	11.33	2	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **ST-6**

Boring ID:	601-19	Material:	LPR	Swelling Strain Index, Csε:	0.023
Depth (ft):	13-15	Total Unit Weight (pcf):	132.2	Swell Pressure (psf):	1,578

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thicknes s (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,638	1,945	156	1,789	0.00	0.00	0.00
3	4	1	1,528	1,966	218	1,748	0.00	0.00	0.00
4	5	1	1,431	2,002	281	1,721	0.00	0.00	0.00
5	6	1	1,346	2,049	343	1,706	0.00	0.00	0.00
6	7	1	1,271	2,106	406	1,700	0.00	0.00	0.00
7	8	1	1,203	2,170	468	1,702	0.00	0.00	0.00
8	10	2	1,115	2,280	562	1,718	0.00	0.00	0.00
10	12	2	1,015	2,445	686	1,758	0.00	0.00	0.00
12	14	2	931	2,626	811	1,814	0.00	0.00	0.00
14	24	10	747	3,235	1,186	2,049	0.00	0.00	0.00
							SUM	**0.00**	**0.00**

SWELL CALCULATIONS
PROPOSED RCC SPILLWAY
STILLING BASIN - SLAB

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Stilling Basin - Slab	0	10	0	450	24	9	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: ST-3
Boring ID: 601-19 — Material: LPR — Swelling Strain Index, Cs: 0.029
Depth (ft): 3.5-5.5 — Total Unit Weight (pcf): 123.6 — Swell Pressure (psf): 5,121

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
9	10	1	322	1,464	593	871	2.23	0.27	0.27
10	11	1	313	1,578	655	923	2.16	0.26	0.26
11	12	1	304	1,693	718	976	2.09	0.25	0.25
12	13	1	296	1,808	780	1,028	2.02	0.24	0.00
13	14	1	288	1,924	842	1,082	1.96	0.23	0.00
14	15	1	281	2,040	905	1,136	1.90	0.23	0.00
15	17	2	270	2,215	998	1,217	1.81	0.43	0.00
17	19	2	257	2,450	1,123	1,326	1.70	0.41	0.00
19	21	2	245	2,685	1,248	1,437	1.60	0.38	0.00
21	31	10	216	3,397	1,622	1,775	1.33	1.60	0.00
							SUM	**4.31**	**0.78**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Stilling Basin - Slab	0	10	0	450	24	2	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: ST-6

Boring ID:	601-19	Material:	LPR	Swelling Strain Index, Cs:	0.023
Depth (ft):	13-15	Total Unit Weight (pcf):	132.2	Swell Pressure (psf):	1,578

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	408	714	156	558	1.04	0.12	0.12
3	4	1	393	831	218	613	0.95	0.11	0.11
4	5	1	379	949	281	669	0.86	0.10	0.10
5	6	1	366	1,069	343	726	0.78	0.09	0.09
6	7	1	354	1,189	406	783	0.70	0.08	0.08
7	8	1	343	1,310	468	842	0.63	0.08	0.08
8	10	2	327	1,493	562	931	0.53	0.13	0.13
10	12	2	309	1,738	686	1,052	0.41	0.10	0.10
12	14	2	292	1,986	811	1,175	0.29	0.07	0.00
14	24	10	251	2,739	1,186	1,553	0.02	0.02	0.00
							SUM	**0.91**	**0.82**

SUMMARY OF SWELL CALCULATIONS FOR PROPOSED STRUCTURES

Analysis Case: Limit heave to 1.5 inch or less

				RCC SPLLWAY - CREST STRUCTURE - WALLS					RCC SPLLWAY - CREST STRUCTURE - SLAB					RCC SPLLWAY - CHUTE STRUCTURE - WALLS					RCC SPLLWAY - CHUTE STRUCTURE - SLAB				
				Sustained Foundation Pressure:			1,500	psf	Sustained Foundation Pressure:			450	psf	Sustained Foundation Pressure:			1,800	psf	Sustained Foundation Pressure:			450	psf
				Foundation Base Width:			11.33	feet	Foundation Base Width:			30	feet	Foundation Base Width:			11.33	feet	Foundation Base Width:			48	feet
Boring ID	Sample ID	Sample Depth Interval (ft bgs)	Stratum	GWT Depth Below Footing (ft)	Footing Depth Below Existing (ft)	Thickness of Underdrain (ft)	Total Fill Replacement Below Footing (ft)	Potential Vertical Heave (inch)	GWT Depth Below Footing (ft)	Footing Depth Below Existing (ft)	Thickness of Underdrain (ft)	Total Fill Replacement Below Footing (ft)	Potential Vertical Heave (inch)	GWT Depth Below Footing (ft)	Footing Depth Below Existing (ft)	Thickness of Underdrain (ft)	Total Fill Replacement Below Footing (ft)	Potential Vertical Heave (inch)	GWT Depth Below Footing (ft)	Footing Depth Below Existing (ft)	Thickness of Underdrain (ft)	Total Fill Replacement Below Footing (ft)	Potential Vertical Heave (inch)
9-19	ST-5 (SPU)	8-10	Embank. Core	0	3	2	3	1.13	0	3	2	6	1.21	0	5	2	2	0.89	0	5	2	6	1.17
9-19	ST-5 (IC)	8-10	Embank. Core	0	3	2	2	1.15	0	3	2	6	1.21	0	5	2	2	0.82	0	5	2	5	1.42
9-19	ST-8	23-25	MPR	0	3	2	2	1.05	0	3	2	5.5	1.44	0	5	2	2	0.82	0	5	2	5	1.42
13-20	ST-4 (SPU)	6-8	Embank. Core	0	3	2	2	0.11	0	3	2	2	0.49	0	5	2	2	0.02	0	5	2	2	0.46
13-20	ST-4 (IC)	6-8	Embank. Core	0	3	2	3	1.32	0	3	2	6	1.17	0	5	2	2	0.92	0	5	2	5	1.50
COMP-1700A	COMP-1700A	0 to 4/8	Embank. Shell	-	-	-	-	-	-	-	-	-	-	0	5	2	2	0.00	0	5	2	2	0.03
Minimum				---	---	---	---	0.11	---	---	---	---	0.49	---	---	---	---	0.00	---	---	---	---	0.03
Average				---	---	---	---	0.95	---	---	---	---	1.10	---	---	---	---	0.58	---	---	---	---	1.00
Maximum				---	---	---	---	1.32	---	---	---	---	1.44	---	---	---	---	0.92	---	---	---	---	1.50

				RCC SPILLWAY - STILLING BASIN - WALLS					RCC SPILLWAY - STILLING BASIN - SLAB				
				Sustained Foundation Pressure:			2,000	psf	Sustained Foundation Pressure:			450	psf
				Foundation Base Width:			11.33	feet	Foundation Base Width:			24	feet
Boring ID	Sample ID	Sample Depth Interval (ft bgs)	Stratum	GWT Depth Below Footing (ft)	Footing Depth Below Existing (ft)	Thickness of Underdrain (ft)	Total Fill Replacement Below Footing (ft)	Potential Vertical Heave (inch)	GWT Depth Below Footing (ft)	Footing Depth Below Existing (ft)	Thickness of Underdrain (ft)	Total Fill Replacement Below Footing (ft)	Potential Vertical Heave (inch)
601-19	ST-5 (SPU)	3.5-5.5	LPR	0	10	2	4	1.36	0	10	2	7	1.33
601-19	ST-5 (IC)	13-15	LPR	0	10	2	2	0.00	0	10	2	2	0.82
Minimum				---	---	---	---	0.00	---	---	---	---	0.82
Average				---	---	---	---	0.68	---	---	---	---	1.08
Maximum				---	---	---	---	1.36	---	---	---	---	1.33

				PRINCIPAL SPILLWAY - IMPACT BASIN					PRINCIPAL SPILLWAY - INLET TOWER				
				Sustained Foundation Pressure:			2,000	psf	Sustained Foundation Pressure:			1,500	psf
				Foundation Base Width:			17.7	feet	Foundation Base Width:			13.5	feet
Boring ID	Sample ID	Sample Depth Interval (ft bgs)	Stratum	GWT Depth Below Footing (ft)	Footing Depth Below Existing (ft)	Thickness of Underdrain (ft)	Total Fill Replacement Below Footing (ft)	Potential Vertical Heave (inch)	GWT Depth Below Footing (ft)	Footing Depth Below Existing (ft)	Thickness of Underdrain (ft)	Total Fill Replacement Below Footing (ft)	Potential Vertical Heave (inch)
603-19	ST-5	8-10	MPR	0	8.5	0	6	1.43	0	3	0	2.00	1.53
603-19	ST-5	8-10	MPR	0	8.5	0	6	1.43	0	3	0	2.00	1.53
Minimum				---	---	---	---	1.43	---	---	---	---	1.53
Average				---	---	---	---	1.43	---	---	---	---	1.53
Maximum				---	---	---	---	1.43	---	---	---	---	1.53

SWELL CALCULATIONS
PROPOSED PRINCIPAL SPILLWAY
INLET TOWER

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
Inlet Tower	0	3	0	1500	13.5	2	120

Swell parameters from the Impact Basin were extrapolated to Inlet Tower

Footing Depth Below Finish (ft bgs):	3
Active Zone Depth (ft bgs):	10

Sample ID: **ST-5**

Boring ID: 603-19 Material: MPR Swelling Strain Index, Csε: 0.045

Depth (ft): 8-10 Total Unit Weight (pcf): 129.4 Swell Pressure (psf): 5,200

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,266	1,570	156	1,414	2.54	0.31	0.31
3	4	1	1,191	1,625	218	1,407	2.55	0.31	0.31
4	5	1	1,125	1,689	281	1,408	2.55	0.31	0.31
5	6	1	1,066	1,759	343	1,415	2.54	0.31	0.31
6	7	1	1,013	1,835	406	1,429	2.52	0.30	0.30
7	8	1	964	1,916	468	1,448	2.50	0.30	0.00
8	10	2	900	2,046	562	1,484	2.45	0.59	0.00
10	12	2	827	2,231	686	1,545	2.37	0.57	0.00
12	14	2	764	2,428	811	1,616	2.28	0.55	0.00
14	24	10	623	3,063	1,186	1,877	1.99	2.39	0.00
							SUM	**5.92**	**1.53**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
Inlet Tower	0	3	0	1500	13.5	2	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	10

Sample ID: **ST-5**

Boring ID: 603-19 Material: MPR Swelling Strain Index, Csε: 0.045

Depth (ft): 8-10 Total Unit Weight (pcf): 129.4 Swell Pressure (psf): 5,200

Depth Below Fndtn: Top (ft)	Depth Below Fndtn: Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,266	1,570	156	1,414	2.54	0.31	0.31
3	4	1	1,191	1,625	218	1,407	2.55	0.31	0.31
4	5	1	1,125	1,689	281	1,408	2.55	0.31	0.31
5	6	1	1,066	1,759	343	1,415	2.54	0.31	0.31
6	7	1	1,013	1,835	406	1,429	2.52	0.30	0.30
7	8	1	964	1,916	468	1,448	2.50	0.30	0.00
8	10	2	900	2,046	562	1,484	2.45	0.59	0.00
10	12	2	827	2,231	686	1,545	2.37	0.57	0.00
12	14	2	764	2,428	811	1,616	2.28	0.55	0.00
14	24	10	623	3,063	1,186	1,877	1.99	2.39	0.00
							SUM	**5.92**	**1.53**

SWELL CALCULATIONS
PROPOSED PRINCIPAL SPILLWAY
IMPACT BASIN

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
Impact Basin	0	8.5	0	2000	17.7	6	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **ST-5**
Boring ID: 603-19
Depth (ft): 8-10
Material: MPR
Total Unit Weight (pcf): 129.4
Swelling Strain Index, Csε: 0.045
Swell Pressure (psf): 5,200

Depth Below Fndtn									
Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
6	7	1	1,463	2,248	406	1,842	2.03	0.24	0.24
7	8	1	1,405	2,319	468	1,851	2.02	0.24	0.24
8	9	1	1,351	2,395	530	1,864	2.00	0.24	0.24
9	10	1	1,301	2,474	593	1,882	1.99	0.24	0.24
10	11	1	1,255	2,558	655	1,902	1.97	0.24	0.24
11	12	1	1,212	2,644	718	1,926	1.94	0.23	0.23
12	14	2	1,153	2,779	811	1,968	1.90	0.46	0.00
14	16	2	1,083	2,967	936	2,031	1.84	0.44	0.00
16	18	2	1,020	3,164	1,061	2,103	1.77	0.42	0.00
18	28	10	870	3,790	1,435	2,354	1.55	1.86	0.00
							SUM	**4.61**	**1.43**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
Impact Basin	0	8.5	0	2000	17.7	6	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **ST-5**

Boring ID: 603-19 Material: MPR Swelling Strain Index, Csε: 0.045

Depth (ft): 8-10 Total Unit Weight (pcf): 129.4 Swell Pressure (psf): 5,200

Depth Below Fndtn									
Top (ft)	**Bottom (ft)**	**Layer Thickness (ft)**	**Fndtn Stress at Mid (psf) - 2V:1H Mtd**	**Total Stress at Mid (psf)**	**u at Mid (psf)**	**Eff. Stress at Mid (psf)**	**Swell at Eff. Stress (%)**	**Layer Heave (inch)**	**Heave limited to 15' active zone (inch)**
6	7	1	1,463	2,248	406	1,842	2.03	0.24	0.24
7	8	1	1,405	2,319	468	1,851	2.02	0.24	0.24
8	9	1	1,351	2,395	530	1,864	2.00	0.24	0.24
9	10	1	1,301	2,474	593	1,882	1.99	0.24	0.24
10	11	1	1,255	2,558	655	1,902	1.97	0.24	0.24
11	12	1	1,212	2,644	718	1,926	1.94	0.23	0.23
12	14	2	1,153	2,779	811	1,968	1.90	0.46	0.00
14	16	2	1,083	2,967	936	2,031	1.84	0.44	0.00
16	18	2	1,020	3,164	1,061	2,103	1.77	0.42	0.00
18	28	10	870	3,790	1,435	2,354	1.55	1.86	0.00
							SUM	**4.61**	**1.43**

SWELL CALCULATIONS
PROPOSED RCC SPILLWAY
CREST STRUCTURE - WALLS

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Walls	0	3	0	1500	11.33	3	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **ST-5 (SPU)**

Boring ID: 9-19 | Material: Embank. Core | Swelling Strain Index, Csε: 0.037

Depth (ft): 8-10 | Total Unit Weight (pcf): 128.3 | Swell Pressure (psf): 2,517

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
3	4	1	1,146	1,570	218	1,352	1.00	0.12	0.12
4	5	1	1,074	1,626	281	1,345	1.01	0.12	0.12
5	6	1	1,010	1,691	343	1,347	1.00	0.12	0.12
6	7	1	953	1,762	406	1,357	0.99	0.12	0.12
7	8	1	903	1,840	468	1,372	0.98	0.12	0.12
8	9	1	857	1,923	530	1,392	0.95	0.11	0.11
9	11	2	797	2,055	624	1,431	0.91	0.22	0.22
11	13	2	728	2,243	749	1,494	0.84	0.20	0.20
13	15	2	671	2,442	874	1,569	0.76	0.18	0.00
15	25	10	542	3,084	1,248	1,836	0.51	0.61	0.00
							SUM	1.92	1.13

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Walls	0	3	0	1500	11.33	2	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **ST-5 (IC)**

Boring ID: 9-19 | Material: Embank. Core | Swelling Strain Index, Csε: 0.035

Depth (ft): 8-10 | Total Unit Weight (pcf): 128.3 | Swell Pressure (psf): 6,338

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,229	1,525	156	1,369	0.98	0.12	0.12
3	4	1	1,146	1,570	218	1,352	1.00	0.12	0.12
4	5	1	1,074	1,626	281	1,345	1.01	0.12	0.12
5	6	1	1,010	1,691	343	1,347	1.00	0.12	0.12
6	7	1	953	1,762	406	1,357	0.99	0.12	0.12
7	8	1	903	1,840	468	1,372	0.98	0.12	0.12
8	10	2	836	1,966	562	1,404	0.94	0.23	0.23
10	12	2	761	2,147	686	1,461	0.87	0.21	0.21
12	14	2	699	2,342	811	1,530	0.80	0.19	0.00
14	24	10	560	2,973	1,186	1,788	0.55	0.66	0.00
							SUM	2.00	1.15

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Walls	0	3	0	1500	11.33	2	120

Footing Depth Below Finish (ft bgs):	3
Active Zone Depth (ft bgs):	15

Sample ID: **ST-8**

Boring ID:	9-19	Material:	MPR	Swelling Strain Index, Csε:	0.034
Depth (ft):	23-25	Total Unit Weight (pcf):	128.7	Swell Pressure (psf):	2,521

Depth Below Fndtn									
Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,229	1,533	156	1,377	0.89	0.11	0.11
3	4	1	1,146	1,579	218	1,361	0.91	0.11	0.11
4	5	1	1,074	1,635	281	1,355	0.92	0.11	0.11
5	6	1	1,010	1,700	343	1,357	0.91	0.11	0.11
6	7	1	953	1,772	406	1,367	0.90	0.11	0.11
7	8	1	903	1,850	468	1,382	0.89	0.11	0.11
8	10	2	836	1,977	562	1,415	0.85	0.20	0.20
10	12	2	761	2,159	686	1,473	0.79	0.19	0.19
12	14	2	699	2,354	811	1,543	0.72	0.17	0.00
14	24	10	560	2,988	1,186	1,803	0.50	0.59	0.00
							SUM	**1.81**	**1.05**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Walls	0	3	0	1500	11.33	2	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: **ST-4 (SPU)**

Boring ID: 13-20 Material: Embank. Core Swelling Strain Index, Csε: 0.013

Depth (ft): 6-8 Total Unit Weight (pcf): 129.1 Swell Pressure (psf): 1,637

Depth Below Fndtn Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,229	1,533	156	1,377	0.10	0.01	0.01
3	4	1	1,146	1,580	218	1,361	0.10	0.01	0.01
4	5	1	1,074	1,636	281	1,356	0.11	0.01	0.01
5	6	1	1,010	1,702	343	1,358	0.11	0.01	0.01
6	7	1	953	1,774	406	1,369	0.10	0.01	0.01
7	8	1	903	1,853	468	1,385	0.09	0.01	0.01
8	10	2	836	1,980	562	1,418	0.08	0.02	0.02
10	12	2	761	2,163	686	1,477	0.06	0.01	0.01
12	14	2	699	2,359	811	1,547	0.03	0.01	0.01
14	24	10	560	2,995	1,186	1,809	0.00	0.00	0.00
							SUM	**0.11**	**0.11**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Walls	0	3	0	1500	11.33	3	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: ST-4 (IC)

Boring ID:	13-20	Material:	Embank. Core	Swelling Strain Index, Csε:	0.034
Depth (ft):	6-8	Total Unit Weight (pcf):	129.1	Swell Pressure (psf):	2,666

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
3	4	1	1,146	1,571	218	1,352	1.00	0.12	0.12
4	5	1	1,074	1,627	281	1,346	1.01	0.12	0.12
5	6	1	1,010	1,693	343	1,349	1.01	0.12	0.12
6	7	1	953	1,765	406	1,359	0.99	0.12	0.12
7	8	1	903	1,843	468	1,375	0.98	0.12	0.12
8	9	1	857	1,927	530	1,397	0.95	0.11	0.11
9	11	2	797	2,060	624	1,436	0.91	0.22	0.22
11	13	2	728	2,250	749	1,502	0.85	0.20	0.20
13	15	2	671	2,451	874	1,577	0.77	0.19	0.19
15	25	10	542	3,097	1,248	1,849	0.54	0.65	0.00
							SUM	**1.97**	**1.32**

SWELL CALCULATIONS
PROPOSED RCC SPILLWAY
CREST STRUCTURE - SLAB

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Slab	0	3	0	450	30	6	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: ST-5 (SPU)

Boring ID:	9-19	Material:	Embank. Core	Swelling Strain Index, Csε:	0.037
Depth (ft):	8-10	Total Unit Weight (pcf):	128.3	Swell Pressure (psf):	2,517

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
6	7	1	370	1,154	406	748	1.95	0.23	0.23
7	8	1	360	1,272	468	804	1.83	0.22	0.22
8	9	1	351	1,391	530	861	1.72	0.21	0.21
9	10	1	342	1,511	593	918	1.62	0.19	0.19
10	11	1	333	1,631	655	975	1.52	0.18	0.18
11	12	1	325	1,751	718	1,033	1.43	0.17	0.17
12	14	2	314	1,932	811	1,121	1.30	0.31	0.00
14	16	2	300	2,175	936	1,239	1.14	0.27	0.00
16	18	2	287	2,419	1,061	1,358	0.99	0.24	0.00
18	28	10	255	3,156	1,435	1,721	0.61	0.73	0.00
							SUM	**2.77**	**1.21**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Slab	0	3	0	450	30	6	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: ST-5 (IC)

Boring ID:	9-19	Material:	Embank. Core	Swelling Strain Index, Csε:	0.035
Depth (ft):	8-10	Total Unit Weight (pcf):	128.3	Swell Pressure (psf):	6,338

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
6	7	1	370	1,154	406	748	1.95	0.23	0.23
7	8	1	360	1,272	468	804	1.83	0.22	0.22
8	9	1	351	1,391	530	861	1.72	0.21	0.21
9	10	1	342	1,511	593	918	1.62	0.19	0.19
10	11	1	333	1,631	655	975	1.52	0.18	0.18
11	12	1	325	1,751	718	1,033	1.43	0.17	0.17
12	14	2	314	1,932	811	1,121	1.30	0.31	0.00
14	16	2	300	2,175	936	1,239	1.14	0.27	0.00
16	18	2	287	2,419	1,061	1,358	0.99	0.24	0.00
18	28	10	255	3,156	1,435	1,721	0.61	0.73	0.00
							SUM	**2.77**	**1.21**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Slab	0	3	0	450	30	5.5	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: ST-8

Boring ID: 9-19

Depth (ft): 23-25

Material: MPR

Total Unit Weight (pcf): 128.7

Swelling Strain Index, Csε: 0.034

Swell Pressure (psf): 2,521

Depth Below Fndtn									
Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
5.5	6.5	1	375	1,099	374	725	1.84	0.22	0.22
6.5	7.5	1	365	1,218	437	781	1.73	0.21	0.21
7.5	8.5	1	355	1,337	499	838	1.63	0.20	0.20
8.5	9.5	1	346	1,457	562	895	1.53	0.18	0.18
9.5	10.5	1	338	1,577	624	953	1.44	0.17	0.17
10.5	11.5	1	329	1,697	686	1,011	1.35	0.16	0.16
11.5	13.5	2	318	1,879	780	1,099	1.23	0.29	0.29
13.5	15.5	2	303	2,122	905	1,217	1.08	0.26	0.00
15.5	17.5	2	290	2,366	1,030	1,336	0.94	0.22	0.00
17.5	27.5	10	257	3,105	1,404	1,701	0.58	0.70	0.00
							SUM	**2.62**	**1.44**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Slab	0	3	0	450	30	2	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **ST-4 (SPU)**

Boring ID:	13-20	Material:	Embank. Core	Swelling Strain Index, Csε:	0.013
Depth (ft):	6-8	Total Unit Weight (pcf):	129.1	Swell Pressure (psf):	1,637

Depth Below Fndtn									
Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	415	720	156	564	0.60	0.07	0.07
3	4	1	403	837	218	618	0.55	0.07	0.07
4	5	1	391	954	281	673	0.50	0.06	0.06
5	6	1	380	1,072	343	729	0.46	0.05	0.05
6	7	1	370	1,191	406	785	0.41	0.05	0.05
7	8	1	360	1,310	468	842	0.38	0.05	0.05
8	10	2	346	1,490	562	928	0.32	0.08	0.08
10	12	2	329	1,731	686	1,045	0.25	0.06	0.06
12	14	2	314	1,974	811	1,163	0.19	0.05	0.00
14	24	10	276	2,710	1,186	1,525	0.04	0.05	0.00
							SUM	**0.58**	**0.49**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Crest Structure - Slab	0	3	0	450	30	6	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **ST-4 (IC)**

Boring ID:	13-20	Material:	Embank. Core	Swelling Strain Index, Csε:	0.034
Depth (ft):	6-8	Total Unit Weight (pcf):	129.1	Swell Pressure (psf):	2,666

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
6	7	1	370	1,154	406	749	1.88	0.23	0.23
7	8	1	360	1,274	468	806	1.77	0.21	0.21
8	9	1	351	1,393	530	863	1.67	0.20	0.20
9	10	1	342	1,514	593	921	1.57	0.19	0.19
10	11	1	333	1,634	655	979	1.48	0.18	0.18
11	12	1	325	1,755	718	1,038	1.39	0.17	0.17
12	14	2	314	1,938	811	1,126	1.27	0.31	0.00
14	16	2	300	2,182	936	1,246	1.12	0.27	0.00
16	18	2	287	2,427	1,061	1,367	0.99	0.24	0.00
18	28	10	255	3,169	1,435	1,734	0.63	0.76	0.00
							SUM	**2.74**	**1.17**

SWELL CALCULATIONS
PROPOSED RCC SPILLWAY
CHUTE STRUCTURE - WALLS

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Walls	0	5	0	1800	11.33	2	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: ST-5 (SPU)

Boring ID: 9-19 | Material: Embank. Core | Swelling Strain Index, Csε: 0.037

Depth (ft): 8-10 | Total Unit Weight (pcf): 128.3 | Swell Pressure (psf): 2,517

Depth Below Fndtn									
Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,475	1,779	156	1,623	0.71	0.08	0.08
3	4	1	1,375	1,808	218	1,589	0.74	0.09	0.09
4	5	1	1,288	1,849	281	1,568	0.76	0.09	0.09
5	6	1	1,212	1,901	343	1,558	0.77	0.09	0.09
6	7	1	1,144	1,961	406	1,556	0.77	0.09	0.09
7	8	1	1,083	2,029	468	1,561	0.77	0.09	0.09
8	10	2	1,003	2,141	562	1,580	0.75	0.18	0.18
10	12	2	913	2,308	686	1,622	0.71	0.17	0.17
12	14	2	838	2,490	811	1,678	0.65	0.16	0.00
14	24	10	672	3,094	1,186	1,908	0.45	0.53	0.00
							SUM	1.58	0.89

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Walls	0	5	0	1800	11.33	2	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: ST-5 (IC)

Boring ID: 9-19 | Material: Embank. Core | Swelling Strain Index, Csε: 0.035

Depth (ft): 8-10 | Total Unit Weight (pcf): 128.3 | Swell Pressure (psf): 6,338

Depth Below Fndtn									
Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,475	1,779	156	1,623	0.65	0.08	0.08
3	4	1	1,375	1,808	218	1,590	0.68	0.08	0.08
4	5	1	1,288	1,850	281	1,569	0.70	0.08	0.08
5	6	1	1,212	1,902	343	1,559	0.71	0.09	0.09
6	7	1	1,144	1,963	406	1,557	0.71	0.09	0.09
7	8	1	1,083	2,031	468	1,563	0.71	0.08	0.08
8	10	2	1,003	2,144	562	1,582	0.69	0.17	0.17
10	12	2	913	2,312	686	1,625	0.65	0.16	0.16
12	14	2	838	2,494	811	1,683	0.60	0.14	0.00
14	24	10	672	3,100	1,186	1,915	0.41	0.49	0.00
							SUM	1.45	0.82

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Walls	0	5	0	1800	11.33	2	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **ST-8**

Boring ID: 9-19 Material: MPR Swelling Strain Index, Csε: 0.034

Depth (ft): 23-25 Total Unit Weight (pcf): 128.7 Swell Pressure (psf): 2,521

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,475	1,779	156	1,623	0.65	0.08	0.08
3	4	1	1,375	1,808	218	1,590	0.68	0.08	0.08
4	5	1	1,288	1,850	281	1,569	0.70	0.08	0.08
5	6	1	1,212	1,902	343	1,559	0.71	0.09	0.09
6	7	1	1,144	1,963	406	1,557	0.71	0.09	0.09
7	8	1	1,083	2,031	468	1,563	0.71	0.08	0.08
8	10	2	1,003	2,144	562	1,582	0.69	0.17	0.17
10	12	2	913	2,312	686	1,625	0.65	0.16	0.16
12	14	2	838	2,494	811	1,683	0.60	0.14	0.00
14	24	10	672	3,100	1,186	1,915	0.41	0.49	0.00
							SUM	**1.45**	**0.82**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Walls	0	5	0	1800	11.33	2	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: **ST-4 (SPU)**

Boring ID:	13-20	Material:	Embank. Core	Swelling Strain Index, Csε:	0.013
Depth (ft):	6-8	Total Unit Weight (pcf):	129.1	Swell Pressure (psf):	1,637

Depth Below Fndtn: Top (ft)	Depth Below Fndtn: Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,475	1,779	156	1,623	0.00	0.00	0.00
3	4	1	1,375	1,809	218	1,590	0.02	0.00	0.00
4	5	1	1,288	1,851	281	1,570	0.02	0.00	0.00
5	6	1	1,212	1,904	343	1,560	0.03	0.00	0.00
6	7	1	1,144	1,965	406	1,559	0.03	0.00	0.00
7	8	1	1,083	2,033	468	1,565	0.03	0.00	0.00
8	10	2	1,003	2,147	562	1,585	0.02	0.00	0.00
10	12	2	913	2,315	686	1,629	0.00	0.00	0.00
12	14	2	838	2,498	811	1,687	0.00	0.00	0.00
14	24	10	672	3,107	1,186	1,922	0.00	0.00	0.00
							SUM	**0.02**	**0.02**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Walls	0	5	0	1800	11.33	2	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **ST-4 (IC)**

Boring ID:	13-20	Material:	Embank. Core	Swelling Strain Index, Csε:	0.034
Depth (ft):	6-8	Total Unit Weight (pcf):	129.1	Swell Pressure (psf):	2,666

Depth Below Fndtn									
Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,475	1,779	156	1,623	0.73	0.09	0.09
3	4	1	1,375	1,809	218	1,590	0.76	0.09	0.09
4	5	1	1,288	1,851	281	1,570	0.78	0.09	0.09
5	6	1	1,212	1,904	343	1,560	0.79	0.09	0.09
6	7	1	1,144	1,965	406	1,559	0.79	0.10	0.10
7	8	1	1,083	2,033	468	1,565	0.79	0.09	0.09
8	10	2	1,003	2,147	562	1,585	0.77	0.18	0.18
10	12	2	913	2,315	686	1,629	0.73	0.17	0.17
12	14	2	838	2,498	811	1,687	0.68	0.16	0.00
14	24	10	672	3,107	1,186	1,922	0.48	0.58	0.00
							SUM	**1.66**	**0.92**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Walls	0	5	0	1800	11.33	2	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **COMP-1700A**

Boring ID:	mix	Material:	Embank. Shell	Swelling Strain Index, Csε:	0.011
Depth (ft):	0 to 4,8	Total Unit Weight (pcf):	125.0	Swell Pressure (psf):	746

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,475	1,777	156	1,621	0.00	0.00	0.00
3	4	1	1,375	1,803	218	1,584	0.00	0.00	0.00
4	5	1	1,288	1,841	281	1,560	0.00	0.00	0.00
5	6	1	1,212	1,889	343	1,546	0.00	0.00	0.00
6	7	1	1,144	1,946	406	1,541	0.00	0.00	0.00
7	8	1	1,083	2,011	468	1,543	0.00	0.00	0.00
8	10	2	1,003	2,118	562	1,557	0.00	0.00	0.00
10	12	2	913	2,278	686	1,592	0.00	0.00	0.00
12	14	2	838	2,453	811	1,642	0.00	0.00	0.00
14	24	10	672	3,037	1,186	1,852	0.00	0.00	0.00
							SUM	**0.00**	**0.00**

SWELL CALCULATIONS
PROPOSED RCC SPILLWAY
CHUTE STRUCTURE - SLAB

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Slab	0	5	0	450	48	6	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: ST-5 (SPU)
Boring ID: 9-19
Depth (ft): 8-10
Material: Embank. Core
Total Unit Weight (pcf): 128.3
Swelling Strain Index, Csε: 0.037
Swell Pressure (psf): 2,517

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
6	7	1	396	1,180	406	775	1.89	0.23	0.23
7	8	1	389	1,302	468	834	1.78	0.21	0.21
8	9	1	382	1,423	530	893	1.67	0.20	0.20
9	10	1	376	1,545	593	952	1.56	0.19	0.19
10	11	1	369	1,667	655	1,011	1.47	0.18	0.18
11	12	1	363	1,789	718	1,071	1.37	0.16	0.16
12	14	2	354	1,972	811	1,161	1.24	0.30	0.00
14	16	2	343	2,218	936	1,282	1.08	0.26	0.00
16	18	2	332	2,464	1,061	1,403	0.94	0.23	0.00
18	28	10	304	3,205	1,435	1,770	0.57	0.68	0.00
							SUM	**2.63**	**1.17**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Slab	0	5	0	450	48	5	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: ST-5 (IC)
Boring ID: 9-19
Depth (ft): 8-10
Material: Embank. Core
Total Unit Weight (pcf): 128.3
Swelling Strain Index, Csε: 0.035
Swell Pressure (psf): 6,338

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
5	6	1	404	1,068	343	725	1.84	0.22	0.22
6	7	1	396	1,189	406	784	1.73	0.21	0.21
7	8	1	389	1,311	468	843	1.62	0.19	0.19
8	9	1	382	1,433	530	902	1.52	0.18	0.18
9	10	1	376	1,555	593	962	1.42	0.17	0.17
10	11	1	369	1,677	655	1,022	1.33	0.16	0.16
11	13	2	360	1,861	749	1,112	1.21	0.29	0.29
13	15	2	348	2,107	874	1,233	1.06	0.25	0.00
15	17	2	338	2,353	998	1,355	0.92	0.22	0.00
17	27	10	309	3,096	1,373	1,724	0.56	0.67	0.00
							SUM	**2.57**	**1.42**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Slab	0	5	0	450	48	5	120
						Footing Depth Below Finish (ft bgs):	3
						Active Zone Depth (ft bgs):	15

Sample ID: **ST-8**
Boring ID: 9-19
Depth (ft): 23-25
Material: MPR
Total Unit Weight (pcf): 128.7
Swelling Strain Index, Csε: 0.034
Swell Pressure (psf): 2,521

Depth Below Fndtn: Top (ft)	Depth Below Fndtn: Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
5	6	1	404	1,068	343	725	1.84	0.22	0.22
6	7	1	396	1,189	406	784	1.73	0.21	0.21
7	8	1	389	1,311	468	843	1.62	0.19	0.19
8	9	1	382	1,433	530	902	1.52	0.18	0.18
9	10	1	376	1,555	593	962	1.42	0.17	0.17
10	11	1	369	1,677	655	1,022	1.33	0.16	0.16
11	13	2	360	1,861	749	1,112	1.21	0.29	0.29
13	15	2	348	2,107	874	1,233	1.06	0.25	0.00
15	17	2	338	2,353	998	1,355	0.92	0.22	0.00
17	27	10	309	3,096	1,373	1,724	0.56	0.67	0.00
							SUM	**2.57**	**1.42**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Slab	0	5	0	450	48	2	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **ST-4 (SPU)**

Boring ID:	13-20	Material:	Embank. Core	Swelling Strain Index, Csε:	0.013
Depth (ft):	6-8	Total Unit Weight (pcf):	129.1	Swell Pressure (psf):	1,637

Depth Below Fndtn									
Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	428	732	156	576	0.59	0.07	0.07
3	4	1	419	853	218	635	0.53	0.06	0.06
4	5	1	411	974	281	693	0.49	0.06	0.06
5	6	1	404	1,096	343	752	0.44	0.05	0.05
6	7	1	396	1,217	406	812	0.40	0.05	0.05
7	8	1	389	1,339	468	871	0.36	0.04	0.04
8	10	2	379	1,523	562	961	0.30	0.07	0.07
10	12	2	366	1,768	686	1,082	0.23	0.06	0.06
12	14	2	354	2,014	811	1,203	0.17	0.04	0.00
14	24	10	322	2,757	1,186	1,571	0.02	0.03	0.00
							SUM	**0.53**	**0.46**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Slab	0	5	0	450	48	5	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **ST-4 (IC)**

Boring ID:	13-20	Material:	Embank. Core	Swelling Strain Index, Csε:	0.034
Depth (ft):	6-8	Total Unit Weight (pcf):	129.1	Swell Pressure (psf):	2,666

Depth Below Fndtn									
Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
5	6	1	404	1,068	343	725	1.92	0.23	0.23
6	7	1	396	1,190	406	784	1.81	0.22	0.22
7	8	1	389	1,312	468	844	1.70	0.20	0.20
8	9	1	382	1,434	530	904	1.60	0.19	0.19
9	10	1	376	1,557	593	964	1.50	0.18	0.18
10	11	1	369	1,679	655	1,024	1.41	0.17	0.17
11	13	2	360	1,864	749	1,115	1.29	0.31	0.31
13	15	2	348	2,110	874	1,237	1.13	0.27	0.00
15	17	2	338	2,358	998	1,359	0.99	0.24	0.00
17	27	10	309	3,103	1,373	1,730	0.64	0.77	0.00
							SUM	**2.78**	**1.50**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Chute Structure - Slab	0	5	0	450	48	2	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **COMP-1700A**

Boring ID: mix | Material: Embank. Shell | Swelling Strain Index, Csε: 0.011

Depth (ft): 0 to 4,8 | Total Unit Weight (pcf): 125.0 | Swell Pressure (psf): 746

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	428	730	156	574	0.13	0.02	0.02
3	4	1	419	847	218	629	0.08	0.01	0.01
4	5	1	411	964	281	683	0.04	0.01	0.01
5	6	1	404	1,081	343	738	0.01	0.00	0.00
6	7	1	396	1,199	406	793	0.00	0.00	0.00
7	8	1	389	1,317	468	849	0.00	0.00	0.00
8	10	2	379	1,494	562	932	0.00	0.00	0.00
10	12	2	366	1,731	686	1,045	0.00	0.00	0.00
12	14	2	354	1,969	811	1,158	0.00	0.00	0.00
14	24	10	322	2,687	1,186	1,502	0.00	0.00	0.00
							SUM	**0.03**	**0.03**

SWELL CALCULATIONS
PROPOSED RCC SPILLWAY
STILLING BASIN - WALLS

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Stilling Basin - Walls	0	10	0	2000	11.33	4	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **ST-3**

Boring ID:	601-19	Material:	LPR	Swelling Strain Index, Csε:	0.029
Depth (ft):	3.5-5.5	Total Unit Weight (pcf):	123.6	Swell Pressure (psf):	5,121

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
4	5	1	1,431	1,973	281	1,692	1.39	0.17	0.17
5	6	1	1,346	2,012	343	1,669	1.41	0.17	0.17
6	7	1	1,271	2,060	406	1,654	1.42	0.17	0.17
7	8	1	1,203	2,116	468	1,648	1.43	0.17	0.17
8	9	1	1,143	2,179	530	1,649	1.43	0.17	0.17
9	10	1	1,088	2,248	593	1,655	1.42	0.17	0.17
10	12	2	1,015	2,360	686	1,674	1.41	0.34	0.34
12	14	2	931	2,524	811	1,713	1.38	0.33	0.00
14	16	2	861	2,700	936	1,764	1.34	0.32	0.00
16	26	10	701	3,282	1,310	1,972	1.20	1.44	0.00
							SUM	**3.45**	**1.36**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Stilling Basin - Walls	0	10	0	2000	11.33	2	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **ST-6**

Boring ID: 601-19 | Material: LPR | Swelling Strain Index, Csε: 0.023

Depth (ft): 13-15 | Total Unit Weight (pcf): 132.2 | Swell Pressure (psf): 1,578

Depth Below Fndtn Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	1,638	1,945	156	1,789	0.00	0.00	0.00
3	4	1	1,528	1,966	218	1,748	0.00	0.00	0.00
4	5	1	1,431	2,002	281	1,721	0.00	0.00	0.00
5	6	1	1,346	2,049	343	1,706	0.00	0.00	0.00
6	7	1	1,271	2,106	406	1,700	0.00	0.00	0.00
7	8	1	1,203	2,170	468	1,702	0.00	0.00	0.00
8	10	2	1,115	2,280	562	1,718	0.00	0.00	0.00
10	12	2	1,015	2,445	686	1,758	0.00	0.00	0.00
12	14	2	931	2,626	811	1,814	0.00	0.00	0.00
14	24	10	747	3,235	1,186	2,049	0.00	0.00	0.00
							SUM	**0.00**	**0.00**

SWELL CALCULATIONS
PROPOSED RCC SPILLWAY
STILLING BASIN - SLAB

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Stilling Basin - Slab	0	10	0	450	24	7	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **ST-3**

Boring ID:	601-19	Material:	LPR	Swelling Strain Index, Csε:	0.029
Depth (ft):	3.5-5.5	Total Unit Weight (pcf):	123.6	Swell Pressure (psf):	5,121

Depth Below Fndtn: Top (ft)	Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
7	8	1	343	1,245	468	777	2.38	0.29	0.29
8	9	1	332	1,358	530	827	2.30	0.28	0.28
9	10	1	322	1,471	593	879	2.22	0.27	0.27
10	11	1	313	1,586	655	930	2.15	0.26	0.26
11	12	1	304	1,700	718	983	2.08	0.25	0.25
12	13	1	296	1,816	780	1,036	2.01	0.24	0.00
13	15	2	284	1,989	874	1,116	1.92	0.46	0.00
15	17	2	270	2,222	998	1,224	1.80	0.43	0.00
17	19	2	257	2,457	1,123	1,334	1.69	0.41	0.00
19	29	10	225	3,166	1,498	1,669	1.41	1.69	0.00
							SUM	**4.57**	**1.33**

Heave Calculations on Foundation using Constant-Volume Swell Tests

Structure	GWT Depth Below Existing (ft)	Footing Depth Below Existing (ft)	GWT Depth Below Footing (ft)	Sustained Fndtn Load (psf)*	Fndtn Width (ft)	Thickness of Non-Expansive Fill Below Footing (ft)	Unit Weight of Non-Expansive Fill (pcf)
RCC Stilling Basin - Slab	0	10	0	450	24	2	120
				Footing Depth Below Finish (ft bgs):			3
				Active Zone Depth (ft bgs):			15

Sample ID: **ST-6**

Boring ID:	601-19	Material:	LPR	Swelling Strain Index, Csε:	0.023
Depth (ft):	13-15	Total Unit Weight (pcf):	132.2	Swell Pressure (psf):	1,578

Depth Below Fndtn Top (ft)	Depth Below Fndtn Bottom (ft)	Layer Thickness (ft)	Fndtn Stress at Mid (psf) - 2V:1H Mtd	Total Stress at Mid (psf)	u at Mid (psf)	Eff. Stress at Mid (psf)	Swell at Eff. Stress (%)	Layer Heave (inch)	Heave limited to 15' active zone (inch)
2	3	1	408	714	156	558	1.04	0.12	0.12
3	4	1	393	831	218	613	0.95	0.11	0.11
4	5	1	379	949	281	669	0.86	0.10	0.10
5	6	1	366	1,069	343	726	0.78	0.09	0.09
6	7	1	354	1,189	406	783	0.70	0.08	0.08
7	8	1	343	1,310	468	842	0.63	0.08	0.08
8	10	2	327	1,493	562	931	0.53	0.13	0.13
10	12	2	309	1,738	686	1,052	0.41	0.10	0.10
12	14	2	292	1,986	811	1,175	0.29	0.07	0.00
14	24	10	251	2,739	1,186	1,553	0.02	0.02	0.00
							SUM	**0.91**	**0.82**

Appendix G Foundation Settlement Analysis

OBJECTIVES:

1. Develop estimated subsurface stratigraphy and select soil consolidation parameters for geologic units;
2. Perform calculations to develop estimates of settlement for proposed structure foundations; and
3. Provide design recommendations based on results of settlement analysis.

REFERENCES:

External references:

1. Holtz, R. D., Kovacs, W. D., & Sheahan, T. C. (2010). Chapter 8 Compressibility of Soil and Rock. In *An introduction to geotechnical engineering* (2nd. ed.). Pearson.
2. Holtz, R. D., Kovacs, W. D., & Sheahan, T. C. (2010). Chapter 9.3 Terzaghi's One Dimensional Consolidation Theory. In *An introduction to geotechnical engineering* (2nd. ed.). Pearson.
3. Holtz, R. D., Kovacs, W. D., & Sheahan, T. C. (2010). Chapter 10.3.2 Boussinesq Theory. In *An introduction to geotechnical engineering* (2nd. ed.). Pearson.

Project specific references:

1. USDA-SCS. 1967. Geologic Investigation Report (GIR), Plum Creek Watershed, Site No. 2.
2. USDA-SCS. 1967. Soil Mechanics Report (SMR), Plum Creek Site 2.
3. USDA-SCS. 1969. As-Built Drawings, Plum Creek Watershed Project Floodwater Retarding Dam No. 2.
4. AECOM. 2021. GIR, Plum Creek Watershed FRS No. 2 Rehabilitation Design.
5. AECOM. 2021. SMR, Plum Creek Watershed FRS No. 2 Rehabilitation Design.
6. AECOM. 2020. 90% Design Drawings, Floodwater Retarding Structure Site No. 2 Rehabilitation Caldwell County, Texas.

PROJECT DESCRIPTION

Rehabilitation of the Plum Creek Watershed FRS No. 2 will generally include the following design elements:

- Raising the existing auxiliary spillway crest by 1.15 feet to El. 659.8 feet;
- Widening the existing auxiliary spillway from 150 feet to 250 feet;
- Constructing a new 200-foot-wide roller-compacted concrete (RCC) spillway with crest at El. 658.6 feet;
- Replacing the existing 30-inch principal spillway (PSW) conduit with a new 48-inch diameter conduit, and constructing new PSW impact basin and inlet riser with crest at El. 645.4 feet; and
- Restoring the crest of the dam to nominal elevation of 662.8 feet.

Refer to the GIR, SMR, and 90% design drawings for additional project details.

MATERIAL CHARACTERIZATION

Stratigraphy

Site stratigraphy is described in detail in the Geologic Investigation Report and Soil Mechanics Report. Characterization of the various materials with respect to consolidation and settlement behavior are described as follows:

- Embankment Fill: The existing Embankment Fill was generally described on the boring logs as medium stiff to hard fat clay (CH) with minor sand, silt, and/or gravel content. This unit is expected to experience slow drainage and exhibit long-term consolidation characteristics due to high fines and clay contents.

- Downstream Fill: Suspected Downstream Fill materials up to about 8 feet thick were encountered in boring 305-19, which was drilled on the PSW crossing berm at the downstream toe. While boring 603-19 was drilled within these station limits, it appears to have been drilled just downstream of the fill area based on visual characteristics of the material and examination of topographic data. The suspected fill material consisted of medium stiff to hard lean to fat clay (CL, CH). The fill designation was due to a somewhat lower consistency of this material. However, the visual similarity of the fill to natural overburden materials suggests that this unit is likely reworked residuum/alluvium. This unit is expected to experience slow drainage and exhibit long-term consolidation characteristics due to high fines and clay contents.

- Alluvium: This unit consisted of dark brown, medium stiff to hard fat clays (CH) with minor proportion of sand and/or gravel ranging from 0 to 20%. The Alluvium contained trace to abundant organics, trace to some fine to coarse subrounded to subangular gravel, calcareous nodules and inclusions, iron oxidation staining, and trace shell fragments. This unit is expected to experience slow drainage and exhibit long-term consolidation characteristics due to high fines and clay contents.

- Residuum: This unit consisted of light gray to tan, medium stiff to hard lean to fat clays (CL, CH) with some clayey sand (SC) and silty clay (CL-ML) layers. Characterization of this material in the GIR and SMR was subdivided into a calacareous and friable Low Plasticity Residuum (LPR) consisting mostly of silty CL and some CH with less frequent SC and CL-ML intervals, and a Medium Plasticity Residuum (MPR) consisting of consisting of CH with some CL intervals. For engineering analysis, this material was generally considered as a single "Residuum". This unit is expected to experience slow drainage and exhibit long-term consolidation characteristics due to high fines and clay contents.

- Shale: This unit consisted of extremely weak to weak calcareous shale with occasional chalky marl layers. The weathering ranged from moderately to highly weathered. On the basis of SPT N-values, the shale is considered to be "unyielding" and will not experience consolidation characteristics.

Proposed fill materials include fine and coarse filter/drain fill, RCC, and new embankment fill. These materials are described below.

- Drain Fill: This material will consist of a compacted fine filter and a coarse filter with gradations similar to ASTM C-33 aggregates. These materials will be placed under the RCC spillway and around the new and existing PSW conduits. These materials are free-draining.

- RCC: This material will consist of low-slump concrete compacted in lifts that will be used to construct the RCC spillway. The material was treated as relatively low permeability with high frictional resistance.

- New Embankment Fill: The proposed embankment fill will be constructed of moisture-conditioned and recompacted clayey soils from on-site and/or imported borrow sources. Selective placement of imported low-plasticity (PI=7-15) lean clay (CL) or clayey sand (SC) is planned for under and adjacent to the RCC spillway to reduce swelling potential. The exterior zones of planned embankment fill (crest re-shaping and embankment reconstruction at new PSW) will be low-plasticity clay/clayey sand (CL, SC) with LL<50 and PI=10-30. Interior zones of planned embankment fill for reconstruction at new PSW will consist of medium- to high-plasticity clays (CL, CH) with LL<60 and PI=10-35. Considering the clayey composition of proposed embankment fill, this material was considered to exhibit both undrained and drained strength behavior.

Fence diagrams showing boring stick logs, field test results, and interpretations of stratigraphy for analysis are provided in **Attachment 1**.

FOUNDATION SETTLEMENT ANALYSIS

Proposed Structures

Proposed structures considered in settlement analysis are those associated with the proposed new PSW and RCC spillway as follows:

- PSW Inlet Riser (reinforced-concrete mat footing)
- PSW Impact Basin (reinforced-concrete mat footing)
- RCC Crest Structure (RCC gravity walls and chute slab)
- RCC Chute Structure (RCC gravity walls and chute slab)
- RCC Stilling Basin (RCC gravity walls and chute slab)

Additional details regarding foundation dimensions and loading are provided later in the Results section herein. For the RCC spillway, only the proposed foundations for the RCC gravity training walls were considered for settlement analysis, since the 3-foot thick RCC slabs in the interior portion of the spillway are subject to sustained loading consisting of only self-weight. A summary of proposed structures, footing dimensions, and design bearing pressures are provided in **Table 2**.

Consolidation Parameters

Consolidation parameters selected for settlement analysis and foundation design were based on the results of laboratory consolidation testing, correlation with field and laboratory strength tests, and experience at nearby sites and other sites within Central Texas. Development of consolidation parameters is discussed in the "Material Properties Calculation Package". A summary of consolidation parameters used for analyses is provided in **Table 1**.

Table 1. Consolidation Parameters for Settlement Analysis

Material	γ (pcf)	e_0	Min. OCR	Minimum P'_c (psf)	C_c	C_r	E_s (ksf)	Cv (ft^2/day)
Embankment Fill	125	0.60	2.0	4,000	0.20	0.03	---	0.001
Alluvium / DS Fill	123	0.65	2.0	4,000	0.20	0.03	--	0.01
Residuum	126	0.60	2.0	4,000	0.20	0.03	--	0.01
Shale	130	0.50	---	---	--	--	--	---
Proposed Embankment Fill (CL,SC)	125	0.65	2.0	3,000	0.20	0.02	---	0.001

Notes:

1. Abbreviations legend:
   a) γ – Total Moist Unit Weight
   b) e_0 – Initial Void Ratio;
   c) OCR – Overconsolidation Ratio (applies to zones at depth where σ'v is greater than the minimum P'c value);
   d) P'_c – Maximum Past Pressure (minimum value accounts for near-surface desiccated "crust");
   e) C_c – Compression Index from e-log(p) curve;
   f) C_r – Recompression Index from e-log(p) curve
   g) E_s – Elastic Modulus; refer to text
   h) Cv – Coefficient of consolidation

Groundwater Assumptions

Groundwater levels for analysis were estimated based on measured groundwater levels in the borings and piezometers. Groundwater measurement from borings are discussed in the Geologic Investigation Report and the "Material Properties Calculation Package".

For the purposes of settlement analysis, the following groundwater levels were used. The groundwater levels used for the various structures were conservatively selected based on the measured groundwater levels and results of the seepage analyses for STA. 11+50 (PSW) and STA. 18+50 (RCC spillway). The selected groundwater levels for the RCC spillway structures are based on the normal pool reservoir level, which is well below the existing ground surface and proposed RCC spillway crest elevation, and considers that full saturation of the embankment during a temporary short-term flood pool is unlikely to develop.

- PSW Inlet Riser: El. 632 (proposed finish ground surface; above footing base)
- PSW Impact Basin: El. 633 (0.1 feet below footing base)

- RCC Crest Structure: El. 642 (20± ft below existing embankment crest, and 13.5 feet below RCC footing base)
- RCC Chute Structure: El. 640 (20± ft below existing downstream toe, and 1.5 feet below RCC footing base)
- RCC Stilling Basin: El. 640 (20± ft below existing downstream toe, and 1 feet below RCC footing base)

As discussed later, analyses were also performed for proposed overexcavation/replacement under the RCC spillway to mitigate for expansive soil conditions. The replacement fill material will be new embankment fill, which in some cases is below the design groundwater level. Although it is anticipated that construction dewatering will be implemented to allow dry placement of the compacted new embankment fill, the analysis groundwater level remained the same as listed above to account for the potential post-construction rise in groundwater levels to pre-construction conditions.

Design Criteria

No specific NRCS criteria exists regarding tolerable settlement for spillway structures. Based on AECOM's experience with similar reinforced concrete and RCC structures, total settlement less than 1.5 inch and differential settlement less than 0.75 inch are generally considered to be acceptable from a foundation serviceability standpoint.

Methodology

Settlement analysis of structures founded on materials subject to long-term consolidation were analyzed using Terzaghi's one-dimensional theory of consolidation in conjunction with Boussinesq's method for stress distribution. A spreadsheet developed by AECOM was used to perform the settlement calculations. Settlements were calculated at the center of each footing. The calculations were checked using the commercial software program Settle3D 4.0 by Rocscience, and were found to be in general agreement with the spreadsheet results.

Where structures will be founded below existing grade (cut), the net stress increase imposed by foundations (q_{net}) relative to the existing in-situ stress removed by excavation ($\sigma'v$) was considered as the foundation load according to the following equation. This assumes that foundation construction occurs more quickly than subgrade rebound from unloading occurs (i.e., no settlement occurs when reloading the subgrade to current $\sigma'v$).

$$q_{net} = q_{max} - (\gamma \times D)_{removed}$$

The subgrade materials were subdivided into approximately 1-foot layers for settlement calculations using a spreadsheet. Stress distribution with depth imparted by the footing load was calculated according to the Boussinesq (1883) equations for influence factor (I_4) under the center of a uniformly loaded rectangular area according to the following equations (after Das 2010):

$$\Delta P_{fndn} = q_{net} * I_4$$

where

$$I_4 = \frac{2}{\pi}\left[\frac{m_1 n_1}{\sqrt{1 + m_1^2 + n_1^2}}\frac{1 + m_1^2 + 2n_1^2}{(1 + n_1^2)(m_1^2 + n_1^2)} + \sin^{-1}\frac{m_1}{\sqrt{m_1^2 + n_1^2}\sqrt{1 + n_1^2}}\right] \quad (10.35)$$

$$m_1 = \frac{L}{B} \quad (10.36)$$

$$n_1 = \frac{z}{b} \quad (10.37)$$

$$b = \frac{B}{2} \quad (10.38)$$

where z = effective depth of a point below the footing. In cases where footings are founded above existing grade (fill), the fill thickness between the footing and the existing ground is incorporated into the effective depth, z. However, it is noted that all proposed structures will be founded below existing ground surface for this project.

Settlement within each sublayer was calculated using a spreadsheet according to the following formulas:

$$\text{Settle} = \begin{cases} \sum_{i=1}^{n}\left[H_i\left(\frac{C_r}{1+e_0}\right)\log\left(\frac{\sigma'_{vo}+\Delta P}{\sigma'_{vo}}\right)\right] & \text{where } P_c \geq (\sigma'_{vo}+\Delta P) \\ \sum_{i=1}^{n}\left[H_i\left(\frac{C_c}{1+e_0}\right)\log\left(\frac{P'_c}{\sigma'_{vo}}\right) + H_i\left(\frac{C_r}{1+e_0}\right)\log\left(\frac{\sigma'_{vo}+\Delta P}{P'_c}\right)\right] & \text{where } P_c < (\sigma'_{vo}+\Delta P) \end{cases}$$

where ΔP = stress influence due to footing + areal fill; and Hi= height of the sublayer. Settlement from individual sublayers was summed to evaluate total settlement of the structure.

It is noted that RCC spillway wall footings were conservatively analyzed using the maximum bearing pressure at the toe, although the actual bearing pressure at the heel and the average bearing pressure across the footing is much less due to overturning eccentricity.

For the proposed RCC spillway structures, a 2-foot thick granular underdrain layer is planned under the downstream end of the crest structure, and the entire footprint of the chute structure and stilling basin. Due to the granular nature of the underdrain fill material, it was assumed that settlement in this layer is immediate (occurs during placement) and does not contribute to long-term settlement, and thus was neglected in the analysis.

For this project, additional overexcavation of existing subgrade materials and replacement with engineered fill is required to mitigate expansive soil shrink/swell for PSW and RCC spillway footings (see "Foundation Heave Calculation Package"). Settlement analyses were performed for two cases: 1) the original design cross-section without additional overexcavation for subgrade improvement; and 2) the revised final design cross-section incorporating the additional overexcavation/replacement. The assumptions for the proposed replacement fill are as follows:

- For the proposed PSW inlet riser and impact basin, well-graded crushed aggregate fill (i.e., TxDOT Flexbase material) is planned as replacement fill. This fill material is assumed to experience only immediate settlement, and does not contribute to consolidation settlement.

- For the RCC spillway structures, non-expansive clay-rich embankment fill is proposed for the additional overexcavation/replacement zone to provide low permeability barrier. Although this material will generally be unsaturated (above groundwater table), it was conservatively modeled to exhibit long-term consolidation settlement to account for potential development of excess pore pressures during compaction and/or structure loading and associated long-term dissipation.

ANALYSIS RESULTS AND DISCUSSION

Settlement analysis results are summarized in **Table 2**. Calculations are provided in **Attachments 2-6**.

Analysis results indicate that the estimated settlement is generally within tolerable ranges for proposed structures if the planned overexcavation/replacement is performed. However, for the Stilling Basin foundations, the design bearing pressure of 2,500 psf produces excessive settlement in the proposed new embankment fill (>1.5 inches). Alternatives for limiting settlement to 1.5 inches or less for the stilling basin walls are listed as follows:

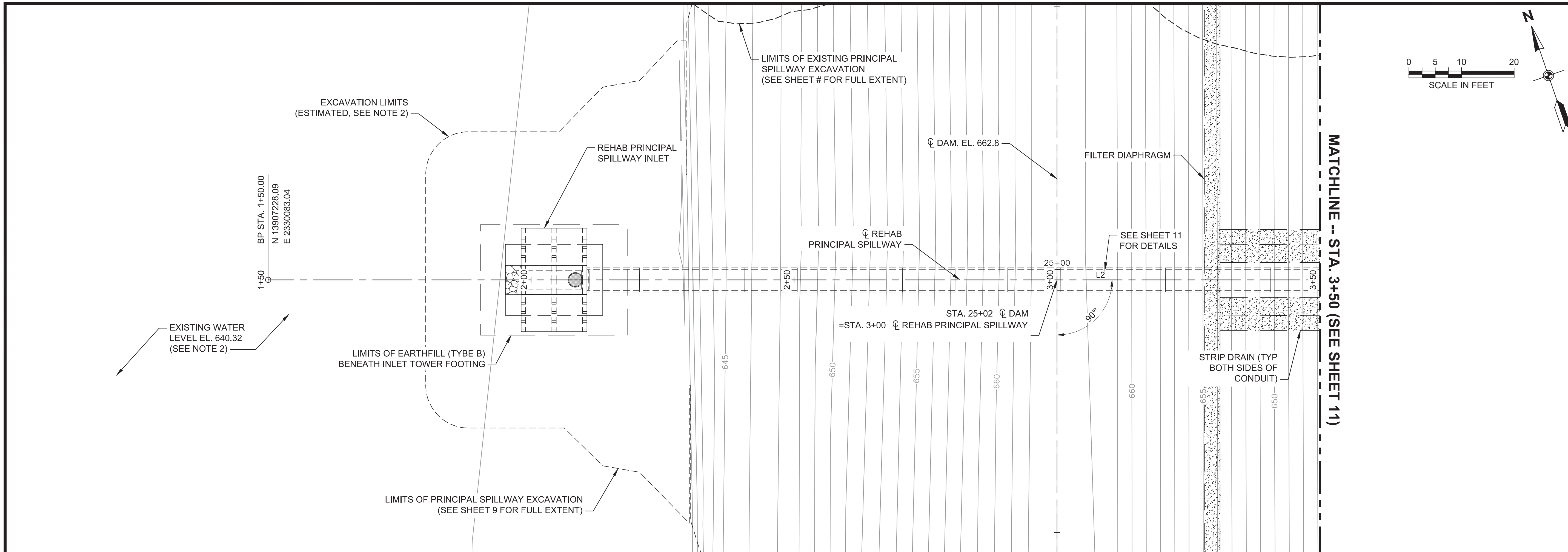
1. Reduce the design bearing pressure from 2,500 psf to 2,000 psf.
2. Increase the thickness of the granular underdrain from 2 feet to 3.5 feet.

Table 2. Settlement Analysis Results

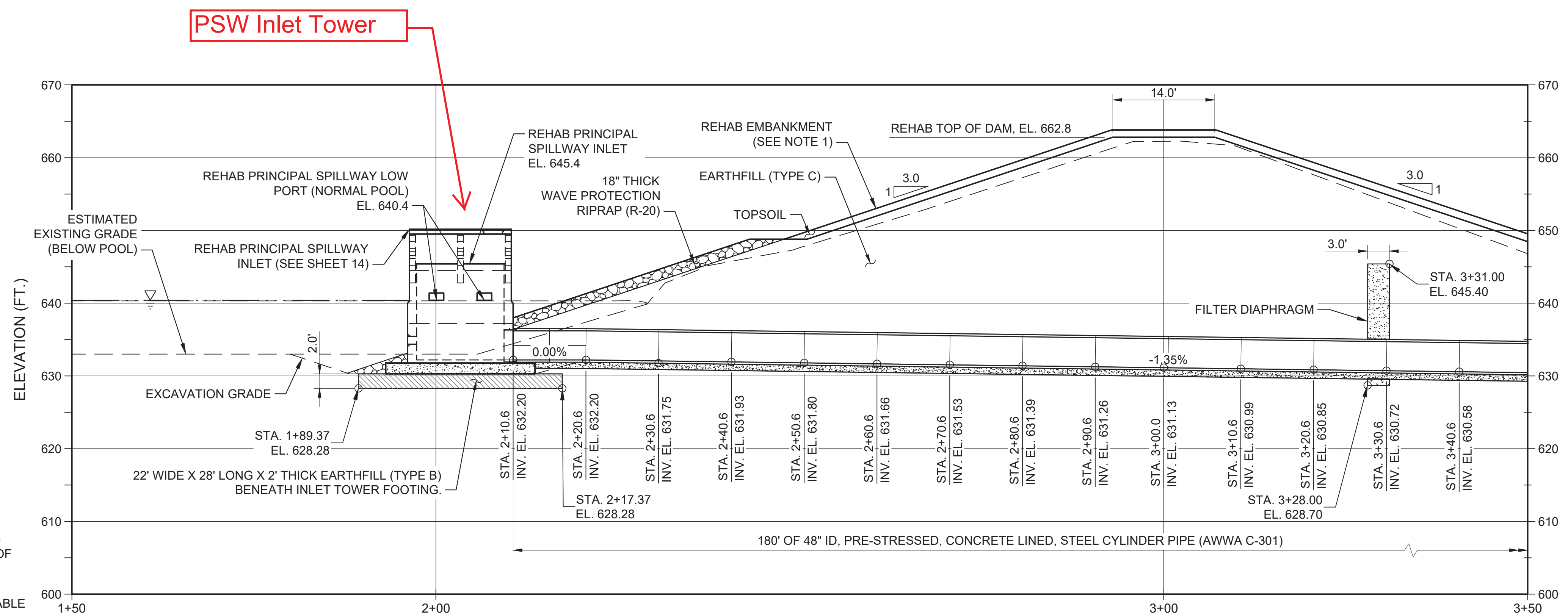
Proposed Structure	Footing Dimension, B x L (ft)	Design Bearing Pressure (psf)	Analysis Section	Calculated Settlement (inches)		Expansive Soil Mitigation (Overexcavation / Replacement) Analysis Details	
				No Expansive Soil Mitigation	With Expansive Soil Mitigation	Thickness Below Bottom of Footing (feet)	Replacement Material
PSW Inlet Tower	13.5x20.5	1,500	Tower Centerline	1.77	1.35	2	2’ Flexbase
PSW Impact Basin	19.5x24.75	2,000	Basin Centerline	1.22	0.48	6	6’ Flexbase
RCC Spillway - Crest Structure – Walls	11.33 x 30	1,500	Prop. Dam CL	0.41	1.34	8	8’ Prop. Embank. Fill
			Prop. DS Crest	0.49 (1)	1.00	8	2’ Granular Drain 6’ Prop. Embank. Fill
RCC Spillway - Chute Structure – Walls	11.33 x 48	1,800	Existing DS Toe	0.57 (1)	1.43	8	2’ Granular Drain 6’ Prop. Embank. Fill
RCC Spillway - Stilling Basin –Walls	11.33 x 24	2,500	Basin Centerline	0.64 (1)	1.70	8	2’ Granular Drain 6’ Prop. Embank. Fill
		2,500	Basin Centerline	---	1.50 (2)	8	3.5’ Granular Drain 4.5’ Prop EmbankFill
		2,000 (3)	Basin Centerline	---	1.50 (3)	8	2’ Granular Drain 6’ Prop. Embank. Fill

Notes:
(1) Includes nominal 2-foot thick overexcavation to construct 2-foot thick granular underdrain.
(2) Requires increasing the thickness of the granular underdrain from 2 to 3.5 feet.
(3) Requires reduction of design bearing pressure from 2,500 to 2,000 psf.

ATTACHMENT 1
Fence Diagrams and Analysis Sections



REHAB PRINCIPAL SPILLWAY PLAN (1 OF 2)



REHAB PRINCIPAL SPILLWAY PROFILE (1 OF 2)

NOTES:

1. EMBANKMENT FILLS TO MATCH EXISTING EMBANKMENT SLOPES ON EITHER SIDE OF THE REHAB PRINCIPAL SPILLWAY EXCAVATION.
2. BATHYMETRIC SURVEY WAS NOT AVAILABLE FOR THIS DESIGN. EXISTING GROUND BELOW THE WATER LEVEL NEAR THE UPSTREAM TOE WAS ESTIMATED TO BE AT EL. 633 BASED ON AVAILABLE AS-BUILT DATA AND AN ASSUMED 3-FT OF SEDIMENTATION.

C:\Users\matthew.engel\OneDrive — AECOM Directory\011-PlumCreek02\Plan_Sheets\Plum 2 — PrincSpill P & P.dwg

REVISIONS		
DATE	APPROVED	TITLE

THIS DRAWING IS ISSUED FOR REVIEW ONLY UNDER THE AUTHORITY OF MICHAEL J. LENHERR TEXAS P.E. #100021 ON November 30, 2020.

DESIGNED BY: MRD
DRAWN BY: MDE
CHECKED BY: MJL
FILE NAME: Plum 2 — PrincSpill P & P.dwg
DATE CHECKED: 11/30/2020

PRINCIPAL SPILLWAY PLAN & PROFILE (1 OF 2)
FLOODWATER RETARDING STRUCTURE SITE NO. 2 REHABILITATION
PLUM CREEK WATERSHED
IN
HAYS COUNTY, TEXAS

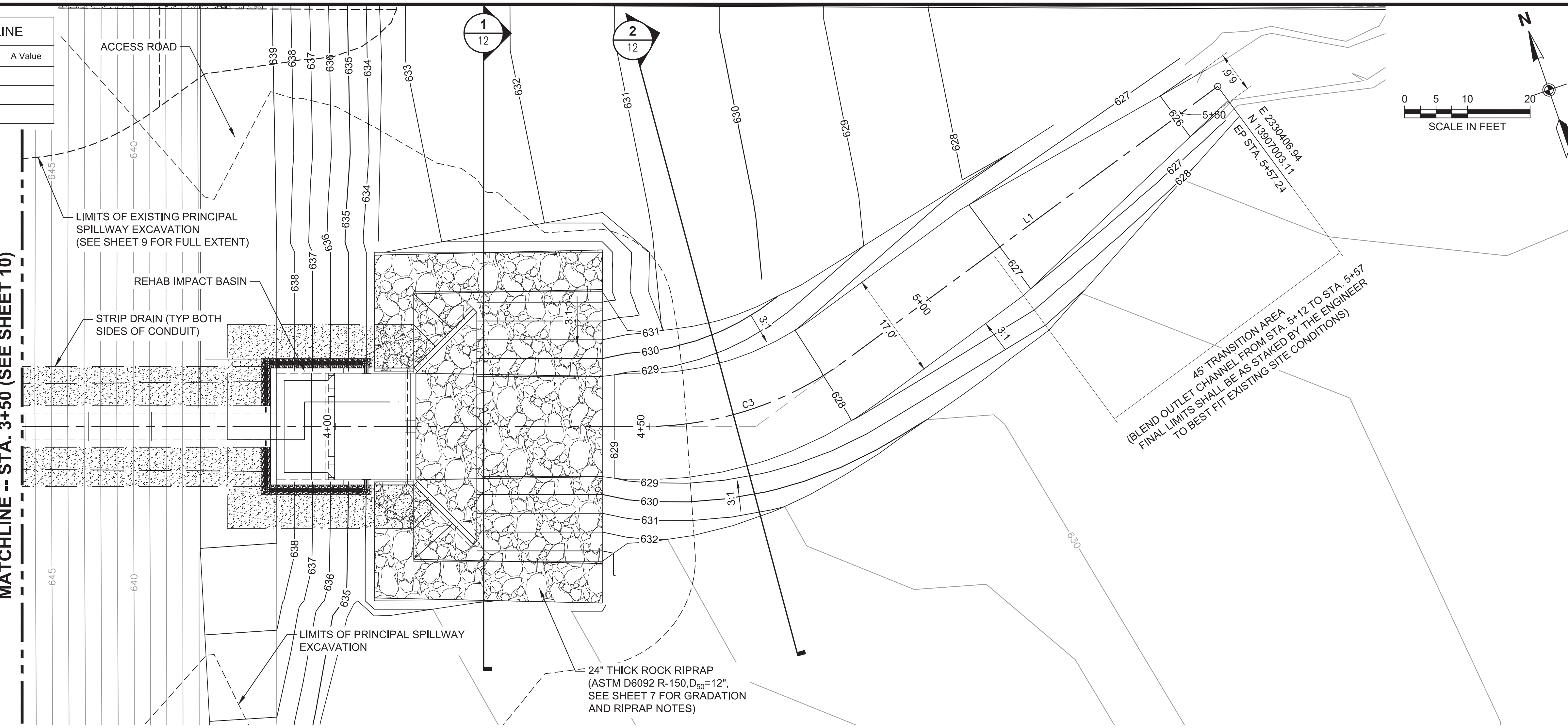
Texas State Soil & Water Conservation Board

AECOM Technical Services, Inc.
9400 Amberglen Blvd
Austin, Texas 78729
www.aecom.com
TBPE Reg. No. F-3580

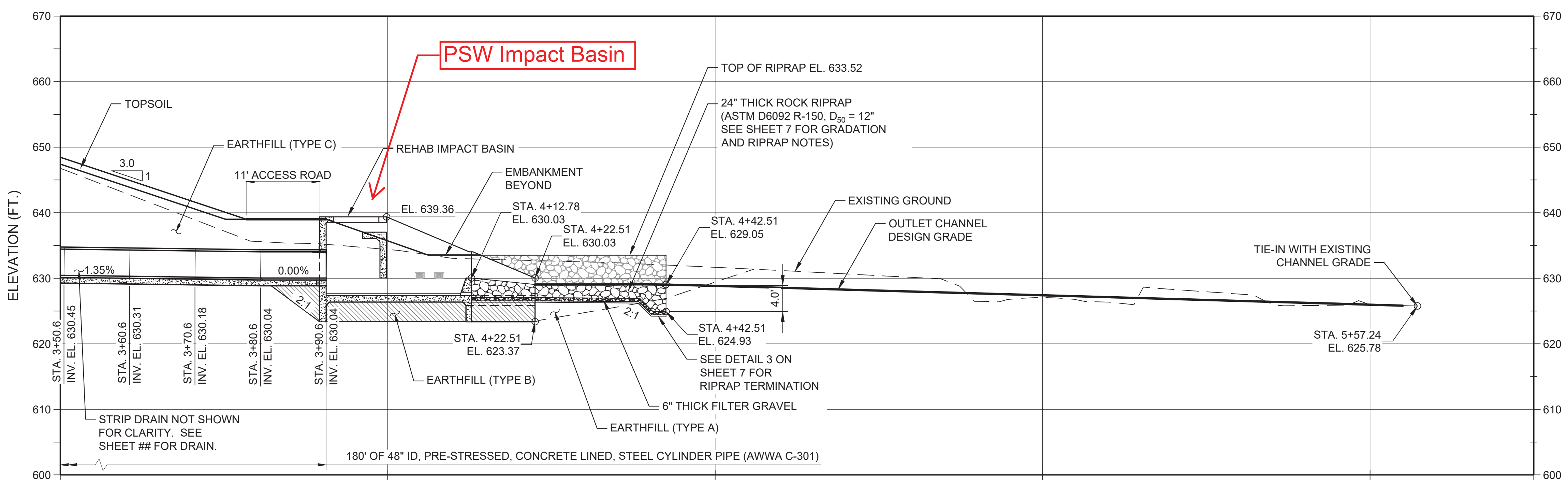
SHEET NO. 10
OF 58

REHAB PRINCIPAL SPILLWAY CENTERLINE

Number	Radius	Length	Line/Chord Direction	A Value
L2		299.22	S47° 18' 35.64"E	
C3	54.05	34.32	S65° 29' 57.63"E	
L1		73.71	S83° 41' 19.61"E	



REHAB PRINCIPAL SPILLWAY PLAN (2 OF 2)



REHAB PRINCIPAL SPILLWAY PROFILE (2 OF 2)

THIS DRAWING IS ISSUED FOR REVIEW ONLY UNDER THE AUTHORITY OF MICHAEL J. LENHERR TEXAS P.E. #100021 ON November 30, 2020.

DESIGNED BY: MRD
DRAWN BY: MDE
CHECKED BY: MJL
FILE NAME: Plum 2 – PrincSpill P & P.dwg
DATE CHECKED: 11/30/2020

PRINCIPAL SPILLWAY PLAN & PROFILE (2 OF 2)

FLOODWATER RETARDING STRUCTURE SITE NO. 2 REHABILITATION
PLUM CREEK WATERSHED
IN
HAYS COUNTY, TEXAS

Texas State Soil & Water Conservation Board

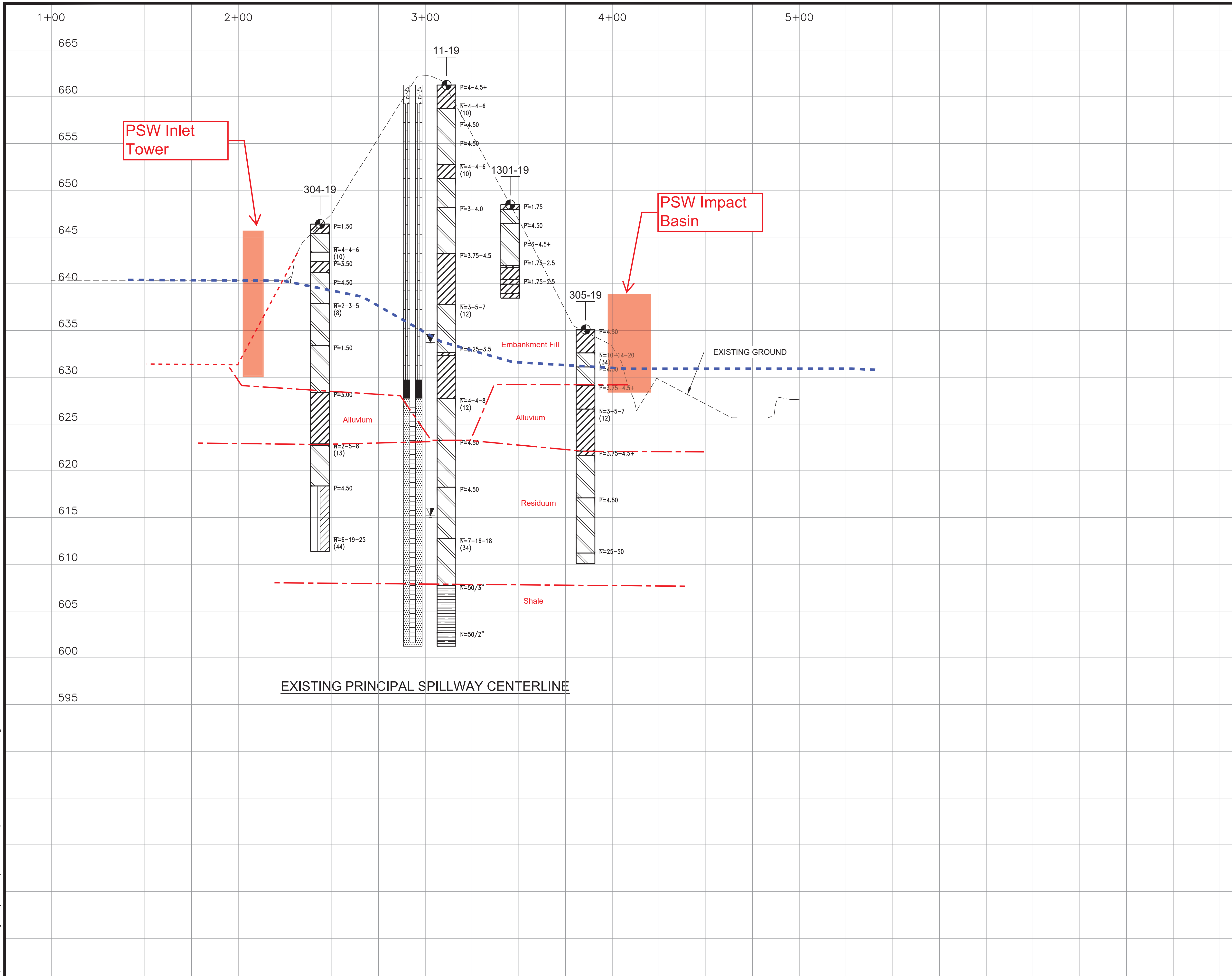
AECOM Technical Services, Inc.
9400 Amberglen Blvd
Austin, Texas 78729
www.aecom.com
TBPE Reg. No. F-3580

AECOM

REVISIONS		
DATE	APPROVED	TITLE

SHEET NO. 11
OF 58

C:\Users\matthew.engel\OneDrive – AECOM Directory\011–PlumCreek02\Plan_Sheets\Plum 2 – PrincSpill P & P.dwg



THIS DRAWING IS ISSUED FOR REVIEW ONLY UNDER THE AUTHORITY OF MICHAEL J. LENHERR TEXAS P.E. #100021 ON NOVEMBER 30, 2020.

DESIGNED BY: MRD
DRAWN BY: CAD
CHECKED BY: MJL
FILE NAME: Plum 2 – Sht 49–55.dwg
DATE CHECKED: 11/30/2020

GEOLOGIC INVESTIGATIONS – PROFILES (3 OF 7)

FLOODWATER RETARDING STRUCTURE SITE NO. 2 REHABILITATION
PLUM CREEK WATERSHED
IN
HAYS COUNTY, TEXAS

Texas State Soil & Water Conservation Board

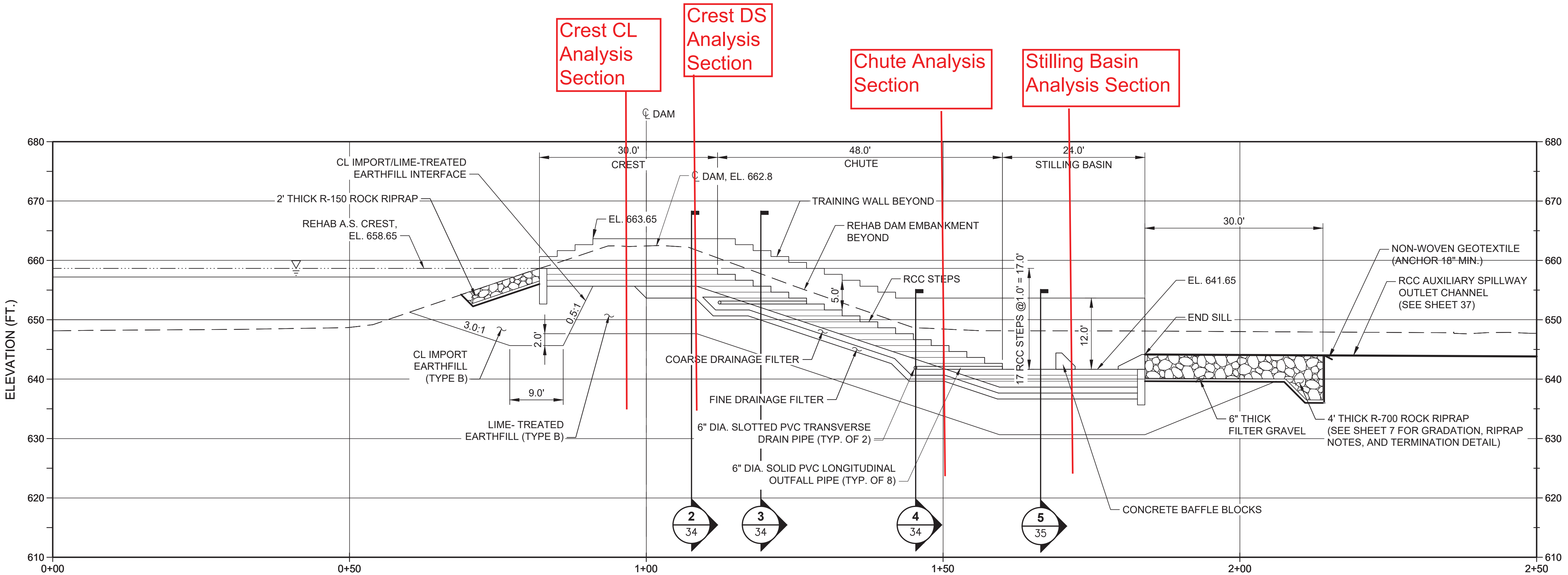
AECOM Technical Services, Inc.
9400 Amberglen Blvd
Austin, Texas 78729
www.aecom.com
TBPE Reg. No. F-3580

AECOM

REVISIONS		
DATE	APPROVED	TITLE

SHEET NO. 52 OF 58

C:\Civil 3D Projects\Plum 2\Plan_Sheets\Plum 2 – Sht 49–55.dwg



1 29 **TYPICAL AUXILIARY SPILLWAY SECTION AT OUTFALL PIPES**

0 10 20 30 HORIZONTAL SCALE IN FEET

0 10 20 30 VERTICAL SCALE IN FEET

THIS DRAWING IS ISSUED FOR REVIEW ONLY UNDER THE AUTHORITY OF MICHAEL J. LENHERR TEXAS P.E. #100021 ON November 30, 2020.

DESIGNED BY: MRD
DRAWN BY: MDE
CHECKED BY: MJL
FILE NAME: Plum 2 - RCCAuxSpillProf.dwg
DATE CHECKED: 11/30/2020

AUXILIARY SPILLWAY PROFILE

FLOODWATER RETARDING STRUCTURE SITE NO. 2 REHABILITATION
PLUM CREEK WATERSHED
IN
HAYS COUNTY, TEXAS

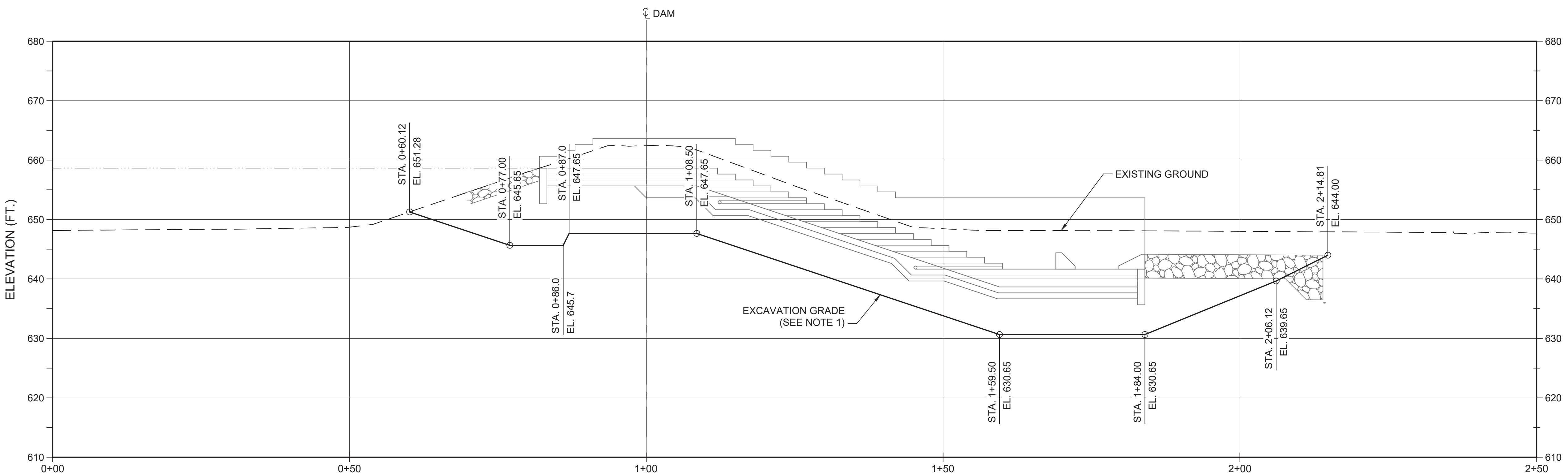
Texas State Soil & Water Conservation Board

AECOM
AECOM Technical Services, Inc.
9400 Amberglen Blvd
Austin, Texas 78729
www.aecom.com
TBPE Reg. No. F-3580

REVISIONS		
DATE	APPROVED	TITLE

SHEET NO. 30 OF 58

C:\Users\matthew.engel\OneDrive - AECOM Directory\011-PlumCreek02\Plan_Sheets\Plum 2 - RCCAuxSpillProf.dwg



1
31
AUXILIARY SPILLWAY CENTERLINE EXCAVATION SECTION

0 10 20 30
HORIZONTAL SCALE IN FEET

0 10 20 30
VERTICAL SCALE IN FEET

NOTES:

1. THE EXCAVATION PLAN SHOWN HEREON IS CONCEPTUAL AND SHOWS THE MINIMUM EXCAVATION REQUIRED TO PROVIDE FOR 6 FEET OF TYPE B EARTHFILL BETWEEN SUBGRADE ELEVATION AND THE BOTTOM OF THE RCC FINE FILTER DRAINAGE LAYER. WITH THE APPROVAL OF THE ENGINEER, THE CONTRACTOR MAY DEVIATE FROM THE EXCAVATION PLAN PROVIDED THE REQUIRED 6 FEET MINIMUM DEPTH OF TYPE B EARTHFILL IS MAINTAINED.

REVISIONS		
DATE	APPROVED	TITLE

THIS DRAWING IS ISSUED FOR REVIEW ONLY UNDER THE AUTHORITY OF MICHAEL J. LENHERR TEXAS P.E. #100021 ON November 30, 2020.

