Geotechnical Evaluation Report

Treehouse Apartments
Near 2319 7th Street West
St. Paul, Minnesota

Prepared for

Trellis Co.

Professional Certification:
I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Nat McKinney

Nathan L. McKinney, PE
Vice President, Principal Engineer
License Number: 45791
December 2, 2022

NATHAN LYLE McKINNEY
45791

Project B2207530

Braun Intertec Corporation

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December 2, 2022 Project B2207530

Mr. Dan Walsh
Trellis Co.
614 North First Street, Suite 100
Minneapolis, MN 55401

Re: Geotechnical Evaluation
Treehouse Apartments
Near 2319 7th Street West
St. Paul, Minnesota

Dear Mr. Walsh:

We are pleased to present this Geotechnical Evaluation Report for the Treehouse Apartments located in St. Paul, Minnesota. Please read the report in its entirety.

Thank you for making Braun Intertec your geotechnical consultant for this project. If you have questions about this report, or if there are other services that we can provide in support of our work to date, please contact Austin Bizal at 612.357.5257 (abizal@braunintertec.com) or Nate McKinney at 952.995.2228 (nmckinney@braunintertec.com).

Sincerely,

BRAUN INTERTEC CORPORATION

Austin M. Bizal, EIT
Staff Engineer

Nathan L. McKinney, PE
Vice President, Principal Engineer

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A. Introduction

A.1. Project Description

This Geotechnical Evaluation Report addresses the design and construction of the proposed Treehouse Apartments, located at 2319 7th Street West in St. Paul, Minnesota. The project will include the construction of a building with one level below grade parking and four levels above grade. In addition to the building, associated parking lot, and utilities will also be constructed. Table 1 provides project details.

Table 1. Building Description

Aspect	Description
Below grade levels	1 (Provided)
Above grade levels	4 (Provided)
Below grade parking level elevation	820 (Provided)
Maximum Column Loads (kips)	450 (Assumed)
Maximum Wall Loads (kips/lineal foot)	6-8 (Assumed)
Nature of construction	Cast-in-place concrete or masonry construction below grade with a precast first floor and wood construction above grade
Cuts or fills for buildings	Cuts up to 30 feet
Pavement type	Bituminous
Assumed pavement loads	Light-duty (automobile parking): 50,000 ESALs*
	Heavy-duty (drive lanes, loading docks, etc.): 100,000 ESALs*
Utilities	New underground utilities to be installed as part of this project will include water, sanitary sewer and storm sewer lines. We anticipate utilities will bear within about 15 feet or less of finished grades.
Site Features	The building will be cut into a hillside and a retaining wall on the order of 15 feet tall will be constructed behind the building to provide a flat grade near elevation 840.

*Equivalent 18,000-lb single axle loads based on X-year design.

The figure below shows an illustration of the proposed site layout.

Figure 1. Site Layout

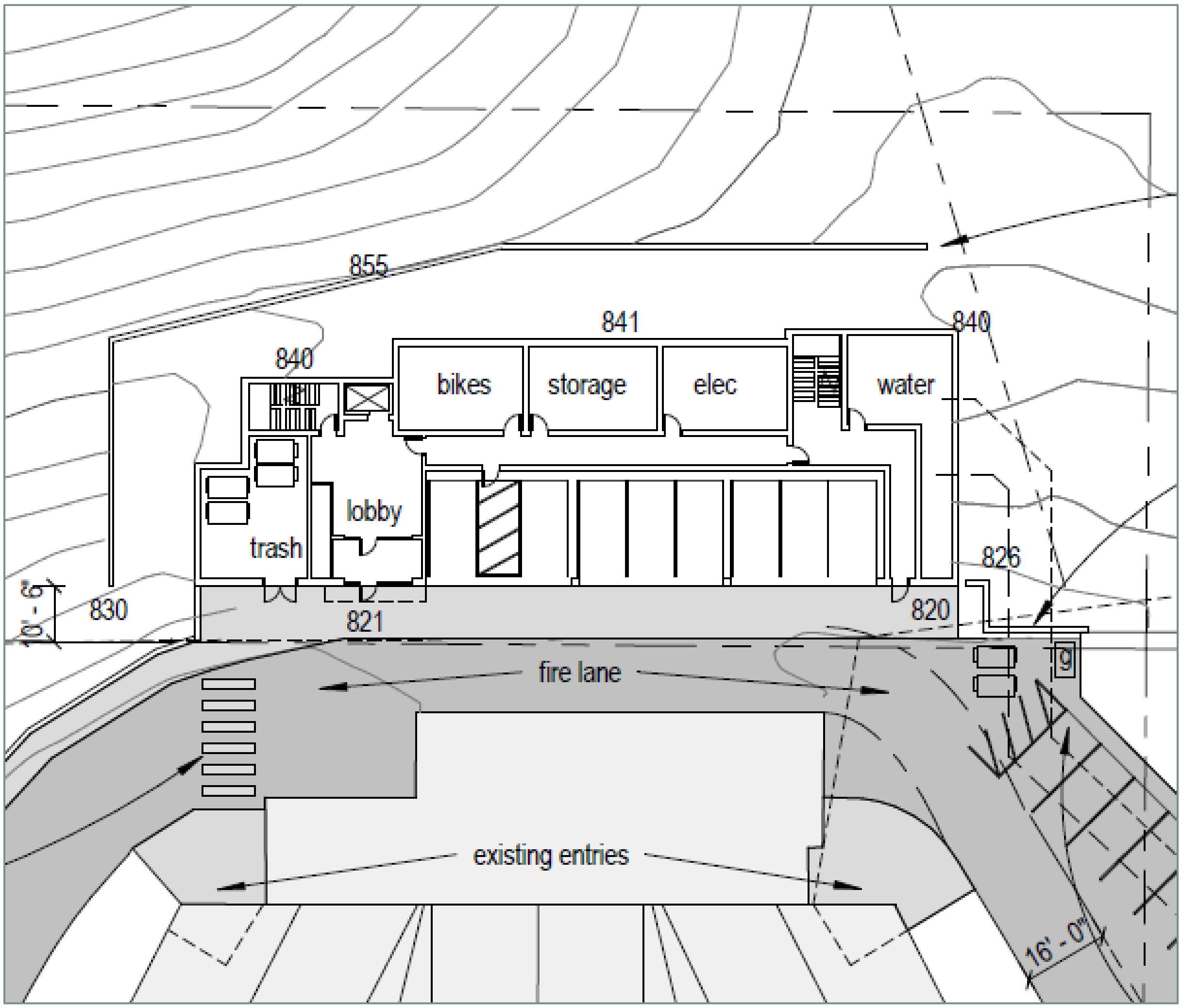


Figure prepared by LHB, Inc. dated April 12, 2022.

A.2. Site Conditions and History

The project site is approximately 1/2 acre of land in St. Paul, Minnesota. Currently, the site exists as wooded area. The site is bound by a wooded area to the north, east, and west, and Highland Chateau to the south. Current grades range from about 820 to 913. Generally, the site is heavily sloped from the North down to the South.

A.3. Purpose

The purpose of our geotechnical evaluation will be to characterize subsurface geologic conditions at selected exploration locations, evaluate their impact on the project, and provide geotechnical recommendations for use in the design and construction of the residential building.

A.4. Background Information and Reference Documents

We reviewed the following information:

- Site Plan prepared by LHB, Inc., dated April 12, 2022.
- We reviewed the Surficial Geology Map for Ramsey County prepared by the University of Minnesota. The map is denoted as Atlas C-7, Plate 3, Surficial Geology, and is dated 1992.
- We reviewed the Bedrock Geology Map for Ramsey County prepared by the University of Minnesota. The map is denoted as Atlas C-7, Plate 2, Bedrock Geology, and is dated 1992.
- Available public aerial photographs from Google Earth showing the existing site conditions.

In addition to the provided sources, we have used several publicly available sources of information.

We have described our understanding of the proposed construction and site to the extent others reported it to us. Depending on the extent of available information, we may have made assumptions based on our experience with similar projects. If we have not correctly recorded or interpreted the project details, the project team should notify us. New or changed information could require additional evaluation, analyses and/or recommendations.

A.5. Scope of Services

We performed our scope of services for the project in accordance with our Change Order 1 for B2207530, dated September 2, 2022. The following list describes the geotechnical tasks completed in accordance with our authorized scope of services.

- Reviewing the background information and reference documents previously cited.

- Staking and clearing the exploration location of underground utilities. We selected and staked the new exploration locations. We acquired the surface elevations and locations with GPS technology using the State of Minnesota’s permanent GPS base station network. The Soil Boring Location Sketch included in the Appendix shows the approximate locations of the borings.

- Performing 2 standard penetration test (SPT) borings, denoted as ST-1 to ST-2, to nominal depths of 30 feet below grade across the site, and then coring if auger refusal is encountered (which it was not).

- Performing laboratory testing on select samples to aid in soil classification and engineering analysis.

- Perform engineering analysis including a slope stability analysis to evaluate the stability of the slope in relation to the new building.

- Preparing this report containing a boring location sketch, logs of soil borings, a summary of the soils encountered, results of laboratory tests, and recommendations for structure and pavement subgrade preparation and the design of foundations, floor slabs, below grade walls, exterior slabs, utilities, stormwater improvements and pavements.

Our scope of services did not include environmental services or testing and our geotechnical personnel performing this evaluation are not trained to provide environmental services or testing. We can provide environmental services or testing at your request.