DESIGNED BY: MRD
DRAWN BY: MDE
CHECKED BY: MJL
FILE NAME: PLUM 2 – RCCAuxSpillExcProf.dwg
DATE CHECKED: 11/30/2020

AUXILIARY SPILLWAY EXCAVATION PROFILE

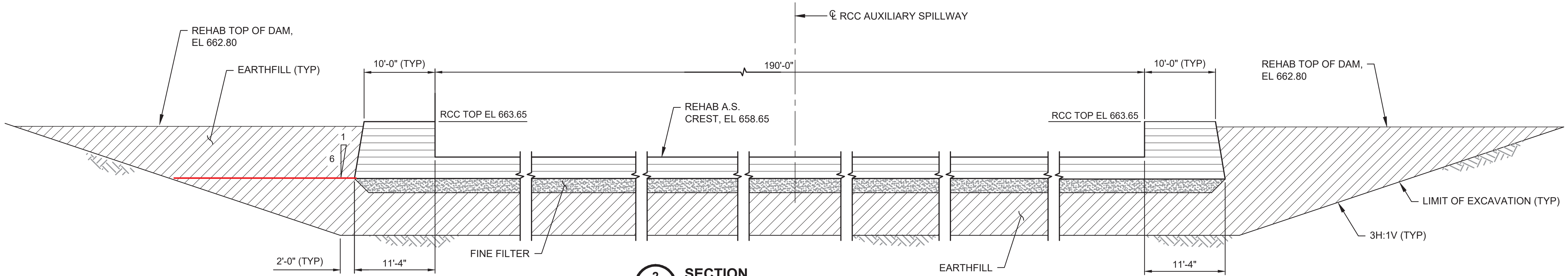
FLOODWATER RETARDING STRUCTURE SITE NO. 2 REHABILITATION
PLUM CREEK WATERSHED
IN
HAYS COUNTY, TEXAS

Texas State Soil & Water Conservation Board

AECOM
AECOM Technical Services, Inc.
9400 Amberglen Blvd
Austin, Texas 78729
www.aecom.com
TBPE Reg. No. F-3580

SHEET NO.
32
OF
58

C:\Users\matthew.engel\OneDrive – AECOM Directory\011–PlumCreek02\Plan_Sheets\Plum 2 – RCCAuxSpillExcProf.dwg



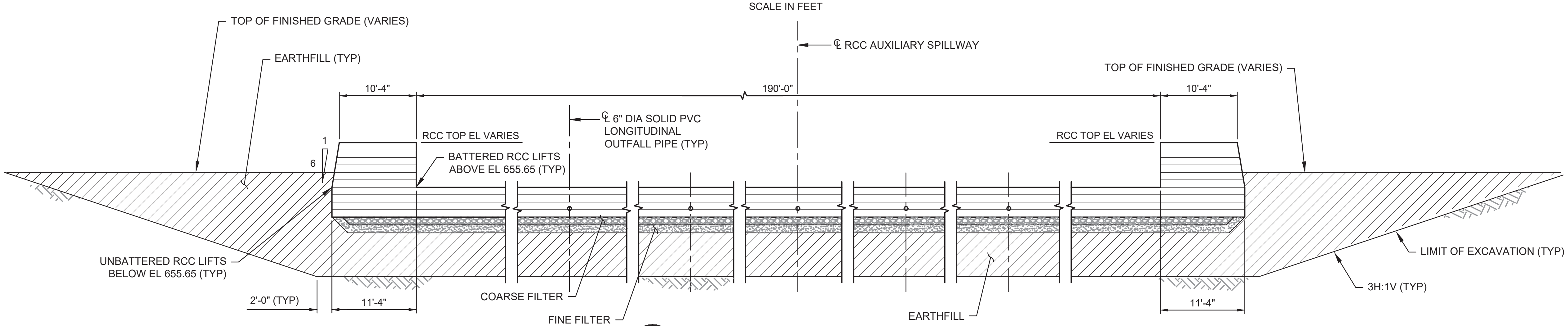
2 / 29 SECTION

SCALE: 1/8" = 1'

STA 1+08 PROPOSED DAM CREST

0 4 8 16 24

SCALE IN FEET



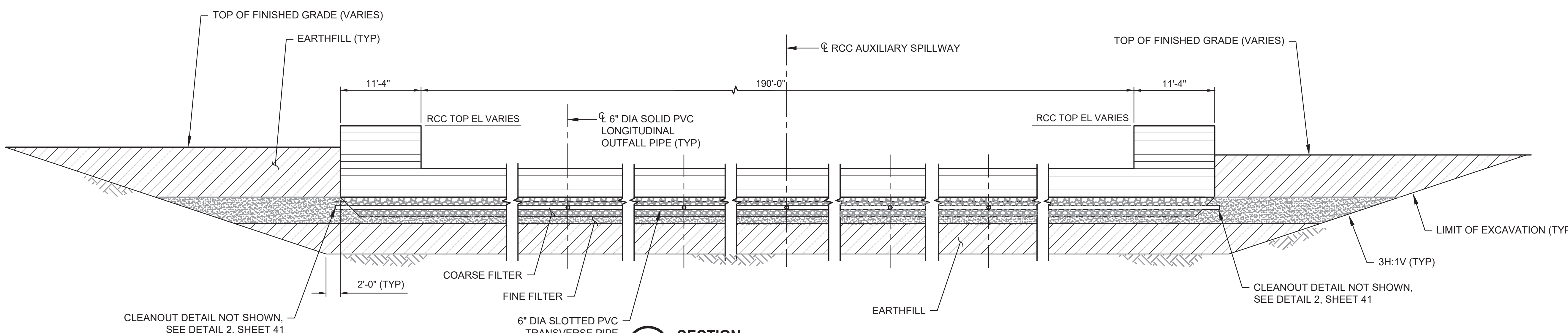
3 / 29 SECTION

SCALE: 1/8" = 1'

STA 1+20 THROUGH THE LONGITUDINAL OUTFALL PIPE

0 4 8 16 24

SCALE IN FEET



4 / 29 SECTION

SCALE: 1/8" = 1'

STA 1+45 THROUGH THE CENTERLINE TRANSVERSE DRAIN PIPE

0 4 8 16 24

SCALE IN FEET

REVISIONS		
DATE	APPROVED	TITLE

THIS DRAWING IS ISSUED FOR REVIEW ONLY UNDER THE AUTHORITY OF MICHAEL J. LENHERR TEXAS P.E. #100021 ON November 30, 2020.

DESIGNED BY: KNF
DRAWN BY: JAM
CHECKED BY: ALL
FILE NAME: Plum 2 – Sht 34.dwg
DATE CHECKED: 11/30/2020

AUXILIARY SPILLWAY SECTIONS AND DETAILS (2 OF 4)

FLOODWATER RETARDING STRUCTURE SITE NO. 2 REHABILITATION

PLUM CREEK WATERSHED

IN

HAYS COUNTY, TEXAS

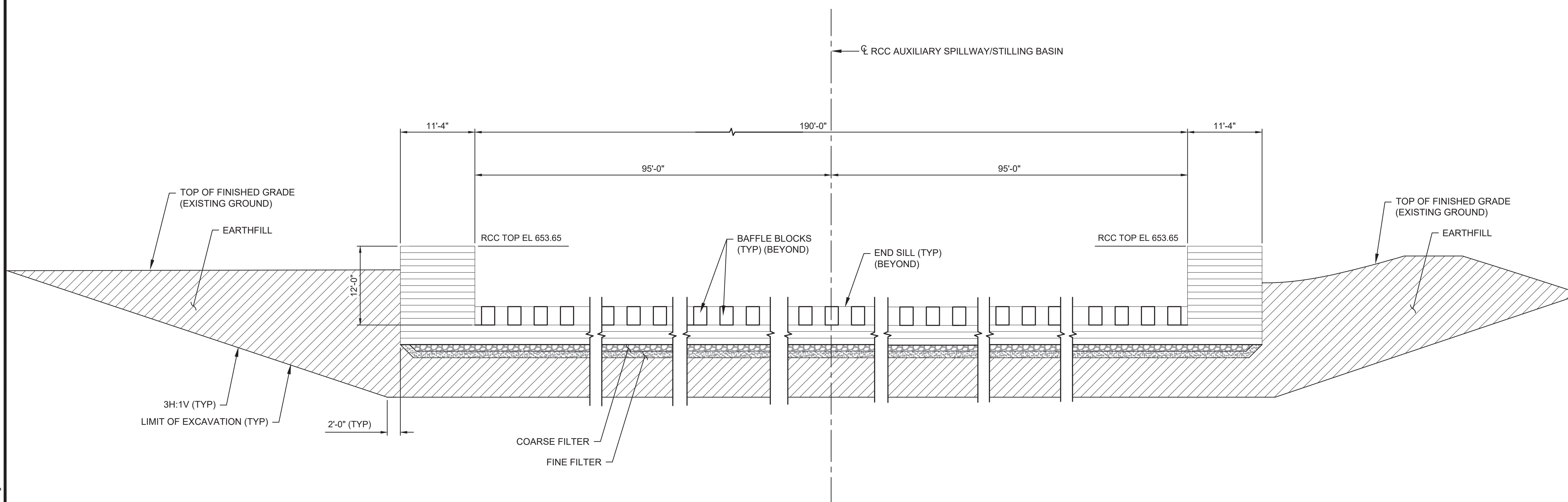
Texas State Soil & Water Conservation Board

AECOM

AECOM Technical Services, Inc.
9400 Amberglen Blvd
Austin, Texas 78729
www.aecom.com
TBPE Reg. No. F-3580

SHEET NO. 34 OF 58

M:\DCS\resources\WTR\GeoCivil\Projects\plum Creek 2\90%CAD\plan_sheets\Plum 2 – Sht 34.dwg



5 / 29 **SECTION**

SCALE: 1/8" = 1'

STA 1+66 - STILLING BASIN

0 4 8 16 24

SCALE IN FEET

M:\DCS\resources\WTR\GeoCivil\Projects\plum Creek 2\90%CAD\plan_sheets\Plum 2 – Sht 35.dwg

THIS DRAWING IS ISSUED FOR REVIEW ONLY UNDER THE AUTHORITY OF MICHAEL J. LENHERR TEXAS P.E. #100021 ON November 30, 2020.

DESIGNED BY: KNF
DRAWN BY: JAM
CHECKED BY: ALL
FILE NAME: Plum 2 – Sht 35.dwg
DATE CHECKED: 11/30/2020

AUXILIARY SPILLWAY SECTIONS AND DETAILS (3 OF 4)

FLOODWATER RETARDING STRUCTURE SITE NO. 2 REHABILITATION
PLUM CREEK WATERSHED
IN
HAYS COUNTY, TEXAS

Texas State Soil & Water Conservation Board

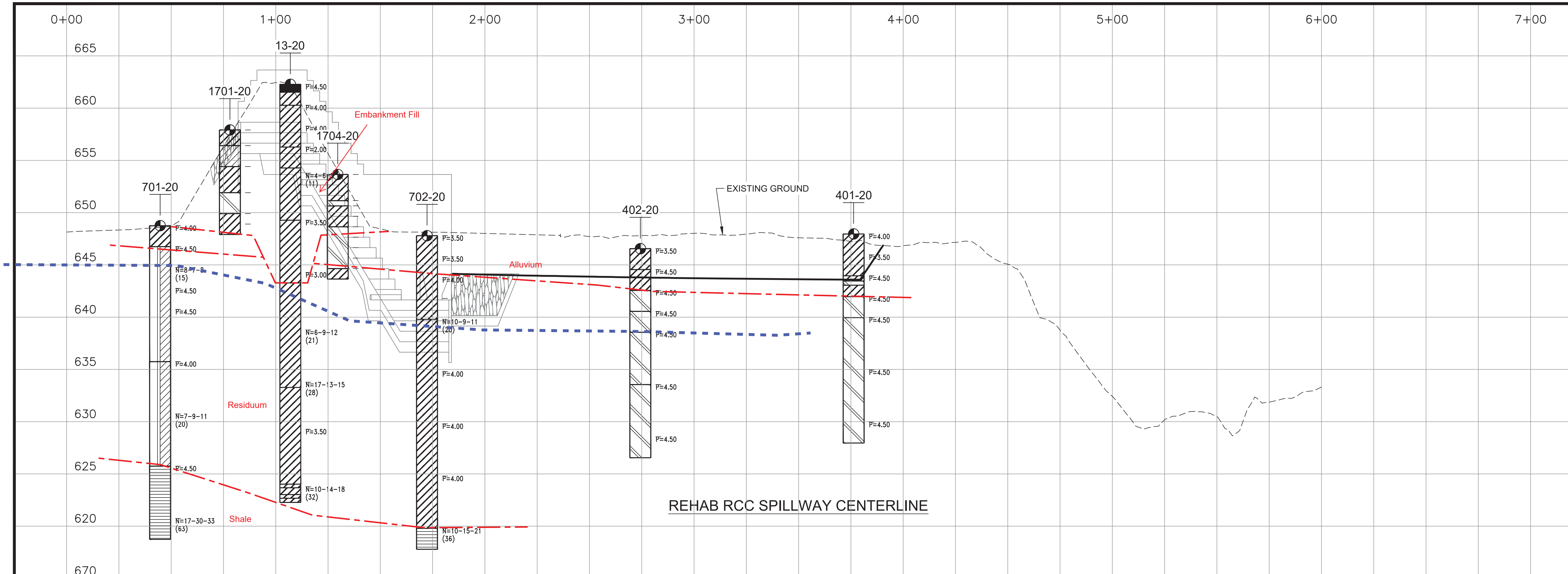
AECOM

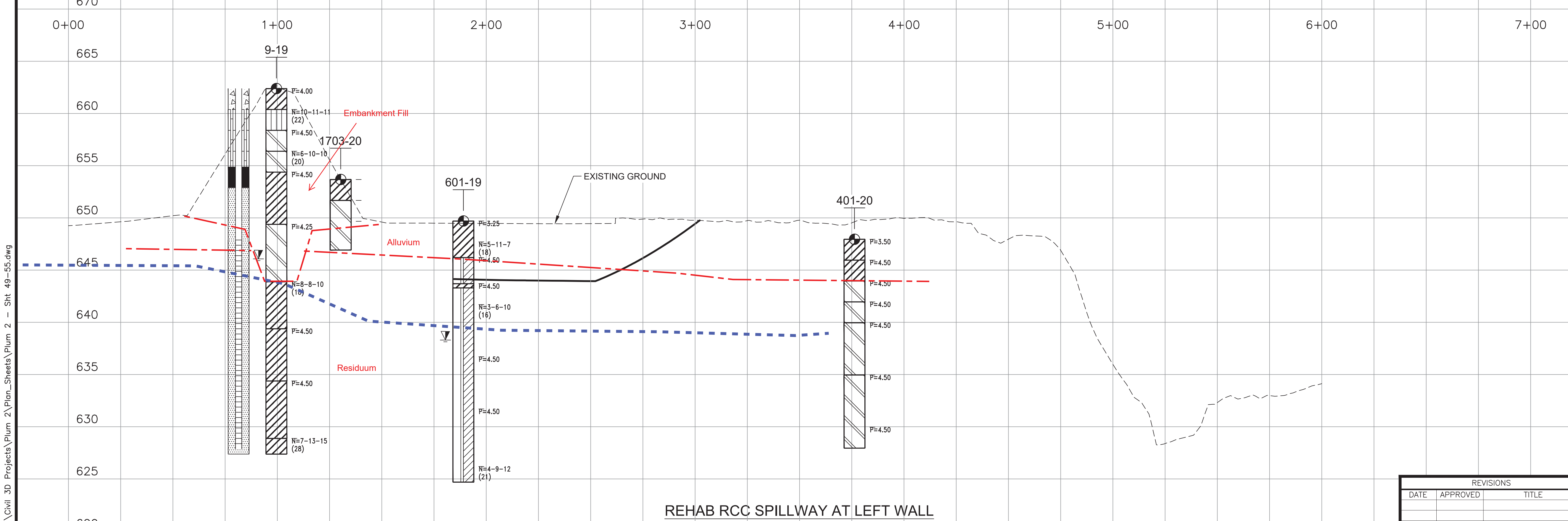
AECOM Technical Services, Inc.
9400 Amberglen Blvd
Austin, Texas 78729
www.aecom.com
TBPE Reg. No. F-3580

REVISIONS		
DATE	APPROVED	TITLE

SHEET NO. 35

OF 58





C:\Civil 3D Projects\Plum 2\Plan_Sheets\Plum 2 – Sht 49–55.dwg

THIS DRAWING IS ISSUED FOR REVIEW ONLY UNDER THE AUTHORITY OF MICHAEL J. LENHERR TEXAS P.E. #100021 ON NOVEMBER 30, 2020.

DESIGNED BY: MRD
DRAWN BY: CAD
CHECKED BY: MJL
FILE NAME: Plum 2 – Sht 49–55.dwg
DATE CHECKED: 11/30/2020

GEOLOGIC INVESTIGATIONS – PROFILES (4 OF 7)

FLOODWATER RETARDING STRUCTURE SITE NO. 2 REHABILITATION
PLUM CREEK WATERSHED
IN
HAYS COUNTY, TEXAS

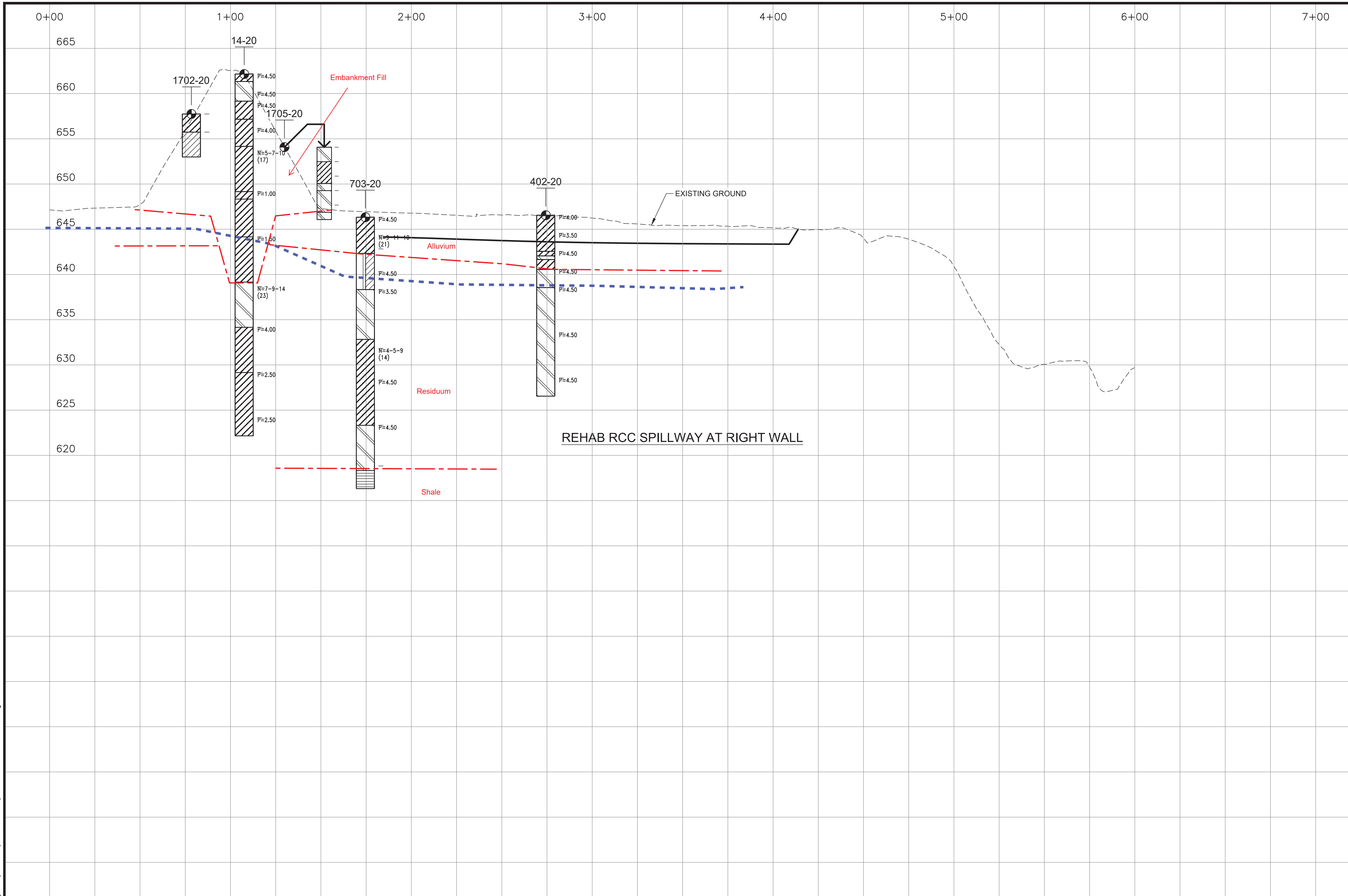
Texas State Soil & Water Conservation Board

AECOM Technical Services, Inc.
9400 Amberglen Blvd
Austin, Texas 78729
www.aecom.com
TBPE Reg. No. F-3580

AECOM

REVISIONS		
DATE	APPROVED	TITLE

SHEET NO. 53
OF 58



REVISIONS		
DATE	APPROVED	TITLE

THIS DRAWING IS ISSUED FOR REVIEW ONLY UNDER THE AUTHORITY OF MICHAEL J. LENHERR TEXAS P.E. #100021 ON NOVEMBER 30, 2020.

DESIGNED BY: MRD
DRAWN BY: CAD
CHECKED BY: MJL
FILE NAME: Plum 2 – Sht 49–55.dwg
DATE CHECKED: 11/30/2020

GEOLOGIC INVESTIGATIONS – PROFILES (5 OF 7)

FLOODWATER RETARDING STRUCTURE SITE NO. 2 REHABILITATION
PLUM CREEK WATERSHED
IN
HAYS COUNTY, TEXAS

Texas State Soil & Water Conservation Board

AECOM Technical Services, Inc.
9400 Amberglen Blvd
Austin, Texas 78729
www.aecom.com
TBPE Reg. No. F-3580

AECOM

SHEET NO.
54
OF
58

C:\Civil 3D Projects\Plum 2\Plan_Sheets\Plum 2 – Sht 49–55.dwg

ATTACHMENT 2
Settlement Calculations for PSW – Inlet Riser

Project Name:	Plum Creek FRS No. 2 Rehabilitation	Structure	PSW - Inlet Tower Structure
Job Number:	60615067	Analysis Section	Center of Inlet Tower
Client:	TSSWCB	Notes	Reinf. concrete foundation on in-situ subgrade

Geotechnical Data

Relevant Boring	304-19	-
Boring Ground Elev.	647	ft NAVD88
Depth to GWT at Boring:	15	feet
GWT Elev.*	632	ft NAVD88

**GW set at existing ground elevation at proposed structure*

Exiting Ground at Structure Location

Structure Existing Ground:	632	ft NAVD88
Footing Bearing Elev.:	630	ft NAVD88
Footing Bearing Elev.:	2	ft below existing (cut)
GWT Depth below Exist.:	0	feet
GWT Depth below footing.:	0	feet

Area Fill

Fill between existing/footing?	no	-
Include load from area fill?	no	-
Finish Grade of Area Fill:	655.5	ft NAVD88
Height above existing:	#N/A	feet
Height above footing base:	#N/A	feet
Thickness under footing:	#N/A	feet
Area Fill Unit Weight:	125	pcf

Subgrade Overexcavation/Replacement

Include Overex/Replacement?	no	-
Overex/Replace Bottom Elev.	655.5	ft NAVD88
Depth below footing:	#N/A	feet
Depth below existing:	#N/A	feet

Structure Footing Size & Maximum Bearing Pressure

Footing Width, B:	13.5	feet
Footing Length, L (rect):	20.5	feet
Gross Footing Pressure, $q_{0\text{-gross}}$	1,500	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula do not edit

Design Soil Profile and Properties

					1	2	3	4	5	6	7	8	9	10
Depth at Boring (feet)		Elevation (feet)		Thickness in Boring	Existing Depth at Structure (feet)		Thickness at Structure	Layer Name	Total Unit Wt	Initial Void Ratio, e_0*	Compression Index, C_c*	Recomp. Index, C_r*	Min. Over Consolidation Ratio, OCR*	Min. Preconsol. Pressure, P'c*
Top	Bottom	Top	Bottom	(feet)	Top	Bottom	(feet)		(pcf)	(-)				(psf)
0	19	647.0	628.0	19.0	0.0	4.0	4.0	Embank. Fill (Shell)	125	0.60	0.20	0.030	2.0	4,000
19	24	628.0	623.0	5.0	4.0	9.0	5.0	Alluvium	123	0.65	0.20	0.030	2.0	4,000
24	37	623.0	610.0	13.0	9.0	22.0	13.0	Residuum (MPR)	126	0.60	0.20	0.030	2.0	4,000
37	100	610.0	547.0	63.0	22.0	85.0	63.0	Shale	130	0.50	0.0	0.000	0.0	0

Notes: *Copy down elevation and thickness formulas if more layers are needed, delete formulas where not needed.*

*Enter "0" for incompressible layers (i.e., granular soils and bedrock)

Method: Settlement Below Center of Uniformly Loaded Rectangular Footing

Project	Plum Creek FRS No. 2 Rehabilitation
Structure	PSW - Inlet Tower Structure
Analysis Section	Center of Inlet Tower

Elev. - Existing Ground @ Structure:	632	ft NAVD88	-2	ft from footing base (above)	0	ft from existing (below)
Elev. - Base of Footing / Bearing Depth	630	ft NAVD88	0	ft from footing base (below)	2	ft from existing (below)
Elev. - Top of Area Fill	#N/A	ft NAVD88	#N/A	#N/A	#N/A	#N/A
Elev. - Bottom of Overex./Replace	#N/A	ft NAVD88	#N/A	#N/A	#N/A	#N/A
Elev. - Groundwater	632	ft NAVD88	-2	ft from footing base (above)	0	ft from existing (below)
Thickness - Area Fill	#N/A	feet below footing base				
Thickness - Overex/Replace	#N/A	feet below footing base				

Footing Width, B:	13.5	feet
Footing Length, L (square):	13.5	feet
Footing Length, L (rect):	20.5	feet

Gross Footing Pressure, $q_{0\text{-gross}}$	1,500	psf
Removed in-situ stress	125	psf
Net Footing Pressure, $q_{0\text{-net}}$	1,375	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula (do not edit)
xxx	= Unique Formula (do not edit)

$$\Delta\sigma_z = qI_4 \tag{10.34}$$

where

$$I_4 = \frac{2}{\pi}\left[\frac{m_1 n_1}{\sqrt{1+m_1^2+n_1^2}}\,\frac{1+m_1^2+2n_1^2}{(1+n_1^2)(m_1^2+n_1^2)} + \sin^{-1}\frac{m_1}{\sqrt{m_1^2+n_1^2}\,\sqrt{1+n_1^2}}\right] \tag{10.35}$$

$$m_1 = \frac{L}{B} \tag{10.36}$$

$$n_1 = \frac{z}{b} \tag{10.37}$$

$$b = \frac{B}{2} \tag{10.38}$$

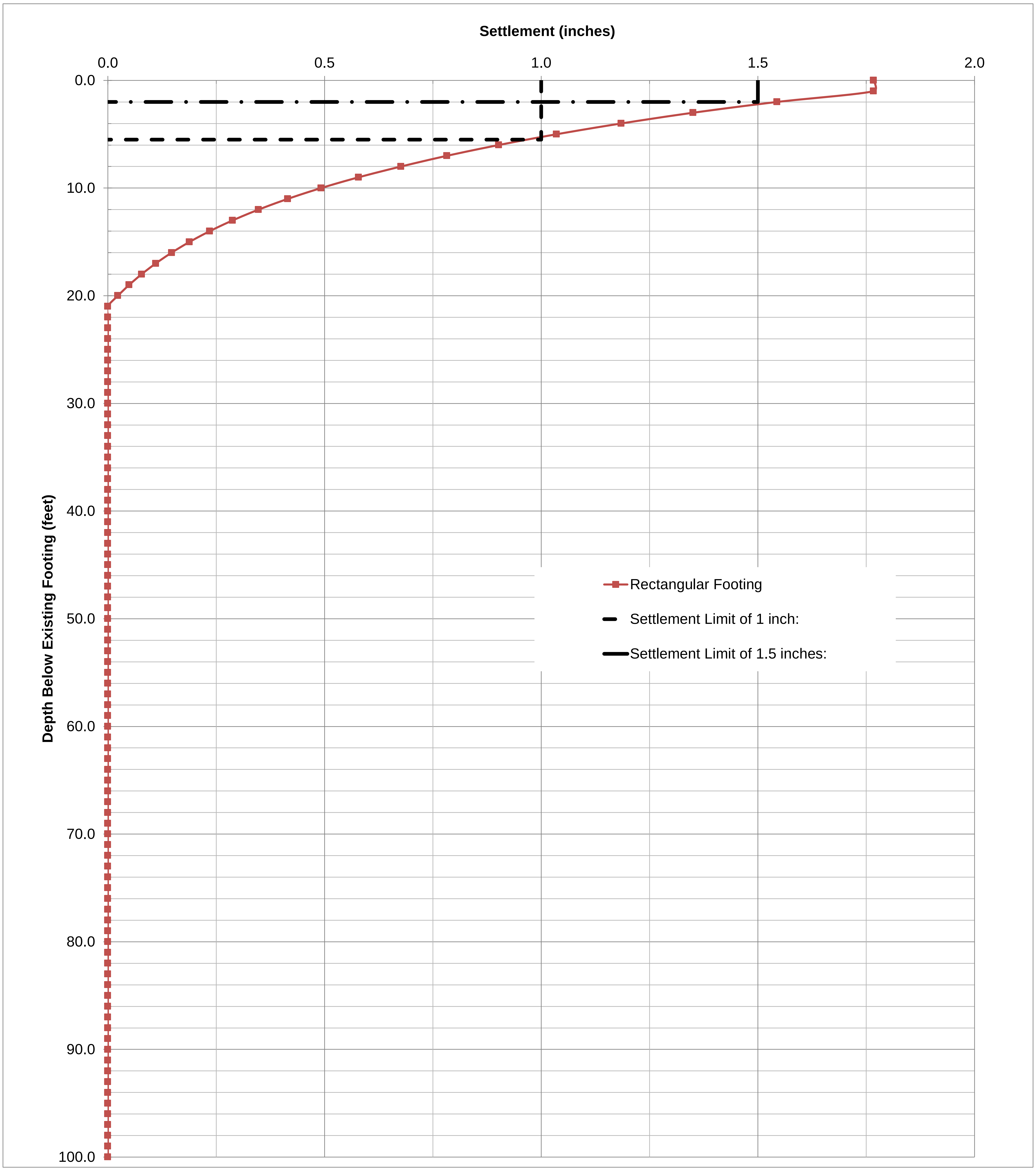
*Negative values indicate height above existing ground

*Granular fill, assumed zero

Total Settlement (inch) = 1.77

	Depth from Existing*			Elevation		Layer Thickness	Layer Unit Wt.	In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom			Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	S_t
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	(inch)
Fill below footing/above exist.	0.0	0.0	0.0	632.0	632.0	0.0	125	-	-	-	-	-	-	-	-	0	0	-	2	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-
Existing Soil Above Footing	0.0	2.0	1.0	632.0	630.0	2.0	125	-	-	-	-	-	-	-	-	0	0	-	2	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-
Overex. below Existing	0.0	2.0	1.0	632.0	632.0	2.0	125	-	-	-	-	-	-	-	-	0	0	-	2	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-
Embank. Fill (Shell)	2.0	3.0	2.5	630.0	629.0	1.0	125	313	156	157	0.20	0.030	0.60	2.0	4,000	0	0	-	2	0.50	0.1	6.8	1.00	1,375	0.22	0.00	**0.223**
Embank. Fill (Shell)	3.0	4.0	3.5	629.0	628.0	1.0	125	438	218	219	0.20	0.030	0.60	2.0	4,000	0	0	-	2	1.50	0.2	6.8	0.99	1,368	0.19	0.00	**0.193**
Alluvium	4.0	5.0	4.5	628.0	627.0	1.0	123	562	281	281	0.20	0.030	0.65	2.0	4,000	0	0	-	2	2.50	0.4	6.8	0.98	1,345	0.17	0.00	**0.166**
Alluvium	5.0	6.0	5.5	627.0	626.0	1.0	123	685	343	341	0.20	0.030	0.65	2.0	4,000	0	0	-	2	3.50	0.5	6.8	0.95	1,302	0.15	0.00	**0.149**
Alluvium	6.0	7.0	6.5	626.0	625.0	1.0	123	808	406	402	0.20	0.030	0.65	2.0	4,000	0	0	-	2	4.50	0.7	6.8	0.90	1,241	0.13	0.00	**0.133**
Alluvium	7.0	8.0	7.5	625.0	624.0	1.0	123	931	468	463	0.20	0.030	0.65	2.0	4,000	0	0	-	2	5.50	0.8	6.8	0.85	1,168	0.12	0.00	**0.119**
Alluvium	8.0	9.0	8.5	624.0	623.0	1.0	123	1,054	530	523	0.20	0.030	0.65	2.0	4,000	0	0	-	2	6.50	1.0	6.8	0.79	1,087	0.11	0.00	**0.107**
Residuum (MPR)	9.0	10.0	9.5	623.0	622.0	1.0	126	1,178	593	585	0.20	0.030	0.60	2.0	4,000	0	0	-	2	7.50	1.1	6.8	0.73	1,005	0.10	0.00	**0.098**
Residuum (MPR)	10.0	11.0	10.5	622.0	621.0	1.0	126	1,304	655	649	0.20	0.030	0.60	2.0	4,000	0	0	-	2	8.50	1.3	6.8	0.67	924	0.09	0.00	**0.087**
Residuum (MPR)	11.0	12.0	11.5	621.0	620.0	1.0	126	1,430	718	712	0.20	0.030	0.60	2.0	4,000	0	0	-	2	9.50	1.4	6.8	0.62	847	0.08	0.00	**0.077**
Residuum (MPR)	12.0	13.0	12.5	620.0	619.0	1.0	126	1,556	780	776	0.20	0.030	0.60	2.0	4,000	0	0	-	2	10.50	1.6	6.8	0.56	775	0.07	0.00	**0.068**
Residuum (MPR)	13.0	14.0	13.5	619.0	618.0	1.0	126	1,682	842	840	0.20	0.030	0.60	2.0	4,000	0	0	-	2	11.50	1.7	6.8	0.51	708	0.06	0.00	**0.060**
Residuum (MPR)	14.0	15.0	14.5	618.0	617.0	1.0	126	1,808	905	903	0.20	0.030	0.60	2.0	4,000	0	0	-	2	12.50	1.9	6.8	0.47	647	0.05	0.00	**0.053**
Residuum (MPR)	15.0	16.0	15.5	617.0	616.0	1.0	126	1,934	967	967	0.20	0.030	0.60	2.0	4,000	0	0	-	2	13.50	2.0	6.8	0.43	592	0.05	0.00	**0.047**
Residuum (MPR)	16.0	17.0	16.5	616.0	615.0	1.0	126	2,060	1,030	1,030	0.20	0.030	0.60	2.0	4,000	0	0	-	2	14.50	2.1	6.8	0.39	543	0.04	0.00	**0.041**
Residuum (MPR)	17.0	18.0	17.5	615.0	614.0	1.0	126	2,186	1,092	1,094	0.20	0.030	0.60	2.0	4,000	0	0	-	2	15.50	2.3	6.8	0.36	498	0.04	0.00	**0.037**
Residuum (MPR)	18.0	19.0	18.5	614.0	613.0	1.0	126	2,312	1,154	1,158	0.20	0.030	0.60	2.0	4,000	0	0	-	2	16.50	2.4	6.8	0.33	458	0.03	0.00	**0.033**
Residuum (MPR)	19.0	20.0	19.5	613.0	612.0	1.0	126	2,438	1,217	1,221	0.20	0.030	0.60	2.0	4,000	0	0	-	2	17.50	2.6	6.8	0.31	422	0.03	0.00	**0.029**
Residuum (MPR)	20.0	21.0	20.5	612.0	611.0	1.0	126	2,564	1,279	1,285	0.20	0.030	0.60	2.0	4,000	0	0	-	2	18.50	2.7	6.8	0.28	389	0.03	0.00	**0.026**
Residuum (MPR)	21.0	22.0	21.5	611.0	610.0	1.0	126	2,690	1,342	1,348	0.20	0.030	0.60	2.0	4,000	0	0	-	2	19.50	2.9	6.8	0.26	360	0.02	0.00	**0.023**
Shale	22.0	23.0	22.5	610.0	609.0	1.0	130	2,818	1,404	1,414	0.00	0.000	0.50	0.0	0	0	0	-	2	20.50	3.0	6.8	0.24	333	-	-	**-**
Shale	23.0	24.0	23.5	609.0	608.0	1.0	130	2,948	1,466	1,482	0.00	0.000	0.50	0.0	0	0	0	-	2	21.50	3.2	6.8	0.23	309	-	-	**-**
Shale	24.0	25.0	24.5	608.0	607.0	1.0	130	3,078	1,529	1,549	0.00	0.000	0.50	0.0	0	0	0	-	2	22.50	3.3	6.8	0.21	288	-	-	**-**
Shale	25.0	26.0	25.5	607.0	606.0	1.0	130	3,208	1,591	1,617	0.00	0.000	0.50	0.0	0	0	0	-	2	23.50	3.5	6.8	0.20	268	-	-	**-**
Shale	26.0	27.0	26.5	606.0	605.0	1.0	130	3,338	1,654	1,684	0.00	0.000	0.50	0.0	0	0	0	-	2	24.50	3.6	6.8	0.18	250	-	-	**-**
Shale	27.0	28.0	27.5	605.0	604.0	1.0	130	3,468	1,716	1,752	0.00	0.000	0.50	0.0	0	0	0	-	2	25.50	3.8	6.8	0.17	234	-	-	**-**
Shale	28.0	29.0	28.5	604.0	603.0	1.0	130	3,598	1,778	1,820	0.00	0.000	0.50	0.0	0	0	0	-	2	26.50	3.9	6.8	0.16	220	-	-	**-**
Shale	29.0	30.0	29.5	603.0	602.0	1.0	130	3,728	1,841	1,887	0.00	0.000	0.50	0.0	0	0	0	-	2	27.50	4.1	6.8	0.15	206	-	-	**-**
Shale	30.0	31.0	30.5	602.0	601.0	1.0	130	3,858	1,903	1,955	0.00	0.000	0.50	0.0	0	0	0	-	2	28.50	4.2	6.8	0.14	194	-	-	**-**
Shale	31.0	32.0	31.5	601.0	600.0	1.0	130	3,988	1,966	2,022	0.00	0.000	0.50	0.0	0	0	0	-	2	29.50	4.4	6.8	0.13	183	-	-	**-**
Shale	32.0	33.0	32.5	600.0	599.0	1.0	130	4,118	2,028	2,090	0.00	0.000	0.50	0.0	0	0	0	-	2	30.50	4.5	6.8	0.13	172	-	-	**-**
Shale	33.0	34.0	33.5	599.0	598.0	1.0	130	4,248	2,090	2,158	0.00	0.000	0.50	0.0	0	0	0	-	2	31.50	4.7	6.8	0.12	163	-	-	**-**
Shale	34.0	35.0	34.5	598.0	597.0	1.0	130	4,378	2,153	2,225	0.00	0.000	0.50	0.0	0	0	0	-	2	32.50	4.8	6.8	0.11	154	-	-	**-**
Shale	35.0	36.0	35.5	597.0	596.0	1.0	130	4,508	2,215	2,293	0.00	0.000	0.50	0.0	0	0	0	-	2	33.50	5.0	6.8	0.11	146	-	-	**-**
Shale	36.0	37.0	36.5	596.0	595.0	1.0	130	4,638	2,278	2,360	0.00	0.000	0.50	0.0	0	0	0	-	2	34.50	5.1	6.8	0.10	138	-	-	**-**
Shale	37.0	38.0	37.5	595.0	594.0	1.0	130	4,768	2,340	2,428	0.00	0.000	0.50	0.0	0	0	0	-	2	35.50	5.3	6.8	0.10	131	-	-	**-**
Shale	38.0	39.0	38.5	594.0	593.0	1.0	130	4,898	2,402	2,496	0.00	0.000	0.50	0.0	0	0	0	-	2	36.50	5.4	6.8	0.09	125	-	-	**-**
Shale	39.0	40.0	39.5	593.0	592.0	1.0	130	5,028	2,465	2,563	0.00	0.000	0.50	0.0	0	0	0	-	2	37.50	5.6	6.8	0.09	119	-	-	**-**
Shale	40.0	41.0	40.5	592.0	591.0	1.0	130	5,158	2,527	2,631	0.00	0.000	0.50	0.0	0	0	0	-	2	38.50	5.7	6.8	0.08	113	-	-	**-**
Shale	41.0	42.0	41.5	591.0	590.0	1.0	130	5,288	2,590	2,698	0.00	0.000	0.50	0.0	0	0	0	-	2	39.50	5.9	6.8	0.08	108	-	-	**-**
Shale	42.0	43.0	42.5	590.0	589.0	1.0	130	5,418	2,652	2,766	0.00	0.000	0.50	0.0	0	0	0	-	2	40.50	6.0	6.8	0.07	103	-	-	**-**

	Depth from Existing*			Elevation				In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing							
Stratum	Top	Bottom	MP	Top	Bottom	Layer Thickness	Layer Unit Wt.	Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	**S_t**
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	**(inch)**
Shale	43.0	44.0	43.5	589.0	588.0	1.0	130	5,548	2,714	2,834	0.00	0.000	0.50	0.0	0	0	0	-	2	41.50	6.1	6.8	0.07	98	-	-	-
Shale	44.0	45.0	44.5	588.0	587.0	1.0	130	5,678	2,777	2,901	0.00	0.000	0.50	0.0	0	0	0	-	2	42.50	6.3	6.8	0.07	94	-	-	-
Shale	45.0	46.0	45.5	587.0	586.0	1.0	130	5,808	2,839	2,969	0.00	0.000	0.50	0.0	0	0	0	-	2	43.50	6.4	6.8	0.07	90	-	-	-
Shale	46.0	47.0	46.5	586.0	585.0	1.0	130	5,938	2,902	3,036	0.00	0.000	0.50	0.0	0	0	0	-	2	44.50	6.6	6.8	0.06	86	-	-	-
Shale	47.0	48.0	47.5	585.0	584.0	1.0	130	6,068	2,964	3,104	0.00	0.000	0.50	0.0	0	0	0	-	2	45.50	6.7	6.8	0.06	83	-	-	-
Shale	48.0	49.0	48.5	584.0	583.0	1.0	130	6,198	3,026	3,172	0.00	0.000	0.50	0.0	0	0	0	-	2	46.50	6.9	6.8	0.06	79	-	-	-
Shale	49.0	50.0	49.5	583.0	582.0	1.0	130	6,328	3,089	3,239	0.00	0.000	0.50	0.0	0	0	0	-	2	47.50	7.0	6.8	0.06	76	-	-	-
Shale	50.0	51.0	50.5	582.0	581.0	1.0	130	6,458	3,151	3,307	0.00	0.000	0.50	0.0	0	0	0	-	2	48.50	7.2	6.8	0.05	73	-	-	-
Shale	51.0	52.0	51.5	581.0	580.0	1.0	130	6,588	3,214	3,374	0.00	0.000	0.50	0.0	0	0	0	-	2	49.50	7.3	6.8	0.05	71	-	-	-
Shale	52.0	53.0	52.5	580.0	579.0	1.0	130	6,718	3,276	3,442	0.00	0.000	0.50	0.0	0	0	0	-	2	50.50	7.5	6.8	0.05	68	-	-	-
Shale	53.0	54.0	53.5	579.0	578.0	1.0	130	6,848	3,338	3,510	0.00	0.000	0.50	0.0	0	0	0	-	2	51.50	7.6	6.8	0.05	65	-	-	-
Shale	54.0	55.0	54.5	578.0	577.0	1.0	130	6,978	3,401	3,577	0.00	0.000	0.50	0.0	0	0	0	-	2	52.50	7.8	6.8	0.05	63	-	-	-
Shale	55.0	56.0	55.5	577.0	576.0	1.0	130	7,108	3,463	3,645	0.00	0.000	0.50	0.0	0	0	0	-	2	53.50	7.9	6.8	0.04	61	-	-	-
Shale	56.0	57.0	56.5	576.0	575.0	1.0	130	7,238	3,526	3,712	0.00	0.000	0.50	0.0	0	0	0	-	2	54.50	8.1	6.8	0.04	59	-	-	-
Shale	57.0	58.0	57.5	575.0	574.0	1.0	130	7,368	3,588	3,780	0.00	0.000	0.50	0.0	0	0	0	-	2	55.50	8.2	6.8	0.04	57	-	-	-
Shale	58.0	59.0	58.5	574.0	573.0	1.0	130	7,498	3,650	3,848	0.00	0.000	0.50	0.0	0	0	0	-	2	56.50	8.4	6.8	0.04	55	-	-	-
Shale	59.0	60.0	59.5	573.0	572.0	1.0	130	7,628	3,713	3,915	0.00	0.000	0.50	0.0	0	0	0	-	2	57.50	8.5	6.8	0.04	53	-	-	-
Shale	60.0	61.0	60.5	572.0	571.0	1.0	130	7,758	3,775	3,983	0.00	0.000	0.50	0.0	0	0	0	-	2	58.50	8.7	6.8	0.04	51	-	-	-
Shale	61.0	62.0	61.5	571.0	570.0	1.0	130	7,888	3,838	4,050	0.00	0.000	0.50	0.0	0	0	0	-	2	59.50	8.8	6.8	0.04	50	-	-	-
Shale	62.0	63.0	62.5	570.0	569.0	1.0	130	8,018	3,900	4,118	0.00	0.000	0.50	0.0	0	0	0	-	2	60.50	9.0	6.8	0.03	48	-	-	-
Shale	63.0	64.0	63.5	569.0	568.0	1.0	130	8,148	3,962	4,186	0.00	0.000	0.50	0.0	0	0	0	-	2	61.50	9.1	6.8	0.03	46	-	-	-
Shale	64.0	65.0	64.5	568.0	567.0	1.0	130	8,278	4,025	4,253	0.00	0.000	0.50	0.0	0	0	0	-	2	62.50	9.3	6.8	0.03	45	-	-	-
Shale	65.0	66.0	65.5	567.0	566.0	1.0	130	8,408	4,087	4,321	0.00	0.000	0.50	0.0	0	0	0	-	2	63.50	9.4	6.8	0.03	44	-	-	-
Shale	66.0	67.0	66.5	566.0	565.0	1.0	130	8,538	4,150	4,388	0.00	0.000	0.50	0.0	0	0	0	-	2	64.50	9.6	6.8	0.03	42	-	-	-
Shale	67.0	68.0	67.5	565.0	564.0	1.0	130	8,668	4,212	4,456	0.00	0.000	0.50	0.0	0	0	0	-	2	65.50	9.7	6.8	0.03	41	-	-	-
Shale	68.0	69.0	68.5	564.0	563.0	1.0	130	8,798	4,274	4,524	0.00	0.000	0.50	0.0	0	0	0	-	2	66.50	9.9	6.8	0.03	40	-	-	-
Shale	69.0	70.0	69.5	563.0	562.0	1.0	130	8,928	4,337	4,591	0.00	0.000	0.50	0.0	0	0	0	-	2	67.50	10.0	6.8	0.03	39	-	-	-
Shale	70.0	71.0	70.5	562.0	561.0	1.0	130	9,058	4,399	4,659	0.00	0.000	0.50	0.0	0	0	0	-	2	68.50	10.1	6.8	0.03	38	-	-	-
Shale	71.0	72.0	71.5	561.0	560.0	1.0	130	9,188	4,462	4,726	0.00	0.000	0.50	0.0	0	0	0	-	2	69.50	10.3	6.8	0.03	37	-	-	-
Shale	72.0	73.0	72.5	560.0	559.0	1.0	130	9,318	4,524	4,794	0.00	0.000	0.50	0.0	0	0	0	-	2	70.50	10.4	6.8	0.03	36	-	-	-
Shale	73.0	74.0	73.5	559.0	558.0	1.0	130	9,448	4,586	4,862	0.00	0.000	0.50	0.0	0	0	0	-	2	71.50	10.6	6.8	0.03	35	-	-	-
Shale	74.0	75.0	74.5	558.0	557.0	1.0	130	9,578	4,649	4,929	0.00	0.000	0.50	0.0	0	0	0	-	2	72.50	10.7	6.8	0.02	34	-	-	-
Shale	75.0	76.0	75.5	557.0	556.0	1.0	130	9,708	4,711	4,997	0.00	0.000	0.50	0.0	0	0	0	-	2	73.50	10.9	6.8	0.02	33	-	-	-
Shale	76.0	77.0	76.5	556.0	555.0	1.0	130	9,838	4,774	5,064	0.00	0.000	0.50	0.0	0	0	0	-	2	74.50	11.0	6.8	0.02	32	-	-	-
Shale	77.0	78.0	77.5	555.0	554.0	1.0	130	9,968	4,836	5,132	0.00	0.000	0.50	0.0	0	0	0	-	2	75.50	11.2	6.8	0.02	31	-	-	-
Shale	78.0	79.0	78.5	554.0	553.0	1.0	130	10,098	4,898	5,200	0.00	0.000	0.50	0.0	0	0	0	-	2	76.50	11.3	6.8	0.02	30	-	-	-
Shale	79.0	80.0	79.5	553.0	552.0	1.0	130	10,228	4,961	5,267	0.00	0.000	0.50	0.0	0	0	0	-	2	77.50	11.5	6.8	0.02	30	-	-	-
Shale	80.0	81.0	80.5	552.0	551.0	1.0	130	10,358	5,023	5,335	0.00	0.000	0.50	0.0	0	0	0	-	2	78.50	11.6	6.8	0.02	29	-	-	-
Shale	81.0	82.0	81.5	551.0	550.0	1.0	130	10,488	5,086	5,402	0.00	0.000	0.50	0.0	0	0	0	-	2	79.50	11.8	6.8	0.02	28	-	-	-
Shale	82.0	83.0	82.5	550.0	549.0	1.0	130	10,618	5,148	5,470	0.00	0.000	0.50	0.0	0	0	0	-	2	80.50	11.9	6.8	0.02	28	-	-	-
Shale	83.0	84.0	83.5	549.0	548.0	1.0	130	10,748	5,210	5,538	0.00	0.000	0.50	0.0	0	0	0	-	2	81.50	12.1	6.8	0.02	27	-	-	-
Shale	84.0	85.0	84.5	548.0	547.0	1.0	130	10,878	5,273	5,605	0.00	0.000	0.50	0.0	0	0	0	-	2	82.50	12.2	6.8	0.02	26	-	-	-
Shale	85.0	86.0	85.5	547.0	546.0	1.0	130	11,008	5,335	5,673	0.00	0.000	0.50	0.0	0	0	0	-	2	83.50	12.4	6.8	0.02	26	-	-	-
#N/A	86.0	87.0	86.5	546.0	545.0	1.0	#N/A	#N/A	5,398	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	84.50	12.5	6.8	0.02	25	-	-	-
#N/A	87.0	88.0	87.5	545.0	544.0	1.0	#N/A	#N/A	5,460	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	85.50	12.7	6.8	0.02	24	-	-	-
#N/A	88.0	89.0	88.5	544.0	543.0	1.0	#N/A	#N/A	5,522	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	86.50	12.8	6.8	0.02	24	-	-	-
#N/A	89.0	90.0	89.5	543.0	542.0	1.0	#N/A	#N/A	5,585	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	87.50	13.0	6.8	0.02	23	-	-	-
#N/A	90.0	91.0	90.5	542.0	541.0	1.0	#N/A	#N/A	5,647	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	88.50	13.1	6.8	0.02	23	-	-	-
#N/A	91.0	92.0	91.5	541.0	540.0	1.0	#N/A	#N/A	5,710	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	89.50	13.3	6.8	0.02	22	-	-	-
#N/A	92.0	93.0	92.5	540.0	539.0	1.0	#N/A	#N/A	5,772	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	90.50	13.4	6.8	0.02	22	-	-	-
#N/A	93.0	94.0	93.5	539.0	538.0	1.0	#N/A	#N/A	5,834	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	91.50	13.6	6.8	0.02	21	-	-	-
#N/A	94.0	95.0	94.5	538.0	537.0	1.0	#N/A	#N/A	5,897	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	92.50	13.7	6.8	0.02	21	-	-	-
#N/A	95.0	96.0	95.5	537.0	536.0	1.0	#N/A	#N/A	5,959	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	93.50	13.9	6.8	0.01	20	-	-	-
#N/A	96.0	97.0	96.5	536.0	535.0	1.0	#N/A	#N/A	6,022	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	94.50	14.0	6.8	0.01	20	-	-	-
#N/A	97.0	98.0	97.5	535.0	534.0	1.0	#N/A	#N/A	6,084	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	95.50	14.1	6.8	0.01	20	-	-	-
#N/A	98.0	99.0	98.5	534.0	533.0	1.0	#N/A	#N/A	6,146	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	96.50	14.3	6.8	0.01	19	-	-	-
#N/A	99.0	100.0	99.5	533.0	532.0	1.0	#N/A	#N/A	6,209	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	97.50	14.4	6.8	0.01	19	-	-	-
#N/A	100.0	101.0	100.5	532.0	531.0	1.0	#N/A	#N/A	6,271	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	98.50	14.6	6.8	0.01	18	-	-	-
#N/A	101.0	102.0	101.5	531.0	530.0	1.0	#N/A	#N/A	6,334	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	99.50	14.7	6.8	0.01	18	-	-	-
#N/A	102.0	103.0	102.5	530.0	529.0	1.0	#N/A	#N/A	6,396	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	100.50	14.9	6.8	0.01	18	-	-	-
#N/A	103.0	104.0	103.5	529.0	528.0	1.0	#N/A	#N/A	6,458	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	101.50	15.0	6.8	0.01	17	-	-	-
#N/A	104.0	105.0	104.5	528.0	527.0	1.0	#N/A	#N/A	6,521	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	102.50	15.2	6.8	0.01	17	-	-	-
#N/A	105.0	200.0	152.5	527.0	432.0	95.0	#N/A	#N/A	9,516	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	150.50	22.3	6.8	0.01	8	-	-	-



Settlement (inches)
0.0
0.5
1.0
1.5
2.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Depth Below Existing Footing (feet)
Rectangular Footing
Settlement Limit of 1 inch:
Settlement Limit of 1.5 inches:

Project Name:	Plum Creek FRS No. 2 Rehabilitation		Structure	PSW - Inlet Tower Structure
Job Number:	60615067		Analysis Section	Center of Inlet Tower
Client:	TSSWCB		Notes	Reinf. concrete foundation on overex/replace fill

Geotechnical Data

Relevant Boring	304-19	-
Boring Ground Elev.	647	ft NAVD88
Depth to GWT at Boring:	15	feet
GWT Elev.*	632	ft NAVD88

**GW set at existing ground elevation at proposed structure*

Exiting Ground at Structure Location

Structure Existing Ground:	632	ft NAVD88
Footing Bearing Elev.:	630	ft NAVD88
Footing Bearing Elev.:	2	ft below existing (cut)
GWT Depth below Exist.:	0	feet
GWT Depth below footing.:	0	feet

Area Fill

Fill between existing/footing?	no	-
Include load from area fill?	no	-
Finish Grade of Area Fill:	655.5	ft NAVD88
Height above existing:	#N/A	feet
Height above footing base:	#N/A	feet
Thickness under footing:	#N/A	feet
Area Fill Unit Weight:	125	pcf

Subgrade Overexcavation/Replacement

Include Overex/Replacement?	yes	-
Overex/Replace Bottom Elev.	628	ft NAVD88
Depth below footing:	2	feet
Depth below existing:	4	feet

Structure Footing Size & Maximum Bearing Pressure

Footing Width, B:	13.5	feet
Footing Length, L (rect):	20.5	feet
Gross Footing Pressure, $q_{0\text{-gross}}$	1,500	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula do not edit

Design Soil Profile and Properties

Depth at Boring (feet)		Elevation (feet)		Thickness in Boring	1 Existing Depth at Structure (feet)	2	3 Thickness at Structure	4 Layer Name	5 Total Unit Wt	6 Initial Void Ratio, e_0*	7 Compression Index, C_c*	8 Recomp. Index, C_r*	9 Min. Over Consolidation Ratio, OCR*	10 Min. Preconsol. Pressure, P'c*
Top	Bottom	Top	Bottom	(feet)	Top	Bottom	(feet)		(pcf)	(-)				(psf)
0	19	647.0	628.0	19.0	0.0	4.0	4.0	Embank. Fill (Shell)	125	0.60	0.20	0.030	2.0	4,000
19	24	628.0	623.0	5.0	4.0	9.0	5.0	Alluvium	123	0.65	0.20	0.030	2.0	4,000
24	37	623.0	610.0	13.0	9.0	22.0	13.0	Residuum (MPR)	126	0.60	0.20	0.030	2.0	4,000
37	100	610.0	547.0	63.0	22.0	85.0	63.0	Shale	130	0.50	0.0	0.000	0.0	0

Notes: *Copy down elevation and thickness formulas if more layers are needed, delete formulas where not needed.*

*Enter "0" for incompressible layers (i.e., granular soils and bedrock)

Project	Plum Creek FRS No. 2 Rehabilitation
Structure	PSW - Inlet Tower Structure
Analysis Section	Center of Inlet Tower

Method: Settlement Below Center of Uniformly Loaded Rectangular Footing

Elev. - Existing Ground @ Structure:	632	ft NAVD88	-2	ft from footing base (above)	0	ft from existing (below)
Elev. - Base of Footing / Bearing Depth	630	ft NAVD88	0	ft from footing base (below)	2	ft from existing (below)
Elev. - Top of Area Fill	#N/A	ft NAVD88	#N/A	#N/A	#N/A	#N/A
Elev. - Bottom of Overex./Replace	628	ft NAVD88	2	ft from footing base (below)	4	ft from existing (below)
Elev. - Groundwater	632	ft NAVD88	-2	ft from footing base (above)	0	ft from existing (below)
Thickness - Area Fill	#N/A	feet below footing base				
Thickness - Overex/Replace	2	feet below footing base				

Footing Width, B:	13.5	feet
Footing Length, L (square):	13.5	feet
Footing Length, L (rect):	20.5	feet

Gross Footing Pressure, $q_{0\text{-gross}}$	1,500	psf
Removed in-situ stress	125	psf
Net Footing Pressure, $q_{0\text{-net}}$	1,375	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula (do not edit)
xxx	= Unique Formula (do not edit)

$$\Delta\sigma_z = qI_4 \quad (10.34)$$

where

$$I_4 = \frac{2}{\pi}\left[\frac{m_1 n_1}{\sqrt{1+m_1^2+n_1^2}}\,\frac{1+m_1^2+2n_1^2}{(1+n_1^2)(m_1^2+n_1^2)} + \sin^{-1}\frac{m_1}{\sqrt{m_1^2+n_1^2}\sqrt{1+n_1^2}}\right] \quad (10.35)$$

$$m_1 = \frac{L}{B} \quad (10.36)$$

$$n_1 = \frac{z}{b} \quad (10.37)$$

$$b = \frac{B}{2} \quad (10.38)$$

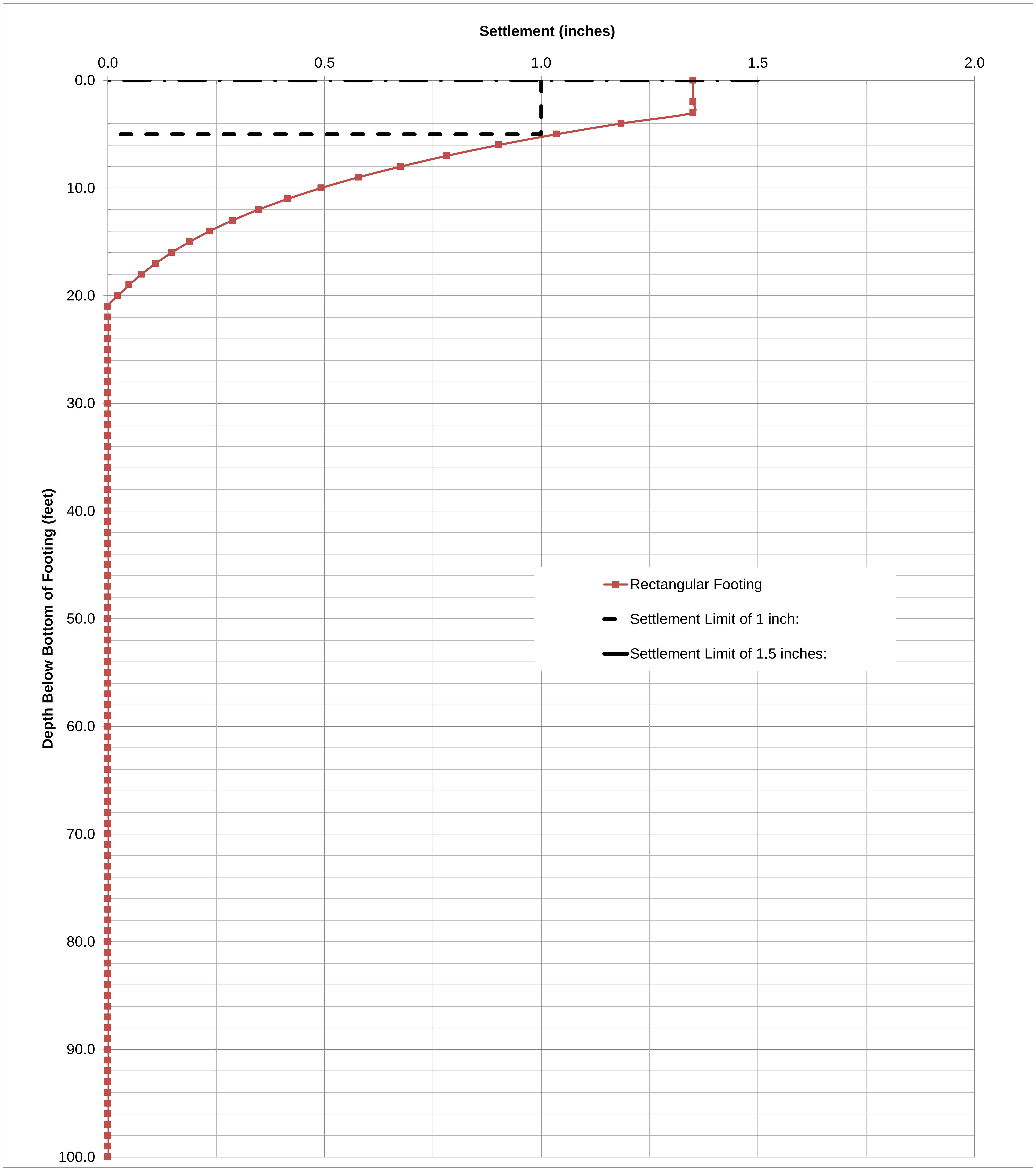
*Negative values indicate height above existing ground

*Granular fill, assumed zero

Total Settlement (inch) = 1.35

	Depth from Existing*			Elevation				In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom	Layer Thickness	Layer Unit Wt.	Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	**S_t**
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	**(inch)**
Fill below footing/above exist.	0.0	0.0	0.0	632.0	632.0	0.0	125	-	-	-	-	-	-	-	-	0	0	-	2	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	**-**
Existing Soil Above Footing	0.0	2.0	1.0	632.0	630.0	2.0	125	-	-	-	-	-	-	-	-	0	0	-	2	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	**-**
Overex. below Existing	0.0	4.0	2.0	632.0	628.0	4.0	125	-	-	-	-	-	-	-	-	0	0	-	2	0.00	0.0	6.8	1.00	1,375	-	-	**-**
Alluvium	4.0	5.0	4.5	628.0	627.0	1.0	123	562	281	281	0.20	0.030	0.65	2.0	4,000	0	0	-	2	2.50	0.4	6.8	0.98	1,345	0.17	0.00	**0.166**
Alluvium	5.0	6.0	5.5	627.0	626.0	1.0	123	685	343	341	0.20	0.030	0.65	2.0	4,000	0	0	-	2	3.50	0.5	6.8	0.95	1,302	0.15	0.00	**0.149**
Alluvium	6.0	7.0	6.5	626.0	625.0	1.0	123	808	406	402	0.20	0.030	0.65	2.0	4,000	0	0	-	2	4.50	0.7	6.8	0.90	1,241	0.13	0.00	**0.133**
Alluvium	7.0	8.0	7.5	625.0	624.0	1.0	123	931	468	463	0.20	0.030	0.65	2.0	4,000	0	0	-	2	5.50	0.8	6.8	0.85	1,168	0.12	0.00	**0.119**
Alluvium	8.0	9.0	8.5	624.0	623.0	1.0	123	1,054	530	523	0.20	0.030	0.65	2.0	4,000	0	0	-	2	6.50	1.0	6.8	0.79	1,087	0.11	0.00	**0.107**
Residuum (MPR)	9.0	10.0	9.5	623.0	622.0	1.0	126	1,178	593	585	0.20	0.030	0.60	2.0	4,000	0	0	-	2	7.50	1.1	6.8	0.73	1,005	0.10	0.00	**0.098**
Residuum (MPR)	10.0	11.0	10.5	622.0	621.0	1.0	126	1,304	655	649	0.20	0.030	0.60	2.0	4,000	0	0	-	2	8.50	1.3	6.8	0.67	924	0.09	0.00	**0.087**
Residuum (MPR)	11.0	12.0	11.5	621.0	620.0	1.0	126	1,430	718	712	0.20	0.030	0.60	2.0	4,000	0	0	-	2	9.50	1.4	6.8	0.62	847	0.08	0.00	**0.077**
Residuum (MPR)	12.0	13.0	12.5	620.0	619.0	1.0	126	1,556	780	776	0.20	0.030	0.60	2.0	4,000	0	0	-	2	10.50	1.6	6.8	0.56	775	0.07	0.00	**0.068**
Residuum (MPR)	13.0	14.0	13.5	619.0	618.0	1.0	126	1,682	842	840	0.20	0.030	0.60	2.0	4,000	0	0	-	2	11.50	1.7	6.8	0.51	708	0.06	0.00	**0.060**
Residuum (MPR)	14.0	15.0	14.5	618.0	617.0	1.0	126	1,808	905	903	0.20	0.030	0.60	2.0	4,000	0	0	-	2	12.50	1.9	6.8	0.47	647	0.05	0.00	**0.053**
Residuum (MPR)	15.0	16.0	15.5	617.0	616.0	1.0	126	1,934	967	967	0.20	0.030	0.60	2.0	4,000	0	0	-	2	13.50	2.0	6.8	0.43	592	0.05	0.00	**0.047**
Residuum (MPR)	16.0	17.0	16.5	616.0	615.0	1.0	126	2,060	1,030	1,030	0.20	0.030	0.60	2.0	4,000	0	0	-	2	14.50	2.1	6.8	0.39	543	0.04	0.00	**0.041**
Residuum (MPR)	17.0	18.0	17.5	615.0	614.0	1.0	126	2,186	1,092	1,094	0.20	0.030	0.60	2.0	4,000	0	0	-	2	15.50	2.3	6.8	0.36	498	0.04	0.00	**0.037**
Residuum (MPR)	18.0	19.0	18.5	614.0	613.0	1.0	126	2,312	1,154	1,158	0.20	0.030	0.60	2.0	4,000	0	0	-	2	16.50	2.4	6.8	0.33	458	0.03	0.00	**0.033**
Residuum (MPR)	19.0	20.0	19.5	613.0	612.0	1.0	126	2,438	1,217	1,221	0.20	0.030	0.60	2.0	4,000	0	0	-	2	17.50	2.6	6.8	0.31	422	0.03	0.00	**0.029**
Residuum (MPR)	20.0	21.0	20.5	612.0	611.0	1.0	126	2,564	1,279	1,285	0.20	0.030	0.60	2.0	4,000	0	0	-	2	18.50	2.7	6.8	0.28	389	0.03	0.00	**0.026**
Residuum (MPR)	21.0	22.0	21.5	611.0	610.0	1.0	126	2,690	1,342	1,348	0.20	0.030	0.60	2.0	4,000	0	0	-	2	19.50	2.9	6.8	0.26	360	0.02	0.00	**0.023**
Shale	22.0	23.0	22.5	610.0	609.0	1.0	130	2,818	1,404	1,414	0.00	0.000	0.50	0.0	0	0	0	-	2	20.50	3.0	6.8	0.24	333	-	-	**-**
Shale	23.0	24.0	23.5	609.0	608.0	1.0	130	2,948	1,466	1,482	0.00	0.000	0.50	0.0	0	0	0	-	2	21.50	3.2	6.8	0.23	309	-	-	**-**
Shale	24.0	25.0	24.5	608.0	607.0	1.0	130	3,078	1,529	1,549	0.00	0.000	0.50	0.0	0	0	0	-	2	22.50	3.3	6.8	0.21	288	-	-	**-**
Shale	25.0	26.0	25.5	607.0	606.0	1.0	130	3,208	1,591	1,617	0.00	0.000	0.50	0.0	0	0	0	-	2	23.50	3.5	6.8	0.20	268	-	-	**-**
Shale	26.0	27.0	26.5	606.0	605.0	1.0	130	3,338	1,654	1,684	0.00	0.000	0.50	0.0	0	0	0	-	2	24.50	3.6	6.8	0.18	250	-	-	**-**
Shale	27.0	28.0	27.5	605.0	604.0	1.0	130	3,468	1,716	1,752	0.00	0.000	0.50	0.0	0	0	0	-	2	25.50	3.8	6.8	0.17	234	-	-	**-**
Shale	28.0	29.0	28.5	604.0	603.0	1.0	130	3,598	1,778	1,820	0.00	0.000	0.50	0.0	0	0	0	-	2	26.50	3.9	6.8	0.16	220	-	-	**-**
Shale	29.0	30.0	29.5	603.0	602.0	1.0	130	3,728	1,841	1,887	0.00	0.000	0.50	0.0	0	0	0	-	2	27.50	4.1	6.8	0.15	206	-	-	**-**
Shale	30.0	31.0	30.5	602.0	601.0	1.0	130	3,858	1,903	1,955	0.00	0.000	0.50	0.0	0	0	0	-	2	28.50	4.2	6.8	0.14	194	-	-	**-**
Shale	31.0	32.0	31.5	601.0	600.0	1.0	130	3,988	1,966	2,022	0.00	0.000	0.50	0.0	0	0	0	-	2	29.50	4.4	6.8	0.13	183	-	-	**-**
Shale	32.0	33.0	32.5	600.0	599.0	1.0	130	4,118	2,028	2,090	0.00	0.000	0.50	0.0	0	0	0	-	2	30.50	4.5	6.8	0.13	172	-	-	**-**
Shale	33.0	34.0	33.5	599.0	598.0	1.0	130	4,248	2,090	2,158	0.00	0.000	0.50	0.0	0	0	0	-	2	31.50	4.7	6.8	0.12	163	-	-	**-**
Shale	34.0	35.0	34.5	598.0	597.0	1.0	130	4,378	2,153	2,225	0.00	0.000	0.50	0.0	0	0	0	-	2	32.50	4.8	6.8	0.11	154	-	-	**-**
Shale	35.0	36.0	35.5	597.0	596.0	1.0	130	4,508	2,215	2,293	0.00	0.000	0.50	0.0	0	0	0	-	2	33.50	5.0	6.8	0.11	146	-	-	**-**
Shale	36.0	37.0	36.5	596.0	595.0	1.0	130	4,638	2,278	2,360	0.00	0.000	0.50	0.0	0	0	0	-	2	34.50	5.1	6.8	0.10	138	-	-	**-**
Shale	37.0	38.0	37.5	595.0	594.0	1.0	130	4,768	2,340	2,428	0.00	0.000	0.50	0.0	0	0	0	-	2	35.50	5.3	6.8	0.10	131	-	-	**-**
Shale	38.0	39.0	38.5	594.0	593.0	1.0	130	4,898	2,402	2,496	0.00	0.000	0.50	0.0	0	0	0	-	2	36.50	5.4	6.8	0.09	125	-	-	**-**
Shale	39.0	40.0	39.5	593.0	592.0	1.0	130	5,028	2,465	2,563	0.00	0.000	0.50	0.0	0	0	0	-	2	37.50	5.6	6.8	0.09	119	-	-	**-**
Shale	40.0	41.0	40.5	592.0	591.0	1.0	130	5,158	2,527	2,631	0.00	0.000	0.50	0.0	0	0	0	-	2	38.50	5.7	6.8	0.08	113	-	-	**-**
Shale	41.0	42.0	41.5	591.0	590.0	1.0	130	5,288	2,590	2,698	0.00	0.000	0.50	0.0	0	0	0	-	2	39.50	5.9	6.8	0.08	108	-	-	**-**
Shale	42.0	43.0	42.5	590.0	589.0	1.0	130	5,418	2,652	2,766	0.00	0.000	0.50	0.0	0	0	0	-	2	40.50	6.0	6.8	0.07	103	-	-	**-**
Shale	43.0	44.0	43.5	589.0	588.0	1.0	130	5,548	2,714	2,834	0.00	0.000	0.50	0.0	0	0	0	-	2	41.50	6.1	6.8	0.07	98	-	-	**-**
Shale	44.0	45.0	44.5	588.0	587.0	1.0	130	5,678	2,777	2,901	0.00	0.000	0.50	0.0	0	0	0	-	2	42.50	6.3	6.8	0.07	94	-	-	**-**

	Depth from Existing*			Elevation		Layer Thickness	Layer Unit Wt.	In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom			Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	**S_t**
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	**(inch)**
Shale	45.0	46.0	45.5	587.0	586.0	1.0	130	5,808	2,839	2,969	0.00	0.000	0.50	0.0	0	0	0	-	2	43.50	6.4	6.8	0.07	90	-	-	-
Shale	46.0	47.0	46.5	586.0	585.0	1.0	130	5,938	2,902	3,036	0.00	0.000	0.50	0.0	0	0	0	-	2	44.50	6.6	6.8	0.06	86	-	-	-
Shale	47.0	48.0	47.5	585.0	584.0	1.0	130	6,068	2,964	3,104	0.00	0.000	0.50	0.0	0	0	0	-	2	45.50	6.7	6.8	0.06	83	-	-	-
Shale	48.0	49.0	48.5	584.0	583.0	1.0	130	6,198	3,026	3,172	0.00	0.000	0.50	0.0	0	0	0	-	2	46.50	6.9	6.8	0.06	79	-	-	-
Shale	49.0	50.0	49.5	583.0	582.0	1.0	130	6,328	3,089	3,239	0.00	0.000	0.50	0.0	0	0	0	-	2	47.50	7.0	6.8	0.06	76	-	-	-
Shale	50.0	51.0	50.5	582.0	581.0	1.0	130	6,458	3,151	3,307	0.00	0.000	0.50	0.0	0	0	0	-	2	48.50	7.2	6.8	0.05	73	-	-	-
Shale	51.0	52.0	51.5	581.0	580.0	1.0	130	6,588	3,214	3,374	0.00	0.000	0.50	0.0	0	0	0	-	2	49.50	7.3	6.8	0.05	71	-	-	-
Shale	52.0	53.0	52.5	580.0	579.0	1.0	130	6,718	3,276	3,442	0.00	0.000	0.50	0.0	0	0	0	-	2	50.50	7.5	6.8	0.05	68	-	-	-
Shale	53.0	54.0	53.5	579.0	578.0	1.0	130	6,848	3,338	3,510	0.00	0.000	0.50	0.0	0	0	0	-	2	51.50	7.6	6.8	0.05	65	-	-	-
Shale	54.0	55.0	54.5	578.0	577.0	1.0	130	6,978	3,401	3,577	0.00	0.000	0.50	0.0	0	0	0	-	2	52.50	7.8	6.8	0.05	63	-	-	-
Shale	55.0	56.0	55.5	577.0	576.0	1.0	130	7,108	3,463	3,645	0.00	0.000	0.50	0.0	0	0	0	-	2	53.50	7.9	6.8	0.04	61	-	-	-
Shale	56.0	57.0	56.5	576.0	575.0	1.0	130	7,238	3,526	3,712	0.00	0.000	0.50	0.0	0	0	0	-	2	54.50	8.1	6.8	0.04	59	-	-	-
Shale	57.0	58.0	57.5	575.0	574.0	1.0	130	7,368	3,588	3,780	0.00	0.000	0.50	0.0	0	0	0	-	2	55.50	8.2	6.8	0.04	57	-	-	-
Shale	58.0	59.0	58.5	574.0	573.0	1.0	130	7,498	3,650	3,848	0.00	0.000	0.50	0.0	0	0	0	-	2	56.50	8.4	6.8	0.04	55	-	-	-
Shale	59.0	60.0	59.5	573.0	572.0	1.0	130	7,628	3,713	3,915	0.00	0.000	0.50	0.0	0	0	0	-	2	57.50	8.5	6.8	0.04	53	-	-	-
Shale	60.0	61.0	60.5	572.0	571.0	1.0	130	7,758	3,775	3,983	0.00	0.000	0.50	0.0	0	0	0	-	2	58.50	8.7	6.8	0.04	51	-	-	-
Shale	61.0	62.0	61.5	571.0	570.0	1.0	130	7,888	3,838	4,050	0.00	0.000	0.50	0.0	0	0	0	-	2	59.50	8.8	6.8	0.04	50	-	-	-
Shale	62.0	63.0	62.5	570.0	569.0	1.0	130	8,018	3,900	4,118	0.00	0.000	0.50	0.0	0	0	0	-	2	60.50	9.0	6.8	0.03	48	-	-	-
Shale	63.0	64.0	63.5	569.0	568.0	1.0	130	8,148	3,962	4,186	0.00	0.000	0.50	0.0	0	0	0	-	2	61.50	9.1	6.8	0.03	46	-	-	-
Shale	64.0	65.0	64.5	568.0	567.0	1.0	130	8,278	4,025	4,253	0.00	0.000	0.50	0.0	0	0	0	-	2	62.50	9.3	6.8	0.03	45	-	-	-
Shale	65.0	66.0	65.5	567.0	566.0	1.0	130	8,408	4,087	4,321	0.00	0.000	0.50	0.0	0	0	0	-	2	63.50	9.4	6.8	0.03	44	-	-	-
Shale	66.0	67.0	66.5	566.0	565.0	1.0	130	8,538	4,150	4,388	0.00	0.000	0.50	0.0	0	0	0	-	2	64.50	9.6	6.8	0.03	42	-	-	-
Shale	67.0	68.0	67.5	565.0	564.0	1.0	130	8,668	4,212	4,456	0.00	0.000	0.50	0.0	0	0	0	-	2	65.50	9.7	6.8	0.03	41	-	-	-
Shale	68.0	69.0	68.5	564.0	563.0	1.0	130	8,798	4,274	4,524	0.00	0.000	0.50	0.0	0	0	0	-	2	66.50	9.9	6.8	0.03	40	-	-	-
Shale	69.0	70.0	69.5	563.0	562.0	1.0	130	8,928	4,337	4,591	0.00	0.000	0.50	0.0	0	0	0	-	2	67.50	10.0	6.8	0.03	39	-	-	-
Shale	70.0	71.0	70.5	562.0	561.0	1.0	130	9,058	4,399	4,659	0.00	0.000	0.50	0.0	0	0	0	-	2	68.50	10.1	6.8	0.03	38	-	-	-
Shale	71.0	72.0	71.5	561.0	560.0	1.0	130	9,188	4,462	4,726	0.00	0.000	0.50	0.0	0	0	0	-	2	69.50	10.3	6.8	0.03	37	-	-	-
Shale	72.0	73.0	72.5	560.0	559.0	1.0	130	9,318	4,524	4,794	0.00	0.000	0.50	0.0	0	0	0	-	2	70.50	10.4	6.8	0.03	36	-	-	-
Shale	73.0	74.0	73.5	559.0	558.0	1.0	130	9,448	4,586	4,862	0.00	0.000	0.50	0.0	0	0	0	-	2	71.50	10.6	6.8	0.03	35	-	-	-
Shale	74.0	75.0	74.5	558.0	557.0	1.0	130	9,578	4,649	4,929	0.00	0.000	0.50	0.0	0	0	0	-	2	72.50	10.7	6.8	0.02	34	-	-	-
Shale	75.0	76.0	75.5	557.0	556.0	1.0	130	9,708	4,711	4,997	0.00	0.000	0.50	0.0	0	0	0	-	2	73.50	10.9	6.8	0.02	33	-	-	-
Shale	76.0	77.0	76.5	556.0	555.0	1.0	130	9,838	4,774	5,064	0.00	0.000	0.50	0.0	0	0	0	-	2	74.50	11.0	6.8	0.02	32	-	-	-
Shale	77.0	78.0	77.5	555.0	554.0	1.0	130	9,968	4,836	5,132	0.00	0.000	0.50	0.0	0	0	0	-	2	75.50	11.2	6.8	0.02	31	-	-	-
Shale	78.0	79.0	78.5	554.0	553.0	1.0	130	10,098	4,898	5,200	0.00	0.000	0.50	0.0	0	0	0	-	2	76.50	11.3	6.8	0.02	30	-	-	-
Shale	79.0	80.0	79.5	553.0	552.0	1.0	130	10,228	4,961	5,267	0.00	0.000	0.50	0.0	0	0	0	-	2	77.50	11.5	6.8	0.02	30	-	-	-
Shale	80.0	81.0	80.5	552.0	551.0	1.0	130	10,358	5,023	5,335	0.00	0.000	0.50	0.0	0	0	0	-	2	78.50	11.6	6.8	0.02	29	-	-	-
Shale	81.0	82.0	81.5	551.0	550.0	1.0	130	10,488	5,086	5,402	0.00	0.000	0.50	0.0	0	0	0	-	2	79.50	11.8	6.8	0.02	28	-	-	-
Shale	82.0	83.0	82.5	550.0	549.0	1.0	130	10,618	5,148	5,470	0.00	0.000	0.50	0.0	0	0	0	-	2	80.50	11.9	6.8	0.02	28	-	-	-
Shale	83.0	84.0	83.5	549.0	548.0	1.0	130	10,748	5,210	5,538	0.00	0.000	0.50	0.0	0	0	0	-	2	81.50	12.1	6.8	0.02	27	-	-	-
Shale	84.0	85.0	84.5	548.0	547.0	1.0	130	10,878	5,273	5,605	0.00	0.000	0.50	0.0	0	0	0	-	2	82.50	12.2	6.8	0.02	26	-	-	-
Shale	85.0	86.0	85.5	547.0	546.0	1.0	130	11,008	5,335	5,673	0.00	0.000	0.50	0.0	0	0	0	-	2	83.50	12.4	6.8	0.02	26	-	-	-
#N/A	86.0	87.0	86.5	546.0	545.0	1.0	#N/A	#N/A	5,398	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	84.50	12.5	6.8	0.02	25	-	-	-
#N/A	87.0	88.0	87.5	545.0	544.0	1.0	#N/A	#N/A	5,460	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	85.50	12.7	6.8	0.02	24	-	-	-
#N/A	88.0	89.0	88.5	544.0	543.0	1.0	#N/A	#N/A	5,522	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	86.50	12.8	6.8	0.02	24	-	-	-
#N/A	89.0	90.0	89.5	543.0	542.0	1.0	#N/A	#N/A	5,585	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	87.50	13.0	6.8	0.02	23	-	-	-
#N/A	90.0	91.0	90.5	542.0	541.0	1.0	#N/A	#N/A	5,647	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	88.50	13.1	6.8	0.02	23	-	-	-
#N/A	91.0	92.0	91.5	541.0	540.0	1.0	#N/A	#N/A	5,710	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	89.50	13.3	6.8	0.02	22	-	-	-
#N/A	92.0	93.0	92.5	540.0	539.0	1.0	#N/A	#N/A	5,772	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	90.50	13.4	6.8	0.02	22	-	-	-
#N/A	93.0	94.0	93.5	539.0	538.0	1.0	#N/A	#N/A	5,834	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	91.50	13.6	6.8	0.02	21	-	-	-
#N/A	94.0	95.0	94.5	538.0	537.0	1.0	#N/A	#N/A	5,897	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	92.50	13.7	6.8	0.02	21	-	-	-
#N/A	95.0	96.0	95.5	537.0	536.0	1.0	#N/A	#N/A	5,959	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	93.50	13.9	6.8	0.01	20	-	-	-
#N/A	96.0	97.0	96.5	536.0	535.0	1.0	#N/A	#N/A	6,022	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	94.50	14.0	6.8	0.01	20	-	-	-
#N/A	97.0	98.0	97.5	535.0	534.0	1.0	#N/A	#N/A	6,084	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	95.50	14.1	6.8	0.01	20	-	-	-
#N/A	98.0	99.0	98.5	534.0	533.0	1.0	#N/A	#N/A	6,146	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	96.50	14.3	6.8	0.01	19	-	-	-
#N/A	99.0	100.0	99.5	533.0	532.0	1.0	#N/A	#N/A	6,209	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	97.50	14.4	6.8	0.01	19	-	-	-
#N/A	100.0	101.0	100.5	532.0	531.0	1.0	#N/A	#N/A	6,271	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	98.50	14.6	6.8	0.01	18	-	-	-
#N/A	101.0	102.0	101.5	531.0	530.0	1.0	#N/A	#N/A	6,334	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	99.50	14.7	6.8	0.01	18	-	-	-
#N/A	102.0	103.0	102.5	530.0	529.0	1.0	#N/A	#N/A	6,396	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	100.50	14.9	6.8	0.01	18	-	-	-
#N/A	103.0	104.0	103.5	529.0	528.0	1.0	#N/A	#N/A	6,458	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	101.50	15.0	6.8	0.01	17	-	-	-
#N/A	104.0	105.0	104.5	528.0	527.0	1.0	#N/A	#N/A	6,521	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	102.50	15.2	6.8	0.01	17	-	-	-
#N/A	105.0	106.0	105.5	527.0	526.0	1.0	#N/A	#N/A	6,583	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	103.50	15.3	6.8	0.01	17	-	-	-
#N/A	106.0	107.0	106.5	526.0	525.0	1.0	#N/A	#N/A	6,646	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	104.50	15.5	6.8	0.01	16	-	-	-
#N/A	107.0	200.0	153.5	525.0	432.0	93.0	#N/A	#N/A	9,578	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	151.50	22.4	6.8	0.01	8	-	-	-



Settlement (inches)
0.0
0.5
1.0
1.5
2.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Depth Below Bottom of Footing (feet)
Rectangular Footing
Settlement Limit of 1 inch:
Settlement Limit of 1.5 inches:

ATTACHMENT 3
Settlement Calculations for PSW – Impact Basin

Project Name:	Plum Creek FRS No. 2 Rehabilitation		Structure	PSW - Impact Basin Structure
Job Number:	60615067		Analysis Section	Center of Impact Basin
Client:	TSSWCB		Notes	Reinf. concrete footing on in-situ subgrade

Geotechnical Data

Relevant Boring	305-19	-
Boring Ground Elev.	635	ft NAVD88
Depth to GWT at Boring:	2	feet
GWT Elev.	633	ft NAVD88

Exiting Ground at Structure Location

Structure Existing Ground:	633.1	ft NAVD88
Footing Bearing Elev.:	626.5	ft NAVD88
Footing Bearing Elev.:	6.6	ft below existing (cut)
GWT Depth below Exist.:	0.1	feet
GWT Depth below footing.:	0	feet

Area Fill

Fill between existing/footing?	no	-
Include load from area fill?	no	-
Finish Grade of Area Fill:	655.5	ft NAVD88
Height above existing:	#N/A	feet
Height above footing base:	#N/A	feet
Thickness under footing:	#N/A	feet
Area Fill Unit Weight:	125	pcf

Subgrade Overexcavation/Replacement

Include Overex/Replacement?	no	-
Overex/Replace Bottom Elev.	655.5	ft NAVD88
Depth below footing:	#N/A	feet
Depth below existing:	#N/A	feet

Structure Footing Size & Maximum Bearing Pressure

Footing Width, B:	19.5	feet
Footing Length, L (rect):	24.75	feet
Gross Footing Pressure, $q_{0\text{-gross}}$	2,000	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula do not edit

Design Soil Profile and Properties

					1	2	3	4	5	6	7	8	9	10
Depth at Boring (feet)		Elevation (feet)		Thickness in Boring	Existing Depth at Structure (feet)		Thickness at Structure	Layer Name	Total Unit Wt	Initial Void Ratio, e_0*	Compression Index, C_c*	Recomp. Index, C_r*	Min. Over Consolidation Ratio, OCR*	Min. Preconsol. Pressure, P'c*
Top	Bottom	Top	Bottom	(feet)	Top	Bottom	(feet)		(pcf)	(-)				(psf)
0	6	635.0	629.0	6.0	0.0	4.1	4.1	Embank. Fill (Shell)	125	0.60	0.20	0.300	2.0	4,000
6	13	629.0	622.0	7.0	4.1	11.1	7.0	Alluvium	123	0.65	0.20	0.030	2.0	4,000
13	23	622.0	612.0	10.0	11.1	21.1	10.0	Residuum (MPR)	126	0.60	0.20	0.030	2.0	4,000
20	97	615.0	538.0	77.0	18.1	95.1	77.0	Shale	130	0.50	0.0	0.000	0.0	0

Notes: *Copy down elevation and thickness formulas if more layers are needed, delete formulas where not needed.*

*Enter "0" for incompressible layers (i.e., granular soils and bedrock)

Method: Settlement Below Center of Uniformly Loaded Rectangular Footing

Project	Plum Creek FRS No. 2 Rehabilitation
Structure	PSW - Impact Basin Structure
Analysis Section	Center of Impact Basin

Elev. - Existing Ground @ Structure:	633.1	ft NAVD88	-6.6	ft from footing base (above)	0	ft from existing (below)
Elev. - Base of Footing / Bearing Depth	626.5	ft NAVD88	0	ft from footing base (below)	6.6	ft from existing (below)
Elev. - Top of Area Fill	#N/A	ft NAVD88	#N/A	#N/A	#N/A	#N/A
Elev. - Bottom of Overex./Replace	#N/A	ft NAVD88	#N/A	#N/A	#N/A	#N/A
Elev. - Groundwater	633	ft NAVD88	-6.5	ft from footing base (above)	0.1	ft from existing (below)
Thickness - Area Fill	#N/A	feet below footing base				
Thickness - Overex/Replace	#N/A	feet below footing base				

Footing Width, B:	19.5	feet
Footing Length, L (square):	19.5	feet
Footing Length, L (rect):	24.75	feet