B. Results

B.1. Geologic Overview

Based on review of the geology maps for this area, the soils overlying the bedrock are expected to be sandy sediment from Glacial River Warren as well as sandy deposits from the Grantsburg Glacial Sublobe. Bedrock is expected to be shallow and consist of the Decorah Shale underlain near the base of the slope by the Platteville Limestone and Glenwood Shale formations.

We based the geologic origins used in this report on the soil types, in-situ and laboratory testing, and available common knowledge of the geological history of the site. Because of the complex depositional history, geologic origins can be difficult to ascertain. We did not perform a detailed investigation of the geologic history for the site.

B.2. Boring Results

Table 2 provides a summary of the soil boring results, in the general order we encountered the strata. Please refer to the Log of Boring sheets in the Appendix for additional details. The Descriptive Terminology sheets in the Appendix include definitions of abbreviations used in Table 2.

Table 2. Subsurface Profile Summary*

Strata	Soil Type - ASTM Classification	Range of Penetration Resistances	Commentary and Details
Topsoil	SM	---	▪ Dark brown in color. ▪ Thicknesses at boring locations varied from 1 to 2 feet. ▪ Moisture condition generally moist.
Bedrock	CH	11 BPF to 50 blows per 3 inches	▪ Apparent bedrock from the Decorah Shale formation. ▪ Hand deformed samples classified as Fat Clay (CH). ▪ Bluish gray in color ▪ Decomposed near the surface, transitioning to highly weathered at depth. ▪ Moisture condition generally moist to dry.

*Abbreviations defined in the attached Descriptive Terminology sheets.

B.3. Groundwater

We did not observe groundwater while advancing our borings. While we did not observe it, horizontal bedding planes within the shale bedrock have at times been known to promote lateral movement of groundwater within the bedrock. Hydrostatic water levels are known to exist within the underlying St. Peter Sandstone at appreciable depth (beyond the depths explored by the borings).

B.4. Laboratory Test Results

We performed Atterberg limit tests, moisture content tests, and unit weight measurements in general accordance with ASTM procedures on samples recovered from the SPT borings. The moisture contents of the soils indicate the material is generally near to dry of its estimated optimum moisture content. The laboratory tests results are shown on the log of Boring Sheets included in the Appendix, across from the associated sample. Tables 3, present the results of our laboratory tests.

Table 3. Laboratory Classification Test Results

Soil Type (USCS)	Moisture Content (%)	Dry Density (pcf)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)
CH	13 to 26	96 to 113	47 to 62	21 to 27	23 to 41

B.5. Slope Stability

We understand the City of St. Paul requires you to have an engineering analysis of the slope. To facilitate this evaluation, computer analyses were performed on a selected cross section using GeoStudio 2022.1. The following sections provide more detail to the analysis.

B.5.a. Selection of Analytical Cross-Section

We selected a cross section for analysis at the location where the slope appeared steepest and tallest. LHB provided us with topographic data along the cross section for both existing and proposed conditions. We utilized the MnTOPO web application to interpret slope conditions above and below what was provided by LHB.

B.5.b. Material Properties

We estimated the strength properties of the soils and bedrock based on the results of the SPT borings, laboratory testing, empirical correlations and geotechnical data from similar geology. We estimated the effective friction angles of the granular materials based on Figure 7 of the NAVFAC DM 7.1 and ignored cohesion. We assessed the peak strength parameters consisting of effective friction angle and effective cohesion of glacial till and intact Decorah shale based on “Case Histories of Embankment Dams on Prairies” by P. J. Rivard.

Being a highly plastic material, the Decorah Shale is highly sensitive to stress release, moisture change and natural weathering. The high plastic clay shale typically develops slickensides when stresses are released, for example, in the formation of the river or other geologic processes. In addition, moisture change and weathering over time could cause softening of this formation resulting in loss of peak effective strength near the exposed face. Considering these factors, we assumed approximately 70 feet of the exposed slope face has been weathered over time and developed slickensides during the formation of the Mississippi river floodplain.

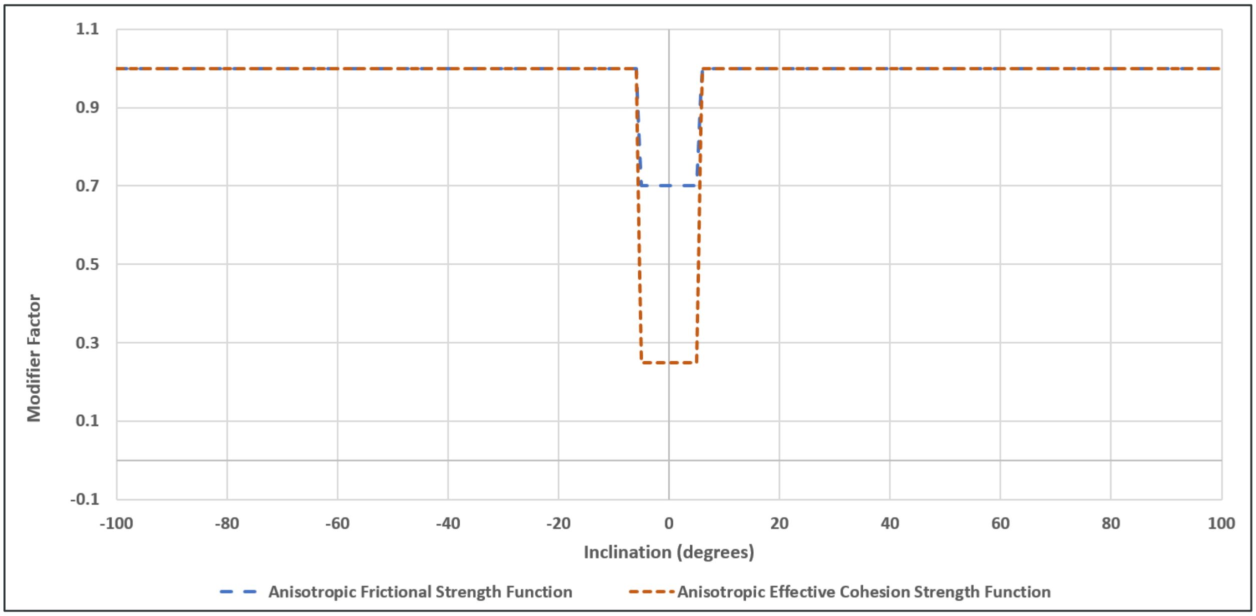
We assigned anisotropic strengths consisting of softened and residual strengths to the weathered portion of the Decorah Shale. We assigned the residual strengths along the direction of slickensides and softened strength in the other directions. To estimate the softened and residual strengths of the weathered Decorah shale, we used the liquid limit based correlations developed by Timothy Stark and his collaborators. Table 4 below presents the soil parameters used in the stability analyses.

Table 4. Summary of Material Properties

			Effective Strength Parameters		Residual Strength Parameters	
Soil/Bedrock	**Unit Weight (pcf)**	**Material Model**	**Friction Angle (deg)**	**Friction Angle (deg)**	**Friction Angle (deg)**	**Friction Angle (deg)**
Glacial Till	130	Mohr-Coulomb	32	200	---	---
Intact Shale	120	Mohr-Coulomb	30	500	---	---
Weathered Shale	115	Anisotropic Function	24	400	17	100
Sandstone	125	Mohr-Coulomb	30	0	---	---
Sand Fill	120	Mohr-Coulomb	30	0	---	---

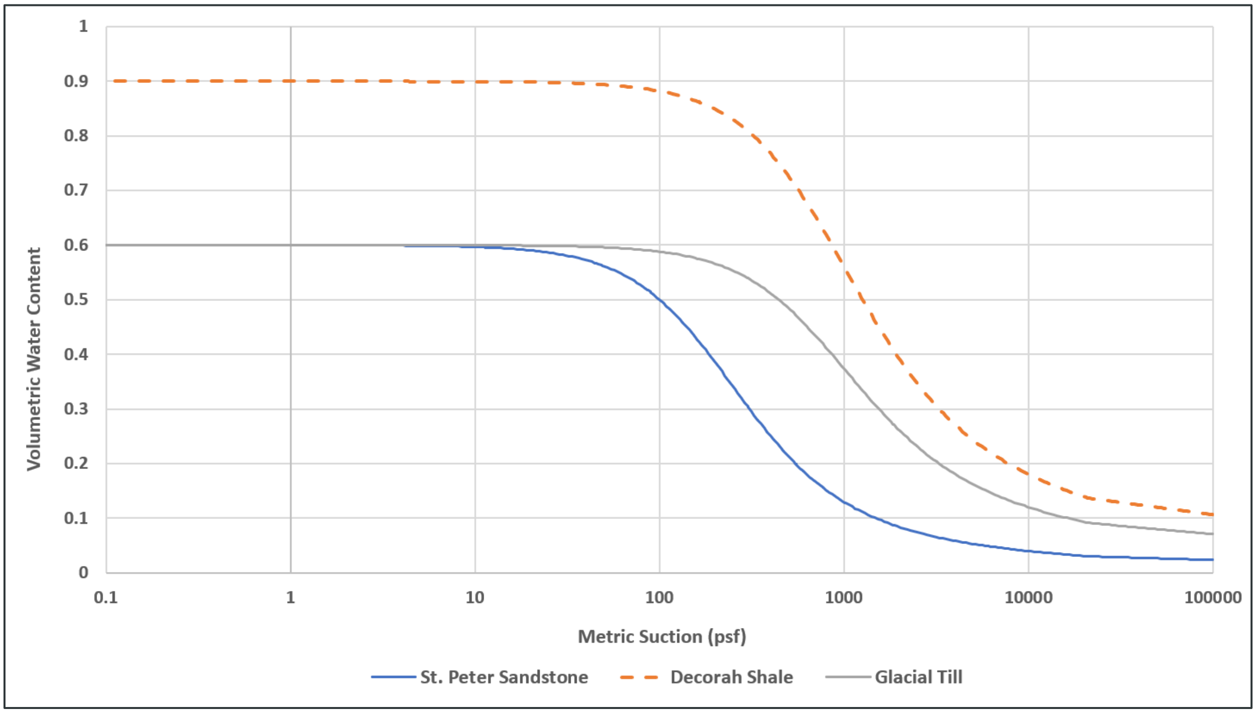
Figure 2 below presents the anisotropic strength functions we used to model the weathered shale. The inclination along the abscissa in the figure represents the direction the strength values apply. The modifier factor defines the ratios between the weaker and stronger strengths assuming stronger strength as a reference (modifier factor of 1).