Gross Footing Pressure, $q_{0\text{-gross}}$	2,000	psf
Removed in-situ stress	419	psf
Net Footing Pressure, $q_{0\text{-net}}$	1,581	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula (do not edit)
xxx	= Unique Formula (do not edit)

$$\Delta\sigma_z = qI_4 \quad (10.34)$$

where

$$I_4 = \frac{2}{\pi}\left[\frac{m_1 n_1}{\sqrt{1+m_1^2+n_1^2}}\frac{1+m_1^2+2n_1^2}{(1+n_1^2)(m_1^2+n_1^2)} + \sin^{-1}\frac{m_1}{\sqrt{m_1^2+n_1^2}\sqrt{1+n_1^2}}\right] \quad (10.35)$$

$$m_1 = \frac{L}{B} \quad (10.36)$$

$$n_1 = \frac{z}{b} \quad (10.37)$$

$$b = \frac{B}{2} \quad (10.38)$$

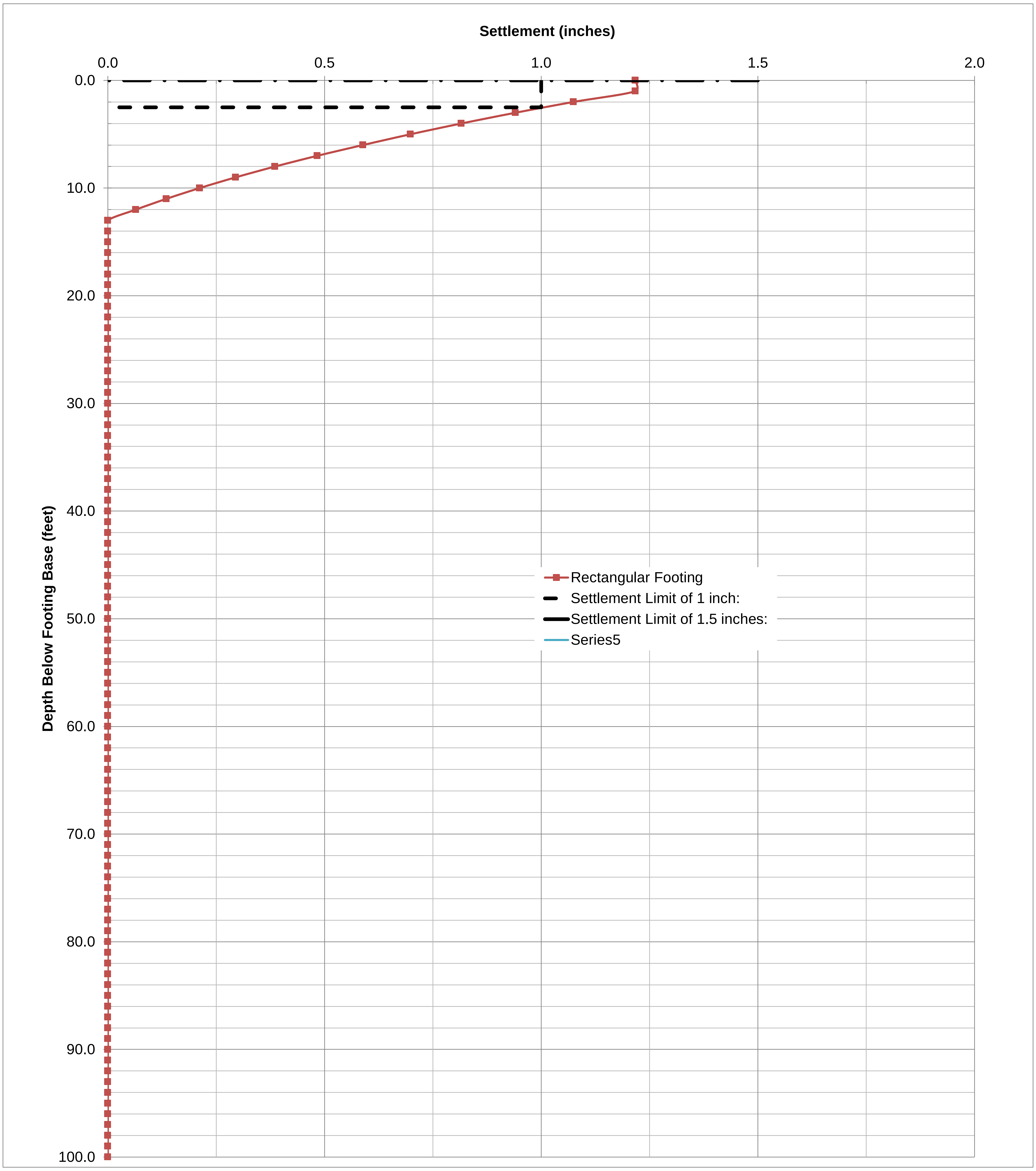
*Negative values indicate height above existing ground

*Granular fill, assumed zero

Total Settlement (inch) = 1.22

	Depth from Existing*			Elevation				In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom	Layer Thickness	Layer Unit Wt.	Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	S_t
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	(inch)
Fill below footing/above exist.	0.0	0.0	0.0	633.1	633.1	0.0	125	-	-	-	-	-	-	-	-	0	0	-	1	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-
Existing Soil Above Footing	0.0	6.6	3.3	633.1	626.5	6.6	125	-	-	-	-	-	-	-	-	0	0	-	1	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-
Overex. below Existing	0.0	6.6	3.3	633.1	633.1	6.6	125	-	-	-	-	-	-	-	-	0	0	-	1	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-
Alluvium	6.6	7.6	7.1	626.5	625.5	1.0	123	887	437	450	0.20	0.030	0.65	2.0	4,000	0	0	-	1	0.50	0.1	9.8	1.00	1,580	0.14	0.00	**0.143**
Alluvium	7.6	8.6	8.1	625.5	624.5	1.0	123	1,010	499	510	0.20	0.030	0.65	2.0	4,000	0	0	-	1	1.50	0.2	9.8	1.00	1,577	0.13	0.00	**0.133**
Alluvium	8.6	9.6	9.1	624.5	623.5	1.0	123	1,133	562	571	0.20	0.030	0.65	2.0	4,000	0	0	-	1	2.50	0.3	9.8	0.99	1,567	0.13	0.00	**0.125**
Alluvium	9.6	10.6	10.1	623.5	622.5	1.0	123	1,256	624	632	0.20	0.030	0.65	2.0	4,000	0	0	-	1	3.50	0.4	9.8	0.98	1,545	0.12	0.00	**0.117**
Alluvium	10.6	11.6	11.1	622.5	621.5	1.0	123	1,379	686	692	0.20	0.030	0.65	2.0	4,000	0	0	-	1	4.50	0.5	9.8	0.96	1,510	0.11	0.00	**0.110**
Residuum (MPR)	11.6	12.6	12.1	621.5	620.5	1.0	126	1,503	749	754	0.20	0.030	0.60	2.0	4,000	0	0	-	1	5.50	0.6	9.8	0.93	1,464	0.11	0.00	**0.105**
Residuum (MPR)	12.6	13.6	13.1	620.5	619.5	1.0	126	1,629	811	818	0.20	0.030	0.60	2.0	4,000	0	0	-	1	6.50	0.7	9.8	0.89	1,407	0.10	0.00	**0.098**
Residuum (MPR)	13.6	14.6	14.1	619.5	618.5	1.0	126	1,755	874	881	0.20	0.030	0.60	2.0	4,000	0	0	-	1	7.50	0.8	9.8	0.85	1,344	0.09	0.00	**0.090**
Residuum (MPR)	14.6	15.6	15.1	618.5	617.5	1.0	126	1,881	936	945	0.20	0.030	0.60	2.0	4,000	0	0	-	1	8.50	0.9	9.8	0.81	1,275	0.08	0.00	**0.083**
Residuum (MPR)	15.6	16.6	16.1	617.5	616.5	1.0	126	2,007	998	1,009	0.20	0.030	0.60	2.0	4,000	0	0	-	1	9.50	1.0	9.8	0.76	1,204	0.08	0.00	**0.077**
Residuum (MPR)	16.6	17.6	17.1	616.5	615.5	1.0	126	2,133	1,061	1,072	0.20	0.030	0.60	2.0	4,000	0	0	-	1	10.50	1.1	9.8	0.72	1,132	0.07	0.00	**0.070**
Residuum (MPR)	17.6	18.6	18.1	615.5	614.5	1.0	126	2,259	1,123	1,136	0.20	0.030	0.60	2.0	4,000	0	0	-	1	11.50	1.2	9.8	0.67	1,062	0.06	0.00	**0.065**
Shale	18.6	19.6	19.1	614.5	613.5	1.0	130	2,387	1,186	1,201	0.00	0.000	0.50	0.0	0	0	0	-	1	12.50	1.3	9.8	0.63	994	-	-	-
Shale	19.6	20.6	20.1	613.5	612.5	1.0	130	2,517	1,248	1,269	0.00	0.000	0.50	0.0	0	0	0	-	1	13.50	1.4	9.8	0.59	930	-	-	-
Shale	20.6	21.6	21.1	612.5	611.5	1.0	130	2,647	1,310	1,337	0.00	0.000	0.50	0.0	0	0	0	-	1	14.50	1.5	9.8	0.55	869	-	-	-
Shale	21.6	22.6	22.1	611.5	610.5	1.0	130	2,777	1,373	1,404	0.00	0.000	0.50	0.0	0	0	0	-	1	15.50	1.6	9.8	0.51	811	-	-	-
Shale	22.6	23.6	23.1	610.5	609.5	1.0	130	2,907	1,435	1,472	0.00	0.000	0.50	0.0	0	0	0	-	1	16.50	1.7	9.8	0.48	758	-	-	-
Shale	23.6	24.6	24.1	609.5	608.5	1.0	130	3,037	1,498	1,539	0.00	0.000	0.50	0.0	0	0	0	-	1	17.50	1.8	9.8	0.45	708	-	-	-
Shale	24.6	25.6	25.1	608.5	607.5	1.0	130	3,167	1,560	1,607	0.00	0.000	0.50	0.0	0	0	0	-	1	18.50	1.9	9.8	0.42	662	-	-	-
Shale	25.6	26.6	26.1	607.5	606.5	1.0	130	3,297	1,622	1,675	0.00	0.000	0.50	0.0	0	0	0	-	1	19.50	2.0	9.8	0.39	619	-	-	-
Shale	26.6	27.6	27.1	606.5	605.5	1.0	130	3,427	1,685	1,742	0.00	0.000	0.50	0.0	0	0	0	-	1	20.50	2.1	9.8	0.37	580	-	-	-
Shale	27.6	28.6	28.1	605.5	604.5	1.0	130	3,557	1,747	1,810	0.00	0.000	0.50	0.0	0	0	0	-	1	21.50	2.2	9.8	0.34	544	-	-	-
Shale	28.6	29.6	29.1	604.5	603.5	1.0	130	3,687	1,810	1,877	0.00	0.000	0.50	0.0	0	0	0	-	1	22.50	2.3	9.8	0.32	510	-	-	-
Shale	29.6	30.6	30.1	603.5	602.5	1.0	130	3,817	1,872	1,945	0.00	0.000	0.50	0.0	0	0	0	-	1	23.50	2.4	9.8	0.30	479	-	-	-
Shale	30.6	31.6	31.1	602.5	601.5	1.0	130	3,947	1,934	2,013	0.00	0.000	0.50	0.0	0	0	0	-	1	24.50	2.5	9.8	0.29	451	-	-	-
Shale	31.6	32.6	32.1	601.5	600.5	1.0	130	4,077	1,997	2,080	0.00	0.000	0.50	0.0	0	0	0	-	1	25.50	2.6	9.8	0.27	425	-	-	-
Shale	32.6	33.6	33.1	600.5	599.5	1.0	130	4,207	2,059	2,148	0.00	0.000	0.50	0.0	0	0	0	-	1	26.50	2.7	9.8	0.25	400	-	-	-
Shale	33.6	34.6	34.1	599.5	598.5	1.0	130	4,337	2,122	2,215	0.00	0.000	0.50	0.0	0	0	0	-	1	27.50	2.8	9.8	0.24	378	-	-	-
Shale	34.6	35.6	35.1	598.5	597.5	1.0	130	4,467	2,184	2,283	0.00	0.000	0.50	0.0	0	0	0	-	1	28.50	2.9	9.8	0.23	357	-	-	-
Shale	35.6	36.6	36.1	597.5	596.5	1.0	130	4,597	2,246	2,351	0.00	0.000	0.50	0.0	0	0	0	-	1	29.50	3.0	9.8	0.21	338	-	-	-
Shale	36.6	37.6	37.1	596.5	595.5	1.0	130	4,727	2,309	2,418	0.00	0.000	0.50	0.0	0	0	0	-	1	30.50	3.1	9.8	0.20	320	-	-	-
Shale	37.6	38.6	38.1	595.5	594.5	1.0	130	4,857	2,371	2,486	0.00	0.000	0.50	0.0	0	0	0	-	1	31.50	3.2	9.8	0.19	304	-	-	-
Shale	38.6	39.6	39.1	594.5	593.5	1.0	130	4,987	2,434	2,553	0.00	0.000	0.50	0.0	0	0	0	-	1	32.50	3.3	9.8	0.18	288	-	-	-
Shale	39.6	40.6	40.1	593.5	592.5	1.0	130	5,117	2,496	2,621	0.00	0.000	0.50	0.0	0	0	0	-	1	33.50	3.4	9.8	0.17	274	-	-	-
Shale	40.6	41.6	41.1	592.5	591.5	1.0	130	5,247	2,558	2,689	0.00	0.000	0.50	0.0	0	0	0	-	1	34.50	3.5	9.8	0.16	261	-	-	-
Shale	41.6	42.6	42.1	591.5	590.5	1.0	130	5,377	2,621	2,756	0.00	0.000	0.50	0.0	0	0	0	-	1	35.50	3.6	9.8	0.16	248	-	-	-
Shale	42.6	43.6	43.1	590.5	589.5	1.0	130	5,507	2,683	2,824	0.00	0.000	0.50	0.0	0	0	0	-	1	36.50	3.7	9.8	0.15	237	-	-	-
Shale	43.6	44.6	44.1	589.5	588.5	1.0	130	5,637	2,746	2,891	0.00	0.000	0.50	0.0	0	0	0	-	1	37.50	3.8	9.8	0.14	226	-	-	-
Shale	44.6	45.6	45.1	588.5	587.5	1.0	130	5,767	2,808	2,959	0.00	0.000	0.50	0.0	0	0	0	-	1	38.50	3.9	9.8	0.14	216	-	-	-
Shale	45.6	46.6	46.1	587.5	586.5	1.0	130	5,897	2,870	3,027	0.00	0.000	0.50	0.0	0	0	0	-	1	39.50	4.1	9.8	0.13	206	-	-	-
Shale	46.6	47.6	47.1	586.5	585.5	1.0	130	6,027	2,933	3,094	0.00	0.000	0.50	0.0	0	0	0	-	1	40.50	4.2	9.8	0.12	197	-	-	-

	Depth from Existing*			Elevation		Layer	Layer	In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom	Thickness	Unit Wt.	Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	**S_t**
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	**(inch)**
Shale	47.6	48.6	48.1	585.5	584.5	1.0	130	6,157	2,995	3,162	0.00	0.000	0.50	0.0	0	0	0	-	1	41.50	4.3	9.8	0.12	189	-	-	-
Shale	48.6	49.6	49.1	584.5	583.5	1.0	130	6,287	3,058	3,229	0.00	0.000	0.50	0.0	0	0	0	-	1	42.50	4.4	9.8	0.11	181	-	-	-
Shale	49.6	50.6	50.1	583.5	582.5	1.0	130	6,417	3,120	3,297	0.00	0.000	0.50	0.0	0	0	0	-	1	43.50	4.5	9.8	0.11	174	-	-	-
Shale	50.6	51.6	51.1	582.5	581.5	1.0	130	6,547	3,182	3,365	0.00	0.000	0.50	0.0	0	0	0	-	1	44.50	4.6	9.8	0.11	167	-	-	-
Shale	51.6	52.6	52.1	581.5	580.5	1.0	130	6,677	3,245	3,432	0.00	0.000	0.50	0.0	0	0	0	-	1	45.50	4.7	9.8	0.10	160	-	-	-
Shale	52.6	53.6	53.1	580.5	579.5	1.0	130	6,807	3,307	3,500	0.00	0.000	0.50	0.0	0	0	0	-	1	46.50	4.8	9.8	0.10	154	-	-	-
Shale	53.6	54.6	54.1	579.5	578.5	1.0	130	6,937	3,370	3,567	0.00	0.000	0.50	0.0	0	0	0	-	1	47.50	4.9	9.8	0.09	148	-	-	-
Shale	54.6	55.6	55.1	578.5	577.5	1.0	130	7,067	3,432	3,635	0.00	0.000	0.50	0.0	0	0	0	-	1	48.50	5.0	9.8	0.09	142	-	-	-
Shale	55.6	56.6	56.1	577.5	576.5	1.0	130	7,197	3,494	3,703	0.00	0.000	0.50	0.0	0	0	0	-	1	49.50	5.1	9.8	0.09	137	-	-	-
Shale	56.6	57.6	57.1	576.5	575.5	1.0	130	7,327	3,557	3,770	0.00	0.000	0.50	0.0	0	0	0	-	1	50.50	5.2	9.8	0.08	132	-	-	-
Shale	57.6	58.6	58.1	575.5	574.5	1.0	130	7,457	3,619	3,838	0.00	0.000	0.50	0.0	0	0	0	-	1	51.50	5.3	9.8	0.08	127	-	-	-
Shale	58.6	59.6	59.1	574.5	573.5	1.0	130	7,587	3,682	3,905	0.00	0.000	0.50	0.0	0	0	0	-	1	52.50	5.4	9.8	0.08	123	-	-	-
Shale	59.6	60.6	60.1	573.5	572.5	1.0	130	7,717	3,744	3,973	0.00	0.000	0.50	0.0	0	0	0	-	1	53.50	5.5	9.8	0.08	119	-	-	-
Shale	60.6	61.6	61.1	572.5	571.5	1.0	130	7,847	3,806	4,041	0.00	0.000	0.50	0.0	0	0	0	-	1	54.50	5.6	9.8	0.07	115	-	-	-
Shale	61.6	62.6	62.1	571.5	570.5	1.0	130	7,977	3,869	4,108	0.00	0.000	0.50	0.0	0	0	0	-	1	55.50	5.7	9.8	0.07	111	-	-	-
Shale	62.6	63.6	63.1	570.5	569.5	1.0	130	8,107	3,931	4,176	0.00	0.000	0.50	0.0	0	0	0	-	1	56.50	5.8	9.8	0.07	107	-	-	-
Shale	63.6	64.6	64.1	569.5	568.5	1.0	130	8,237	3,994	4,243	0.00	0.000	0.50	0.0	0	0	0	-	1	57.50	5.9	9.8	0.07	104	-	-	-
Shale	64.6	65.6	65.1	568.5	567.5	1.0	130	8,367	4,056	4,311	0.00	0.000	0.50	0.0	0	0	0	-	1	58.50	6.0	9.8	0.06	100	-	-	-
Shale	65.6	66.6	66.1	567.5	566.5	1.0	130	8,497	4,118	4,379	0.00	0.000	0.50	0.0	0	0	0	-	1	59.50	6.1	9.8	0.06	97	-	-	-
Shale	66.6	67.6	67.1	566.5	565.5	1.0	130	8,627	4,181	4,446	0.00	0.000	0.50	0.0	0	0	0	-	1	60.50	6.2	9.8	0.06	94	-	-	-
Shale	67.6	68.6	68.1	565.5	564.5	1.0	130	8,757	4,243	4,514	0.00	0.000	0.50	0.0	0	0	0	-	1	61.50	6.3	9.8	0.06	91	-	-	-
Shale	68.6	69.6	69.1	564.5	563.5	1.0	130	8,887	4,306	4,581	0.00	0.000	0.50	0.0	0	0	0	-	1	62.50	6.4	9.8	0.06	89	-	-	-
Shale	69.6	70.6	70.1	563.5	562.5	1.0	130	9,017	4,368	4,649	0.00	0.000	0.50	0.0	0	0	0	-	1	63.50	6.5	9.8	0.05	86	-	-	-
Shale	70.6	71.6	71.1	562.5	561.5	1.0	130	9,147	4,430	4,717	0.00	0.000	0.50	0.0	0	0	0	-	1	64.50	6.6	9.8	0.05	83	-	-	-
Shale	71.6	72.6	72.1	561.5	560.5	1.0	130	9,277	4,493	4,784	0.00	0.000	0.50	0.0	0	0	0	-	1	65.50	6.7	9.8	0.05	81	-	-	-
Shale	72.6	73.6	73.1	560.5	559.5	1.0	130	9,407	4,555	4,852	0.00	0.000	0.50	0.0	0	0	0	-	1	66.50	6.8	9.8	0.05	79	-	-	-
Shale	73.6	74.6	74.1	559.5	558.5	1.0	130	9,537	4,618	4,919	0.00	0.000	0.50	0.0	0	0	0	-	1	67.50	6.9	9.8	0.05	76	-	-	-
Shale	74.6	75.6	75.1	558.5	557.5	1.0	130	9,667	4,680	4,987	0.00	0.000	0.50	0.0	0	0	0	-	1	68.50	7.0	9.8	0.05	74	-	-	-
Shale	75.6	76.6	76.1	557.5	556.5	1.0	130	9,797	4,742	5,055	0.00	0.000	0.50	0.0	0	0	0	-	1	69.50	7.1	9.8	0.05	72	-	-	-
Shale	76.6	77.6	77.1	556.5	555.5	1.0	130	9,927	4,805	5,122	0.00	0.000	0.50	0.0	0	0	0	-	1	70.50	7.2	9.8	0.04	70	-	-	-
Shale	77.6	78.6	78.1	555.5	554.5	1.0	130	10,057	4,867	5,190	0.00	0.000	0.50	0.0	0	0	0	-	1	71.50	7.3	9.8	0.04	68	-	-	-
Shale	78.6	79.6	79.1	554.5	553.5	1.0	130	10,187	4,930	5,257	0.00	0.000	0.50	0.0	0	0	0	-	1	72.50	7.4	9.8	0.04	67	-	-	-
Shale	79.6	80.6	80.1	553.5	552.5	1.0	130	10,317	4,992	5,325	0.00	0.000	0.50	0.0	0	0	0	-	1	73.50	7.5	9.8	0.04	65	-	-	-
Shale	80.6	81.6	81.1	552.5	551.5	1.0	130	10,447	5,054	5,393	0.00	0.000	0.50	0.0	0	0	0	-	1	74.50	7.6	9.8	0.04	63	-	-	-
Shale	81.6	82.6	82.1	551.5	550.5	1.0	130	10,577	5,117	5,460	0.00	0.000	0.50	0.0	0	0	0	-	1	75.50	7.7	9.8	0.04	62	-	-	-
Shale	82.6	83.6	83.1	550.5	549.5	1.0	130	10,707	5,179	5,528	0.00	0.000	0.50	0.0	0	0	0	-	1	76.50	7.8	9.8	0.04	60	-	-	-
Shale	83.6	84.6	84.1	549.5	548.5	1.0	130	10,837	5,242	5,595	0.00	0.000	0.50	0.0	0	0	0	-	1	77.50	7.9	9.8	0.04	59	-	-	-
Shale	84.6	85.6	85.1	548.5	547.5	1.0	130	10,967	5,304	5,663	0.00	0.000	0.50	0.0	0	0	0	-	1	78.50	8.1	9.8	0.04	57	-	-	-
Shale	85.6	86.6	86.1	547.5	546.5	1.0	130	11,097	5,366	5,731	0.00	0.000	0.50	0.0	0	0	0	-	1	79.50	8.2	9.8	0.04	56	-	-	-
Shale	86.6	87.6	87.1	546.5	545.5	1.0	130	11,227	5,429	5,798	0.00	0.000	0.50	0.0	0	0	0	-	1	80.50	8.3	9.8	0.03	54	-	-	-
Shale	87.6	88.6	88.1	545.5	544.5	1.0	130	11,357	5,491	5,866	0.00	0.000	0.50	0.0	0	0	0	-	1	81.50	8.4	9.8	0.03	53	-	-	-
Shale	88.6	89.6	89.1	544.5	543.5	1.0	130	11,487	5,554	5,933	0.00	0.000	0.50	0.0	0	0	0	-	1	82.50	8.5	9.8	0.03	52	-	-	-
Shale	89.6	90.6	90.1	543.5	542.5	1.0	130	11,617	5,616	6,001	0.00	0.000	0.50	0.0	0	0	0	-	1	83.50	8.6	9.8	0.03	51	-	-	-
Shale	90.6	91.6	91.1	542.5	541.5	1.0	130	11,747	5,678	6,069	0.00	0.000	0.50	0.0	0	0	0	-	1	84.50	8.7	9.8	0.03	50	-	-	-
Shale	91.6	92.6	92.1	541.5	540.5	1.0	130	11,877	5,741	6,136	0.00	0.000	0.50	0.0	0	0	0	-	1	85.50	8.8	9.8	0.03	48	-	-	-
Shale	92.6	93.6	93.1	540.5	539.5	1.0	130	12,007	5,803	6,204	0.00	0.000	0.50	0.0	0	0	0	-	1	86.50	8.9	9.8	0.03	47	-	-	-
Shale	93.6	94.6	94.1	539.5	538.5	1.0	130	12,137	5,866	6,271	0.00	0.000	0.50	0.0	0	0	0	-	1	87.50	9.0	9.8	0.03	46	-	-	-
Shale	94.6	95.6	95.1	538.5	537.5	1.0	130	12,267	5,928	6,339	0.00	0.000	0.50	0.0	0	0	0	-	1	88.50	9.1	9.8	0.03	45	-	-	-
#N/A	95.6	96.6	96.1	537.5	536.5	1.0	#N/A	#N/A	5,990	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	89.50	9.2	9.8	0.03	44	-	-	-
#N/A	96.6	97.6	97.1	536.5	535.5	1.0	#N/A	#N/A	6,053	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	90.50	9.3	9.8	0.03	43	-	-	-
#N/A	97.6	98.6	98.1	535.5	534.5	1.0	#N/A	#N/A	6,115	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	91.50	9.4	9.8	0.03	42	-	-	-
#N/A	98.6	99.6	99.1	534.5	533.5	1.0	#N/A	#N/A	6,178	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	92.50	9.5	9.8	0.03	42	-	-	-
#N/A	99.6	100.6	100.1	533.5	532.5	1.0	#N/A	#N/A	6,240	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	93.50	9.6	9.8	0.03	41	-	-	-
#N/A	100.6	101.6	101.1	532.5	531.5	1.0	#N/A	#N/A	6,302	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	94.50	9.7	9.8	0.03	40	-	-	-
#N/A	101.6	102.6	102.1	531.5	530.5	1.0	#N/A	#N/A	6,365	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	95.50	9.8	9.8	0.02	39	-	-	-
#N/A	102.6	103.6	103.1	530.5	529.5	1.0	#N/A	#N/A	6,427	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	96.50	9.9	9.8	0.02	38	-	-	-
#N/A	103.6	104.6	104.1	529.5	528.5	1.0	#N/A	#N/A	6,490	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	97.50	10.0	9.8	0.02	37	-	-	-
#N/A	104.6	105.6	105.1	528.5	527.5	1.0	#N/A	#N/A	6,552	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	98.50	10.1	9.8	0.02	37	-	-	-
#N/A	105.6	106.6	106.1	527.5	526.5	1.0	#N/A	#N/A	6,614	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	99.50	10.2	9.8	0.02	36	-	-	-
#N/A	106.6	107.6	107.1	526.5	525.5	1.0	#N/A	#N/A	6,677	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	100.50	10.3	9.8	0.02	35	-	-	-
#N/A	107.6	108.6	108.1	525.5	524.5	1.0	#N/A	#N/A	6,739	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	101.50	10.4	9.8	0.02	35	-	-	-
#N/A	108.6	109.6	109.1	524.5	523.5	1.0	#N/A	#N/A	6,802	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	102.50	10.5	9.8	0.02	34	-	-	-
#N/A	109.6	200.0	154.8	523.5	433.1	90.4	#N/A	#N/A	9,653	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	148.20	15.2	9.8	0.01	16	-	-	-


Settlement (inches)
0.0
0.5
1.0
1.5
2.0
Depth Below Footing Base (feet)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Rectangular Footing
Settlement Limit of 1 inch:
Settlement Limit of 1.5 inches:
Series5

Project Name:	Plum Creek FRS No. 2 Rehabilitation		Structure	PSW - Impact Basin Structure
Job Number:	60615067		Analysis Section	Center of Impact Basin
Client:	TSSWCB		Notes	Reinf. concrete footing on overexcavation/replacement fill

Geotechnical Data

Relevant Boring	305-19	-
Boring Ground Elev.	635	ft NAVD88
Depth to GWT at Boring:	2	feet
GWT Elev.	633	ft NAVD88

Exiting Ground at Structure Location

Structure Existing Ground:	633.1	ft NAVD88
Footing Bearing Elev.:	626.5	ft NAVD88
Footing Bearing Elev.:	6.6	ft below existing (cut)
GWT Depth below Exist.:	0.1	feet
GWT Depth below footing.:	0	feet

Area Fill

Fill between existing/footing?	no	-
Include load from area fill?	no	-
Finish Grade of Area Fill:	655.5	ft NAVD88
Height above existing:	#N/A	feet
Height above footing base:	#N/A	feet
Thickness under footing:	#N/A	feet
Area Fill Unit Weight:	125	pcf

Subgrade Overexcavation/Replacement

Include Overex/Replacement?	yes	-
Overex/Replace Bottom Elev.	620.5	ft NAVD88
Depth below footing:	6	feet
Depth below existing:	12.6	feet

Structure Footing Size & Maximum Bearing Pressure

Footing Width, B:	19.5	feet
Footing Length, L (rect):	24.75	feet
Gross Footing Pressure, $q_{0\text{-gross}}$	2,000	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula do not edit

Design Soil Profile and Properties

Depth at Boring (feet)		Elevation (feet)		Thickness in Boring	1 Existing Depth at Structure (feet)	2	3 Thickness at Structure	4 Layer Name	5 Total Unit Wt	6 Initial Void Ratio, e_0*	7 Compression Index, C_c*	8 Recomp. Index, C_r*	9 Min. Over Consolidation Ratio, OCR*	10 Min. Preconsol. Pressure, P'c*
Top	Bottom	Top	Bottom	(feet)	Top	Bottom	(feet)		(pcf)	(-)				(psf)
0	6	635.0	629.0	6.0	0.0	4.1	4.1	Embank. Fill (Shell)	125	0.60	0.20	0.300	2.0	4,000
6	13	629.0	622.0	7.0	4.1	11.1	7.0	Alluvium	123	0.65	0.20	0.030	2.0	4,000
13	23	622.0	612.0	10.0	11.1	21.1	10.0	Residuum (MPR)	126	0.60	0.20	0.030	2.0	4,000
20	97	615.0	538.0	77.0	18.1	95.1	77.0	Shale	130	0.50	0.0	0.000	0.0	0

Notes: Copy down elevation and thickness formulas if more layers are needed, delete formulas where not needed.

*Enter "0" for incompressible layers (i.e., granular soils and bedrock)

Method: Settlement Below Center of Uniformly Loaded Rectangular Footing

Project	Plum Creek FRS No. 2 Rehabilitation
Structure	PSW - Impact Basin Structure
Analysis Section	Center of Impact Basin

Elev. - Existing Ground @ Structure:	633.1	ft NAVD88	-6.6	ft from footing base (above)	0	ft from existing (below)
Elev. - Base of Footing / Bearing Depth	626.5	ft NAVD88	0	ft from footing base (below)	6.6	ft from existing (below)
Elev. - Top of Area Fill	#N/A	ft NAVD88	#N/A	#N/A	#N/A	#N/A
Elev. - Bottom of Overex./Replace	620.5	ft NAVD88	6	ft from footing base (below)	12.6	ft from existing (below)
Elev. - Groundwater	633	ft NAVD88	-6.5	ft from footing base (above)	0.1	ft from existing (below)
Thickness - Area Fill	#N/A	feet below footing base				
Thickness - Overex/Replace	6	feet below footing base				

Footing Width, B:	19.5	feet
Footing Length, L (square):	19.5	feet
Footing Length, L (rect):	24.75	feet

Gross Footing Pressure, $q_{0\text{-gross}}$	2,000	psf
Removed in-situ stress	419	psf
Net Footing Pressure, $q_{0\text{-net}}$	1,581	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula (do not edit)
xxx	= Unique Formula (do not edit)

$$\Delta\sigma_z = qI_4 \tag{10.34}$$

where

$$I_4 = \frac{2}{\pi}\left[\frac{m_1 n_1}{\sqrt{1+m_1^2+n_1^2}}\frac{1+m_1^2+2n_1^2}{(1+n_1^2)(m_1^2+n_1^2)} + \sin^{-1}\frac{m_1}{\sqrt{m_1^2+n_1^2}\sqrt{1+n_1^2}}\right] \tag{10.35}$$

$$m_1 = \frac{L}{B} \tag{10.36}$$

$$n_1 = \frac{z}{b} \tag{10.37}$$

$$b = \frac{B}{2} \tag{10.38}$$

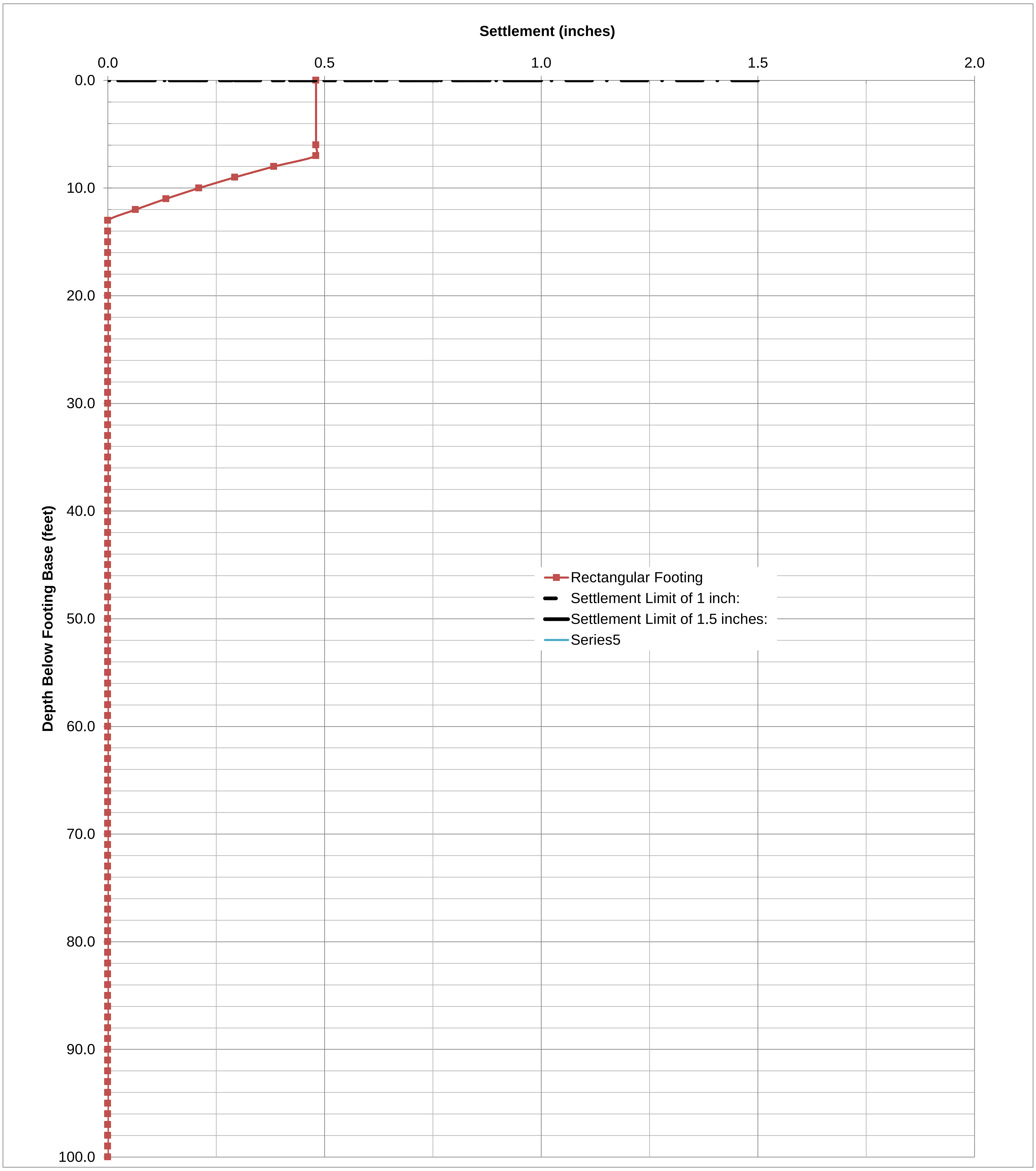
*Negative values indicate height above existing ground

*Granular fill, assumed zero

Total Settlement (inch) = 0.48

	Depth from Existing*			Elevation		Layer	Layer	In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom	Thickness	Unit Wt.	Total P_0	µ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	S_t
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	(inch)
Fill below footing/above exist.	0.0	0.0	0.0	633.1	633.1	0.0	125	-	-	-	-	-	-	-	-	0	0	-	1	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-
Existing Soil Above Footing	0.0	6.6	3.3	633.1	626.5	6.6	125	-	-	-	-	-	-	-	-	0	0	-	1	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-
Overex. below Existing	0.0	12.6	6.3	633.1	620.5	12.6	125	-	-	-	-	-	-	-	-	0	0	-	1	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-
Residuum (MPR)	12.6	13.6	13.1	620.5	619.5	1.0	126	1,638	811	827	0.20	0.030	0.60	2.0	4,000	0	0	-	1	6.50	0.7	9.8	0.89	1,407	0.10	0.00	**0.097**
Residuum (MPR)	13.6	14.6	14.1	619.5	618.5	1.0	126	1,764	874	890	0.20	0.030	0.60	2.0	4,000	0	0	-	1	7.50	0.8	9.8	0.85	1,344	0.09	0.00	**0.090**
Residuum (MPR)	14.6	15.6	15.1	618.5	617.5	1.0	126	1,890	936	954	0.20	0.030	0.60	2.0	4,000	0	0	-	1	8.50	0.9	9.8	0.81	1,275	0.08	0.00	**0.083**
Residuum (MPR)	15.6	16.6	16.1	617.5	616.5	1.0	126	2,016	998	1,018	0.20	0.030	0.60	2.0	4,000	0	0	-	1	9.50	1.0	9.8	0.76	1,204	0.08	0.00	**0.076**
Residuum (MPR)	16.6	17.6	17.1	616.5	615.5	1.0	126	2,142	1,061	1,081	0.20	0.030	0.60	2.0	4,000	0	0	-	1	10.50	1.1	9.8	0.72	1,132	0.07	0.00	**0.070**
Residuum (MPR)	17.6	18.6	18.1	615.5	614.5	1.0	126	2,268	1,123	1,145	0.20	0.030	0.60	2.0	4,000	0	0	-	1	11.50	1.2	9.8	0.67	1,062	0.06	0.00	**0.064**
Shale	18.6	19.6	19.1	614.5	613.5	1.0	130	2,396	1,186	1,210	0.00	0.000	0.50	0.0	0	0	0	-	1	12.50	1.3	9.8	0.63	994	-	-	-
Shale	19.6	20.6	20.1	613.5	612.5	1.0	130	2,526	1,248	1,278	0.00	0.000	0.50	0.0	0	0	0	-	1	13.50	1.4	9.8	0.59	930	-	-	-
Shale	20.6	21.6	21.1	612.5	611.5	1.0	130	2,656	1,310	1,346	0.00	0.000	0.50	0.0	0	0	0	-	1	14.50	1.5	9.8	0.55	869	-	-	-
Shale	21.6	22.6	22.1	611.5	610.5	1.0	130	2,786	1,373	1,413	0.00	0.000	0.50	0.0	0	0	0	-	1	15.50	1.6	9.8	0.51	811	-	-	-
Shale	22.6	23.6	23.1	610.5	609.5	1.0	130	2,916	1,435	1,481	0.00	0.000	0.50	0.0	0	0	0	-	1	16.50	1.7	9.8	0.48	758	-	-	-
Shale	23.6	24.6	24.1	609.5	608.5	1.0	130	3,046	1,498	1,548	0.00	0.000	0.50	0.0	0	0	0	-	1	17.50	1.8	9.8	0.45	708	-	-	-
Shale	24.6	25.6	25.1	608.5	607.5	1.0	130	3,176	1,560	1,616	0.00	0.000	0.50	0.0	0	0	0	-	1	18.50	1.9	9.8	0.42	662	-	-	-
Shale	25.6	26.6	26.1	607.5	606.5	1.0	130	3,306	1,622	1,684	0.00	0.000	0.50	0.0	0	0	0	-	1	19.50	2.0	9.8	0.39	619	-	-	-
Shale	26.6	27.6	27.1	606.5	605.5	1.0	130	3,436	1,685	1,751	0.00	0.000	0.50	0.0	0	0	0	-	1	20.50	2.1	9.8	0.37	580	-	-	-
Shale	27.6	28.6	28.1	605.5	604.5	1.0	130	3,566	1,747	1,819	0.00	0.000	0.50	0.0	0	0	0	-	1	21.50	2.2	9.8	0.34	544	-	-	-
Shale	28.6	29.6	29.1	604.5	603.5	1.0	130	3,696	1,810	1,886	0.00	0.000	0.50	0.0	0	0	0	-	1	22.50	2.3	9.8	0.32	510	-	-	-
Shale	29.6	30.6	30.1	603.5	602.5	1.0	130	3,826	1,872	1,954	0.00	0.000	0.50	0.0	0	0	0	-	1	23.50	2.4	9.8	0.30	479	-	-	-
Shale	30.6	31.6	31.1	602.5	601.5	1.0	130	3,956	1,934	2,022	0.00	0.000	0.50	0.0	0	0	0	-	1	24.50	2.5	9.8	0.29	451	-	-	-
Shale	31.6	32.6	32.1	601.5	600.5	1.0	130	4,086	1,997	2,089	0.00	0.000	0.50	0.0	0	0	0	-	1	25.50	2.6	9.8	0.27	425	-	-	-
Shale	32.6	33.6	33.1	600.5	599.5	1.0	130	4,216	2,059	2,157	0.00	0.000	0.50	0.0	0	0	0	-	1	26.50	2.7	9.8	0.25	400	-	-	-
Shale	33.6	34.6	34.1	599.5	598.5	1.0	130	4,346	2,122	2,224	0.00	0.000	0.50	0.0	0	0	0	-	1	27.50	2.8	9.8	0.24	378	-	-	-
Shale	34.6	35.6	35.1	598.5	597.5	1.0	130	4,476	2,184	2,292	0.00	0.000	0.50	0.0	0	0	0	-	1	28.50	2.9	9.8	0.23	357	-	-	-
Shale	35.6	36.6	36.1	597.5	596.5	1.0	130	4,606	2,246	2,360	0.00	0.000	0.50	0.0	0	0	0	-	1	29.50	3.0	9.8	0.21	338	-	-	-
Shale	36.6	37.6	37.1	596.5	595.5	1.0	130	4,736	2,309	2,427	0.00	0.000	0.50	0.0	0	0	0	-	1	30.50	3.1	9.8	0.20	320	-	-	-
Shale	37.6	38.6	38.1	595.5	594.5	1.0	130	4,866	2,371	2,495	0.00	0.000	0.50	0.0	0	0	0	-	1	31.50	3.2	9.8	0.19	304	-	-	-
Shale	38.6	39.6	39.1	594.5	593.5	1.0	130	4,996	2,434	2,562	0.00	0.000	0.50	0.0	0	0	0	-	1	32.50	3.3	9.8	0.18	288	-	-	-
Shale	39.6	40.6	40.1	593.5	592.5	1.0	130	5,126	2,496	2,630	0.00	0.000	0.50	0.0	0	0	0	-	1	33.50	3.4	9.8	0.17	274	-	-	-
Shale	40.6	41.6	41.1	592.5	591.5	1.0	130	5,256	2,558	2,698	0.00	0.000	0.50	0.0	0	0	0	-	1	34.50	3.5	9.8	0.16	261	-	-	-
Shale	41.6	42.6	42.1	591.5	590.5	1.0	130	5,386	2,621	2,765	0.00	0.000	0.50	0.0	0	0	0	-	1	35.50	3.6	9.8	0.16	248	-	-	-
Shale	42.6	43.6	43.1	590.5	589.5	1.0	130	5,516	2,683	2,833	0.00	0.000	0.50	0.0	0	0	0	-	1	36.50	3.7	9.8	0.15	237	-	-	-
Shale	43.6	44.6	44.1	589.5	588.5	1.0	130	5,646	2,746	2,900	0.00	0.000	0.50	0.0	0	0	0	-	1	37.50	3.8	9.8	0.14	226	-	-	-
Shale	44.6	45.6	45.1	588.5	587.5	1.0	130	5,776	2,808	2,968	0.00	0.000	0.50	0.0	0	0	0	-	1	38.50	3.9	9.8	0.14	216	-	-	-
Shale	45.6	46.6	46.1	587.5	586.5	1.0	130	5,906	2,870	3,036	0.00	0.000	0.50	0.0	0	0	0	-	1	39.50	4.1	9.8	0.13	206	-	-	-
Shale	46.6	47.6	47.1	586.5	585.5	1.0	130	6,036	2,933	3,103	0.00	0.000	0.50	0.0	0	0	0	-	1	40.50	4.2	9.8	0.12	197	-	-	-
Shale	47.6	48.6	48.1	585.5	584.5	1.0	130	6,166	2,995	3,171	0.00	0.000	0.50	0.0	0	0	0	-	1	41.50	4.3	9.8	0.12	189	-	-	-
Shale	48.6	49.6	49.1	584.5	583.5	1.0	130	6,296	3,058	3,238	0.00	0.000	0.50	0.0	0	0	0	-	1	42.50	4.4	9.8	0.11	181	-	-	-
Shale	49.6	50.6	50.1	583.5	582.5	1.0	130	6,426	3,120	3,306	0.00	0.000	0.50	0.0	0	0	0	-	1	43.50	4.5	9.8	0.11	174	-	-	-
Shale	50.6	51.6	51.1	582.5	581.5	1.0	130	6,556	3,182	3,374	0.00	0.000	0.50	0.0	0	0	0	-	1	44.50	4.6	9.8	0.11	167	-	-	-
Shale	51.6	52.6	52.1	581.5	580.5	1.0	130	6,686	3,245	3,441	0.00	0.000	0.50	0.0	0	0	0	-	1	45.50	4.7	9.8	0.10	160	-	-	-
Shale	52.6	53.6	53.1	580.5	579.5	1.0	130	6,816	3,307	3,509	0.00	0.000	0.50	0.0	0	0	0	-	1	46.50	4.8	9.8	0.10	154	-	-	-

	Depth from Existing*			Elevation		Layer Thickness	Layer Unit Wt.	In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom			Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	**S_t**
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	**(inch)**
Shale	53.6	54.6	54.1	579.5	578.5	1.0	130	6,946	3,370	3,576	0.00	0.000	0.50	0.0	0	0	0	-	1	47.50	4.9	9.8	0.09	148	-	-	**-**
Shale	54.6	55.6	55.1	578.5	577.5	1.0	130	7,076	3,432	3,644	0.00	0.000	0.50	0.0	0	0	0	-	1	48.50	5.0	9.8	0.09	142	-	-	**-**
Shale	55.6	56.6	56.1	577.5	576.5	1.0	130	7,206	3,494	3,712	0.00	0.000	0.50	0.0	0	0	0	-	1	49.50	5.1	9.8	0.09	137	-	-	**-**
Shale	56.6	57.6	57.1	576.5	575.5	1.0	130	7,336	3,557	3,779	0.00	0.000	0.50	0.0	0	0	0	-	1	50.50	5.2	9.8	0.08	132	-	-	**-**
Shale	57.6	58.6	58.1	575.5	574.5	1.0	130	7,466	3,619	3,847	0.00	0.000	0.50	0.0	0	0	0	-	1	51.50	5.3	9.8	0.08	127	-	-	**-**
Shale	58.6	59.6	59.1	574.5	573.5	1.0	130	7,596	3,682	3,914	0.00	0.000	0.50	0.0	0	0	0	-	1	52.50	5.4	9.8	0.08	123	-	-	**-**
Shale	59.6	60.6	60.1	573.5	572.5	1.0	130	7,726	3,744	3,982	0.00	0.000	0.50	0.0	0	0	0	-	1	53.50	5.5	9.8	0.08	119	-	-	**-**
Shale	60.6	61.6	61.1	572.5	571.5	1.0	130	7,856	3,806	4,050	0.00	0.000	0.50	0.0	0	0	0	-	1	54.50	5.6	9.8	0.07	115	-	-	**-**
Shale	61.6	62.6	62.1	571.5	570.5	1.0	130	7,986	3,869	4,117	0.00	0.000	0.50	0.0	0	0	0	-	1	55.50	5.7	9.8	0.07	111	-	-	**-**
Shale	62.6	63.6	63.1	570.5	569.5	1.0	130	8,116	3,931	4,185	0.00	0.000	0.50	0.0	0	0	0	-	1	56.50	5.8	9.8	0.07	107	-	-	**-**
Shale	63.6	64.6	64.1	569.5	568.5	1.0	130	8,246	3,994	4,252	0.00	0.000	0.50	0.0	0	0	0	-	1	57.50	5.9	9.8	0.07	104	-	-	**-**
Shale	64.6	65.6	65.1	568.5	567.5	1.0	130	8,376	4,056	4,320	0.00	0.000	0.50	0.0	0	0	0	-	1	58.50	6.0	9.8	0.06	100	-	-	**-**
Shale	65.6	66.6	66.1	567.5	566.5	1.0	130	8,506	4,118	4,388	0.00	0.000	0.50	0.0	0	0	0	-	1	59.50	6.1	9.8	0.06	97	-	-	**-**
Shale	66.6	67.6	67.1	566.5	565.5	1.0	130	8,636	4,181	4,455	0.00	0.000	0.50	0.0	0	0	0	-	1	60.50	6.2	9.8	0.06	94	-	-	**-**
Shale	67.6	68.6	68.1	565.5	564.5	1.0	130	8,766	4,243	4,523	0.00	0.000	0.50	0.0	0	0	0	-	1	61.50	6.3	9.8	0.06	91	-	-	**-**
Shale	68.6	69.6	69.1	564.5	563.5	1.0	130	8,896	4,306	4,590	0.00	0.000	0.50	0.0	0	0	0	-	1	62.50	6.4	9.8	0.06	89	-	-	**-**
Shale	69.6	70.6	70.1	563.5	562.5	1.0	130	9,026	4,368	4,658	0.00	0.000	0.50	0.0	0	0	0	-	1	63.50	6.5	9.8	0.05	86	-	-	**-**
Shale	70.6	71.6	71.1	562.5	561.5	1.0	130	9,156	4,430	4,726	0.00	0.000	0.50	0.0	0	0	0	-	1	64.50	6.6	9.8	0.05	83	-	-	**-**
Shale	71.6	72.6	72.1	561.5	560.5	1.0	130	9,286	4,493	4,793	0.00	0.000	0.50	0.0	0	0	0	-	1	65.50	6.7	9.8	0.05	81	-	-	**-**
Shale	72.6	73.6	73.1	560.5	559.5	1.0	130	9,416	4,555	4,861	0.00	0.000	0.50	0.0	0	0	0	-	1	66.50	6.8	9.8	0.05	79	-	-	**-**
Shale	73.6	74.6	74.1	559.5	558.5	1.0	130	9,546	4,618	4,928	0.00	0.000	0.50	0.0	0	0	0	-	1	67.50	6.9	9.8	0.05	76	-	-	**-**
Shale	74.6	75.6	75.1	558.5	557.5	1.0	130	9,676	4,680	4,996	0.00	0.000	0.50	0.0	0	0	0	-	1	68.50	7.0	9.8	0.05	74	-	-	**-**
Shale	75.6	76.6	76.1	557.5	556.5	1.0	130	9,806	4,742	5,064	0.00	0.000	0.50	0.0	0	0	0	-	1	69.50	7.1	9.8	0.05	72	-	-	**-**
Shale	76.6	77.6	77.1	556.5	555.5	1.0	130	9,936	4,805	5,131	0.00	0.000	0.50	0.0	0	0	0	-	1	70.50	7.2	9.8	0.04	70	-	-	**-**
Shale	77.6	78.6	78.1	555.5	554.5	1.0	130	10,066	4,867	5,199	0.00	0.000	0.50	0.0	0	0	0	-	1	71.50	7.3	9.8	0.04	68	-	-	**-**
Shale	78.6	79.6	79.1	554.5	553.5	1.0	130	10,196	4,930	5,266	0.00	0.000	0.50	0.0	0	0	0	-	1	72.50	7.4	9.8	0.04	67	-	-	**-**
Shale	79.6	80.6	80.1	553.5	552.5	1.0	130	10,326	4,992	5,334	0.00	0.000	0.50	0.0	0	0	0	-	1	73.50	7.5	9.8	0.04	65	-	-	**-**
Shale	80.6	81.6	81.1	552.5	551.5	1.0	130	10,456	5,054	5,402	0.00	0.000	0.50	0.0	0	0	0	-	1	74.50	7.6	9.8	0.04	63	-	-	**-**
Shale	81.6	82.6	82.1	551.5	550.5	1.0	130	10,586	5,117	5,469	0.00	0.000	0.50	0.0	0	0	0	-	1	75.50	7.7	9.8	0.04	62	-	-	**-**
Shale	82.6	83.6	83.1	550.5	549.5	1.0	130	10,716	5,179	5,537	0.00	0.000	0.50	0.0	0	0	0	-	1	76.50	7.8	9.8	0.04	60	-	-	**-**
Shale	83.6	84.6	84.1	549.5	548.5	1.0	130	10,846	5,242	5,604	0.00	0.000	0.50	0.0	0	0	0	-	1	77.50	7.9	9.8	0.04	59	-	-	**-**
Shale	84.6	85.6	85.1	548.5	547.5	1.0	130	10,976	5,304	5,672	0.00	0.000	0.50	0.0	0	0	0	-	1	78.50	8.1	9.8	0.04	57	-	-	**-**
Shale	85.6	86.6	86.1	547.5	546.5	1.0	130	11,106	5,366	5,740	0.00	0.000	0.50	0.0	0	0	0	-	1	79.50	8.2	9.8	0.04	56	-	-	**-**
Shale	86.6	87.6	87.1	546.5	545.5	1.0	130	11,236	5,429	5,807	0.00	0.000	0.50	0.0	0	0	0	-	1	80.50	8.3	9.8	0.03	54	-	-	**-**
Shale	87.6	88.6	88.1	545.5	544.5	1.0	130	11,366	5,491	5,875	0.00	0.000	0.50	0.0	0	0	0	-	1	81.50	8.4	9.8	0.03	53	-	-	**-**
Shale	88.6	89.6	89.1	544.5	543.5	1.0	130	11,496	5,554	5,942	0.00	0.000	0.50	0.0	0	0	0	-	1	82.50	8.5	9.8	0.03	52	-	-	**-**
Shale	89.6	90.6	90.1	543.5	542.5	1.0	130	11,626	5,616	6,010	0.00	0.000	0.50	0.0	0	0	0	-	1	83.50	8.6	9.8	0.03	51	-	-	**-**
Shale	90.6	91.6	91.1	542.5	541.5	1.0	130	11,756	5,678	6,078	0.00	0.000	0.50	0.0	0	0	0	-	1	84.50	8.7	9.8	0.03	50	-	-	**-**
Shale	91.6	92.6	92.1	541.5	540.5	1.0	130	11,886	5,741	6,145	0.00	0.000	0.50	0.0	0	0	0	-	1	85.50	8.8	9.8	0.03	48	-	-	**-**
Shale	92.6	93.6	93.1	540.5	539.5	1.0	130	12,016	5,803	6,213	0.00	0.000	0.50	0.0	0	0	0	-	1	86.50	8.9	9.8	0.03	47	-	-	**-**
Shale	93.6	94.6	94.1	539.5	538.5	1.0	130	12,146	5,866	6,280	0.00	0.000	0.50	0.0	0	0	0	-	1	87.50	9.0	9.8	0.03	46	-	-	**-**
Shale	94.6	95.6	95.1	538.5	537.5	1.0	130	12,276	5,928	6,348	0.00	0.000	0.50	0.0	0	0	0	-	1	88.50	9.1	9.8	0.03	45	-	-	**-**
#N/A	95.6	96.6	96.1	537.5	536.5	1.0	#N/A	#N/A	5,990	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	89.50	9.2	9.8	0.03	44	-	-	**-**
#N/A	96.6	97.6	97.1	536.5	535.5	1.0	#N/A	#N/A	6,053	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	90.50	9.3	9.8	0.03	43	-	-	**-**
#N/A	97.6	98.6	98.1	535.5	534.5	1.0	#N/A	#N/A	6,115	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	91.50	9.4	9.8	0.03	42	-	-	**-**
#N/A	98.6	99.6	99.1	534.5	533.5	1.0	#N/A	#N/A	6,178	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	92.50	9.5	9.8	0.03	42	-	-	**-**
#N/A	99.6	100.6	100.1	533.5	532.5	1.0	#N/A	#N/A	6,240	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	93.50	9.6	9.8	0.03	41	-	-	**-**
#N/A	100.6	101.6	101.1	532.5	531.5	1.0	#N/A	#N/A	6,302	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	94.50	9.7	9.8	0.03	40	-	-	**-**
#N/A	101.6	102.6	102.1	531.5	530.5	1.0	#N/A	#N/A	6,365	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	95.50	9.8	9.8	0.02	39	-	-	**-**
#N/A	102.6	103.6	103.1	530.5	529.5	1.0	#N/A	#N/A	6,427	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	96.50	9.9	9.8	0.02	38	-	-	**-**
#N/A	103.6	104.6	104.1	529.5	528.5	1.0	#N/A	#N/A	6,490	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	97.50	10.0	9.8	0.02	37	-	-	**-**
#N/A	104.6	105.6	105.1	528.5	527.5	1.0	#N/A	#N/A	6,552	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	98.50	10.1	9.8	0.02	37	-	-	**-**
#N/A	105.6	106.6	106.1	527.5	526.5	1.0	#N/A	#N/A	6,614	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	99.50	10.2	9.8	0.02	36	-	-	**-**
#N/A	106.6	107.6	107.1	526.5	525.5	1.0	#N/A	#N/A	6,677	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	100.50	10.3	9.8	0.02	35	-	-	**-**
#N/A	107.6	108.6	108.1	525.5	524.5	1.0	#N/A	#N/A	6,739	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	101.50	10.4	9.8	0.02	35	-	-	**-**
#N/A	108.6	109.6	109.1	524.5	523.5	1.0	#N/A	#N/A	6,802	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	102.50	10.5	9.8	0.02	34	-	-	**-**
#N/A	109.6	110.6	110.1	523.5	522.5	1.0	#N/A	#N/A	6,864	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	103.50	10.6	9.8	0.02	33	-	-	**-**
#N/A	110.6	111.6	111.1	522.5	521.5	1.0	#N/A	#N/A	6,926	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	104.50	10.7	9.8	0.02	33	-	-	**-**
#N/A	111.6	112.6	112.1	521.5	520.5	1.0	#N/A	#N/A	6,989	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	105.50	10.8	9.8	0.02	32	-	-	**-**
#N/A	112.6	113.6	113.1	520.5	519.5	1.0	#N/A	#N/A	7,051	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	106.50	10.9	9.8	0.02	32	-	-	**-**
#N/A	113.6	114.6	114.1	519.5	518.5	1.0	#N/A	#N/A	7,114	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	107.50	11.0	9.8	0.02	31	-	-	**-**
#N/A	114.6	115.6	115.1	518.5	517.5	1.0	#N/A	#N/A	7,176	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	108.50	11.1	9.8	0.02	30	-	-	**-**
#N/A	115.6	200.0	157.8	517.5	433.1	84.4	#N/A	#N/A	9,840	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	1	151.20	15.5	9.8	0.01	16	-	-	**-**



Settlement (inches)
0.0
0.5
1.0
1.5
2.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Depth Below Footing Base (feet)
Rectangular Footing
Settlement Limit of 1 inch:
Settlement Limit of 1.5 inches:
Series5

ATTACHMENT 4

Settlement Calculations for RCC Spillway – Crest Structure

Project Name:	Plum Creek FRS No. 2 Rehabilitation	Structure	Overtopping RCC Spillway - Crest Structure - Walls
Job Number:	60615067	Analysis Section	Proposed dam crest centerline
Client:	TSSWCB	Notes	RCC footing on in-situ subgrade

Geotechnical Data

Relevant Boring	13-20	-
Boring Ground Elev.	662.27	ft NAVD88
Depth to GWT at Boring:	20.27	feet
GWT Elev.	642	ft NAVD88

Exiting Ground at Structure Location

Structure Existing Ground:	662.8	ft NAVD88
Footing Bearing Elev.:	655.5	ft NAVD88
Footing Bearing Elev.:	7.3	ft below existing (cut)
GWT Depth below Exist.:	20.8	feet
GWT Depth below footing.:	13.5	feet

Area Fill

Fill between existing/footing?	no	-
Include load from area fill?	no	-
Finish Grade of Area Fill:	655.5	ft NAVD88
Height above existing:	#N/A	feet
Height above footing base:	#N/A	feet
Thickness under footing:	#N/A	feet
Area Fill Unit Weight:	126	pcf

Subgrade Overexcavation/Replacement

Include Overex/Replace?	no	-
Overex/Replace Bottom Elev.	653.5	ft NAVD88
Depth below footing:	#N/A	feet
Depth below existing:	#N/A	feet

Structure Footing Size & Maximum Bearing Pressure

Footing Width, B:	11.33	feet
Footing Length, L (rect):	30	feet
Gross Footing Pressure, $q_{0\text{-gross}}$	1,500	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula do not edit

Design Soil Profile and Properties

Depth at Boring (feet)		Elevation (feet)		Thickness in Boring	1 Existing Depth at Structure (feet)	2	3 Thickness at Structure	4 Layer Name	5 Total Unit Wt	6 Initial Void Ratio, e_0*	7 Compression Index, C_c*	8 Recomp. Index, C_r*	9 Min. Over Consolidation Ratio, OCR*	10 Min. Preconsol. Pressure, P'c*
Top	Bottom	Top	Bottom	(feet)	Top	Bottom	(feet)		(pcf)	(-)				(psf)
0	19	662.3	643.3	19.0	0.5	19.5	19.0	Embank. Fill (Core)	125	0.60	0.20	0.030	2.0	4,000
19	40	643.3	622.3	21.0	19.5	40.5	21.0	Residuum (MPR)	126	0.60	0.20	0.030	2.0	4,000
40	100	622.3	562.3	60.0	40.5	100.5	60.0	Shale	130	0.50	0.0	0.000	0.0	0

Notes: Copy down elevation and thickness formulas if more layers are needed, delete formulas where not needed.

*Enter "0" for incompressible layers (i.e., granular soils and bedrock)

Method: Settlement Below Center of Uniformly Loaded Rectangular Footing

Project	Plum Creek FRS No. 2 Rehabilitation
Structure	Overtopping RCC Spillway - Crest Structure - Walls
Analysis Section	Proposed dam crest centerline

Elev. - Existing Ground @ Structure:	662.8	ft NAVD88	-7.3	ft from footing base (above)	0	ft from existing (below)
Elev. - Base of Footing / Bearing Depth	655.5	ft NAVD88	0	ft from footing base (below)	7.3	ft from existing (below)
Elev. - Top of Area Fill	#N/A	ft NAVD88	#N/A	#N/A	#N/A	#N/A
Elev. - Bottom of Overex./Replace	#N/A	ft NAVD88	#N/A	#N/A	#N/A	#N/A
Elev. - Groundwater	642	ft NAVD88	13.5	ft from footing base (below)	20.8	ft from existing (below)
Thickness - Area Fill	#N/A	feet below footing base				
Thickness - Overex/Replace	#N/A	feet below footing base				

Footing Width, B:	11.33	feet
Footing Length, L (square):	11.33	feet
Footing Length, L (rect):	30	feet

Gross Footing Pressure, $q_{0\text{-gross}}$	1,500	psf
Removed in-situ stress	920	psf
Net Footing Pressure, $q_{0\text{-net}}$	580	psf

$$\Delta\sigma_z = qI_4 \qquad (10.34)$$

where

$$I_4 = \frac{2}{\pi}\left[\frac{m_1 n_1}{\sqrt{1+m_1^2+n_1^2}}\,\frac{1+m_1^2+2n_1^2}{(1+n_1^2)(m_1^2+n_1^2)} + \sin^{-1}\frac{m_1}{\sqrt{m_1^2+n_1^2}\sqrt{1+n_1^2}}\right] \qquad (10.35)$$

$$m_1 = \frac{L}{B} \qquad (10.36)$$

$$n_1 = \frac{z}{b} \qquad (10.37)$$

$$b = \frac{B}{2} \qquad (10.38)$$

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula (do not edit)
xxx	= Unique Formula (do not edit)

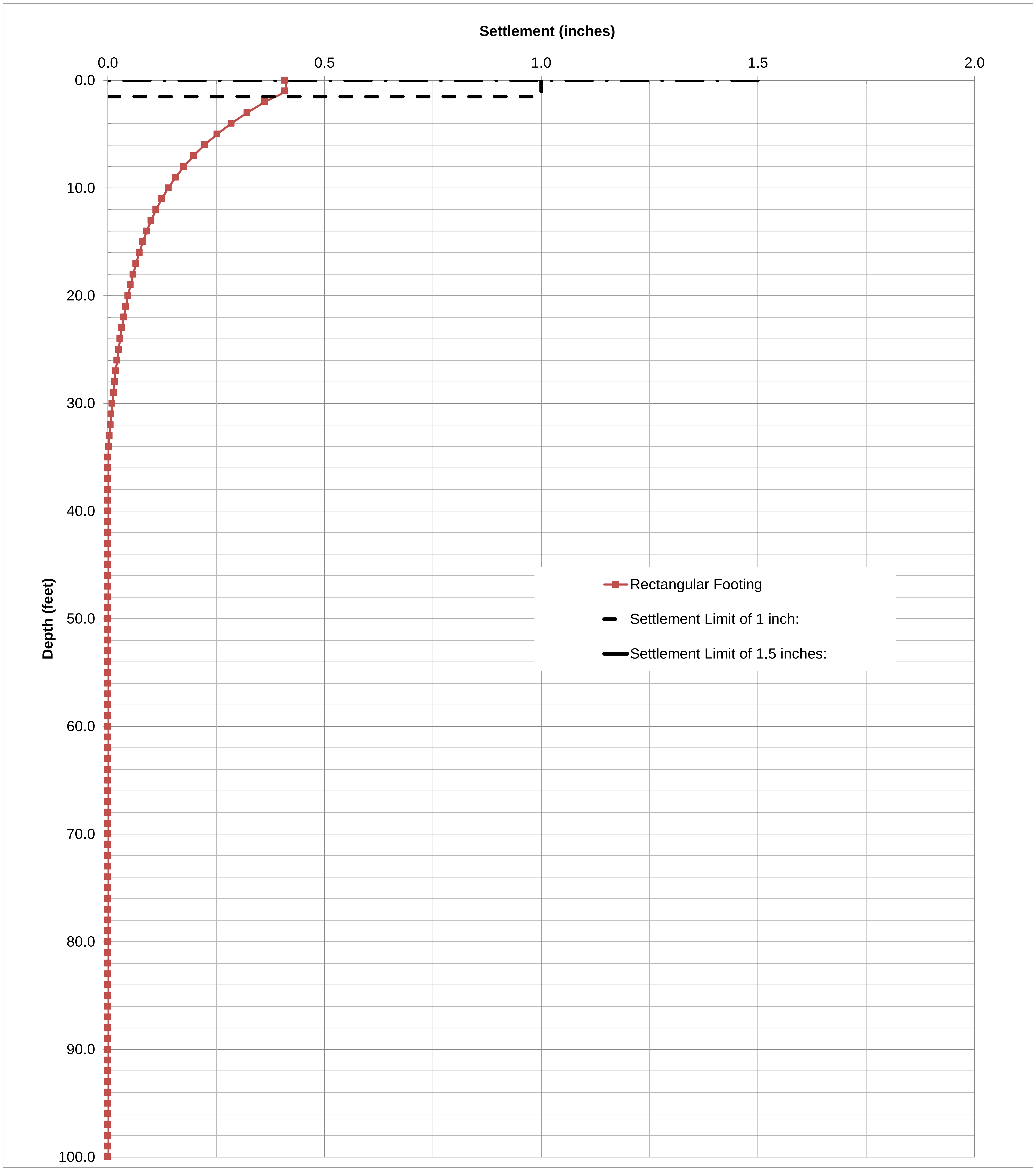
**Negative values indicate height above existing ground*

**Assume granular*

Total Settlement (inch) = 0.41

	Depth from Existing*			Elevation		Layer	Layer	In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom	Thickness	Unit Wt.	Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	**S_t**
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	**(inch)**
Fill below footing/above exist.	0.0	0.0	0.0	662.8	662.8	0.0	126	-	-	-	-	-	-	-	-	0	0	-	3	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	**-**
Existing Soil Above Footing	0.0	7.3	3.6	662.8	655.5	7.3	126	-	-	-	-	-	-	-	-	0	0	-	3	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	**-**
Overex. below Existing	0.0	7.3	3.6	662.8	662.8	7.3	126	-	-	-	-	-	-	-	-	0	0	-	3	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	**-**
Embank. Fill (Core)	7.3	8.3	7.8	655.5	654.5	1.0	125	982	0	982	0.20	0.030	0.60	2.0	4,000	0	0	-	3	0.50	0.1	5.7	1.00	580	0.05	0.00	**0.045**
Embank. Fill (Core)	8.3	9.3	8.8	654.5	653.5	1.0	125	1,107	0	1,107	0.20	0.030	0.60	2.0	4,000	0	0	-	3	1.50	0.3	5.7	0.99	576	0.04	0.00	**0.041**
Embank. Fill (Core)	9.3	10.3	9.8	653.5	652.5	1.0	125	1,232	0	1,232	0.20	0.030	0.60	2.0	4,000	0	0	-	3	2.50	0.4	5.7	0.97	563	0.04	0.00	**0.037**
Embank. Fill (Core)	10.3	11.3	10.8	652.5	651.5	1.0	125	1,357	0	1,357	0.20	0.030	0.60	2.0	4,000	0	0	-	3	3.50	0.6	5.7	0.93	540	0.03	0.00	**0.033**
Embank. Fill (Core)	11.3	12.3	11.8	651.5	650.5	1.0	125	1,482	0	1,482	0.20	0.030	0.60	2.0	4,000	0	0	-	3	4.50	0.8	5.7	0.88	510	0.03	0.00	**0.029**
Embank. Fill (Core)	12.3	13.3	12.8	650.5	649.5	1.0	125	1,607	0	1,607	0.20	0.030	0.60	2.0	4,000	0	0	-	3	5.50	1.0	5.7	0.82	476	0.03	0.00	**0.025**
Embank. Fill (Core)	13.3	14.3	13.8	649.5	648.5	1.0	125	1,732	0	1,732	0.20	0.030	0.60	2.0	4,000	0	0	-	3	6.50	1.1	5.7	0.76	442	0.02	0.00	**0.022**
Embank. Fill (Core)	14.3	15.3	14.8	648.5	647.5	1.0	125	1,857	0	1,857	0.20	0.030	0.60	2.0	4,000	0	0	-	3	7.50	1.3	5.7	0.70	408	0.02	0.00	**0.019**
Embank. Fill (Core)	15.3	16.3	15.8	647.5	646.5	1.0	125	1,982	0	1,982	0.20	0.030	0.60	2.0	4,000	0	0	-	3	8.50	1.5	5.7	0.65	376	0.02	0.00	**0.017**
Embank. Fill (Core)	16.3	17.3	16.8	646.5	645.5	1.0	125	2,107	0	2,107	0.20	0.030	0.60	2.0	4,215	0	0	-	3	9.50	1.7	5.7	0.60	347	0.01	0.00	**0.015**
Embank. Fill (Core)	17.3	18.3	17.8	645.5	644.5	1.0	125	2,232	0	2,232	0.20	0.030	0.60	2.0	4,465	0	0	-	3	10.50	1.9	5.7	0.55	320	0.01	0.00	**0.013**
Embank. Fill (Core)	18.3	19.3	18.8	644.5	643.5	1.0	125	2,357	0	2,357	0.20	0.030	0.60	2.0	4,715	0	0	-	3	11.50	2.0	5.7	0.51	295	0.01	0.00	**0.012**
Embank. Fill (Core)	19.3	20.3	19.8	643.5	642.5	1.0	125	2,482	0	2,482	0.20	0.030	0.60	2.0	4,965	0	0	-	3	12.50	2.2	5.7	0.47	272	0.01	0.00	**0.010**
Residuum (MPR)	20.3	21.3	20.8	642.5	641.5	1.0	126	2,608	0	2,608	0.20	0.030	0.60	2.0	5,216	0	0	-	3	13.50	2.4	5.7	0.43	252	0.01	0.00	**0.009**
Residuum (MPR)	21.3	22.3	21.8	641.5	640.5	1.0	126	2,734	62	2,671	0.20	0.030	0.60	2.0	5,343	0	0	-	3	14.50	2.6	5.7	0.40	233	0.01	0.00	**0.008**
Residuum (MPR)	22.3	23.3	22.8	640.5	639.5	1.0	126	2,860	125	2,735	0.20	0.030	0.60	2.0	5,470	0	0	-	3	15.50	2.7	5.7	0.37	216	0.01	0.00	**0.007**
Residuum (MPR)	23.3	24.3	23.8	639.5	638.5	1.0	126	2,986	187	2,799	0.20	0.030	0.60	2.0	5,597	0	0	-	3	16.50	2.9	5.7	0.35	201	0.01	0.00	**0.007**
Residuum (MPR)	24.3	25.3	24.8	638.5	637.5	1.0	126	3,112	250	2,862	0.20	0.030	0.60	2.0	5,724	0	0	-	3	17.50	3.1	5.7	0.32	186	0.01	0.00	**0.006**
Residuum (MPR)	25.3	26.3	25.8	637.5	636.5	1.0	126	3,238	312	2,926	0.20	0.030	0.60	2.0	5,852	0	0	-	3	18.50	3.3	5.7	0.30	174	0.01	0.00	**0.006**
Residuum (MPR)	26.3	27.3	26.8	636.5	635.5	1.0	126	3,364	374	2,989	0.20	0.030	0.60	2.0	5,979	0	0	-	3	19.50	3.4	5.7	0.28	162	0.01	0.00	**0.005**
Residuum (MPR)	27.3	28.3	27.8	635.5	634.5	1.0	126	3,490	437	3,053	0.20	0.030	0.60	2.0	6,106	0	0	-	3	20.50	3.6	5.7	0.26	151	0.00	0.00	**0.005**
Residuum (MPR)	28.3	29.3	28.8	634.5	633.5	1.0	126	3,616	499	3,117	0.20	0.030	0.60	2.0	6,233	0	0	-	3	21.50	3.8	5.7	0.24	142	0.00	0.00	**0.004**
Residuum (MPR)	29.3	30.3	29.8	633.5	632.5	1.0	126	3,742	562	3,180	0.20	0.030	0.60	2.0	6,360	0	0	-	3	22.50	4.0	5.7	0.23	133	0.00	0.00	**0.004**
Residuum (MPR)	30.3	31.3	30.8	632.5	631.5	1.0	126	3,868	624	3,244	0.20	0.030	0.60	2.0	6,488	0	0	-	3	23.50	4.1	5.7	0.21	124	0.00	0.00	**0.004**
Residuum (MPR)	31.3	32.3	31.8	631.5	630.5	1.0	126	3,994	686	3,307	0.20	0.030	0.60	2.0	6,615	0	0	-	3	24.50	4.3	5.7	0.20	117	0.00	0.00	**0.003**
Residuum (MPR)	32.3	33.3	32.8	630.5	629.5	1.0	126	4,120	749	3,371	0.20	0.030	0.60	2.0	6,742	0	0	-	3	25.50	4.5	5.7	0.19	110	0.00	0.00	**0.003**
Residuum (MPR)	33.3	34.3	33.8	629.5	628.5	1.0	126	4,246	811	3,435	0.20	0.030	0.60	2.0	6,869	0	0	-	3	26.50	4.7	5.7	0.18	104	0.00	0.00	**0.003**
Residuum (MPR)	34.3	35.3	34.8	628.5	627.5	1.0	126	4,372	874	3,498	0.20	0.030	0.60	2.0	6,996	0	0	-	3	27.50	4.9	5.7	0.17	98	0.00	0.00	**0.003**
Residuum (MPR)	35.3	36.3	35.8	627.5	626.5	1.0	126	4,498	936	3,562	0.20	0.030	0.60	2.0	7,124	0	0	-	3	28.50	5.0	5.7	0.16	92	0.00	0.00	**0.003**
Residuum (MPR)	36.3	37.3	36.8	626.5	625.5	1.0	126	4,624	998	3,625	0.20	0.030	0.60	2.0	7,251	0	0	-	3	29.50	5.2	5.7	0.15	87	0.00	0.00	**0.002**
Residuum (MPR)	37.3	38.3	37.8	625.5	624.5	1.0	126	4,750	1,061	3,689	0.20	0.030	0.60	2.0	7,378	0	0	-	3	30.50	5.4	5.7	0.14	83	0.00	0.00	**0.002**
Residuum (MPR)	38.3	39.3	38.8	624.5	623.5	1.0	126	4,876	1,123	3,753	0.20	0.030	0.60	2.0	7,505	0	0	-	3	31.50	5.6	5.7	0.14	78	0.00	0.00	**0.002**
Residuum (MPR)	39.3	40.3	39.8	623.5	622.5	1.0	126	5,002	1,186	3,816	0.20	0.030	0.60	2.0	7,632	0	0	-	3	32.50	5.7	5.7	0.13	74	0.00	0.00	**0.002**
Residuum (MPR)	40.3	41.3	40.8	622.5	621.5	1.0	126	5,128	1,248	3,880	0.20	0.030	0.60	2.0	7,760	0	0	-	3	33.50	5.9	5.7	0.12	71	0.00	0.00	**0.002**
Shale	41.3	42.3	41.8	621.5	620.5	1.0	130	5,256	1,310	3,945	0.00	0.000	0.50	0.0	0	0	0	-	3	34.50	6.1	5.7	0.12	67	-	-	**-**
Shale	42.3	43.3	42.8	620.5	619.5	1.0	130	5,386	1,373	4,013	0.00	0.000	0.50	0.0	0	0	0	-	3	35.50	6.3	5.7	0.11	64	-	-	**-**
Shale	43.3	44.3	43.8	619.5	618.5	1.0	130	5,516	1,435	4,081	0.00	0.000	0.50	0.0	0	0	0	-	3	36.50	6.4	5.7	0.11	61	-	-	**-**
Shale	44.3	45.3	44.8	618.5	617.5	1.0	130	5,646	1,498	4,148	0.00	0.000	0.50	0.0	0	0	0	-	3	37.50	6.6	5.7	0.10	58	-	-	**-**
Shale	45.3	46.3	45.8	617.5	616.5	1.0	130	5,776	1,560	4,216	0.00	0.000	0.50	0.0	0	0	0	-	3	38.50	6.8	5.7	0.10	56	-	-	**-**
Shale	46.3	47.3	46.8	616.5	615.5	1.0	130	5,906	1,622	4,283	0.00	0.000	0.50	0.0	0	0	0	-	3	39.50	7.0	5.7	0.09	53	-	-	**-**
Shale	47.3	48.3	47.8	615.5	614.5	1.0	130	6,036	1,685	4,351	0.00	0.000	0.50	0.0	0	0	0	-	3	40.50	7.1	5.7	0.09	51	-	-	**-**

	Depth from Existing*			Elevation				In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom	Layer Thickness	Layer Unit Wt.	Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	**S_t**
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	**(inch)**
Shale	48.3	49.3	48.8	614.5	613.5	1.0	130	6,166	1,747	4,419	0.00	0.000	0.50	0.0	0	0	0	-	3	41.50	7.3	5.7	0.08	49	-	-	-
Shale	49.3	50.3	49.8	613.5	612.5	1.0	130	6,296	1,810	4,486	0.00	0.000	0.50	0.0	0	0	0	-	3	42.50	7.5	5.7	0.08	47	-	-	-
Shale	50.3	51.3	50.8	612.5	611.5	1.0	130	6,426	1,872	4,554	0.00	0.000	0.50	0.0	0	0	0	-	3	43.50	7.7	5.7	0.08	45	-	-	-
Shale	51.3	52.3	51.8	611.5	610.5	1.0	130	6,556	1,934	4,621	0.00	0.000	0.50	0.0	0	0	0	-	3	44.50	7.9	5.7	0.07	43	-	-	-
Shale	52.3	53.3	52.8	610.5	609.5	1.0	130	6,686	1,997	4,689	0.00	0.000	0.50	0.0	0	0	0	-	3	45.50	8.0	5.7	0.07	41	-	-	-
Shale	53.3	54.3	53.8	609.5	608.5	1.0	130	6,816	2,059	4,757	0.00	0.000	0.50	0.0	0	0	0	-	3	46.50	8.2	5.7	0.07	40	-	-	-
Shale	54.3	55.3	54.8	608.5	607.5	1.0	130	6,946	2,122	4,824	0.00	0.000	0.50	0.0	0	0	0	-	3	47.50	8.4	5.7	0.07	38	-	-	-
Shale	55.3	56.3	55.8	607.5	606.5	1.0	130	7,076	2,184	4,892	0.00	0.000	0.50	0.0	0	0	0	-	3	48.50	8.6	5.7	0.06	37	-	-	-
Shale	56.3	57.3	56.8	606.5	605.5	1.0	130	7,206	2,246	4,959	0.00	0.000	0.50	0.0	0	0	0	-	3	49.50	8.7	5.7	0.06	35	-	-	-
Shale	57.3	58.3	57.8	605.5	604.5	1.0	130	7,336	2,309	5,027	0.00	0.000	0.50	0.0	0	0	0	-	3	50.50	8.9	5.7	0.06	34	-	-	-
Shale	58.3	59.3	58.8	604.5	603.5	1.0	130	7,466	2,371	5,095	0.00	0.000	0.50	0.0	0	0	0	-	3	51.50	9.1	5.7	0.06	33	-	-	-
Shale	59.3	60.3	59.8	603.5	602.5	1.0	130	7,596	2,434	5,162	0.00	0.000	0.50	0.0	0	0	0	-	3	52.50	9.3	5.7	0.05	32	-	-	-
Shale	60.3	61.3	60.8	602.5	601.5	1.0	130	7,726	2,496	5,230	0.00	0.000	0.50	0.0	0	0	0	-	3	53.50	9.4	5.7	0.05	31	-	-	-
Shale	61.3	62.3	61.8	601.5	600.5	1.0	130	7,856	2,558	5,297	0.00	0.000	0.50	0.0	0	0	0	-	3	54.50	9.6	5.7	0.05	30	-	-	-
Shale	62.3	63.3	62.8	600.5	599.5	1.0	130	7,986	2,621	5,365	0.00	0.000	0.50	0.0	0	0	0	-	3	55.50	9.8	5.7	0.05	29	-	-	-
Shale	63.3	64.3	63.8	599.5	598.5	1.0	130	8,116	2,683	5,433	0.00	0.000	0.50	0.0	0	0	0	-	3	56.50	10.0	5.7	0.05	28	-	-	-
Shale	64.3	65.3	64.8	598.5	597.5	1.0	130	8,246	2,746	5,500	0.00	0.000	0.50	0.0	0	0	0	-	3	57.50	10.2	5.7	0.05	27	-	-	-
Shale	65.3	66.3	65.8	597.5	596.5	1.0	130	8,376	2,808	5,568	0.00	0.000	0.50	0.0	0	0	0	-	3	58.50	10.3	5.7	0.04	26	-	-	-
Shale	66.3	67.3	66.8	596.5	595.5	1.0	130	8,506	2,870	5,635	0.00	0.000	0.50	0.0	0	0	0	-	3	59.50	10.5	5.7	0.04	25	-	-	-
Shale	67.3	68.3	67.8	595.5	594.5	1.0	130	8,636	2,933	5,703	0.00	0.000	0.50	0.0	0	0	0	-	3	60.50	10.7	5.7	0.04	24	-	-	-
Shale	68.3	69.3	68.8	594.5	593.5	1.0	130	8,766	2,995	5,771	0.00	0.000	0.50	0.0	0	0	0	-	3	61.50	10.9	5.7	0.04	24	-	-	-
Shale	69.3	70.3	69.8	593.5	592.5	1.0	130	8,896	3,058	5,838	0.00	0.000	0.50	0.0	0	0	0	-	3	62.50	11.0	5.7	0.04	23	-	-	-
Shale	70.3	71.3	70.8	592.5	591.5	1.0	130	9,026	3,120	5,906	0.00	0.000	0.50	0.0	0	0	0	-	3	63.50	11.2	5.7	0.04	22	-	-	-
Shale	71.3	72.3	71.8	591.5	590.5	1.0	130	9,156	3,182	5,973	0.00	0.000	0.50	0.0	0	0	0	-	3	64.50	11.4	5.7	0.04	22	-	-	-
Shale	72.3	73.3	72.8	590.5	589.5	1.0	130	9,286	3,245	6,041	0.00	0.000	0.50	0.0	0	0	0	-	3	65.50	11.6	5.7	0.04	21	-	-	-
Shale	73.3	74.3	73.8	589.5	588.5	1.0	130	9,416	3,307	6,109	0.00	0.000	0.50	0.0	0	0	0	-	3	66.50	11.7	5.7	0.04	20	-	-	-
Shale	74.3	75.3	74.8	588.5	587.5	1.0	130	9,546	3,370	6,176	0.00	0.000	0.50	0.0	0	0	0	-	3	67.50	11.9	5.7	0.03	20	-	-	-
Shale	75.3	76.3	75.8	587.5	586.5	1.0	130	9,676	3,432	6,244	0.00	0.000	0.50	0.0	0	0	0	-	3	68.50	12.1	5.7	0.03	19	-	-	-
Shale	76.3	77.3	76.8	586.5	585.5	1.0	130	9,806	3,494	6,311	0.00	0.000	0.50	0.0	0	0	0	-	3	69.50	12.3	5.7	0.03	19	-	-	-
Shale	77.3	78.3	77.8	585.5	584.5	1.0	130	9,936	3,557	6,379	0.00	0.000	0.50	0.0	0	0	0	-	3	70.50	12.4	5.7	0.03	18	-	-	-
Shale	78.3	79.3	78.8	584.5	583.5	1.0	130	10,066	3,619	6,447	0.00	0.000	0.50	0.0	0	0	0	-	3	71.50	12.6	5.7	0.03	18	-	-	-
Shale	79.3	80.3	79.8	583.5	582.5	1.0	130	10,196	3,682	6,514	0.00	0.000	0.50	0.0	0	0	0	-	3	72.50	12.8	5.7	0.03	17	-	-	-
Shale	80.3	81.3	80.8	582.5	581.5	1.0	130	10,326	3,744	6,582	0.00	0.000	0.50	0.0	0	0	0	-	3	73.50	13.0	5.7	0.03	17	-	-	-
Shale	81.3	82.3	81.8	581.5	580.5	1.0	130	10,456	3,806	6,649	0.00	0.000	0.50	0.0	0	0	0	-	3	74.50	13.2	5.7	0.03	16	-	-	-
Shale	82.3	83.3	82.8	580.5	579.5	1.0	130	10,586	3,869	6,717	0.00	0.000	0.50	0.0	0	0	0	-	3	75.50	13.3	5.7	0.03	16	-	-	-
Shale	83.3	84.3	83.8	579.5	578.5	1.0	130	10,716	3,931	6,785	0.00	0.000	0.50	0.0	0	0	0	-	3	76.50	13.5	5.7	0.03	16	-	-	-
Shale	84.3	85.3	84.8	578.5	577.5	1.0	130	10,846	3,994	6,852	0.00	0.000	0.50	0.0	0	0	0	-	3	77.50	13.7	5.7	0.03	15	-	-	-
Shale	85.3	86.3	85.8	577.5	576.5	1.0	130	10,976	4,056	6,920	0.00	0.000	0.50	0.0	0	0	0	-	3	78.50	13.9	5.7	0.03	15	-	-	-
Shale	86.3	87.3	86.8	576.5	575.5	1.0	130	11,106	4,118	6,987	0.00	0.000	0.50	0.0	0	0	0	-	3	79.50	14.0	5.7	0.02	14	-	-	-
Shale	87.3	88.3	87.8	575.5	574.5	1.0	130	11,236	4,181	7,055	0.00	0.000	0.50	0.0	0	0	0	-	3	80.50	14.2	5.7	0.02	14	-	-	-
Shale	88.3	89.3	88.8	574.5	573.5	1.0	130	11,366	4,243	7,123	0.00	0.000	0.50	0.0	0	0	0	-	3	81.50	14.4	5.7	0.02	14	-	-	-
Shale	89.3	90.3	89.8	573.5	572.5	1.0	130	11,496	4,306	7,190	0.00	0.000	0.50	0.0	0	0	0	-	3	82.50	14.6	5.7	0.02	13	-	-	-
Shale	90.3	91.3	90.8	572.5	571.5	1.0	130	11,626	4,368	7,258	0.00	0.000	0.50	0.0	0	0	0	-	3	83.50	14.7	5.7	0.02	13	-	-	-
Shale	91.3	92.3	91.8	571.5	570.5	1.0	130	11,756	4,430	7,325	0.00	0.000	0.50	0.0	0	0	0	-	3	84.50	14.9	5.7	0.02	13	-	-	-
Shale	92.3	93.3	92.8	570.5	569.5	1.0	130	11,886	4,493	7,393	0.00	0.000	0.50	0.0	0	0	0	-	3	85.50	15.1	5.7	0.02	13	-	-	-
Shale	93.3	94.3	93.8	569.5	568.5	1.0	130	12,016	4,555	7,461	0.00	0.000	0.50	0.0	0	0	0	-	3	86.50	15.3	5.7	0.02	12	-	-	-
Shale	94.3	95.3	94.8	568.5	567.5	1.0	130	12,146	4,618	7,528	0.00	0.000	0.50	0.0	0	0	0	-	3	87.50	15.4	5.7	0.02	12	-	-	-
Shale	95.3	96.3	95.8	567.5	566.5	1.0	130	12,276	4,680	7,596	0.00	0.000	0.50	0.0	0	0	0	-	3	88.50	15.6	5.7	0.02	12	-	-	-
Shale	96.3	97.3	96.8	566.5	565.5	1.0	130	12,406	4,742	7,663	0.00	0.000	0.50	0.0	0	0	0	-	3	89.50	15.8	5.7	0.02	11	-	-	-
Shale	97.3	98.3	97.8	565.5	564.5	1.0	130	12,536	4,805	7,731	0.00	0.000	0.50	0.0	0	0	0	-	3	90.50	16.0	5.7	0.02	11	-	-	-
Shale	98.3	99.3	98.8	564.5	563.5	1.0	130	12,666	4,867	7,799	0.00	0.000	0.50	0.0	0	0	0	-	3	91.50	16.2	5.7	0.02	11	-	-	-
Shale	99.3	100.3	99.8	563.5	562.5	1.0	130	12,796	4,930	7,866	0.00	0.000	0.50	0.0	0	0	0	-	3	92.50	16.3	5.7	0.02	11	-	-	-
Shale	100.3	101.3	100.8	562.5	561.5	1.0	130	12,926	4,992	7,934	0.00	0.000	0.50	0.0	0	0	0	-	3	93.50	16.5	5.7	0.02	11	-	-	-
#N/A	101.3	102.3	101.8	561.5	560.5	1.0	#N/A	#N/A	5,054	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	94.50	16.7	5.7	0.02	10	-	-	-
#N/A	102.3	103.3	102.8	560.5	559.5	1.0	#N/A	#N/A	5,117	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	95.50	16.9	5.7	0.02	10	-	-	-
#N/A	103.3	104.3	103.8	559.5	558.5	1.0	#N/A	#N/A	5,179	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	96.50	17.0	5.7	0.02	10	-	-	-
#N/A	104.3	105.3	104.8	558.5	557.5	1.0	#N/A	#N/A	5,242	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	97.50	17.2	5.7	0.02	10	-	-	-
#N/A	105.3	106.3	105.8	557.5	556.5	1.0	#N/A	#N/A	5,304	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	98.50	17.4	5.7	0.02	9	-	-	-
#N/A	106.3	107.3	106.8	556.5	555.5	1.0	#N/A	#N/A	5,366	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	99.50	17.6	5.7	0.02	9	-	-	-
#N/A	107.3	108.3	107.8	555.5	554.5	1.0	#N/A	#N/A	5,429	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	100.50	17.7	5.7	0.02	9	-	-	-
#N/A	108.3	109.3	108.8	554.5	553.5	1.0	#N/A	#N/A	5,491	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	101.50	17.9	5.7	0.02	9	-	-	-
#N/A	109.3	110.3	109.8	553.5	552.5	1.0	#N/A	#N/A	5,554	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	102.50	18.1	5.7	0.02	9	-	-	-
#N/A	110.3	200.0	155.2	552.5	462.8	89.7	#N/A	#N/A	8,383	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	147.85	26.1	5.7	0.01	4	-	-	-


Settlement (inches)
0.0
0.5
1.0
1.5
2.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Depth (feet)
Rectangular Footing
Settlement Limit of 1 inch:
Settlement Limit of 1.5 inches:

Project Name:	Plum Creek FRS No. 2 Rehabilitation
Job Number:	60615067
Client:	TSSWCB

Structure	Overtopping RCC Spillway - Crest Structure - Walls
Analysis Section	Proposed dam crest centerline
Notes	RCC footing on overexcavation/replacement embankment fill

Geotechnical Data

Relevant Boring	n/a	-
Boring Ground Elev.	655.5	ft NAVD88
Depth to GWT at Boring:	13.5	feet
GWT Elev.	642	ft NAVD88

Exiting Ground at Structure Location

Structure Existing Ground:	655.5	ft NAVD88
Footing Bearing Elev.:	655.5	ft NAVD88
Footing Bearing Elev.:	0	ft below existing (cut)
GWT Depth below Exist.:	13.5	feet
GWT Depth below footing.:	13.5	feet

Area Fill

Fill between existing/footing?	no	-
Include load from area fill?	no	-
Finish Grade of Area Fill:	655.5	ft NAVD88
Height above existing:	#N/A	feet
Height above footing base:	#N/A	feet
Thickness under footing:	#N/A	feet
Area Fill Unit Weight:	126	pcf

Subgrade Overexcavation/Replacement

Include Overex/Replacement?	no	-
Overex/Replace Bottom Elev.	653.5	ft NAVD88
Depth below footing:	#N/A	feet
Depth below existing:	#N/A	feet

Structure Footing Size & Maximum Bearing Pressure

Footing Width, B:	11.33	feet
Footing Length, L (rect):	30	feet
Gross Footing Pressure, $q_{0\text{-gross}}$	1,500	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula do not edit

Design Soil Profile and Properties

					1	2	3	4	5	6	7	8	9	10
Depth at Boring (feet)		Elevation (feet)		Thickness in Boring	Existing Depth at Structure (feet)		Thickness at Structure	Layer Name	Total Unit Wt	Initial Void Ratio, e_0*	Compression Index, C_c*	Recomp. Index, C_r*	Min. Over Consolidation Ratio, OCR*	Min. Preconsol. Pressure, P'c*
Top	Bottom	Top	Bottom	(feet)	Top	Bottom	(feet)		(pcf)	(-)				(psf)
0	8	655.5	647.5	8.0	0.0	8.0	8.0	New Embank. Fill	125	0.65	0.20	0.020	2.0	3,000
8	12.3	647.5	643.2	4.3	8.0	12.3	4.3	Embank. Fill (Core)	125	0.60	0.20	0.030	2.0	4,000
12.3	33.3	643.2	622.2	21.0	12.3	33.3	21.0	Residuum (MPR)	126	0.60	0.20	0.030	2.0	4,000
33.3	100	622.2	555.5	66.7	33.3	100.0	66.7	Shale	130	0.50	0.0	0.000	0.0	0

Notes: *Copy down elevation and thickness formulas if more layers are needed, delete formulas where not needed.*

*Enter "0" for incompressible layers (i.e., granular soils and bedrock)

Method: Settlement Below Center of Uniformly Loaded Rectangular Footing

Project	Plum Creek FRS No. 2 Rehabilitation
Structure	Overtopping RCC Spillway - Crest Structure - Walls
Analysis Section	Proposed dam crest centerline

$$\Delta\sigma_z = qI_4 \tag{10.34}$$

where

$$I_4 = \frac{2}{\pi}\left[\frac{m_1 n_1}{\sqrt{1+m_1^2+n_1^2}}\frac{1+m_1^2+2n_1^2}{(1+n_1^2)(m_1^2+n_1^2)} + \sin^{-1}\frac{m_1}{\sqrt{m_1^2+n_1^2}\sqrt{1+n_1^2}}\right] \tag{10.35}$$

$$m_1 = \frac{L}{B} \tag{10.36}$$

$$n_1 = \frac{z}{b} \tag{10.37}$$

$$b = \frac{B}{2} \tag{10.38}$$

Elev. - Existing Ground @ Structure:	655.5	ft NAVD88	0	ft from footing base (below)	0	ft from existing (below)
Elev. - Base of Footing / Bearing Depth	655.5	ft NAVD88	0	ft from footing base (below)	0	ft from existing (below)
Elev. - Top of Area Fill	#N/A	ft NAVD88	#N/A	#N/A	#N/A	#N/A
Elev. - Bottom of Overex./Replace	#N/A	ft NAVD88	#N/A	#N/A	#N/A	#N/A
Elev. - Groundwater	642	ft NAVD88	13.5	ft from footing base (below)	13.5	ft from existing (below)
Thickness - Area Fill	#N/A	feet below footing base				
Thickness - Overex/Replace	#N/A	feet below footing base				

Footing Width, B:	11.33	feet
Footing Length, L (square):	11.33	feet
Footing Length, L (rect):	30	feet

Gross Footing Pressure, $q_{0\text{-gross}}$	1,500	psf
Removed in-situ stress	0	psf
Net Footing Pressure, $q_{0\text{-net}}$	1,500	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula (do not edit)
xxx	= Unique Formula (do not edit)

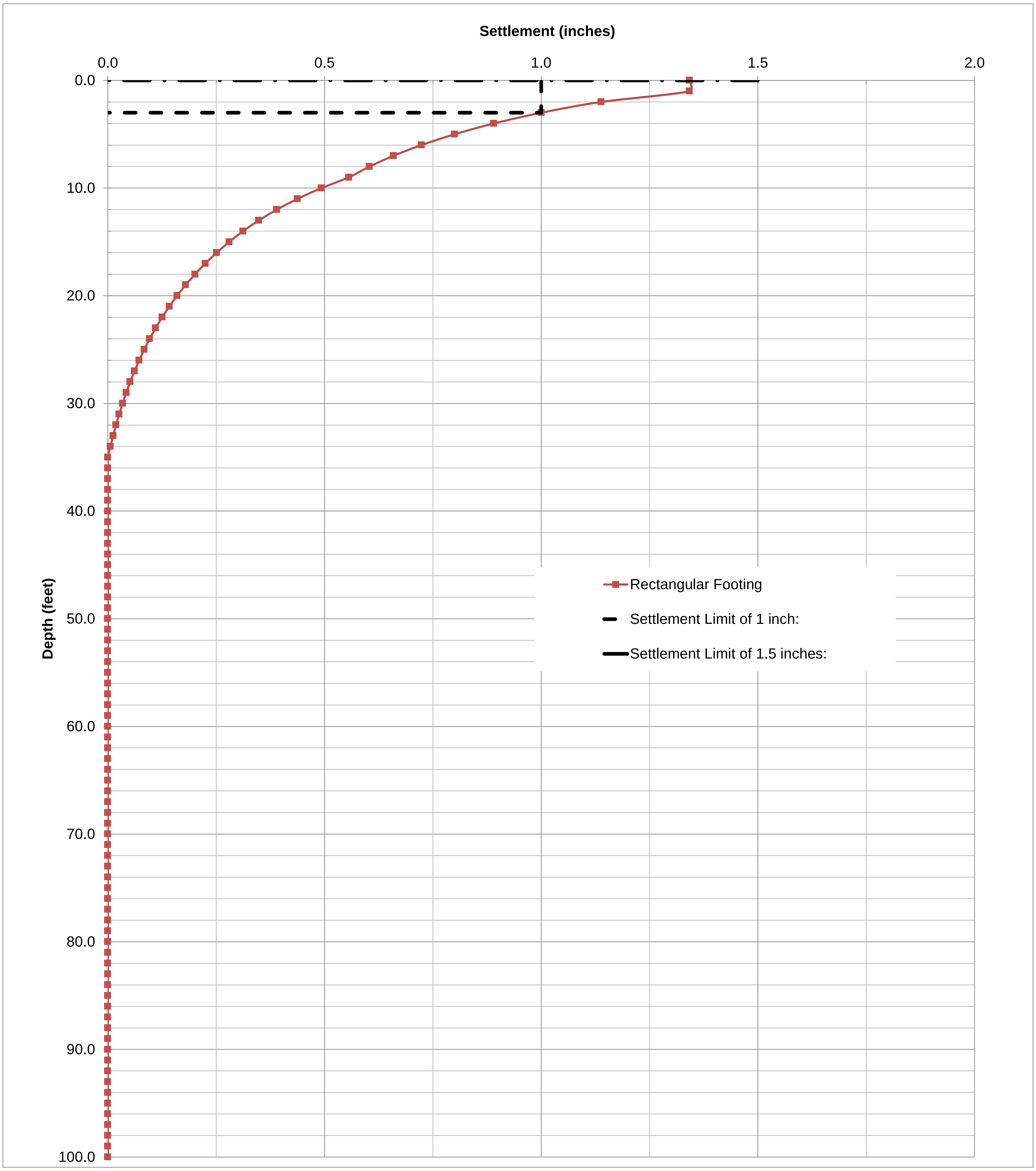
*Negative values indicate height above existing ground

*Assume granular

Total Settlement (inch) = 1.34

	Depth from Existing*			Elevation		Layer Thickness	Layer Unit Wt.	In-Situ Stress at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom			Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	S_t
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	**(inch)**
Fill below footing/above exist.	0.0	0.0	0.0	655.5	655.5	0.0	126	-	-	-	-	-	-	-	-	0	0	-	3	0.00	0.0	5.7	1.00	1,500	-	-	**-**
Existing Soil Above Footing	0.0	0.0	0.0	655.5	655.5	0.0	125	-	-	-	-	-	-	-	-	0	0	-	3	0.00	0.0	5.7	1.00	1,500	-	-	**-**
Overex. below Existing	0.0	0.0	0.0	655.5	655.5	0.0	125	-	-	-	-	-	-	-	-	0	0	-	3	0.00	0.0	5.7	1.00	1,500	-	-	**-**
New Embank. Fill	0.0	1.0	0.5	655.5	654.5	1.0	125	63	0	63	0.20	0.020	0.65	2.0	3,000	0	0	-	3	0.50	0.1	5.7	1.00	1,500	0.20	0.00	**0.203**
New Embank. Fill	1.0	2.0	1.5	654.5	653.5	1.0	125	188	0	188	0.20	0.020	0.65	2.0	3,000	0	0	-	3	1.50	0.3	5.7	0.99	1,489	0.14	0.00	**0.138**
New Embank. Fill	2.0	3.0	2.5	653.5	652.5	1.0	125	313	0	313	0.20	0.020	0.65	2.0	3,000	0	0	-	3	2.50	0.4	5.7	0.97	1,455	0.11	0.00	**0.109**
New Embank. Fill	3.0	4.0	3.5	652.5	651.5	1.0	125	438	0	438	0.20	0.020	0.65	2.0	3,000	0	0	-	3	3.50	0.6	5.7	0.93	1,396	0.09	0.00	**0.091**
New Embank. Fill	4.0	5.0	4.5	651.5	650.5	1.0	125	563	0	563	0.20	0.020	0.65	2.0	3,000	0	0	-	3	4.50	0.8	5.7	0.88	1,318	0.08	0.00	**0.076**
New Embank. Fill	5.0	6.0	5.5	650.5	649.5	1.0	125	688	0	688	0.20	0.020	0.65	2.0	3,000	0	0	-	3	5.50	1.0	5.7	0.82	1,231	0.06	0.00	**0.065**
New Embank. Fill	6.0	7.0	6.5	649.5	648.5	1.0	125	813	0	813	0.20	0.020	0.65	2.0	3,000	0	0	-	3	6.50	1.1	5.7	0.76	1,142	0.06	0.00	**0.055**
New Embank. Fill	7.0	8.0	7.5	648.5	647.5	1.0	125	938	0	938	0.20	0.020	0.65	2.0	3,000	0	0	-	3	7.50	1.3	5.7	0.70	1,055	0.05	0.00	**0.048**
Embank. Fill (Core)	8.0	9.0	8.5	647.5	646.5	1.0	125	1,063	0	1,063	0.20	0.030	0.60	2.0	4,000	0	0	-	3	8.50	1.5	5.7	0.65	973	0.06	0.00	**0.064**
Embank. Fill (Core)	9.0	10.0	9.5	646.5	645.5	1.0	125	1,188	0	1,188	0.20	0.030	0.60	2.0	4,000	0	0	-	3	9.50	1.7	5.7	0.60	897	0.05	0.00	**0.055**
Embank. Fill (Core)	10.0	11.0	10.5	645.5	644.5	1.0	125	1,313	0	1,313	0.20	0.030	0.60	2.0	4,000	0	0	-	3	10.50	1.9	5.7	0.55	826	0.05	0.00	**0.048**
Embank. Fill (Core)	11.0	12.0	11.5	644.5	643.5	1.0	125	1,438	0	1,438	0.20	0.030	0.60	2.0	4,000	0	0	-	3	11.50	2.0	5.7	0.51	762	0.04	0.00	**0.042**
Embank. Fill (Core)	12.0	13.0	12.5	643.5	642.5	1.0	125	1,563	0	1,563	0.20	0.030	0.60	2.0	4,000	0	0	-	3	12.50	2.2	5.7	0.47	704	0.04	0.00	**0.036**
Residuum (MPR)	13.0	14.0	13.5	642.5	641.5	1.0	126	1,688	0	1,688	0.20	0.030	0.60	2.0	4,000	0	0	-	3	13.50	2.4	5.7	0.43	651	0.03	0.00	**0.032**
Residuum (MPR)	14.0	15.0	14.5	641.5	640.5	1.0	126	1,814	62	1,752	0.20	0.030	0.60	2.0	4,000	0	0	-	3	14.50	2.6	5.7	0.40	602	0.03	0.00	**0.029**
Residuum (MPR)	15.0	16.0	15.5	640.5	639.5	1.0	126	1,940	125	1,815	0.20	0.030	0.60	2.0	4,000	0	0	-	3	15.50	2.7	5.7	0.37	558	0.03	0.00	**0.026**
Residuum (MPR)	16.0	17.0	16.5	639.5	638.5	1.0	126	2,066	187	1,879	0.20	0.030	0.60	2.0	4,000	0	0	-	3	16.50	2.9	5.7	0.35	519	0.02	0.00	**0.024**
Residuum (MPR)	17.0	18.0	17.5	638.5	637.5	1.0	126	2,192	250	1,942	0.20	0.030	0.60	2.0	4,000	0	0	-	3	17.50	3.1	5.7	0.32	482	0.02	0.00	**0.022**
Residuum (MPR)	18.0	19.0	18.5	637.5	636.5	1.0	126	2,318	312	2,006	0.20	0.030	0.60	2.0	4,012	0	0	-	3	18.50	3.3	5.7	0.30	449	0.02	0.00	**0.020**
Residuum (MPR)	19.0	20.0	19.5	636.5	635.5	1.0	126	2,444	374	2,070	0.20	0.030	0.60	2.0	4,139	0	0	-	3	19.50	3.4	5.7	0.28	419	0.02	0.00	**0.018**
Residuum (MPR)	20.0	21.0	20.5	635.5	634.5	1.0	126	2,570	437	2,133	0.20	0.030	0.60	2.0	4,266	0	0	-	3	20.50	3.6	5.7	0.26	391	0.02	0.00	**0.016**
Residuum (MPR)	21.0	22.0	21.5	634.5	633.5	1.0	126	2,696	499	2,197	0.20	0.030	0.60	2.0	4,394	0	0	-	3	21.50	3.8	5.7	0.24	366	0.02	0.00	**0.015**
Residuum (MPR)	22.0	23.0	22.5	633.5	632.5	1.0	126	2,822	562	2,260	0.20	0.030	0.60	2.0	4,521	0	0	-	3	22.50	4.0	5.7	0.23	343	0.01	0.00	**0.014**
Residuum (MPR)	23.0	24.0	23.5	632.5	631.5	1.0	126	2,948	624	2,324	0.20	0.030	0.60	2.0	4,648	0	0	-	3	23.50	4.1	5.7	0.21	322	0.01	0.00	**0.013**
Residuum (MPR)	24.0	25.0	24.5	631.5	630.5	1.0	126	3,074	686	2,388	0.20	0.030	0.60	2.0	4,775	0	0	-	3	24.50	4.3	5.7	0.20	302	0.01	0.00	**0.012**
Residuum (MPR)	25.0	26.0	25.5	630.5	629.5	1.0	126	3,200	749	2,451	0.20	0.030	0.60	2.0	4,902	0	0	-	3	25.50	4.5	5.7	0.19	284	0.01	0.00	**0.011**
Residuum (MPR)	26.0	27.0	26.5	629.5	628.5	1.0	126	3,326	811	2,515	0.20	0.030	0.60	2.0	5,030	0	0	-	3	26.50	4.7	5.7	0.18	268	0.01	0.00	**0.010**
Residuum (MPR)	27.0	28.0	27.5	628.5	627.5	1.0	126	3,452	874	2,578	0.20	0.030	0.60	2.0	5,157	0	0	-	3	27.50	4.9	5.7	0.17	253	0.01	0.00	**0.009**
Residuum (MPR)	28.0	29.0	28.5	627.5	626.5	1.0	126	3,578	936	2,642	0.20	0.030	0.60	2.0	5,284	0	0	-	3	28.50	5.0	5.7	0.16	239	0.01	0.00	**0.008**
Residuum (MPR)	29.0	30.0	29.5	626.5	625.5	1.0	126	3,704	998	2,706	0.20	0.030	0.60	2.0	5,411	0	0	-	3	29.50	5.2	5.7	0.15	226	0.01	0.00	**0.008**
Residuum (MPR)	30.0	31.0	30.5	625.5	624.5	1.0	126	3,830	1,061	2,769	0.20	0.030	0.60	2.0	5,538	0	0	-	3	30.50	5.4	5.7	0.14	214	0.01	0.00	**0.007**
Residuum (MPR)	31.0	32.0	31.5	624.5	623.5	1.0	126	3,956	1,123	2,833	0.20	0.030	0.60	2.0	5,666	0	0	-	3	31.50	5.6	5.7	0.14	203	0.01	0.00	**0.007**
Residuum (MPR)	32.0	33.0	32.5	623.5	622.5	1.0	126	4,082	1,186	2,896	0.20	0.030	0.60	2.0	5,793	0	0	-	3	32.50	5.7	5.7	0.13	192	0.01	0.00	**0.006**
Residuum (MPR)	33.0	34.0	33.5	622.5	621.5	1.0	126	4,208	1,248	2,960	0.20	0.030	0.60	2.0	5,920	0	0	-	3	33.50	5.9	5.7	0.12	183	0.01	0.00	**0.006**
Shale	34.0	35.0	34.5	621.5	620.5	1.0	130	4,336	1,310	3,026	0.00	0.000	0.50	0.0	0	0	0	-	3	34.50	6.1	5.7	0.12	174	-	-	**-**
Shale	35.0	36.0	35.5	620.5	619.5	1.0	130	4,466	1,373	3,093	0.00	0.000	0.50	0.0	0	0	0	-	3	35.50	6.3	5.7	0.11	166	-	-	**-**
Shale	36.0	37.0	36.5	619.5	618.5	1.0	130	4,596	1,435	3,161	0.00	0.000	0.50	0.0	0	0	0	-	3	36.50	6.4	5.7	0.11	158	-	-	**-**
Shale	37.0	38.0	37.5	618.5	617.5	1.0	130	4,726	1,498	3,228	0.00	0.000	0.50	0.0	0	0	0	-	3	37.50	6.6	5.7	0.10	151	-	-	**-**
Shale	38.0	39.0	38.5	617.5	616.5	1.0	130	4,856	1,560	3,296	0.00	0.000	0.50	0.0	0	0	0	-	3	38.50	6.8	5.7	0.10	144	-	-	**-**
Shale	39.0	40.0	39.5	616.5	615.5	1.0	130	4,986	1,622	3,364	0.00	0.000	0.50	0.0	0	0	0	-	3	39.50	7.0	5.7	0.09	137	-	-	**-**
Shale	40.0	41.0	40.5	615.5	614.5	1.0	130	5,116	1,685	3,431	0.00	0.000	0.50	0.0	0	0	0	-	3	40.50	7.1	5.7	0.09	132	-	-	**-**

	Depth from Existing*			Elevation		Layer Thickness	Layer Unit Wt.	In-Situ Stress at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom			Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	**S_t**
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	**(inch)**
Shale	41.0	42.0	41.5	614.5	613.5	1.0	130	5,246	1,747	3,499	0.00	0.000	0.50	0.0	0	0	0	-	3	41.50	7.3	5.7	0.08	126	-	-	**-**
Shale	42.0	43.0	42.5	613.5	612.5	1.0	130	5,376	1,810	3,566	0.00	0.000	0.50	0.0	0	0	0	-	3	42.50	7.5	5.7	0.08	121	-	-	**-**
Shale	43.0	44.0	43.5	612.5	611.5	1.0	130	5,506	1,872	3,634	0.00	0.000	0.50	0.0	0	0	0	-	3	43.50	7.7	5.7	0.08	116	-	-	**-**
Shale	44.0	45.0	44.5	611.5	610.5	1.0	130	5,636	1,934	3,702	0.00	0.000	0.50	0.0	0	0	0	-	3	44.50	7.9	5.7	0.07	111	-	-	**-**
Shale	45.0	46.0	45.5	610.5	609.5	1.0	130	5,766	1,997	3,769	0.00	0.000	0.50	0.0	0	0	0	-	3	45.50	8.0	5.7	0.07	107	-	-	**-**
Shale	46.0	47.0	46.5	609.5	608.5	1.0	130	5,896	2,059	3,837	0.00	0.000	0.50	0.0	0	0	0	-	3	46.50	8.2	5.7	0.07	103	-	-	**-**
Shale	47.0	48.0	47.5	608.5	607.5	1.0	130	6,026	2,122	3,904	0.00	0.000	0.50	0.0	0	0	0	-	3	47.50	8.4	5.7	0.07	99	-	-	**-**
Shale	48.0	49.0	48.5	607.5	606.5	1.0	130	6,156	2,184	3,972	0.00	0.000	0.50	0.0	0	0	0	-	3	48.50	8.6	5.7	0.06	95	-	-	**-**
Shale	49.0	50.0	49.5	606.5	605.5	1.0	130	6,286	2,246	4,040	0.00	0.000	0.50	0.0	0	0	0	-	3	49.50	8.7	5.7	0.06	91	-	-	**-**
Shale	50.0	51.0	50.5	605.5	604.5	1.0	130	6,416	2,309	4,107	0.00	0.000	0.50	0.0	0	0	0	-	3	50.50	8.9	5.7	0.06	88	-	-	**-**
Shale	51.0	52.0	51.5	604.5	603.5	1.0	130	6,546	2,371	4,175	0.00	0.000	0.50	0.0	0	0	0	-	3	51.50	9.1	5.7	0.06	85	-	-	**-**
Shale	52.0	53.0	52.5	603.5	602.5	1.0	130	6,676	2,434	4,242	0.00	0.000	0.50	0.0	0	0	0	-	3	52.50	9.3	5.7	0.05	82	-	-	**-**
Shale	53.0	54.0	53.5	602.5	601.5	1.0	130	6,806	2,496	4,310	0.00	0.000	0.50	0.0	0	0	0	-	3	53.50	9.4	5.7	0.05	79	-	-	**-**
Shale	54.0	55.0	54.5	601.5	600.5	1.0	130	6,936	2,558	4,378	0.00	0.000	0.50	0.0	0	0	0	-	3	54.50	9.6	5.7	0.05	76	-	-	**-**
Shale	55.0	56.0	55.5	600.5	599.5	1.0	130	7,066	2,621	4,445	0.00	0.000	0.50	0.0	0	0	0	-	3	55.50	9.8	5.7	0.05	74	-	-	**-**
Shale	56.0	57.0	56.5	599.5	598.5	1.0	130	7,196	2,683	4,513	0.00	0.000	0.50	0.0	0	0	0	-	3	56.50	10.0	5.7	0.05	72	-	-	**-**
Shale	57.0	58.0	57.5	598.5	597.5	1.0	130	7,326	2,746	4,580	0.00	0.000	0.50	0.0	0	0	0	-	3	57.50	10.2	5.7	0.05	69	-	-	**-**
Shale	58.0	59.0	58.5	597.5	596.5	1.0	130	7,456	2,808	4,648	0.00	0.000	0.50	0.0	0	0	0	-	3	58.50	10.3	5.7	0.04	67	-	-	**-**
Shale	59.0	60.0	59.5	596.5	595.5	1.0	130	7,586	2,870	4,716	0.00	0.000	0.50	0.0	0	0	0	-	3	59.50	10.5	5.7	0.04	65	-	-	**-**
Shale	60.0	61.0	60.5	595.5	594.5	1.0	130	7,716	2,933	4,783	0.00	0.000	0.50	0.0	0	0	0	-	3	60.50	10.7	5.7	0.04	63	-	-	**-**
Shale	61.0	62.0	61.5	594.5	593.5	1.0	130	7,846	2,995	4,851	0.00	0.000	0.50	0.0	0	0	0	-	3	61.50	10.9	5.7	0.04	61	-	-	**-**
Shale	62.0	63.0	62.5	593.5	592.5	1.0	130	7,976	3,058	4,918	0.00	0.000	0.50	0.0	0	0	0	-	3	62.50	11.0	5.7	0.04	59	-	-	**-**
Shale	63.0	64.0	63.5	592.5	591.5	1.0	130	8,106	3,120	4,986	0.00	0.000	0.50	0.0	0	0	0	-	3	63.50	11.2	5.7	0.04	57	-	-	**-**
Shale	64.0	65.0	64.5	591.5	590.5	1.0	130	8,236	3,182	5,054	0.00	0.000	0.50	0.0	0	0	0	-	3	64.50	11.4	5.7	0.04	56	-	-	**-**
Shale	65.0	66.0	65.5	590.5	589.5	1.0	130	8,366	3,245	5,121	0.00	0.000	0.50	0.0	0	0	0	-	3	65.50	11.6	5.7	0.04	54	-	-	**-**
Shale	66.0	67.0	66.5	589.5	588.5	1.0	130	8,496	3,307	5,189	0.00	0.000	0.50	0.0	0	0	0	-	3	66.50	11.7	5.7	0.04	53	-	-	**-**
Shale	67.0	68.0	67.5	588.5	587.5	1.0	130	8,626	3,370	5,256	0.00	0.000	0.50	0.0	0	0	0	-	3	67.50	11.9	5.7	0.03	51	-	-	**-**
Shale	68.0	69.0	68.5	587.5	586.5	1.0	130	8,756	3,432	5,324	0.00	0.000	0.50	0.0	0	0	0	-	3	68.50	12.1	5.7	0.03	50	-	-	**-**
Shale	69.0	70.0	69.5	586.5	585.5	1.0	130	8,886	3,494	5,392	0.00	0.000	0.50	0.0	0	0	0	-	3	69.50	12.3	5.7	0.03	48	-	-	**-**
Shale	70.0	71.0	70.5	585.5	584.5	1.0	130	9,016	3,557	5,459	0.00	0.000	0.50	0.0	0	0	0	-	3	70.50	12.4	5.7	0.03	47	-	-	**-**
Shale	71.0	72.0	71.5	584.5	583.5	1.0	130	9,146	3,619	5,527	0.00	0.000	0.50	0.0	0	0	0	-	3	71.50	12.6	5.7	0.03	46	-	-	**-**
Shale	72.0	73.0	72.5	583.5	582.5	1.0	130	9,276	3,682	5,594	0.00	0.000	0.50	0.0	0	0	0	-	3	72.50	12.8	5.7	0.03	45	-	-	**-**
Shale	73.0	74.0	73.5	582.5	581.5	1.0	130	9,406	3,744	5,662	0.00	0.000	0.50	0.0	0	0	0	-	3	73.50	13.0	5.7	0.03	43	-	-	**-**
Shale	74.0	75.0	74.5	581.5	580.5	1.0	130	9,536	3,806	5,730	0.00	0.000	0.50	0.0	0	0	0	-	3	74.50	13.2	5.7	0.03	42	-	-	**-**
Shale	75.0	76.0	75.5	580.5	579.5	1.0	130	9,666	3,869	5,797	0.00	0.000	0.50	0.0	0	0	0	-	3	75.50	13.3	5.7	0.03	41	-	-	**-**
Shale	76.0	77.0	76.5	579.5	578.5	1.0	130	9,796	3,931	5,865	0.00	0.000	0.50	0.0	0	0	0	-	3	76.50	13.5	5.7	0.03	40	-	-	**-**
Shale	77.0	78.0	77.5	578.5	577.5	1.0	130	9,926	3,994	5,932	0.00	0.000	0.50	0.0	0	0	0	-	3	77.50	13.7	5.7	0.03	39	-	-	**-**
Shale	78.0	79.0	78.5	577.5	576.5	1.0	130	10,056	4,056	6,000	0.00	0.000	0.50	0.0	0	0	0	-	3	78.50	13.9	5.7	0.03	38	-	-	**-**
Shale	79.0	80.0	79.5	576.5	575.5	1.0	130	10,186	4,118	6,068	0.00	0.000	0.50	0.0	0	0	0	-	3	79.50	14.0	5.7	0.02	37	-	-	**-**
Shale	80.0	81.0	80.5	575.5	574.5	1.0	130	10,316	4,181	6,135	0.00	0.000	0.50	0.0	0	0	0	-	3	80.50	14.2	5.7	0.02	36	-	-	**-**
Shale	81.0	82.0	81.5	574.5	573.5	1.0	130	10,446	4,243	6,203	0.00	0.000	0.50	0.0	0	0	0	-	3	81.50	14.4	5.7	0.02	36	-	-	**-**
Shale	82.0	83.0	82.5	573.5	572.5	1.0	130	10,576	4,306	6,270	0.00	0.000	0.50	0.0	0	0	0	-	3	82.50	14.6	5.7	0.02	35	-	-	**-**
Shale	83.0	84.0	83.5	572.5	571.5	1.0	130	10,706	4,368	6,338	0.00	0.000	0.50	0.0	0	0	0	-	3	83.50	14.7	5.7	0.02	34	-	-	**-**
Shale	84.0	85.0	84.5	571.5	570.5	1.0	130	10,836	4,430	6,406	0.00	0.000	0.50	0.0	0	0	0	-	3	84.50	14.9	5.7	0.02	33	-	-	**-**
Shale	85.0	86.0	85.5	570.5	569.5	1.0	130	10,966	4,493	6,473	0.00	0.000	0.50	0.0	0	0	0	-	3	85.50	15.1	5.7	0.02	32	-	-	**-**
Shale	86.0	87.0	86.5	569.5	568.5	1.0	130	11,096	4,555	6,541	0.00	0.000	0.50	0.0	0	0	0	-	3	86.50	15.3	5.7	0.02	32	-	-	**-**
Shale	87.0	88.0	87.5	568.5	567.5	1.0	130	11,226	4,618	6,608	0.00	0.000	0.50	0.0	0	0	0	-	3	87.50	15.4	5.7	0.02	31	-	-	**-**
Shale	88.0	89.0	88.5	567.5	566.5	1.0	130	11,356	4,680	6,676	0.00	0.000	0.50	0.0	0	0	0	-	3	88.50	15.6	5.7	0.02	30	-	-	**-**
Shale	89.0	90.0	89.5	566.5	565.5	1.0	130	11,486	4,742	6,744	0.00	0.000	0.50	0.0	0	0	0	-	3	89.50	15.8	5.7	0.02	30	-	-	**-**
Shale	90.0	91.0	90.5	565.5	564.5	1.0	130	11,616	4,805	6,811	0.00	0.000	0.50	0.0	0	0	0	-	3	90.50	16.0	5.7	0.02	29	-	-	**-**
Shale	91.0	92.0	91.5	564.5	563.5	1.0	130	11,746	4,867	6,879	0.00	0.000	0.50	0.0	0	0	0	-	3	91.50	16.2	5.7	0.02	28	-	-	**-**
Shale	92.0	93.0	92.5	563.5	562.5	1.0	130	11,876	4,930	6,946	0.00	0.000	0.50	0.0	0	0	0	-	3	92.50	16.3	5.7	0.02	28	-	-	**-**
Shale	93.0	94.0	93.5	562.5	561.5	1.0	130	12,006	4,992	7,014	0.00	0.000	0.50	0.0	0	0	0	-	3	93.50	16.5	5.7	0.02	27	-	-	**-**
Shale	94.0	95.0	94.5	561.5	560.5	1.0	130	12,136	5,054	7,082	0.00	0.000	0.50	0.0	0	0	0	-	3	94.50	16.7	5.7	0.02	27	-	-	**-**
Shale	95.0	96.0	95.5	560.5	559.5	1.0	130	12,266	5,117	7,149	0.00	0.000	0.50	0.0	0	0	0	-	3	95.50	16.9	5.7	0.02	26	-	-	**-**
Shale	96.0	97.0	96.5	559.5	558.5	1.0	130	12,396	5,179	7,217	0.00	0.000	0.50	0.0	0	0	0	-	3	96.50	17.0	5.7	0.02	26	-	-	**-**
Shale	97.0	98.0	97.5	558.5	557.5	1.0	130	12,526	5,242	7,284	0.00	0.000	0.50	0.0	0	0	0	-	3	97.50	17.2	5.7	0.02	25	-	-	**-**
Shale	98.0	99.0	98.5	557.5	556.5	1.0	130	12,656	5,304	7,352	0.00	0.000	0.50	0.0	0	0	0	-	3	98.50	17.4	5.7	0.02	25	-	-	**-**
Shale	99.0	100.0	99.5	556.5	555.5	1.0	130	12,786	5,366	7,420	0.00	0.000	0.50	0.0	0	0	0	-	3	99.50	17.6	5.7	0.02	24	-	-	**-**
Shale	100.0	101.0	100.5	555.5	554.5	1.0	130	12,916	5,429	7,487	0.00	0.000	0.50	0.0	0	0	0	-	3	100.50	17.7	5.7	0.02	24	-	-	**-**
#N/A	101.0	102.0	101.5	554.5	553.5	1.0	#N/A	#N/A	5,491	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	101.50	17.9	5.7	0.02	23	-	-	**-**
#N/A	102.0	103.0	102.5	553.5	552.5	1.0	#N/A	#N/A	5,554	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	102.50	18.1	5.7	0.02	23	-	-	**-**
#N/A	103.0	200.0	151.5	552.5	455.5	97.0	#N/A	#N/A	8,611	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	151.50	26.7	5.7	0.01	11	-	-	**-**



Settlement (inches)
0.0
0.5
1.0
1.5
2.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Depth (feet)
Rectangular Footing
Settlement Limit of 1 inch:
Settlement Limit of 1.5 inches:

Project Name:	Plum Creek FRS No. 2 Rehabilitation		Structure	Overtopping RCC Spillway - Crest Structure - Walls
Job Number:	60615067		Analysis Section	Downstream end of crest structure
Client:	TSSWCB		Notes	RCC footing on 2' granular underdrain on in-situ subgrade

Geotechnical Data

Relevant Boring	13-20	-
Boring Ground Elev.	662.27	ft NAVD88
Depth to GWT at Boring:	20.27	feet
GWT Elev.	642	ft NAVD88

Exiting Ground at Structure Location

Structure Existing Ground:	661	ft NAVD88
Footing Bearing Elev.:	655.5	ft NAVD88
Footing Bearing Elev.:	5.5	ft below existing (cut)
GWT Depth below Exist.:	19	feet
GWT Depth below footing.:	13.5	feet

Area Fill

Fill between existing/footing?	no	-
Include load from area fill?	no	-
Finish Grade of Area Fill:	655.5	ft NAVD88
Height above existing:	#N/A	feet
Height above footing base:	#N/A	feet
Thickness under footing:	#N/A	feet
Area Fill Unit Weight:	126	pcf

Subgrade Overexcavation/Replacement

Include Overex/Replacement?	yes	-
Overex/Replace Bottom Elev.	653.5	ft NAVD88
Depth below footing:	2	feet
Depth below existing:	7.5	feet

Structure Footing Size & Maximum Bearing Pressure

Footing Width, B:	11.33	feet
Footing Length, L (rect):	30	feet
Gross Footing Pressure, $q_{0\text{-gross}}$	1,500	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula do not edit

Design Soil Profile and Properties

					1	2	3	4	5	6	7	8	9	10
Depth at Boring (feet)		Elevation (feet)		Thickness in Boring	Existing Depth at Structure (feet)		Thickness at Structure	Layer Name	Total Unit Wt	Initial Void Ratio, e_0*	Compression Index, C_c*	Recomp. Index, C_r*	Min. Over Consolidation Ratio, OCR*	Min. Preconsol. Pressure, P'c*
Top	Bottom	Top	Bottom	(feet)	Top	Bottom	(feet)		(pcf)	(-)				(psf)
0	19	662.3	643.3	19.0	0.0	17.7	17.7	Embank. Fill (Core)	125	0.60	0.20	0.030	2.0	4,000
19	40	643.3	622.3	21.0	17.7	38.7	21.0	Residuum (MPR)	126	0.60	0.20	0.030	2.0	4,000
40	100	622.3	562.3	60.0	38.7	98.7	60.0	Shale	130	0.50	0.0	0.000	0.0	0

Notes: *Copy down elevation and thickness formulas if more layers are needed, delete formulas where not needed.*

*Enter "0" for incompressible layers (i.e., granular soils and bedrock)

Method: Settlement Below Center of Uniformly Loaded Rectangular Footing

Project	Plum Creek FRS No. 2 Rehabilitation
Structure	Overtopping RCC Spillway - Crest Structure - Walls
Analysis Section	Downstream end of crest structure

Elev. - Existing Ground @ Structure:	661	ft NAVD88	-5.5	ft from footing base (above)	0	ft from existing (below)
Elev. - Base of Footing / Bearing Depth	655.5	ft NAVD88	0	ft from footing base (below)	5.5	ft from existing (below)
Elev. - Top of Area Fill	#N/A	ft NAVD88	#N/A	#N/A	#N/A	#N/A
Elev. - Bottom of Overex./Replace	653.5	ft NAVD88	2	ft from footing base (below)	7.5	ft from existing (below)
Elev. - Groundwater	642	ft NAVD88	13.5	ft from footing base (below)	19	ft from existing (below)
Thickness - Area Fill	#N/A	feet below footing base				
Thickness - Overex/Replace	2	feet below footing base				

Footing Width, B:	11.33	feet
Footing Length, L (square):	11.33	feet
Footing Length, L (rect):	30	feet

Gross Footing Pressure, $q_{0\text{-gross}}$	1,500	psf
Removed in-situ stress	688	psf
Net Footing Pressure, $q_{0\text{-net}}$	813	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula (do not edit)
xxx	= Unique Formula (do not edit)

$$\Delta\sigma_z = qI_4 \tag{10.34}$$

where

$$I_4 = \frac{2}{\pi}\left[\frac{m_1 n_1}{\sqrt{1+m_1^2+n_1^2}}\frac{1+m_1^2+2n_1^2}{(1+n_1^2)(m_1^2+n_1^2)} + \sin^{-1}\frac{m_1}{\sqrt{m_1^2+n_1^2}\sqrt{1+n_1^2}}\right] \tag{10.35}$$

$$m_1 = \frac{L}{B} \tag{10.36}$$

$$n_1 = \frac{z}{b} \tag{10.37}$$

$$b = \frac{B}{2} \tag{10.38}$$

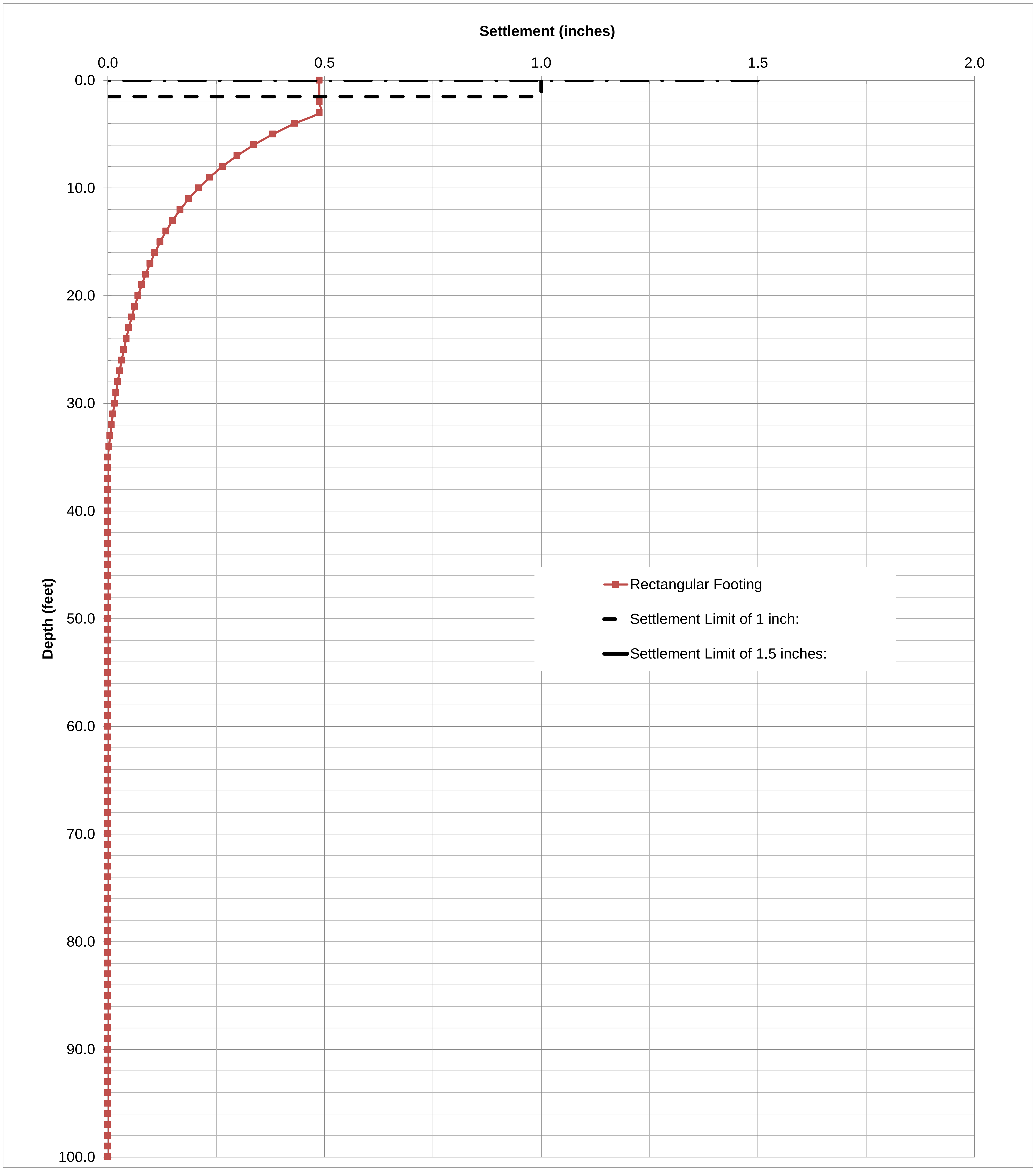
Negative values indicate height above existing ground

**Assume granular*

Total Settlement (inch) = 0.49

Stratum	Depth from Existing* Top	Bottom	MP	Elevation Top	Bottom	Layer Thickness	Layer Unit Wt.	In-Situ Stresse at MP Total P_0	μ	Eff. P'_0	Consolidation Parameters Cc	Cr	e0	OCR	P'_c	Area Fill above Existing Thick-ness	ΔP_{Fill}	Self Compress*	Rectangular Footing m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	S_t
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	(inch)
Fill below footing/above exist.	0.0	0.0	0.0	661.0	661.0	0.0	126	-	-	-	-	-	-	-	-	0	0	-	3	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-
Existing Soil Above Footing	0.0	5.5	2.8	661.0	655.5	5.5	125	-	-	-	-	-	-	-	-	0	0	-	3	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-
Overex. below Existing	0.0	7.5	3.8	661.0	653.5	7.5	125	-	-	-	-	-	-	-	-	0	0	-	3	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-
Embank. Fill (Core)	7.5	8.5	8	653.5	652.5	1.0	125	1,000	0	1,000	0.20	0.030	0.60	2.0	4,000	0	0	-	3	2.50	0.4	5.7	0.97	788	0.06	0.00	0.057
Embank. Fill (Core)	8.5	9.5	9	652.5	651.5	1.0	125	1,125	0	1,125	0.20	0.030	0.60	2.0	4,000	0	0	-	3	3.50	0.6	5.7	0.93	756	0.05	0.00	0.050
Embank. Fill (Core)	9.5	10.5	10	651.5	650.5	1.0	125	1,250	0	1,250	0.20	0.030	0.60	2.0	4,000	0	0	-	3	4.50	0.8	5.7	0.88	714	0.04	0.00	0.044
Embank. Fill (Core)	10.5	11.5	11	650.5	649.5	1.0	125	1,375	0	1,375	0.20	0.030	0.60	2.0	4,000	0	0	-	3	5.50	1.0	5.7	0.82	667	0.04	0.00	0.039
Embank. Fill (Core)	11.5	12.5	12	649.5	648.5	1.0	125	1,500	0	1,500	0.20	0.030	0.60	2.0	4,000	0	0	-	3	6.50	1.1	5.7	0.76	619	0.03	0.00	0.034
Embank. Fill (Core)	12.5	13.5	13	648.5	647.5	1.0	125	1,625	0	1,625	0.20	0.030	0.60	2.0	4,000	0	0	-	3	7.50	1.3	5.7	0.70	572	0.03	0.00	0.029
Embank. Fill (Core)	13.5	14.5	14	647.5	646.5	1.0	125	1,750	0	1,750	0.20	0.030	0.60	2.0	4,000	0	0	-	3	8.50	1.5	5.7	0.65	527	0.03	0.00	0.026
Embank. Fill (Core)	14.5	15.5	15	646.5	645.5	1.0	125	1,875	0	1,875	0.20	0.030	0.60	2.0	4,000	0	0	-	3	9.50	1.7	5.7	0.60	486	0.02	0.00	0.023
Embank. Fill (Core)	15.5	16.5	16	645.5	644.5	1.0	125	2,000	0	2,000	0.20	0.030	0.60	2.0	4,000	0	0	-	3	10.50	1.9	5.7	0.55	448	0.02	0.00	0.020
Embank. Fill (Core)	16.5	17.5	17	644.5	643.5	1.0	125	2,125	0	2,125	0.20	0.030	0.60	2.0	4,250	0	0	-	3	11.50	2.0	5.7	0.51	413	0.02	0.00	0.017
Embank. Fill (Core)	17.5	18.5	18	643.5	642.5	1.0	125	2,250	0	2,250	0.20	0.030	0.60	2.0	4,500	0	0	-	3	12.50	2.2	5.7	0.47	381	0.02	0.00	0.015
Residuum (MPR)	18.5	19.5	19	642.5	641.5	1.0	126	2,376	0	2,376	0.20	0.030	0.60	2.0	4,751	0	0	-	3	13.50	2.4	5.7	0.43	352	0.01	0.00	0.014
Residuum (MPR)	19.5	20.5	20	641.5	640.5	1.0	126	2,502	62	2,439	0.20	0.030	0.60	2.0	4,878	0	0	-	3	14.50	2.6	5.7	0.40	326	0.01	0.00	0.012
Residuum (MPR)	20.5	21.5	21	640.5	639.5	1.0	126	2,628	125	2,503	0.20	0.030	0.60	2.0	5,005	0	0	-	3	15.50	2.7	5.7	0.37	303	0.01	0.00	0.011
Residuum (MPR)	21.5	22.5	22	639.5	638.5	1.0	126	2,754	187	2,566	0.20	0.030	0.60	2.0	5,133	0	0	-	3	16.50	2.9	5.7	0.35	281	0.01	0.00	0.010
Residuum (MPR)	22.5	23.5	23	638.5	637.5	1.0	126	2,880	250	2,630	0.20	0.030	0.60	2.0	5,260	0	0	-	3	17.50	3.1	5.7	0.32	261	0.01	0.00	0.009
Residuum (MPR)	23.5	24.5	24	637.5	636.5	1.0	126	3,006	312	2,694	0.20	0.030	0.60	2.0	5,387	0	0	-	3	18.50	3.3	5.7	0.30	243	0.01	0.00	0.008
Residuum (MPR)	24.5	25.5	25	636.5	635.5	1.0	126	3,132	374	2,757	0.20	0.030	0.60	2.0	5,514	0	0	-	3	19.50	3.4	5.7	0.28	227	0.01	0.00	0.008
Residuum (MPR)	25.5	26.5	26	635.5	634.5	1.0	126	3,258	437	2,821	0.20	0.030	0.60	2.0	5,641	0	0	-	3	20.50	3.6	5.7	0.26	212	0.01	0.00	0.007
Residuum (MPR)	26.5	27.5	27	634.5	633.5	1.0	126	3,384	499	2,884	0.20	0.030	0.60	2.0	5,769	0	0	-	3	21.50	3.8	5.7	0.24	198	0.01	0.00	0.006
Residuum (MPR)	27.5	28.5	28	633.5	632.5	1.0	126	3,510	562	2,948	0.20	0.030	0.60	2.0	5,896	0	0	-	3	22.50	4.0	5.7	0.23	186	0.01	0.00	0.006
Residuum (MPR)	28.5	29.5	29	632.5	631.5	1.0	126	3,636	624	3,012	0.20	0.030	0.60	2.0	6,023	0	0	-	3	23.50	4.1	5.7	0.21	174	0.01	0.00	0.005
Residuum (MPR)	29.5	30.5	30	631.5	630.5	1.0	126	3,762	686	3,075	0.20	0.030	0.60	2.0	6,150	0	0	-	3	24.50	4.3	5.7	0.20	164	0.01	0.00	0.005
Residuum (MPR)	30.5	31.5	31	630.5	629.5	1.0	126	3,888	749	3,139	0.20	0.030	0.60	2.0	6,277	0	0	-	3	25.50	4.5	5.7	0.19	154	0.00	0.00	0.005
Residuum (MPR)	31.5	32.5	32	629.5	628.5	1.0	126	4,014	811	3,202	0.20	0.030	0.60	2.0	6,405	0	0	-	3	26.50	4.7	5.7	0.18	145	0.00	0.00	0.004
Residuum (MPR)	32.5	33.5	33	628.5	627.5	1.0	126	4,140	874	3,266	0.20	0.030	0.60	2.0	6,532	0	0	-	3	27.50	4.9	5.7	0.17	137	0.00	0.00	0.004
Residuum (MPR)	33.5	34.5	34	627.5	626.5	1.0	126	4,266	936	3,330	0.20	0.030	0.60	2.0	6,659	0	0	-	3	28.50	5.0	5.7	0.16	129	0.00	0.00	0.004
Residuum (MPR)	34.5	35.5	35	626.5	625.5	1.0	126	4,392	998	3,393	0.20	0.030	0.60	2.0	6,786	0	0	-	3	29.50	5.2	5.7	0.15	122	0.00	0.00	0.003
Residuum (MPR)	35.5	36.5	36	625.5	624.5	1.0	126	4,518	1,061	3,457	0.20	0.030	0.60	2.0	6,913	0	0	-	3	30.50	5.4	5.7	0.14	116	0.00	0.00	0.003
Residuum (MPR)	36.5	37.5	37	624.5	623.5	1.0	126	4,644	1,123	3,520	0.20	0.030	0.60	2.0	7,041	0	0	-	3	31.50	5.6	5.7	0.14	110	0.00	0.00	0.003
Residuum (MPR)	37.5	38.5	38	623.5	622.5	1.0	126	4,770	1,186	3,584	0.20	0.030	0.60	2.0	7,168	0	0	-	3	32.50	5.7	5.7	0.13	104	0.00	0.00	0.003
Residuum (MPR)	38.5	39.5	39	622.5	621.5	1.0	126	4,896	1,248	3,648	0.20	0.030	0.60	2.0	7,295	0	0	-	3	33.50	5.9	5.7	0.12	99	0.00	0.00	0.003
Shale	39.5	40.5	40	621.5	620.5	1.0	130	5,024	1,310	3,713	0.00	0.000	0.50	0.0	0	0	0	-	3	34.50	6.1	5.7	0.12	94	-	-	-
Shale	40.5	41.5	41	620.5	619.5	1.0	130	5,154	1,373	3,781	0.00	0.000	0.50	0.0	0	0	0	-	3	35.50	6.3	5.7	0.11	90	-	-	-
Shale	41.5	42.5	42	619.5	618.5	1.0	130	5,284	1,435	3,848	0.00	0.000	0.50	0.0	0	0	0	-	3	36.50	6.4	5.7	0.11	86	-	-	-
Shale	42.5	43.5	43	618.5	617.5	1.0	130	5,414	1,498	3,916	0.00	0.000	0.50	0.0	0	0	0	-	3	37.50	6.6	5.7	0.10	82	-	-	-
Shale	43.5	44.5	44	617.5	616.5	1.0	130	5,544	1,560	3,984	0.00	0.000	0.50	0.0	0	0	0	-	3	38.50	6.8	5.7	0.10	78	-	-	-
Shale	44.5	45.5	45	616.5	615.5	1.0	130	5,674	1,622	4,051	0.00	0.000	0.50	0.0	0	0	0	-	3	39.50	7.0	5.7	0.09	74	-	-	-
Shale	45.5	46.5	46	615.5	614.5	1.0	130	5,804	1,685	4,119	0.00	0.000	0.50	0.0	0	0	0	-	3	40.50	7.1	5.7	0.09	71	-	-	-
Shale	46.5	47.5	47	614.5	613.5	1.0	130	5,934	1,747	4,186	0.00	0.000	0.50	0.0	0	0	0	-	3	41.50	7.3	5.7	0.08	68	-	-	-
Shale	47.5	48.5	48	613.5	612.5	1.0	130	6,064	1,810	4,254	0.00	0.000	0.50	0.0	0	0	0	-	3	42.50	7.5	5.7	0.08	65	-	-	-

	Depth from Existing*			Elevation		Layer Thickness	Layer Unit Wt.	In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom			Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	**S_t**
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	**(inch)**
Shale	48.5	49.5	49	612.5	611.5	1.0	130	6,194	1,872	4,322	0.00	0.000	0.50	0.0	0	0	0	-	3	43.50	7.7	5.7	0.08	63	-	-	-
Shale	49.5	50.5	50	611.5	610.5	1.0	130	6,324	1,934	4,389	0.00	0.000	0.50	0.0	0	0	0	-	3	44.50	7.9	5.7	0.07	60	-	-	-
Shale	50.5	51.5	51	610.5	609.5	1.0	130	6,454	1,997	4,457	0.00	0.000	0.50	0.0	0	0	0	-	3	45.50	8.0	5.7	0.07	58	-	-	-
Shale	51.5	52.5	52	609.5	608.5	1.0	130	6,584	2,059	4,524	0.00	0.000	0.50	0.0	0	0	0	-	3	46.50	8.2	5.7	0.07	56	-	-	-
Shale	52.5	53.5	53	608.5	607.5	1.0	130	6,714	2,122	4,592	0.00	0.000	0.50	0.0	0	0	0	-	3	47.50	8.4	5.7	0.07	53	-	-	-
Shale	53.5	54.5	54	607.5	606.5	1.0	130	6,844	2,184	4,660	0.00	0.000	0.50	0.0	0	0	0	-	3	48.50	8.6	5.7	0.06	51	-	-	-
Shale	54.5	55.5	55	606.5	605.5	1.0	130	6,974	2,246	4,727	0.00	0.000	0.50	0.0	0	0	0	-	3	49.50	8.7	5.7	0.06	50	-	-	-
Shale	55.5	56.5	56	605.5	604.5	1.0	130	7,104	2,309	4,795	0.00	0.000	0.50	0.0	0	0	0	-	3	50.50	8.9	5.7	0.06	48	-	-	-
Shale	56.5	57.5	57	604.5	603.5	1.0	130	7,234	2,371	4,862	0.00	0.000	0.50	0.0	0	0	0	-	3	51.50	9.1	5.7	0.06	46	-	-	-
Shale	57.5	58.5	58	603.5	602.5	1.0	130	7,364	2,434	4,930	0.00	0.000	0.50	0.0	0	0	0	-	3	52.50	9.3	5.7	0.05	44	-	-	-
Shale	58.5	59.5	59	602.5	601.5	1.0	130	7,494	2,496	4,998	0.00	0.000	0.50	0.0	0	0	0	-	3	53.50	9.4	5.7	0.05	43	-	-	-
Shale	59.5	60.5	60	601.5	600.5	1.0	130	7,624	2,558	5,065	0.00	0.000	0.50	0.0	0	0	0	-	3	54.50	9.6	5.7	0.05	41	-	-	-
Shale	60.5	61.5	61	600.5	599.5	1.0	130	7,754	2,621	5,133	0.00	0.000	0.50	0.0	0	0	0	-	3	55.50	9.8	5.7	0.05	40	-	-	-
Shale	61.5	62.5	62	599.5	598.5	1.0	130	7,884	2,683	5,200	0.00	0.000	0.50	0.0	0	0	0	-	3	56.50	10.0	5.7	0.05	39	-	-	-
Shale	62.5	63.5	63	598.5	597.5	1.0	130	8,014	2,746	5,268	0.00	0.000	0.50	0.0	0	0	0	-	3	57.50	10.2	5.7	0.05	37	-	-	-
Shale	63.5	64.5	64	597.5	596.5	1.0	130	8,144	2,808	5,336	0.00	0.000	0.50	0.0	0	0	0	-	3	58.50	10.3	5.7	0.04	36	-	-	-
Shale	64.5	65.5	65	596.5	595.5	1.0	130	8,274	2,870	5,403	0.00	0.000	0.50	0.0	0	0	0	-	3	59.50	10.5	5.7	0.04	35	-	-	-
Shale	65.5	66.5	66	595.5	594.5	1.0	130	8,404	2,933	5,471	0.00	0.000	0.50	0.0	0	0	0	-	3	60.50	10.7	5.7	0.04	34	-	-	-
Shale	66.5	67.5	67	594.5	593.5	1.0	130	8,534	2,995	5,538	0.00	0.000	0.50	0.0	0	0	0	-	3	61.50	10.9	5.7	0.04	33	-	-	-
Shale	67.5	68.5	68	593.5	592.5	1.0	130	8,664	3,058	5,606	0.00	0.000	0.50	0.0	0	0	0	-	3	62.50	11.0	5.7	0.04	32	-	-	-
Shale	68.5	69.5	69	592.5	591.5	1.0	130	8,794	3,120	5,674	0.00	0.000	0.50	0.0	0	0	0	-	3	63.50	11.2	5.7	0.04	31	-	-	-
Shale	69.5	70.5	70	591.5	590.5	1.0	130	8,924	3,182	5,741	0.00	0.000	0.50	0.0	0	0	0	-	3	64.50	11.4	5.7	0.04	30	-	-	-
Shale	70.5	71.5	71	590.5	589.5	1.0	130	9,054	3,245	5,809	0.00	0.000	0.50	0.0	0	0	0	-	3	65.50	11.6	5.7	0.04	29	-	-	-
Shale	71.5	72.5	72	589.5	588.5	1.0	130	9,184	3,307	5,876	0.00	0.000	0.50	0.0	0	0	0	-	3	66.50	11.7	5.7	0.04	28	-	-	-
Shale	72.5	73.5	73	588.5	587.5	1.0	130	9,314	3,370	5,944	0.00	0.000	0.50	0.0	0	0	0	-	3	67.50	11.9	5.7	0.03	28	-	-	-
Shale	73.5	74.5	74	587.5	586.5	1.0	130	9,444	3,432	6,012	0.00	0.000	0.50	0.0	0	0	0	-	3	68.50	12.1	5.7	0.03	27	-	-	-
Shale	74.5	75.5	75	586.5	585.5	1.0	130	9,574	3,494	6,079	0.00	0.000	0.50	0.0	0	0	0	-	3	69.50	12.3	5.7	0.03	26	-	-	-
Shale	75.5	76.5	76	585.5	584.5	1.0	130	9,704	3,557	6,147	0.00	0.000	0.50	0.0	0	0	0	-	3	70.50	12.4	5.7	0.03	25	-	-	-
Shale	76.5	77.5	77	584.5	583.5	1.0	130	9,834	3,619	6,214	0.00	0.000	0.50	0.0	0	0	0	-	3	71.50	12.6	5.7	0.03	25	-	-	-
Shale	77.5	78.5	78	583.5	582.5	1.0	130	9,964	3,682	6,282	0.00	0.000	0.50	0.0	0	0	0	-	3	72.50	12.8	5.7	0.03	24	-	-	-
Shale	78.5	79.5	79	582.5	581.5	1.0	130	10,094	3,744	6,350	0.00	0.000	0.50	0.0	0	0	0	-	3	73.50	13.0	5.7	0.03	23	-	-	-
Shale	79.5	80.5	80	581.5	580.5	1.0	130	10,224	3,806	6,417	0.00	0.000	0.50	0.0	0	0	0	-	3	74.50	13.2	5.7	0.03	23	-	-	-
Shale	80.5	81.5	81	580.5	579.5	1.0	130	10,354	3,869	6,485	0.00	0.000	0.50	0.0	0	0	0	-	3	75.50	13.3	5.7	0.03	22	-	-	-
Shale	81.5	82.5	82	579.5	578.5	1.0	130	10,484	3,931	6,552	0.00	0.000	0.50	0.0	0	0	0	-	3	76.50	13.5	5.7	0.03	22	-	-	-
Shale	82.5	83.5	83	578.5	577.5	1.0	130	10,614	3,994	6,620	0.00	0.000	0.50	0.0	0	0	0	-	3	77.50	13.7	5.7	0.03	21	-	-	-
Shale	83.5	84.5	84	577.5	576.5	1.0	130	10,744	4,056	6,688	0.00	0.000	0.50	0.0	0	0	0	-	3	78.50	13.9	5.7	0.03	21	-	-	-
Shale	84.5	85.5	85	576.5	575.5	1.0	130	10,874	4,118	6,755	0.00	0.000	0.50	0.0	0	0	0	-	3	79.50	14.0	5.7	0.02	20	-	-	-
Shale	85.5	86.5	86	575.5	574.5	1.0	130	11,004	4,181	6,823	0.00	0.000	0.50	0.0	0	0	0	-	3	80.50	14.2	5.7	0.02	20	-	-	-
Shale	86.5	87.5	87	574.5	573.5	1.0	130	11,134	4,243	6,890	0.00	0.000	0.50	0.0	0	0	0	-	3	81.50	14.4	5.7	0.02	19	-	-	-
Shale	87.5	88.5	88	573.5	572.5	1.0	130	11,264	4,306	6,958	0.00	0.000	0.50	0.0	0	0	0	-	3	82.50	14.6	5.7	0.02	19	-	-	-
Shale	88.5	89.5	89	572.5	571.5	1.0	130	11,394	4,368	7,026	0.00	0.000	0.50	0.0	0	0	0	-	3	83.50	14.7	5.7	0.02	18	-	-	-
Shale	89.5	90.5	90	571.5	570.5	1.0	130	11,524	4,430	7,093	0.00	0.000	0.50	0.0	0	0	0	-	3	84.50	14.9	5.7	0.02	18	-	-	-
Shale	90.5	91.5	91	570.5	569.5	1.0	130	11,654	4,493	7,161	0.00	0.000	0.50	0.0	0	0	0	-	3	85.50	15.1	5.7	0.02	18	-	-	-
Shale	91.5	92.5	92	569.5	568.5	1.0	130	11,784	4,555	7,228	0.00	0.000	0.50	0.0	0	0	0	-	3	86.50	15.3	5.7	0.02	17	-	-	-
Shale	92.5	93.5	93	568.5	567.5	1.0	130	11,914	4,618	7,296	0.00	0.000	0.50	0.0	0	0	0	-	3	87.50	15.4	5.7	0.02	17	-	-	-
Shale	93.5	94.5	94	567.5	566.5	1.0	130	12,044	4,680	7,364	0.00	0.000	0.50	0.0	0	0	0	-	3	88.50	15.6	5.7	0.02	16	-	-	-
Shale	94.5	95.5	95	566.5	565.5	1.0	130	12,174	4,742	7,431	0.00	0.000	0.50	0.0	0	0	0	-	3	89.50	15.8	5.7	0.02	16	-	-	-
Shale	95.5	96.5	96	565.5	564.5	1.0	130	12,304	4,805	7,499	0.00	0.000	0.50	0.0	0	0	0	-	3	90.50	16.0	5.7	0.02	16	-	-	-
Shale	96.5	97.5	97	564.5	563.5	1.0	130	12,434	4,867	7,566	0.00	0.000	0.50	0.0	0	0	0	-	3	91.50	16.2	5.7	0.02	15	-	-	-
Shale	97.5	98.5	98	563.5	562.5	1.0	130	12,564	4,930	7,634	0.00	0.000	0.50	0.0	0	0	0	-	3	92.50	16.3	5.7	0.02	15	-	-	-
Shale	98.5	99.5	99	562.5	561.5	1.0	130	12,694	4,992	7,702	0.00	0.000	0.50	0.0	0	0	0	-	3	93.50	16.5	5.7	0.02	15	-	-	-
#N/A	99.5	100.5	100	561.5	560.5	1.0	#N/A	#N/A	5,054	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	94.50	16.7	5.7	0.02	14	-	-	-
#N/A	100.5	101.5	101	560.5	559.5	1.0	#N/A	#N/A	5,117	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	95.50	16.9	5.7	0.02	14	-	-	-
#N/A	101.5	102.5	102	559.5	558.5	1.0	#N/A	#N/A	5,179	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	96.50	17.0	5.7	0.02	14	-	-	-
#N/A	102.5	103.5	103	558.5	557.5	1.0	#N/A	#N/A	5,242	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	97.50	17.2	5.7	0.02	14	-	-	-
#N/A	103.5	104.5	104	557.5	556.5	1.0	#N/A	#N/A	5,304	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	98.50	17.4	5.7	0.02	13	-	-	-
#N/A	104.5	105.5	105	556.5	555.5	1.0	#N/A	#N/A	5,366	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	99.50	17.6	5.7	0.02	13	-	-	-
#N/A	105.5	106.5	106	555.5	554.5	1.0	#N/A	#N/A	5,429	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	100.50	17.7	5.7	0.02	13	-	-	-
#N/A	106.5	107.5	107	554.5	553.5	1.0	#N/A	#N/A	5,491	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	101.50	17.9	5.7	0.02	13	-	-	-
#N/A	107.5	108.5	108	553.5	552.5	1.0	#N/A	#N/A	5,554	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	102.50	18.1	5.7	0.02	12	-	-	-
#N/A	108.5	109.5	109	552.5	551.5	1.0	#N/A	#N/A	5,616	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	103.50	18.3	5.7	0.01	12	-	-	-
#N/A	109.5	110.5	110	551.5	550.5	1.0	#N/A	#N/A	5,678	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	104.50	18.4	5.7	0.01	12	-	-	-
#N/A	110.5	200.0	155.3	550.5	461.0	89.5	#N/A	#N/A	8,502	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	149.75	26.4	5.7	0.01	6	-	-	-


Settlement (inches)
0.0
0.5
1.0
1.5
2.0
Depth (feet)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Rectangular Footing
Settlement Limit of 1 inch:
Settlement Limit of 1.5 inches:

Project Name:	Plum Creek FRS No. 2 Rehabilitation		Structure	Overtopping RCC Spillway - Crest Structure - Walls
Job Number:	60615067		Analysis Section	Downstream end of crest structure
Client:	TSSWCB		Notes	RCC footing on overexcavation/replacement embankment fill

Geotechnical Data

Relevant Boring	n/a	-
Boring Ground Elev.	655.5	ft NAVD88
Depth to GWT at Boring:	13.5	feet
GWT Elev.	642	ft NAVD88

Exiting Ground at Structure Location

Structure Existing Ground:	655.5	ft NAVD88
Footing Bearing Elev.:	655.5	ft NAVD88
Footing Bearing Elev.:	0	ft below existing (cut)
GWT Depth below Exist.:	13.5	feet
GWT Depth below footing.:	13.5	feet

Area Fill

Fill between existing/footing?	no	-
Include load from area fill?	no	-
Finish Grade of Area Fill:	655.5	ft NAVD88
Height above existing:	#N/A	feet
Height above footing base:	#N/A	feet
Thickness under footing:	#N/A	feet
Area Fill Unit Weight:	126	pcf

Subgrade Overexcavation/Replacement

Include Overex/Replacement?	yes	-
Overex/Replace Bottom Elev.	653.5	ft NAVD88
Depth below footing:	2	feet
Depth below existing:	2	feet

Structure Footing Size & Maximum Bearing Pressure

Footing Width, B:	11.33	feet
Footing Length, L (rect):	30	feet
Gross Footing Pressure, $q_{0\text{-gross}}$	1,500	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula do not edit

Design Soil Profile and Properties

Depth at Boring (feet)		Elevation (feet)		Thickness in Boring	1 Existing Depth at Structure (feet)	2	3 Thickness at Structure	4 Layer Name	5 Total Unit Wt	6 Initial Void Ratio, e_0*	7 Compression Index, C_c*	8 Recomp. Index, C_r*	9 Min. Over Consolidation Ratio, OCR*	10 Min. Preconsol. Pressure, P'c*
Top	Bottom	Top	Bottom	(feet)	Top	Bottom	(feet)		(pcf)	(-)				(psf)
0	8	655.5	647.5	8.0	0.0	8.0	8.0	New Embank. Fill	125	0.65	0.20	0.020	2.0	3,000
8	12.3	647.5	643.2	4.3	8.0	12.3	4.3	Embank. Fill (Core)	125	0.60	0.20	0.030	2.0	4,000
12.3	33.3	643.2	622.2	21.0	12.3	33.3	21.0	Residuum (MPR)	126	0.60	0.20	0.030	2.0	4,000
33.3	100	622.2	555.5	66.7	33.3	100.0	66.7	Shale	130	0.50	0.0	0.000	0.0	0

Notes: *Copy down elevation and thickness formulas if more layers are needed, delete formulas where not needed.*

*Enter "0" for incompressible layers (i.e., granular soils and bedrock)

Method: Settlement Below Center of Uniformly Loaded Rectangular Footing

Project	Plum Creek FRS No. 2 Rehabilitation
Structure	Overtopping RCC Spillway - Crest Structure - Walls
Analysis Section	Downstream end of crest structure

Elev. - Existing Ground @ Structure:	655.5	ft NAVD88	0	ft from footing base (below)	0	ft from existing (below)
Elev. - Base of Footing / Bearing Depth	655.5	ft NAVD88	0	ft from footing base (below)	0	ft from existing (below)
Elev. - Top of Area Fill	#N/A	ft NAVD88	#N/A	#N/A	#N/A	#N/A
Elev. - Bottom of Overex./Replace	653.5	ft NAVD88	2	ft from footing base (below)	2	ft from existing (below)
Elev. - Groundwater	642	ft NAVD88	13.5	ft from footing base (below)	13.5	ft from existing (below)
Thickness - Area Fill	#N/A	feet below footing base				
Thickness - Overex/Replace	2	feet below footing base				

Footing Width, B:	11.33	feet
Footing Length, L (square):	11.33	feet
Footing Length, L (rect):	30	feet

Gross Footing Pressure, $q_{0\text{-gross}}$	1,500	psf
Removed in-situ stress	0	psf
Net Footing Pressure, $q_{0\text{-net}}$	1,500	psf

$$\Delta\sigma_z = qI_4 \qquad (10.34)$$

where

$$I_4 = \frac{2}{\pi}\left[\frac{m_1 n_1}{\sqrt{1+m_1^2+n_1^2}}\,\frac{1+m_1^2+2n_1^2}{(1+n_1^2)(m_1^2+n_1^2)} + \sin^{-1}\frac{m_1}{\sqrt{m_1^2+n_1^2}\sqrt{1+n_1^2}}\right] \qquad (10.35)$$

$$m_1 = \frac{L}{B} \qquad (10.36)$$

$$n_1 = \frac{z}{b} \qquad (10.37)$$

$$b = \frac{B}{2} \qquad (10.38)$$

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula (do not edit)
xxx	= Unique Formula (do not edit)

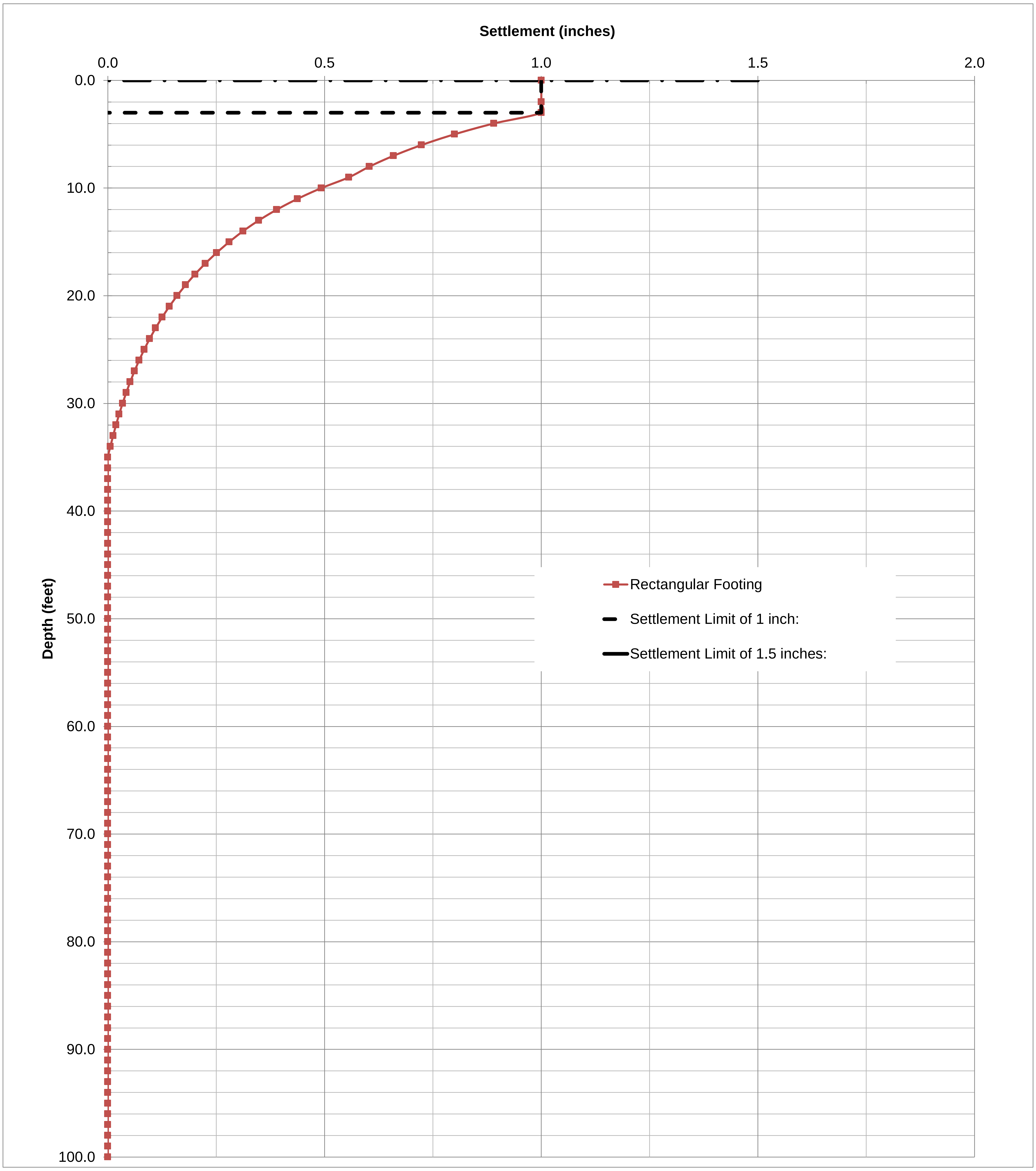
*Negative values indicate height above existing ground

*Assume granular

Total Settlement (inch) = 1.00

Stratum	Depth from Existing*			Elevation		Layer Thickness	Layer Unit Wt.	In-Situ Stress at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom	Layer Thickness	Layer Unit Wt.	Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	**S_t**
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	**(inch)**
Fill below footing/above exist.	0.0	0.0	0.0	655.5	655.5	0.0	126	-	-	-	-	-	-	-	-	0	0	-	3	0.00	0.0	5.7	1.00	1,500	-	-	**-**
Existing Soil Above Footing	0.0	0.0	0.0	655.5	655.5	0.0	125	-	-	-	-	-	-	-	-	0	0	-	3	0.00	0.0	5.7	1.00	1,500	-	-	**-**
Overex. below Existing	0.0	2.0	1.0	655.5	653.5	2.0	125	-	-	-	-	-	-	-	-	0	0	-	3	1.00	0.2	5.7	1.00	1,497	-	-	**-**
New Embank. Fill	2.0	3.0	2.5	653.5	652.5	1.0	125	313	0	313	0.20	0.020	0.65	2.0	3,000	0	0	-	3	2.50	0.4	5.7	0.97	1,455	0.11	0.00	**0.109**
New Embank. Fill	3.0	4.0	3.5	652.5	651.5	1.0	125	438	0	438	0.20	0.020	0.65	2.0	3,000	0	0	-	3	3.50	0.6	5.7	0.93	1,396	0.09	0.00	**0.091**
New Embank. Fill	4.0	5.0	4.5	651.5	650.5	1.0	125	563	0	563	0.20	0.020	0.65	2.0	3,000	0	0	-	3	4.50	0.8	5.7	0.88	1,318	0.08	0.00	**0.076**
New Embank. Fill	5.0	6.0	5.5	650.5	649.5	1.0	125	688	0	688	0.20	0.020	0.65	2.0	3,000	0	0	-	3	5.50	1.0	5.7	0.82	1,231	0.06	0.00	**0.065**
New Embank. Fill	6.0	7.0	6.5	649.5	648.5	1.0	125	813	0	813	0.20	0.020	0.65	2.0	3,000	0	0	-	3	6.50	1.1	5.7	0.76	1,142	0.06	0.00	**0.055**
New Embank. Fill	7.0	8.0	7.5	648.5	647.5	1.0	125	938	0	938	0.20	0.020	0.65	2.0	3,000	0	0	-	3	7.50	1.3	5.7	0.70	1,055	0.05	0.00	**0.048**
Embank. Fill (Core)	8.0	9.0	8.5	647.5	646.5	1.0	125	1,063	0	1,063	0.20	0.030	0.60	2.0	4,000	0	0	-	3	8.50	1.5	5.7	0.65	973	0.06	0.00	**0.064**
Embank. Fill (Core)	9.0	10.0	9.5	646.5	645.5	1.0	125	1,188	0	1,188	0.20	0.030	0.60	2.0	4,000	0	0	-	3	9.50	1.7	5.7	0.60	897	0.05	0.00	**0.055**
Embank. Fill (Core)	10.0	11.0	10.5	645.5	644.5	1.0	125	1,313	0	1,313	0.20	0.030	0.60	2.0	4,000	0	0	-	3	10.50	1.9	5.7	0.55	826	0.05	0.00	**0.048**
Embank. Fill (Core)	11.0	12.0	11.5	644.5	643.5	1.0	125	1,438	0	1,438	0.20	0.030	0.60	2.0	4,000	0	0	-	3	11.50	2.0	5.7	0.51	762	0.04	0.00	**0.042**
Embank. Fill (Core)	12.0	13.0	12.5	643.5	642.5	1.0	125	1,563	0	1,563	0.20	0.030	0.60	2.0	4,000	0	0	-	3	12.50	2.2	5.7	0.47	704	0.04	0.00	**0.036**
Residuum (MPR)	13.0	14.0	13.5	642.5	641.5	1.0	126	1,688	0	1,688	0.20	0.030	0.60	2.0	4,000	0	0	-	3	13.50	2.4	5.7	0.43	651	0.03	0.00	**0.032**
Residuum (MPR)	14.0	15.0	14.5	641.5	640.5	1.0	126	1,814	62	1,752	0.20	0.030	0.60	2.0	4,000	0	0	-	3	14.50	2.6	5.7	0.40	602	0.03	0.00	**0.029**
Residuum (MPR)	15.0	16.0	15.5	640.5	639.5	1.0	126	1,940	125	1,815	0.20	0.030	0.60	2.0	4,000	0	0	-	3	15.50	2.7	5.7	0.37	558	0.03	0.00	**0.026**
Residuum (MPR)	16.0	17.0	16.5	639.5	638.5	1.0	126	2,066	187	1,879	0.20	0.030	0.60	2.0	4,000	0	0	-	3	16.50	2.9	5.7	0.35	519	0.02	0.00	**0.024**
Residuum (MPR)	17.0	18.0	17.5	638.5	637.5	1.0	126	2,192	250	1,942	0.20	0.030	0.60	2.0	4,000	0	0	-	3	17.50	3.1	5.7	0.32	482	0.02	0.00	**0.022**
Residuum (MPR)	18.0	19.0	18.5	637.5	636.5	1.0	126	2,318	312	2,006	0.20	0.030	0.60	2.0	4,012	0	0	-	3	18.50	3.3	5.7	0.30	449	0.02	0.00	**0.020**
Residuum (MPR)	19.0	20.0	19.5	636.5	635.5	1.0	126	2,444	374	2,070	0.20	0.030	0.60	2.0	4,139	0	0	-	3	19.50	3.4	5.7	0.28	419	0.02	0.00	**0.018**
Residuum (MPR)	20.0	21.0	20.5	635.5	634.5	1.0	126	2,570	437	2,133	0.20	0.030	0.60	2.0	4,266	0	0	-	3	20.50	3.6	5.7	0.26	391	0.02	0.00	**0.016**
Residuum (MPR)	21.0	22.0	21.5	634.5	633.5	1.0	126	2,696	499	2,197	0.20	0.030	0.60	2.0	4,394	0	0	-	3	21.50	3.8	5.7	0.24	366	0.02	0.00	**0.015**
Residuum (MPR)	22.0	23.0	22.5	633.5	632.5	1.0	126	2,822	562	2,260	0.20	0.030	0.60	2.0	4,521	0	0	-	3	22.50	4.0	5.7	0.23	343	0.01	0.00	**0.014**
Residuum (MPR)	23.0	24.0	23.5	632.5	631.5	1.0	126	2,948	624	2,324	0.20	0.030	0.60	2.0	4,648	0	0	-	3	23.50	4.1	5.7	0.21	322	0.01	0.00	**0.013**
Residuum (MPR)	24.0	25.0	24.5	631.5	630.5	1.0	126	3,074	686	2,388	0.20	0.030	0.60	2.0	4,775	0	0	-	3	24.50	4.3	5.7	0.20	302	0.01	0.00	**0.012**
Residuum (MPR)	25.0	26.0	25.5	630.5	629.5	1.0	126	3,200	749	2,451	0.20	0.030	0.60	2.0	4,902	0	0	-	3	25.50	4.5	5.7	0.19	284	0.01	0.00	**0.011**
Residuum (MPR)	26.0	27.0	26.5	629.5	628.5	1.0	126	3,326	811	2,515	0.20	0.030	0.60	2.0	5,030	0	0	-	3	26.50	4.7	5.7	0.18	268	0.01	0.00	**0.010**
Residuum (MPR)	27.0	28.0	27.5	628.5	627.5	1.0	126	3,452	874	2,578	0.20	0.030	0.60	2.0	5,157	0	0	-	3	27.50	4.9	5.7	0.17	253	0.01	0.00	**0.009**
Residuum (MPR)	28.0	29.0	28.5	627.5	626.5	1.0	126	3,578	936	2,642	0.20	0.030	0.60	2.0	5,284	0	0	-	3	28.50	5.0	5.7	0.16	239	0.01	0.00	**0.008**
Residuum (MPR)	29.0	30.0	29.5	626.5	625.5	1.0	126	3,704	998	2,706	0.20	0.030	0.60	2.0	5,411	0	0	-	3	29.50	5.2	5.7	0.15	226	0.01	0.00	**0.008**
Residuum (MPR)	30.0	31.0	30.5	625.5	624.5	1.0	126	3,830	1,061	2,769	0.20	0.030	0.60	2.0	5,538	0	0	-	3	30.50	5.4	5.7	0.14	214	0.01	0.00	**0.007**
Residuum (MPR)	31.0	32.0	31.5	624.5	623.5	1.0	126	3,956	1,123	2,833	0.20	0.030	0.60	2.0	5,666	0	0	-	3	31.50	5.6	5.7	0.14	203	0.01	0.00	**0.007**
Residuum (MPR)	32.0	33.0	32.5	623.5	622.5	1.0	126	4,082	1,186	2,896	0.20	0.030	0.60	2.0	5,793	0	0	-	3	32.50	5.7	5.7	0.13	192	0.01	0.00	**0.006**
Residuum (MPR)	33.0	34.0	33.5	622.5	621.5	1.0	126	4,208	1,248	2,960	0.20	0.030	0.60	2.0	5,920	0	0	-	3	33.50	5.9	5.7	0.12	183	0.01	0.00	**0.006**
Shale	34.0	35.0	34.5	621.5	620.5	1.0	130	4,336	1,310	3,026	0.00	0.000	0.50	0.0	0	0	0	-	3	34.50	6.1	5.7	0.12	174	-	-	**-**
Shale	35.0	36.0	35.5	620.5	619.5	1.0	130	4,466	1,373	3,093	0.00	0.000	0.50	0.0	0	0	0	-	3	35.50	6.3	5.7	0.11	166	-	-	**-**
Shale	36.0	37.0	36.5	619.5	618.5	1.0	130	4,596	1,435	3,161	0.00	0.000	0.50	0.0	0	0	0	-	3	36.50	6.4	5.7	0.11	158	-	-	**-**
Shale	37.0	38.0	37.5	618.5	617.5	1.0	130	4,726	1,498	3,228	0.00	0.000	0.50	0.0	0	0	0	-	3	37.50	6.6	5.7	0.10	151	-	-	**-**
Shale	38.0	39.0	38.5	617.5	616.5	1.0	130	4,856	1,560	3,296	0.00	0.000	0.50	0.0	0	0	0	-	3	38.50	6.8	5.7	0.10	144	-	-	**-**
Shale	39.0	40.0	39.5	616.5	615.5	1.0	130	4,986	1,622	3,364	0.00	0.000	0.50	0.0	0	0	0	-	3	39.50	7.0	5.7	0.09	137	-	-	**-**
Shale	40.0	41.0	40.5	615.5	614.5	1.0	130	5,116	1,685	3,431	0.00	0.000	0.50	0.0	0	0	0	-	3	40.50	7.1	5.7	0.09	132	-	-	**-**
Shale	41.0	42.0	41.5	614.5	613.5	1.0	130	5,246	1,747	3,499	0.00	0.000	0.50	0.0	0	0	0	-	3	41.50	7.3	5.7	0.08	126	-	-	**-**
Shale	42.0	43.0	42.5	613.5	612.5	1.0	130	5,376	1,810	3,566	0.00	0.000	0.50	0.0	0	0	0	-	3	42.50	7.5	5.7	0.08	121	-	-	**-**