Figure 2. Anisotropic Strength Functions for Weathered Decorah Shale.



In addition to the strength parameters, we also assigned volumetric water content to each soil and bedrock layer to allow the software to incorporate the effect of matric suction in the stability analysis. The suction generally improves the stability of the slope by adding strength to the unsaturated zones above the piezometric level. Figure 3 below presents the volumetric water content functions assigned to the soil and bedrock units.

Figure 3. Volumetric Water Content Functions Used to Model Suction.



B.5.c. Groundwater Conditions

Groundwater was not observed in our soil borings at the time of our exploration. Given the proximity of the site to the Mississippi river and the difference in elevation between the site and the river, we do not expect groundwater to be within the slope. For analytical purposes, we modeled the piezometric surface at an elevation of 785 feet, corresponding roughly to the Mississippi river water level.

B.5.d. Stages of Stability Models

We analyzed the stability of the slope at various assumed stages to evaluate the intermediate and final construction (after final grading is completed) conditions. Table 5 below summarizes the different stages analyzed for this project. Graphics for each stage are included in the Appendix.

Table 5. Summary of Model Stages

Stage Name	Commentary
Existing Slope	Stability of existing slope at its present condition.
Upper excavation	Intermediate slope stability at some phase during construction.
Foundation excavation	Intermediate slope stability after installation of soil retention and foundation excavation. The excavation depth is about 41 feet. The top and bottom elevations of the excavation are 855 and 813.5 feet above MSL.
Foundation installation	Intermediate slope stability after building foundation installation. The total depth of excavation is 41 feet.
Final stability	Final stability calculation of the slope after building and the permanent retaining wall installation and final grading is completed. The exposed height of the permanent retaining wall is approximately 14 feet.

Please note that these construction stages are approximated based on the information provided to us. If the construction sequencing or dimensions change, we should be notified to reevaluate the stability of the slope.

B.5.e. Stability Analysis

We used the Slope/W program from the GeoStudio 2022.1 (Version 11.4.0.18) software suite to evaluate the slope stability for the design cross-section. We performed long-term stability using effective stress parameters using Spencer’s limit equilibrium method, which utilizes both force and moment equilibrium to calculate the factor of safety.

Given the soils at this site are highly overconsolidated and construction will primarily involve excavation, short-term stability using total stress parameters is unlikely to control the stability. Therefore, we did not perform a short-term stability analysis using total stress parameters.

Initially, we performed a slope stability analysis for the existing slope to evaluate the stability condition at present state. We subsequently performed stability analysis for each intermediate stage described above. Note that some of the graphics in the Appendix show low factors of safety. These are conditions where excavations are conducted without the use of reinforcement to provide soil retention and are only provided to demonstrate the need for soil retention. We used piles to stabilize the slope when needed. The stabilizing piles in the model for temporary shoring were spaced 6 feet apart and have a minimum shear force of 200,000 lbs. We understand others will design the actual soil retention system. For this project, we considered the factor of safety values of 1.3 and 1.5 as acceptable for the intermediate (temporary) construction and final post-construction conditions, respectively. These are common industry standards for slopes adjacent structures.

B.5.f. Results and Discussion

Table 6 below summarizes the results of the stability analyses for the existing slope and different construction conditions outlined in the earlier sections.

Table 6. Summary of Stability Factor of Safety.

Analysis Condition	Stage	Estimated Factor of Safety	Target Factor of Safety
Existing Slope	A. Existing Slope	1.4	N/A
Construction Conditions without Stabilizing Piles	B. Upper Excavation	1.4	1.3
	C. Foundation Excavation	1.0	1.3
	D. Foundation Installation	1.1	1.3
Construction Conditions with Stabilizing Piles	F. Upper Excavation	1.6	1.3
	G. Foundation Excavation	1.3	1.3
	H. Foundation Installation	1.4	1.3
Built condition with permanent retaining wall	E. Final Condition	1.5	1.5

Our stability analyses demonstrate that soil reinforcement via a soil retention system is required to facilitate excavations necessary for construction, which was anticipated. They also demonstrate the permanent retaining wall will require a structural element in order to provide an adequate factor of safety for the slope. We utilized parameters for a structural element common from a retaining wall constructed with piles to demonstrate an adequate factor of safety can be achieved. Parameters used in our analysis are provided on the slope stability graphics in the Appendix. Ultimately, the wall designer will need to conduct their own analysis based on actual wall conditions, installation methods, and performance metrics.

C. Recommendations

C.1. Design and Construction Discussion

C.1.a. Building Support

Based on the results of the borings, the building can be designed for traditional spread footing and slab on grade construction. With the anticipated basement floor elevation at 820 feet, the footings for the planned building will bear on weathered shale bedrock. This may require some selective subcutting and replacement of the subgrade materials as discussed in the following sections.

C.1.b. Shale and Expansive Clays

Weathered shale (generally classified as fat clay), and more competent shale bedrock, can be expansive and subject to volume changes when exposed to moisture variations and when confining pressure is removed. Conversely, the material can also shrink if dried. If not properly managed, volume changes and associated expansive forces can be detrimental to footings, slabs, pavements, utilities or other items bearing on or above the shale. The shale with the greatest risk for volume change and expansion is where the material is partially weathered and/or its natural moisture content is dry of its optimum moisture content.

Methods for best managing the fat clay and shale include limiting their exposure to moisture variations by selective removal and sealing off exposed surfaces with other non-expansive, low permeability material (such as lean clay) and not leaving surfaces exposed for extended periods of time. Utilizing confining pressures that exceed the swell pressure of the fat clay and shale will also negate the expansive forces.

C.1.c. Soil Retention

Permanent soil retention methods are anticipated to retain the slope to the north of the building. Although generally not anticipated, temporary retention may also be required for excavation and construction of the building or utilities. The following site conditions should be considered when evaluating and designing the permanent and temporary retention systems, as well as open cut excavations:

- The vibrations related to installation and removal of retention systems may result in settlement from lateral movement systems.

- The weathered shale has the potential to swell with reduced confining pressure and when wetted. This swell pressure could increase the lateral earth pressure on the soil retention structure or system.

C.1.d. Below Grade Building Walls

Backfill depths for the perimeter building walls may exceed 20 feet in some areas, and the majority of the excavations are expected to be into the weathered shale. The weathered shale has potential to swell when wetted. This swell pressure could significantly increase the lateral earth pressure on the below-grade walls, or adversely affect the slabs if water migrates below the floor slab. To reduce the risk of increased lateral earth pressures on the walls, we recommend at least 5 feet of material against the wall consist of non-expansive material.

Additionally, due to the height of backfill, settlement of the backfill should be considered. If sand is used to backfill the walls, settlement is of little concern, but clay will be needed at the base to seal off the shale. If clay is used to backfill the walls, the clay will continue to settle for several months after the backfill is placed. Any structures placed over the wall backfill should consider this settlement or delay construction until the settlement of the backfill has ceased.

C.1.e. Reuse of On-Site Soils

Weathered shale or shale should not be reused as engineered fill below structures, pavements, slabs, or as utility trench backfill. We anticipate the backfill material will need to be imported. Any material used as engineered fill should be tested and approved by the geotechnical engineer prior to placement.

C.1.f. Groundwater

We did not observe groundwater in the borings. During wetter periods, horizontal bedding planes within the shale bedrock may promote movement of water towards excavations. Additionally, the shale is relatively impermeable and water from precipitation or surface runoff will collect in excavations. We recommend removing any collected water from within excavations to facilitate proper backfilling or concrete placement. Based upon the borings, we anticipate sumps and pumps would be suitable for temporary dewatering activities at this site. We recommend the contractor remove any water that collects in work areas before performing further work.

C.1.g. Construction Disturbance

The on-site weathered shale are highly susceptible to disturbance and loss of strength from construction traffic. As discussed in C.1.b, the weathered shale and shale bedrock, can be expansive and subject to volume changes when exposed to moisture variations and when confining pressure is removed. Conversely, the material can also shrink if dried. To minimize disturbance of these soils and facilitate access during construction, crushed rock could be placed in designated traffic areas.

C.1.h. Predicted Heave

Based on swell testing conducted for area projects, we estimate the shale to have a free swell heave up to about 1 1/2 inches and swell pressures ranging from 1,000 to 2,000 pounds per square foot, if inundated with no confining pressure (no floor loading, foundation loading, or overburden pressure).

C.2. Site Grading and Subgrade Preparation

C.2.a. Recommendations for Fat Clay and Shale Subgrades

Weathered shale (fat clay) is anticipated to be present at pavement, slab, structure, utility, or other site subgrades. Depending on the condition of the soil or bedrock, these materials have the potential for volume change and expansive forces. To reduce the risk for volume change and expansive force, we recommend the following general steps be taken to help manage the fat clay and shale exposed within or below subgrades that would be affected by volume changes or expansive forces.