	Depth from Existing*			Elevation		Layer Thickness	Layer Unit Wt.	In-Situ Stress at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom			Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	**S_t**
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	**(inch)**
Shale	43.0	44.0	43.5	612.5	611.5	1.0	130	5,506	1,872	3,634	0.00	0.000	0.50	0.0	0	0	0	-	3	43.50	7.7	5.7	0.08	116	-	-	-
Shale	44.0	45.0	44.5	611.5	610.5	1.0	130	5,636	1,934	3,702	0.00	0.000	0.50	0.0	0	0	0	-	3	44.50	7.9	5.7	0.07	111	-	-	-
Shale	45.0	46.0	45.5	610.5	609.5	1.0	130	5,766	1,997	3,769	0.00	0.000	0.50	0.0	0	0	0	-	3	45.50	8.0	5.7	0.07	107	-	-	-
Shale	46.0	47.0	46.5	609.5	608.5	1.0	130	5,896	2,059	3,837	0.00	0.000	0.50	0.0	0	0	0	-	3	46.50	8.2	5.7	0.07	103	-	-	-
Shale	47.0	48.0	47.5	608.5	607.5	1.0	130	6,026	2,122	3,904	0.00	0.000	0.50	0.0	0	0	0	-	3	47.50	8.4	5.7	0.07	99	-	-	-
Shale	48.0	49.0	48.5	607.5	606.5	1.0	130	6,156	2,184	3,972	0.00	0.000	0.50	0.0	0	0	0	-	3	48.50	8.6	5.7	0.06	95	-	-	-
Shale	49.0	50.0	49.5	606.5	605.5	1.0	130	6,286	2,246	4,040	0.00	0.000	0.50	0.0	0	0	0	-	3	49.50	8.7	5.7	0.06	91	-	-	-
Shale	50.0	51.0	50.5	605.5	604.5	1.0	130	6,416	2,309	4,107	0.00	0.000	0.50	0.0	0	0	0	-	3	50.50	8.9	5.7	0.06	88	-	-	-
Shale	51.0	52.0	51.5	604.5	603.5	1.0	130	6,546	2,371	4,175	0.00	0.000	0.50	0.0	0	0	0	-	3	51.50	9.1	5.7	0.06	85	-	-	-
Shale	52.0	53.0	52.5	603.5	602.5	1.0	130	6,676	2,434	4,242	0.00	0.000	0.50	0.0	0	0	0	-	3	52.50	9.3	5.7	0.05	82	-	-	-
Shale	53.0	54.0	53.5	602.5	601.5	1.0	130	6,806	2,496	4,310	0.00	0.000	0.50	0.0	0	0	0	-	3	53.50	9.4	5.7	0.05	79	-	-	-
Shale	54.0	55.0	54.5	601.5	600.5	1.0	130	6,936	2,558	4,378	0.00	0.000	0.50	0.0	0	0	0	-	3	54.50	9.6	5.7	0.05	76	-	-	-
Shale	55.0	56.0	55.5	600.5	599.5	1.0	130	7,066	2,621	4,445	0.00	0.000	0.50	0.0	0	0	0	-	3	55.50	9.8	5.7	0.05	74	-	-	-
Shale	56.0	57.0	56.5	599.5	598.5	1.0	130	7,196	2,683	4,513	0.00	0.000	0.50	0.0	0	0	0	-	3	56.50	10.0	5.7	0.05	72	-	-	-
Shale	57.0	58.0	57.5	598.5	597.5	1.0	130	7,326	2,746	4,580	0.00	0.000	0.50	0.0	0	0	0	-	3	57.50	10.2	5.7	0.05	69	-	-	-
Shale	58.0	59.0	58.5	597.5	596.5	1.0	130	7,456	2,808	4,648	0.00	0.000	0.50	0.0	0	0	0	-	3	58.50	10.3	5.7	0.04	67	-	-	-
Shale	59.0	60.0	59.5	596.5	595.5	1.0	130	7,586	2,870	4,716	0.00	0.000	0.50	0.0	0	0	0	-	3	59.50	10.5	5.7	0.04	65	-	-	-
Shale	60.0	61.0	60.5	595.5	594.5	1.0	130	7,716	2,933	4,783	0.00	0.000	0.50	0.0	0	0	0	-	3	60.50	10.7	5.7	0.04	63	-	-	-
Shale	61.0	62.0	61.5	594.5	593.5	1.0	130	7,846	2,995	4,851	0.00	0.000	0.50	0.0	0	0	0	-	3	61.50	10.9	5.7	0.04	61	-	-	-
Shale	62.0	63.0	62.5	593.5	592.5	1.0	130	7,976	3,058	4,918	0.00	0.000	0.50	0.0	0	0	0	-	3	62.50	11.0	5.7	0.04	59	-	-	-
Shale	63.0	64.0	63.5	592.5	591.5	1.0	130	8,106	3,120	4,986	0.00	0.000	0.50	0.0	0	0	0	-	3	63.50	11.2	5.7	0.04	57	-	-	-
Shale	64.0	65.0	64.5	591.5	590.5	1.0	130	8,236	3,182	5,054	0.00	0.000	0.50	0.0	0	0	0	-	3	64.50	11.4	5.7	0.04	56	-	-	-
Shale	65.0	66.0	65.5	590.5	589.5	1.0	130	8,366	3,245	5,121	0.00	0.000	0.50	0.0	0	0	0	-	3	65.50	11.6	5.7	0.04	54	-	-	-
Shale	66.0	67.0	66.5	589.5	588.5	1.0	130	8,496	3,307	5,189	0.00	0.000	0.50	0.0	0	0	0	-	3	66.50	11.7	5.7	0.04	53	-	-	-
Shale	67.0	68.0	67.5	588.5	587.5	1.0	130	8,626	3,370	5,256	0.00	0.000	0.50	0.0	0	0	0	-	3	67.50	11.9	5.7	0.03	51	-	-	-
Shale	68.0	69.0	68.5	587.5	586.5	1.0	130	8,756	3,432	5,324	0.00	0.000	0.50	0.0	0	0	0	-	3	68.50	12.1	5.7	0.03	50	-	-	-
Shale	69.0	70.0	69.5	586.5	585.5	1.0	130	8,886	3,494	5,392	0.00	0.000	0.50	0.0	0	0	0	-	3	69.50	12.3	5.7	0.03	48	-	-	-
Shale	70.0	71.0	70.5	585.5	584.5	1.0	130	9,016	3,557	5,459	0.00	0.000	0.50	0.0	0	0	0	-	3	70.50	12.4	5.7	0.03	47	-	-	-
Shale	71.0	72.0	71.5	584.5	583.5	1.0	130	9,146	3,619	5,527	0.00	0.000	0.50	0.0	0	0	0	-	3	71.50	12.6	5.7	0.03	46	-	-	-
Shale	72.0	73.0	72.5	583.5	582.5	1.0	130	9,276	3,682	5,594	0.00	0.000	0.50	0.0	0	0	0	-	3	72.50	12.8	5.7	0.03	45	-	-	-
Shale	73.0	74.0	73.5	582.5	581.5	1.0	130	9,406	3,744	5,662	0.00	0.000	0.50	0.0	0	0	0	-	3	73.50	13.0	5.7	0.03	43	-	-	-
Shale	74.0	75.0	74.5	581.5	580.5	1.0	130	9,536	3,806	5,730	0.00	0.000	0.50	0.0	0	0	0	-	3	74.50	13.2	5.7	0.03	42	-	-	-
Shale	75.0	76.0	75.5	580.5	579.5	1.0	130	9,666	3,869	5,797	0.00	0.000	0.50	0.0	0	0	0	-	3	75.50	13.3	5.7	0.03	41	-	-	-
Shale	76.0	77.0	76.5	579.5	578.5	1.0	130	9,796	3,931	5,865	0.00	0.000	0.50	0.0	0	0	0	-	3	76.50	13.5	5.7	0.03	40	-	-	-
Shale	77.0	78.0	77.5	578.5	577.5	1.0	130	9,926	3,994	5,932	0.00	0.000	0.50	0.0	0	0	0	-	3	77.50	13.7	5.7	0.03	39	-	-	-
Shale	78.0	79.0	78.5	577.5	576.5	1.0	130	10,056	4,056	6,000	0.00	0.000	0.50	0.0	0	0	0	-	3	78.50	13.9	5.7	0.03	38	-	-	-
Shale	79.0	80.0	79.5	576.5	575.5	1.0	130	10,186	4,118	6,068	0.00	0.000	0.50	0.0	0	0	0	-	3	79.50	14.0	5.7	0.02	37	-	-	-
Shale	80.0	81.0	80.5	575.5	574.5	1.0	130	10,316	4,181	6,135	0.00	0.000	0.50	0.0	0	0	0	-	3	80.50	14.2	5.7	0.02	36	-	-	-
Shale	81.0	82.0	81.5	574.5	573.5	1.0	130	10,446	4,243	6,203	0.00	0.000	0.50	0.0	0	0	0	-	3	81.50	14.4	5.7	0.02	36	-	-	-
Shale	82.0	83.0	82.5	573.5	572.5	1.0	130	10,576	4,306	6,270	0.00	0.000	0.50	0.0	0	0	0	-	3	82.50	14.6	5.7	0.02	35	-	-	-
Shale	83.0	84.0	83.5	572.5	571.5	1.0	130	10,706	4,368	6,338	0.00	0.000	0.50	0.0	0	0	0	-	3	83.50	14.7	5.7	0.02	34	-	-	-
Shale	84.0	85.0	84.5	571.5	570.5	1.0	130	10,836	4,430	6,406	0.00	0.000	0.50	0.0	0	0	0	-	3	84.50	14.9	5.7	0.02	33	-	-	-
Shale	85.0	86.0	85.5	570.5	569.5	1.0	130	10,966	4,493	6,473	0.00	0.000	0.50	0.0	0	0	0	-	3	85.50	15.1	5.7	0.02	32	-	-	-
Shale	86.0	87.0	86.5	569.5	568.5	1.0	130	11,096	4,555	6,541	0.00	0.000	0.50	0.0	0	0	0	-	3	86.50	15.3	5.7	0.02	32	-	-	-
Shale	87.0	88.0	87.5	568.5	567.5	1.0	130	11,226	4,618	6,608	0.00	0.000	0.50	0.0	0	0	0	-	3	87.50	15.4	5.7	0.02	31	-	-	-
Shale	88.0	89.0	88.5	567.5	566.5	1.0	130	11,356	4,680	6,676	0.00	0.000	0.50	0.0	0	0	0	-	3	88.50	15.6	5.7	0.02	30	-	-	-
Shale	89.0	90.0	89.5	566.5	565.5	1.0	130	11,486	4,742	6,744	0.00	0.000	0.50	0.0	0	0	0	-	3	89.50	15.8	5.7	0.02	30	-	-	-
Shale	90.0	91.0	90.5	565.5	564.5	1.0	130	11,616	4,805	6,811	0.00	0.000	0.50	0.0	0	0	0	-	3	90.50	16.0	5.7	0.02	29	-	-	-
Shale	91.0	92.0	91.5	564.5	563.5	1.0	130	11,746	4,867	6,879	0.00	0.000	0.50	0.0	0	0	0	-	3	91.50	16.2	5.7	0.02	28	-	-	-
Shale	92.0	93.0	92.5	563.5	562.5	1.0	130	11,876	4,930	6,946	0.00	0.000	0.50	0.0	0	0	0	-	3	92.50	16.3	5.7	0.02	28	-	-	-
Shale	93.0	94.0	93.5	562.5	561.5	1.0	130	12,006	4,992	7,014	0.00	0.000	0.50	0.0	0	0	0	-	3	93.50	16.5	5.7	0.02	27	-	-	-
Shale	94.0	95.0	94.5	561.5	560.5	1.0	130	12,136	5,054	7,082	0.00	0.000	0.50	0.0	0	0	0	-	3	94.50	16.7	5.7	0.02	27	-	-	-
Shale	95.0	96.0	95.5	560.5	559.5	1.0	130	12,266	5,117	7,149	0.00	0.000	0.50	0.0	0	0	0	-	3	95.50	16.9	5.7	0.02	26	-	-	-
Shale	96.0	97.0	96.5	559.5	558.5	1.0	130	12,396	5,179	7,217	0.00	0.000	0.50	0.0	0	0	0	-	3	96.50	17.0	5.7	0.02	26	-	-	-
Shale	97.0	98.0	97.5	558.5	557.5	1.0	130	12,526	5,242	7,284	0.00	0.000	0.50	0.0	0	0	0	-	3	97.50	17.2	5.7	0.02	25	-	-	-
Shale	98.0	99.0	98.5	557.5	556.5	1.0	130	12,656	5,304	7,352	0.00	0.000	0.50	0.0	0	0	0	-	3	98.50	17.4	5.7	0.02	25	-	-	-
Shale	99.0	100.0	99.5	556.5	555.5	1.0	130	12,786	5,366	7,420	0.00	0.000	0.50	0.0	0	0	0	-	3	99.50	17.6	5.7	0.02	24	-	-	-
Shale	100.0	101.0	100.5	555.5	554.5	1.0	130	12,916	5,429	7,487	0.00	0.000	0.50	0.0	0	0	0	-	3	100.50	17.7	5.7	0.02	24	-	-	-
#N/A	101.0	102.0	101.5	554.5	553.5	1.0	#N/A	#N/A	5,491	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	101.50	17.9	5.7	0.02	23	-	-	-
#N/A	102.0	103.0	102.5	553.5	552.5	1.0	#N/A	#N/A	5,554	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	102.50	18.1	5.7	0.02	23	-	-	-
#N/A	103.0	104.0	103.5	552.5	551.5	1.0	#N/A	#N/A	5,616	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	103.50	18.3	5.7	0.01	22	-	-	-
#N/A	104.0	105.0	104.5	551.5	550.5	1.0	#N/A	#N/A	5,678	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	104.50	18.4	5.7	0.01	22	-	-	-
#N/A	105.0	200.0	152.5	550.5	455.5	95.0	#N/A	#N/A	8,674	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	3	152.50	26.9	5.7	0.01	10	-	-	-


Settlement (inches)
0.0
0.5
1.0
1.5
2.0
Depth (feet)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Rectangular Footing
Settlement Limit of 1 inch:
Settlement Limit of 1.5 inches:

ATTACHMENT 5

Settlement Calculations for RCC Spillway – Chute Structure

Project Name:	Plum Creek FRS No. 2 Rehabilitation	Structure	Overtopping RCC Spillway - Chute Structure - Walls
Job Number:	60615067	Analysis Section	Existing downstream toe of dam
Client:	TSSWCB	Notes	RCC footing on in-situ subgrade

Geotechnical Data

Relevant Boring	702-20	-
Boring Ground Elev.	647.79	ft NAVD88
Depth to GWT at Boring:	7.79	feet
GWT Elev.	640	ft NAVD88

Exiting Ground at Structure Location

Structure Existing Ground:	648.3	ft NAVD88
Footing Bearing Elev.:	641.5	ft NAVD88
Footing Bearing Elev.:	6.8	ft below existing (cut)
GWT Depth below Exist.:	8.3	feet
GWT Depth below footing.:	1.5	feet

Area Fill

Fill between existing/footing?	no	-
Include load from area fill?	no	-
Finish Grade of Area Fill:	655.5	ft NAVD88
Height above existing:	#N/A	feet
Height above footing base:	#N/A	feet
Thickness under footing:	#N/A	feet
Area Fill Unit Weight:	126	pcf

Subgrade Overexcavation/Replacement

Include Overex/Replacement?	yes	-
Overex/Replace Bottom Elev.	639.5	ft NAVD88
Depth below footing:	2	feet
Depth below existing:	8.8	feet

Structure Footing Size & Maximum Bearing Pressure

Footing Width, B:	11.33	feet
Footing Length, L (rect):	48	feet
Gross Footing Pressure, $q_{0\text{-gross}}$	1,800	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula do not edit

Design Soil Profile and Properties

Depth at Boring (feet)		Elevation (feet)		Thickness in Boring	1 Existing Depth at Structure (feet)	2	3 Thickness at Structure	4 Layer Name	5 Total Unit Wt	6 Initial Void Ratio, e_0*	7 Compression Index, C_c*	8 Recomp. Index, C_r*	9 Min. Over Consolidation Ratio, OCR*	10 Min. Preconsol. Pressure, P'c*
Top	Bottom	Top	Bottom	(feet)	Top	Bottom	(feet)		(pcf)	(-)				(psf)
0	8	647.8	639.8	8.0	0.5	8.5	8.0	Alluvium	123	0.65	0.20	0.030	2.0	4,000
8	28	639.8	619.8	20.0	8.5	28.5	20.0	Residuum (MPR)	126	0.60	0.20	0.030	2.0	4,000
28	100	619.8	547.8	72.0	28.5	100.5	72.0	Shale	130	0.50	0.0	0.000	0.0	0

Notes: *Copy down elevation and thickness formulas if more layers are needed, delete formulas where not needed.*

*Enter "0" for incompressible layers (i.e., granular soils and bedrock)

Method: Settlement Below Center of Uniformly Loaded Rectangular Footing

Project	Plum Creek FRS No. 2 Rehabilitation
Structure	Overtopping RCC Spillway - Chute Structure - Walls
Analysis Section	Existing downstream toe of dam

Elev. - Existing Ground @ Structure:	648.3	ft NAVD88	-6.8	ft from footing base (above)	0	ft from existing (below)
Elev. - Base of Footing / Bearing Depth	641.5	ft NAVD88	0	ft from footing base (below)	6.8	ft from existing (below)
Elev. - Top of Area Fill	#N/A	ft NAVD88	#N/A	#N/A	#N/A	#N/A
Elev. - Bottom of Overex./Replace	639.5	ft NAVD88	2	ft from footing base (below)	8.8	ft from existing (below)
Elev. - Groundwater	640	ft NAVD88	1.5	ft from footing base (below)	8.3	ft from existing (below)
Thickness - Area Fill	#N/A	feet below footing base				
Thickness - Overex/Replace	2	feet below footing base				

Footing Width, B:	11.33	feet
Footing Length, L (square):	11.33	feet
Footing Length, L (rect):	48	feet

Gross Footing Pressure, $q_{0\text{-gross}}$	1,800	psf
Removed in-situ stress	857	psf
Net Footing Pressure, $q_{0\text{-net}}$	943	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula (do not edit)
xxx	= Unique Formula (do not edit)

$$\Delta\sigma_z = qI_4 \tag{10.34}$$

where

$$I_4 = \frac{2}{\pi}\left[\frac{m_1 n_1}{\sqrt{1+m_1^2+n_1^2}}\,\frac{1+m_1^2+2n_1^2}{(1+n_1^2)(m_1^2+n_1^2)} + \sin^{-1}\frac{m_1}{\sqrt{m_1^2+n_1^2}\,\sqrt{1+n_1^2}}\right] \tag{10.35}$$

$$m_1 = \frac{L}{B} \tag{10.36}$$

$$n_1 = \frac{z}{b} \tag{10.37}$$

$$b = \frac{B}{2} \tag{10.38}$$

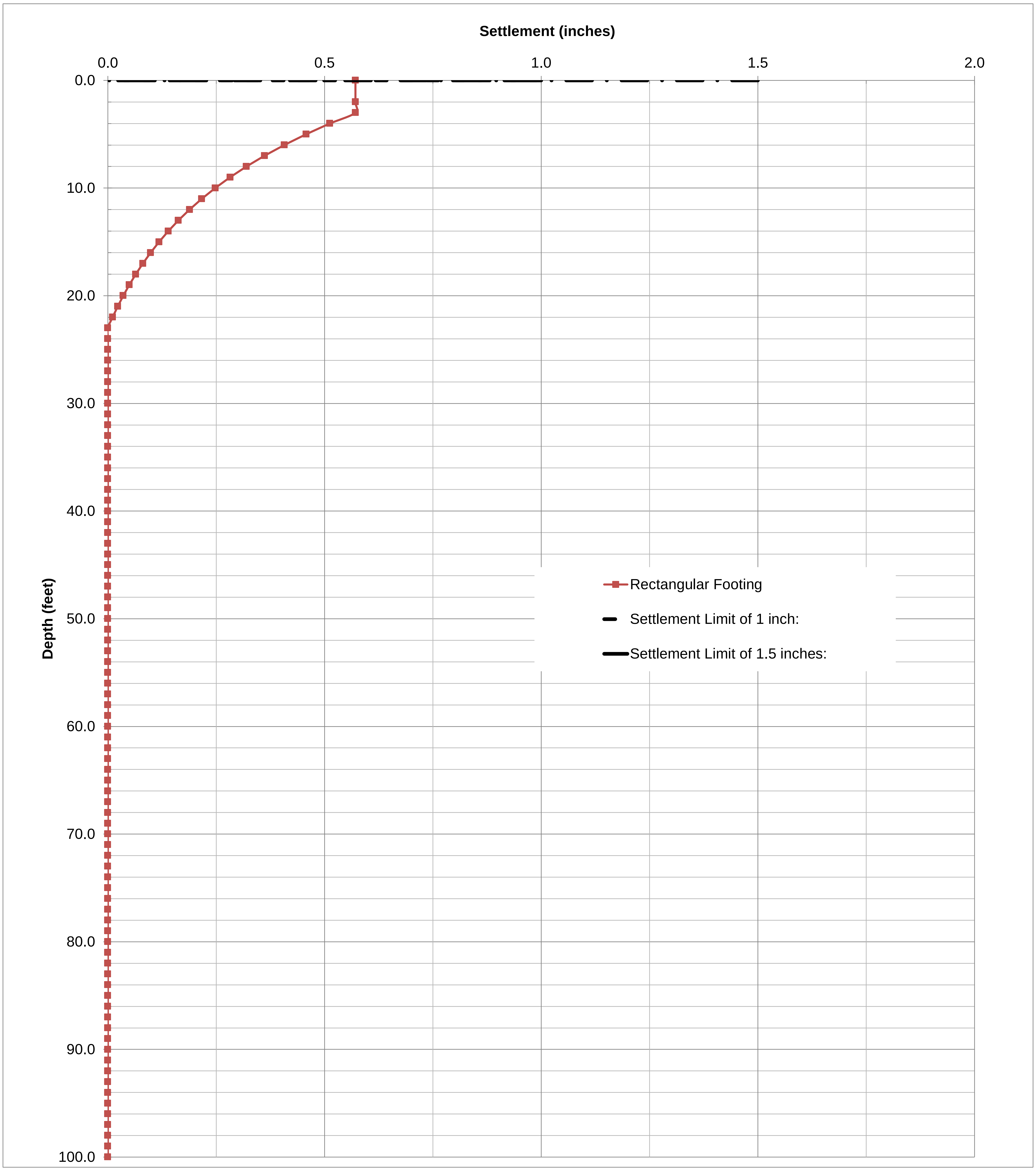
*Negative values indicate height above existing ground

*Assume granular

Total Settlement (inch) = 0.57

Stratum	Depth from Existing*			Elevation		Layer Thickness	Layer Unit Wt.	In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
	Top	Bottom	MP	Top	Bottom			Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	S_t
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	(inch)
Fill below footing/above exist.	0.0	0.0	0.0	648.3	648.3	0.0	126	-	-	-	-	-	-	-	-	0	0	-	4	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-
Existing Soil Above Footing	0.0	6.8	3.4	648.3	641.5	6.8	126	-	-	-	-	-	-	-	-	0	0	-	4	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-
Overex. below Existing	0.0	8.8	4.4	648.3	639.5	8.8	126	-	-	-	-	-	-	-	-	0	0	-	4	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-
Residuum (MPR)	8.8	9.8	9.3	639.5	638.5	1.0	126	1,172	62	1,109	0.20	0.030	0.60	2.0	4,000	0	0	-	4	2.50	0.4	5.7	0.97	915	0.06	0.00	0.059
Residuum (MPR)	9.8	10.8	10.3	638.5	637.5	1.0	126	1,298	125	1,173	0.20	0.030	0.60	2.0	4,000	0	0	-	4	3.50	0.6	5.7	0.93	879	0.05	0.00	0.055
Residuum (MPR)	10.8	11.8	11.3	637.5	636.5	1.0	126	1,424	187	1,237	0.20	0.030	0.60	2.0	4,000	0	0	-	4	4.50	0.8	5.7	0.88	832	0.05	0.00	0.050
Residuum (MPR)	11.8	12.8	12.3	636.5	635.5	1.0	126	1,550	250	1,300	0.20	0.030	0.60	2.0	4,000	0	0	-	4	5.50	1.0	5.7	0.83	779	0.05	0.00	0.046
Residuum (MPR)	12.8	13.8	13.3	635.5	634.5	1.0	126	1,676	312	1,364	0.20	0.030	0.60	2.0	4,000	0	0	-	4	6.50	1.1	5.7	0.77	726	0.04	0.00	0.042
Residuum (MPR)	13.8	14.8	14.3	634.5	633.5	1.0	126	1,802	374	1,427	0.20	0.030	0.60	2.0	4,000	0	0	-	4	7.50	1.3	5.7	0.72	675	0.04	0.00	0.038
Residuum (MPR)	14.8	15.8	15.3	633.5	632.5	1.0	126	1,928	437	1,491	0.20	0.030	0.60	2.0	4,000	0	0	-	4	8.50	1.5	5.7	0.66	626	0.03	0.00	0.034
Residuum (MPR)	15.8	16.8	16.3	632.5	631.5	1.0	126	2,054	499	1,555	0.20	0.030	0.60	2.0	4,000	0	0	-	4	9.50	1.7	5.7	0.62	582	0.03	0.00	0.031
Residuum (MPR)	16.8	17.8	17.3	631.5	630.5	1.0	126	2,180	562	1,618	0.20	0.030	0.60	2.0	4,000	0	0	-	4	10.50	1.9	5.7	0.57	542	0.03	0.00	0.028
Residuum (MPR)	17.8	18.8	18.3	630.5	629.5	1.0	126	2,306	624	1,682	0.20	0.030	0.60	2.0	4,000	0	0	-	4	11.50	2.0	5.7	0.54	505	0.03	0.00	0.026
Residuum (MPR)	18.8	19.8	19.3	629.5	628.5	1.0	126	2,432	686	1,745	0.20	0.030	0.60	2.0	4,000	0	0	-	4	12.50	2.2	5.7	0.50	471	0.02	0.00	0.023
Residuum (MPR)	19.8	20.8	20.3	628.5	627.5	1.0	126	2,558	749	1,809	0.20	0.030	0.60	2.0	4,000	0	0	-	4	13.50	2.4	5.7	0.47	441	0.02	0.00	0.021
Residuum (MPR)	20.8	21.8	21.3	627.5	626.5	1.0	126	2,684	811	1,873	0.20	0.030	0.60	2.0	4,000	0	0	-	4	14.50	2.6	5.7	0.44	414	0.02	0.00	0.019
Residuum (MPR)	21.8	22.8	22.3	626.5	625.5	1.0	126	2,810	874	1,936	0.20	0.030	0.60	2.0	4,000	0	0	-	4	15.50	2.7	5.7	0.41	388	0.02	0.00	0.018
Residuum (MPR)	22.8	23.8	23.3	625.5	624.5	1.0	126	2,936	936	2,000	0.20	0.030	0.60	2.0	4,000	0	0	-	4	16.50	2.9	5.7	0.39	365	0.02	0.00	0.016
Residuum (MPR)	23.8	24.8	24.3	624.5	623.5	1.0	126	3,062	998	2,063	0.20	0.030	0.60	2.0	4,127	0	0	-	4	17.50	3.1	5.7	0.36	344	0.02	0.00	0.015
Residuum (MPR)	24.8	25.8	25.3	623.5	622.5	1.0	126	3,188	1,061	2,127	0.20	0.030	0.60	2.0	4,254	0	0	-	4	18.50	3.3	5.7	0.34	325	0.01	0.00	0.014
Residuum (MPR)	25.8	26.8	26.3	622.5	621.5	1.0	126	3,314	1,123	2,191	0.20	0.030	0.60	2.0	4,381	0	0	-	4	19.50	3.4	5.7	0.33	307	0.01	0.00	0.013
Residuum (MPR)	26.8	27.8	27.3	621.5	620.5	1.0	126	3,440	1,186	2,254	0.20	0.030	0.60	2.0	4,508	0	0	-	4	20.50	3.6	5.7	0.31	290	0.01	0.00	0.012
Residuum (MPR)	27.8	28.8	28.3	620.5	619.5	1.0	126	3,566	1,248	2,318	0.20	0.030	0.60	2.0	4,636	0	0	-	4	21.50	3.8	5.7	0.29	275	0.01	0.00	0.011
Shale	28.8	29.8	29.3	619.5	618.5	1.0	130	3,694	1,310	2,383	0.00	0.000	0.50	0.0	0	0	0	-	4	22.50	4.0	5.7	0.28	261	-	-	-
Shale	29.8	30.8	30.3	618.5	617.5	1.0	130	3,824	1,373	2,451	0.00	0.000	0.50	0.0	0	0	0	-	4	23.50	4.1	5.7	0.26	247	-	-	-
Shale	30.8	31.8	31.3	617.5	616.5	1.0	130	3,954	1,435	2,519	0.00	0.000	0.50	0.0	0	0	0	-	4	24.50	4.3	5.7	0.25	235	-	-	-
Shale	31.8	32.8	32.3	616.5	615.5	1.0	130	4,084	1,498	2,586	0.00	0.000	0.50	0.0	0	0	0	-	4	25.50	4.5	5.7	0.24	223	-	-	-
Shale	32.8	33.8	33.3	615.5	614.5	1.0	130	4,214	1,560	2,654	0.00	0.000	0.50	0.0	0	0	0	-	4	26.50	4.7	5.7	0.23	213	-	-	-
Shale	33.8	34.8	34.3	614.5	613.5	1.0	130	4,344	1,622	2,721	0.00	0.000	0.50	0.0	0	0	0	-	4	27.50	4.9	5.7	0.21	203	-	-	-
Shale	34.8	35.8	35.3	613.5	612.5	1.0	130	4,474	1,685	2,789	0.00	0.000	0.50	0.0	0	0	0	-	4	28.50	5.0	5.7	0.20	193	-	-	-
Shale	35.8	36.8	36.3	612.5	611.5	1.0	130	4,604	1,747	2,857	0.00	0.000	0.50	0.0	0	0	0	-	4	29.50	5.2	5.7	0.20	184	-	-	-
Shale	36.8	37.8	37.3	611.5	610.5	1.0	130	4,734	1,810	2,924	0.00	0.000	0.50	0.0	0	0	0	-	4	30.50	5.4	5.7	0.19	176	-	-	-
Shale	37.8	38.8	38.3	610.5	609.5	1.0	130	4,864	1,872	2,992	0.00	0.000	0.50	0.0	0	0	0	-	4	31.50	5.6	5.7	0.18	168	-	-	-
Shale	38.8	39.8	39.3	609.5	608.5	1.0	130	4,994	1,934	3,059	0.00	0.000	0.50	0.0	0	0	0	-	4	32.50	5.7	5.7	0.17	161	-	-	-
Shale	39.8	40.8	40.3	608.5	607.5	1.0	130	5,124	1,997	3,127	0.00	0.000	0.50	0.0	0	0	0	-	4	33.50	5.9	5.7	0.16	154	-	-	-
Shale	40.8	41.8	41.3	607.5	606.5	1.0	130	5,254	2,059	3,195	0.00	0.000	0.50	0.0	0	0	0	-	4	34.50	6.1	5.7	0.16	148	-	-	-
Shale	41.8	42.8	42.3	606.5	605.5	1.0	130	5,384	2,122	3,262	0.00	0.000	0.50	0.0	0	0	0	-	4	35.50	6.3	5.7	0.15	141	-	-	-
Shale	42.8	43.8	43.3	605.5	604.5	1.0	130	5,514	2,184	3,330	0.00	0.000	0.50	0.0	0	0	0	-	4	36.50	6.4	5.7	0.14	136	-	-	-
Shale	43.8	44.8	44.3	604.5	603.5	1.0	130	5,644	2,246	3,397	0.00	0.000	0.50	0.0	0	0	0	-	4	37.50	6.6	5.7	0.14	130	-	-	-
Shale	44.8	45.8	45.3	603.5	602.5	1.0	130	5,774	2,309	3,465	0.00	0.000	0.50	0.0	0	0	0	-	4	38.50	6.8	5.7	0.13	125	-	-	-
Shale	45.8	46.8	46.3	602.5	601.5	1.0	130	5,904	2,371	3,533	0.00	0.000	0.50	0.0	0	0	0	-	4	39.50	7.0	5.7	0.13	120	-	-	-
Shale	46.8	47.8	47.3	601.5	600.5	1.0	130	6,034	2,434	3,600	0.00	0.000	0.50	0.0	0	0	0	-	4	40.50	7.1	5.7	0.12	116	-	-	-
Shale	47.8	48.8	48.3	600.5	599.5	1.0	130	6,164	2,496	3,668	0.00	0.000	0.50	0.0	0	0	0	-	4	41.50	7.3	5.7	0.12	111	-	-	-
Shale	48.8	49.8	49.3	599.5	598.5	1.0	130	6,294	2,558	3,735	0.00	0.000	0.50	0.0	0	0	0	-	4	42.50	7.5	5.7	0.11	107	-	-	-

	Depth from Existing*			Elevation		Layer Thickness	Layer Unit Wt.	In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom			Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	**S_t**
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	**(inch)**
Shale	49.8	50.8	50.3	598.5	597.5	1.0	130	6,424	2,621	3,803	0.00	0.000	0.50	0.0	0	0	0	-	4	43.50	7.7	5.7	0.11	103	-	-	-
Shale	50.8	51.8	51.3	597.5	596.5	1.0	130	6,554	2,683	3,871	0.00	0.000	0.50	0.0	0	0	0	-	4	44.50	7.9	5.7	0.11	99	-	-	-
Shale	51.8	52.8	52.3	596.5	595.5	1.0	130	6,684	2,746	3,938	0.00	0.000	0.50	0.0	0	0	0	-	4	45.50	8.0	5.7	0.10	96	-	-	-
Shale	52.8	53.8	53.3	595.5	594.5	1.0	130	6,814	2,808	4,006	0.00	0.000	0.50	0.0	0	0	0	-	4	46.50	8.2	5.7	0.10	93	-	-	-
Shale	53.8	54.8	54.3	594.5	593.5	1.0	130	6,944	2,870	4,073	0.00	0.000	0.50	0.0	0	0	0	-	4	47.50	8.4	5.7	0.09	89	-	-	-
Shale	54.8	55.8	55.3	593.5	592.5	1.0	130	7,074	2,933	4,141	0.00	0.000	0.50	0.0	0	0	0	-	4	48.50	8.6	5.7	0.09	86	-	-	-
Shale	55.8	56.8	56.3	592.5	591.5	1.0	130	7,204	2,995	4,209	0.00	0.000	0.50	0.0	0	0	0	-	4	49.50	8.7	5.7	0.09	83	-	-	-
Shale	56.8	57.8	57.3	591.5	590.5	1.0	130	7,334	3,058	4,276	0.00	0.000	0.50	0.0	0	0	0	-	4	50.50	8.9	5.7	0.09	81	-	-	-
Shale	57.8	58.8	58.3	590.5	589.5	1.0	130	7,464	3,120	4,344	0.00	0.000	0.50	0.0	0	0	0	-	4	51.50	9.1	5.7	0.08	78	-	-	-
Shale	58.8	59.8	59.3	589.5	588.5	1.0	130	7,594	3,182	4,411	0.00	0.000	0.50	0.0	0	0	0	-	4	52.50	9.3	5.7	0.08	75	-	-	-
Shale	59.8	60.8	60.3	588.5	587.5	1.0	130	7,724	3,245	4,479	0.00	0.000	0.50	0.0	0	0	0	-	4	53.50	9.4	5.7	0.08	73	-	-	-
Shale	60.8	61.8	61.3	587.5	586.5	1.0	130	7,854	3,307	4,547	0.00	0.000	0.50	0.0	0	0	0	-	4	54.50	9.6	5.7	0.08	71	-	-	-
Shale	61.8	62.8	62.3	586.5	585.5	1.0	130	7,984	3,370	4,614	0.00	0.000	0.50	0.0	0	0	0	-	4	55.50	9.8	5.7	0.07	69	-	-	-
Shale	62.8	63.8	63.3	585.5	584.5	1.0	130	8,114	3,432	4,682	0.00	0.000	0.50	0.0	0	0	0	-	4	56.50	10.0	5.7	0.07	66	-	-	-
Shale	63.8	64.8	64.3	584.5	583.5	1.0	130	8,244	3,494	4,749	0.00	0.000	0.50	0.0	0	0	0	-	4	57.50	10.2	5.7	0.07	64	-	-	-
Shale	64.8	65.8	65.3	583.5	582.5	1.0	130	8,374	3,557	4,817	0.00	0.000	0.50	0.0	0	0	0	-	4	58.50	10.3	5.7	0.07	63	-	-	-
Shale	65.8	66.8	66.3	582.5	581.5	1.0	130	8,504	3,619	4,885	0.00	0.000	0.50	0.0	0	0	0	-	4	59.50	10.5	5.7	0.06	61	-	-	-
Shale	66.8	67.8	67.3	581.5	580.5	1.0	130	8,634	3,682	4,952	0.00	0.000	0.50	0.0	0	0	0	-	4	60.50	10.7	5.7	0.06	59	-	-	-
Shale	67.8	68.8	68.3	580.5	579.5	1.0	130	8,764	3,744	5,020	0.00	0.000	0.50	0.0	0	0	0	-	4	61.50	10.9	5.7	0.06	57	-	-	-
Shale	68.8	69.8	69.3	579.5	578.5	1.0	130	8,894	3,806	5,087	0.00	0.000	0.50	0.0	0	0	0	-	4	62.50	11.0	5.7	0.06	56	-	-	-
Shale	69.8	70.8	70.3	578.5	577.5	1.0	130	9,024	3,869	5,155	0.00	0.000	0.50	0.0	0	0	0	-	4	63.50	11.2	5.7	0.06	54	-	-	-
Shale	70.8	71.8	71.3	577.5	576.5	1.0	130	9,154	3,931	5,223	0.00	0.000	0.50	0.0	0	0	0	-	4	64.50	11.4	5.7	0.06	53	-	-	-
Shale	71.8	72.8	72.3	576.5	575.5	1.0	130	9,284	3,994	5,290	0.00	0.000	0.50	0.0	0	0	0	-	4	65.50	11.6	5.7	0.05	51	-	-	-
Shale	72.8	73.8	73.3	575.5	574.5	1.0	130	9,414	4,056	5,358	0.00	0.000	0.50	0.0	0	0	0	-	4	66.50	11.7	5.7	0.05	50	-	-	-
Shale	73.8	74.8	74.3	574.5	573.5	1.0	130	9,544	4,118	5,425	0.00	0.000	0.50	0.0	0	0	0	-	4	67.50	11.9	5.7	0.05	48	-	-	-
Shale	74.8	75.8	75.3	573.5	572.5	1.0	130	9,674	4,181	5,493	0.00	0.000	0.50	0.0	0	0	0	-	4	68.50	12.1	5.7	0.05	47	-	-	-
Shale	75.8	76.8	76.3	572.5	571.5	1.0	130	9,804	4,243	5,561	0.00	0.000	0.50	0.0	0	0	0	-	4	69.50	12.3	5.7	0.05	46	-	-	-
Shale	76.8	77.8	77.3	571.5	570.5	1.0	130	9,934	4,306	5,628	0.00	0.000	0.50	0.0	0	0	0	-	4	70.50	12.4	5.7	0.05	45	-	-	-
Shale	77.8	78.8	78.3	570.5	569.5	1.0	130	10,064	4,368	5,696	0.00	0.000	0.50	0.0	0	0	0	-	4	71.50	12.6	5.7	0.05	44	-	-	-
Shale	78.8	79.8	79.3	569.5	568.5	1.0	130	10,194	4,430	5,763	0.00	0.000	0.50	0.0	0	0	0	-	4	72.50	12.8	5.7	0.05	43	-	-	-
Shale	79.8	80.8	80.3	568.5	567.5	1.0	130	10,324	4,493	5,831	0.00	0.000	0.50	0.0	0	0	0	-	4	73.50	13.0	5.7	0.04	42	-	-	-
Shale	80.8	81.8	81.3	567.5	566.5	1.0	130	10,454	4,555	5,899	0.00	0.000	0.50	0.0	0	0	0	-	4	74.50	13.2	5.7	0.04	40	-	-	-
Shale	81.8	82.8	82.3	566.5	565.5	1.0	130	10,584	4,618	5,966	0.00	0.000	0.50	0.0	0	0	0	-	4	75.50	13.3	5.7	0.04	40	-	-	-
Shale	82.8	83.8	83.3	565.5	564.5	1.0	130	10,714	4,680	6,034	0.00	0.000	0.50	0.0	0	0	0	-	4	76.50	13.5	5.7	0.04	39	-	-	-
Shale	83.8	84.8	84.3	564.5	563.5	1.0	130	10,844	4,742	6,101	0.00	0.000	0.50	0.0	0	0	0	-	4	77.50	13.7	5.7	0.04	38	-	-	-
Shale	84.8	85.8	85.3	563.5	562.5	1.0	130	10,974	4,805	6,169	0.00	0.000	0.50	0.0	0	0	0	-	4	78.50	13.9	5.7	0.04	37	-	-	-
Shale	85.8	86.8	86.3	562.5	561.5	1.0	130	11,104	4,867	6,237	0.00	0.000	0.50	0.0	0	0	0	-	4	79.50	14.0	5.7	0.04	36	-	-	-
Shale	86.8	87.8	87.3	561.5	560.5	1.0	130	11,234	4,930	6,304	0.00	0.000	0.50	0.0	0	0	0	-	4	80.50	14.2	5.7	0.04	35	-	-	-
Shale	87.8	88.8	88.3	560.5	559.5	1.0	130	11,364	4,992	6,372	0.00	0.000	0.50	0.0	0	0	0	-	4	81.50	14.4	5.7	0.04	34	-	-	-
Shale	88.8	89.8	89.3	559.5	558.5	1.0	130	11,494	5,054	6,439	0.00	0.000	0.50	0.0	0	0	0	-	4	82.50	14.6	5.7	0.04	34	-	-	-
Shale	89.8	90.8	90.3	558.5	557.5	1.0	130	11,624	5,117	6,507	0.00	0.000	0.50	0.0	0	0	0	-	4	83.50	14.7	5.7	0.03	33	-	-	-
Shale	90.8	91.8	91.3	557.5	556.5	1.0	130	11,754	5,179	6,575	0.00	0.000	0.50	0.0	0	0	0	-	4	84.50	14.9	5.7	0.03	32	-	-	-
Shale	91.8	92.8	92.3	556.5	555.5	1.0	130	11,884	5,242	6,642	0.00	0.000	0.50	0.0	0	0	0	-	4	85.50	15.1	5.7	0.03	31	-	-	-
Shale	92.8	93.8	93.3	555.5	554.5	1.0	130	12,014	5,304	6,710	0.00	0.000	0.50	0.0	0	0	0	-	4	86.50	15.3	5.7	0.03	31	-	-	-
Shale	93.8	94.8	94.3	554.5	553.5	1.0	130	12,144	5,366	6,777	0.00	0.000	0.50	0.0	0	0	0	-	4	87.50	15.4	5.7	0.03	30	-	-	-
Shale	94.8	95.8	95.3	553.5	552.5	1.0	130	12,274	5,429	6,845	0.00	0.000	0.50	0.0	0	0	0	-	4	88.50	15.6	5.7	0.03	29	-	-	-
Shale	95.8	96.8	96.3	552.5	551.5	1.0	130	12,404	5,491	6,913	0.00	0.000	0.50	0.0	0	0	0	-	4	89.50	15.8	5.7	0.03	29	-	-	-
Shale	96.8	97.8	97.3	551.5	550.5	1.0	130	12,534	5,554	6,980	0.00	0.000	0.50	0.0	0	0	0	-	4	90.50	16.0	5.7	0.03	28	-	-	-
Shale	97.8	98.8	98.3	550.5	549.5	1.0	130	12,664	5,616	7,048	0.00	0.000	0.50	0.0	0	0	0	-	4	91.50	16.2	5.7	0.03	28	-	-	-
Shale	98.8	99.8	99.3	549.5	548.5	1.0	130	12,794	5,678	7,115	0.00	0.000	0.50	0.0	0	0	0	-	4	92.50	16.3	5.7	0.03	27	-	-	-
Shale	99.8	100.8	100.3	548.5	547.5	1.0	130	12,924	5,741	7,183	0.00	0.000	0.50	0.0	0	0	0	-	4	93.50	16.5	5.7	0.03	26	-	-	-
#N/A	100.8	101.8	101.3	547.5	546.5	1.0	#N/A	#N/A	5,803	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	4	94.50	16.7	5.7	0.03	26	-	-	-
#N/A	101.8	102.8	102.3	546.5	545.5	1.0	#N/A	#N/A	5,866	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	4	95.50	16.9	5.7	0.03	25	-	-	-
#N/A	102.8	103.8	103.3	545.5	544.5	1.0	#N/A	#N/A	5,928	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	4	96.50	17.0	5.7	0.03	25	-	-	-
#N/A	103.8	104.8	104.3	544.5	543.5	1.0	#N/A	#N/A	5,990	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	4	97.50	17.2	5.7	0.03	24	-	-	-
#N/A	104.8	105.8	105.3	543.5	542.5	1.0	#N/A	#N/A	6,053	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	4	98.50	17.4	5.7	0.03	24	-	-	-
#N/A	105.8	106.8	106.3	542.5	541.5	1.0	#N/A	#N/A	6,115	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	4	99.50	17.6	5.7	0.02	24	-	-	-
#N/A	106.8	107.8	107.3	541.5	540.5	1.0	#N/A	#N/A	6,178	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	4	100.50	17.7	5.7	0.02	23	-	-	-
#N/A	107.8	108.8	108.3	540.5	539.5	1.0	#N/A	#N/A	6,240	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	4	101.50	17.9	5.7	0.02	23	-	-	-
#N/A	108.8	109.8	109.3	539.5	538.5	1.0	#N/A	#N/A	6,302	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	4	102.50	18.1	5.7	0.02	22	-	-	-
#N/A	109.8	110.8	110.3	538.5	537.5	1.0	#N/A	#N/A	6,365	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	4	103.50	18.3	5.7	0.02	22	-	-	-
#N/A	110.8	111.8	111.3	537.5	536.5	1.0	#N/A	#N/A	6,427	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	4	104.50	18.4	5.7	0.02	21	-	-	-
#N/A	111.8	200.0	155.9	536.5	448.3	88.2	#N/A	#N/A	9,210	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	4	149.10	26.3	5.7	0.01	11	-	-	-


Settlement (inches)
0.0
0.5
1.0
1.5
2.0
Depth (feet)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Rectangular Footing
Settlement Limit of 1 inch:
Settlement Limit of 1.5 inches:

Project Name:	Plum Creek FRS No. 2 Rehabilitation
Job Number:	60615067
Client:	TSSWCB

Structure	Overtopping RCC Spillway - Chute Structure - Walls
Analysis Section	Existing downstream toe of dam
Notes	RCC footing on overexcavation/replacement embankment fill

Geotechnical Data

Relevant Boring	702-20	-
Boring Ground Elev.	641.5	ft NAVD88
Depth to GWT at Boring:	1.5	feet
GWT Elev.	640	ft NAVD88

Exiting Ground at Structure Location

Structure Existing Ground:	641.5	ft NAVD88
Footing Bearing Elev.:	641.5	ft NAVD88
Footing Bearing Elev.:	0	ft below existing (cut)
GWT Depth below Exist.:	1.5	feet
GWT Depth below footing.:	1.5	feet

Area Fill

Fill between existing/footing?	no	-
Include load from area fill?	no	-
Finish Grade of Area Fill:	655.5	ft NAVD88
Height above existing:	#N/A	feet
Height above footing base:	#N/A	feet
Thickness under footing:	#N/A	feet
Area Fill Unit Weight:	126	pcf

Subgrade Overexcavation/Replacement

Include Overex/Replacement?	yes	-
Overex/Replace Bottom Elev.	639.5	ft NAVD88
Depth below footing:	2	feet
Depth below existing:	2	feet

Structure Footing Size & Maximum Bearing Pressure

Footing Width, B:	11.33	feet
Footing Length, L (rect):	48	feet
Gross Footing Pressure, $q_{0\text{-gross}}$	1,800	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula do not edit

Design Soil Profile and Properties

					1	2	3	4	5	6	7	8	9	10
Depth at Boring (feet)		Elevation (feet)		Thickness in Boring	Existing Depth at Structure (feet)		Thickness at Structure	Layer Name	Total Unit Wt	Initial Void Ratio, e_0*	Compression Index, C_c*	Recomp. Index, C_r*	Min. Over Consolidation Ratio, OCR*	Min. Preconsol. Pressure, P'c*
Top	Bottom	Top	Bottom	(feet)	Top	Bottom	(feet)		(pcf)	(-)				(psf)
0	8	641.5	633.5	8.0	0.0	8.0	8.0	New Embank. Fill	125	0.65	0.20	0.020	2.0	3,000
8	8	633.5	633.5	0.0	8.0	8.0	0.0	Alluvium	123	0.65	0.20	0.030	2.0	4,000
8	21.7	633.5	619.8	13.7	8.0	21.7	13.7	Residuum (MPR)	126	0.60	0.20	0.030	2.0	4,000
21.7	100	619.8	541.5	78.3	21.7	100.0	78.3	Shale	130	0.50	0.0	0.000	0.0	0

Notes: *Copy down elevation and thickness formulas if more layers are needed, delete formulas where not needed.*

*Enter "0" for incompressible layers (i.e., granular soils and bedrock)

Method: Settlement Below Center of Uniformly Loaded Rectangular Footing

Project	Plum Creek FRS No. 2 Rehabilitation
Structure	Overtopping RCC Spillway - Chute Structure - Walls
Analysis Section	Existing downstream toe of dam

Elev. - Existing Ground @ Structure:	641.5	ft NAVD88	0	ft from footing base (below)	0	ft from existing (below)
Elev. - Base of Footing / Bearing Depth	641.5	ft NAVD88	0	ft from footing base (below)	0	ft from existing (below)
Elev. - Top of Area Fill	#N/A	ft NAVD88	#N/A	#N/A	#N/A	#N/A
Elev. - Bottom of Overex./Replace	639.5	ft NAVD88	2	ft from footing base (below)	2	ft from existing (below)
Elev. - Groundwater	640	ft NAVD88	1.5	ft from footing base (below)	1.5	ft from existing (below)
Thickness - Area Fill	#N/A	feet below footing base				
Thickness - Overex/Replace	2	feet below footing base				

Footing Width, B:	11.33	feet
Footing Length, L (square):	11.33	feet
Footing Length, L (rect):	48	feet

Gross Footing Pressure, $q_{0\text{-gross}}$	1,800	psf
Removed in-situ stress	0	psf
Net Footing Pressure, $q_{0\text{-net}}$	1,800	psf

$$\Delta\sigma_z = qI_4 \tag{10.34}$$

where

$$I_4 = \frac{2}{\pi}\left[\frac{m_1 n_1}{\sqrt{1+m_1^2+n_1^2}}\frac{1+m_1^2+2n_1^2}{(1+n_1^2)(m_1^2+n_1^2)} + \sin^{-1}\frac{m_1}{\sqrt{m_1^2+n_1^2}\sqrt{1+n_1^2}}\right] \tag{10.35}$$

$$m_1 = \frac{L}{B} \tag{10.36}$$

$$n_1 = \frac{z}{b} \tag{10.37}$$

$$b = \frac{B}{2} \tag{10.38}$$

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula (do not edit)
xxx	= Unique Formula (do not edit)

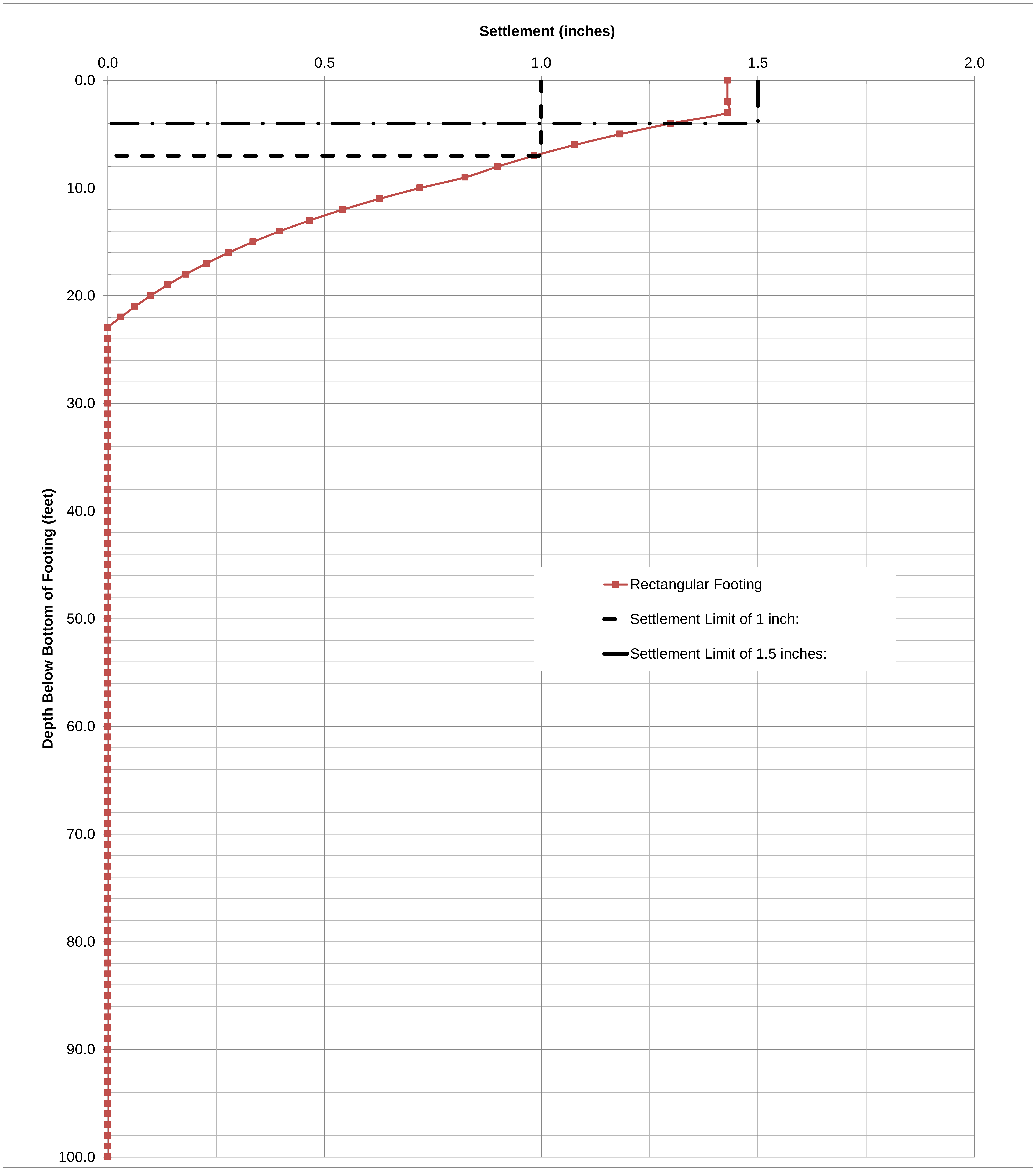
**Negative values indicate height above existing ground*

**Assume granular*

Total Settlement (inch) = 1.43

Stratum	Depth from Existing*			Elevation		Layer Thickness	Layer Unit Wt.	In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
	Top	Bottom	MP	Top	Bottom			Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	S_t
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	(inch)
Fill below footing/above exist.	0.0	0.0	0.0	641.5	641.5	0.0	126	-	-	-	-	-	-	-	-	0	0	-	4	0.00	0.0	5.7	1.00	1,800	-	-	-
Existing Soil Above Footing	0.0	0.0	0.0	641.5	641.5	0.0	125	-	-	-	-	-	-	-	-	0	0	-	4	0.00	0.0	5.7	1.00	1,800	-	-	-
Overex. below Existing	0.0	2.0	1.0	641.5	639.5	2.0	125	-	-	-	-	-	-	-	-	0	0	-	4	1.00	0.2	5.7	1.00	1,796	-	-	-
New Embank. Fill	2.0	3.0	2.5	639.5	638.5	1.0	125	313	62	250	0.20	0.020	0.65	2.0	3,000	0	0	-	4	2.50	0.4	5.7	0.97	1,747	0.13	0.00	**0.131**
New Embank. Fill	3.0	4.0	3.5	638.5	637.5	1.0	125	438	125	313	0.20	0.020	0.65	2.0	3,000	0	0	-	4	3.50	0.6	5.7	0.93	1,678	0.12	0.00	**0.117**
New Embank. Fill	4.0	5.0	4.5	637.5	636.5	1.0	125	563	187	375	0.20	0.020	0.65	2.0	3,000	0	0	-	4	4.50	0.8	5.7	0.88	1,588	0.10	0.00	**0.105**
New Embank. Fill	5.0	6.0	5.5	636.5	635.5	1.0	125	688	250	438	0.20	0.020	0.65	2.0	3,000	0	0	-	4	5.50	1.0	5.7	0.83	1,487	0.09	0.00	**0.094**
New Embank. Fill	6.0	7.0	6.5	635.5	634.5	1.0	125	813	312	501	0.20	0.020	0.65	2.0	3,000	0	0	-	4	6.50	1.1	5.7	0.77	1,386	0.08	0.00	**0.084**
New Embank. Fill	7.0	8.0	7.5	634.5	633.5	1.0	125	938	374	563	0.20	0.020	0.65	2.0	3,000	0	0	-	4	7.50	1.3	5.7	0.72	1,287	0.08	0.00	**0.075**
Residuum (MPR)	8.0	9.0	8.5	633.5	632.5	1.0	126	1,063	437	626	0.20	0.030	0.60	2.0	4,000	0	0	-	4	8.50	1.5	5.7	0.66	1,195	0.10	0.00	**0.104**
Residuum (MPR)	9.0	10.0	9.5	632.5	631.5	1.0	126	1,189	499	690	0.20	0.030	0.60	2.0	4,000	0	0	-	4	9.50	1.7	5.7	0.62	1,111	0.09	0.00	**0.094**
Residuum (MPR)	10.0	11.0	10.5	631.5	630.5	1.0	126	1,315	562	753	0.20	0.030	0.60	2.0	4,000	0	0	-	4	10.50	1.9	5.7	0.57	1,033	0.08	0.00	**0.084**
Residuum (MPR)	11.0	12.0	11.5	630.5	629.5	1.0	126	1,441	624	817	0.20	0.030	0.60	2.0	4,000	0	0	-	4	11.50	2.0	5.7	0.54	963	0.08	0.00	**0.076**
Residuum (MPR)	12.0	13.0	12.5	629.5	628.5	1.0	126	1,567	686	881	0.20	0.030	0.60	2.0	4,000	0	0	-	4	12.50	2.2	5.7	0.50	900	0.07	0.00	**0.069**
Residuum (MPR)	13.0	14.0	13.5	628.5	627.5	1.0	126	1,693	749	944	0.20	0.030	0.60	2.0	4,000	0	0	-	4	13.50	2.4	5.7	0.47	842	0.06	0.00	**0.062**
Residuum (MPR)	14.0	15.0	14.5	627.5	626.5	1.0	126	1,819	811	1,008	0.20	0.030	0.60	2.0	4,000	0	0	-	4	14.50	2.6	5.7	0.44	789	0.06	0.00	**0.057**
Residuum (MPR)	15.0	16.0	15.5	626.5	625.5	1.0	126	1,945	874	1,071	0.20	0.030	0.60	2.0	4,000	0	0	-	4	15.50	2.7	5.7	0.41	741	0.05	0.00	**0.051**
Residuum (MPR)	16.0	17.0	16.5	625.5	624.5	1.0	126	2,071	936	1,135	0.20	0.030	0.60	2.0	4,000	0	0	-	4	16.50	2.9	5.7	0.39	697	0.05	0.00	**0.047**
Residuum (MPR)	17.0	18.0	17.5	624.5	623.5	1.0	126	2,197	998	1,199	0.20	0.030	0.60	2.0	4,000	0	0	-	4	17.50	3.1	5.7	0.36	657	0.04	0.00	**0.043**
Residuum (MPR)	18.0	19.0	18.5	623.5	622.5	1.0	126	2,323	1,061	1,262	0.20	0.030	0.60	2.0	4,000	0	0	-	4	18.50	3.3	5.7	0.34	620	0.04	0.00	**0.039**
Residuum (MPR)	19.0	20.0	19.5	622.5	621.5	1.0	126	2,449	1,123	1,326	0.20	0.030	0.60	2.0	4,000	0	0	-	4	19.50	3.4	5.7	0.33	586	0.04	0.00	**0.036**
Residuum (MPR)	20.0	21.0	20.5	621.5	620.5	1.0	126	2,575	1,186	1,389	0.20	0.030	0.60	2.0	4,000	0	0	-	4	20.50	3.6	5.7	0.31	554	0.03	0.00	**0.033**
Residuum (MPR)	21.0	22.0	21.5	620.5	619.5	1.0	126	2,701	1,248	1,453	0.20	0.030	0.60	2.0	4,000	0	0	-	4	21.50	3.8	5.7	0.29	525	0.03	0.00	**0.030**
Shale	22.0	23.0	22.5	619.5	618.5	1.0	130	2,829	1,310	1,519	0.00	0.000	0.50	0.0	0	0	0	-	4	22.50	4.0	5.7	0.28	497	-	-	-
Shale	23.0	24.0	23.5	618.5	617.5	1.0	130	2,959	1,373	1,586	0.00	0.000	0.50	0.0	0	0	0	-	4	23.50	4.1	5.7	0.26	472	-	-	-
Shale	24.0	25.0	24.5	617.5	616.5	1.0	130	3,089	1,435	1,654	0.00	0.000	0.50	0.0	0	0	0	-	4	24.50	4.3	5.7	0.25	448	-	-	-
Shale	25.0	26.0	25.5	616.5	615.5	1.0	130	3,219	1,498	1,721	0.00	0.000	0.50	0.0	0	0	0	-	4	25.50	4.5	5.7	0.24	426	-	-	-
Shale	26.0	27.0	26.5	615.5	614.5	1.0	130	3,349	1,560	1,789	0.00	0.000	0.50	0.0	0	0	0	-	4	26.50	4.7	5.7	0.23	406	-	-	-
Shale	27.0	28.0	27.5	614.5	613.5	1.0	130	3,479	1,622	1,857	0.00	0.000	0.50	0.0	0	0	0	-	4	27.50	4.9	5.7	0.21	387	-	-	-
Shale	28.0	29.0	28.5	613.5	612.5	1.0	130	3,609	1,685	1,924	0.00	0.000	0.50	0.0	0	0	0	-	4	28.50	5.0	5.7	0.20	369	-	-	-
Shale	29.0	30.0	29.5	612.5	611.5	1.0	130	3,739	1,747	1,992	0.00	0.000	0.50	0.0	0	0	0	-	4	29.50	5.2	5.7	0.20	352	-	-	-
Shale	30.0	31.0	30.5	611.5	610.5	1.0	130	3,869	1,810	2,059	0.00	0.000	0.50	0.0	0	0	0	-	4	30.50	5.4	5.7	0.19	336	-	-	-
Shale	31.0	32.0	31.5	610.5	609.5	1.0	130	3,999	1,872	2,127	0.00	0.000	0.50	0.0	0	0	0	-	4	31.50	5.6	5.7	0.18	321	-	-	-
Shale	32.0	33.0	32.5	609.5	608.5	1.0	130	4,129	1,934	2,195	0.00	0.000	0.50	0.0	0	0	0	-	4	32.50	5.7	5.7	0.17	307	-	-	-
Shale	33.0	34.0	33.5	608.5	607.5	1.0	130	4,259	1,997	2,262	0.00	0.000	0.50	0.0	0	0	0	-	4	33.50	5.9	5.7	0.16	294	-	-	-
Shale	34.0	35.0	34.5	607.5	606.5	1.0	130	4,389	2,059	2,330	0.00	0.000	0.50	0.0	0	0	0	-	4	34.50	6.1	5.7	0.16	282	-	-	-
Shale	35.0	36.0	35.5	606.5	605.5	1.0	130	4,519	2,122	2,397	0.00	0.000	0.50	0.0	0	0	0	-	4	35.50	6.3	5.7	0.15	270	-	-	-
Shale	36.0	37.0	36.5	605.5	604.5	1.0	130	4,649	2,184	2,465	0.00	0.000	0.50	0.0	0	0	0	-	4	36.50	6.4	5.7	0.14	259	-	-	-
Shale	37.0	38.0	37.5	604.5	603.5	1.0	130	4,779	2,246	2,533	0.00	0.000	0.50	0.0	0	0	0	-	4	37.50	6.6	5.7	0.14	249	-	-	-
Shale	38.0	39.0	38.5	603.5	602.5	1.0	130	4,909	2,309	2,600	0.00	0.000	0.50	0.0	0	0	0	-	4	38.50	6.8	5.7	0.13	239	-	-	-
Shale	39.0	40.0	39.5	602.5	601.5	1.0	130	5,039	2,371	2,668	0.00	0.000	0.50	0.0	0	0	0	-	4	39.50	7.0	5.7	0.13	229	-	-	-
Shale	40.0	41.0	40.5	601.5	600.5	1.0	130	5,169	2,434	2,735	0.00	0.000	0.50	0.0	0	0	0	-	4	40.50	7.1	5.7	0.12	221	-	-	-
Shale	41.0	42.0	41.5	600.5	599.5	1.0	130	5,299	2,496	2,803	0.00	0.000	0.50	0.0	0	0	0	-	4	41.50	7.3	5.7	0.12	212	-	-	-
Shale	42.0	43.0	42.5	599.5	598.5	1.0	130	5,429	2,558	2,871	0.00	0.000	0.50	0.0	0	0	0	-	4	42.50	7.5	5.7	0.11	204	-	-	-

	Depth from Existing*			Elevation				In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom	Layer Thickness	Layer Unit Wt.	Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	**S_t**
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	**(inch)**
Shale	43.0	44.0	43.5	598.5	597.5	1.0	130	5,559	2,621	2,938	0.00	0.000	0.50	0.0	0	0	0	-	4	43.50	7.7	5.7	0.11	197	-	-	-
Shale	44.0	45.0	44.5	597.5	596.5	1.0	130	5,689	2,683	3,006	0.00	0.000	0.50	0.0	0	0	0	-	4	44.50	7.9	5.7	0.11	190	-	-	-
Shale	45.0	46.0	45.5	596.5	595.5	1.0	130	5,819	2,746	3,073	0.00	0.000	0.50	0.0	0	0	0	-	4	45.50	8.0	5.7	0.10	183	-	-	-
Shale	46.0	47.0	46.5	595.5	594.5	1.0	130	5,949	2,808	3,141	0.00	0.000	0.50	0.0	0	0	0	-	4	46.50	8.2	5.7	0.10	177	-	-	-
Shale	47.0	48.0	47.5	594.5	593.5	1.0	130	6,079	2,870	3,209	0.00	0.000	0.50	0.0	0	0	0	-	4	47.50	8.4	5.7	0.09	170	-	-	-
Shale	48.0	49.0	48.5	593.5	592.5	1.0	130	6,209	2,933	3,276	0.00	0.000	0.50	0.0	0	0	0	-	4	48.50	8.6	5.7	0.09	165	-	-	-
Shale	49.0	50.0	49.5	592.5	591.5	1.0	130	6,339	2,995	3,344	0.00	0.000	0.50	0.0	0	0	0	-	4	49.50	8.7	5.7	0.09	159	-	-	-
Shale	50.0	51.0	50.5	591.5	590.5	1.0	130	6,469	3,058	3,411	0.00	0.000	0.50	0.0	0	0	0	-	4	50.50	8.9	5.7	0.09	154	-	-	-
Shale	51.0	52.0	51.5	590.5	589.5	1.0	130	6,599	3,120	3,479	0.00	0.000	0.50	0.0	0	0	0	-	4	51.50	9.1	5.7	0.08	149	-	-	-
Shale	52.0	53.0	52.5	589.5	588.5	1.0	130	6,729	3,182	3,547	0.00	0.000	0.50	0.0	0	0	0	-	4	52.50	9.3	5.7	0.08	144	-	-	-
Shale	53.0	54.0	53.5	588.5	587.5	1.0	130	6,859	3,245	3,614	0.00	0.000	0.50	0.0	0	0	0	-	4	53.50	9.4	5.7	0.08	139	-	-	-
Shale	54.0	55.0	54.5	587.5	586.5	1.0	130	6,989	3,307	3,682	0.00	0.000	0.50	0.0	0	0	0	-	4	54.50	9.6	5.7	0.08	135	-	-	-
Shale	55.0	56.0	55.5	586.5	585.5	1.0	130	7,119	3,370	3,749	0.00	0.000	0.50	0.0	0	0	0	-	4	55.50	9.8	5.7	0.07	131	-	-	-
Shale	56.0	57.0	56.5	585.5	584.5	1.0	130	7,249	3,432	3,817	0.00	0.000	0.50	0.0	0	0	0	-	4	56.50	10.0	5.7	0.07	127	-	-	-
Shale	57.0	58.0	57.5	584.5	583.5	1.0	130	7,379	3,494	3,885	0.00	0.000	0.50	0.0	0	0	0	-	4	57.50	10.2	5.7	0.07	123	-	-	-
Shale	58.0	59.0	58.5	583.5	582.5	1.0	130	7,509	3,557	3,952	0.00	0.000	0.50	0.0	0	0	0	-	4	58.50	10.3	5.7	0.07	119	-	-	-
Shale	59.0	60.0	59.5	582.5	581.5	1.0	130	7,639	3,619	4,020	0.00	0.000	0.50	0.0	0	0	0	-	4	59.50	10.5	5.7	0.06	116	-	-	-
Shale	60.0	61.0	60.5	581.5	580.5	1.0	130	7,769	3,682	4,087	0.00	0.000	0.50	0.0	0	0	0	-	4	60.50	10.7	5.7	0.06	113	-	-	-
Shale	61.0	62.0	61.5	580.5	579.5	1.0	130	7,899	3,744	4,155	0.00	0.000	0.50	0.0	0	0	0	-	4	61.50	10.9	5.7	0.06	109	-	-	-
Shale	62.0	63.0	62.5	579.5	578.5	1.0	130	8,029	3,806	4,223	0.00	0.000	0.50	0.0	0	0	0	-	4	62.50	11.0	5.7	0.06	106	-	-	-
Shale	63.0	64.0	63.5	578.5	577.5	1.0	130	8,159	3,869	4,290	0.00	0.000	0.50	0.0	0	0	0	-	4	63.50	11.2	5.7	0.06	103	-	-	-
Shale	64.0	65.0	64.5	577.5	576.5	1.0	130	8,289	3,931	4,358	0.00	0.000	0.50	0.0	0	0	0	-	4	64.50	11.4	5.7	0.06	100	-	-	-
Shale	65.0	66.0	65.5	576.5	575.5	1.0	130	8,419	3,994	4,425	0.00	0.000	0.50	0.0	0	0	0	-	4	65.50	11.6	5.7	0.05	98	-	-	-
Shale	66.0	67.0	66.5	575.5	574.5	1.0	130	8,549	4,056	4,493	0.00	0.000	0.50	0.0	0	0	0	-	4	66.50	11.7	5.7	0.05	95	-	-	-
Shale	67.0	68.0	67.5	574.5	573.5	1.0	130	8,679	4,118	4,561	0.00	0.000	0.50	0.0	0	0	0	-	4	67.50	11.9	5.7	0.05	93	-	-	-
Shale	68.0	69.0	68.5	573.5	572.5	1.0	130	8,809	4,181	4,628	0.00	0.000	0.50	0.0	0	0	0	-	4	68.50	12.1	5.7	0.05	90	-	-	-
Shale	69.0	70.0	69.5	572.5	571.5	1.0	130	8,939	4,243	4,696	0.00	0.000	0.50	0.0	0	0	0	-	4	69.50	12.3	5.7	0.05	88	-	-	-
Shale	70.0	71.0	70.5	571.5	570.5	1.0	130	9,069	4,306	4,763	0.00	0.000	0.50	0.0	0	0	0	-	4	70.50	12.4	5.7	0.05	85	-	-	-
Shale	71.0	72.0	71.5	570.5	569.5	1.0	130	9,199	4,368	4,831	0.00	0.000	0.50	0.0	0	0	0	-	4	71.50	12.6	5.7	0.05	83	-	-	-
Shale	72.0	73.0	72.5	569.5	568.5	1.0	130	9,329	4,430	4,899	0.00	0.000	0.50	0.0	0	0	0	-	4	72.50	12.8	5.7	0.05	81	-	-	-
Shale	73.0	74.0	73.5	568.5	567.5	1.0	130	9,459	4,493	4,966	0.00	0.000	0.50	0.0	0	0	0	-	4	73.50	13.0	5.7	0.04	79	-	-	-
Shale	74.0	75.0	74.5	567.5	566.5	1.0	130	9,589	4,555	5,034	0.00	0.000	0.50	0.0	0	0	0	-	4	74.50	13.2	5.7	0.04	77	-	-	-
Shale	75.0	76.0	75.5	566.5	565.5	1.0	130	9,719	4,618	5,101	0.00	0.000	0.50	0.0	0	0	0	-	4	75.50	13.3	5.7	0.04	75	-	-	-
Shale	76.0	77.0	76.5	565.5	564.5	1.0	130	9,849	4,680	5,169	0.00	0.000	0.50	0.0	0	0	0	-	4	76.50	13.5	5.7	0.04	74	-	-	-
Shale	77.0	78.0	77.5	564.5	563.5	1.0	130	9,979	4,742	5,237	0.00	0.000	0.50	0.0	0	0	0	-	4	77.50	13.7	5.7	0.04	72	-	-	-
Shale	78.0	79.0	78.5	563.5	562.5	1.0	130	10,109	4,805	5,304	0.00	0.000	0.50	0.0	0	0	0	-	4	78.50	13.9	5.7	0.04	70	-	-	-
Shale	79.0	80.0	79.5	562.5	561.5	1.0	130	10,239	4,867	5,372	0.00	0.000	0.50	0.0	0	0	0	-	4	79.50	14.0	5.7	0.04	69	-	-	-
Shale	80.0	81.0	80.5	561.5	560.5	1.0	130	10,369	4,930	5,439	0.00	0.000	0.50	0.0	0	0	0	-	4	80.50	14.2	5.7	0.04	67	-	-	-
Shale	81.0	82.0	81.5	560.5	559.5	1.0	130	10,499	4,992	5,507	0.00	0.000	0.50	0.0	0	0	0	-	4	81.50	14.4	5.7	0.04	65	-	-	-
Shale	82.0	83.0	82.5	559.5	558.5	1.0	130	10,629	5,054	5,575	0.00	0.000	0.50	0.0	0	0	0	-	4	82.50	14.6	5.7	0.04	64	-	-	-
Shale	83.0	84.0	83.5	558.5	557.5	1.0	130	10,759	5,117	5,642	0.00	0.000	0.50	0.0	0	0	0	-	4	83.50	14.7	5.7	0.03	63	-	-	-
Shale	84.0	85.0	84.5	557.5	556.5	1.0	130	10,889	5,179	5,710	0.00	0.000	0.50	0.0	0	0	0	-	4	84.50	14.9	5.7	0.03	61	-	-	-
Shale	85.0	86.0	85.5	556.5	555.5	1.0	130	11,019	5,242	5,777	0.00	0.000	0.50	0.0	0	0	0	-	4	85.50	15.1	5.7	0.03	60	-	-	-
Shale	86.0	87.0	86.5	555.5	554.5	1.0	130	11,149	5,304	5,845	0.00	0.000	0.50	0.0	0	0	0	-	4	86.50	15.3	5.7	0.03	59	-	-	-
Shale	87.0	88.0	87.5	554.5	553.5	1.0	130	11,279	5,366	5,913	0.00	0.000	0.50	0.0	0	0	0	-	4	87.50	15.4	5.7	0.03	57	-	-	-
Shale	88.0	89.0	88.5	553.5	552.5	1.0	130	11,409	5,429	5,980	0.00	0.000	0.50	0.0	0	0	0	-	4	88.50	15.6	5.7	0.03	56	-	-	-
Shale	89.0	90.0	89.5	552.5	551.5	1.0	130	11,539	5,491	6,048	0.00	0.000	0.50	0.0	0	0	0	-	4	89.50	15.8	5.7	0.03	55	-	-	-
Shale	90.0	91.0	90.5	551.5	550.5	1.0	130	11,669	5,554	6,115	0.00	0.000	0.50	0.0	0	0	0	-	4	90.50	16.0	5.7	0.03	54	-	-	-
Shale	91.0	92.0	91.5	550.5	549.5	1.0	130	11,799	5,616	6,183	0.00	0.000	0.50	0.0	0	0	0	-	4	91.50	16.2	5.7	0.03	53	-	-	-
Shale	92.0	93.0	92.5	549.5	548.5	1.0	130	11,929	5,678	6,251	0.00	0.000	0.50	0.0	0	0	0	-	4	92.50	16.3	5.7	0.03	52	-	-	-
Shale	93.0	94.0	93.5	548.5	547.5	1.0	130	12,059	5,741	6,318	0.00	0.000	0.50	0.0	0	0	0	-	4	93.50	16.5	5.7	0.03	51	-	-	-
Shale	94.0	95.0	94.5	547.5	546.5	1.0	130	12,189	5,803	6,386	0.00	0.000	0.50	0.0	0	0	0	-	4	94.50	16.7	5.7	0.03	50	-	-	-
Shale	95.0	96.0	95.5	546.5	545.5	1.0	130	12,319	5,866	6,453	0.00	0.000	0.50	0.0	0	0	0	-	4	95.50	16.9	5.7	0.03	49	-	-	-
Shale	96.0	97.0	96.5	545.5	544.5	1.0	130	12,449	5,928	6,521	0.00	0.000	0.50	0.0	0	0	0	-	4	96.50	17.0	5.7	0.03	48	-	-	-
Shale	97.0	98.0	97.5	544.5	543.5	1.0	130	12,579	5,990	6,589	0.00	0.000	0.50	0.0	0	0	0	-	4	97.50	17.2	5.7	0.03	47	-	-	-
Shale	98.0	99.0	98.5	543.5	542.5	1.0	130	12,709	6,053	6,656	0.00	0.000	0.50	0.0	0	0	0	-	4	98.50	17.4	5.7	0.03	46	-	-	-
Shale	99.0	100.0	99.5	542.5	541.5	1.0	130	12,839	6,115	6,724	0.00	0.000	0.50	0.0	0	0	0	-	4	99.50	17.6	5.7	0.02	45	-	-	-
Shale	100.0	101.0	100.5	541.5	540.5	1.0	130	12,969	6,178	6,791	0.00	0.000	0.50	0.0	0	0	0	-	4	100.50	17.7	5.7	0.02	44	-	-	-
#N/A	101.0	102.0	101.5	540.5	539.5	1.0	#N/A	#N/A	6,240	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	4	101.50	17.9	5.7	0.02	43	-	-	-
#N/A	102.0	103.0	102.5	539.5	538.5	1.0	#N/A	#N/A	6,302	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	4	102.50	18.1	5.7	0.02	42	-	-	-
#N/A	103.0	104.0	103.5	538.5	537.5	1.0	#N/A	#N/A	6,365	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	4	103.50	18.3	5.7	0.02	42	-	-	-
#N/A	104.0	105.0	104.5	537.5	536.5	1.0	#N/A	#N/A	6,427	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	4	104.50	18.4	5.7	0.02	41	-	-	-
#N/A	105.0	200.0	152.5	536.5	441.5	95.0	#N/A	#N/A	9,422	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	4	152.50	26.9	5.7	0.01	20	-	-	-



Settlement (inches)
0.0
0.5
1.0
1.5
2.0
Depth Below Bottom of Footing (feet)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Rectangular Footing
Settlement Limit of 1 inch:
Settlement Limit of 1.5 inches:

ATTACHMENT 6
Settlement Calculations for RCC Spillway – Stilling Basin Structure

Project Name:	Plum Creek FRS No. 2 Rehabilitation		Structure	Overtopping RCC Spillway - Chute Structure - Walls
Job Number:	60615067		Analysis Section	Existing downstream toe of dam
Client:	TSSWCB		Notes	RCC footing on in-situ subgrade

Geotechnical Data

Relevant Boring	702-20	-
Boring Ground Elev.	647.79	ft NAVD88
Depth to GWT at Boring:	7.79	feet
GWT Elev.	640	ft NAVD88

Exiting Ground at Structure Location

Structure Existing Ground:	648.1	ft NAVD88
Footing Bearing Elev.:	638.7	ft NAVD88
Footing Bearing Elev.:	9.4	ft below existing (cut)
GWT Depth below Exist.:	8.1	feet
GWT Depth below footing.:	0	feet

Area Fill

Fill between existing/footing?	no	-
Include load from area fill?	no	-
Finish Grade of Area Fill:	655.5	ft NAVD88
Height above existing:	#N/A	feet
Height above footing base:	#N/A	feet
Thickness under footing:	#N/A	feet
Area Fill Unit Weight:	126	pcf

Subgrade Overexcavation/Replacement

Include Overex/Replacement?	yes	-
Overex/Replace Bottom Elev.	636.7	ft NAVD88
Depth below footing:	2	feet
Depth below existing:	11.4	feet

Structure Footing Size & Maximum Bearing Pressure

Footing Width, B:	11.33	feet
Footing Length, L (rect):	24	feet
Gross Footing Pressure, $q_{0\text{-gross}}$	2,500	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula do not edit

Design Soil Profile and Properties

Depth at Boring (feet)		Elevation (feet)		Thickness in Boring	1 Existing Depth at Structure (feet)	2	3 Thickness at Structure	4 Layer Name	5 Total Unit Wt	6 Initial Void Ratio, e_0*	7 Compression Index, C_c*	8 Recomp. Index, C_r*	9 Min. Over Consolidation Ratio, OCR*	10 Min. Preconsol. Pressure, P'c*
Top	Bottom	Top	Bottom	(feet)	Top	Bottom	(feet)		(pcf)	(-)				(psf)
0	8	647.8	639.8	8.0	0.3	8.3	8.0	Alluvium	123	0.65	0.20	0.030	2.0	4,000
8	28	639.8	619.8	20.0	8.3	28.3	20.0	Residuum (MPR)	126	0.60	0.20	0.030	2.0	4,000
28	100	619.8	547.8	72.0	28.3	100.3	72.0	Shale	130	0.50	0.0	0.000	0.0	0

Notes: *Copy down elevation and thickness formulas if more layers are needed, delete formulas where not needed.*

*Enter "0" for incompressible layers (i.e., granular soils and bedrock)

Method: Settlement Below Center of Uniformly Loaded Rectangular Footing

Project	Plum Creek FRS No. 2 Rehabilitation
Structure	Overtopping RCC Spillway - Chute Structure - Walls
Analysis Section	Existing downstream toe of dam

Elev. - Existing Ground @ Structure:	648.1	ft NAVD88	-9.4	ft from footing base (above)	0	ft from existing (below)
Elev. - Base of Footing / Bearing Depth	638.7	ft NAVD88	0	ft from footing base (below)	9.4	ft from existing (below)
Elev. - Top of Area Fill	#N/A	ft NAVD88	#N/A	#N/A	#N/A	#N/A
Elev. - Bottom of Overex./Replace	636.7	ft NAVD88	2	ft from footing base (below)	11.4	ft from existing (below)
Elev. - Groundwater	640	ft NAVD88	-1.3	ft from footing base (above)	8.1	ft from existing (below)
Thickness - Area Fill	#N/A	feet below footing base				
Thickness - Overex/Replace	2	feet below footing base				

Footing Width, B:	11.33	feet
Footing Length, L (square):	11.33	feet
Footing Length, L (rect):	24	feet

Gross Footing Pressure, $q_{0\text{-gross}}$	2,500	psf
Removed in-situ stress	1,103	psf
Net Footing Pressure, $q_{0\text{-net}}$	1,397	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula (do not edit)
xxx	= Unique Formula (do not edit)

$$\Delta\sigma_z = qI_4 \tag{10.34}$$

where

$$I_4 = \frac{2}{\pi}\left[\frac{m_1 n_1}{\sqrt{1+m_1^2+n_1^2}}\,\frac{1+m_1^2+2n_1^2}{(1+n_1^2)(m_1^2+n_1^2)} + \sin^{-1}\frac{m_1}{\sqrt{m_1^2+n_1^2}\sqrt{1+n_1^2}}\right] \tag{10.35}$$

$$m_1 = \frac{L}{B} \tag{10.36}$$

$$n_1 = \frac{z}{b} \tag{10.37}$$

$$b = \frac{B}{2} \tag{10.38}$$

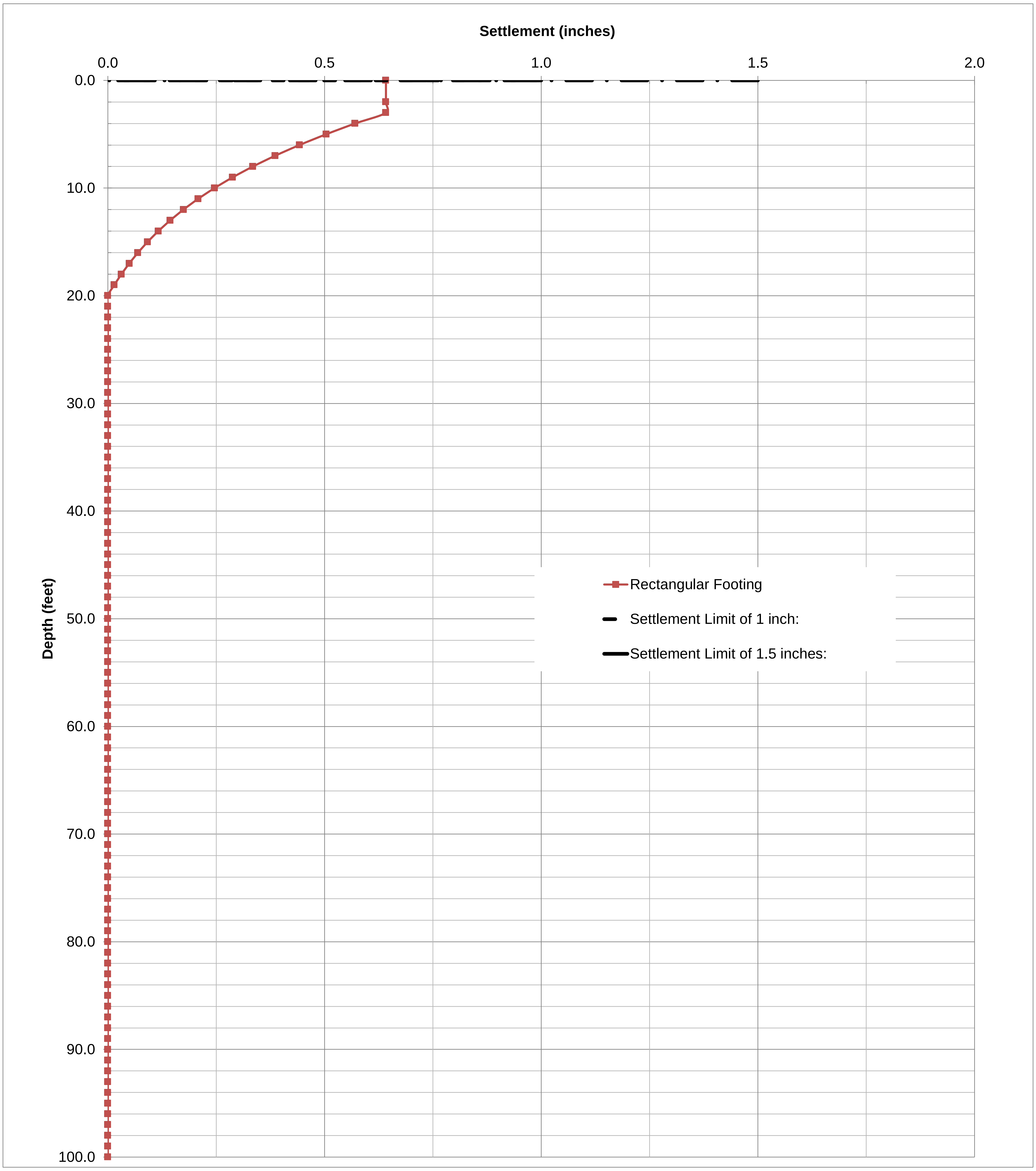
*Negative values indicate height above existing ground