- Subcutting these materials as defined within their respective subgrade preparation subsections for the various structures or site improvements. Removals should include loose or disturbed materials from exposed subgrades, including excavation side slopes.

- Where exposed, seal off fat clay or weathered shale subgrades from moisture variations within 48 hours of exposure using low permeability clayey fill with a plastic index (PI) between 8 and 25 or flowable fill (or place structure to seal off the subgrade, such as footing).

- Promptly remove water from fat clay or shale subgrades.

- Have a geotechnical representative observe the exposed subgrades to evaluate if additional subgrade improvements are necessary.

C.2.b. Building Subgrade Excavations

We recommend removing unsuitable materials from the proposed building pad and oversizing area. We define unsuitable materials as existing fill, frozen materials, organic soils, existing structures, existing utilities, vegetation, and soft/loose soils. Based on the borings, we do not anticipate soil corrections to remove unsuitable materials beyond that of topsoil stripping. However, additional subcuts of the weathered shale (fat clay) will be needed.

Foundations may bear directly on competent weathered shale provided the surface is protected as recommended in Section C.2.a. and the foundation element has a load that creates a bearing pressure of at least 2,000 pounds per square foot (psf).

Below interior floor slabs, we recommend weathered shale bedrock be subcut to a minimum depth of 2 1/2 feet below the bottom of the interior floor slab subgrade. The bottom of the subcut should be backfilled with a minimum of 12-inches of non-expansive, low permeability clay in accordance with C.2.h to seal off the exposed subgrade. Other features below the interior slab, such as elevator pits or utility pipes should also be backfilled with non-expansive clay or other low permeability materials.

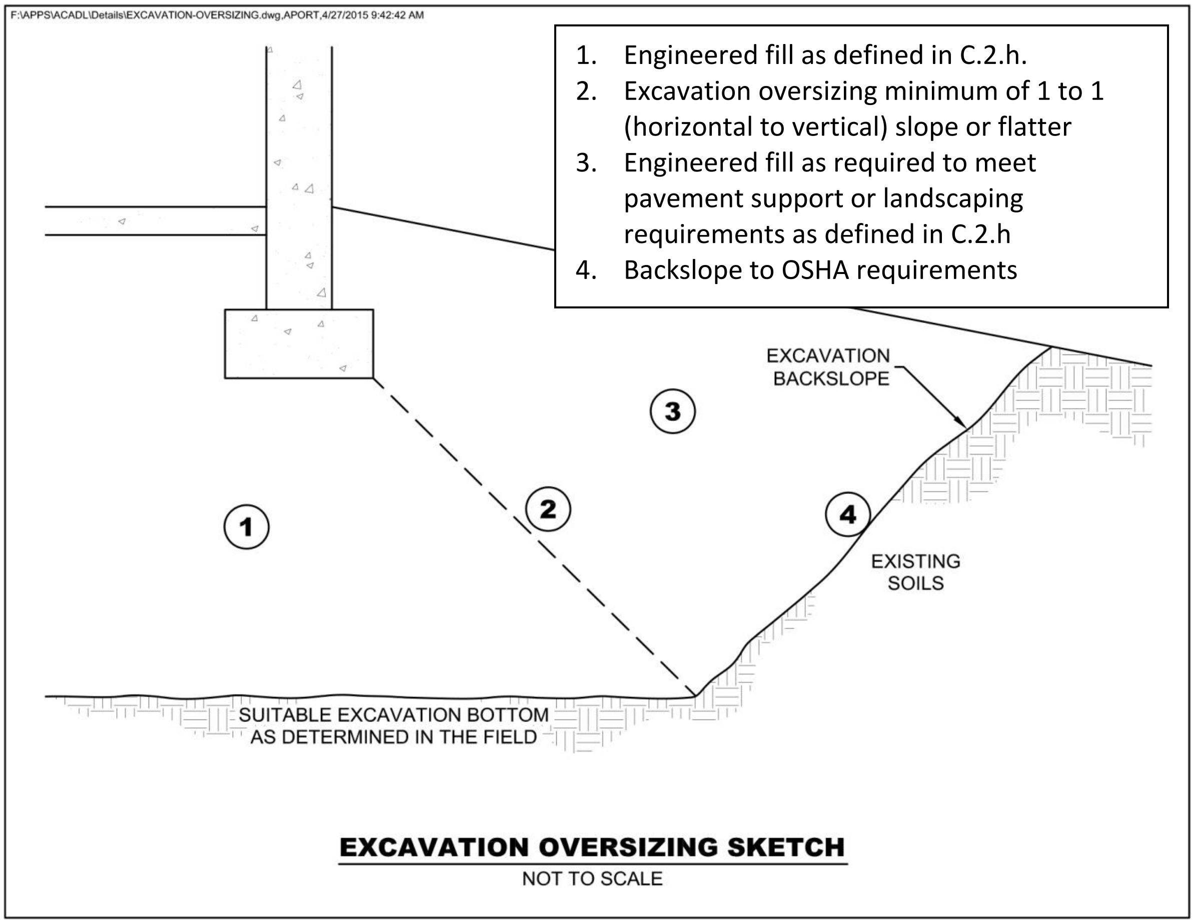
The contractor should use equipment and techniques to minimize soil disturbance. If soils become disturbed or wet, we recommend excavation and replacement of the disturbed soils.

We also recommend having a geotechnical engineer, or an engineering technician working under the direction of a geotechnical engineer (geotechnical representative) evaluate the suitability of exposed subgrade soils to support the proposed structure.

C.2.c. Excavation Oversizing

When removing unsuitable materials below structures or pavements, we recommend the excavation extend outward and downward at a slope of 1H:1V (horizontal:vertical) or flatter. See Figure 4 for an illustration of excavation oversizing.

Figure 4. Generalized Illustration of Oversizing



1. Engineered fill as defined in C.2.h.
2. Excavation oversizing minimum of 1 to 1 (horizontal to vertical) slope or flatter
3. Engineered fill as required to meet pavement support or landscaping requirements as defined in C.2.h
4. Backslope to OSHA requirements

EXCAVATION OVERSIZING SKETCH

NOT TO SCALE

C.2.d. Excavated Slopes

Based on the borings, we anticipate on-site soils in excavations will consist of weathered shale (fat clay). These soils are typically considered Type B Soil under OSHA (Occupational Safety and Health Administration) guidelines. OSHA guidelines indicate unsupported excavations in Type B soils should have a gradient no steeper than 1H:1V. Slopes constructed in this manner may still exhibit surface sloughing, especially where wet or saturated soils are present. Slopes constructed in this manner may still exhibit surface sloughing. OSHA requires an engineer to evaluate slopes or excavations over 20 feet in depth.

An OSHA-approved qualified person should review the soil classification in the field. Excavations must comply with the requirements of OSHA 29 CFR, Part 1926, Subpart P, “Excavations and Trenches.” This document states excavation safety is the responsibility of the contractor. The project specifications should reference these OSHA requirements.

C.2.e. Excavation Dewatering

When encountered, we recommend removing groundwater from the excavations as promptly as possible. Allowing water to pond on subgrades for extended periods will cause them to become saturated and make them more susceptible to disturbance and strength loss during construction or swelling (for shale and fat clay subgrades). Project planning should include temporary sumps and pumps for excavations in the low-permeability soils.

C.2.f. Pavement and Exterior Slab Subgrade Preparation

We recommend the following steps for pavement and exterior slab subgrade preparation, presuming the paved areas will have conditions consistent to those found in the soil borings with topsoil over weathered shale bedrock. Note that project planning may need to require additional subcuts to limit frost heave.

1. Remove topsoil or organic soils, pavements/slabs, structures and utilities to a minimum depth of 3 feet below pavement subgrades.

2. Remove weathered shale (fat clay) to a minimum depth of 12 inches below pavement subgrades (defined as bottom of aggregate base, or sand subbase if utilized).

3. Have a geotechnical representative observe the excavated subgrade to evaluate if additional subgrade improvements are necessary.

4. Slope subgrade soils to areas of sand or drain tile to allow the removal of accumulating water.

5. Scarify, moisture condition and surface compact to at least 100 percent of maximum Standard Proctor density.

6. Place pavement engineered fill to grade and compact in accordance with Section C.2.h. to bottom of pavement and exterior slab section.

7. Where weathered shale is present at the pavement section subgrade (bottom of aggregate base, or sand subbase if utilized), it should be capped with a minimum of 12 inches of non-expansive clayey soil with a plasticity index between 8 and 25.

8. Proofroll the pavement or exterior slab subgrade as described in Section C.2.g.

C.2.g. Pavement Subgrade Proofroll

After preparing the subgrade as described above and prior to the placement of the aggregate base, we recommend proofrolling the subgrade soils with a fully loaded tandem-axle truck. We also recommend having a geotechnical representative observe the proofroll. Areas that fail the proofroll likely indicate soft or weak areas that will require additional soil correction work to support pavements.

The contractor should correct areas that display excessive yielding or rutting during the proofroll, as determined by the geotechnical representative. Possible options for subgrade correction include moisture conditioning and recompaction, subcutting and replacement with soil or crushed aggregate, chemical stabilization and/or geotextiles. We recommend performing a second proofroll after the aggregate base material is in place, and prior to placing bituminous or concrete pavement.

C.2.h. Engineered Fill Materials and Compaction

Table 7 below contains our recommendations for engineered fill materials.

Table 7. Engineered Fill Materials*

Locations To Be Used	Engineered Fill Classification	Possible Soil Type Descriptions	Gradation	Additional Requirements
▪ Below foundations ▪ Below interior slabs	Structural fill	SP, SP-SM, SM, SC, CL	100% passing 2-inch sieve	< 2% Organic Content (OC) Plasticity Index (PI) 8% < PI < 25% No Shale or CH
▪ Drainage layer ▪ Non-frost-susceptible	▪ Free-draining ▪ Non-frost-susceptible fill	GP, GW, SP, SW	100% passing 1-inch sieve < 50% passing #40 sieve < 5% passing #200 sieve	< 2% OC

Locations To Be Used	Engineered Fill Classification	Possible Soil Type Descriptions	Gradation	Additional Requirements
Behind below-grade walls, beyond drainage layer	Imported Sand	SP, SP-SM	100% passing 3-inch sieve < 12% passing #200 sieve	< 2% OC
	Imported Clay	CL	100% passing 3-inch sieve	< 2% OC 8% < PI < 25% No Shale or CH
Pavements	Pavement fill	SP, SM, SC, CL	100% passing 3-inch sieve	< 2% OC 8% < PI < 25% No Shale or CH
Below landscaped surfaces, where subsidence is not a concern	Non-structural fill	---	100% passing 6-inch sieve	< 10% OC
Low permeability fill to cap shale or fat clay subgrades	Non-expansive clay fill	CL	100% passing 2-inch sieve > 50% passing #200 sieve	8% < PI < 25%

* More select soils comprised of coarse sands with < 5% passing #200 sieve may be needed to accommodate work occurring in periods of wet or freezing weather.

We recommend spreading engineered fill in loose lifts of approximately 8 inches thick. We recommend compacting engineered fill in accordance with the criteria presented below in Table 8. The project documents should specify relative compaction of engineered fill, based on the structure located above the engineered fill, and vertical proximity to that structure.

Table 8. Compaction Recommendations Summary

Reference	Relative Compaction, percent (ASTM D698 – Standard Proctor)	Moisture Content Variance from Optimum, percentage points	
		< 12% Passing #200 Sieve (typically SP, SP-SM)	> 12% Passing #200 Sieve (typically CL, SC, SM)
Below foundations and oversizing zones	100	±3	-1 to +3
Below interior slabs	95	±3	-1 to +3
Within 3 feet of pavement subgrade	100	±3	-1 to +3
More than 3 feet below pavement subgrade	95	±3	±3
Below landscaped surfaces	90	±5	±4
Adjacent to below-grade wall	95*	±3	-1 to +3

*Increase compaction requirement to meet compaction required for structure supported by this engineered fill.

The project documents should not allow the contractor to use frozen material as engineered fill or to place engineered fill on frozen material. Frost should not penetrate under foundations during construction.

We recommend performing density tests in engineered fill to evaluate if the contractors are effectively compacting the soil and meeting project requirements.

C.2.i. Special Inspections of Soils

We recommend including the site grading and placement of engineered fill within the building pad under the requirements of Special Inspections, as provided in Chapter 17 of the International Building Code, which is part of the Minnesota State Building Code. Special Inspection requires observation of soil conditions below engineered fill or footings, evaluations to determine if excavations extend to the anticipated soils, and if engineered fill materials meet requirements for type of engineered fill and compaction condition of engineered fill. A licensed geotechnical engineer should direct the Special Inspections of site grading and engineered fill placement. The purpose of these Special Inspections is to evaluate whether the work is in accordance with the approved Geotechnical Report for the project. Special Inspections should include evaluation of the subgrade, observing preparation of the subgrade (surface compaction or dewatering, excavation oversizing, placement procedures and materials used for engineered fill, etc.) and compaction testing of the engineered fill.

C.3. Soil Retention

We recommend the soil retention system be designed using the parameters presented in Table 9. Designs should consider the slope of any permanent or temporary configuration and any dead or live loads, which are near the soil retaining walls or system. The active, passive and at-rest earth pressure coefficients are provided to compute the magnitude of and resistance available to earth and structure loads, depending on the amount of foundation movement that is anticipated to occur, or can be tolerated. Our recommended parameters do not include safety factors.

A professional engineer experienced in this type of construction should perform design of temporary and permanent retention systems.

Table 9. Lateral Load Parameters – Drained Conditions

Soil Type	Wet Unit Weight, pcf	Friction Angle, degrees	Active Lateral Coefficient (K_A)	At-Rest Lateral Coefficient (K_O)	Passive Lateral Coefficient (K_P)
Imported Clay (SC/CL)	125	26	0.40	0.56	2.56
Weathered Shale (CH)[A]	115	22	0.45	0.63	2.20
Imported Sand (SP/SP-SM)	120	34	0.25	0.42	3.53

[A] If retention systems are constructed to retain shale bedrock, we recommend design parameters and the retention system be designed to account of potential lateral swell pressures. If not mitigated, these pressures would be additive to the pressures provided in Table 9.

As discussed in Section C.1.c, weathered shale has the potential to swell and increase the lateral pressure. The potential for swell pressures will be highly variable depending on exposed shale surface, presence of water or saturated conditions, and type of retention system. The weathered shale values in Table 9 do not account for potential swell pressures. For initial design, we recommend an additive lateral swell pressure of up to 1,000 psf where shale is present within the excavation face behind the retention system, unless these forces are mitigated. Means of mitigation may include sealing off exposed shale subgrades from moisture variations or the use of an attenuation medium such as a compressible foam member.

We should be consulted to review the design.

C.4. Spread Footings

Table 10 below contains our recommended parameters for foundation design.

Table 10. Recommended Spread Footing Design Parameters

Item	Description
Maximum net allowable bearing pressure (psf) Interior column pad footings Perimeter strip footings	6,000 (minimum recommend design bearing capacity is 2,000 psf to offset potential swell forces)
Minimum factor of safety for bearing capacity failure	3.0
Minimum width (inches) Perimeter Strip Footings Column Pads	 24 36
Minimum embedment below final exterior grade for heated structures (inches)	42
Minimum embedment below final exterior grade for unheated structures or for footings not protected from freezing temperatures during construction (inches)	60
Total estimated settlement (inches)	1 inch
Differential settlement	Typically about 2/3 of total settlement*

* Actual differential settlement amounts will depend on final loads and foundation layout. We can evaluate differential settlement based on final foundation plans and loadings.

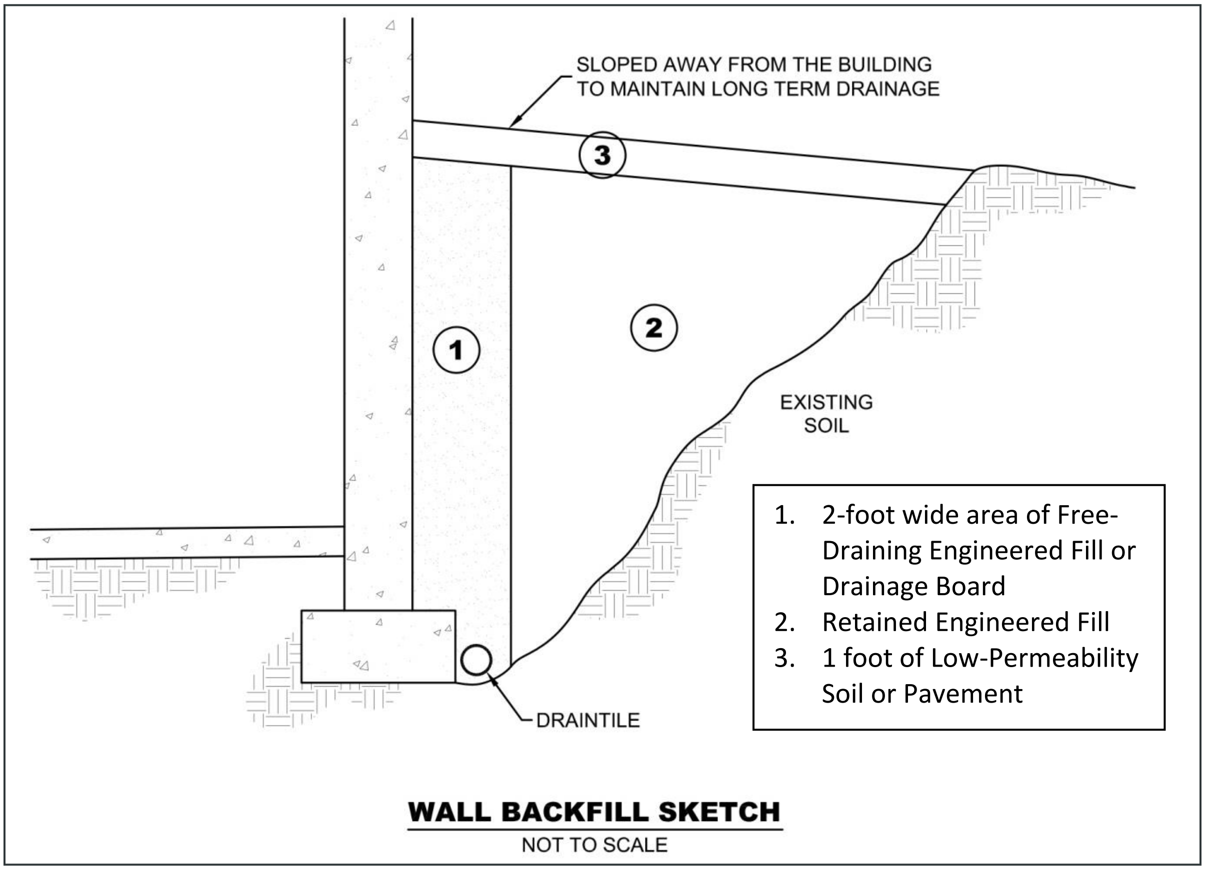
C.5. Below-Grade Walls

C.5.a. Drainage Control and Wall Backfill

We recommend installing drain tile to remove water behind the below-grade walls, at the location shown in Figure 5. The below-grade wall drainage system should also incorporate free-draining, engineered fill or a drainage board placed against the wall and connected to the drain tile.