*Assume granular

Total Settlement (inch) = 0.64

Stratum	Depth from Existing* Top	Bottom	MP	Elevation Top	Bottom	Layer Thickness	Layer Unit Wt.	In-Situ Stresse at MP Total P_0	μ	Eff. P'_0	Consolidation Parameters Cc	Cr	e0	OCR	P'_c	Area Fill above Existing Thick-ness	ΔP_{Fill}	Self Compress*	Rectangular Footing m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	S_t
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	(inch)
Fill below footing/above exist.	0.0	0.0	0.0	648.1	648.1	0.0	126	-	-	-	-	-	-	-	-	0	0	-	2	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-
Existing Soil Above Footing	0.0	9.4	4.7	648.1	638.7	9.4	126	-	-	-	-	-	-	-	-	0	0	-	2	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-
Overex. below Existing	0.0	11.4	5.7	648.1	636.7	11.4	126	-	-	-	-	-	-	-	-	0	0	-	2	#N/A	#N/A	#N/A	#N/A	#N/A	-	-	-
Residuum (MPR)	11.4	12.4	11.9	636.7	635.7	1.0	126	1,499	237	1,262	0.20	0.030	0.60	2.0	4,000	0	0	-	2	2.50	0.4	5.7	0.97	1,353	0.07	0.00	0.071
Residuum (MPR)	12.4	13.4	12.9	635.7	634.7	1.0	126	1,625	300	1,326	0.20	0.030	0.60	2.0	4,000	0	0	-	2	3.50	0.6	5.7	0.93	1,296	0.07	0.00	0.067
Residuum (MPR)	13.4	14.4	13.9	634.7	633.7	1.0	126	1,751	362	1,389	0.20	0.030	0.60	2.0	4,000	0	0	-	2	4.50	0.8	5.7	0.87	1,221	0.06	0.00	0.062
Residuum (MPR)	14.4	15.4	14.9	633.7	632.7	1.0	126	1,877	424	1,453	0.20	0.030	0.60	2.0	4,000	0	0	-	2	5.50	1.0	5.7	0.81	1,136	0.06	0.00	0.056
Residuum (MPR)	15.4	16.4	15.9	632.7	631.7	1.0	126	2,003	487	1,517	0.20	0.030	0.60	2.0	4,000	0	0	-	2	6.50	1.1	5.7	0.75	1,048	0.05	0.00	0.051
Residuum (MPR)	16.4	17.4	16.9	631.7	630.7	1.0	126	2,129	549	1,580	0.20	0.030	0.60	2.0	4,000	0	0	-	2	7.50	1.3	5.7	0.69	962	0.05	0.00	0.046
Residuum (MPR)	17.4	18.4	17.9	630.7	629.7	1.0	126	2,255	612	1,644	0.20	0.030	0.60	2.0	4,000	0	0	-	2	8.50	1.5	5.7	0.63	881	0.04	0.00	0.042
Residuum (MPR)	18.4	19.4	18.9	629.7	628.7	1.0	126	2,381	674	1,707	0.20	0.030	0.60	2.0	4,000	0	0	-	2	9.50	1.7	5.7	0.58	805	0.04	0.00	0.038
Residuum (MPR)	19.4	20.4	19.9	628.7	627.7	1.0	126	2,507	736	1,771	0.20	0.030	0.60	2.0	4,000	0	0	-	2	10.50	1.9	5.7	0.53	736	0.03	0.00	0.034
Residuum (MPR)	20.4	21.4	20.9	627.7	626.7	1.0	126	2,633	799	1,835	0.20	0.030	0.60	2.0	4,000	0	0	-	2	11.50	2.0	5.7	0.48	673	0.03	0.00	0.031
Residuum (MPR)	21.4	22.4	21.9	626.7	625.7	1.0	126	2,759	861	1,898	0.20	0.030	0.60	2.0	4,000	0	0	-	2	12.50	2.2	5.7	0.44	616	0.03	0.00	0.027
Residuum (MPR)	22.4	23.4	22.9	625.7	624.7	1.0	126	2,885	924	1,962	0.20	0.030	0.60	2.0	4,000	0	0	-	2	13.50	2.4	5.7	0.40	564	0.02	0.00	0.025
Residuum (MPR)	23.4	24.4	23.9	624.7	623.7	1.0	126	3,011	986	2,025	0.20	0.030	0.60	2.0	4,051	0	0	-	2	14.50	2.6	5.7	0.37	518	0.02	0.00	0.022
Residuum (MPR)	24.4	25.4	24.9	623.7	622.7	1.0	126	3,137	1,048	2,089	0.20	0.030	0.60	2.0	4,178	0	0	-	2	15.50	2.7	5.7	0.34	476	0.02	0.00	0.020
Residuum (MPR)	25.4	26.4	25.9	622.7	621.7	1.0	126	3,263	1,111	2,153	0.20	0.030	0.60	2.0	4,305	0	0	-	2	16.50	2.9	5.7	0.31	439	0.02	0.00	0.018
Residuum (MPR)	26.4	27.4	26.9	621.7	620.7	1.0	126	3,389	1,173	2,216	0.20	0.030	0.60	2.0	4,433	0	0	-	2	17.50	3.1	5.7	0.29	405	0.02	0.00	0.016
Residuum (MPR)	27.4	28.4	27.9	620.7	619.7	1.0	126	3,515	1,236	2,280	0.20	0.030	0.60	2.0	4,560	0	0	-	2	18.50	3.3	5.7	0.27	375	0.01	0.00	0.015
Shale	28.4	29.4	28.9	619.7	618.7	1.0	130	3,643	1,298	2,345	0.00	0.000	0.50	0.0	0	0	0	-	2	19.50	3.4	5.7	0.25	347	-	-	-
Shale	29.4	30.4	29.9	618.7	617.7	1.0	130	3,773	1,360	2,413	0.00	0.000	0.50	0.0	0	0	0	-	2	20.50	3.6	5.7	0.23	322	-	-	-
Shale	30.4	31.4	30.9	617.7	616.7	1.0	130	3,903	1,423	2,481	0.00	0.000	0.50	0.0	0	0	0	-	2	21.50	3.8	5.7	0.21	300	-	-	-
Shale	31.4	32.4	31.9	616.7	615.7	1.0	130	4,033	1,485	2,548	0.00	0.000	0.50	0.0	0	0	0	-	2	22.50	4.0	5.7	0.20	279	-	-	-
Shale	32.4	33.4	32.9	615.7	614.7	1.0	130	4,163	1,548	2,616	0.00	0.000	0.50	0.0	0	0	0	-	2	23.50	4.1	5.7	0.19	261	-	-	-
Shale	33.4	34.4	33.9	614.7	613.7	1.0	130	4,293	1,610	2,683	0.00	0.000	0.50	0.0	0	0	0	-	2	24.50	4.3	5.7	0.17	244	-	-	-
Shale	34.4	35.4	34.9	613.7	612.7	1.0	130	4,423	1,672	2,751	0.00	0.000	0.50	0.0	0	0	0	-	2	25.50	4.5	5.7	0.16	228	-	-	-
Shale	35.4	36.4	35.9	612.7	611.7	1.0	130	4,553	1,735	2,819	0.00	0.000	0.50	0.0	0	0	0	-	2	26.50	4.7	5.7	0.15	214	-	-	-
Shale	36.4	37.4	36.9	611.7	610.7	1.0	130	4,683	1,797	2,886	0.00	0.000	0.50	0.0	0	0	0	-	2	27.50	4.9	5.7	0.14	201	-	-	-
Shale	37.4	38.4	37.9	610.7	609.7	1.0	130	4,813	1,860	2,954	0.00	0.000	0.50	0.0	0	0	0	-	2	28.50	5.0	5.7	0.14	190	-	-	-
Shale	38.4	39.4	38.9	609.7	608.7	1.0	130	4,943	1,922	3,021	0.00	0.000	0.50	0.0	0	0	0	-	2	29.50	5.2	5.7	0.13	179	-	-	-
Shale	39.4	40.4	39.9	608.7	607.7	1.0	130	5,073	1,984	3,089	0.00	0.000	0.50	0.0	0	0	0	-	2	30.50	5.4	5.7	0.12	169	-	-	-
Shale	40.4	41.4	40.9	607.7	606.7	1.0	130	5,203	2,047	3,157	0.00	0.000	0.50	0.0	0	0	0	-	2	31.50	5.6	5.7	0.11	159	-	-	-
Shale	41.4	42.4	41.9	606.7	605.7	1.0	130	5,333	2,109	3,224	0.00	0.000	0.50	0.0	0	0	0	-	2	32.50	5.7	5.7	0.11	151	-	-	-
Shale	42.4	43.4	42.9	605.7	604.7	1.0	130	5,463	2,172	3,292	0.00	0.000	0.50	0.0	0	0	0	-	2	33.50	5.9	5.7	0.10	143	-	-	-
Shale	43.4	44.4	43.9	604.7	603.7	1.0	130	5,593	2,234	3,359	0.00	0.000	0.50	0.0	0	0	0	-	2	34.50	6.1	5.7	0.10	136	-	-	-
Shale	44.4	45.4	44.9	603.7	602.7	1.0	130	5,723	2,296	3,427	0.00	0.000	0.50	0.0	0	0	0	-	2	35.50	6.3	5.7	0.09	129	-	-	-
Shale	45.4	46.4	45.9	602.7	601.7	1.0	130	5,853	2,359	3,495	0.00	0.000	0.50	0.0	0	0	0	-	2	36.50	6.4	5.7	0.09	123	-	-	-
Shale	46.4	47.4	46.9	601.7	600.7	1.0	130	5,983	2,421	3,562	0.00	0.000	0.50	0.0	0	0	0	-	2	37.50	6.6	5.7	0.08	117	-	-	-
Shale	47.4	48.4	47.9	600.7	599.7	1.0	130	6,113	2,484	3,630	0.00	0.000	0.50	0.0	0	0	0	-	2	38.50	6.8	5.7	0.08	111	-	-	-
Shale	48.4	49.4	48.9	599.7	598.7	1.0	130	6,243	2,546	3,697	0.00	0.000	0.50	0.0	0	0	0	-	2	39.50	7.0	5.7	0.08	106	-	-	-
Shale	49.4	50.4	49.9	598.7	597.7	1.0	130	6,373	2,608	3,765	0.00	0.000	0.50	0.0	0	0	0	-	2	40.50	7.1	5.7	0.07	102	-	-	-
Shale	50.4	51.4	50.9	597.7	596.7	1.0	130	6,503	2,671	3,833	0.00	0.000	0.50	0.0	0	0	0	-	2	41.50	7.3	5.7	0.07	97	-	-	-
Shale	51.4	52.4	51.9	596.7	595.7	1.0	130	6,633	2,733	3,900	0.00	0.000	0.50	0.0	0	0	0	-	2	42.50	7.5	5.7	0.07	93	-	-	-

	Depth from Existing*			Elevation		Layer Thickness	Layer Unit Wt.	In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom			Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	**S_t**
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	**(inch)**
Shale	52.4	53.4	52.9	595.7	594.7	1.0	130	6,763	2,796	3,968	0.00	0.000	0.50	0.0	0	0	0	-	2	43.50	7.7	5.7	0.06	89	-	-	-
Shale	53.4	54.4	53.9	594.7	593.7	1.0	130	6,893	2,858	4,035	0.00	0.000	0.50	0.0	0	0	0	-	2	44.50	7.9	5.7	0.06	85	-	-	-
Shale	54.4	55.4	54.9	593.7	592.7	1.0	130	7,023	2,920	4,103	0.00	0.000	0.50	0.0	0	0	0	-	2	45.50	8.0	5.7	0.06	82	-	-	-
Shale	55.4	56.4	55.9	592.7	591.7	1.0	130	7,153	2,983	4,171	0.00	0.000	0.50	0.0	0	0	0	-	2	46.50	8.2	5.7	0.06	79	-	-	-
Shale	56.4	57.4	56.9	591.7	590.7	1.0	130	7,283	3,045	4,238	0.00	0.000	0.50	0.0	0	0	0	-	2	47.50	8.4	5.7	0.05	75	-	-	-
Shale	57.4	58.4	57.9	590.7	589.7	1.0	130	7,413	3,108	4,306	0.00	0.000	0.50	0.0	0	0	0	-	2	48.50	8.6	5.7	0.05	73	-	-	-
Shale	58.4	59.4	58.9	589.7	588.7	1.0	130	7,543	3,170	4,373	0.00	0.000	0.50	0.0	0	0	0	-	2	49.50	8.7	5.7	0.05	70	-	-	-
Shale	59.4	60.4	59.9	588.7	587.7	1.0	130	7,673	3,232	4,441	0.00	0.000	0.50	0.0	0	0	0	-	2	50.50	8.9	5.7	0.05	67	-	-	-
Shale	60.4	61.4	60.9	587.7	586.7	1.0	130	7,803	3,295	4,509	0.00	0.000	0.50	0.0	0	0	0	-	2	51.50	9.1	5.7	0.05	65	-	-	-
Shale	61.4	62.4	61.9	586.7	585.7	1.0	130	7,933	3,357	4,576	0.00	0.000	0.50	0.0	0	0	0	-	2	52.50	9.3	5.7	0.04	62	-	-	-
Shale	62.4	63.4	62.9	585.7	584.7	1.0	130	8,063	3,420	4,644	0.00	0.000	0.50	0.0	0	0	0	-	2	53.50	9.4	5.7	0.04	60	-	-	-
Shale	63.4	64.4	63.9	584.7	583.7	1.0	130	8,193	3,482	4,711	0.00	0.000	0.50	0.0	0	0	0	-	2	54.50	9.6	5.7	0.04	58	-	-	-
Shale	64.4	65.4	64.9	583.7	582.7	1.0	130	8,323	3,544	4,779	0.00	0.000	0.50	0.0	0	0	0	-	2	55.50	9.8	5.7	0.04	56	-	-	-
Shale	65.4	66.4	65.9	582.7	581.7	1.0	130	8,453	3,607	4,847	0.00	0.000	0.50	0.0	0	0	0	-	2	56.50	10.0	5.7	0.04	54	-	-	-
Shale	66.4	67.4	66.9	581.7	580.7	1.0	130	8,583	3,669	4,914	0.00	0.000	0.50	0.0	0	0	0	-	2	57.50	10.2	5.7	0.04	53	-	-	-
Shale	67.4	68.4	67.9	580.7	579.7	1.0	130	8,713	3,732	4,982	0.00	0.000	0.50	0.0	0	0	0	-	2	58.50	10.3	5.7	0.04	51	-	-	-
Shale	68.4	69.4	68.9	579.7	578.7	1.0	130	8,843	3,794	5,049	0.00	0.000	0.50	0.0	0	0	0	-	2	59.50	10.5	5.7	0.04	49	-	-	-
Shale	69.4	70.4	69.9	578.7	577.7	1.0	130	8,973	3,856	5,117	0.00	0.000	0.50	0.0	0	0	0	-	2	60.50	10.7	5.7	0.03	48	-	-	-
Shale	70.4	71.4	70.9	577.7	576.7	1.0	130	9,103	3,919	5,185	0.00	0.000	0.50	0.0	0	0	0	-	2	61.50	10.9	5.7	0.03	46	-	-	-
Shale	71.4	72.4	71.9	576.7	575.7	1.0	130	9,233	3,981	5,252	0.00	0.000	0.50	0.0	0	0	0	-	2	62.50	11.0	5.7	0.03	45	-	-	-
Shale	72.4	73.4	72.9	575.7	574.7	1.0	130	9,363	4,044	5,320	0.00	0.000	0.50	0.0	0	0	0	-	2	63.50	11.2	5.7	0.03	43	-	-	-
Shale	73.4	74.4	73.9	574.7	573.7	1.0	130	9,493	4,106	5,387	0.00	0.000	0.50	0.0	0	0	0	-	2	64.50	11.4	5.7	0.03	42	-	-	-
Shale	74.4	75.4	74.9	573.7	572.7	1.0	130	9,623	4,168	5,455	0.00	0.000	0.50	0.0	0	0	0	-	2	65.50	11.6	5.7	0.03	41	-	-	-
Shale	75.4	76.4	75.9	572.7	571.7	1.0	130	9,753	4,231	5,523	0.00	0.000	0.50	0.0	0	0	0	-	2	66.50	11.7	5.7	0.03	40	-	-	-
Shale	76.4	77.4	76.9	571.7	570.7	1.0	130	9,883	4,293	5,590	0.00	0.000	0.50	0.0	0	0	0	-	2	67.50	11.9	5.7	0.03	39	-	-	-
Shale	77.4	78.4	77.9	570.7	569.7	1.0	130	10,013	4,356	5,658	0.00	0.000	0.50	0.0	0	0	0	-	2	68.50	12.1	5.7	0.03	37	-	-	-
Shale	78.4	79.4	78.9	569.7	568.7	1.0	130	10,143	4,418	5,725	0.00	0.000	0.50	0.0	0	0	0	-	2	69.50	12.3	5.7	0.03	36	-	-	-
Shale	79.4	80.4	79.9	568.7	567.7	1.0	130	10,273	4,480	5,793	0.00	0.000	0.50	0.0	0	0	0	-	2	70.50	12.4	5.7	0.03	35	-	-	-
Shale	80.4	81.4	80.9	567.7	566.7	1.0	130	10,403	4,543	5,861	0.00	0.000	0.50	0.0	0	0	0	-	2	71.50	12.6	5.7	0.02	34	-	-	-
Shale	81.4	82.4	81.9	566.7	565.7	1.0	130	10,533	4,605	5,928	0.00	0.000	0.50	0.0	0	0	0	-	2	72.50	12.8	5.7	0.02	34	-	-	-
Shale	82.4	83.4	82.9	565.7	564.7	1.0	130	10,663	4,668	5,996	0.00	0.000	0.50	0.0	0	0	0	-	2	73.50	13.0	5.7	0.02	33	-	-	-
Shale	83.4	84.4	83.9	564.7	563.7	1.0	130	10,793	4,730	6,063	0.00	0.000	0.50	0.0	0	0	0	-	2	74.50	13.2	5.7	0.02	32	-	-	-
Shale	84.4	85.4	84.9	563.7	562.7	1.0	130	10,923	4,792	6,131	0.00	0.000	0.50	0.0	0	0	0	-	2	75.50	13.3	5.7	0.02	31	-	-	-
Shale	85.4	86.4	85.9	562.7	561.7	1.0	130	11,053	4,855	6,199	0.00	0.000	0.50	0.0	0	0	0	-	2	76.50	13.5	5.7	0.02	30	-	-	-
Shale	86.4	87.4	86.9	561.7	560.7	1.0	130	11,183	4,917	6,266	0.00	0.000	0.50	0.0	0	0	0	-	2	77.50	13.7	5.7	0.02	29	-	-	-
Shale	87.4	88.4	87.9	560.7	559.7	1.0	130	11,313	4,980	6,334	0.00	0.000	0.50	0.0	0	0	0	-	2	78.50	13.9	5.7	0.02	29	-	-	-
Shale	88.4	89.4	88.9	559.7	558.7	1.0	130	11,443	5,042	6,401	0.00	0.000	0.50	0.0	0	0	0	-	2	79.50	14.0	5.7	0.02	28	-	-	-
Shale	89.4	90.4	89.9	558.7	557.7	1.0	130	11,573	5,104	6,469	0.00	0.000	0.50	0.0	0	0	0	-	2	80.50	14.2	5.7	0.02	27	-	-	-
Shale	90.4	91.4	90.9	557.7	556.7	1.0	130	11,703	5,167	6,537	0.00	0.000	0.50	0.0	0	0	0	-	2	81.50	14.4	5.7	0.02	27	-	-	-
Shale	91.4	92.4	91.9	556.7	555.7	1.0	130	11,833	5,229	6,604	0.00	0.000	0.50	0.0	0	0	0	-	2	82.50	14.6	5.7	0.02	26	-	-	-
Shale	92.4	93.4	92.9	555.7	554.7	1.0	130	11,963	5,292	6,672	0.00	0.000	0.50	0.0	0	0	0	-	2	83.50	14.7	5.7	0.02	25	-	-	-
Shale	93.4	94.4	93.9	554.7	553.7	1.0	130	12,093	5,354	6,739	0.00	0.000	0.50	0.0	0	0	0	-	2	84.50	14.9	5.7	0.02	25	-	-	-
Shale	94.4	95.4	94.9	553.7	552.7	1.0	130	12,223	5,416	6,807	0.00	0.000	0.50	0.0	0	0	0	-	2	85.50	15.1	5.7	0.02	24	-	-	-
Shale	95.4	96.4	95.9	552.7	551.7	1.0	130	12,353	5,479	6,875	0.00	0.000	0.50	0.0	0	0	0	-	2	86.50	15.3	5.7	0.02	24	-	-	-
Shale	96.4	97.4	96.9	551.7	550.7	1.0	130	12,483	5,541	6,942	0.00	0.000	0.50	0.0	0	0	0	-	2	87.50	15.4	5.7	0.02	23	-	-	-
Shale	97.4	98.4	97.9	550.7	549.7	1.0	130	12,613	5,604	7,010	0.00	0.000	0.50	0.0	0	0	0	-	2	88.50	15.6	5.7	0.02	23	-	-	-
Shale	98.4	99.4	98.9	549.7	548.7	1.0	130	12,743	5,666	7,077	0.00	0.000	0.50	0.0	0	0	0	-	2	89.50	15.8	5.7	0.02	22	-	-	-
Shale	99.4	100.4	99.9	548.7	547.7	1.0	130	12,873	5,728	7,145	0.00	0.000	0.50	0.0	0	0	0	-	2	90.50	16.0	5.7	0.02	22	-	-	-
#N/A	100.4	101.4	100.9	547.7	546.7	1.0	#N/A	#N/A	5,791	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	91.50	16.2	5.7	0.02	21	-	-	-
#N/A	101.4	102.4	101.9	546.7	545.7	1.0	#N/A	#N/A	5,853	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	92.50	16.3	5.7	0.01	21	-	-	-
#N/A	102.4	103.4	102.9	545.7	544.7	1.0	#N/A	#N/A	5,916	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	93.50	16.5	5.7	0.01	20	-	-	-
#N/A	103.4	104.4	103.9	544.7	543.7	1.0	#N/A	#N/A	5,978	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	94.50	16.7	5.7	0.01	20	-	-	-
#N/A	104.4	105.4	104.9	543.7	542.7	1.0	#N/A	#N/A	6,040	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	95.50	16.9	5.7	0.01	20	-	-	-
#N/A	105.4	106.4	105.9	542.7	541.7	1.0	#N/A	#N/A	6,103	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	96.50	17.0	5.7	0.01	19	-	-	-
#N/A	106.4	107.4	106.9	541.7	540.7	1.0	#N/A	#N/A	6,165	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	97.50	17.2	5.7	0.01	19	-	-	-
#N/A	107.4	108.4	107.9	540.7	539.7	1.0	#N/A	#N/A	6,228	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	98.50	17.4	5.7	0.01	18	-	-	-
#N/A	108.4	109.4	108.9	539.7	538.7	1.0	#N/A	#N/A	6,290	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	99.50	17.6	5.7	0.01	18	-	-	-
#N/A	109.4	110.4	109.9	538.7	537.7	1.0	#N/A	#N/A	6,352	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	100.50	17.7	5.7	0.01	18	-	-	-
#N/A	110.4	111.4	110.9	537.7	536.7	1.0	#N/A	#N/A	6,415	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	101.50	17.9	5.7	0.01	17	-	-	-
#N/A	111.4	112.4	111.9	536.7	535.7	1.0	#N/A	#N/A	6,477	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	102.50	18.1	5.7	0.01	17	-	-	-
#N/A	112.4	113.4	112.9	535.7	534.7	1.0	#N/A	#N/A	6,540	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	103.50	18.3	5.7	0.01	17	-	-	-
#N/A	113.4	114.4	113.9	534.7	533.7	1.0	#N/A	#N/A	6,602	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	104.50	18.4	5.7	0.01	16	-	-	-
#N/A	114.4	200.0	157.2	533.7	448.1	85.6	#N/A	#N/A	9,304	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	147.80	26.1	5.7	0.01	8	-	-	-



Settlement (inches)
0.0
0.5
1.0
1.5
2.0
Depth (feet)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Rectangular Footing
Settlement Limit of 1 inch:
Settlement Limit of 1.5 inches:

Project Name:	Plum Creek FRS No. 2 Rehabilitation		Structure	Overtopping RCC Spillway - Chute Structure - Walls
Job Number:	60615067		Analysis Section	Existing downstream toe of dam
Client:	TSSWCB		Notes	RCC footing on in-situ subgrade

Geotechnical Data

Relevant Boring	n/a	-
Boring Ground Elev.	638.7	ft NAVD88
Depth to GWT at Boring:	0	feet
GWT Elev.	638.7	ft NAVD88

Exiting Ground at Structure Location

Structure Existing Ground:	638.7	ft NAVD88
Footing Bearing Elev.:	638.7	ft NAVD88
Footing Bearing Elev.:	0	ft below existing (cut)
GWT Depth below Exist.:	0	feet
GWT Depth below footing.:	0	feet

Area Fill

Fill between existing/footing?	no	-
Include load from area fill?	no	-
Finish Grade of Area Fill:	655.5	ft NAVD88
Height above existing:	#N/A	feet
Height above footing base:	#N/A	feet
Thickness under footing:	#N/A	feet
Area Fill Unit Weight:	126	pcf

Subgrade Overexcavation/Replacement

Include Overex/Replacement?	yes	-
Overex/Replace Bottom Elev.	636.7	ft NAVD88
Depth below footing:	2	feet
Depth below existing:	2	feet

Structure Footing Size & Maximum Bearing Pressure

Footing Width, B:	11.33	feet
Footing Length, L (rect):	24	feet
Gross Footing Pressure, $q_{0\text{-gross}}$	2,500	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula do not edit

Design Soil Profile and Properties

Depth at Boring (feet)		Elevation (feet)		Thickness in Boring	1 Existing Depth at Structure (feet)	2	3 Thickness at Structure	4 Layer Name	5 Total Unit Wt	6 Initial Void Ratio, e_0*	7 Compression Index, C_c*	8 Recomp. Index, C_r*	9 Min. Over Consolidation Ratio, OCR*	10 Min. Preconsol. Pressure, P'c*
Top	Bottom	Top	Bottom	(feet)	Top	Bottom	(feet)		(pcf)	(-)				(psf)
0	8	638.7	630.7	8.0	0.0	8.0	8.0	New Embank. Fill	125	0.65	0.20	0.020	2.0	3,000
8	8	630.7	630.7	0.0	8.0	8.0	0.0	Alluvium	123	0.65	0.20	0.030	2.0	4,000
8	18.9	630.7	619.8	10.9	8.0	18.9	10.9	Residuum (MPR)	126	0.60	0.20	0.030	2.0	4,000
18.9	100	619.8	538.7	81.1	18.9	100.0	81.1	Shale	130	0.50	0.0	0.000	0.0	0

Notes: *Copy down elevation and thickness formulas if more layers are needed, delete formulas where not needed.*

*Enter "0" for incompressible layers (i.e., granular soils and bedrock)

Method: Settlement Below Center of Uniformly Loaded Rectangular Footing

Project	Plum Creek FRS No. 2 Rehabilitation
Structure	Overtopping RCC Spillway - Chute Structure - Walls
Analysis Section	Existing downstream toe of dam

Elev. - Existing Ground @ Structure:	638.7	ft NAVD88	0	ft from footing base (below)	0	ft from existing (below)
Elev. - Base of Footing / Bearing Depth	638.7	ft NAVD88	0	ft from footing base (below)	0	ft from existing (below)
Elev. - Top of Area Fill	#N/A	ft NAVD88	#N/A	#N/A	#N/A	#N/A
Elev. - Bottom of Overex./Replace	636.7	ft NAVD88	2	ft from footing base (below)	2	ft from existing (below)
Elev. - Groundwater	638.7	ft NAVD88	0	ft from footing base (below)	0	ft from existing (below)
Thickness - Area Fill	#N/A	feet below footing base				
Thickness - Overex/Replace	2	feet below footing base				

Footing Width, B:	11.33	feet
Footing Length, L (square):	11.33	feet
Footing Length, L (rect):	24	feet

Gross Footing Pressure, $q_{0\text{-gross}}$	2,500	psf
Removed in-situ stress	0	psf
Net Footing Pressure, $q_{0\text{-net}}$	2,500	psf

Legend:

- xxx = Dropdown menu
- xxx = Input cell
- xxx = Cell formula overwritten
- xxx = Formula (do not edit)
- xxx = Unique Formula (do not edit)

$$\Delta\sigma_z = qI_4 \qquad (10.34)$$

where

$$I_4 = \frac{2}{\pi}\left[\frac{m_1 n_1}{\sqrt{1+m_1^2+n_1^2}}\,\frac{1+m_1^2+2n_1^2}{(1+n_1^2)(m_1^2+n_1^2)} + \sin^{-1}\frac{m_1}{\sqrt{m_1^2+n_1^2}\sqrt{1+n_1^2}}\right] \qquad (10.35)$$

$$m_1 = \frac{L}{B} \qquad (10.36)$$

$$n_1 = \frac{z}{b} \qquad (10.37)$$

$$b = \frac{B}{2} \qquad (10.38)$$

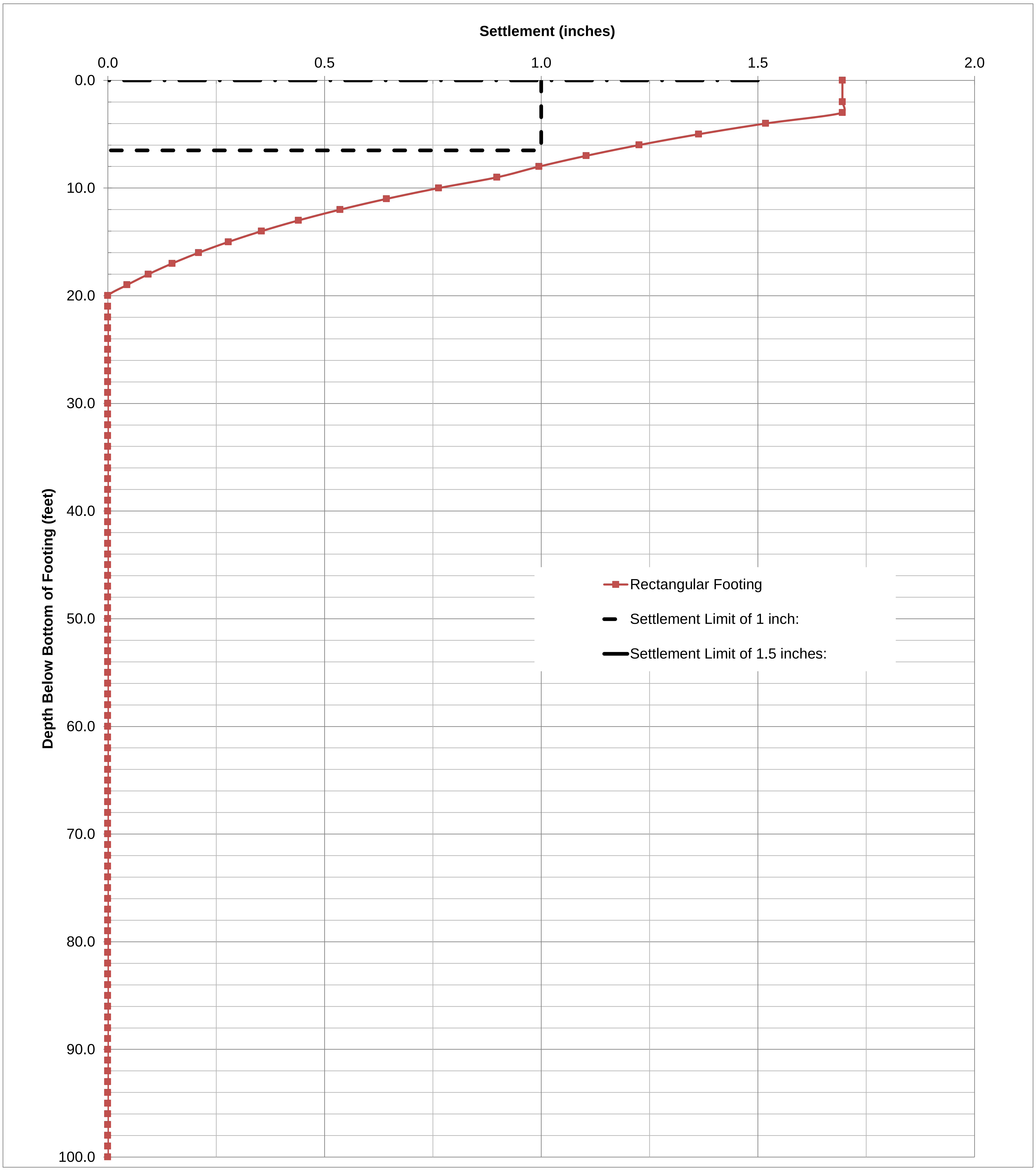
*Negative values indicate height above existing ground

*Assume granular

Total Settlement (inch) = 1.70

	Depth from Existing*			Elevation				In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom	Layer Thickness	Layer Unit Wt.	Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	S_t
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	(inch)
Fill below footing/above exist.	0.0	0.0	0.0	638.7	638.7	0.0	126	-	-	-	-	-	-	-	-	0	0	-	2	0.00	0.0	5.7	1.00	2,500	-	-	-
Existing Soil Above Footing	0.0	0.0	0.0	638.7	638.7	0.0	125	-	-	-	-	-	-	-	-	0	0	-	2	0.00	0.0	5.7	1.00	2,500	-	-	-
Overex. below Existing	0.0	2.0	1.0	638.7	636.7	2.0	125	-	-	-	-	-	-	-	-	0	0	-	2	1.00	0.2	5.7	1.00	2,494	-	-	-
New Embank. Fill	2.0	3.0	2.5	636.7	635.7	1.0	125	313	156	157	0.20	0.020	0.65	2.0	3,000	0	0	-	2	2.50	0.4	5.7	0.97	2,422	0.18	0.00	0.177
New Embank. Fill	3.0	4.0	3.5	635.7	634.7	1.0	125	438	218	219	0.20	0.020	0.65	2.0	3,000	0	0	-	2	3.50	0.6	5.7	0.93	2,320	0.15	0.00	0.155
New Embank. Fill	4.0	5.0	4.5	634.7	633.7	1.0	125	563	281	282	0.20	0.020	0.65	2.0	3,000	0	0	-	2	4.50	0.8	5.7	0.87	2,185	0.14	0.00	0.137
New Embank. Fill	5.0	6.0	5.5	633.7	632.7	1.0	125	688	343	344	0.20	0.020	0.65	2.0	3,000	0	0	-	2	5.50	1.0	5.7	0.81	2,033	0.12	0.00	0.122
New Embank. Fill	6.0	7.0	6.5	632.7	631.7	1.0	125	813	406	407	0.20	0.020	0.65	2.0	3,000	0	0	-	2	6.50	1.1	5.7	0.75	1,876	0.11	0.00	0.109
New Embank. Fill	7.0	8.0	7.5	631.7	630.7	1.0	125	938	468	470	0.20	0.020	0.65	2.0	3,000	0	0	-	2	7.50	1.3	5.7	0.69	1,722	0.10	0.00	0.097
Residuum (MPR)	8.0	9.0	8.5	630.7	629.7	1.0	126	1,063	530	533	0.20	0.030	0.60	2.0	4,000	0	0	-	2	8.50	1.5	5.7	0.63	1,577	0.13	0.00	0.134
Residuum (MPR)	9.0	10.0	9.5	629.7	628.7	1.0	126	1,189	593	596	0.20	0.030	0.60	2.0	4,000	0	0	-	2	9.50	1.7	5.7	0.58	1,441	0.12	0.00	0.120
Residuum (MPR)	10.0	11.0	10.5	628.7	627.7	1.0	126	1,315	655	660	0.20	0.030	0.60	2.0	4,000	0	0	-	2	10.50	1.9	5.7	0.53	1,317	0.11	0.00	0.107
Residuum (MPR)	11.0	12.0	11.5	627.7	626.7	1.0	126	1,441	718	723	0.20	0.030	0.60	2.0	4,000	0	0	-	2	11.50	2.0	5.7	0.48	1,204	0.10	0.00	0.096
Residuum (MPR)	12.0	13.0	12.5	626.7	625.7	1.0	126	1,567	780	787	0.20	0.030	0.60	2.0	4,000	0	0	-	2	12.50	2.2	5.7	0.44	1,102	0.09	0.00	0.086
Residuum (MPR)	13.0	14.0	13.5	625.7	624.7	1.0	126	1,693	842	851	0.20	0.030	0.60	2.0	4,000	0	0	-	2	13.50	2.4	5.7	0.40	1,010	0.08	0.00	0.076
Residuum (MPR)	14.0	15.0	14.5	624.7	623.7	1.0	126	1,819	905	914	0.20	0.030	0.60	2.0	4,000	0	0	-	2	14.50	2.6	5.7	0.37	927	0.07	0.00	0.068
Residuum (MPR)	15.0	16.0	15.5	623.7	622.7	1.0	126	1,945	967	978	0.20	0.030	0.60	2.0	4,000	0	0	-	2	15.50	2.7	5.7	0.34	853	0.06	0.00	0.061
Residuum (MPR)	16.0	17.0	16.5	622.7	621.7	1.0	126	2,071	1,030	1,041	0.20	0.030	0.60	2.0	4,000	0	0	-	2	16.50	2.9	5.7	0.31	785	0.05	0.00	0.055
Residuum (MPR)	17.0	18.0	17.5	621.7	620.7	1.0	126	2,197	1,092	1,105	0.20	0.030	0.60	2.0	4,000	0	0	-	2	17.50	3.1	5.7	0.29	725	0.05	0.00	0.049
Residuum (MPR)	18.0	19.0	18.5	620.7	619.7	1.0	126	2,323	1,154	1,169	0.20	0.030	0.60	2.0	4,000	0	0	-	2	18.50	3.3	5.7	0.27	670	0.04	0.00	0.044
Shale	19.0	20.0	19.5	619.7	618.7	1.0	130	2,451	1,217	1,234	0.00	0.000	0.50	0.0	0	0	0	-	2	19.50	3.4	5.7	0.25	621	-	-	-
Shale	20.0	21.0	20.5	618.7	617.7	1.0	130	2,581	1,279	1,302	0.00	0.000	0.50	0.0	0	0	0	-	2	20.50	3.6	5.7	0.23	577	-	-	-
Shale	21.0	22.0	21.5	617.7	616.7	1.0	130	2,711	1,342	1,369	0.00	0.000	0.50	0.0	0	0	0	-	2	21.50	3.8	5.7	0.21	536	-	-	-
Shale	22.0	23.0	22.5	616.7	615.7	1.0	130	2,841	1,404	1,437	0.00	0.000	0.50	0.0	0	0	0	-	2	22.50	4.0	5.7	0.20	500	-	-	-
Shale	23.0	24.0	23.5	615.7	614.7	1.0	130	2,971	1,466	1,505	0.00	0.000	0.50	0.0	0	0	0	-	2	23.50	4.1	5.7	0.19	466	-	-	-
Shale	24.0	25.0	24.5	614.7	613.7	1.0	130	3,101	1,529	1,572	0.00	0.000	0.50	0.0	0	0	0	-	2	24.50	4.3	5.7	0.17	436	-	-	-
Shale	25.0	26.0	25.5	613.7	612.7	1.0	130	3,231	1,591	1,640	0.00	0.000	0.50	0.0	0	0	0	-	2	25.50	4.5	5.7	0.16	409	-	-	-
Shale	26.0	27.0	26.5	612.7	611.7	1.0	130	3,361	1,654	1,707	0.00	0.000	0.50	0.0	0	0	0	-	2	26.50	4.7	5.7	0.15	383	-	-	-
Shale	27.0	28.0	27.5	611.7	610.7	1.0	130	3,491	1,716	1,775	0.00	0.000	0.50	0.0	0	0	0	-	2	27.50	4.9	5.7	0.14	360	-	-	-
Shale	28.0	29.0	28.5	610.7	609.7	1.0	130	3,621	1,778	1,843	0.00	0.000	0.50	0.0	0	0	0	-	2	28.50	5.0	5.7	0.14	339	-	-	-
Shale	29.0	30.0	29.5	609.7	608.7	1.0	130	3,751	1,841	1,910	0.00	0.000	0.50	0.0	0	0	0	-	2	29.50	5.2	5.7	0.13	320	-	-	-
Shale	30.0	31.0	30.5	608.7	607.7	1.0	130	3,881	1,903	1,978	0.00	0.000	0.50	0.0	0	0	0	-	2	30.50	5.4	5.7	0.12	302	-	-	-
Shale	31.0	32.0	31.5	607.7	606.7	1.0	130	4,011	1,966	2,045	0.00	0.000	0.50	0.0	0	0	0	-	2	31.50	5.6	5.7	0.11	285	-	-	-
Shale	32.0	33.0	32.5	606.7	605.7	1.0	130	4,141	2,028	2,113	0.00	0.000	0.50	0.0	0	0	0	-	2	32.50	5.7	5.7	0.11	270	-	-	-
Shale	33.0	34.0	33.5	605.7	604.7	1.0	130	4,271	2,090	2,181	0.00	0.000	0.50	0.0	0	0	0	-	2	33.50	5.9	5.7	0.10	256	-	-	-
Shale	34.0	35.0	34.5	604.7	603.7	1.0	130	4,401	2,153	2,248	0.00	0.000	0.50	0.0	0	0	0	-	2	34.50	6.1	5.7	0.10	243	-	-	-
Shale	35.0	36.0	35.5	603.7	602.7	1.0	130	4,531	2,215	2,316	0.00	0.000	0.50	0.0	0	0	0	-	2	35.50	6.3	5.7	0.09	231	-	-	-
Shale	36.0	37.0	36.5	602.7	601.7	1.0	130	4,661	2,278	2,383	0.00	0.000	0.50	0.0	0	0	0	-	2	36.50	6.4	5.7	0.09	220	-	-	-
Shale	37.0	38.0	37.5	601.7	600.7	1.0	130	4,791	2,340	2,451	0.00	0.000	0.50	0.0	0	0	0	-	2	37.50	6.6	5.7	0.08	209	-	-	-
Shale	38.0	39.0	38.5	600.7	599.7	1.0	130	4,921	2,402	2,519	0.00	0.000	0.50	0.0	0	0	0	-	2	38.50	6.8	5.7	0.08	199	-	-	-
Shale	39.0	40.0	39.5	599.7	598.7	1.0	130	5,051	2,465	2,586	0.00	0.000	0.50	0.0	0	0	0	-	2	39.50	7.0	5.7	0.08	190	-	-	-
Shale	40.0	41.0	40.5	598.7	597.7	1.0	130	5,181	2,527	2,654	0.00	0.000	0.50	0.0	0	0	0	-	2	40.50	7.1	5.7	0.07	182	-	-	-
Shale	41.0	42.0	41.5	597.7	596.7	1.0	130	5,311	2,590	2,721	0.00	0.000	0.50	0.0	0	0	0	-	2	41.50	7.3	5.7	0.07	174	-	-	-
Shale	42.0	43.0	42.5	596.7	595.7	1.0	130	5,441	2,652	2,789	0.00	0.000	0.50	0.0	0	0	0	-	2	42.50	7.5	5.7	0.07	166	-	-	-

Stratum	Depth from Existing* Top	Depth from Existing* Bottom	Depth from Existing* MP	Elevation Top	Elevation Bottom	Layer Thickness	Layer Unit Wt.	In-Situ Stresse at MP Total P_0	In-Situ Stresse at MP μ	In-Situ Stresse at MP Eff. P'_0	Consolidation Parameters Cc	Consolidation Parameters Cr	Consolidation Parameters e0	Consolidation Parameters OCR	Consolidation Parameters P'_c	Area Fill above Existing Thick-ness	Area Fill above Existing ΔP_{Fill}	Area Fill above Existing Self Compress*	Rectangular Footing m1	Rectangular Footing Eff. Z	Rectangular Footing n1	Rectangular Footing b	Rectangular Footing I4	Rectangular Footing ΔP_{Fndn}	Rectangular Footing S_{re}	Rectangular Footing S_c	Rectangular Footing **S_t**
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	**(inch)**
Shale	43.0	44.0	43.5	595.7	594.7	1.0	130	5,571	2,714	2,857	0.00	0.000	0.50	0.0	0	0	0	-	2	43.50	7.7	5.7	0.06	159	-	-	-
Shale	44.0	45.0	44.5	594.7	593.7	1.0	130	5,701	2,777	2,924	0.00	0.000	0.50	0.0	0	0	0	-	2	44.50	7.9	5.7	0.06	153	-	-	-
Shale	45.0	46.0	45.5	593.7	592.7	1.0	130	5,831	2,839	2,992	0.00	0.000	0.50	0.0	0	0	0	-	2	45.50	8.0	5.7	0.06	146	-	-	-
Shale	46.0	47.0	46.5	592.7	591.7	1.0	130	5,961	2,902	3,059	0.00	0.000	0.50	0.0	0	0	0	-	2	46.50	8.2	5.7	0.06	141	-	-	-
Shale	47.0	48.0	47.5	591.7	590.7	1.0	130	6,091	2,964	3,127	0.00	0.000	0.50	0.0	0	0	0	-	2	47.50	8.4	5.7	0.05	135	-	-	-
Shale	48.0	49.0	48.5	590.7	589.7	1.0	130	6,221	3,026	3,195	0.00	0.000	0.50	0.0	0	0	0	-	2	48.50	8.6	5.7	0.05	130	-	-	-
Shale	49.0	50.0	49.5	589.7	588.7	1.0	130	6,351	3,089	3,262	0.00	0.000	0.50	0.0	0	0	0	-	2	49.50	8.7	5.7	0.05	125	-	-	-
Shale	50.0	51.0	50.5	588.7	587.7	1.0	130	6,481	3,151	3,330	0.00	0.000	0.50	0.0	0	0	0	-	2	50.50	8.9	5.7	0.05	120	-	-	-
Shale	51.0	52.0	51.5	587.7	586.7	1.0	130	6,611	3,214	3,397	0.00	0.000	0.50	0.0	0	0	0	-	2	51.50	9.1	5.7	0.05	116	-	-	-
Shale	52.0	53.0	52.5	586.7	585.7	1.0	130	6,741	3,276	3,465	0.00	0.000	0.50	0.0	0	0	0	-	2	52.50	9.3	5.7	0.04	112	-	-	-
Shale	53.0	54.0	53.5	585.7	584.7	1.0	130	6,871	3,338	3,533	0.00	0.000	0.50	0.0	0	0	0	-	2	53.50	9.4	5.7	0.04	108	-	-	-
Shale	54.0	55.0	54.5	584.7	583.7	1.0	130	7,001	3,401	3,600	0.00	0.000	0.50	0.0	0	0	0	-	2	54.50	9.6	5.7	0.04	104	-	-	-
Shale	55.0	56.0	55.5	583.7	582.7	1.0	130	7,131	3,463	3,668	0.00	0.000	0.50	0.0	0	0	0	-	2	55.50	9.8	5.7	0.04	101	-	-	-
Shale	56.0	57.0	56.5	582.7	581.7	1.0	130	7,261	3,526	3,735	0.00	0.000	0.50	0.0	0	0	0	-	2	56.50	10.0	5.7	0.04	97	-	-	-
Shale	57.0	58.0	57.5	581.7	580.7	1.0	130	7,391	3,588	3,803	0.00	0.000	0.50	0.0	0	0	0	-	2	57.50	10.2	5.7	0.04	94	-	-	-
Shale	58.0	59.0	58.5	580.7	579.7	1.0	130	7,521	3,650	3,871	0.00	0.000	0.50	0.0	0	0	0	-	2	58.50	10.3	5.7	0.04	91	-	-	-
Shale	59.0	60.0	59.5	579.7	578.7	1.0	130	7,651	3,713	3,938	0.00	0.000	0.50	0.0	0	0	0	-	2	59.50	10.5	5.7	0.04	88	-	-	-
Shale	60.0	61.0	60.5	578.7	577.7	1.0	130	7,781	3,775	4,006	0.00	0.000	0.50	0.0	0	0	0	-	2	60.50	10.7	5.7	0.03	85	-	-	-
Shale	61.0	62.0	61.5	577.7	576.7	1.0	130	7,911	3,838	4,073	0.00	0.000	0.50	0.0	0	0	0	-	2	61.50	10.9	5.7	0.03	83	-	-	-
Shale	62.0	63.0	62.5	576.7	575.7	1.0	130	8,041	3,900	4,141	0.00	0.000	0.50	0.0	0	0	0	-	2	62.50	11.0	5.7	0.03	80	-	-	-
Shale	63.0	64.0	63.5	575.7	574.7	1.0	130	8,171	3,962	4,209	0.00	0.000	0.50	0.0	0	0	0	-	2	63.50	11.2	5.7	0.03	78	-	-	-
Shale	64.0	65.0	64.5	574.7	573.7	1.0	130	8,301	4,025	4,276	0.00	0.000	0.50	0.0	0	0	0	-	2	64.50	11.4	5.7	0.03	75	-	-	-
Shale	65.0	66.0	65.5	573.7	572.7	1.0	130	8,431	4,087	4,344	0.00	0.000	0.50	0.0	0	0	0	-	2	65.50	11.6	5.7	0.03	73	-	-	-
Shale	66.0	67.0	66.5	572.7	571.7	1.0	130	8,561	4,150	4,411	0.00	0.000	0.50	0.0	0	0	0	-	2	66.50	11.7	5.7	0.03	71	-	-	-
Shale	67.0	68.0	67.5	571.7	570.7	1.0	130	8,691	4,212	4,479	0.00	0.000	0.50	0.0	0	0	0	-	2	67.50	11.9	5.7	0.03	69	-	-	-
Shale	68.0	69.0	68.5	570.7	569.7	1.0	130	8,821	4,274	4,547	0.00	0.000	0.50	0.0	0	0	0	-	2	68.50	12.1	5.7	0.03	67	-	-	-
Shale	69.0	70.0	69.5	569.7	568.7	1.0	130	8,951	4,337	4,614	0.00	0.000	0.50	0.0	0	0	0	-	2	69.50	12.3	5.7	0.03	65	-	-	-
Shale	70.0	71.0	70.5	568.7	567.7	1.0	130	9,081	4,399	4,682	0.00	0.000	0.50	0.0	0	0	0	-	2	70.50	12.4	5.7	0.03	63	-	-	-
Shale	71.0	72.0	71.5	567.7	566.7	1.0	130	9,211	4,462	4,749	0.00	0.000	0.50	0.0	0	0	0	-	2	71.50	12.6	5.7	0.02	62	-	-	-
Shale	72.0	73.0	72.5	566.7	565.7	1.0	130	9,341	4,524	4,817	0.00	0.000	0.50	0.0	0	0	0	-	2	72.50	12.8	5.7	0.02	60	-	-	-
Shale	73.0	74.0	73.5	565.7	564.7	1.0	130	9,471	4,586	4,885	0.00	0.000	0.50	0.0	0	0	0	-	2	73.50	13.0	5.7	0.02	58	-	-	-
Shale	74.0	75.0	74.5	564.7	563.7	1.0	130	9,601	4,649	4,952	0.00	0.000	0.50	0.0	0	0	0	-	2	74.50	13.2	5.7	0.02	57	-	-	-
Shale	75.0	76.0	75.5	563.7	562.7	1.0	130	9,731	4,711	5,020	0.00	0.000	0.50	0.0	0	0	0	-	2	75.50	13.3	5.7	0.02	56	-	-	-
Shale	76.0	77.0	76.5	562.7	561.7	1.0	130	9,861	4,774	5,087	0.00	0.000	0.50	0.0	0	0	0	-	2	76.50	13.5	5.7	0.02	54	-	-	-
Shale	77.0	78.0	77.5	561.7	560.7	1.0	130	9,991	4,836	5,155	0.00	0.000	0.50	0.0	0	0	0	-	2	77.50	13.7	5.7	0.02	53	-	-	-
Shale	78.0	79.0	78.5	560.7	559.7	1.0	130	10,121	4,898	5,223	0.00	0.000	0.50	0.0	0	0	0	-	2	78.50	13.9	5.7	0.02	51	-	-	-
Shale	79.0	80.0	79.5	559.7	558.7	1.0	130	10,251	4,961	5,290	0.00	0.000	0.50	0.0	0	0	0	-	2	79.50	14.0	5.7	0.02	50	-	-	-
Shale	80.0	81.0	80.5	558.7	557.7	1.0	130	10,381	5,023	5,358	0.00	0.000	0.50	0.0	0	0	0	-	2	80.50	14.2	5.7	0.02	49	-	-	-
Shale	81.0	82.0	81.5	557.7	556.7	1.0	130	10,511	5,086	5,425	0.00	0.000	0.50	0.0	0	0	0	-	2	81.50	14.4	5.7	0.02	48	-	-	-
Shale	82.0	83.0	82.5	556.7	555.7	1.0	130	10,641	5,148	5,493	0.00	0.000	0.50	0.0	0	0	0	-	2	82.50	14.6	5.7	0.02	47	-	-	-
Shale	83.0	84.0	83.5	555.7	554.7	1.0	130	10,771	5,210	5,561	0.00	0.000	0.50	0.0	0	0	0	-	2	83.50	14.7	5.7	0.02	46	-	-	-
Shale	84.0	85.0	84.5	554.7	553.7	1.0	130	10,901	5,273	5,628	0.00	0.000	0.50	0.0	0	0	0	-	2	84.50	14.9	5.7	0.02	45	-	-	-
Shale	85.0	86.0	85.5	553.7	552.7	1.0	130	11,031	5,335	5,696	0.00	0.000	0.50	0.0	0	0	0	-	2	85.50	15.1	5.7	0.02	44	-	-	-
Shale	86.0	87.0	86.5	552.7	551.7	1.0	130	11,161	5,398	5,763	0.00	0.000	0.50	0.0	0	0	0	-	2	86.50	15.3	5.7	0.02	43	-	-	-
Shale	87.0	88.0	87.5	551.7	550.7	1.0	130	11,291	5,460	5,831	0.00	0.000	0.50	0.0	0	0	0	-	2	87.50	15.4	5.7	0.02	42	-	-	-
Shale	88.0	89.0	88.5	550.7	549.7	1.0	130	11,421	5,522	5,899	0.00	0.000	0.50	0.0	0	0	0	-	2	88.50	15.6	5.7	0.02	41	-	-	-
Shale	89.0	90.0	89.5	549.7	548.7	1.0	130	11,551	5,585	5,966	0.00	0.000	0.50	0.0	0	0	0	-	2	89.50	15.8	5.7	0.02	40	-	-	-
Shale	90.0	91.0	90.5	548.7	547.7	1.0	130	11,681	5,647	6,034	0.00	0.000	0.50	0.0	0	0	0	-	2	90.50	16.0	5.7	0.02	39	-	-	-
Shale	91.0	92.0	91.5	547.7	546.7	1.0	130	11,811	5,710	6,101	0.00	0.000	0.50	0.0	0	0	0	-	2	91.50	16.2	5.7	0.02	38	-	-	-
Shale	92.0	93.0	92.5	546.7	545.7	1.0	130	11,941	5,772	6,169	0.00	0.000	0.50	0.0	0	0	0	-	2	92.50	16.3	5.7	0.01	37	-	-	-
Shale	93.0	94.0	93.5	545.7	544.7	1.0	130	12,071	5,834	6,237	0.00	0.000	0.50	0.0	0	0	0	-	2	93.50	16.5	5.7	0.01	37	-	-	-
Shale	94.0	95.0	94.5	544.7	543.7	1.0	130	12,201	5,897	6,304	0.00	0.000	0.50	0.0	0	0	0	-	2	94.50	16.7	5.7	0.01	36	-	-	-
Shale	95.0	96.0	95.5	543.7	542.7	1.0	130	12,331	5,959	6,372	0.00	0.000	0.50	0.0	0	0	0	-	2	95.50	16.9	5.7	0.01	35	-	-	-
Shale	96.0	97.0	96.5	542.7	541.7	1.0	130	12,461	6,022	6,439	0.00	0.000	0.50	0.0	0	0	0	-	2	96.50	17.0	5.7	0.01	34	-	-	-
Shale	97.0	98.0	97.5	541.7	540.7	1.0	130	12,591	6,084	6,507	0.00	0.000	0.50	0.0	0	0	0	-	2	97.50	17.2	5.7	0.01	34	-	-	-
Shale	98.0	99.0	98.5	540.7	539.7	1.0	130	12,721	6,146	6,575	0.00	0.000	0.50	0.0	0	0	0	-	2	98.50	17.4	5.7	0.01	33	-	-	-
Shale	99.0	100.0	99.5	539.7	538.7	1.0	130	12,851	6,209	6,642	0.00	0.000	0.50	0.0	0	0	0	-	2	99.50	17.6	5.7	0.01	32	-	-	-
Shale	100.0	101.0	100.5	538.7	537.7	1.0	130	12,981	6,271	6,710	0.00	0.000	0.50	0.0	0	0	0	-	2	100.50	17.7	5.7	0.01	32	-	-	-
#N/A	101.0	102.0	101.5	537.7	536.7	1.0	#N/A	#N/A	6,334	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	101.50	17.9	5.7	0.01	31	-	-	-
#N/A	102.0	103.0	102.5	536.7	535.7	1.0	#N/A	#N/A	6,396	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	102.50	18.1	5.7	0.01	30	-	-	-
#N/A	103.0	104.0	103.5	535.7	534.7	1.0	#N/A	#N/A	6,458	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	103.50	18.3	5.7	0.01	30	-	-	-
#N/A	104.0	105.0	104.5	534.7	533.7	1.0	#N/A	#N/A	6,521	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	104.50	18.4	5.7	0.01	29	-	-	-
#N/A	105.0	200.0	152.5	533.7	438.7	95.0	#N/A	#N/A	9,516	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	152.50	26.9	5.7	0.01	14	-	-	-


Settlement (inches)
0.0
0.5
1.0
1.5
2.0
Depth Below Bottom of Footing (feet)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Rectangular Footing
Settlement Limit of 1 inch:
Settlement Limit of 1.5 inches:

Project Name:	Plum Creek FRS No. 2 Rehabilitation		Structure	Overtopping RCC Spillway - Chute Structure - Walls
Job Number:	60615067		Analysis Section	Existing downstream toe of dam
Client:	TSSWCB		Notes	RCC footing on in-situ subgrade

Geotechnical Data

Relevant Boring	n/a	-
Boring Ground Elev.	638.7	ft NAVD88
Depth to GWT at Boring:	0	feet
GWT Elev.	638.7	ft NAVD88

Exiting Ground at Structure Location

Structure Existing Ground:	638.7	ft NAVD88
Footing Bearing Elev.:	638.7	ft NAVD88
Footing Bearing Elev.:	0	ft below existing (cut)
GWT Depth below Exist.:	0	feet
GWT Depth below footing.:	0	feet

Area Fill

Fill between existing/footing?	no	-
Include load from area fill?	no	-
Finish Grade of Area Fill:	655.5	ft NAVD88
Height above existing:	#N/A	feet
Height above footing base:	#N/A	feet
Thickness under footing:	#N/A	feet
Area Fill Unit Weight:	126	pcf

Subgrade Overexcavation/Replacement

Include Overex/Replacement?	yes	-
Overex/Replace Bottom Elev.	636.7	ft NAVD88
Depth below footing:	2	feet
Depth below existing:	2	feet

Structure Footing Size & Maximum Bearing Pressure

Footing Width, B:	11.33	feet
Footing Length, L (rect):	24	feet
Gross Footing Pressure, $q_{0\text{-gross}}$	2,000	psf

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula do not edit

Design Soil Profile and Properties

Depth at Boring (feet)		Elevation (feet)		Thickness in Boring	1 Existing Depth at Structure (feet)	2	3 Thickness at Structure	4 Layer Name	5 Total Unit Wt	6 Initial Void Ratio, e_0*	7 Compression Index, C_c*	8 Recomp. Index, C_r*	9 Min. Over Consolidation Ratio, OCR*	10 Min. Preconsol. Pressure, P'c*
Top	Bottom	Top	Bottom	(feet)	Top	Bottom	(feet)		(pcf)	(-)				(psf)
0	8	638.7	630.7	8.0	0.0	8.0	8.0	New Embank. Fill	125	0.65	0.20	0.020	2.0	3,000
8	8	630.7	630.7	0.0	8.0	8.0	0.0	Alluvium	123	0.65	0.20	0.030	2.0	4,000
8	18.9	630.7	619.8	10.9	8.0	18.9	10.9	Residuum (MPR)	126	0.60	0.20	0.030	2.0	4,000
18.9	100	619.8	538.7	81.1	18.9	100.0	81.1	Shale	130	0.50	0.0	0.000	0.0	0

Notes: *Copy down elevation and thickness formulas if more layers are needed, delete formulas where not needed.*

*Enter "0" for incompressible layers (i.e., granular soils and bedrock)

Method: Settlement Below Center of Uniformly Loaded Rectangular Footing

Project	Plum Creek FRS No. 2 Rehabilitation
Structure	Overtopping RCC Spillway - Chute Structure - Walls
Analysis Section	Existing downstream toe of dam

Elev. - Existing Ground @ Structure:	638.7	ft NAVD88	0	ft from footing base (below)	0	ft from existing (below)
Elev. - Base of Footing / Bearing Depth	638.7	ft NAVD88	0	ft from footing base (below)	0	ft from existing (below)
Elev. - Top of Area Fill	#N/A	ft NAVD88	#N/A	#N/A	#N/A	#N/A
Elev. - Bottom of Overex./Replace	636.7	ft NAVD88	2	ft from footing base (below)	2	ft from existing (below)
Elev. - Groundwater	638.7	ft NAVD88	0	ft from footing base (below)	0	ft from existing (below)
Thickness - Area Fill	#N/A	feet below footing base				
Thickness - Overex/Replace	2	feet below footing base				

Footing Width, B:	11.33	feet
Footing Length, L (square):	11.33	feet
Footing Length, L (rect):	24	feet

Gross Footing Pressure, $q_{0\text{-gross}}$	2,000	psf
Removed in-situ stress	0	psf
Net Footing Pressure, $q_{0\text{-net}}$	2,000	psf

$$\Delta\sigma_z = qI_4 \qquad (10.34)$$

where

$$I_4 = \frac{2}{\pi}\left[\frac{m_1 n_1}{\sqrt{1+m_1^2+n_1^2}}\,\frac{1+m_1^2+2n_1^2}{(1+n_1^2)(m_1^2+n_1^2)} + \sin^{-1}\frac{m_1}{\sqrt{m_1^2+n_1^2}\sqrt{1+n_1^2}}\right] \qquad (10.35)$$

$$m_1 = \frac{L}{B} \qquad (10.36)$$

$$n_1 = \frac{z}{b} \qquad (10.37)$$

$$b = \frac{B}{2} \qquad (10.38)$$

Legend:

xxx	= Dropdown menu
xxx	= Input cell
xxx	= Cell formula overwritten
xxx	= Formula (do not edit)
xxx	= Unique Formula (do not edit)

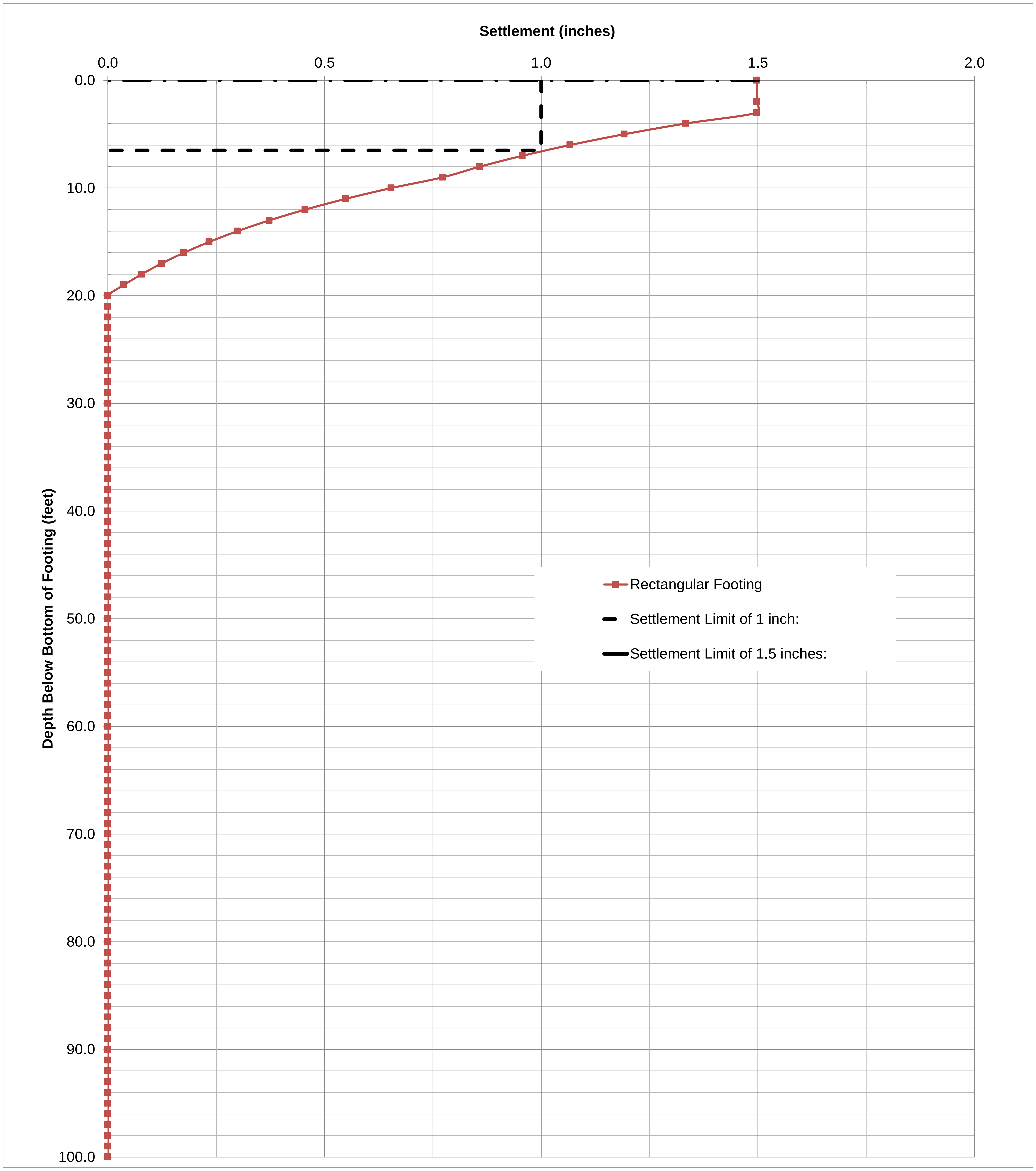
*Negative values indicate height above existing ground

*Assume granular

Total Settlement (inch) = 1.50

	Depth from Existing*			Elevation				In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom	Layer Thickness	Layer Unit Wt.	Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	S_t
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	**(inch)**
Fill below footing/above exist.	0.0	0.0	0.0	638.7	638.7	0.0	126	-	-	-	-	-	-	-	-	0	0	-	2	0.00	0.0	5.7	1.00	2,000	-	-	**-**
Existing Soil Above Footing	0.0	0.0	0.0	638.7	638.7	0.0	125	-	-	-	-	-	-	-	-	0	0	-	2	0.00	0.0	5.7	1.00	2,000	-	-	**-**
Overex. below Existing	0.0	2.0	1.0	638.7	636.7	2.0	125	-	-	-	-	-	-	-	-	0	0	-	2	1.00	0.2	5.7	1.00	1,995	-	-	**-**
New Embank. Fill	2.0	3.0	2.5	636.7	635.7	1.0	125	313	156	157	0.20	0.020	0.65	2.0	3,000	0	0	-	2	2.50	0.4	5.7	0.97	1,938	0.16	0.00	**0.164**
New Embank. Fill	3.0	4.0	3.5	635.7	634.7	1.0	125	438	218	219	0.20	0.020	0.65	2.0	3,000	0	0	-	2	3.50	0.6	5.7	0.93	1,856	0.14	0.00	**0.142**
New Embank. Fill	4.0	5.0	4.5	634.7	633.7	1.0	125	563	281	282	0.20	0.020	0.65	2.0	3,000	0	0	-	2	4.50	0.8	5.7	0.87	1,748	0.12	0.00	**0.125**
New Embank. Fill	5.0	6.0	5.5	633.7	632.7	1.0	125	688	343	344	0.20	0.020	0.65	2.0	3,000	0	0	-	2	5.50	1.0	5.7	0.81	1,626	0.11	0.00	**0.110**
New Embank. Fill	6.0	7.0	6.5	632.7	631.7	1.0	125	813	406	407	0.20	0.020	0.65	2.0	3,000	0	0	-	2	6.50	1.1	5.7	0.75	1,501	0.10	0.00	**0.098**
New Embank. Fill	7.0	8.0	7.5	631.7	630.7	1.0	125	938	468	470	0.20	0.020	0.65	2.0	3,000	0	0	-	2	7.50	1.3	5.7	0.69	1,378	0.09	0.00	**0.087**
Residuum (MPR)	8.0	9.0	8.5	630.7	629.7	1.0	126	1,063	530	533	0.20	0.030	0.60	2.0	4,000	0	0	-	2	8.50	1.5	5.7	0.63	1,261	0.12	0.00	**0.119**
Residuum (MPR)	9.0	10.0	9.5	629.7	628.7	1.0	126	1,189	593	596	0.20	0.030	0.60	2.0	4,000	0	0	-	2	9.50	1.7	5.7	0.58	1,153	0.11	0.00	**0.105**
Residuum (MPR)	10.0	11.0	10.5	628.7	627.7	1.0	126	1,315	655	660	0.20	0.030	0.60	2.0	4,000	0	0	-	2	10.50	1.9	5.7	0.53	1,054	0.09	0.00	**0.093**
Residuum (MPR)	11.0	12.0	11.5	627.7	626.7	1.0	126	1,441	718	723	0.20	0.030	0.60	2.0	4,000	0	0	-	2	11.50	2.0	5.7	0.48	964	0.08	0.00	**0.083**
Residuum (MPR)	12.0	13.0	12.5	626.7	625.7	1.0	126	1,567	780	787	0.20	0.030	0.60	2.0	4,000	0	0	-	2	12.50	2.2	5.7	0.44	882	0.07	0.00	**0.073**
Residuum (MPR)	13.0	14.0	13.5	625.7	624.7	1.0	126	1,693	842	851	0.20	0.030	0.60	2.0	4,000	0	0	-	2	13.50	2.4	5.7	0.40	808	0.07	0.00	**0.065**
Residuum (MPR)	14.0	15.0	14.5	624.7	623.7	1.0	126	1,819	905	914	0.20	0.030	0.60	2.0	4,000	0	0	-	2	14.50	2.6	5.7	0.37	742	0.06	0.00	**0.058**
Residuum (MPR)	15.0	16.0	15.5	623.7	622.7	1.0	126	1,945	967	978	0.20	0.030	0.60	2.0	4,000	0	0	-	2	15.50	2.7	5.7	0.34	682	0.05	0.00	**0.052**
Residuum (MPR)	16.0	17.0	16.5	622.7	621.7	1.0	126	2,071	1,030	1,041	0.20	0.030	0.60	2.0	4,000	0	0	-	2	16.50	2.9	5.7	0.31	628	0.05	0.00	**0.046**
Residuum (MPR)	17.0	18.0	17.5	621.7	620.7	1.0	126	2,197	1,092	1,105	0.20	0.030	0.60	2.0	4,000	0	0	-	2	17.50	3.1	5.7	0.29	580	0.04	0.00	**0.041**
Residuum (MPR)	18.0	19.0	18.5	620.7	619.7	1.0	126	2,323	1,154	1,169	0.20	0.030	0.60	2.0	4,000	0	0	-	2	18.50	3.3	5.7	0.27	536	0.04	0.00	**0.037**
Shale	19.0	20.0	19.5	619.7	618.7	1.0	130	2,451	1,217	1,234	0.00	0.000	0.50	0.0	0	0	0	-	2	19.50	3.4	5.7	0.25	497	-	-	**-**
Shale	20.0	21.0	20.5	618.7	617.7	1.0	130	2,581	1,279	1,302	0.00	0.000	0.50	0.0	0	0	0	-	2	20.50	3.6	5.7	0.23	461	-	-	**-**
Shale	21.0	22.0	21.5	617.7	616.7	1.0	130	2,711	1,342	1,369	0.00	0.000	0.50	0.0	0	0	0	-	2	21.50	3.8	5.7	0.21	429	-	-	**-**
Shale	22.0	23.0	22.5	616.7	615.7	1.0	130	2,841	1,404	1,437	0.00	0.000	0.50	0.0	0	0	0	-	2	22.50	4.0	5.7	0.20	400	-	-	**-**
Shale	23.0	24.0	23.5	615.7	614.7	1.0	130	2,971	1,466	1,505	0.00	0.000	0.50	0.0	0	0	0	-	2	23.50	4.1	5.7	0.19	373	-	-	**-**
Shale	24.0	25.0	24.5	614.7	613.7	1.0	130	3,101	1,529	1,572	0.00	0.000	0.50	0.0	0	0	0	-	2	24.50	4.3	5.7	0.17	349	-	-	**-**
Shale	25.0	26.0	25.5	613.7	612.7	1.0	130	3,231	1,591	1,640	0.00	0.000	0.50	0.0	0	0	0	-	2	25.50	4.5	5.7	0.16	327	-	-	**-**
Shale	26.0	27.0	26.5	612.7	611.7	1.0	130	3,361	1,654	1,707	0.00	0.000	0.50	0.0	0	0	0	-	2	26.50	4.7	5.7	0.15	307	-	-	**-**
Shale	27.0	28.0	27.5	611.7	610.7	1.0	130	3,491	1,716	1,775	0.00	0.000	0.50	0.0	0	0	0	-	2	27.50	4.9	5.7	0.14	288	-	-	**-**
Shale	28.0	29.0	28.5	610.7	609.7	1.0	130	3,621	1,778	1,843	0.00	0.000	0.50	0.0	0	0	0	-	2	28.50	5.0	5.7	0.14	271	-	-	**-**
Shale	29.0	30.0	29.5	609.7	608.7	1.0	130	3,751	1,841	1,910	0.00	0.000	0.50	0.0	0	0	0	-	2	29.50	5.2	5.7	0.13	256	-	-	**-**
Shale	30.0	31.0	30.5	608.7	607.7	1.0	130	3,881	1,903	1,978	0.00	0.000	0.50	0.0	0	0	0	-	2	30.50	5.4	5.7	0.12	242	-	-	**-**
Shale	31.0	32.0	31.5	607.7	606.7	1.0	130	4,011	1,966	2,045	0.00	0.000	0.50	0.0	0	0	0	-	2	31.50	5.6	5.7	0.11	228	-	-	**-**
Shale	32.0	33.0	32.5	606.7	605.7	1.0	130	4,141	2,028	2,113	0.00	0.000	0.50	0.0	0	0	0	-	2	32.50	5.7	5.7	0.11	216	-	-	**-**
Shale	33.0	34.0	33.5	605.7	604.7	1.0	130	4,271	2,090	2,181	0.00	0.000	0.50	0.0	0	0	0	-	2	33.50	5.9	5.7	0.10	205	-	-	**-**
Shale	34.0	35.0	34.5	604.7	603.7	1.0	130	4,401	2,153	2,248	0.00	0.000	0.50	0.0	0	0	0	-	2	34.50	6.1	5.7	0.10	194	-	-	**-**
Shale	35.0	36.0	35.5	603.7	602.7	1.0	130	4,531	2,215	2,316	0.00	0.000	0.50	0.0	0	0	0	-	2	35.50	6.3	5.7	0.09	185	-	-	**-**
Shale	36.0	37.0	36.5	602.7	601.7	1.0	130	4,661	2,278	2,383	0.00	0.000	0.50	0.0	0	0	0	-	2	36.50	6.4	5.7	0.09	176	-	-	**-**
Shale	37.0	38.0	37.5	601.7	600.7	1.0	130	4,791	2,340	2,451	0.00	0.000	0.50	0.0	0	0	0	-	2	37.50	6.6	5.7	0.08	167	-	-	**-**
Shale	38.0	39.0	38.5	600.7	599.7	1.0	130	4,921	2,402	2,519	0.00	0.000	0.50	0.0	0	0	0	-	2	38.50	6.8	5.7	0.08	160	-	-	**-**
Shale	39.0	40.0	39.5	599.7	598.7	1.0	130	5,051	2,465	2,586	0.00	0.000	0.50	0.0	0	0	0	-	2	39.50	7.0	5.7	0.08	152	-	-	**-**
Shale	40.0	41.0	40.5	598.7	597.7	1.0	130	5,181	2,527	2,654	0.00	0.000	0.50	0.0	0	0	0	-	2	40.50	7.1	5.7	0.07	145	-	-	**-**
Shale	41.0	42.0	41.5	597.7	596.7	1.0	130	5,311	2,590	2,721	0.00	0.000	0.50	0.0	0	0	0	-	2	41.50	7.3	5.7	0.07	139	-	-	**-**
Shale	42.0	43.0	42.5	596.7	595.7	1.0	130	5,441	2,652	2,789	0.00	0.000	0.50	0.0	0	0	0	-	2	42.50	7.5	5.7	0.07	133	-	-	**-**

	Depth from Existing*			Elevation		Layer Thickness	Layer Unit Wt.	In-Situ Stresse at MP			Consolidation Parameters					Area Fill above Existing			Rectangular Footing								
Stratum	Top	Bottom	MP	Top	Bottom			Total P_0	μ	Eff. P'_0	Cc	Cr	e0	OCR	P'_c	Thick-ness	ΔP_{Fill}	Self Compress*	m1	Eff. Z	n1	b	I4	ΔP_{Fndn}	S_{re}	S_c	**S_t**
(-)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(-)	(-)	(psf)	(ft)	(psf)	(inch)	(-)	(ft)	(-)	(ft)	(-)	(psf)	(inch)	(inch)	**(inch)**
Shale	43.0	44.0	43.5	595.7	594.7	1.0	130	5,571	2,714	2,857	0.00	0.000	0.50	0.0	0	0	0	-	2	43.50	7.7	5.7	0.06	127	-	-	-
Shale	44.0	45.0	44.5	594.7	593.7	1.0	130	5,701	2,777	2,924	0.00	0.000	0.50	0.0	0	0	0	-	2	44.50	7.9	5.7	0.06	122	-	-	-
Shale	45.0	46.0	45.5	593.7	592.7	1.0	130	5,831	2,839	2,992	0.00	0.000	0.50	0.0	0	0	0	-	2	45.50	8.0	5.7	0.06	117	-	-	-
Shale	46.0	47.0	46.5	592.7	591.7	1.0	130	5,961	2,902	3,059	0.00	0.000	0.50	0.0	0	0	0	-	2	46.50	8.2	5.7	0.06	113	-	-	-
Shale	47.0	48.0	47.5	591.7	590.7	1.0	130	6,091	2,964	3,127	0.00	0.000	0.50	0.0	0	0	0	-	2	47.50	8.4	5.7	0.05	108	-	-	-
Shale	48.0	49.0	48.5	590.7	589.7	1.0	130	6,221	3,026	3,195	0.00	0.000	0.50	0.0	0	0	0	-	2	48.50	8.6	5.7	0.05	104	-	-	-
Shale	49.0	50.0	49.5	589.7	588.7	1.0	130	6,351	3,089	3,262	0.00	0.000	0.50	0.0	0	0	0	-	2	49.50	8.7	5.7	0.05	100	-	-	-
Shale	50.0	51.0	50.5	588.7	587.7	1.0	130	6,481	3,151	3,330	0.00	0.000	0.50	0.0	0	0	0	-	2	50.50	8.9	5.7	0.05	96	-	-	-
Shale	51.0	52.0	51.5	587.7	586.7	1.0	130	6,611	3,214	3,397	0.00	0.000	0.50	0.0	0	0	0	-	2	51.50	9.1	5.7	0.05	93	-	-	-
Shale	52.0	53.0	52.5	586.7	585.7	1.0	130	6,741	3,276	3,465	0.00	0.000	0.50	0.0	0	0	0	-	2	52.50	9.3	5.7	0.04	89	-	-	-
Shale	53.0	54.0	53.5	585.7	584.7	1.0	130	6,871	3,338	3,533	0.00	0.000	0.50	0.0	0	0	0	-	2	53.50	9.4	5.7	0.04	86	-	-	-
Shale	54.0	55.0	54.5	584.7	583.7	1.0	130	7,001	3,401	3,600	0.00	0.000	0.50	0.0	0	0	0	-	2	54.50	9.6	5.7	0.04	83	-	-	-
Shale	55.0	56.0	55.5	583.7	582.7	1.0	130	7,131	3,463	3,668	0.00	0.000	0.50	0.0	0	0	0	-	2	55.50	9.8	5.7	0.04	80	-	-	-
Shale	56.0	57.0	56.5	582.7	581.7	1.0	130	7,261	3,526	3,735	0.00	0.000	0.50	0.0	0	0	0	-	2	56.50	10.0	5.7	0.04	78	-	-	-
Shale	57.0	58.0	57.5	581.7	580.7	1.0	130	7,391	3,588	3,803	0.00	0.000	0.50	0.0	0	0	0	-	2	57.50	10.2	5.7	0.04	75	-	-	-
Shale	58.0	59.0	58.5	580.7	579.7	1.0	130	7,521	3,650	3,871	0.00	0.000	0.50	0.0	0	0	0	-	2	58.50	10.3	5.7	0.04	73	-	-	-
Shale	59.0	60.0	59.5	579.7	578.7	1.0	130	7,651	3,713	3,938	0.00	0.000	0.50	0.0	0	0	0	-	2	59.50	10.5	5.7	0.04	70	-	-	-
Shale	60.0	61.0	60.5	578.7	577.7	1.0	130	7,781	3,775	4,006	0.00	0.000	0.50	0.0	0	0	0	-	2	60.50	10.7	5.7	0.03	68	-	-	-
Shale	61.0	62.0	61.5	577.7	576.7	1.0	130	7,911	3,838	4,073	0.00	0.000	0.50	0.0	0	0	0	-	2	61.50	10.9	5.7	0.03	66	-	-	-
Shale	62.0	63.0	62.5	576.7	575.7	1.0	130	8,041	3,900	4,141	0.00	0.000	0.50	0.0	0	0	0	-	2	62.50	11.0	5.7	0.03	64	-	-	-
Shale	63.0	64.0	63.5	575.7	574.7	1.0	130	8,171	3,962	4,209	0.00	0.000	0.50	0.0	0	0	0	-	2	63.50	11.2	5.7	0.03	62	-	-	-
Shale	64.0	65.0	64.5	574.7	573.7	1.0	130	8,301	4,025	4,276	0.00	0.000	0.50	0.0	0	0	0	-	2	64.50	11.4	5.7	0.03	60	-	-	-
Shale	65.0	66.0	65.5	573.7	572.7	1.0	130	8,431	4,087	4,344	0.00	0.000	0.50	0.0	0	0	0	-	2	65.50	11.6	5.7	0.03	59	-	-	-
Shale	66.0	67.0	66.5	572.7	571.7	1.0	130	8,561	4,150	4,411	0.00	0.000	0.50	0.0	0	0	0	-	2	66.50	11.7	5.7	0.03	57	-	-	-
Shale	67.0	68.0	67.5	571.7	570.7	1.0	130	8,691	4,212	4,479	0.00	0.000	0.50	0.0	0	0	0	-	2	67.50	11.9	5.7	0.03	55	-	-	-
Shale	68.0	69.0	68.5	570.7	569.7	1.0	130	8,821	4,274	4,547	0.00	0.000	0.50	0.0	0	0	0	-	2	68.50	12.1	5.7	0.03	54	-	-	-
Shale	69.0	70.0	69.5	569.7	568.7	1.0	130	8,951	4,337	4,614	0.00	0.000	0.50	0.0	0	0	0	-	2	69.50	12.3	5.7	0.03	52	-	-	-
Shale	70.0	71.0	70.5	568.7	567.7	1.0	130	9,081	4,399	4,682	0.00	0.000	0.50	0.0	0	0	0	-	2	70.50	12.4	5.7	0.03	51	-	-	-
Shale	71.0	72.0	71.5	567.7	566.7	1.0	130	9,211	4,462	4,749	0.00	0.000	0.50	0.0	0	0	0	-	2	71.50	12.6	5.7	0.02	49	-	-	-
Shale	72.0	73.0	72.5	566.7	565.7	1.0	130	9,341	4,524	4,817	0.00	0.000	0.50	0.0	0	0	0	-	2	72.50	12.8	5.7	0.02	48	-	-	-
Shale	73.0	74.0	73.5	565.7	564.7	1.0	130	9,471	4,586	4,885	0.00	0.000	0.50	0.0	0	0	0	-	2	73.50	13.0	5.7	0.02	47	-	-	-
Shale	74.0	75.0	74.5	564.7	563.7	1.0	130	9,601	4,649	4,952	0.00	0.000	0.50	0.0	0	0	0	-	2	74.50	13.2	5.7	0.02	46	-	-	-
Shale	75.0	76.0	75.5	563.7	562.7	1.0	130	9,731	4,711	5,020	0.00	0.000	0.50	0.0	0	0	0	-	2	75.50	13.3	5.7	0.02	44	-	-	-
Shale	76.0	77.0	76.5	562.7	561.7	1.0	130	9,861	4,774	5,087	0.00	0.000	0.50	0.0	0	0	0	-	2	76.50	13.5	5.7	0.02	43	-	-	-
Shale	77.0	78.0	77.5	561.7	560.7	1.0	130	9,991	4,836	5,155	0.00	0.000	0.50	0.0	0	0	0	-	2	77.50	13.7	5.7	0.02	42	-	-	-
Shale	78.0	79.0	78.5	560.7	559.7	1.0	130	10,121	4,898	5,223	0.00	0.000	0.50	0.0	0	0	0	-	2	78.50	13.9	5.7	0.02	41	-	-	-
Shale	79.0	80.0	79.5	559.7	558.7	1.0	130	10,251	4,961	5,290	0.00	0.000	0.50	0.0	0	0	0	-	2	79.50	14.0	5.7	0.02	40	-	-	-
Shale	80.0	81.0	80.5	558.7	557.7	1.0	130	10,381	5,023	5,358	0.00	0.000	0.50	0.0	0	0	0	-	2	80.50	14.2	5.7	0.02	39	-	-	-
Shale	81.0	82.0	81.5	557.7	556.7	1.0	130	10,511	5,086	5,425	0.00	0.000	0.50	0.0	0	0	0	-	2	81.50	14.4	5.7	0.02	38	-	-	-
Shale	82.0	83.0	82.5	556.7	555.7	1.0	130	10,641	5,148	5,493	0.00	0.000	0.50	0.0	0	0	0	-	2	82.50	14.6	5.7	0.02	37	-	-	-
Shale	83.0	84.0	83.5	555.7	554.7	1.0	130	10,771	5,210	5,561	0.00	0.000	0.50	0.0	0	0	0	-	2	83.50	14.7	5.7	0.02	36	-	-	-
Shale	84.0	85.0	84.5	554.7	553.7	1.0	130	10,901	5,273	5,628	0.00	0.000	0.50	0.0	0	0	0	-	2	84.50	14.9	5.7	0.02	36	-	-	-
Shale	85.0	86.0	85.5	553.7	552.7	1.0	130	11,031	5,335	5,696	0.00	0.000	0.50	0.0	0	0	0	-	2	85.50	15.1	5.7	0.02	35	-	-	-
Shale	86.0	87.0	86.5	552.7	551.7	1.0	130	11,161	5,398	5,763	0.00	0.000	0.50	0.0	0	0	0	-	2	86.50	15.3	5.7	0.02	34	-	-	-
Shale	87.0	88.0	87.5	551.7	550.7	1.0	130	11,291	5,460	5,831	0.00	0.000	0.50	0.0	0	0	0	-	2	87.50	15.4	5.7	0.02	33	-	-	-
Shale	88.0	89.0	88.5	550.7	549.7	1.0	130	11,421	5,522	5,899	0.00	0.000	0.50	0.0	0	0	0	-	2	88.50	15.6	5.7	0.02	33	-	-	-
Shale	89.0	90.0	89.5	549.7	548.7	1.0	130	11,551	5,585	5,966	0.00	0.000	0.50	0.0	0	0	0	-	2	89.50	15.8	5.7	0.02	32	-	-	-
Shale	90.0	91.0	90.5	548.7	547.7	1.0	130	11,681	5,647	6,034	0.00	0.000	0.50	0.0	0	0	0	-	2	90.50	16.0	5.7	0.02	31	-	-	-
Shale	91.0	92.0	91.5	547.7	546.7	1.0	130	11,811	5,710	6,101	0.00	0.000	0.50	0.0	0	0	0	-	2	91.50	16.2	5.7	0.02	30	-	-	-
Shale	92.0	93.0	92.5	546.7	545.7	1.0	130	11,941	5,772	6,169	0.00	0.000	0.50	0.0	0	0	0	-	2	92.50	16.3	5.7	0.01	30	-	-	-
Shale	93.0	94.0	93.5	545.7	544.7	1.0	130	12,071	5,834	6,237	0.00	0.000	0.50	0.0	0	0	0	-	2	93.50	16.5	5.7	0.01	29	-	-	-
Shale	94.0	95.0	94.5	544.7	543.7	1.0	130	12,201	5,897	6,304	0.00	0.000	0.50	0.0	0	0	0	-	2	94.50	16.7	5.7	0.01	29	-	-	-
Shale	95.0	96.0	95.5	543.7	542.7	1.0	130	12,331	5,959	6,372	0.00	0.000	0.50	0.0	0	0	0	-	2	95.50	16.9	5.7	0.01	28	-	-	-
Shale	96.0	97.0	96.5	542.7	541.7	1.0	130	12,461	6,022	6,439	0.00	0.000	0.50	0.0	0	0	0	-	2	96.50	17.0	5.7	0.01	27	-	-	-
Shale	97.0	98.0	97.5	541.7	540.7	1.0	130	12,591	6,084	6,507	0.00	0.000	0.50	0.0	0	0	0	-	2	97.50	17.2	5.7	0.01	27	-	-	-
Shale	98.0	99.0	98.5	540.7	539.7	1.0	130	12,721	6,146	6,575	0.00	0.000	0.50	0.0	0	0	0	-	2	98.50	17.4	5.7	0.01	26	-	-	-
Shale	99.0	100.0	99.5	539.7	538.7	1.0	130	12,851	6,209	6,642	0.00	0.000	0.50	0.0	0	0	0	-	2	99.50	17.6	5.7	0.01	26	-	-	-
Shale	100.0	101.0	100.5	538.7	537.7	1.0	130	12,981	6,271	6,710	0.00	0.000	0.50	0.0	0	0	0	-	2	100.50	17.7	5.7	0.01	25	-	-	-
#N/A	101.0	102.0	101.5	537.7	536.7	1.0	#N/A	#N/A	6,334	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	101.50	17.9	5.7	0.01	25	-	-	-
#N/A	102.0	103.0	102.5	536.7	535.7	1.0	#N/A	#N/A	6,396	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	102.50	18.1	5.7	0.01	24	-	-	-
#N/A	103.0	104.0	103.5	535.7	534.7	1.0	#N/A	#N/A	6,458	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	103.50	18.3	5.7	0.01	24	-	-	-
#N/A	104.0	105.0	104.5	534.7	533.7	1.0	#N/A	#N/A	6,521	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	104.50	18.4	5.7	0.01	23	-	-	-
#N/A	105.0	200.0	152.5	533.7	438.7	95.0	#N/A	#N/A	9,516	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0	0	-	2	152.50	26.9	5.7	0.01	11	-	-	-



Settlement (inches)
0.0
0.5
1.0
1.5
2.0
Depth Below Bottom of Footing (feet)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Rectangular Footing
Settlement Limit of 1 inch:
Settlement Limit of 1.5 inches:

Appendix H Foundation Bearing Capacity Analysis

AECOM

				Calc No.:	6
Job:	Plum Creek FRS#2 Dam Rehabilitation	Project No.	60615067	Page:	1 of 24
Description:	Bearing Capacity Analysis	Computed By:	L. Finnefrock	Date:	11-24-2020 Rev 5/25/2021
		Checked By:	A.Bukkapatnam	Date:	11-24-2020

OBJECTIVE:

1. Estimate allowable bearing capacity of foundations for the proposed principal spillway inlet tower, impact basin and overtopping spillway structure.

REFERENCES:

1. NAVFAC . 1986. *DM-7.2. Foundations and Earth Structures*. September.
2. NRCS. 2005. *210-VI-TR60, Earth Dams and Reservoirs*. July.
3. USACE. 1994. *EM 1110-1-2908, Rock Foundations.* November 30.
4. AASHTO. 2012. *LRFD Bridge Design Specifications.*
5. Federal Highway Administration (FHWA). 2002. *Geotechnical Engineering Circular No. 6 – Shallow Foundations.* September.
6. Federal Highway Administration (FHWA). 2017. *Geotechnical Engineering Circular No. 5 - Geotechnical Site Characterization*, Publication No. FHWA NHI-16-072.
7. Das, B.J. 2011. *Principles of Foundation Engineering*. Seventh Edition.

Project specific references:

1. USDA-SCS. 1967. Geologic Investigation Report (GIR), Plum Creek Watershed, Site No. 2.
2. USDA-SCS. 1967. Soil Mechanics Report (SMR), Plum Creek Site 2.
3. USDA-SCS. 1969. As-Built Drawings, Plum Creek Watershed Project Floodwater Retarding Dam No. 2.
4. AECOM. 2021. GIR, Plum Creek Watershed FRS No. 2 Rehabilitation Design.
5. AECOM. 2021. SMR, Plum Creek Watershed FRS No. 2 Rehabilitation Design.
6. AECOM. 2020. 90% Design Drawings, Floodwater Retarding Structure Site No. 2 Rehabilitation Caldwell County, Texas.

PROJECT DESCRIPTION

Rehabilitation of the Plum 2 dam will generally include the following design elements:

- Raising the existing vegetated auxiliary spillway crest by 1.15 feet to El. 659.8 feet;
- Widening the existing auxiliary spillway from 150 feet to 250 feet;
- Constructing a new 200-foot-wide roller-compacted concrete (RCC) spillway with crest at El. 658.6 feet;
- Replacing the existing principal spillway inlet with a new principal spillway inlet riser with crest at El. 645.4 feet and replacing the existing conduit with a new 48-inch-diameter conduit;
- Adding a new impact basin for the principal spillway outlet;
- Restoring the crest of the dam to current nominal elevation of 662.8 feet subsequently to rehabilitation.

Refer to the 90% design drawings for additional project details.

PROPOSED STRUCTURES

The proposed principal spillway is composed of the following structural elements:

1. Inlet Tower: consists of a rectangular mat foundation: 20.5 feet long X 13.5 feet wide X 1 foot thick, and
2. Impact Basin: consists of a rectangular mat foundation: 24.2 feet long X 19.5 feet wide X 1 foot thick.

The new RCC spillway is composed of the following structural components:

1. Crest structure: Consists of an RCC crest slab (190 feet long X 30 feet wide) and RCC gravity walls (30 feet long X 11.33 feet wide) on both sides of the spillway;
2. Chute structure: Consists of an RCC chute slab (190 feet long X 48 feet wide) and RCC gravity walls (48 feet long X 11.33 feet wide) on both sides of the spillway; and
3. Stilling basin structure: Consists of an RCC stilling basin slab (190 feet long X 24 feet wide) and RCC gravity walls (24 feet long X 11.33 feet wide) on both sides of the spillway. The stilling basin also includes a series of 3.25 feet long X 2 feet wide X 2.75 feet tall concrete baffle blocks at 2-feet edge to edge spacing along its entire length.

Descriptions of each substructure are provided in the following paragraphs. A summary of proposed structures is provided in **Table 1**, which includes the various geologic units upon which structure foundations will likely be founded.

Principal Spillway (PSW) Structures

Inlet Tower

The proposed Inlet Tower foundation is designed as a reinforced concrete mat to be constructed at approximately Sta. 25+02 of the centerline of the dam. The inlet tower will be located approximately 100 feet from the centerline on the upstream side of the dam. The foundation bearing elevation will be El. 630.28, approximately 32.5 feet below the proposed dam crest elevation of 662.8 feet. Construction of the inlet tower will require consideration for a temporary cofferdam or completely draining out the reservoir. Excavation includes removal of a portion of the existing embankment fill along the upstream toe and residual overburden soils. For the purposes of this analysis, the rectangular mat foundation width (B) of the inlet tower was considered to be 13.5 feet and length (L) was considered to be 20.5 feet. It should be noted that the mat dimensions mentioned include a 3 feet extension on either side of the tower walls in the length direction and 3.5 feet extension on either side of the tower walls in the width direction. A unfactored gross bearing pressure of 1,500 pounds per square foot (psf) was assumed for the analysis.

Impact Basin

The proposed Impact Basin structure foundation is designed as a reinforced concrete mat constructed founded at bearing El. 626.0 at approximately Sta. 25+02 of the centerline of the dam. The impact basin will be located approximately 95 feet from the centerline on the downstream side of the dam. Approximately 8 feet to 10 feet of the existing alluvium/residual soils will be excavated for constructing the impact basin slab. The head wall and wing walls are supported on 36-inch deep strip footings with effective L'=14.5 feet, and subjected to an unfactored gross bearing pressure of 2,000 psf approximately.

Proposed RCC Spillway Structures

Crest Structure

The proposed crest structure is located on the crest of the embankment. Its foundation is designed as an RCC slab constructed in 12-inch thick lifts. It consists of a 3-foot thick RCC foundation slab serving as the flow weir, and 8-ft tall retraining walls along both outside edges (parallel to flow direction). The foundation bearing elevation will be El. 655.5, approximately 8 feet below the proposed dam centerline crest elevation of 663.4 feet. The RCC gravity training walls provided on each side of the crest structure to retain adjacent embankment fill will each have a base width of 11.33 feet. Construction will require excavation and removal of existing embankment fill materials currently providing up to 1,000 psf of in-situ vertical pressure at the bearing surface. The footprint dimensions of the crest structure foundation is approximately 30 feet wide in the direction of flow, and approximately 212.7 feet long perpendicular to the direction of flow. For the purposes of this analysis, the foundation width (B) of the crest structure interior slab was considered to be 30 feet and length (L) was considered to be 190 feet. The crest structure walls were each considered to have equivalent foundations measuring B=11.33 feet and L=30 feet.

Based on experience with similar projects, we have assumed the RCC walls will exert an estimated maximum gross pressure of 1,500 psf due to overturning eccentricity forces. The gross footing pressure on the remaining interior portion of the spillway is about 450 psf during the dry condition (self-weight only) and an estimated 500 psf during flood conditions (assuming nominal flow depth of ~1 foot)..

Chute Structure

The proposed chute structure is located on the downstream slope of the existing embankment, and extends below existing grade beyond the existing downstream toe of the dam to allow construction of the stilling basin. Its foundation is designed as an RCC slab constructed in 12-inch thick lifts. The foundation bearing level for the chute structure extends from El. 655.5 at the crest to El. 641.6 at the stilling basin invert. The footprint of the chute structure is 48 feet long parallel to the direction of flow, and 212.7 feet long perpendicular to the direction of flow. Maximum 10-foot tall RCC gravity training walls (parallel to direction of flow) will be provided on each side of the chute structure to retain adjacent embankment fill, with a base width of 11.33 feet.

Based on experience with similar projects, we have assumed the RCC walls will exert an estimated maximum gross pressure of 1,800 psf due to overturning eccentricity forces. The gross footing pressure on the remaining interior portion of the spillway is about 450 psf during the dry condition (self-weight only) and an estimated 500 psf during flood conditions (assuming nominal flow depth of ~1 foot).

Stilling Basin

The proposed stilling basin structure foundation is located downstream of the existing embankment toe. Its foundation is designed as an RCC slab constructed in 12-inch thick lifts. The structure will be founded at bearing El. 637.0 (approximately 10 feet to 11 feet below existing ground surface). The footprint of the stilling basin structure is 48 feet long parallel to the direction of flow, and 212.7 feet long perpendicular to the direction of flow.

Based on experience with similar projects, we have assumed the RCC walls will exert an estimated maximum gross pressure of 2,500 psf due to overturning forces. The gross footing pressure on the remaining interior portion of the spillway slab is about 450 psf during the dry condition (self-weight only) and an estimated 500 psf during flood conditions (assuming nominal flow depth of ~1 foot).

Table 1. Summary of Structure Dimensions and Loading

Location	Structure Type	Dimensions and Bearing Stratum			Loading		
		Footing Width, B (ft) (1)	Footing Length, L (ft) (2)	Bearing Strata	Existing Maximum Unfactored Gross Bearing Pressure – Static (psf) (3)	Proposed Estimated Maximum Unfactored Gross Bearing Pressure – Static (psf) (3)	Proposed Estimated Maximum Unfactored Gross Bearing Pressure – Flowing (psf) (4)
PSW Inlet Tower	R-C Slab	13.5	20.5	Residuum/Flexbase	---	1,500	---
PSW Impact Basin	R-C Slab	19.5	24.2	Residuum/Flexbase	---	2,000	---
PSW Conduit Pipe	Pipe	5.8	166	Residuum	---	NA	---
Proposed RCC Spillway – Crest Structure	RCC Walls	12	30	Embank. Zone 1 & Embank. Zone 2/ Imported Fill	---	1,500	same
	Chute Slab	30	190		---	450	500
Proposed RCC Spillway – Chute Structure	RCC Walls	12	48	Embankment Zone 2, Alluvium, Residuum/ Drain Fill	---	1,800	Same
	RCC Slab	48	190		---	450	500
Proposed RCC Spillway – Stilling Basin Structure	RCC Walls	19	40	Residuum/Imported Fill	---	2,500	same
	RCC Slab	126	40		---	450	500

Notes:
1) Perpendicular to flow direction
2) Parallel to flow direction
3) Assumed based on our experience with similar projects
4) Based on nominal ~1 feet depth of water

<u>MATERIAL CHARACTERIZATION</u>

Stratigraphy

Site stratigraphy is described in detail in the Geologic Investigation Reprot and Soil Mechanics Report. According to the as-builts and site investigation, the existing embankment consists of 2 distinct zones (core and cutoff trench – Zone 1, upstream and downstream shell – Zone 2). Characterization of the various materials with respect to bearing capacityis described as follows:

- <u>Embankment Fill</u>: The existing Embankment Fill was generally described on the boring logs as medium stiff to hard fat clay (CH) with minor sand, silt, and/or gravel content. While the as-built drawings indicate embankment zoning with distinct core and shell zones, borings and laboratory testing indicate the shell and core zones are comprised by similar materials. This unit is expected to experience slow drainage due to high fines and clay contents, and exhibit distinct drained and undrained shear strength behavior.

- <u>Downstream Fill :</u> Suspected Downstream Fill materials up to about 8 feet thick were encountered in boring 305-19, which was drilled on the PSW crossing berm at the downstream toe. While boring 603-19 was drilled within these station limits, it appears to have been drilled just downstream of the fill area based on visual characteristics of the material and examination of topographic data. The suspected fill material consisted of medium stiff to hard lean to fat clay (CL, CH). The fill designation was due to a somewhat lower consistency of this material. However, the visual similarity of the fill to natural overburden materials suggests that this unit is likely reworked residuum/alluvium. This unit is expected to experience slow drainage due to high fines and clay contents, and exhibit distinct drained and undrained shear strength behavior.

- <u>Alluvium</u>: This unit consisted of dark brown, medium stiff to hard fat clays (CH) with minor proportion of sand and/or gravel ranging from 0 to 20%. The Alluvium contained trace to abundant organics, trace to some fine to coarse subrounded to subangular gravel, calcareous nodules and inclusions, iron oxidation staining, and trace shell fragments. This unit is expected to experience slow drainage due to high fines and clay contents, and exhibit distinct drained and undrained shear strength behavior.

- <u>Residuum</u>: This unit consisted of light gray to tan, medium stiff to hard lean to fat clays (CL, CH) with some clayey sand (SC) and silty clay (CL-ML) layers. Characterization of this material in the GIR and SMR was subdivided into a calacareous and friable Low Plasticity Residuum (LPR) consisting mostly of silty CL and some CH with less frequent SC and CL-ML intervals, and a Medium Plasticity Residuum (MPR) consisting of consisting of CH with some CL intervals. For engineering analysis, this material was generally considered as a single “Residuum”. This unit is expected to experience slow drainage due to high fines and clay contents, and exhibit distinct drained and undrained shear strength behavior.

- <u>Shale</u>: This stratum was generally described as moderately to highly weathered calcareous shale and is expected to experience slow drainage. Based on published data and sample appearance, the bedrock was judged to be part of the Pecan Gap Chalk formation because of the presence of abundant calcite in the clay matrix and the light gray to white color, both characteristic weathering features of this formation. This unit is below the proposed bearing depth of foundations, and will not affect bearing capacity.

Proposed fill material under some structures may include fine and coarse filter/drain fill and roller-compacted concrete (RCC) and embankment fill. These materials are described below.

- Drain Fill: This material will consist of compacted fine filter and coarse filter materials similar to ASTM C-33 aggregate gradation. These materials are free-draining, and will exhibit only drained strength behavior.

- RCC: This material will consist of low-slump concrete compacted in lifts that will be used to construct the RCC spillway. Proposed foundations will be constructed from this material, and bearing capacity of this material does not need to be considered due to high strength.

- Embankment Fill: The proposed embankment fill will be constructed of moisture-conditioned and recompacted clayey soils from on-site and/or imported borrow sources. Selective placement of imported low-plasticity (PI=7-15) lean clay (CL) or clayey sand (SC) is planned for under and adjacent to the RCC spillway to reduce swelling potential. The exterior zones of planned embankment fill (crest re-shaping and embankment reconstruction at new PSW) will be low-plasticity clay/clayey sand (CL, SC) with LL<50 and PI=10-30. Interior zones of planned embankment fill for reconstruction at new PSW will consist of medium- to high-plasticity clays (CL, CH) with LL<60 and PI=10-35. Considering the clayey composition of proposed embankment fill, this material was considered to exhibit both undrained and drained strength behavior

Groundwater

Groundwater level was estimated based on piezometer readings and measured groundwater levels in the borings. Groundwater measurement from borings are discussed in the Geologic Investigation Report and the "Material Properties Calculation Package". For bearing capacity analysis, groundwater level was conservatively modeled at the base of the structures.

Unit Weights and Shear Strength Parameters

Both drained and undrained shear strengths were considered for bearing capacity calculations. Shear strength characterization is presented in the "Material Properties Calculation Package". A summary of analyzed parameters is provided below in **Table 2**.

Table 2. Unit Weights and Design Shear Strength Parameters for Consolidated Moist Materials

Material	USCS	Total Unit Weight (pcf)	Drained Strengths (CD envelope)		Undrained Strengths (UU envelope)	
			c' (psf)	ϕ ' (deg)	c_u (psf)	ϕ_u (deg)
Existing Embankment Fill – Zone 1	CL/CH	125	100	23	1,200	0
Existing Embankment Fill – Zone 2	CL/CH	125	100	23	1,200	0
Alluvium/ DS Fill	CL, CH	123	100	23	1,500	0
Residuum	CH, CL	126	100	23	1,500	0
Proposed Embankment Fill	CL/CH	125	100	23	1,200	0
Filter/Drainfill	SP, GP	120	0	33	---	---
RCC	NA	145	100	45	---	---

BEARING CAPACITY ANALYSIS – INLET TOWER

Soil and Groundwater

The inlet structure will be founded on native alluvium or residuum deposits. Approximately 5-feet of existing embankment fill along the upstream toe will need to be excavated in order to facilitate construction of the inlet tower

Groundwater level on the upstream side of the dam will generally depend on the reservoir head condition. However, construction of the new principal spillway inlet tower may require a temporary cofferdam or a fully drained reservoir. Consequently, groundwater was conservatively assumed at the foundation bearing elevation for the analysis of the inlet tower structure.

Bearing Capacity Analysis

Based on the 90% design drawings, the impact basin foundation bearing level is El. 630.28. The allowable bearing pressure of the saturated residuum stratum is calculated using an undrained strength of 1,500 psf. Analysis results are provided in **Attachment 3**.

General bearing capacity theory was used to estimate allowable bearing pressure for the inlet tower foundation. Bearing capacity equations and factors are provided in **Attachment 2** (from FHWA 2002). The groundwater was set equal to ground surface (using correction factors Cwq and Cwg), conservatively assuming saturation of the subgrade. A nominal foundation embedment of 3 feet from top of slab was considered in analysis. A factor of safety of 3.0 was adopted for allowable bearing pressure.

Results of the analysis are provided in **Attachment 3**. Bearing capacity for drained strengths was found to control, with calculated static allowable gross bearing pressure of 2,341 psf for the inlet tower foundation. Bearing capacity generally can be increased by 1/3 for seismic conditions to 3,114 psf due to short-term transient nature of loading.

Conclusions and Recommendations

Settlement analyses presented under separate cover (see “Settlement Analysis Calculation Package”) indicate that estimated total settlement for the inlet tower foundation can be limited to 1.5 inches or less if the bearing pressure is limited to about 2,000 psf. Therefore, allowable bearing pressure for the inlet is controlled by settlement considerations. Consequently, it is recommended that the allowable gross bearing pressure for the impact basin foundation be limited to <u>2,000 psf for static conditions</u> and <u>2,660 psf for seismic conditions.</u>

BEARING CAPACITY ANALYSIS – IMPACT BASIN

Soil and Groundwater

The impact basin slab will be founded on native alluvium/residuum deposits. Approximately 8-feet to 10-feet of existing embankment fill/residual soils along the downstream toe will need to be excavated in order to facilitate construction of the impact basin.

Groundwater was conservatively assumed at the foundation bearing elevation for the analysis of the impact basin structure.

Bearing Capacity Analysis

Based on the design drawings, the foundation bearing level is El. 626.0 The allowable bearing pressure of the moist alluvium/residuum stratum is calculated using an undrained strength of 1,500 psf. Analysis results are provided in **Attachment 4**.

General bearing capacity theory and a factor of safety of 3.0 against general shear failure were used to estimate the allowable bearing pressure. Groundwater was set equal to ground surface (using correction factors Cwq and Cwγ), conservatively assuming saturation of the subgrade. A nominal foundation embedment of 3 feet from top of slab was conservatively considered in analysis..

Bearing capacity due to drained strengths was found to control, with corresponding static allowable gross bearing pressure of 2,598 psf for the impact basin foundation. Bearing capacity generally can be increased by 1/3 for seismic conditions to 3,455 psf.

The bearing capacity analysis ignores the wingwall footing extensions from the main foundation slab due to analysis limitations of the simplified methods. The wingwall footing extensions will be cast and reinforced as part of the main foundation slab. While the wingwall footings contribute additional loading influence to the subgrade soils (i.e., larger loaded area), the shorter height of the wingwalls are not expected to produced substantial bearing pressure loads that would significantly affect the estimated bearing capacity or settlement of the impact basin. Therefore, the wingwall footing extensions can be ignored for bearing capacity and settlement analysis purposes.

Conclusions and Recommendations

Settlement analyses presented under separate cover (see "Settlement Analysis Calculation Package") indicate that estimated total settlement for the impact basin foundation can be limited to 1.5 inches or less if the bearing pressure is limited to about 2,500 psf. Therefore, allowable bearing pressure for the impact basin is controlled by settlement considerations. Consequently, it is recommended that the allowable gross bearing pressure for the impact basin foundation be limited to <u>2,500 psf for static conditions</u> and <u>3,325 psf for seismic conditions.</u>

BEARING CAPACITY ANALYSIS – RCC SPILLWAY – CREST STRUCTURE

Soil and Groundwater

The crest structure will be founded on Zone 1 or Zone 2 – Existing embankment fill, with a 2-3 foot thick layer of drainfill directly under the slab on the downstream side of the crest structure. However, based on expansive soil considerations (see "Heave Analysis Calculation Package"), additional overexcavation of the Residuum will be required to a depth of about 8 feet below bottom of slab elevation, and will be replaced with compacted low-plasticity Embankment Fill from an off-site source.

Groundwater levels in the embankment are associated with the normal pool (PSW crest) reservoir conditions. While existing phreatic surface is well below the proposed crest structure foundation bearing elevation, the proposed ASW crest of El. 658.6 is several feet above the spillway slab. Although seepage head losses through the embankment and downstream internal drainage will maintain the corresponding phreatic surface well below the foundation bearing level for much of the structure, saturated conditions are likely to develop on the upstream portion of the structure. Consequently, groundwater was conservatively assumed at the ground surface for the analysis of the crest structure.

Overall Bearing Capacity Analysis

Given that the majority of the crest structure is located downstream of the existing dam crest centerline, the actual subgrade materials for bearing capacity of the overall mat structure will be more representative of the existing embankment fill – Zone 2 material.

Since the mat foundation is located on the embankment crest, overall bearing capacity was evaluated using the footing on slope corrections presented in *NAVFAC DM 7.2* (*Figure 4a, Ultimate Bearing Capacity for Shallow Footing Placed on or Near a Slope*). The *Case I: Continuous Footing* at the Top of Slope was considered applicable. Analysis results are provided in **Attachment 5a**.

Based on the design drawings, the foundation bearing level is El. 655.5. The downstream embankment slope/spillway chute extends down to the top of the stilling basin slab at El. 641.6. The upstream slope extends down to the reservoir mudline, estimated to be El. 648. Consequently, dam height (H) at the structure section will range from about 21.2 to 14.8 feet as measured at the downstream and upstream toes, respectively. The larger value (H=21.2 feet) was selected for analysis.

The foundation width is greater than embankment height (B > H), and thus the following equation applies:

$$No = \frac{\gamma H}{Su} = \frac{125pcf * 21.2ft}{1200psf} = 2.2$$

Because the calculated value of $N_0 > 1.0$, the bearing capacity is controlled by global stability of the slope. Therefore, overall foundation bearing capacity is addressed under separate cover in the "Slope Stability Calculation Package". That analysis considered the crest structure foundation as a uniform surcharge load, which indicated that minimum required factors of safety can be achieved for static conditions by limiting the equivalent weight average maximum bearing pressure to 1,530 psf. Seismic condition was not analyzed because of the low seismicity to the site.

Localized bearing capacity of the crest structure wall foundations are also checked in the following sections herein.

Localized Bearing Capacity Analysis for Crest Wall Footings

Given that the tallest portions of the exterior walls (i.e. highest foundation loads) are located on the downstream half of the dam crest, the actual subgrade shear strength for bearing capacity will be more representative of the existing embankment fill – zone 2 material.

General bearing capacity theory and a factor of safety of 3.0 against general shear failure were used to estimate the allowable bearing pressure. Conservatively, the groundwater was set equal to ground surface (using correction factors Cwq and Cwg) to represent the upstream end of the walls. A nominal foundation embedment of 3 feet below top of slab (i.e., equal to slab thickness) was considered.

Results of the analysis are provided in **Attachment 5a**. Bearing capacity for drained strengths was found to control, with corresponding static allowable gross bearing pressure of 2,161 psf for the crest structure wall footings. Bearing capacity generally can be increased by 1/3 for seismic conditions to 2,874 psf.

Conclusions and Recommendations

Slope stability analyses presented under separate cover (see "Slope Stability Analysis Calculation Package") indicate that minimum safety factors for static condition can be met if the overall weighted-average bearing pressure for the crest structure is limited to 1,530 psf. Additionally, settlement analyses presented under separate cover (see "Settlement Analysis Calculation Package") indicate that estimated total settlement for the crest structure wall footings can be limited to 1.5 inches or less if the bearing pressure is limited to the design maximum bearing pressure of about 2,000 psf. Therefore, allowable bearing pressure for the crest structure is controlled by slope stability considerations. Consequently, it is recommended that the allowable gross bearing pressure for the crest structure foundations conservatively be limited to <u>1,500 psf for static conditions</u> and <u>2,000 psf for seismic conditions</u>. This will ensure the minimum safety factors are obtained for both the conventional bearing capacity analysis herein, and the slope stability analyses presented under separate cover.

As discussed above, settlement analyses indicate that estimated total settlement for the crest structure training walls is generally limited to 1.5 inches or less based on a maximum bearing pressure of 2,000 psf. This level of settlement is expected to produce acceptable design performance. Based on reductions in allowable design bearing pressures due to slope stability considerations discussed above, actual settlement will be less. Additionally, further reductions in allowable bearing pressure can be considered in structure foundation design if settlement needs to be limited to smaller values.

It is noted that because the proposed bearing elevation for foundations is located below the existing embankment surface, the subgrade has effectively experienced a "pre-loading" effect. The "pre-loading" from existing embankment is estimated to be approximately 1,000 psf at the embankment crest centerline, which is greater than proposed bearing pressure over much of the mat foundation (except for localized pressures at the exterior walls). Consequently, based on these facts and the calculated allowable bearing pressure, it is expected that adequate foundation bearing capacity is available from embankment soils.

BEARING CAPACITY ANALYSIS – RCC SPILLWAY – CHUTE STRUCTURE

Soil and Groundwater

The chute structure will be founded on 2 feet or more of proposed Drainfill materials. The chute structure will overlie existing embankment fill – Zone 2 material on the downstream embankment slope. Downstream of the existing toe in the cut section of the spillway, the chute will overlie Residuum / Alluvium. However, based on expansive soil considerations (see "Heave Analysis Calculation Package"), additional overexcavation of the Residuum will be required to a depth of about 8 feet below bottom of slab elevation, and will be replaced with compacted low-plasticity Embankment Fill from an off-site source

Based on variation in subsurface conditions, three analyses were conducted for the Chute wall footings: 1) chute structure on the existing embankment with subgrade consisting of Drainfill materials; 2) chute structure on the existing embankment with subgrade consisting of Existing/Proposed Embankment Fill materials; and 3) chute structure in the cut section with subgrade consisting of Residuum material. For both analyses, groundwater was conservatively assumed to be at the ground surface.

A separate analysis was not performed for the RCC stepped chute slab, since the sustained maximum bearing pressure from self-weight is relatively low and periodic high flow events in the spillway are infrequent.

Bearing Capacity Analysis for Chute Wall Footings – Embankment and Cut Section

General bearing capacity theory and a factor of safety of 3.0 against general shear failure were used to estimate the allowable bearing pressure. A nominal foundation embedment of 3 feet below top of slab (i.e., equal to slab thickness) was considered.

Results of the analysis are provided in **Attachment 5b**. Bearing capacity for drained strengths was found to control, with corresponding static allowable gross bearing pressure of 2,142 psf for the chute wall footings on the existing embankment. Bearing capacity generally can be increased by 1/3 for seismic conditions to 2,849 psf.

Conclusions and Recommendations

Settlement analyses presented under separate cover (see "Settlement Analysis Calculation Package") indicate that estimated total settlement for the chute structure wall footings can be limited to 1.5 inches or less if the bearing pressure is limited to the design maximum bearing pressure of about 2,000 psf. Therefore, allowable bearing pressure for the crest structure is controlled by settlement considerations. Consequently, it is recommended that the allowable gross bearing pressure for the crest structure foundations be limited to <u>2,000 psf for static conditions</u> and <u>2,660 psf for seismic conditions.</u> These reduced bearing values will also improve slope stability of the structure.

Settlement analyses for the design bearing pressures are presented under separate cover (see "Settlement Analysis Calculation Package"). That analysis indicate that estimated total settlement is generally limited to 1.5 inches or less for proposed structure foundations, which is expected to produce acceptable design performance. Reduced design bearing pressures can be considered in structure foundation design if settlement needs to be limited to smaller values.

BEARING CAPACITY ANALYSIS – RCC SPILLWAY – STILLING BASIN STRUCTURE

Soil and Groundwater

The stilling basin structure will be founded on a minimum 2-foot thick layer of Drainfill underlain by native Residuum . However, based on expansive soil considerations (see “Heave Analysis Calculation Package”), additional overexcavation of the Residuum will be required to a depth of about 8 feet below bottom of slab elevation, and will be replaced with compacted low-plasticity Embankment Fill from an off-site source.

A separate analysis was not performed for the RCC stilling basin slab, since the sustained maximum bearing pressure from self-weight is relatively low and periodic high flow events in the spillway are infrequent

Bearing Capacity Analysis for Stilling Basin Wall Footings

General bearing capacity theory and a factor of safety of 3.0 against general shear failure were used to estimate the allowable bearing pressure. A nominal foundation embedment of 3 feet below top of slab (i.e., equal to slab thickness) was considered.

Results of the analysis are provided in **Attachment 5c**. Bearing capacity for drained strengths of Residuum and new Embankment Fill was found to control, with corresponding static allowable gross bearing pressure of 2,179 psf for the stilling basin wall footings. Bearing capacity generally can be increased by 1/3 for seismic conditions to 2,898 psf.

Note that these results are considered conservative; the drained strength parameters the existing fat clay Embankment Fill (c'=100 psf, ϕ'=23 degrees) were conservatively applied to the new low-plasticity Embankment Fill to be constructed under the RCC foundation, but similar cohesion with higher friction angles would be expected for the low-plasticity fill (likely 25-28 degrees). In this case, undrained bearing capacity of the new fill would control, which is about 2,313 psf (considering S_u=1,200 psf which is appropriately conservative for both existing and new embankment fill materials based on laboratory testing). Additionally, dissipation of foundation stress with depth through the 8-foot thick fill would serve to reduce bearing pressure on the underlying Residuum which has lower drained strength bearing capacity.

Conclusions and Recommendations

Settlement analyses presented under separate cover (see “Settlement Analysis Calculation Package”) indicate that estimated total settlement for the stilling basin wall footings can be limited to 1.5 inches or less if the bearing pressure is limited to the design maximum bearing pressure of about 2,000 psf. Therefore, allowable bearing pressure for the stilling basin structure is controlled by settlement considerations. Consequently, it is recommended that the allowable gross bearing pressure for the stilling basin structure foundations be limited to 2,000 psf for static conditions and 2,660 psf for seismic conditions.

Settlement analyses for the design bearing pressures are presented under separate cover (see “Settlement Analysis Calculation Package”). That analysis indicate that estimated total settlement is generally limited to 1.5 inches or less for proposed structure foundations, which is expected to produce acceptable design performance. Reduced design bearing pressures can be considered in structure foundation design if settlement needs to be limited to smaller values.

SUMMARY

Based on the analysis herein, recommended allowable bearing pressure for the various structures are summarized in Table 3.

Table 3. Summary of Recommend Allowable Bearing Capacity for Principal Spillway Structures

Structure	Allowable Bearing Capacity (psf)	
	Static Conditions	Seismic Conditions
Inlet Tower	2,000	2,660
Impact Basin	2,500	3,325
ASW – Crest Structure	1,500	2,000
ASW – Chute Structure	2,000	2,660
ASW – Stilling Basin	2,000	2,660

Notes:
1. Assumes factor of safety of 3.0 against general shear failure.
2. Values limited by settlement considerations.

ATTACHMENT 1

Bearing Capacity Equations and Factors

Bearing Capacity Equations

$$q_{ult} = c(N_c) + q(N_q) + 0.5(\gamma)(B_f)(N_\gamma) \quad (5\text{-}7)$$

where:
- c = cohesion of the soil
- N_c = bearing capacity factor for the cohesion term
- q = surcharge at the base of the footing
- N_q = bearing capacity factor for the surcharge term
- B_f = footing width
- γ = unit weight of soil beneath the footing
- N_γ = bearing capacity factor for soil unit weight

$$N_\gamma = 2(N_q + 1)\tan(\phi) \quad (5\text{-}8)$$

N_c = bearing capacity factor for the cohesion term:

$$= (N_q - 1)\cot\phi \qquad \text{for } \phi > 0° \quad (5\text{-}3)$$

$$= 2 + \pi = 5.14 \qquad \text{for } \phi = 0° \quad (5\text{-}4)$$

$$q_{ult\ net} = q_{ult\ gross} - q \quad (5\text{-}5)$$

$$q_{ult\ net} = c\,N_c + q(N_q - 1) \quad (5\text{-}6)$$

Bearing Capacity Factors

TABLE 5-1: BEARING CAPACITY FACTORS (AASHTO, 1996)

ϕ	N_c	N_q	N_γ	ϕ	N_c	N_q	N_γ
0	5.14	1.0	0.0	23	18.1	8.7	8.2
1	5.4	1.1	0.1	24	19.3	9.6	9.4
2	5.6	1.2	0.2	25	20.7	10.7	10.9
3	5.9	1.3	0.2	26	22.3	11.9	12.5
4	6.2	1.4	0.3	27	23.9	13.2	14.5
5	6.5	1.6	0.5	28	25.8	14.7	16.7
6	6.8	1.7	0.6	29	27.9	16.4	19.3
7	7.2	1.9	0.7	30	30.1	18.4	22.4
8	7.5	2.1	0.9	31	32.7	20.6	26.0
9	7.9	2.3	1.0	32	35.5	23.2	30.2
10	8.4	2.5	1.2	33	38.6	26.1	35.2
11	8.8	2.7	1.4	34	42.2	29.4	41.1
12	9.3	3.0	1.7	35	46.1	33.3	48.0
13	9.8	3.3	2.0	36	50.6	37.8	56.3
14	10.4	3.6	2.3	37	55.6	42.9	66.2
15	11.0	3.9	2.7	38	61.4	48.9	78.0
16	11.6	4.3	3.1	39	67.9	56.0	92.3
17	12.3	4.8	3.5	40	75.3	64.2	109.4
18	13.1	5.3	4.1	41	83.9	73.9	130.2
19	13.9	5.8	4.7	42	93.7	85.4	155.6
20	14.8	6.4	5.4	43	105.1	99.0	186.5
21	15.8	7.1	6.2	44	118.4	115.3	224.6
22	16.9	7.8	7.1	45	133.9	134.9	271.8

TABLE 5-2: SHAPE CORRECTION FACTORS (AASHTO 1996)

Factor	Friction Angle	Cohesion Term (s_c)	Unit Weight Term (s_γ)	Surcharge Term (s_q)
Shape Factors, s_c, s_γ, s_q	$\phi = 0$	$1+\left(\frac{B_f}{5L_f}\right)$	1.0	1.0
	$\phi > 0$	$1+\left(\frac{B_f}{L_f}\right)\left(\frac{N_q}{N_c}\right)$	$1-0.4\left(\frac{B_f}{L_f}\right)$	$1+\left(\frac{B_f}{L_f}\tan\phi\right)$

Note: Shape (eccentricity) factors, s, should not be applied simultaneously with inclined loading factors, i. See Section 5.2.3.7.

TABLE 5-3: CORRECTION FACTOR FOR LOCATION OF GROUND WATER TABLE (AASHTO, 1998)

Depth of Ground Water Table, D_W	$C_{w\gamma}$	C_{wq}
0	0.5	0.5
D_f	0.5	1.0
$> 1.5B_f + D_f$	1.0	1.0

Note: For intermediate positions of the ground water table, interpolate between the values shown above or use Equations 5-9 and 5-10.

5.2.3.4 Sloping Ground Surface

Placement of footings on or adjacent to slopes requires that the designer perform calculations to ensure that both the bearing capacity and the overall slope stability are acceptable. The bearing capacity equation should include corrections recommended by AASHTO as adapted from NAVFAC (1986b) to design the footings. Calculation of overall, or global, stability is discussed in Section 5.5.

The ultimate bearing capacity equation (Equation 5-7) is therefore modified to include terms N_{cq} and $N_{\gamma q}$ that replace the N_c and N_γ terms (Equation 5-11).

$$q_{ult} = c\,(N_{cq}) + 0.5\,(\gamma)(B_f)(N_{\gamma q}) \quad (5\text{-}11)$$

Charts are provided (Figure 5-7) to determine these terms for cohesive ($\phi = 0^o$) and cohesionless ($c = 0$) soils. Note in Figure 5-7d that beyond a distance, 'b,' of two to six times the foundation width, the bearing capacity is independent of the slope angle (identical to the horizontal ground surface). Also note that the depth of embedment term goes to zero because the surcharge effect on the slope side of the footing should be ignored.

ATTACHMENT 2
Bearing Capacity Calculations – Inlet Tower

Analysis Description

Structure:	PSW - Inlet Tower Structure	Calc By:	LTF
Analysis Section:	Upstream Toe	Date:	5/25/2021
Subgrade Material:	Residuum		

Undrained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients		
ϕu =	0	deg	B =	13.5	ft	Nc =	5.14	
cu =	1,500	psf	L =	20.5	ft	Nq =	1.00	
$\gamma' a$ =	125	pcf	Df_{toe}=	3	ft	$N\gamma$ =	0.00	
$\gamma' f$ =	126	pcf	Df_{heel} =	3	ft			
			Dw =	0	ft			

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	7,710	psf	sc =	1.132	c term:	8,725	
γ'a*D*Nq =	375	psf	sq =	1.000	q term:	188	
0.5*γ'f*B*Nγ =	0	psf	sγ =	1.000	γ term:	0	
qult =	8,085	psf	Cwq =	0.50	qult =	8,913	psf
qallow =	2,695	psf	Cwγ =	0.50	**qallow =**	**2,971**	**psf**

Drained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients		
ϕ' =	23	deg	B =	13.5	ft	Nc =	18.05	
c' =	100	psf	L =	20.5	ft	Nq =	8.66	
$\gamma' a$ =	125	pcf	Df_{toe}=	3	ft	$N\gamma$ =	8.20	
$\gamma' f$ =	126	pcf	Df_{heel} =	3	ft			
			Dw =	0	ft			

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	1,805	psf	sc =	1.316	c term:	2,375	
γ'a*D*Nq =	3,248	psf	sq =	1.280	q term:	2,078	
0.5*γ'f*B*Nγ =	6,976	psf	sγ =	0.737	γ term:	2,569	
qult =	12,028	psf	Cwq =	0.50	qult =	7,022	psf
qallow =	4,009	psf	Cwγ =	0.50	**qallow =**	**2,341**	**psf**

Structure Loading

Minimum qult =	7,022	psf
Actual qmax (gross) =	1,500	psf
Actual FOS =	**4.68**	

ATTACHMENT 3
Bearing Capacity Calculations – Impact Basin

Analysis Description

Structure:	PSW - Impact Basin Structure	Calc By:	LTF
Analysis Section:	Downstream Toe	Date:	5/25/2021
Subgrade Material:	Residuum		

Undrained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients		
ϕu =	0	deg	B =	17.7	ft	Nc =	5.14	
cu =	1,500	psf	L =	23.2	ft	Nq =	1.00	
γ'a =	125	pcf	Df_{toe}=	3	ft	Nγ =	0.00	
γ'f =	126	pcf	Df_{heel} =	3	ft			
			Dw =	0	ft			

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	7,710	psf	sc =	1.153	c term:	8,886	
γ'a*D*Nq =	375	psf	sq =	1.000	q term:	188	
0.5*γ'f*B*Nγ =	0	psf	sγ =	1.000	γ term:	0	
qult =	8,085	psf	Cwq =	0.50	qult =	9,074	psf
qallow =	2,695	psf	Cwγ =	0.50	**qallow =**	**3,025**	**psf**

Drained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients		
ϕ' =	23	deg	B =	17.7	ft	Nc =	18.05	
c' =	100	psf	L =	23.2	ft	Nq =	8.66	
γ'a =	125	pcf	Df_{toe}=	3	ft	Nγ =	8.20	
γ'f =	126	pcf	Df_{heel} =	3	ft			
			Dw =	0	ft			

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	1,805	psf	sc =	1.366	c term:	2,466	
γ'a*D*Nq =	3,248	psf	sq =	1.324	q term:	2,150	
0.5*γ'f*B*Nγ =	9,146	psf	sγ =	0.695	γ term:	3,177	
qult =	14,199	psf	Cwq =	0.50	qult =	7,793	psf
qallow =	4,733	psf	Cwγ =	0.50	**qallow =**	**2,598**	**psf**

Structure Loading

Minimum qult =	7,793	psf
Actual qmax (gross) =	2,000	psf
Actual FOS =	**3.90**	

ATTACHMENT 4
Bearing Capacity Calculations – RCC CREST STRUCTURE

Analysis Description

Structure:	RCC ASW - Crest Structure - Walls	Calc By:	LTF
Analysis Section:	Proposed Dam Crest Centerline	Date:	5/25/2021
Subgrade Material:	Existing Embankment / New Embankment		

Undrained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients		
ϕu =	0	deg	B =	11.33	ft	Nc =	5.14	
cu =	1,200	psf	L =	30	ft	Nq =	1.00	
γ'a =	125	pcf	Df_{toe}=	3	ft	Nγ =	0.00	
γ'f =	125	pcf	Df_{heel} =	3	ft			
			Dw =	0	ft			

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	6,168	psf	sc =	1.076	c term:	6,634	
γ'a*D*Nq =	375	psf	sq =	1.000	q term:	188	
0.5*γ'f*B*Nγ =	0	psf	sγ =	1.000	γ term:	0	
qult =	6,543	psf	Cwq =	0.50	qult =	6,821	psf
qallow =	2,181	psf	Cwγ =	0.50	**qallow =**	**2,274**	**psf**

Drained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients	
ϕ' =	23	deg	B =	11.33	ft	Nc =	18.05
c' =	100	psf	L =	30	ft	Nq =	8.66
γ'a =	125	pcf	Df_{toe}=	3	ft	Nγ =	8.20
γ'f =	125	pcf	Df_{heel} =	3	ft		
			Dw =	0	ft		

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	1,805	psf	sc =	1.181	c term:	2,132	
γ'a*D*Nq =	3,248	psf	sq =	1.160	q term:	1,884	
0.5*γ'f*B*Nγ =	5,808	psf	sγ =	0.849	γ term:	2,465	
qult =	10,861	psf	Cwq =	0.50	qult =	6,482	psf
qallow =	3,620	psf	Cwγ =	0.50	**qallow =**	**2,161**	**psf**

Structure Loading

Minimum qult =	6,482	psf
Actual qmax (gross) =	1,500	psf
Actual FOS =	**4.32**	

Analysis Description

Structure:	RCC ASW - Crest Structure - Slab	Calc By:	LTF
Analysis Section:	Proposed Dam Crest Centerline	Date:	5/25/2021
Subgrade Material:	Existing Embankment / New Embankment		

Undrained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients		
ϕu =	0	deg	B =	30	ft	Nc =	5.14	
cu =	1,200	psf	L =	190	ft	Nq =	1.00	
γ'a =	125	pcf	Df_{toe}=	3	ft	Nγ =	0.00	
γ'f =	125	pcf	Df_{heel} =	3	ft			
			Dw =	0	ft			

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	6,168	psf	sc =	1.032	c term:	6,363	
γ'a*D*Nq =	375	psf	sq =	1.000	q term:	188	
0.5*γ'f*B*Nγ =	0	psf	sγ =	1.000	γ term:	0	
qult =	6,543	psf	Cwq =	0.50	qult =	6,550	psf
qallow =	2,181	psf	Cwγ =	0.50	**qallow =**	**2,183**	**psf**

Drained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients	
ϕ' =	23	deg	B =	30	ft	Nc =	18.05
c' =	100	psf	L =	190	ft	Nq =	8.66
γ'a =	125	pcf	Df_{toe}=	3	ft	Nγ =	8.20
γ'f =	125	pcf	Df_{heel} =	3	ft		
			Dw =	0	ft		

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	1,805	psf	sc =	1.076	c term:	1,942	
γ'a*D*Nq =	3,248	psf	sq =	1.067	q term:	1,733	
0.5*γ'f*B*Nγ =	15,378	psf	sγ =	0.937	γ term:	7,204	
qult =	20,431	psf	Cwq =	0.50	qult =	10,878	psf
qallow =	6,810	psf	Cwγ =	0.50	**qallow =**	**3,626**	**psf**

Structure Loading

Minimum qult =	6,550	psf
Actual qmax (gross) =	1,500	psf
Actual FOS =	**4.37**	

ATTACHMENT 5
Bearing Capacity Calculations – RCC CHUTE STRUCTURE

Analysis Description

Structure:	RCC ASW - Chute Structure - Walls	Calc By:	LTF
Analysis Section:	Proposed Downstream Slope (midpoint)	Date:	5/25/2021
Subgrade Material:	Existing Embankment / New Embankment		

Undrained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients		
ϕu =	0	deg	B =	11.33	ft	Nc =	5.14	
cu =	1,200	psf	L =	48	ft	Nq =	1.00	
γ'a =	125	pcf	Df_{toe}=	3	ft	Nγ =	0.00	
γ'f =	125	pcf	Df_{heel} =	3	ft			
			Dw =	0	ft			

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	6,168	psf	sc =	1.047	c term:	6,459	
γ'a*D*Nq =	375	psf	sq =	1.000	q term:	188	
0.5*γ'f*B*Nγ =	0	psf	sγ =	1.000	γ term:	0	
qult =	6,543	psf	Cwq =	0.50	qult =	6,647	psf
qallow =	2,181	psf	Cwγ =	0.50	**qallow =**	**2,216**	**psf**

Drained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients		
ϕ' =	23	deg	B =	11.33	ft	Nc =	18.05	
c' =	100	psf	L =	48	ft	Nq =	8.66	
γ'a =	125	pcf	Df_{toe}=	3	ft	Nγ =	8.20	
γ'f =	125	pcf	Df_{heel} =	3	ft			
			Dw =	0	ft			

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	1,805	psf	sc =	1.113	c term:	2,009	
γ'a*D*Nq =	3,248	psf	sq =	1.100	q term:	1,787	
0.5*γ'f*B*Nγ =	5,808	psf	sγ =	0.906	γ term:	2,630	
qult =	10,861	psf	Cwq =	0.50	qult =	6,426	psf
qallow =	3,620	psf	Cwγ =	0.50	**qallow =**	**2,142**	**psf**

Structure Loading

Minimum qult =	6,426	psf
Actual qmax (gross) =	1,800	psf
Actual FOS =	**3.57**	

Analysis Description

Structure:	RCC ASW - Chute Structure - Walls	Calc By:	LTF
Analysis Section:	Proposed Downstream Slope (midpoint)	Date:	5/25/2021
Subgrade Material:	Proposed Drainfill/Filter		

Undrained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients	
ϕu =	33	deg	B =	11.33	ft	Nc =	38.64
cu =	0	psf	L =	48	ft	Nq =	26.09
γ'a =	125	pcf	Df_{toe}=	3	ft	Nγ =	35.19
γ'f =	120	pcf	Df_{heel} =	3	ft		
			Dw =	0	ft		

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	0	psf	sc =	1.159	c term:	0	
γ'a*D*Nq =	9,785	psf	sq =	1.153	q term:	5,642	
0.5*γ'f*B*Nγ =	23,920	psf	sγ =	0.906	γ term:	10,831	
qult =	33,705	psf	Cwq =	0.50	qult =	16,473	psf
qallow =	11,235	psf	Cwγ =	0.50	**qallow =**	**5,491**	**psf**

Drained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients	
ϕ' =	33	deg	B =	11.33	ft	Nc =	38.64
c' =	0	psf	L =	48	ft	Nq =	26.09
γ'a =	125	pcf	Df_{toe}=	3	ft	Nγ =	35.19
γ'f =	120	pcf	Df_{heel} =	3	ft		
			Dw =	0	ft		

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	0	psf	sc =	1.159	c term:	0	
γ'a*D*Nq =	9,785	psf	sq =	1.153	q term:	5,642	
0.5*γ'f*B*Nγ =	23,920	psf	sγ =	0.906	γ term:	10,831	
qult =	33,705	psf	Cwq =	0.50	qult =	16,473	psf
qallow =	11,235	psf	Cwγ =	0.50	**qallow =**	**5,491**	**psf**

Structure Loading

Minimum qult =	16,473	psf
Actual qmax (gross) =	1,800	psf
Actual FOS =	**9.15**	

Analysis Description

Structure:	RCC ASW - Chute Structure - Slab	Calc By:	LTF
Analysis Section:	Proposed Downstream Slope (midpoint)	Date:	5/25/2021
Subgrade Material:	Existing Embankment / New Embankment		

Undrained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients		
ϕu =	0	deg	B =	48	ft	Nc =	5.14	
cu =	1,200	psf	L =	190	ft	Nq =	1.00	
γ'a =	125	pcf	Df_{toe}=	3	ft	Nγ =	0.00	
γ'f =	125	pcf	Df_{heel} =	3	ft			
			Dw =	0	ft			

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	6,168	psf	sc =	1.051	c term:	6,480	
γ'a*D*Nq =	375	psf	sq =	1.000	q term:	188	
0.5*γ'f*B*Nγ =	0	psf	sγ =	1.000	γ term:	0	
qult =	6,543	psf	Cwq =	0.50	qult =	6,667	psf
qallow =	2,181	psf	Cwγ =	0.50	**qallow =**	**2,222**	**psf**

Drained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients	
ϕ' =	23	deg	B =	48	ft	Nc =	18.05
c' =	100	psf	L =	190	ft	Nq =	8.66
γ'a =	125	pcf	Df_{toe}=	3	ft	Nγ =	8.20
γ'f =	125	pcf	Df_{heel} =	3	ft		
			Dw =	0	ft		

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	1,805	psf	sc =	1.121	c term:	2,024	
γ'a*D*Nq =	3,248	psf	sq =	1.107	q term:	1,798	
0.5*γ'f*B*Nγ =	24,606	psf	sγ =	0.899	γ term:	11,060	
qult =	29,658	psf	Cwq =	0.50	qult =	14,881	psf
qallow =	9,886	psf	Cwγ =	0.50	**qallow =**	**4,960**	**psf**

Structure Loading

Minimum qult =	6,667	psf
Actual qmax (gross) =	1,800	psf
Actual FOS =	**3.70**	

ATTACHMENT 6
Bearing Capacity Calculations – RCC STILLING BASIN

Analysis Description

Structure:	RCC ASW - Stilling Basin Structure - Walls	Calc By:	LTF
Analysis Section:	Proposed Downstream Slope (midpoint)	Date:	5/25/2021
Subgrade Material:	Residuum		

Undrained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients	
ϕu =	0	deg	B =	11.33	ft	Nc =	5.14
cu =	1,500	psf	L =	24	ft	Nq =	1.00
γ'a =	125	pcf	Df_{toe}=	3	ft	Nγ =	0.00
γ'f =	126	pcf	Df_{heel} =	3	ft		
			Dw =	0	ft		

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	7,710	psf	sc =	1.094	c term:	8,438	
γ'a*D*Nq =	375	psf	sq =	1.000	q term:	188	
0.5*γ'f*B*Nγ =	0	psf	sγ =	1.000	γ term:	0	
qult =	8,085	psf	Cwq =	0.50	qult =	8,625	psf
qallow =	2,695	psf	Cwγ =	0.50	**qallow =**	**2,875**	**psf**

Drained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients	
ϕ' =	23	deg	B =	11.33	ft	Nc =	18.05
c' =	100	psf	L =	24	ft	Nq =	8.66
γ'a =	125	pcf	Df_{toe}=	3	ft	Nγ =	8.20
γ'f =	126	pcf	Df_{heel} =	3	ft		
			Dw =	0	ft		

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	1,805	psf	sc =	1.227	c term:	2,214	
γ'a*D*Nq =	3,248	psf	sq =	1.200	q term:	1,949	
0.5*γ'f*B*Nγ =	5,854	psf	sγ =	0.811	γ term:	2,374	
qult =	10,907	psf	Cwq =	0.50	qult =	6,538	psf
qallow =	3,636	psf	Cwγ =	0.50	**qallow =**	**2,179**	**psf**

Structure Loading

Minimum qult =	6,538	psf
Actual qmax (gross) =	2,500	psf
Actual FOS =	**2.62**	

Analysis Description

Structure:	RCC ASW - Stilling Basin Structure - Walls	Calc By:	LTF
Analysis Section:	Proposed Downstream Slope (midpoint)	Date:	5/25/2021
Subgrade Material:	New Embankment Fill		

Undrained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients		
ϕu =	0	deg	B =	11.33	ft	Nc =	5.14	
cu =	1,200	psf	L =	24	ft	Nq =	1.00	
γ'a =	125	pcf	Df_{toe}=	3	ft	Nγ =	0.00	
γ'f =	125	pcf	Df_{heel} =	3	ft			
			Dw =	0	ft			

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	6,168	psf	sc =	1.094	c term:	6,750	
γ'a*D*Nq =	375	psf	sq =	1.000	q term:	188	
0.5*γ'f*B*Nγ =	0	psf	sγ =	1.000	γ term:	0	
qult =	6,543	psf	Cwq =	0.50	qult =	6,938	psf
qallow =	2,181	psf	Cwγ =	0.50	**qallow =**	**2,313**	**psf**

Drained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients	
ϕ' =	23	deg	B =	11.33	ft	Nc =	18.05
c' =	100	psf	L =	24	ft	Nq =	8.66
γ'a =	125	pcf	Df_{toe}=	3	ft	Nγ =	8.20
γ'f =	125	pcf	Df_{heel} =	3	ft		
			Dw =	0	ft		

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	1,805	psf	sc =	1.227	c term:	2,214	
γ'a*D*Nq =	3,248	psf	sq =	1.200	q term:	1,949	
0.5*γ'f*B*Nγ =	5,808	psf	sγ =	0.811	γ term:	2,356	
qult =	10,861	psf	Cwq =	0.50	qult =	6,519	psf
qallow =	3,620	psf	Cwγ =	0.50	**qallow =**	**2,173**	**psf**

Structure Loading

Minimum qult =	6,519	psf
Actual qmax (gross) =	2,500	psf
Actual FOS =	**2.61**	

Analysis Description

Structure:	RCC ASW - Stilling Basin Structure - Slab	Calc By:	LTF
Analysis Section:	Proposed Downstream Slope (midpoint)	Date:	5/25/2021
Subgrade Material:	Residuum		

Undrained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients		
ϕu =	0	deg	B =	24	ft	Nc =	5.14	
cu =	1,500	psf	L =	190	ft	Nq =	1.00	
$\gamma'a$ =	125	pcf	Df_{toe}=	3	ft	$N\gamma$ =	0.00	
$\gamma'f$ =	126	pcf	Df_{heel} =	3	ft			
			Dw =	0	ft			

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	7,710	psf	sc =	1.025	c term:	7,905	
$\gamma'a$*D*Nq =	375	psf	sq =	1.000	q term:	188	
0.5*$\gamma'f$*B*$N\gamma$ =	0	psf	sγ =	1.000	γ term:	0	
qult =	8,085	psf	Cwq =	0.50	qult =	8,092	psf
qallow =	2,695	psf	Cwγ =	0.50	**qallow =**	**2,697**	**psf**

Drained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients	
ϕ' =	23	deg	B =	24	ft	Nc =	18.05
c' =	100	psf	L =	190	ft	Nq =	8.66
$\gamma'a$ =	125	pcf	Df_{toe}=	3	ft	$N\gamma$ =	8.20
$\gamma'f$ =	126	pcf	Df_{heel} =	3	ft		
			Dw =	0	ft		

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	1,805	psf	sc =	1.061	c term:	1,914	
$\gamma'a$*D*Nq =	3,248	psf	sq =	1.054	q term:	1,711	
0.5*$\gamma'f$*B*$N\gamma$ =	12,401	psf	sγ =	0.949	γ term:	5,887	
qult =	17,454	psf	Cwq =	0.50	qult =	9,513	psf
qallow =	5,818	psf	Cwγ =	0.50	**qallow =**	**3,171**	**psf**

Structure Loading

Minimum qult =	8,092	psf
Actual qmax (gross) =	2,500	psf
Actual FOS =	**3.24**	

Analysis Description

Structure:	RCC ASW - Stilling Basin Structure - Slab	Calc By:	LTF
Analysis Section:	Proposed Downstream Slope (midpoint)	Date:	5/25/2021
Subgrade Material:	New Embankment Fill		

Undrained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients	
ϕu =	0	deg	B =	24	ft	Nc =	5.14
cu =	1,200	psf	L =	190	ft	Nq =	1.00
$\gamma'a$ =	125	pcf	Df_{toe}=	3	ft	Nγ =	0.00
$\gamma'f$ =	125	pcf	Df_{heel} =	3	ft		
			Dw =	0	ft		

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	6,168	psf	sc =	1.025	c term:	6,324	
$\gamma'a$*D*Nq =	375	psf	sq =	1.000	q term:	188	
0.5*$\gamma'f$*B*Nγ =	0	psf	sγ =	1.000	γ term:	0	
qult =	6,543	psf	Cwq =	0.50	qult =	6,511	psf
qallow =	2,181	psf	Cwγ =	0.50	**qallow =**	**2,170**	**psf**

Drained Bearing Capacity

Soil Parameters			Foundation Size			Coefficients	
ϕ' =	23	deg	B =	24	ft	Nc =	18.05
c' =	100	psf	L =	190	ft	Nq =	8.66
$\gamma'a$ =	125	pcf	Df_{toe}=	3	ft	Nγ =	8.20
$\gamma'f$ =	125	pcf	Df_{heel} =	3	ft		
			Dw =	0	ft		

Uncorrected Bearing Capacity			Corrections		Corrected Bearing Capacity		
c*Nc =	1,805	psf	sc =	1.061	c term:	1,914	
$\gamma'a$*D*Nq =	3,248	psf	sq =	1.054	q term:	1,711	
0.5*$\gamma'f$*B*Nγ =	12,303	psf	sγ =	0.949	γ term:	5,841	
qult =	17,356	psf	Cwq =	0.50	qult =	9,466	psf
qallow =	5,785	psf	Cwγ =	0.50	**qallow =**	**3,155**	**psf**

Structure Loading

Minimum qult =	6,511	psf
Actual qmax (gross) =	2,500	psf
Actual FOS =	**2.60**	

Appendix I Lateral Earth Pressures Analysis

OBJECTIVE:

1. To estimate design shear strengths for soils in the vicinity of proposed structures associated with the new principal spillway (PSW) system.
2. To estimate design shear strengths for soils near proposed structures associated with the overtopping roller compacted concrete (RCC) auxiliary spillway.
3. To estimate lateral earth pressure coefficients, sliding stability parameters, and applicable unit weights for foundation and backfill soils associated the proposed new PSW impact basin, PSW intake riser, and RCC spillway retaining walls.

REFERENCES:

Coduto, D.P. “Foundation Design: Principles and Practices.” 2nd Edition. 2001.

Duncan, Horz, and Yang. “Shear Strength Correlations for Geotechnical Engineering.” Virginia Polytechnic Institute and State University. August, 1989.

Stark and Hussain. “Empirical Correlations – Drained Shear Strength for Slope Stability Analyses.” Journal of Geotechnical and Geoenvironmental Engineering. August 14, 2012.

USACE. *EM 1110-2-2502, Retaining Walls and Flood Walls*. September 29, 1989.

USDA Soil Conservation Service (USDA-SCS). “Lateral Earth Pressures.” 210-VI, TR-74. July, 1989.

ANALYSIS:

Per the rehabilitation drawings sheets No. 12 and 20, proposed foundation bearing elevations are between El. 626.4 and 631.5 feet for the proposed PSW system. Sheet 28 of the rehabilitation drawings shows foundation bearing elevations between El. 638.7 and 655.5 feet for structures associated with the RCC spillway.

For the purposes of lateral earth pressure analyses, the strength of materials between elevations 625 and 655 feet was considered. Because complete laboratory testing results were not available at the time of this report, samples recovered within this elevation range in borings drilled in the existing auxiliary spillway were considered in development of the strength properties considered in the analyses completed.

The samples studied indicated the presence of clayey alluvium and residuum characterized in the field as stiff to hard, medium to highly plastic clays with varying amounts of sand, fine to coarse gravel, and calcareous inclusions (see the 2021 GIR by AECOM for the logs of borings). Lateral earth pressures were estimated considering the long term condition (drained shear strengths) using the results of laboratory testing summarized in the “Material Properties Calculation Package”. Various literature based correlations between different index properties and the friction angle, ϕ’, were employed, refer to the discussion below and Attachment 1.

- Stark & Hussain (2012) correlation for fully-softened friction angle:
    - Liquid Limit = 29 to 82 (averages 58, 70, and 60 for embankment, alluvium, and residuum, respectively)

- Percent Fines = 18 to 99% (averages 89, 90, and 93% for embankment, alluvium, and residuum, respectively)
- Clay Fraction = 29 to 68% (averages 51, 57, and 55% for embankment, alluvium, and residuum, respectively%)
- Normal Stress Range considering estimated average total unit weight of 125 pcf:
    - Minimum (5-feet embedment for PSW inlet): 625 psf (30 kPa)
    - Maximum (17-foot RCC walls in stilling basin): 2,125 psf (102 kPa)
    - Therefore, conservatively consider 100 kPa normal stress curve for correlation
- Estimated $\phi'_{fully\text{-}softened}$:
    - Embankment (average): $\phi' = 24.5°$
    - Alluvium (average): $\phi' = 23$
    - Residuum (average): $\phi' = 24.5°$
    - Generic borderline CL/CH: $\phi' = 25°$

- Duncan correlation for peak friction angle:

    - Plasticity Index = 14 to 62 (averages 37, 48, and 39 for embankment, alluvium, and residuum, respectively)
    - Estimated ϕ'_{peak} :
        - Embankment (average): $\phi' = 27.5° \pm 2.5°$ (25.0° – 30.0°)
        - Alluvium (average): $\phi' = 26.0° \pm 2.5°$ (23.5° – 28.5°)
        - Residuum (average): $\phi' = 27.0° \pm 2.5°$ (24.5° – 29.5°)

- USBR Design of Small Dams (1960)

    - CH soil: $\phi' = 17 \pm 7°$ (10° – 24°)
    - CL soil: $\phi' = 25 \pm 7°$ (18° – 32°)

Based on the correlations above, it is recommended that lateral earth pressures and sliding friction values be calculated based on a design **$\phi' = 25°$** and the cohesion should be neglected (c' = 0 psf) in analyses.

LATERAL EARTH PRESSURES RECOMMENDATIONS

Lateral earth pressures were computed based on drained shear strengths assuming friction angle, $\phi' = 25°$ and Coulomb's equations (1776) as presented in Coduto (2001) for active and passive pressures, and Jaky's equation (1944) as presented in USACE (1989). In addition, lateral earth pressures were computed according to the methods presented in TR-74 (USDA-SCS, 1989) for comparison purposes. Results of both methods are presented herein.

Active Earth Pressure

Active earth pressure coefficients were calculated according to the Coulomb equations as follows:

- Active earth pressure coefficient, K_a, for level backfill:

$$K_a = tan\left(45° - \frac{\phi'}{2}\right)^2$$

$$K_a = tan\left(45° - \frac{25°}{2}\right)^2$$

$$K_a = 0.41$$

- Active earth pressure coefficient, K_a, for sloping backfill at 3H:1V grade (α = 18.4°) with no wall batter from vertical (β=90°) and conservatively neglecting wall/backfill interface friction (δ = 0°):

$$K_a = \frac{sin^2(\beta + \phi')}{sin^2(\beta)sin(\beta - \delta)\left[1 + \sqrt{\frac{sin(\phi' + \delta)sin(\phi' - \alpha)}{sin(\beta - \delta)sin(\alpha + \beta)}}\right]^2}$$

$$K_a = \frac{sin^2(90° + 25°)}{sin^2(90°)sin(90° - 0°)\left[1 + \sqrt{\frac{sin(25° + 0°)sin(25° - 18.4°)}{sin(90° - 0°)sin(18.4° + 90°)}}\right]^2}$$

$$K_a = 0.55$$

The active earth pressure coefficient was also estimated graphically per NRCS TR-74 Figure 43. This methodology suggests K_a of approximately 0.41 for soils with ϕ' = 25° and level backfill, and K_a of approximately 0.55 for soils with sloping backfill at 3H:1V.

At-Rest Earth Pressure

At-rest earth pressure coefficients were calculated for level ground according to Jaky's equation (1944) and for sloping ground according to the Danish Code (Danish Geotechnical Institute) as presented in USACE (1989) as follows:

- At-rest earth pressure coefficient, K_0, for level backfill:

$$K_0 = [1 - sin(\phi')]$$

$$K_0 = [1 - sin(25°)]$$

$$K_0 = 0.57$$

- At-rest earth pressure coefficient, K_0, for sloping backfill at 3H:1V grade (α = 18.4°):

$$K_0 = [1 - sin(\phi')] \cdot [1 + sin(\alpha)]$$

$$K_0 = [1 - sin(25°)] \cdot [1 + sin(18.4°)]$$

$$K_0 = 0.76$$

The at-rest earth pressure coefficient was also estimated graphically per NRCS TR-74, Figure 44. This methodology suggests K_0 = 0.65 for level backfill consisting soils with ϕ' < 27° and more than 5% fines, which is the case for the samples investigated. Using NRCS TR-74, Figure 47 to correct for sloping retained ground, the value of the resulting K_0 = 0.88 (=K_0F = 0.65*1.35) for 3H:1V backslope.

It should be noted that TR-74 further recommends that, in addition to at-rest earth pressures, an additional two feet of soil surcharge pressure be considered in slope stability analyses to account for operation and maintenance loads.

Passive Earth Pressure

Passive earth pressure coefficients were calculated according to the Coulomb equations as follows:

- Passive Earth Pressure Coefficient, K_p, for level ground surface (α = 0°):

$$k_p = \left[\frac{cos(\phi')}{1 - \sqrt{sin(\phi') \cdot [sin(\phi') + cos(\phi') \cdot tan(\alpha)]}}\right]^2$$

$$k_p = \left[\frac{cos(25°)}{1 - \sqrt{sin(25°) \cdot [sin(25°) + cos(25°) \cdot tan(0°)]}}\right]^2$$

$$k_p = 2.46$$

- While downward-sloping ground in front of walls/foundations is not planned for this project, the Passive Earth Pressure Coefficient, K_p, for sloping ground surface away from the wall at -3H:1V grade (α = -18.4°) is shown for comparison purposes to illustrate the detrimental effects:

$$k_p = \left[\frac{cos(\phi')}{1 - \sqrt{sin(\phi') \cdot [sin(\phi') + cos(\phi') \cdot tan(\alpha)]}}\right]^2$$

$$k_p = \left[\frac{cos(25°)}{1-\sqrt{sin(25°)\cdot[sin(25°)+cos(25°)\cdot tan(-18.4°)]}}\right]^2$$

$$k_p = 1.37$$

The passive earth pressure coefficient was also estimated graphically per NRCS TR-74 Figure 45. This methodology obtains similar results, with K_p = 2.45 for level backfills and K_p = 1.35 for downward-sloping ground surface at -3H:1V.

TR-74 also recommends that a large factor of safety be applied to passive resistance to account for the large displacements required to engage passive resistance. Moreover, it should be noted that calculations of passive earth pressures should neglect upper 2 ft of embedment.

UNIT WEIGHT RECOMMENDATIONS

Consider the following unit weights when evaluating lateral earth pressures:

- Total (moist) unit weight from relatively undisturbed Shelby tubes samples (adapted from ranges shown in "Material Properties Calculation Package"):
  - Embankment: 116.1 to 129.8 pcf (average 122 pcf)
  - Alluvium: 112.9 to 132.4 pcf (average 124 pcf)
  - Residuum: 119.2 to 138.8 pcf (average 127 pcf)

- Estimated total (moist) unit weight for compacted fill materials using results of maximum dry density (MDD) and optimum moisture content (OMC) from Standard Proctor Compaction tests with typical compaction criteria (i.e., 95 to 100% of MDD at 0 to +4% OMC]). Conservatively consider middle of compaction range (98% MDD at +2% OMC):

  - Embankment (COMP-1700A): CH with MDD=95.1 pcf and OMC=24.4%
    - Total (moist unit weight): (95.1 pcf)*(98%) x (1 + (24.4% + 2%)/100) = <u>117.8 pcf</u>

  - Alluvium (COMP-400A): CH with MDD=93.9 pcf and OMC=22.3%
    - Total (moist unit weight): (93.9 pcf)*(98%) x (1 + (22.3% + 2%)/100) = <u>114.4 pcf</u>

  - MPR-Residuum (COMP-100A): CH with MDD=99.0 pcf and OMC=22.0%
    - Total (moist unit weight): (99.0 pcf)*(98%) x (1 + (22.0% + 2%)/100) = <u>120.3 pcf</u>

  - LPR-Residuum (COMP-100B): CL with MDD=115.1 pcf and OMC=14.4%
    - Total (moist unit weight): (115.1 pcf)*(98%) x (1 + (14.4% + 2%)/100) = <u>131.3 pcf</u>

- Estimated total (saturated) unit weight from Proctor data considering compaction to 98% MDD, and subsequent increase in moisture content to saturated conditions post-compaction. Saturated moisture content taken from Proctor curves at the zero-air-voids (ZAV) assuming Gs=2.7 as follows:

  - Embankment (COMP-1700A): Saturated WC=30% at 98% MDD (93.2 pcf)
    - Total (saturated unit weight): (95.1 pcf)*(98%) x (1 + (30%)/100) = <u>121.2 pcf</u>

  - Alluvium (COMP-400A): Saturated WC=30% at 98% MDD (92.0 pcf)
    - Total (saturated unit weight): (93.9 pcf)*(98%) x (1 + (27%)/100) = <u>119.6 pcf</u>

  - MPR-Residuum (COMP-100A): Saturated WC=27% at 98% MDD (97.0 pcf)
    - Total (saturated unit weight): (99.0 pcf)*(98%) x (1 + (27%)/100) = <u>123.2 pcf</u>

  - LPR-Residuum (COMP-100B): Saturated WC=18.5% at 98% MDD (112.8 pcf)
    - Total (saturated unit weight): (115.1 pcf)*(98%) x (1 + (18.5%)/100) = <u>133.7 pcf</u>

- USBR Design of Small Dams (1960):

  - CH: 93.6 lb/ft^3 average dry unit weight and 25.7% average moisture content:
    Total (moist) unit weight = 93.6 lb/ft^3 *1.257 = 117.7 lb/ft^3

  - CL: 106.5 lb/ft^3 average dry unit weight and 17.7% average moisture content
    Total (moist) unit weight = 106.5 lb/ft^3 *1.177 = 125.4 lb/ft^3

Thus, moist total unit weight of **126 lb/ft^3** and saturated total unit weight of **128 lb/ft^3** are conservatively recommended for analysis.

<u>SLIDING STABILITY PARAMETERS:</u>

The ultimate coefficient of sliding friction (μ) between the base of the concrete foundation and natural subgrade is used to evaluate sliding stability of structures, and is defined as follows for effective stress (drained) conditions:

$$\mu = \tan(\phi_f')$$

Standard practice is to consider the interface friction angle (ϕ_f') between the concrete and the subgrade soil as 2/3 to 3/4 of the soil friction angle, ϕ' . Since the footings for this project will be cast-in-place concrete cast directly on subgrade, the recommended value for design is as follows:

$$\mu = 0.75*\tan(25') = 0.35$$

The recommended parameter is valid only for smooth bottom footings where a shear key is not provided. Should shear keys be included in design, the interface friction angle may be considered as the full friction angle of the native soil based on which a coefficient of friction of $\mu = 0.47$ may be considered along the base.

Typical friction coefficients between concrete and soil were estimated in accordance with TR-74 Figure 51 and were checked as a comparison. Both the intake tower and impact basin will be founded on compacted clayey soils with moisture contents ranging from below the optimum moisture content (OMC) to slightly above OMC that, for the purposes of analyses, were considered dry to wet, medium dense to dense. For these conditions, TR-74 provides a typical range of sliding stability parameters of 0.25 to 0.5, which bracket the values recommended herein and thus are judged to be resasonable.

TR-74 further highlights that soil cohesion may be neglected in long-term stability analyses; thus, recommended sliding stability parameters neglect any contribution of cohesion.

ATTACHMENT 1

Shear Strength Characterization References

Journal of Geotechnical and Geoenvironmental Engineering. Submitted October 23, 2011; accepted August 27, 2012; posted ahead of print August 30, 2012. doi:10.1061/(ASCE)GT.1943-5606.0000824

EMPIRICAL CORRELATIONS - DRAINED SHEAR STRENGTH FOR SLOPE STABILITY ANALYSES

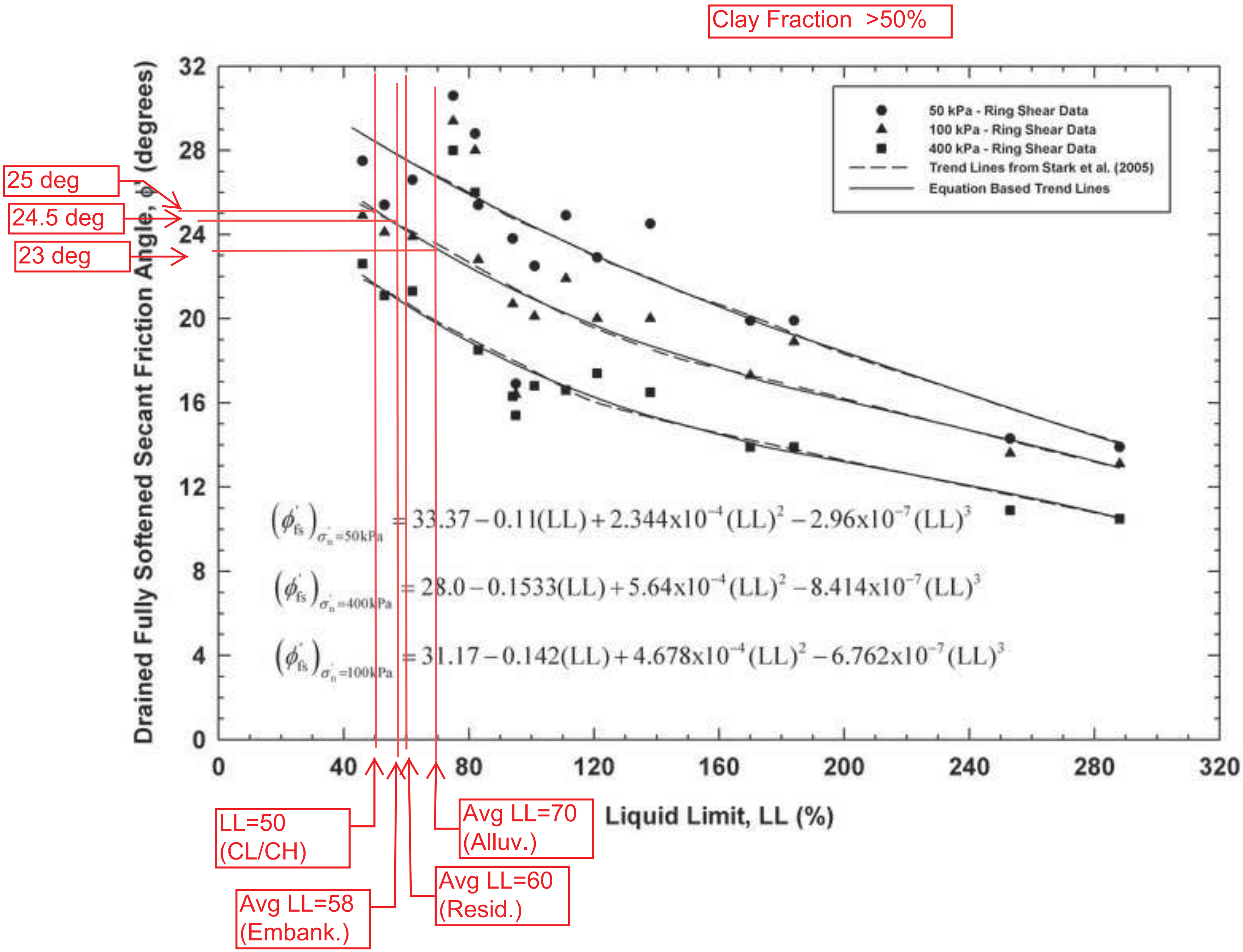
Timothy D. Stark, F.ASCE, D.GE, Ph.D., P.E.
Professor of Civil and Environmental Engineering
University of Illinois at Urbana-Champaign
205 N. Mathews Ave.
Urbana, IL 61801
(217) 333-7394
(217) 333-9464 Fax
tstark@illinois.edu

and

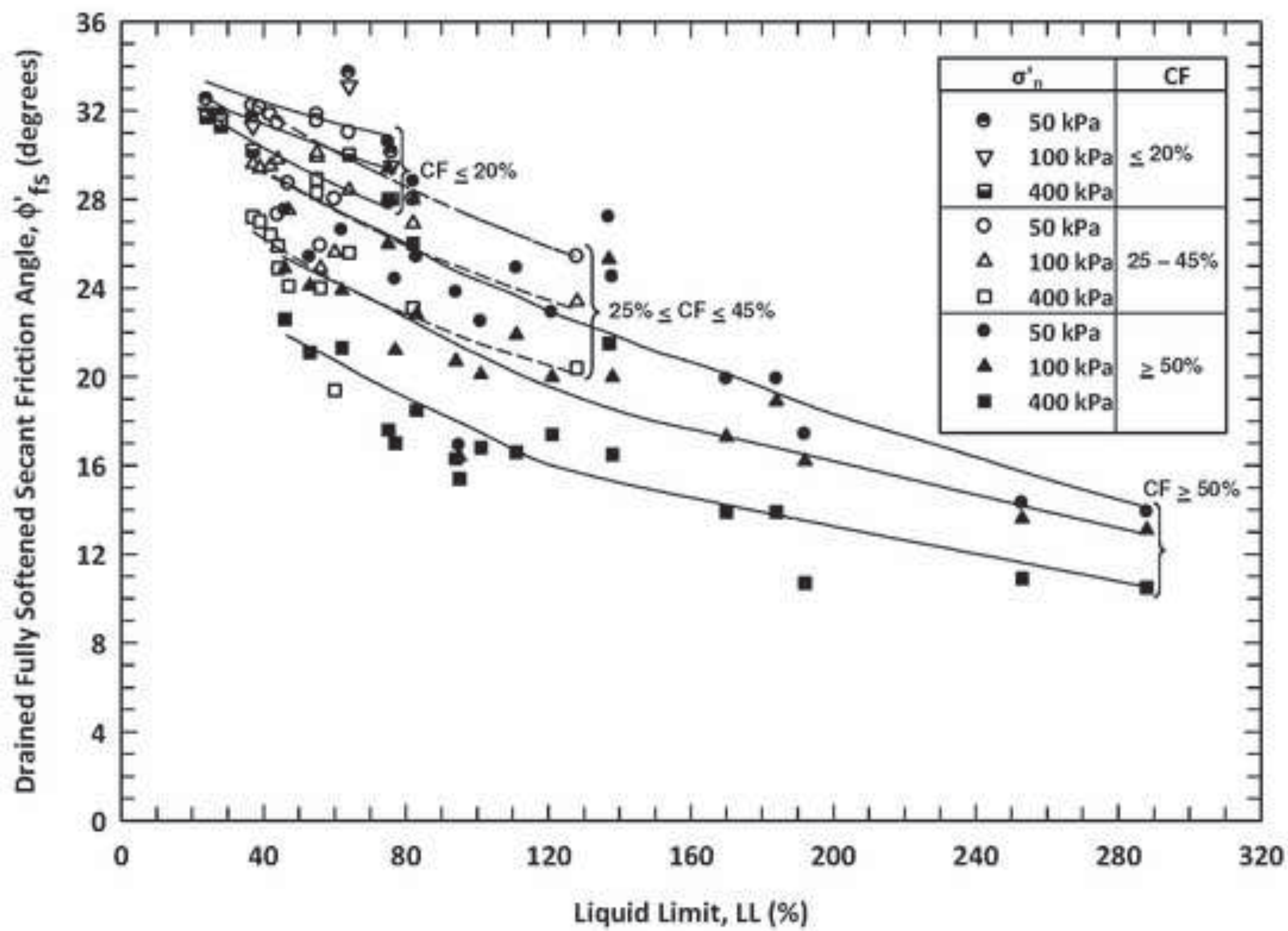
Manzoor Hussain
Ph.D. (Civil Engineering)
College of Civil Engineering, Risalpur
National University of Sciences and Technology
Risalpur, Pakistan
mhussain@mce.nust.edu.pk

August 14, 2012

Journal of Geotechnical and Geoenvironmental Engineering. Submitted October 23, 2011; accepted August 27, 2012;
posted ahead of print August 30, 2012. doi:10.1061/(ASCE)GT.1943-5606.0000824



Journal of Geotechnical and Geoenvironmental Engineering. Submitted October 23, 2011; accepted August 27, 2012; posted ahead of print August 30, 2012. doi:10.1061/(ASCE)GT.1943-5606.0000824



LUEBBERS

Virginia Polytechnic Institute
and State University

The Charles E. Via, Jr.
Department of Civil Engineering

GEOTECHNICAL ENGINEERING

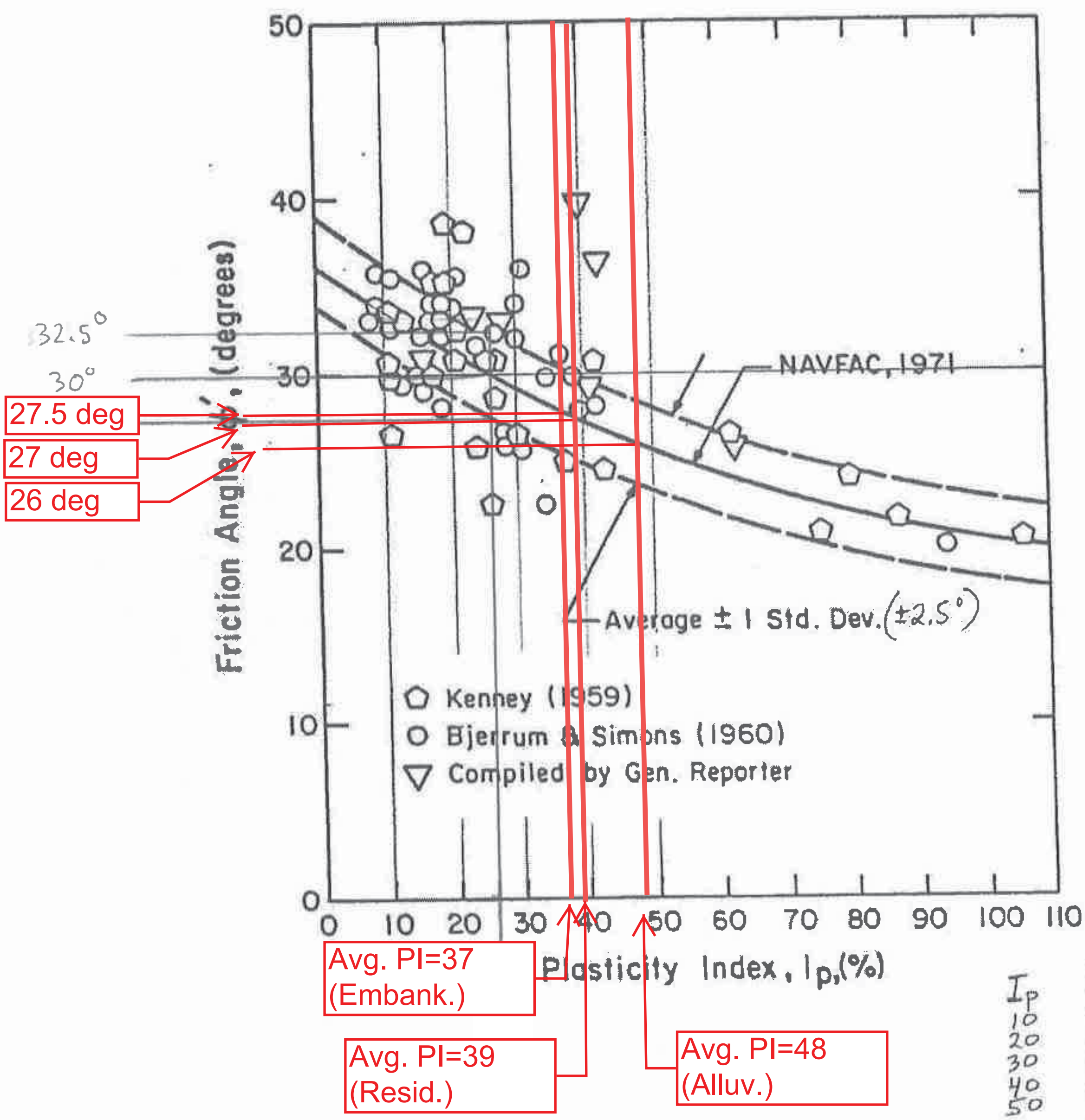
SHEAR STRENGTH CORRELATIONS FOR GEOTECHNICAL ENGINEERING

by

J. M. Duncan
R. C. Horz
T. L. Yang

August, 1989

VIRGINIA TECH
BLACKSBURG



I_p	ϕ
10	33.6
20	31.05
30	29.15
40	27.3
50	25.55

Fig. 42 Correlation between ϕ' at $(\sigma_1/\sigma_3)_{max}$ and I_p from Triaxial Tests on Normally Consolidated Clays, (After Ladd et al, 1977).

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF RECLAMATION

DESIGN OF SMALL DAMS

A Water Resources Technical Publication

First Edition, 1960
Second Edition, 1973
Revised Reprint, 1977
Third Edition, 1987

5.18. *Engineering Characteristics of Soil Groups.*—(a) *General.*—Although there is no substitute for thorough testing to determine the important engineering properties of a particular soil, approximate values for typical soils of each USCS group can be given as a result of statistical analysis of available data (table 5-1). The attempt to put soils data into quantitative form involves the risk of (1) the data not being representative, and (2) using the values in design without adequate safety factors. In the early stages of planning, when different borrow areas and design sections are being studied, these averaged values of soil properties can be taken as useful qualitative guides. Because the values pertain to the soil groups, proper soil classification becomes of vital importance. Verification of field identification by laboratory gradation and Atterberg limits tests for design must be made on representative samples of each soil group encountered.

Table 5-1 is a summary of values obtained from more than 1,500 soil tests performed between 1960 and 1982 in the engineering laboratories of the Bureau of Reclamation in Denver, Colorado. The data, which were obtained from reports for which laboratory soil classifications were available, are arranged according to the USCS groups. The soils are from the 17 Western States in which the Bureau operates. Although the sampling area of the soils tested is limited, it is believed that the USCS is relatively insensitive to geographical distribution. The procedure for determining which of the many submitted samples should be tested was conducive to obtaining a representative range of values because samples were selected from the coarsest, the finest, and the average soil from each source.

For each soil property listed, the average, the standard deviation, the number of tests performed, the minimum test value, and the maximum test value are listed in table 5-1. Because all laboratory tests, except large-sized permeability tests, were made on compacted specimens of the minus No. 4 fraction of the soil, data on average values for the gravels were not available for most properties. The averages shown are subject to uncertainties that may arise from sampling fluctuations, and tend to vary widely from the true averages when the number of tests is small.

The values for laboratory maximum dry unit weight, optimum moisture content, specific gravity, and maximum and minimum index unit weight were obtained by tests described in section 5.49. The MH and CH soil groups have no upper boundary of liquid limits in the classification; therefore, it is necessary to give the range of those soils included in the table. The maximum liquid limits for the MH and the CH soils tested were 82 and 86 percent, respectively. Soils with higher liquid limits than these have inferior engineering properties.

(b) *Shear Strength.*—Two shear strength parameters are given for the soil groups under the headings c' and ϕ'. The values of c' and ϕ' are the vertical intercept and the angle of the envelope, respectively, of the Mohr strength envelope on an effective stress basis. (The Mohr plot is shown on fig. 5-13). The Mohr strength envelope is obtained by testing several specimens of compacted soil in a triaxial shear apparatus in which pore-fluid pressures developed during the test are measured.

The effective stresses are obtained by subtracting the measured pore-fluid pressures in the specimen from the stresses applied by the apparatus. The data used in compiling the values in table 5-1 are taken from UU (unconsolidated-undrained) and CU (consolidated-undrained) triaxial shear tests with pore-fluid pressure measurements and from CD (consolidated-drained) triaxial shear tests.

These values for shear strength are applicable for use in Coulomb's equation:

$$s = c' + (\sigma - \mu) \tan \phi' \qquad (1)$$

where:

s = shear strength,
u = pore-fluid pressure,
σ = applied normal stress,
ϕ' = effective angle of internal friction, and
c' = effective cohesion.

A discussion of the significance of pore-fluid pressure in the laboratory tests is beyond the scope of this text. The application of pore-pressure measurements to the shear strength of cohesive soils is discussed in [7]. The effective-stress principle, which takes the pore-fluid pressures into account, was used in arriving at recommended slopes given in chapter 6.

(c) *Permeability.*—The voids in the soil mass provide passages through which water can move. Such passages vary in size, and the paths of flow are tortuous and interconnected. If, however, a sufficiently large number of paths of flow are considered as acting together, an average rate of flow for

Table 5-1.—Average engineering properties of compacted soils. From the Western United States. Last updated October 6, 1982.