Even with the use of free-draining, engineered fill, we recommend general waterproofing of below-grade walls that surround occupied or potentially occupied areas because of the potential cost impacts related to seepage after construction is complete.

Figure 5. Generalized Illustration of Wall Engineered Fill



The materials listed in the sketch should meet the definitions in Section C.2.h. Low-permeability material is capable of directing water away from the wall, like clay, topsoil or pavement. The project documents should indicate if the contractor should brace the walls prior to filling and allowable unbalanced fill heights.

As shown in Figure 5, we recommend Zone 2 consist of retained, engineered fill, and this material will control lateral pressures on the wall. Shale is expected to be removed from the excavations, but Shale is not an acceptable backfill material so imported soil is anticipated to be used in Zone 2. While imported clay backfill can be an acceptable material to limit swell impacts from adjacent Shale, the project team needs to be aware that the thickness of wall backfill anticipated will lead to settlement of clay backfill, even when well compacted. Thus, structures (slabs, site features, etc.) placed over the clay backfill will be subject to settlement if placed prior to the clay “settling out.” The impacts of the settlement can be lessened if the structures are not built until the clay backfill settles out, which may be on the order of 3 to 6 months, but timing will depend on the actual material used. If this is not acceptable, the below grade walls should be backfilled with imported sand, which is typically more expensive than clay backfill, but has less risks and allows for a less robust wall design. Note that if sand is used, the shale exposed in the excavations should be capped with at least 1 foot of Non-Expansive Clay Fill. The project document should clearly state the material type required for wall backfill.

To mitigate the impacts of the shale swelling and adding lateral pressures to the wall, we recommend imported backfill be placed for at least 5 horizontal feet from the edge of the wall. This is only expected to be impactful if the retention system is placed unusually close to the wall.

C.5.b. Configuring and Resisting Lateral Loads

Below-grade wall design can use active earth pressure conditions, if the walls can rotate slightly. If the wall design cannot tolerate rotation, then design should use at-rest earth pressure conditions. Rotation up to 0.002 times the wall height is generally required for walls supporting sand. Rotation up to 0.02 times the wall height is required when wall supports clay.

Table 11 presents our recommended lateral coefficients and equivalent fluid pressures for wall design of active, at-rest and passive earth pressure conditions. The table also provides recommended wet unit weights and internal friction angles. Designs should also consider the slope of any engineered fill and dead or live loads placed behind the walls within a horizontal distance that is equal to the height of the walls. Our recommended values assume the wall design provides drainage so water cannot accumulate behind the walls. The construction documents should clearly identify what soils the contractor should use for engineered fill of walls.

Table 11. Recommended Below-Grade Wall Design Parameters – Drained Conditions

Retained Soil**	Wet Unit Weight (pcf)	Friction Angle (degrees)	Active Lateral Equivalent Fluid Pressure (pcf)	At-Rest Lateral Equivalent Fluid Pressure (pcf)	Passive Lateral Equivalent Fluid Pressure* (pcf)
Imported Clay (CL)	125	26	50	70	320
Imported Sand (SP, SP-SM)	120	34	35	55	320

* Based on Rankine model for soils in a region behind the wall extending at least 2 horizontal feet beyond the bottom outer edges of the wall footings and then rising up and away from the wall at an angle no steeper than 60 degrees from horizontal.
** Project documents should clearly state which material is required in order to comply with design.

Sliding resistance between the bottom of the footing and the soil can also resist lateral pressures. We recommend assuming a sliding coefficient equal to 0.4 between the concrete and soil.

The values presented in this section are un-factored.

C.6. Interior Slabs

C.6.a. Subgrade Excavation and Drainage

As discussed in Section C.2, weathered shale should be removed to a minimum depth of 2 1/2 feet below the proposed bottom of slab on grade elevation. The subcut beneath the slab on grade is to reduce the risk of detrimental heave associated with the weathered shale (fat clay). After subcutting, the shale/fat clay should be capped with at least 12 inches of non-expansive, low permeability clay soil.

We recommend inclusion of limited drain tile system below the lower level floor slab to provide a means for removal for any potential trapped or infiltrated water, during construction. The drain tile system should consist of perforated pipes placed within free draining gravel, or at the base of the gravel layer. Location and design of the subfloor drain tile should be reviewed as part of the design and construction of the lower level floor slab.

C.6.b. Elevator Pits

We recommend elevator pits, utility pipes, and other features below the interior slab be backfilled with a non-expansive clay or other low permeability material to reduce the risk of collecting groundwater and saturating exposed shale subgrades. If fully backfilled with clay or other low permeability material, drain tile should not be required around elevator pits, however, the elevator pits should be designed to be watertight.

C.6.c. Subgrade Modulus

The anticipated floor subgrade is anticipated to be imported sand or non-expansive clay fill. We recommend using a modulus of subgrade reaction, k, of 100 pounds per square inch per inch of deflection (pci) to design the slabs. If the slab design requires placing 6 inches of compacted crushed aggregate base immediately below the slab, the slab design may increase the k-value by 50 pci. We recommend that the aggregate base materials be free of bituminous. In addition to improving the modulus of subgrade reaction, an aggregate base facilitates construction activities and is less weather sensitive.

C.6.d. Moisture Vapor Protection

Excess transmission of water vapor could cause floor dampness, certain types of floor bonding agents to separate, or mold to form under floor coverings. If project planning includes using floor coverings or coatings, we recommend placing a vapor retarder or vapor barrier immediately beneath the slab. We also recommend consulting with floor covering manufacturers regarding the appropriate type, use and installation of the vapor retarder or barrier to preserve warranty assurances.

C.7. Frost Protection

C.7.a. General

Predominantly imported backfill or weathered shale (fat clay) will underlie exterior slabs, as well as pavements. We consider these soils to be moderately to highly frost susceptible. Soils of this type can retain moisture and heave upon freezing. In general, this characteristic is not an issue unless these soils become saturated, due to surface runoff or infiltration, or are excessively wet in situ. Once frozen, unfavorable amounts of general and isolated heaving of the soils and the surface structures supported on them could develop. This type of heaving could affect design drainage patterns and the performance of exterior slabs and pavements, as well as any isolated exterior footings and piers.

Note that general runoff and infiltration from precipitation are not the only sources of water that can saturate subgrade soils and contribute to frost heave. Roof drainage and irrigation of landscaped areas in close proximity to exterior slabs, pavements, and isolated footings and piers, contribute as well.

C.7.b. Frost Heave Mitigation

To address most of the heave related issues, we recommend setting general site grades and grades for exterior surface features to direct surface drainage away from buildings, across large paved areas and away from walkways. Such grading will limit the potential for saturation of the subgrade and subsequent heaving. General grades should also have enough “slope” to tolerate potential larger areas of heave, which may not fully settle after thawing.

Even small amounts of frost-related differential movement at walkway joints or cracks can create tripping hazards. Project planning can explore several subgrade improvement options to address this condition.

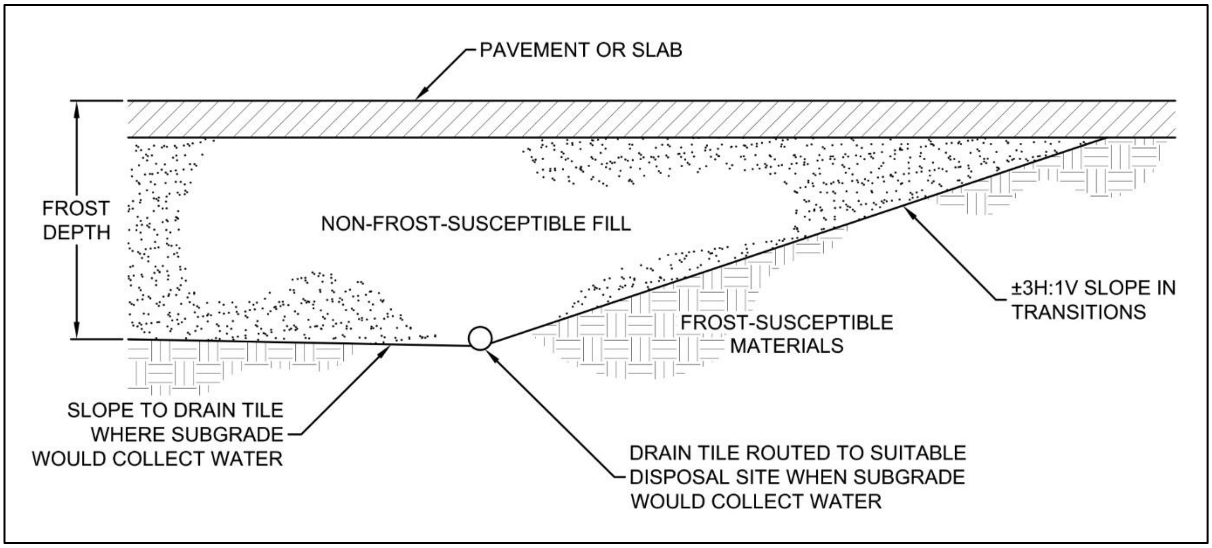
One of the more conservative subgrade improvement options to mitigate potential heave is removing any frost-susceptible soils present below the exterior slab areas down to a minimum depth of 5 feet below subgrade elevations. We recommend filling the resulting excavation with non-frost-susceptible fill.

We also recommend sloping the bottom of the excavation toward one or more collection points to remove any water entering the engineered fill. This approach will not be effective in controlling frost heave without removing the water.

An important geometric aspect of the excavation and replacement approach described above is sloping the banks of the excavations to create a more gradual transition between the unexcavated soils considered frost susceptible and the engineered fill in the excavated area, which is not frost susceptible. The slope allows attenuation of differential movement that may occur along the excavation boundary. We recommend slopes that are 3H:1V, or flatter, along transitions between frost-susceptible and non-frost-susceptible soils.

Figure 6 shows an illustration summarizing some of the recommendations.

Figure 6. Frost Protection Geometry Illustration



Another option is to limit frost heave in critical areas, such as doorways and entrances, via frost-depth footings or localized excavations with sloped transitions between frost-susceptible and non-frost-susceptible soils, as described above.

Over the life of slabs and pavements, cracks will develop and joints will open up, which will expose the subgrade and allow water to enter from the surface and either saturate or perch atop the subgrade soils. This water intrusion increases the potential for frost heave or moisture-related distress near the crack or joint. Therefore, we recommend implementing a detailed maintenance program to seal and/or fill any cracks and joints. The maintenance program should give special attention to areas where dissimilar materials abut one another, where construction joints occur and where shrinkage cracks develop.

C.8. Pavements and Exterior Slabs

C.8.a. Design Sections

Our scope of services for this project did not include laboratory tests on subgrade soils to determine an R-value for pavement design. Based on our experience with similar soils anticipated at the pavement subgrade elevation (anticipated to be 1 foot of lean clay over weathered shale), we recommend pavement design assume an R-value of 10. Note the contractor may need to perform limited removal of unsuitable or less suitable soils to achieve this value. Table 12 provides recommended pavement sections, based on the soils support and traffic loads assumed in Section A.1.

Table 12. Recommended Bituminous Pavement Sections

Use	Light Duty	Heavy Duty
Minimum asphalt thickness (inches)	4	4 1/2
Minimum aggregate base thickness (inches)	8	10

C.8.b. Subgrade Drainage

We recommend installing perforated drainpipes throughout pavement areas at low points, around catch basins, and behind curb in landscaped areas. We also recommend installing drainpipes along pavement and exterior slab edges where exterior grades promote drainage toward those edge areas. The contractor should place drainpipes in small trenches, extended at least 8 inches below the granular subbase layer, or below the aggregate base material where no subbase is present.

C.8.c. Performance and Maintenance

We based the above pavement designs on a 20-year performance life for bituminous. This is the amount of time before we anticipate the pavement will require reconstruction. This performance life assumes routine maintenance, such as seal coating and crack sealing. The actual pavement life will vary depending on variations in weather, traffic conditions and maintenance.

It is common to place the non-wear course of bituminous and then delay placement of wear course. For this situation, we recommend evaluating if the reduced pavement section will have sufficient structure to support construction traffic.

Many conditions affect the overall performance of the exterior slabs and pavements. Some of these conditions include the environment, loading conditions and the level of ongoing maintenance. With regard to bituminous pavements in particular, it is common to have thermal cracking develop within the first few years of placement, and continue throughout the life of the pavement. We recommend developing a regular maintenance plan for filling cracks in exterior slabs and pavements to lessen the potential impacts for cold weather distress due to frost heave or warm weather distress due to wetting and softening of the subgrade.

C.9. Utilities

C.9.a. Pipe Subgrade Excavation and Support

Soils present at utility pipe and structure invert elevations are anticipated to be a weathered shale. In general, we anticipate these materials will be directly suitable for pipe and structure support, although additional subcutting may be required as recommended below.

Earthwork activities associated with utility pipe and structure installations should adhere to the recommendations in Section C.2. In addition, we recommend the following for utility excavations (applies to pipes and structures):

- If bedrock (shale or weathered shale) is present at or above the invert elevation, we recommend they be over-excavated a minimum of 4 inches beneath the invert to reduce the risk of point loads.

- If organic, unstable or soft clays are present at or above the invert elevation, we recommend they be removed to a minimum of 12 inches beneath the invert and be backfilled with crushed aggregate to help provide a stable base for utility support.

In general, we recommend project design and construction not place utilities within the 1H:1V oversizing of foundations. However, for structures supported on bedrock, this influence zone may be reduced and should be reviewed on a case-by-case basis.

C.9.b. Trench and Structure Backfill

We recommend selecting, placing, and compacting utility fill in accordance with the recommendations provided above in Section C.2. Additional considerations pertaining to utility trench fill/backfill include the following:

- If settlement at or around utilities is a concern due to deep utility trench backfill, we recommend backfilling around the structure with sand with less than 12 percent passing the #200 sieve.
- Additional trench backfill considerations may be required within specific areas depending on the presence of perched/trapped groundwater. Low permeability backfill (non-expansive) may be required to reduce or impede groundwater flow along utility trenches into below-grade building areas or other structures/features. These conditions should be reviewed on an individual basis.
- Pipe or structure bedding should be in accordance with manufacturer requirements.
- In general, capping of shale, weathered shale, or fat clay subgrades within utility trenches with low-permeability, non-expansive soil or material is not anticipated to be required due to the confining pressure of the overburden materials. However, the exception would be shallow utility pipes (5 feet or less below grade) or structures with insufficient confining pressure. These pipes and structures should be reviewed on an individual basis.

C.9.c. Corrosion Potential

Based on our experience, the soils encountered by the borings are moderately corrosive to metallic conduits, but only marginally corrosive to concrete. We recommend specifying non-corrosive materials or providing corrosion protection, unless project planning chooses to perform additional tests to demonstrate the soils are not corrosive.

C.10. Equipment Support

The recommendations included in the report may not be applicable to equipment used for the construction and maintenance of this project. We recommend evaluating subgrade conditions in areas of shoring, scaffolding, cranes, pumps, lifts and other construction equipment prior to mobilization to determine if the exposed materials are suitable for equipment support, or require some form of subgrade improvement. We also recommend project planning consider the effect that loads applied by such equipment may have on structures they bear on or surcharge – including pavements, buried utilities, below-grade walls, etc. We can assist you in this evaluation.

D. Procedures

D.1. Penetration Test Borings

We drilled the penetration test borings with a core and auger drill mounted on a floatation-tired carrier and equipped with hollow-stem auger. We performed the borings in general accordance with ASTM D6151 taking penetration test samples at 2 1/2- or 5-foot intervals in general accordance to ASTM D1586. The boring logs show the actual sample intervals and corresponding depths.

We sealed penetration test boreholes meeting the Minnesota Department of Health (MDH) Environmental Borehole criteria with an MDH-approved grout. We will forward sealing records for those boreholes to the Minnesota Department of Health Well Management Section.

D.2. Exploration Logs

D.2.a. Log of Boring Sheets

The Appendix includes Log of Boring sheets for our penetration test borings. The logs identify and describe the penetrated geologic materials, and present the results of penetration resistance tests performed. The logs also present the results of laboratory tests performed on penetration test samples and groundwater measurements.

We inferred strata boundaries from changes in the penetration test samples and the auger cuttings. Because we did not perform continuous sampling, the strata boundary depths are only approximate. The boundary depths likely vary away from the boring locations, and the boundaries themselves may occur as gradual rather than abrupt transitions.

D.2.b. Geologic Origins

We assigned geologic origins to the materials shown on the logs and referenced within this report, based on: (1) a review of the background information and reference documents cited above, (2) visual classification of the various geologic material samples retrieved during the course of our subsurface exploration, (3) penetration resistance performed for the project, (4) laboratory test results, and (5) available common knowledge of the geologic processes and environments that have impacted the site and surrounding area in the past.

D.3. Material Classification and Testing

D.3.a. Visual and Manual Classification

We visually and manually classified the geologic materials encountered based on ASTM D2488. When we performed laboratory classification tests, we used the results to classify the geologic materials in accordance with ASTM D2487. The Appendix includes a chart explaining the classification system we used.

D.3.b. Laboratory Testing

The exploration logs in the Appendix note most of the results of the laboratory tests performed on geologic material samples. The remaining laboratory test results follow the exploration logs. We performed the tests in general accordance with ASTM procedures.

D.4. Groundwater Measurements

The drillers checked for groundwater while advancing the penetration test borings, and again after auger withdrawal. We then filled the boreholes or allowed them to remain open for an extended period of observation, as noted on the boring logs.

E. Qualifications

E.1. Variations in Subsurface Conditions

E.1.a. Material Strata

We developed our evaluation, analyses and recommendations from a limited amount of site and subsurface information. It is not standard engineering practice to retrieve material samples from exploration locations continuously with depth. Therefore, we must infer strata boundaries and thicknesses to some extent. Strata boundaries may also be gradual transitions, and project planning should expect the strata to vary in depth, elevation and thickness, away from the exploration locations.

Variations in subsurface conditions present between exploration locations may not be revealed until performing additional exploration work, or starting construction. If future activity for this project reveals any such variations, you should notify us so that we may reevaluate our recommendations. Such variations could increase construction costs, and we recommend including a contingency to accommodate them.

E.1.b. Groundwater Levels

We made groundwater measurements under the conditions reported herein and shown on the exploration logs, and interpreted in the text of this report. Note that the observation periods were relatively short, and project planning can expect groundwater levels to fluctuate in response to rainfall, flooding, irrigation, seasonal freezing and thawing, surface drainage modifications and other seasonal and annual factors.