USCS soil type	Specific gravity		Compaction				Shear strength				Values listed
			Laboratory		Index unit weight		Avg. placement		Effective stress		
	No. 4 minus	No. 4 plus	Maximum unit weight, lb/ft³	Optimum moisture content, %	Max., lb/ft³	Min., lb/ft³	Unit weight, lb/ft³	Moisture content, %	c' lb/in²	φ', degrees	
GW	2.69	2.58	124.2	11.4	133.6	108.8	—	—	—	—	Average of all values
	0.02	0.08	3.2	1.2	10.4	10.2	—	—	—	—	Standard deviation
	2.65	2.39	119.1	9.9	113.0	88.5	—	—	—	—	Minimum value
	2.75	2.67	127.5	13.3	145.6	132.9	—	—	—	—	Maximum value
	16	9	5		16		0				Total number of tests
GP	2.68	2.57	121.7	11.2	137.2	112.5	127.5	6.5	5.9	41.4	Average of all values
	0.03	0.07	5.9	2.2	6.3	8.3	7.2	1.2	—	2.5	Standard deviation
	2.61	2.42	104.9	9.1	118.3	85.9	117.4	5.3	5.9	38.0	Minimum value
	2.76	2.65	127.7	17.7	148.8	123.7	133.9	8.0	5.9	43.7	Maximum value
	35	12	15		34		3				Total number of tests
GM	2.73	2.43	113.3	15.8	132.0	108.0	125.9	10.3	13.4	34.0	Average of all values
	0.07	0.18	11.5	5.8	3.1	0.2	0.9	1.2	3.7	2.6	Standard deviation
	2.65	2.19	87.0	5.8	128.9	107.8	125.0	9.1	9.7	31.4	Minimum value
	2.92	2.92	133.0	29.5	135.1	108.1	126.9	11.5	17.0	36.5	Maximum value
	34	17	36		2		2				Total number of tests
GC	2.73	2.57	116.6	13.9	—	—	111.1	15.9	10.2	27.5	Average of all values
	0.08	0.21	7.8	3.8	—	—	10.4	1.6	1.5	7.2	Standard deviation
	2.67	2.38	96.0	6.0	—	—	96.8	11.2	5.0	17.7	Minimum value
	3.11	2.94	129.0	23.6	—	—	120.9	22.2	16.0	35.0	Maximum value
	34	6	37		0		3				Total number of tests
SW	2.67	2.57	126.1	9.1	125.0	99.5	—	—	—	—	Average of all values
	0.03	0.03	6.0	1.7	6.0	7.1	—	—	—	—	Standard deviation
	2.61	2.51	118.1	7.4	116.7	87.4	—	—	—	—	Minimum value
	2.72	2.59	135.0	11.2	137.8	109.8	—	—	—	—	Maximum value
	13	2	1		12		0				Total number of tests
SP	2.65	2.62	115.6	10.8	115.1	93.4	103.4	5.4	5.5	37.4	Average of all values
	0.03	0.10	9.7	2.0	7.2	8.8	14.6	—	3.0	2.0	Standard deviation
	2.60	2.52	106.5	7.8	105.9	78.2	88.8	5.4	2.5	35.4	Minimum value
	2.77	2.75	134.8	13.4	137.3	122.4	118.1	5.4	8.4	39.4	Maximum value
	36	3	7		39		2				Total number of tests
SM	2.68	2.18	116.6	12.5	110.1	84.9	112.0	12.7	6.6	33.6	Average of all values
	0.06	0.11	8.9	3.4	8.7	7.9	11.1	5.4	5.6	5.7	Standard deviation
	2.51	2.24	92.9	6.8	88.5	61.6	91.1	1.6	0.2	23.3	Minimum value
	3.11	2.63	132.6	25.5	122.9	97.1	132.5	25.0	21.2	45.0	Maximum value
	149	9	123		21		17				Total number of tests
SC	2.69	2.17	118.9	12.4	—	—	115.6	14.2	5.0	33.9	Average of all values
	0.04	0.18	5.9	2.3	—	—	14.1	5.7	2.5	2.9	Standard deviation
	2.56	2.17	104.3	6.7	—	—	91.1	7.5	0.7	28.4	Minimum value
	2.81	2.59	131.7	18.2	—	—	131.8	22.7	8.5	38.3	Maximum value
	88	4	73		0		10				Total number of tests
ML	2.69	—	103.3	19.7	—	—	98.9	22.1	3.6	34.0	Average of all values
	0.09	—	10.4	5.7	—	—	11.5	8.9	4.3	3.1	Standard deviation
	2.52	—	81.6	10.6	—	—	80.7	11.1	0.1	25.2	Minimum value
	3.10	—	126.0	34.6	—	—	119.3	40.3	11.9	37.7	Maximum value
	65	0	39		0		14				Total number of tests
CL	2.71	2.59	109.3	16.7	—	—	106.5	17.7	10.3	25.1	Average of all values
	0.05	0.13	5.5	2.9	—	—	7.8	5.1	7.6	7.0	Standard deviation
	2.56	2.42	90.0	6.4	—	—	85.6	11.6	0.9	8.0	Minimum value
	2.87	2.75	121.4	29.2	—	—	118.7	35.0	23.8	33.8	Maximum value
	270	3	221		0		31				Total number of tests
MH	2.79	—	85.1	33.6	—	—	—	—	—	—	Average of all values
	0.25	—	2.3	1.6	—	—	—	—	—	—	Standard deviation
	2.47	—	82.9	31.5	—	—	—	—	—	—	Minimum value
	3.50	—	89.0	35.5	—	—	—	—	—	—	Maximum value
	10	0	5		0		0				Total number of tests

Table 5-1.—Average engineering properties of compacted soils. From the Western United States. Last updated October 6, 1982. —Continued.

USCS soil type	Specific gravity		Compaction				Shear strength				Values listed
			Laboratory		Index unit weight		Avg. placement		Effective stress		
	No. 4 minus	No. 4 plus	Maximum unit weight, lb/ft³	Optimum moisture content, %	Max., lb/ft³	Min., lb/ft³	Unit weight, lb/ft³	Moisture, content, %	c′ lb/in²	φ′, degrees	
CH	2.73	—	95.3	25.0	—	—	93.6	25.7	11.5	16.8	Average of all values
	0.06	—	6.6	5.4	—	—	8.1	5.7	7.4	7.2	Standard deviation
	2.51	—	82.3	16.6	—	—	79.3	17.9	1.5	4.0	Minimum value
	2.89	—	107.3	41.8	—	—	104.9	35.3	21.5	27.5	Maximum value
	74	0	36		0		12				Total number of tests

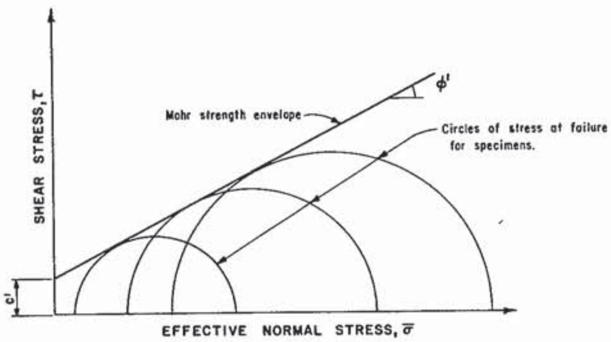


Figure 5-13.—Shear strength of compacted soils. 288–D–2474.

the soil mass can be determined under controlled conditions that will represent a property of the soil.

In 1856, H. Darcy showed experimentally that the rate of flow of water, q, through a soil specimen of cross-sectional area A was directly proportional to the imposed hydraulic gradient ($i = \Delta h/L$) or $q = kiA$. The coefficient of proportionality, k, has been called "Darcy's coefficient of permeability," "coefficient of permeability" (also referred to as hydraulic conductivity) or "permeability." Permeability is the soil property that indicates the ease with which water will flow through the soil. The use of k in estimating flow through soils is discussed in section 6.9(b). Many units of measurement are commonly used for expressing the coefficient of permeability. The units used on figure 5-14 are feet per year (or cubic feet per square foot per year at unit gradient). One foot per year is virtually equal to 10^{-6} cm/s.

Permeability in some soils is very sensitive to small changes in unit weight, water content, or gradation. Because of the possible wide variation in permeability, the numerical value of k should be considered only as an order of magnitude. It is customary in the Bureau of Reclamation to describe soils with permeabilities less than 1 ft/yr as impervious; those with permeabilities between 1 and 100 ft/yr as semipervious; and soils with permeabilities greater than 100 ft/yr as pervious. These values, however, are not absolute for the design of dams. Successful structures have been built whose various zones were constructed of soils with permeabilities not within these respective ranges.

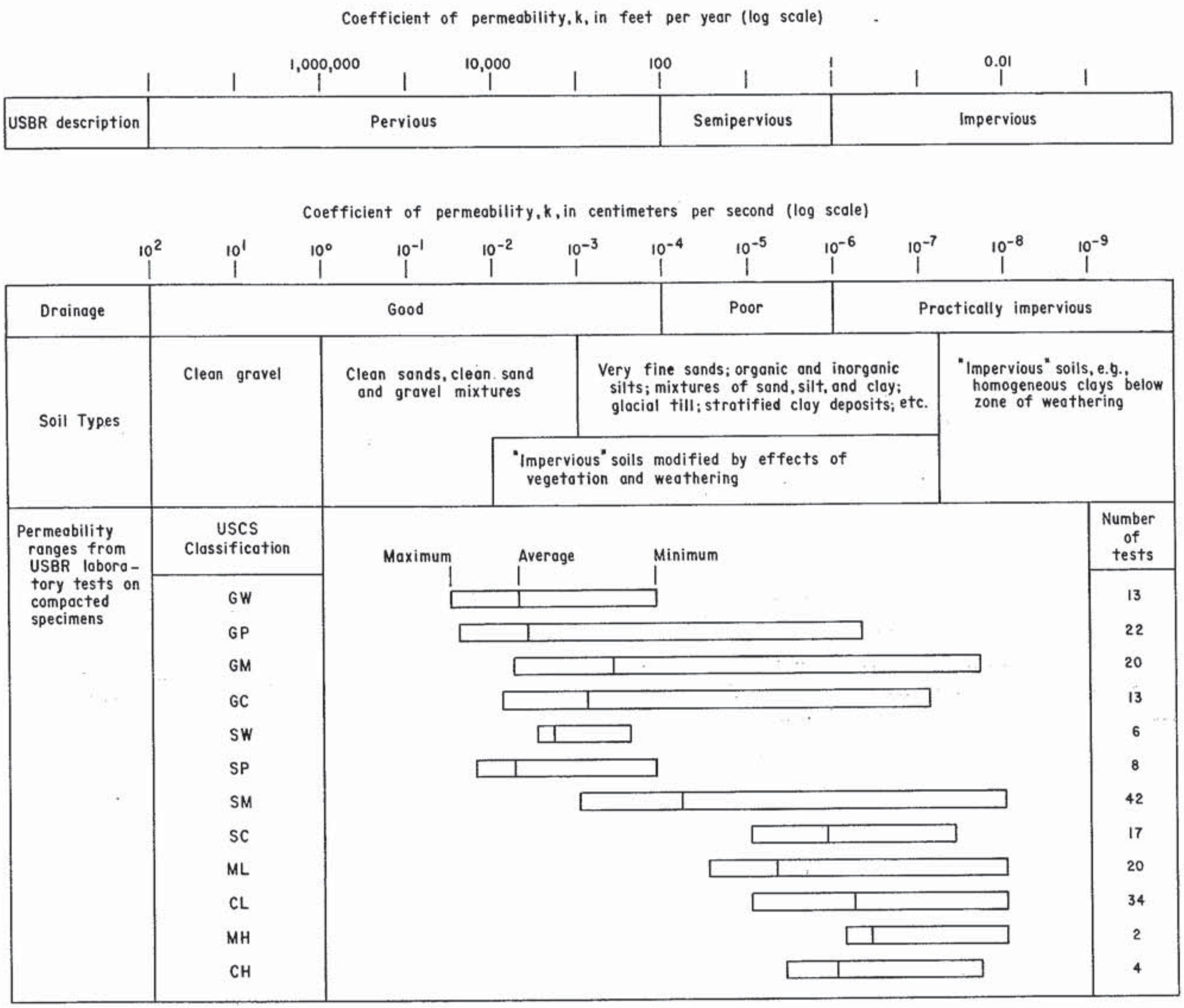


Figure 5-14.—Permeability of soils. (After Casagrande and Fadum, 1940). 103–D–1860.

E. ROCK CLASSIFICATION AND DESCRIPTION OF PHYSICAL PROPERTIES OF ROCK

5.19. *General.*—(a) *Definition and Types.*—Rock is defined as an aggregate of one or more minerals. However, to the engineer the term "rock" usually signifies hard or lithified substances that require mechanical or explosive methods to excavate. Based on their principal mode of origin, rocks are grouped into three large classes: igneous, sedimentary, and metamorphic. These are discussed in more detail in sections 5.20, 5.21, and 5.22, respectively.

(b) *Mineral Identification.*—The physical properties of a mineral, which are controlled by its chemical composition and molecular structure, are valuable aids in its identification and, consequently, in rock identifications. These properties include hardness, cleavage, fracture, luster, color, and streak. Those characteristics that can be determined by simple field tests are introduced to aid in the identification of minerals and indirectly in the identification of rocks.

(1) *Hardness.*—The hardness of a mineral is a measure of its ability to resist abrasion or scratch-

ing. A simple scale based on empirical tests for hardness has been universally accepted. The ten minerals selected to form the standard of comparison are listed in order of increasing hardness from 1 to 10:

Mineral	*Hardness*
Talc or mica	1
Gypsum (fingernail about 2)	2
Calcite	3
Flourite (copper coin between 3 and 4)	4
Apatite (knife blade about 5)	5
Orthoclase feldspar (glass about 5.5)	6
Quartz	7
Topaz or beryl	8
Corundum	9
Diamond	10

When testing the hardness of a mineral always use a fresh surface, and always rub the mark to make sure it is really a grove made by scratching.

(2) *Cleavage.*—A material is said to have cleavage if smooth, plane surfaces are produced when the mineral is broken. Some minerals have one cleavage; others have two, three, or more different cleavage directions, which may have varying degrees of perfection. The number of cleavage directions and the angle at which they intersect serve to help identify a mineral (fig. 5-15).

(3) *Fracture.*—The broken surface of a mineral, in directions other than those of cleavage planes, is called the fracture. In some cases this property may be very helpful in field identification. The common types of fracture are conchoidal if the fracture has concentric curved surfaces like the inside of a clamshell; irregular if the surface is rough; and splintery if it has the appearance of wood.

(4) *Luster.*—the luster of a mineral is the appearance of its surface based on the quality and intensity of the light reflected. Two major kinds are recognized, metallic and nonmetallic. Metallic minerals are opaque, or nearly so; whereas, nonmetallic minerals are transparent on their thin edges.

(5) *Color.*—Using color for identification must be done with proper precaution because some minerals show a wide range of color without a perceptible change in composition.

(6) *Streak.*—The color of the fine powder of a mineral, obtained by rubbing it on the unglazed portion of a porcelain tile is known as its streak. The streak of a mineral is quite consistent within a given range, even though its color may vary.

(c) *Common Rock-Forming Minerals.*—Only about 12 of the 2,000 known varieties of minerals are found in most common rocks. The primary rock-forming minerals or mineral groups are described below.

- *Quartz.*—Silicon dioxide. Quartz is the second most common rock-forming mineral. Hardness, 7, scratches glass easily; no cleavage; fracture, conchoidal; luster, vitreous; common varieties, usually white or colorless; streak, white or colorless.
- *Feldspar group.*—Potassium-aluminum silicates or sodium-calcium-aluminum silicates. Feldspars are the most common rock-forming minerals. Hardness, 6, scratches glass with difficulty; luster, vitreous; streak, white. Orthoclase is a common potassium-rich variety that is typically colorless, white, gray, pink, or red, and has two good directions of cleavage that intersect at 90° to each other (No. 1 on fig. 5-15). The sodium-calcium-rich feldspars, commonly referred to as plagioclase feldspar, are typically of various shades of gray, have two cleavage directions that intersect at angles of nearly 90° to each other, and can be differentiated from orthoclase feldspar by the presence of fine, parallel lines (striations) that appear on the basal cleavage surface.
- *Mica group.*—Complex potassium-aluminum silicates, often with magnesium, iron and sodium. Hardness, 2 to 3, can be scratched with the thumbnail; good cleavage in one direction; luster, vitreous to pearly; transparent, with varying shades of yellow, brown, green, red, and black in thicker specimens; streak, white. The true characteristic of this group is the capability of being split (cleavage) very easily into extremely thin and flexible sheets. Biotite

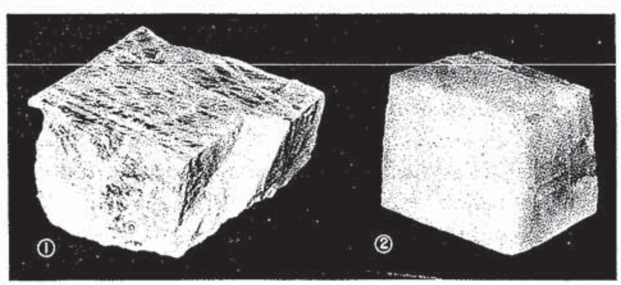


Figure 5-15.—Mineral cleavage. 288-D-2918.

ATTACHMENT 2

Earth Pressure References

TECHNICAL RELEASE

NUMBER 74

LATERAL EARTH PRESSURES

JULY 1989

U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

ENGINEERING

MINIMUM LATERAL EARTH PRESSURE COEFFICIENTS AND EQUIVALENT FLUID PRESSURES (E.F.P.)

BACKFILL MATERIALS*	TYPE OF WALL DEFLECTION		
	YIELDING AWAY FROM FILL	NON-YIELDING	YIELDING INTO FILL
Clean, coarse sands and gravels with less than 5% fines (SW,SP,GW,GP) and $\bar{\phi} \geq 27^0$	Active earth pressure coefficient, K_a, from Figure 43	At Rest earth pressure coefficient, K_o, from the $K_o = 1 - \sin \bar{\phi}$ curve shown on Figure 44.	Passive earth pressure coefficient, K_p, from Figure 45
All other soils with more than 5% fines or $\bar{\phi} < 27^0$ **	Active equivalent fluid pressures, EFP, from Figure 46	At Rest earth pressure coefficient, K_o, from the K_o = at rest curve shown on Figure 44.	Not recommended for design of walls. May use dashed curves on Fig. 45 for K_p to evaluate existing situations or design of anchor blocks only.

* Within a prism defined by a 0.5:1 sloping line projecting upward from a point 2 feet out from the base of the wall to within 2 feet of the backfill surface.

**Swelling soils, soils with LL > 50, and organic soils (OL,OH,Pt), cannot be used for backfill and must be removed from the prism area defined above.

Yielding walls are defined as having a thickness-to-height ratio less than 0.085 ($t/H \leq 0.085$). Non-yielding walls are defined as having a thickness-to-height ratio greater than 0.085 ($t/H > 0.085$) or otherwise restrained.

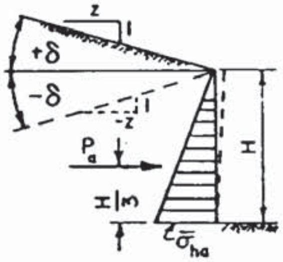
FIGURE 42

MATERIAL	ϕ_f range
Clean, hard rock	0.6 - 0.7
Clean gravels, angular, well-graded	0.5 - 0.6
Sandy gravels, angular, well-graded	0.4 - 0.5
Sandy gravels, rounded, poorly-graded	0.3 - 0.4
Silty, sandy gravels	0.3 - 0.5
Silty sands	0.3 - 0.35
Fine sandy silts	0.27 - 0.35
Dry clays, medium to dense	0.4 - 0.5
Wet clays, medium to dense	0.25 - 0.35
Stiff clays, clayey silts	C (cohesion)
Soft clays, clayey silts, organic soils	Not recommended

Interpolations must be made giving consideration to moisture conditions, gradations, angularity of particles, density, cementation, etc.

FIGURE 51 - TYPICAL COEFFICIENTS OF FRICTION BETWEEN CONCRETE AND SOIL

ACTIVE CONDITION: $t/h \leq 0.085$; Wall deflects away from fill; clean coarse sands and gravels with less than 5% fines (SW, SP, GW, GP) and $\bar{\phi} \geq 27°$



$$K_a = \left[\frac{\cos \bar{\phi}}{1 + \sqrt{\sin \bar{\phi} (\sin \bar{\phi} - \cos \bar{\phi} \ \tan \delta)}} \right]^2$$

$$P_a = K_a \frac{\gamma_m H^2}{2}$$

$$\bar{\sigma}_{ha} = K_a \gamma_m H$$

K_p = Coefficient of passive pressure

γ_m = Moist unit weight of soil

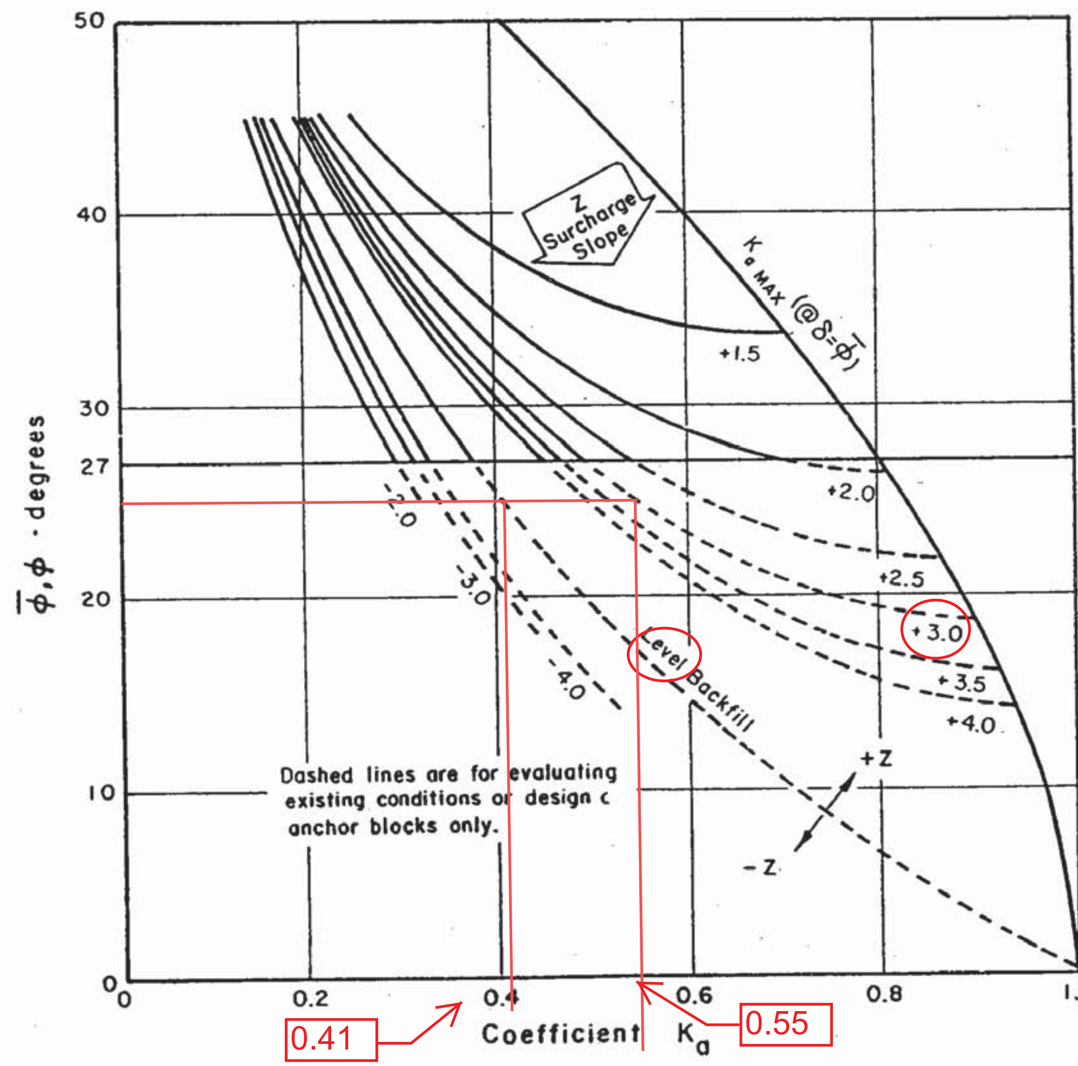
γ_{sub} = Bouyant unit weight of soil to be used in place of γ_m if soil is saturated.

ϕ = Consolidated undrained shear strength angle for all other backfill where water is present and soil will not drain upon loading.

$\bar{\phi}$ = Consolidated drained shear strength angle for clean coarse grained backfill.

δ = Surcharge slope

Z = Surcharge slope (cotangent of δ). See narrative for appropriatness of ϕ vs $\bar{\phi}$.

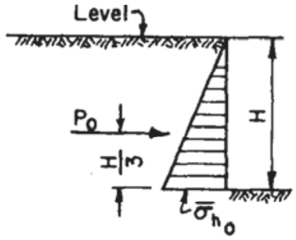


COEFFICIENT OF ACTIVE LATERAL EARTH PRESSURE

FIGURE 43

(210-VI, TR-74, July 1989)

NON-YIELDING CONDITION:
t/h >0.085 or otherwise restrained; use "1 - sin ϕ" if <5% fines and ϕ >27°
use "At Rest" if >5% fines or ϕ <27°



$$P_0 = K_0 \frac{\gamma_m H^2}{2}$$

$$\bar{\sigma}_{h_0} = K_0 \gamma_m H$$

γ_{sub} = Bouyant unit weight of soil - to be used in place of γ_m if soil is saturated.

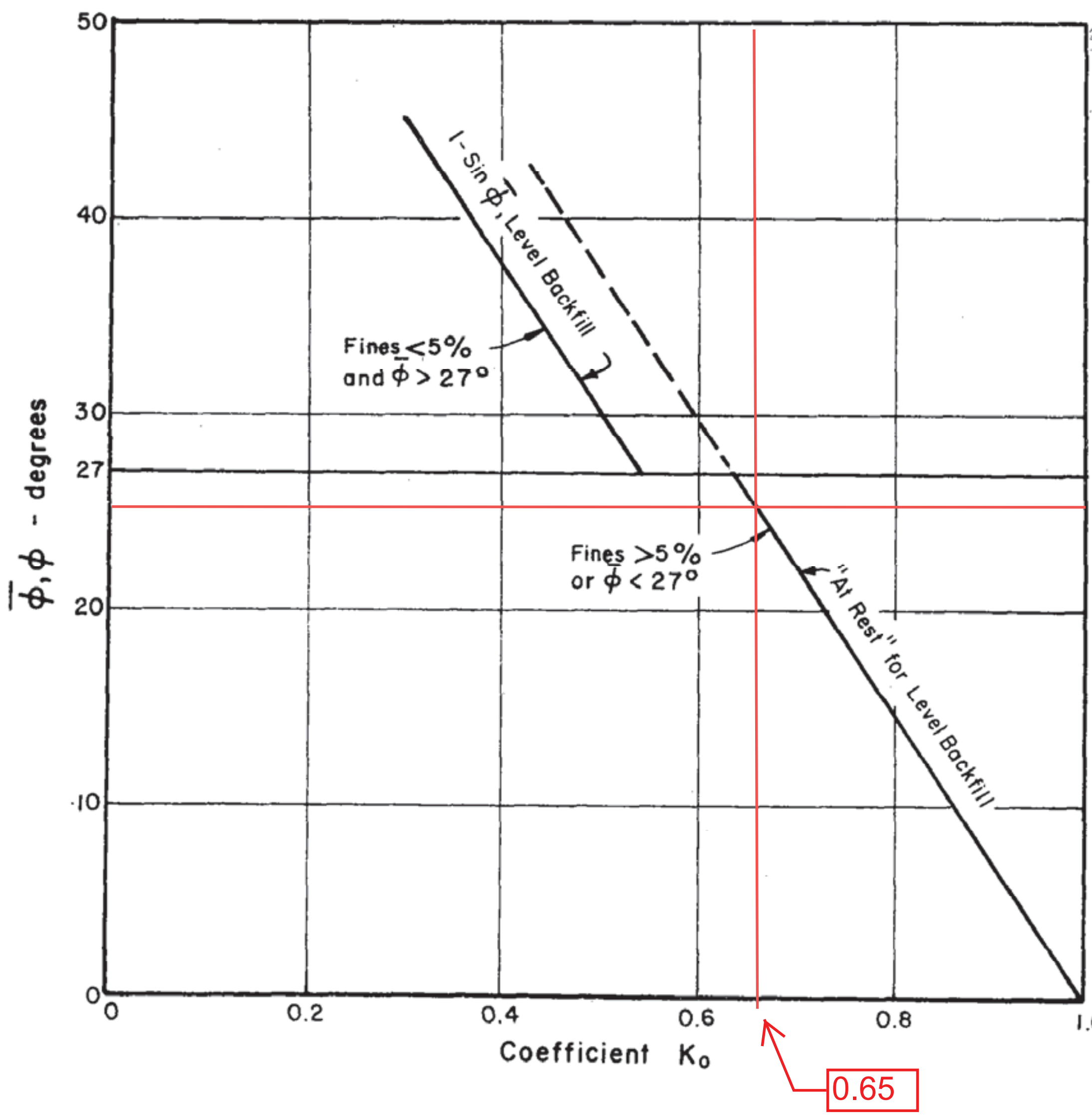
γ_m = Moist unit weight of soil.

$\bar{\phi}$ = Consolidated drained shear strength angle for clean coarse grained backfill.

ϕ = Consolidated undained shear strength angle for all other backfill where water is present and soil will not readily drain upon loading.

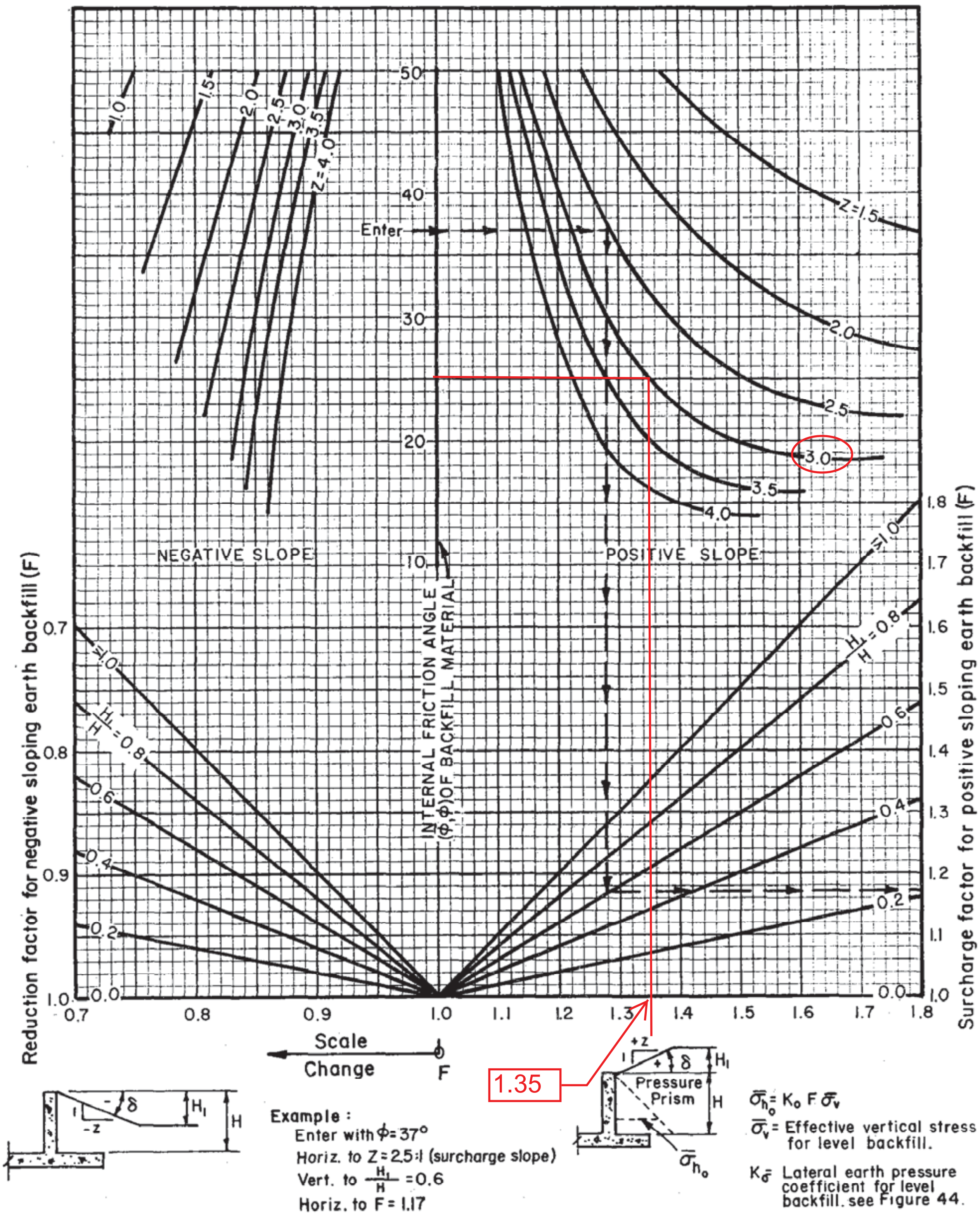
See Figure 47 to correct for sloping backfill surcharge.

See narrative for appropriatness of ϕ vs $\bar{\phi}$.



COEFFICIENT OF AT REST LATERAL EARTH PRESSURE

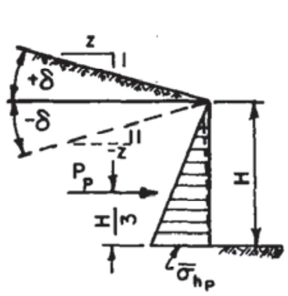
FIGURE 44



PRESSURE FACTORS FOR COMPUTING AT-REST LATERAL EARTH PRESSURE INCREASE DUE TO SLOPING SURCHARGE LOAD

FIGURE 47

PASSIVE CONDITION : Wall deflects into fill



$$K_p = \left[\frac{\cos \bar{\phi}}{1 - \sqrt{\sin \bar{\phi} (\sin \bar{\phi} + \cos \bar{\phi} \tan \delta)}} \right]^2$$

$$P_p = K_p \frac{\gamma_m H^2}{2}$$

$$\bar{\sigma}_{hp} = K_p \gamma_m H$$

K_p = Coefficient of passive pressure

γ_m = Moist unit weight of soil

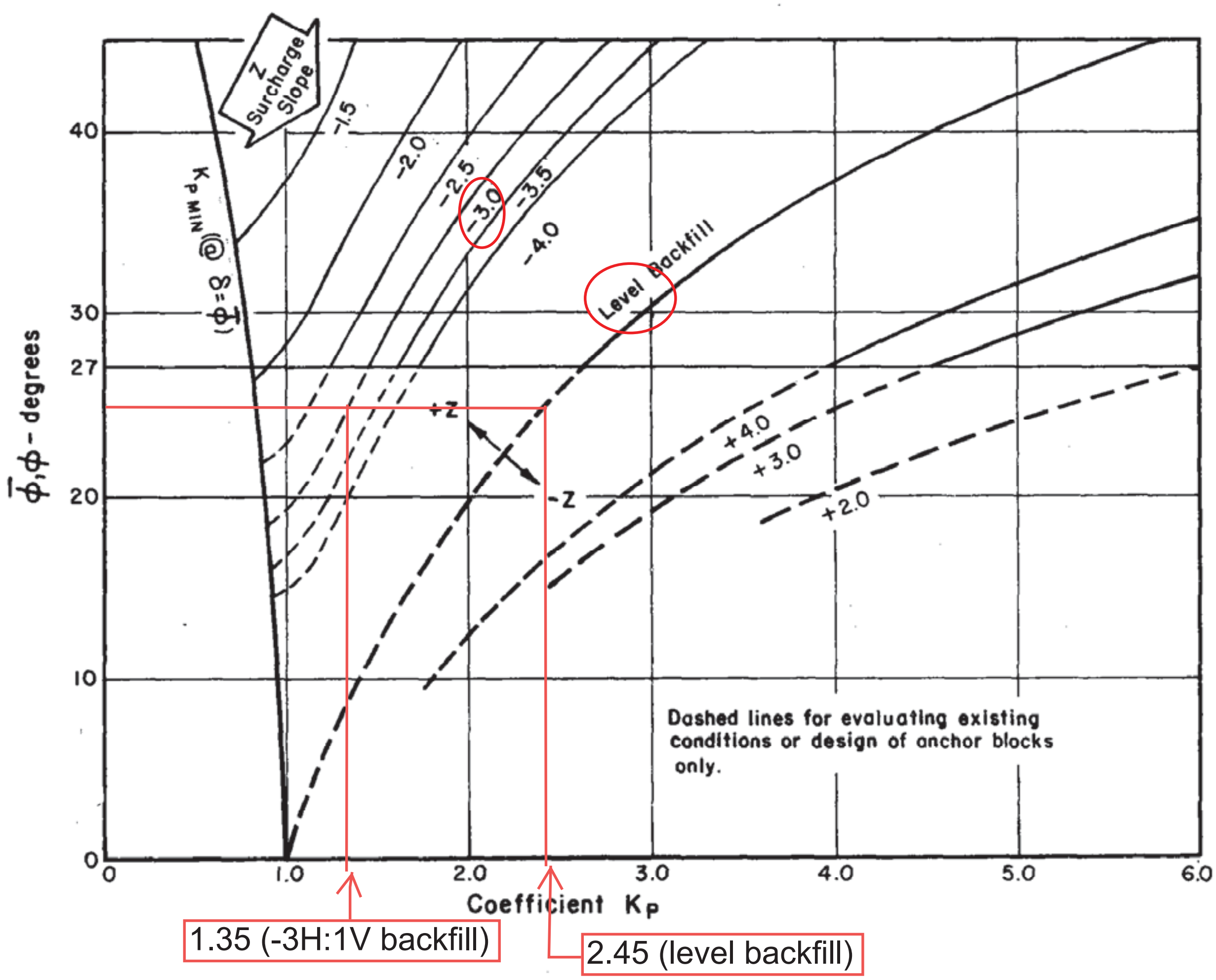
γ_{sub} = Bouyant unit weight of soil to be used in place of γ_m if soil is saturated.

ϕ = Consolidated undrained shear strength angle for all other backfill where water is present and soil will not drain upon loading.

$\bar{\phi}$ = Consolidated drained shear strength angle for clean coarse grained backfill.

δ = Surcharge slope

Z = Surcharge slope (cotangent of δ), See narrative for appropriatness of ϕ vs $\bar{\phi}$.



COEFFICIENT OF PASSIVE LATERAL EARTH PRESSURE

FIGURE 45

ATTACHMENT 3

Proctor Compaction Unit Weight Analysis

TRI ENVIRONMENTAL

TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Laboratory Compaction Characteristics of Soil Using Standard Effort (ASTM D698) with Correction for Oversize Particles (ASTM D4718)

Client: AECOM

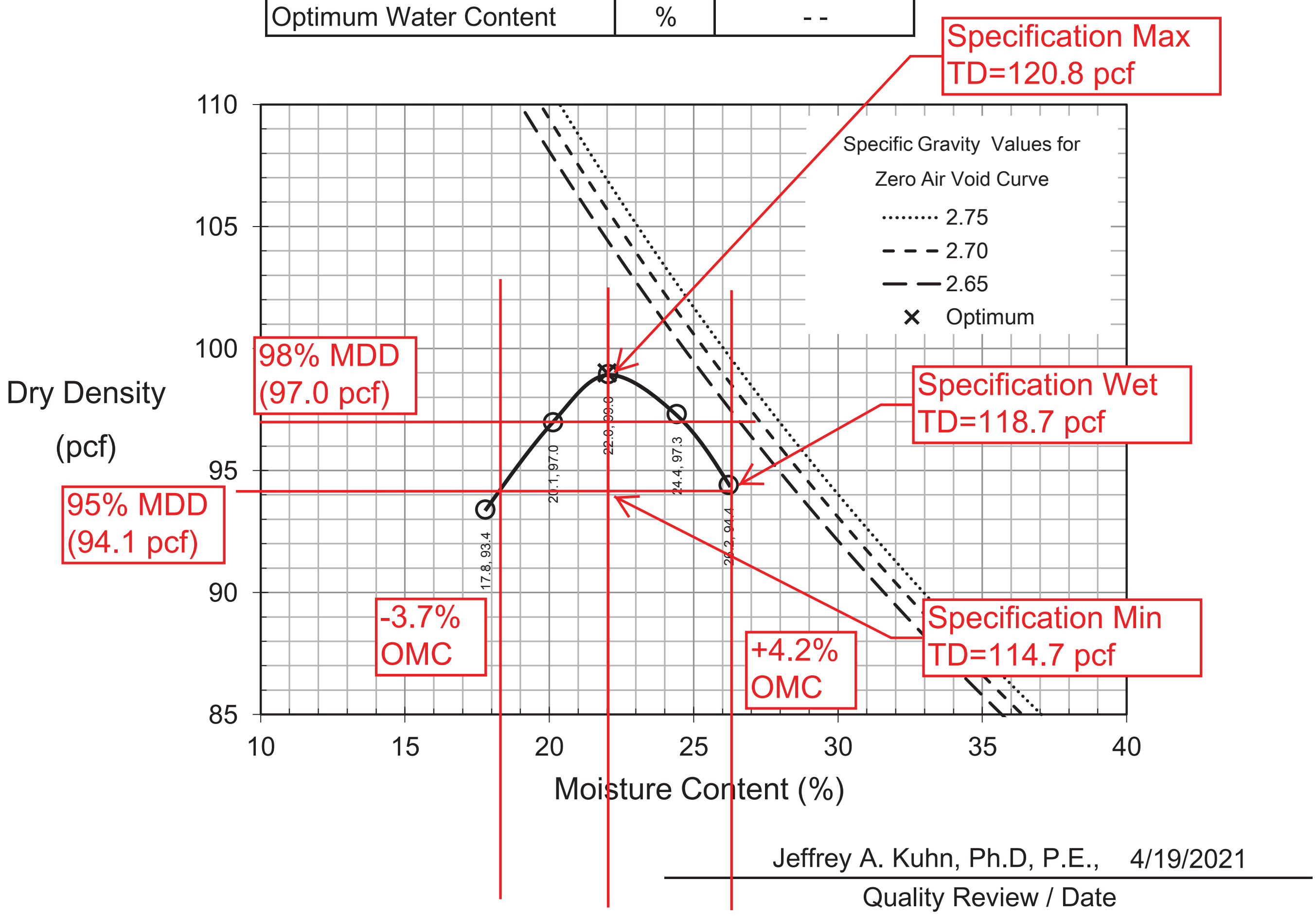
TRI Log #: 62896.1

Project: 60615067-1.4.14 Plum Creek 2

Sample ID: COMP-100A

Compaction Effort	-	Standard
Method	-	A
Rammer Type	-	Automatic
Maximum Dry Density	pcf	99.0
Optimum Water Content	%	22.0

Oversize Particle / "Rock" Correction (ASTM D4718)		
Oversized Particles	%	- -
Maximum Dry Density	pcf	- -
Optimum Water Content	%	- -



Jeffrey A. Kuhn, Ph.D, P.E., 4/19/2021

Quality Review / Date

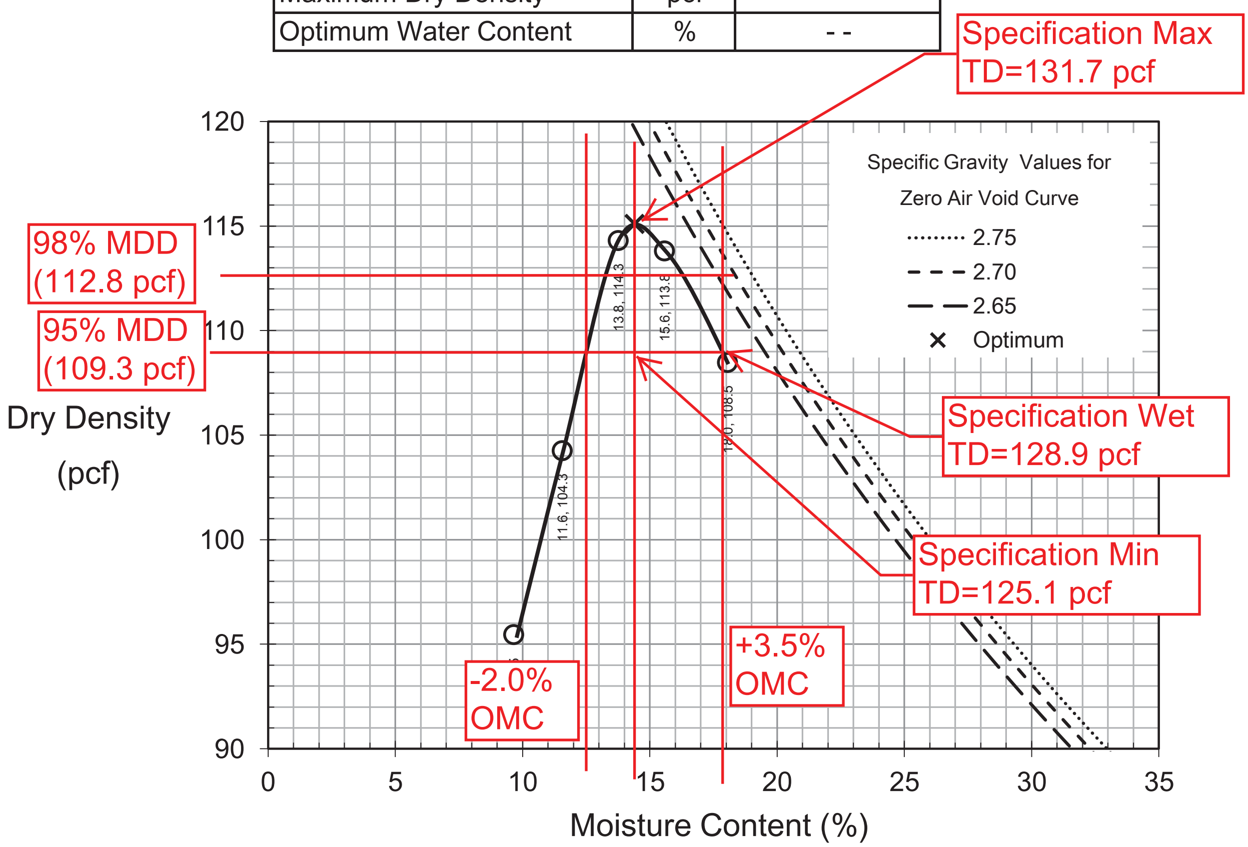
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Laboratory Compaction Characteristics of Soil Using Standard Effort (ASTM D698) with Correction for Oversize Particles (ASTM D4718)

Client: AECOM | TRI Log #: 62867.1
Project: Plum Creek 2 - 60615067, Task 1.4.14
Sample ID: COMP-100B

Compaction Effort	-	Standard
Method	-	A
Rammer Type	-	Automatic
Maximum Dry Density	pcf	115.1
Optimum Water Content	%	14.4

Oversize Particle / "Rock" Correction (ASTM D4718)		
Oversized Particles	%	- -
Maximum Dry Density	pcf	- -
Optimum Water Content	%	- -



Jeffrey A. Kuhn, Ph.D, P.E., 4/19/2021
Quality Review / Date

TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

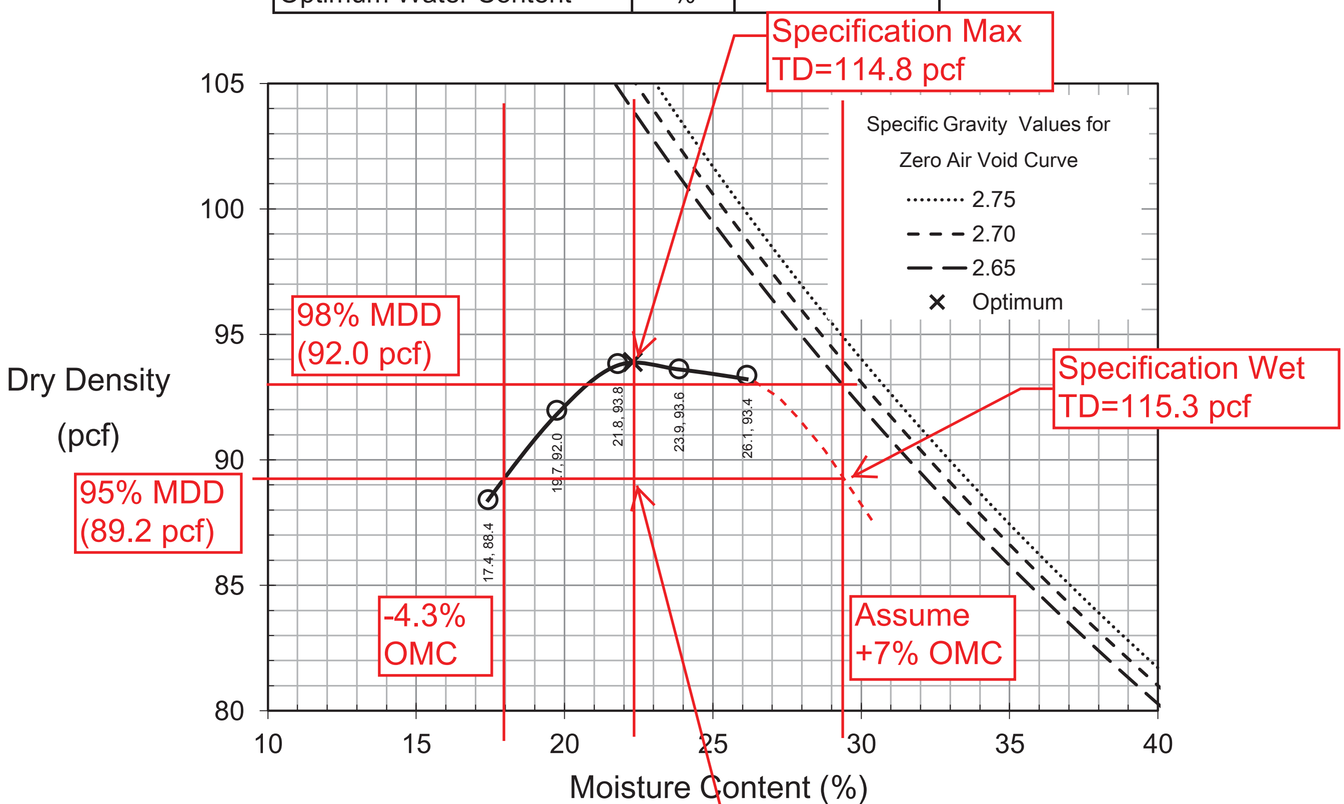
TESTING, RESEARCH, CONSULTING AND FIELD SERVICES
Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Laboratory Compaction Characteristics of Soil Using Standard Effort (ASTM D698) with Correction for Oversize Particles (ASTM D4718)

Client:	AECOM	TRI Log #:	62866.1
Project:	Plum Creek 2 - 60615067, Task 1.4.14		
Sample ID:	COMP-400A		

Compaction Effort	-	Standard
Method	-	A
Rammer Type	-	Automatic
Maximum Dry Density	pcf	93.9
Optimum Water Content	%	22.3

Oversize Particle / "Rock" Correction (ASTM D4718)		
Oversized Particles	%	- -
Maximum Dry Density	pcf	- -
Optimum Water Content	%	- -



Jeffrey A. Kuhn, Ph.D, P.E., 4/19/2021

Quality Review / Date

Specification Min
TD= pcf

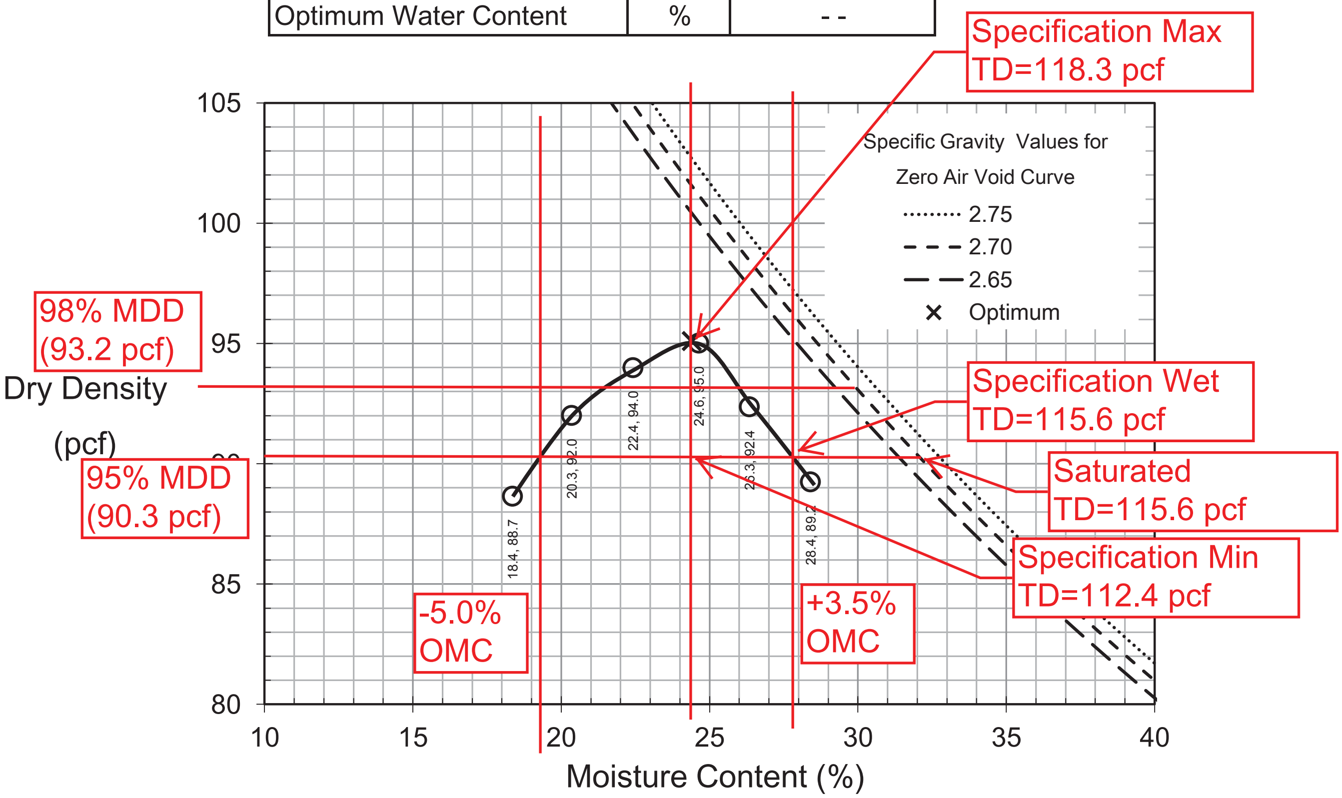
TRI Environmental, Inc.
9063 Bee Caves Rd. – Austin, TX 78733 – USA | Ph: 800.880.TEST or 512.263.2101

Laboratory Compaction Characteristics of Soil Using Standard Effort (ASTM D698)

Client: AECOM TRI Log #: 60056.1
Project: 60615067-1.4.14 Plum Creek 2
Sample ID: COMP-1700A

Compaction Effort	-	Standard
Method	-	A
Rammer Type	-	Automatic
Maximum Dry Density	pcf	95.1
Optimum Water Content	%	24.4

Oversize Particle / "Rock" Correction (ASTM D4718)		
Oversized Particles	%	- -
Maximum Dry Density	pcf	- -
Optimum Water Content	%	- -



Jeffrey A. Kuhn, Ph.D, P.E., 10/29/2020
Quality Review / Date

TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Appendix J Filter Compatibility Analysis

OBJECTIVES:

1. Evaluate the gradation and dispersion characteristics of existing and proposed (base) soil materials;
2. Develop filter-compatible gradations for proposed aggregate filters placed in contact with base materials;
3. Check filter compatibility between different existing and proposed base soil materials.

REFERENCES:

External references:
1. NRCS. 2005. *210-VI-TR-60, Earth Dams and Reservoirs.* July.
2. NRCS. 2017 *National Engineering Handbook, Part 633, Chapter 26, Gradation Design of Sand and Gravel Filters*.

Project-specific references:
1. AECOM. 2021. Geologic Investigation Report (GIR).
2. AECOM. 2021. Soil Mechanics Report (SMR).
3. NRCS. 1967. Geologic Investigation Report
4. NRCS. 1967. Soil Mechanics Report

PROJECT DESCRIPTION

General

The Plum Creek FRS No. 2 is located in Hays County, Texas about 1.5 mile east of downtown Kyle. The proposed rehabilitation of Plum Creek FRS No. 2 is intended to mitigate identified dam safety deficiencies associated with the dam's reclassification as a high hazard dam. The proposed modifications include the following major components:

- Raising the existing vegetated auxiliary spillway (ASW) crest by 1.15 feet to El. 659.8 feet;
- Widening the existing vegetated ASW from 150 feet to 250 feet;
- Constructing a new 200-foot-wide overtopping roller-compacted concrete (RCC) spillway with crest at El. 658.6 feet;
- Abandoning the existing principal spillway (PSW) conduit in-place;
- Constructing a new PSW consisting of 48-inch conduit pipe, inlet riser, and impact basin;
- Restoring the crest of the dam to current nominal elevation of 662.8 feet.

Existing Drainage Elements

The existing embankment has no internal drainage system.

MATERIAL CHARACTERIZATION

Site stratigraphy is described in detail in the Geologic Investigation Report and Soil Mechanic Report, and are summarized briefly as follows:

- Existing Embankment Fill: This material was primarily classified as very stiff to hard lean to fat clay (CL, CH) with some intervals of lean clay (CL) and some sandy intervals (3 to 28% sand). While the as-built drawings indicate embankment zoning with distinct core and shell zones, borings and laboratory testing indicate the shell and core zones are comprised by similar materials. Laboratory dispersion testing (crumb, double-hydrometer) indicate these materials are non-dispersive.

- <u>Alluvium:</u> This unit consisted of dark brown, medium stiff to hard fat clays (CH) with minor proportion of sand and/or gravel ranging from 0 to 20%. Laboratory dispersion testing (crumb) indicate these materials are non-dispersive.

- <u>Residuum:</u> This unit consisted of light gray to tan, medium stiff to hard lean to fat clays (CL, CH) with some clayey sand (SC) and silty clay (CL-ML) layers. Characterization of this material in the GIR and SMR was subdivided into a calacareous and friable Low Plasticity Residuum (LPR) consisting mostly of silty CL and some CH with less frequent SC and CL-ML intervals, and a Medium Plasticity Residuum (MPR) consisting of consisting of CH with some CL intervals. For engineering analysis, this material was generally considered as a single "Residuum". Laboratory dispersion testing (crumb, double-hydrometer) indicate these materials are largely non-dispersive and were treated as such for analysis, although there are isolated cases of slightly dispersive soils.

- <u>Downstream Fill</u>: The suspected fill material was classified as medium stiff to hard lean to fat clay (CL, CH). The fill designation was due to a somewhat lower consistency of this material. However, the visual similarity of the fill to overburden materials suggest that this unit is likely reworked residuum/alluvium. Limited laboratory dispersion testing (crumb) indicate these materials are non-dispersive.

- <u>Bedrock</u>: This unit consisted of extremely weak to weak calcareous shale with occasional chalky marl layers. The weathering ranged from moderately to highly weathered. This material is located well below the depth of proposed filter/drainage layers, and is inconsequential from the perspective of filter compatibility.

Proposed fill materials include fine and coarse filter/drain fill, RCC, and new embankment fill. These materials are described below.

- <u>Drain Fill:</u> This material will consist of a compacted fine filter and a coarse filter. These materials will be placed under the RCC spillway and around the new and existing PSW conduit to provide filter and drainage functions. The purpose of this calculation package is to select suitable gradations for the fine and coarse filter material.

- <u>RCC:</u> This material will consist of low-slump concrete compacted in lifts that will be used to construct the RCC spillway. The material was treated as relatively low permeability.

- <u>New Embankment Fill:</u> The proposed embankment fill will be constructed of moisture-conditioned and recompacted clayey soils from on-site and/or imported borrow sources. Selective placement of imported low-plasticity (PI=7-15) lean clay (CL) or clayey sand (SC) is planned for under and adjacent to the RCC spillway to reduce swelling potential. The exterior zones of planned embankment fill (crest re-shaping and embankment reconstruction at new PSW) will be low-plasticity clay/clayey sand (CL, SC) with LL<50 and PI=10-30. Interior zones of planned embankment fill for reconstruction at new PSW will consist of medium- to high-plasticity clays (CL, CH) with LL<60 and PI=10-35. Considering the clayey composition of proposed embankment fill, this material was considered to exhibit both undrained and drained strength behavior. Laboratory dispersion testing (crumb) indicate these materials are non-dispersive.

A summary of field and laboratory index test results by stratum is provided in the "Material Properties Calculation Package".

FILTER COMPATIBILITY ANALYSIS

Design Criteria

Filter compatibility criteria is provided in the Natural Resources Conservation Service, *National Engineering Handbook (NEH), Part 633 Soils Engineering, Chapter 26 Gradation Design of Sand and Gravel Filters* (NRCS 2017). Filter compatibility calculations herein were performed based on the methodologies presented in that document.

Methodology for Filter Analysis

The current filter analysis was based on the NEH, Part 633, Chapter 26 (NRCS 2017). The filter analysis considered samples recovered in borings in the near vicinity of the rehabilitated principal spillway and RCC auxiliary spillway and at approximate depths where the drain materials would be located. In this analysis, select gradation curves were plotted to assess variability in the materials. In general, and as illustrated in **Figure 1**, the gradations are relatively uniform with little scatter, and so the finest sample gradation (i.e. smallest d_{85}) was selected as the base soil gradation for filter design. The finest sample evaluated was recovered in boring 1301-19 at a depth of 4-6 feet (Embankment Shell material). Therefore, the most restrictive filter gradation resulting from this analyses was used to develop a fine filter gradation design specification. Based on the design fine filter design gradation, an appropriate coarse filter gradation was established considering the fine filter as the base soil material.

The 2017 procedure has 12 steps used to establish the initial filter criteria, which are described in detail below.

1. Step 1 requires the raw gradation curves of the base soil to be plotted as percent passing versus particle diameter (log scale for horizontal axis). This plot can be seen in **Figure 1** with the approximate maximum and minimum boundaries. This step also requires determination of whether the base soils can be characterized as dispersive.

2. Step 2 requires determining if the soils have material larger than the #4 sieve or if they are gap-graded. This step is not required if the base soil is a sand/gravel with less than 15% fines and/or are not gap- or broadly-graded.

3. Step 3 adjusts the gradation curves if required by re-grading to a reference sieve, typically the No. 4 US Standard sieve. The curves are adjusted by multiplying the percent passing each sieve (smaller than #4) by a correction factor taken as 100 divided by the percent passing reference sieve (typically #4 sieve). A similar process is performed for gap-graded soils, but the reference sieve is taken to be the point of inflection in the curve. For this analysis, re-grading to the #4 sieve was adequate. Re-grading was performed for samples with more than 0% retained on the No. 4 sieve and is shown graphically on **Figure 2**.

4. Step 4 requires placing the base soil into a category from 1 to 4 based on the fines content as indicated in Table 26-1 of Chapter 26 and shown below. The majority of evaluated potential base soil materials had over 85% fines content and fell into Category 1 based on re-graded curves. Note that gradation testing on proposed embankment fill material from the on-site borrow area referred to as "Layer B" in the SMR classifies generally as sandy CL with some CH and SC intervals (represented by bulk sample COMP-100B on Figure 1), and this material is relatively coarser than other materials on site. The measured fines content ranges from 19 to 96%, although typical fines content is about 70-75% (and is expected to be representative of as-placed material after handling). This information indicates that the Layer B material is generally base soil Category 2. However, a single fine filter gradation was desirable for this project, and so designing the fine filter gradation based on Category 1 of the other finer CH/CL soils on site was considered appropriate for analysis purposes.

Table 26–1 Base soil categories

Base soil category	Percent finer than No. 200 sieve (0.075 mm) (after regrading where applicable)	Base soil description
1	> 85	Fine silt and clays
2	40–85	Sands, silts, clays, and silty sands
3	15–39	Silty and clayey sands and gravels
4	< 15	Sands and gravels

5. Step 5 uses Table 26-2 to determine the allowable $D_{15,max}$ of the filter based on the d_{85} of the base soil to meet the filtration requirements. The selected base soil d_{85} value was 0.009 mm. The value of $D_{15,max}$ was calculated based on full sieve and hydrometer tests given the base soil fell in Category 1 and was non-dispersive soil according to laboratory tests. The resulting $9*d_{85}$ (=0.081 mm) was less than the limit 0.2 mm set by the Table 26-2. Hence, the value of $D_{15,max}$ for material was considered to be 0.2 mm.

Table 26–2 Filtering criteria

Base soil category	Filtering—maximum D_{15}
1	The maximum D_{15} should be $\leq 9 \times d_{85}$ of the base soil, but not less than 0.2 mm, unless the soils are dispersive. Dispersive soils in category 1 require a filter with a maximum D_{15} that is ≤ 6.5 times the d_{85} of the base soil size, but not less than 0.2 mm.
2	The maximum D_{15} should be ≤ 0.7 mm unless soil is dispersive, in which case the maximum D_{15} should be < 0.5 mm.
3	The maximum D_{15} should be: $\leq \left(\frac{40-A}{40-15}\right)\left[\left(4 \times d_{85}\right) - 0.7\text{ mm}^{*}\right] + 0.7\text{ mm}^{*}$ A = percent passing No. 200 sieve after regrading (when $4 \times d_{85}$ is less than 0.7 mm*, use 0.7 mm*).
4	The maximum D_{15} should be $\leq 4 \times d_{85}$ of base soil after regrading.

* If fines are dispersive, use 0.5 mm rather than 0.7 mm.

26–6 (210-633-H, 1st Ed., Amend. 61, Aug 2017)

6. Step 6 establishes the $D_{15,min}$ of the filter based on the greater of $D_{15,max}$ divided by 5 or 0.1 mm. This step also indicates that $D_{15,min}$ can be adjusted if deemed too fine to provide adequate permeability. Because $D_{15,max}$ divided by 5 was less than 0.1 mm, the value of $D_{15,min}$ was considered to be 0.1 mm for the filter.

7. Step 7 establishes the maximum and minimum values of D_{60}; where $D_{60,min}$ is equal to $D_{15,max}$ and $D_{60,max}$ is five times the $D_{60,min}$ to maintain a band width of 5. This also helps maintain a maximum coefficient of uniformity (CU) of 6.

8. Step 8 sets the maximum particle size as 50 mm (2 inches), and the maximum percent passing the #200 sieve as 5%. However, for specifications purposes, the NRCS 2017 guidance suggests specifying a maximum of 3% prior to placement, which typically leads to 5% after placement. The 3% limit was selected for the filter materials herein.

9. Step 9 establishes $D_{90,max}$ and $D_{10,min}$. A preliminary minimum value of D_{10} can be equal to $D_{15,min}$ divided by 1.2. Then, the value of $D_{90,max}$ is established in Table 26-3 of NEH which is reproduced below.

Table 26–3 Segregation criteria

Base soil category	If D_{10} is: (mm)	Then, maximum D_{90} is: (mm)
ALL categories	< 0.5	20
	0.5-1.0	25
	1.0-2.0	30
	2.0-5.0	40
	5.0-10	50
	> 10	60

10. Step 10 completes the preliminary filter design bands. To form the fine side of the design band the NEH recommends connecting the minimum D_5, D_{10}, and D_{60} with a smooth curve. Then smoothly continue with extrapolating this curve upward to D_{90} size and connect it with a slightly convex shape to D_{100} size. Once maximum values of D_{90} and D_{100} were obtained, the coarse side of the design band can be formed by connecting those points with maximum values of D_{60} and D_{15},. The preliminary design bands were then adjusted inward slightly so that inflection points corresponded with standard sieve sizes to aid in specification writing. The preliminary and adjusted boundaries for the gradation band for the fine filter are presented on **Figure 3**, and adjusted boundaries are summarized below in **Table 2**.

11. Step 11 establishes the maximum slot size for pipes in contact with filter material (discussed later in this calc package).

12. Step 12 allows adjustment of the preliminary design bands to accommodate standard readily available gradations. This produces a more uniformly graded (more steeply graded curve) filter design. This allows the upper portion of the filter band above the D_{15} limits to be adjusted, but the D_{15} and below must remain fixed. The maximum

steepness of the filter band is limited by the requirement to maintain CU ≥2 and CU <6. A design band width is maintained at D_{max}/D_{min} = 5. Step 12 was not used for the fine filter design, because standard gradations (e.g., ASTM C-33 Fine Aggregate) plotted well outside the preliminary design band at D_{15} size and below. A similar issue was identified for coarse filter design.

Table 2. Adjusted boundaries of calculated fine band of filter

Sieve Size	Percent Passing, by Weight
	Composite Sample
No. 4	100
No. 10	84-100
No. 20	55-100
No. 40	36-86
No. 60	21-68
No. 100	7-41
No. 200	<3

A similar process was repeated to check for a suitable Coarse Filter material gradation. In this case, the Fine Filter was considered as the base soil. Since the Fine Filter has less than 15% passing the No. 200 sieve and is a relatively uniformly graded material, re-grading of the grain size distribution curves was not required. As discussed in the next section, a non-standard gradation was found to be necessary for the Fine Filter and was considered as the base soil for determination of Coarse Filter gradation. The selected d_{85} of the base soil (i.e., Fine Filter) was 0.39 mm.

RESULTS AND DISCUSSION

Fine Filter Gradation

The recommended gradation band for fine filter material is shown graphically on **Figure 3**. For reference, the gradation bands for standard ASTM C-33 FA have been plotted in red on the figure to assess potential suitability as fine filter materials. The ASTM C-33 FA falls partly within the fine filter design bands but is excessively coarse with respect to the coarse portion of the C-33 FA band. Based on the analysis results, standard ASTM C-33 FA will not meet filtering criteria. While a modified version of ASTM C-33 FA (on the coarse side) could fall within the recommended fine filter band, the resulting gradation bands would likely be overly restrictive and difficult to procure/implement. Consequently, we recommend a non-standard gradation consisting of the adjusted fine filter band be adopted for design.

The recommended gradation design specifications for the Fine Filter materials are given in **Table 3,** and shown graphically on **Figure 3.** Note that the gradation provided in Table 3 were adjusted from that presented in Table 2 in order to match the sieve sizes specified for ASTM C-33 FA for ease of reference.

Table 3. Recommended Gradation for Fine Filter

Sieve Size	Particle Size (mm)	Recommended Fine Filter Gradation – Percent Finer by Weight	
		Coarse Band	Fine Band
3/8"	9.5	100	---
No. 4	4.75	100	---
No. 8	2.36	90	100
No. 16	1.18	65	100
No. 30	0.6	45	90
No. 50	0.3	45	93
No. 100	0.15	7	40
No. 200	0.074	0	3

Coarse Filter Gradation

Using the recommended fine filter (fine band) as the base soil, the recommended gradation for coarse filter material is shown graphically on **Figure 4.** For reference, the gradation bands for standard ASTM C-33 No. 89 and No. 9 aggregates have also been plotted in red (Figure 4) to assess potential suitability as coarse filter materials. While the No. 9 aggregate gradation fits within the calculated coarse filter band between the D_{90} and D_{40} sizes, the maximum particle sizes are too fine and minimum particles sizes are too coarse. The No. 89 aggregate gradation fits within the calculated coarse filter band at particles sizes larger than the D_{60}, but both the fine and coarse bands are too coarse at smaller sizes. Consequently, we recommend a non-standard gradation consisting of the calculated/adjusted coarse filter band be adopted for design.

The recommended gradation design specifications for the Coarse Filter materials are given in **Table 4,** and shown graphically on **Figure 4.**

Table 4. Recommended Gradation for Coarse Filter

Sieve Size	Particle Size (mm)	Recommended Coarse Filter Gradation – Percent Finer by Weight	
		Coarse Band	Fine Band
2 in.	50	100	---
1 in.	25	90	100
½ in.	12.7	75	100
3/8 in.	9.5	65	100
No. 4	4.75	45	90
No. 10	2	20	65
No. 18	1	3	50
No. 40	0.425	0	25
No. 100	0.15	0	8
No. 200	0.075	0	5

Conclusions and Recommendations for Filter

Design of the drain filter materials have been performed in accordance with filter compatibility criteria documented in NEH Part 633, Chapter 26 Gradation Design of Sand and Gravel Filters (NRCS 2017). Due to the very fine gradation of the on-site clay soils and associated small d_{85} particle size, standard ASTM C-33 gradations are shown not to be filter compatible and custom gradation bands are required for the fine filter and coarse filter materials. The recommended gradation bands for both materials are provided herein.

Compatibility of Filters with Drainpipe Slot Size

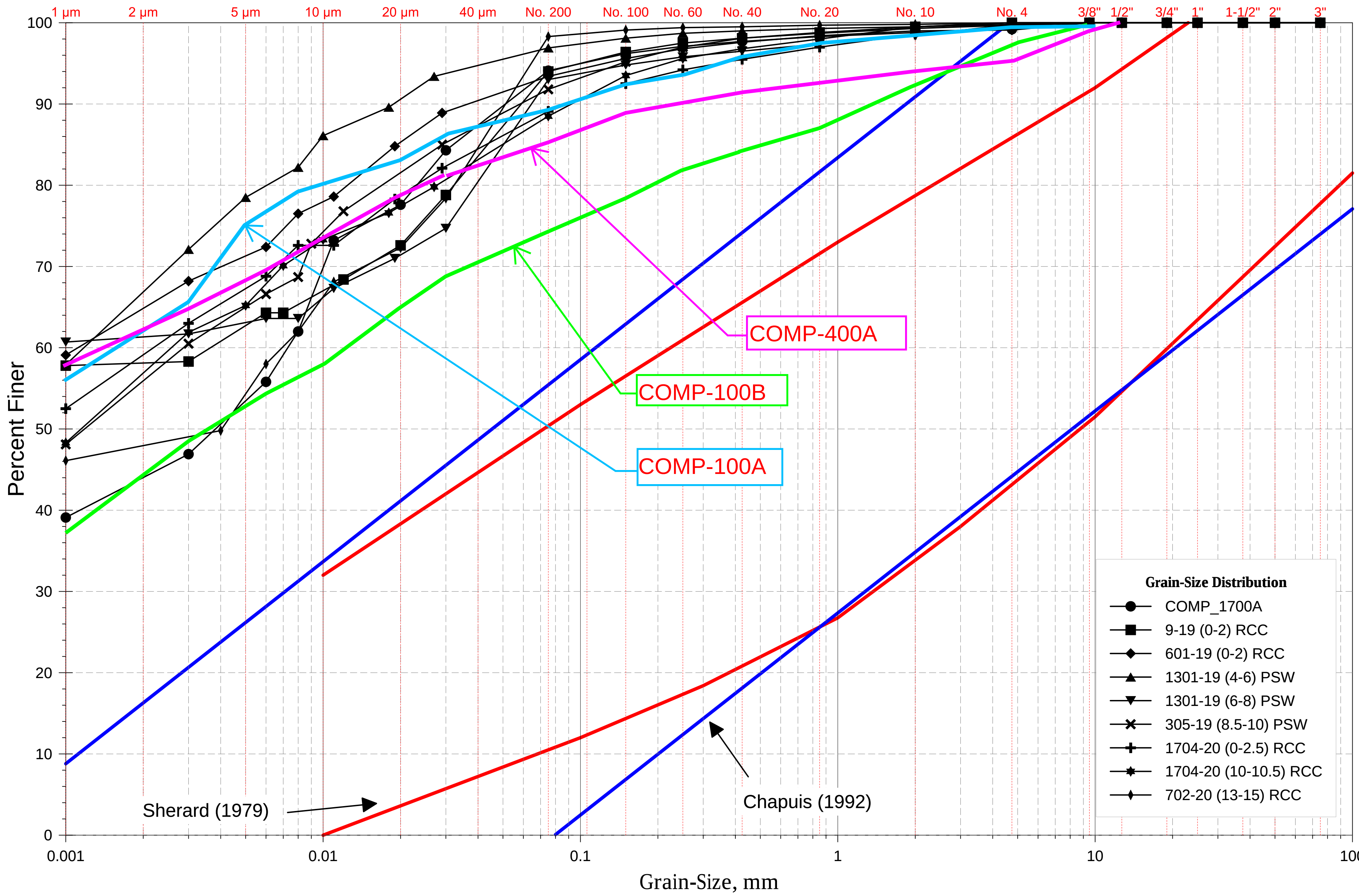
Drainpipes placed inside an envelope of Coarse Filter materials should have slot sizes that are large enough to convey seepage flow, but small enough to be filter compatible with the surrounding filter material. The USACE, USBR, and NRCS have established criteria for maximum pipe slot size based on the gradation of the aggregate material, which is presented below in **Table 5**. Based on this information, drainpipe with maximum slot sizes of 0.04 inches (1mm) is recommended for drainpipe in contact with coarse filter materials consistent with both NRCS and USACE criteria, which is more conservative than the USBR criteria. Drainpipe should not be placed in contact with fine filter materials, embankment fill, or native foundation soils, and geotextile wrapping of the drainpipe is not recommended due to high risk of clogging.

Table 5. Maximum Pipe Slot Opening Dimension for Coarse Filter Materials (1)

Agency	Recommendation for largest slot/perforation	Recommended Maximum Pipe Slot Opening Dimension against Coarse Filter Materials (mm [in.])
USACE	Minimum D_{50} of filter material	1mm (0.04 in.)
Bureau of Reclamation (USBR)	D_{85} / 2	2 mm (0.08 in.)
NRCS (1994)	The smaller of D_{85}/2 or D_{50}	1mm (0.04 in.)

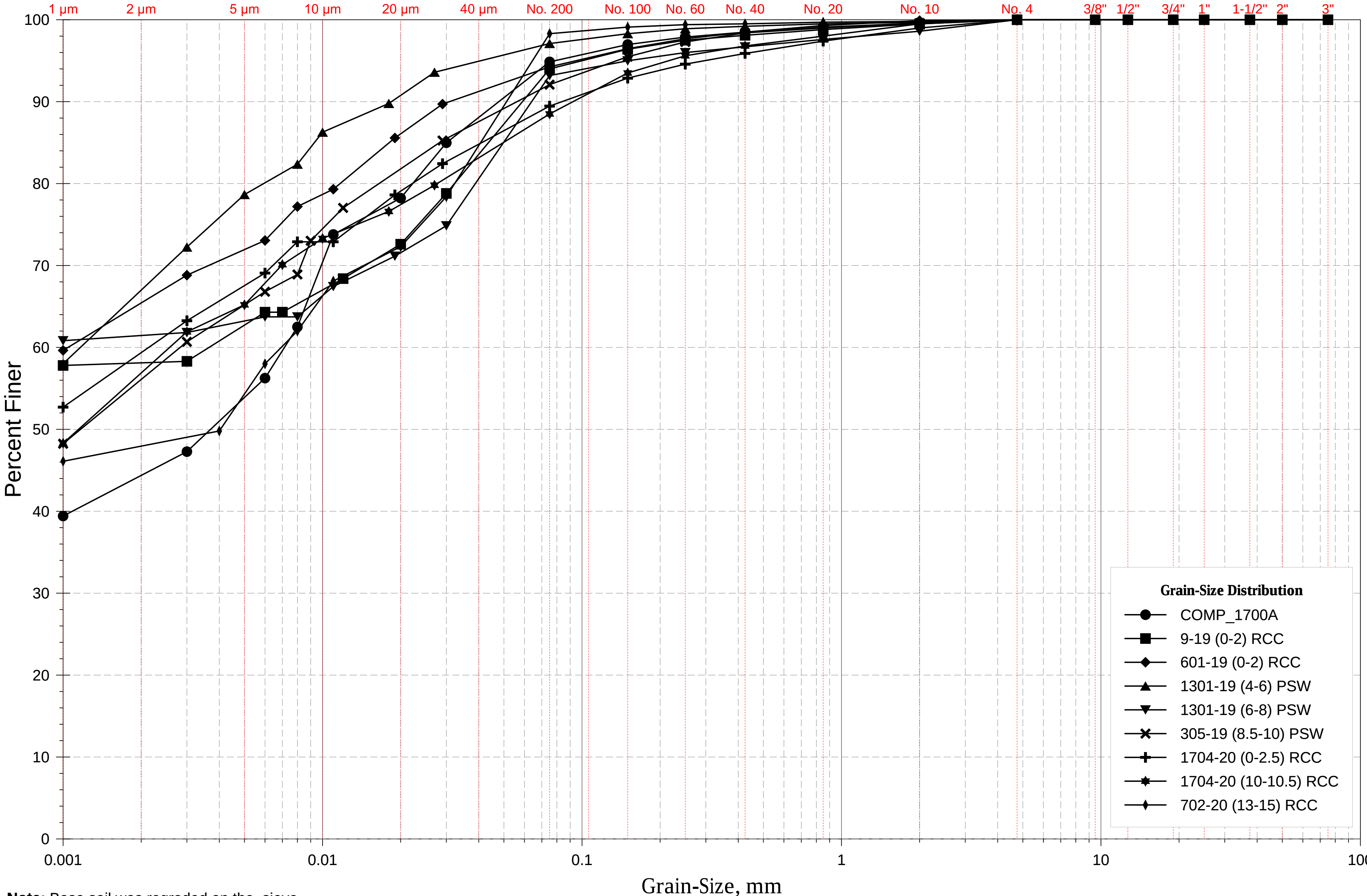
Notes:
(1) The minimum dimension should be used. For a circular perforation, that is the diameter; for slots, the width measurement should be used.

FIGURES



Method: Natural Resources Conservation Service [NRCS]. (2017). "Gradation Design of Sand and Gravel Filters." *National Engineering Handbook, Part 633 - Soil Engineering*, United States Department of Agriculture, Washington, D.C., 62.

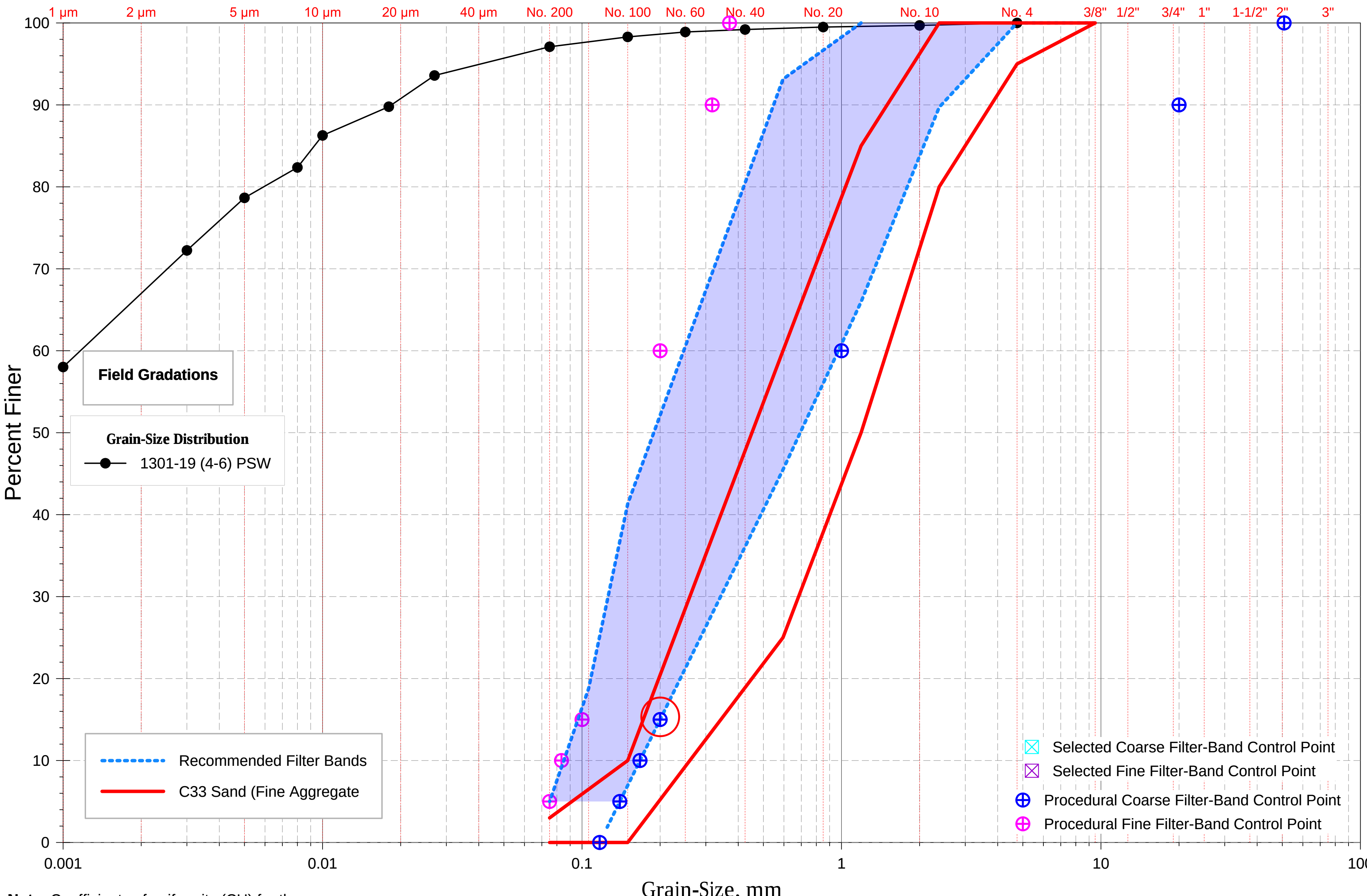
PROJECT NO. 606015067	Elm and Plum Creek Dam Rehab Plum #2	STEP 1 AS-TESTED BASE SOIL GRAIN-SIZE DISTRIBUTION	FIGURE 1
AECOM	Hays County, Texas		



Note: Base soil was regraded on the sieve.

Method: Natural Resources Conservation Service [NRCS]. (2017). "Gradation Design of Sand and Gravel Filters." *National Engineering Handbook, Part 633 - Soil Engineering*, United States Department of Agriculture, Washington, D.C., 62.

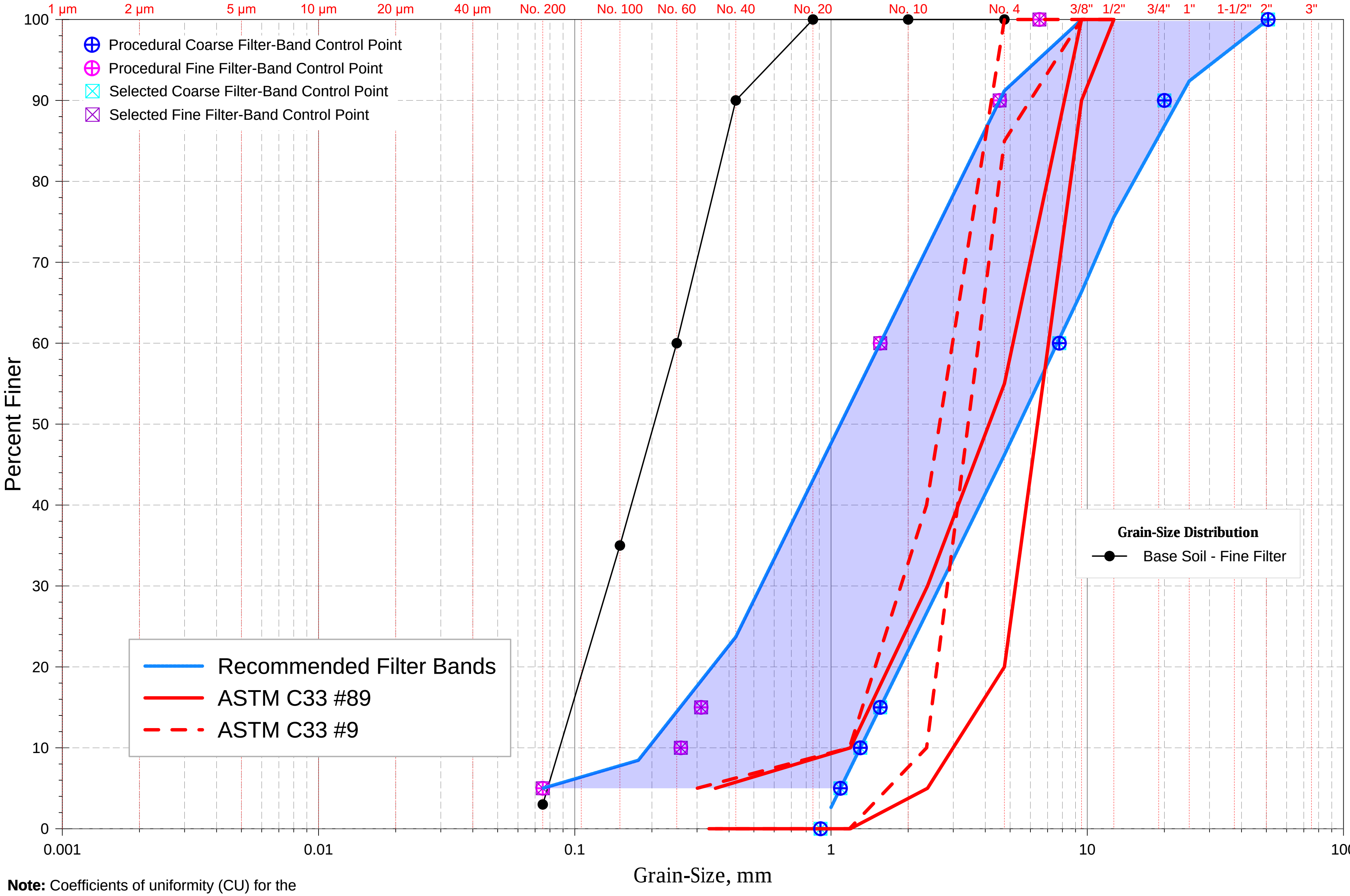
PROJECT NO. 606015067	Elm and Plum Creek Dam Rehab Plum #2	STEP 2b SIEVE REGRADED FINAL BASE SOIL GRAIN-SIZE DISTRIBUTION	FIGURE 2
AECOM	Hays County, Texas		



Note: Coefficients of uniformity (CU) for the recommended fine and coarse filter bands are 2.90 and 5.82, respectively.

Method: Natural Resources Conservation Service [NRCS]. (2017). "Gradation Design of Sand and Gravel Filters." *National Engineering Handbook, Part 633 - Soil Engineering*, United States Department of Agriculture, Washington, D.C., 62.

PROJECT NO. 606015067	Elm and Plum Creek Dam Rehab Plum #2	STEP 10 RECOMMENDED FILTER BAND Showing C33 Sand FA	FIGURE 3
AECOM	Hays County, Texas		



Note: Coefficients of uniformity (CU) for the recommended fine and coarse filter bands are 8.05 and 5.87, respectively.

Method: Natural Resources Conservation Service [NRCS]. (2017). "Gradation Design of Sand and Gravel Filters." *National Engineering Handbook, Part 633 - Soil Engineering*, United States Department of Agriculture, Washington, D.C., 62.

PROJECT NO. 606015067	Elm and Plum Creek Dam Rehab Plum #2	STEP 10 RECOMMENDED FILTER BAND	FIGURE 4
AECOM	Hays County, Texas		

06/04/2021 10:19:00

C:\Users\Braden.Erron\Desktop\Scratch\Plum 2\NRCS COARSE Filter Design\STEP 10 - Filter Bands COARSE.grf