E.2. Continuity of Professional Responsibility

E.2.a. Plan Review

We based this report on a limited amount of information, and we made a number of assumptions to help us develop our recommendations. We should be retained to review the geotechnical aspects of the designs and specifications. This review will allow us to evaluate whether we anticipated the design correctly, if any design changes affect the validity of our recommendations, and if the design and specifications correctly interpret and implement our recommendations.

E.2.b. Construction Observations and Testing

We recommend retaining us to perform the required observations and testing during construction as part of the ongoing geotechnical evaluation. This will allow us to correlate the subsurface conditions exposed during construction with those encountered by the borings and provide professional continuity from the design phase to the construction phase. If we do not perform observations and testing during construction, it becomes the responsibility of others to validate the assumption made during the preparation of this report and to accept the construction-related geotechnical engineer-of-record responsibilities.

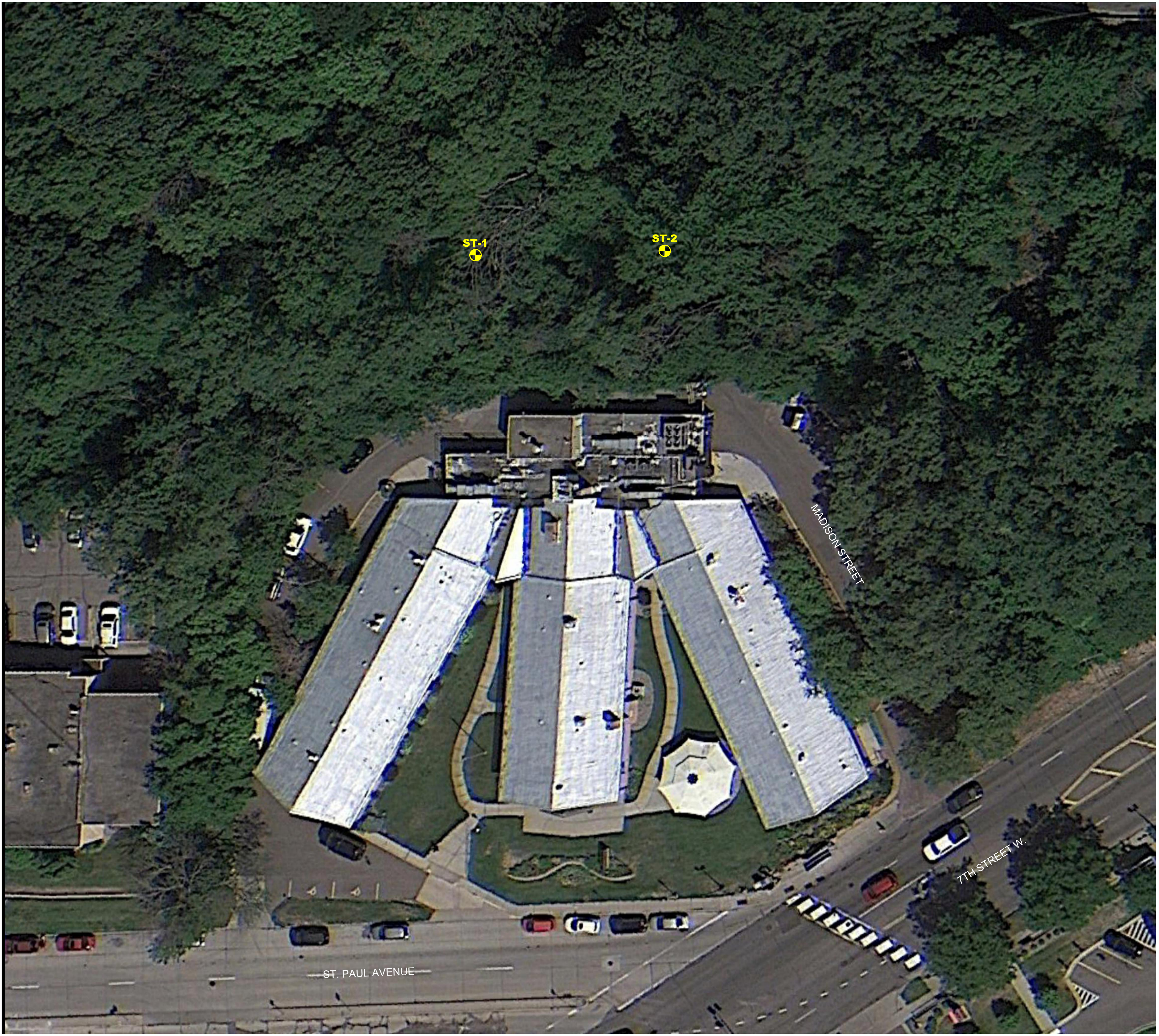
E.3. Use of Report

This report is for the exclusive use of the addressed parties. Without written approval, we assume no responsibility to other parties regarding this report. Our evaluation, analyses and recommendations may not be appropriate for other parties or projects.

E.4. Standard of Care

In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession currently practicing in the same locality. No warranty, express or implied, is made.

Appendix



⊕ **DENOTES APPROXIMATE LOCATION OF STANDARD PENETRATION TEST BORING**

20' 0 40'

SCALE: 1"= 40'

BRAUN INTERTEC
The Science You Build On.

11001 Hampshire Avenue S
Minneapolis, MN 55438
952.995.2000
braunintertec.com

Drawing Information

Project No:
B2207530

Drawing No:
B2207530

Drawn By: JAG
Date Drawn: 8/8/22
Checked By: AB
Last Modified: 10/25/22

Project Information

Treehouse Apartments

2319 7th Street W.

St. Paul, Minnesota

Soil Boring Location Sketch

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2207530
Geotechnical Evaluation
Treehouse Apartments
2319 7th Street West
Saint Paul, Minnesota

BORING:	**ST-1**		
LOCATION: See attached sketch			
DATUM: NAD 1983 HARN Adj MN Ramsey (US Feet)			
NORTHING:	141637	EASTING:	556435
DRILLER:	M. Hoppe	LOGGED BY:	R. Jett
START DATE:	10/14/22	END DATE:	10/14/22
SURFACE ELEVATION:	847.8 ft	RIG:	7504
METHOD:	3 1/4" HSA		
SURFACING:	Grass	WEATHER:	Clear, 42°F

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	qₚ tsf	MC %	Tests or Remarks
		SILTY SAND (SM), fine to coarse-grained, trace Gravel, dark brown, moist (TOPSOIL)					
845.8 2.0		SHALE, bluish gray, moist to dry, decomposed to highly weathered, hand deformed sample classified as "FAT CLAY (CH)" (APPARENT BEDROCK)	⧖	4-5-6 (11) 12"		23	LL=50, PL=27, PI=23 DD=98 pcf
5			⧖	5-9-10 (19) 10"		23	
			⧖	40-28-15 (43) 10"		26	
10			⧖	8-22-26 (48) 10"		21	LL=53, PL=27, PI=26 DD=96 pcf
			⧖	12-16-18 (34) 12"		19	
15			⧖	10-16-20 (36) 16"		19	
20			⧖	16-17-20 (37) 18"		20	LL=54, PL=27, PI=27
25			⧖	16-21-24 (45) 10"			
30			⧖	12-24-26 (50) 12"			

Continued on next page

LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2207530 **Geotechnical Evaluation** **Treehouse Apartments** **2319 7th Street West** **Saint Paul, Minnesota**		BORING: **ST-1**	
		LOCATION: See attached sketch	
		DATUM: NAD 1983 HARN Adj MN Ramsey (US Feet)	
		NORTHING: 141637	EASTING: 556435
DRILLER: M. Hoppe	LOGGED BY: R. Jett	START DATE: 10/14/22	END DATE: 10/14/22
SURFACE ELEVATION: 847.8 ft	RIG: 7504 / METHOD: 3 1/4" HSA	SURFACING: Grass	WEATHER: Clear, 42°F

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)		Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
		SHALE, bluish gray, moist to dry, decomposed to highly weathered, hand deformed sample classified as "FAT CLAY (CH)" (APPARENT BEDROCK)						
			35	⧖	10-18-23 (41) 16"			
			40	⧖	50/3" (REF) 12"		13	
803.0 44.8		END OF BORING Boring then grouted	45	⧖	50/4" (REF) 10"			Water not observed while drilling.
			50					
			55					
			60					

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2207530
Geotechnical Evaluation
Treehouse Apartments
2319 7th Street West
Saint Paul, Minnesota

BORING:	**ST-2**		
LOCATION: See attached sketch			
DATUM: NAD 1983 HARN Adj MN Ramsey (US Feet)			
NORTHING:	141639	EASTING:	556512
DRILLER:	M. Hoppe	LOGGED BY:	R. Jett
START DATE:	10/13/22	END DATE:	10/13/22
SURFACE ELEVATION:	840.5 ft	RIG: 7504	METHOD: 3 1/4" HSA
SURFACING:	Grass	WEATHER:	Clear, 42°F

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
839.6 0.9		SILTY SAND (SM), fine to medium-grained, trace Gravel, dark brown, moist (TOPSOIL)					
		SHALE, bluish gray, moist, decomposed to highly weathered, hand deformed sample classified as "FAT CLAY (CH)" (APPARENT BEDROCK)	⊠	4-5-6 (11) 10"			
		5	⊠	5-12-17 (29) 8"		22	LL=62, PL=21, PI=41
			⊠	12-15-17 (32) 10"		21	LL=57, PL=27, PI=30
		10	⊠	7-12-15 (27) 12"		15	DD=113 pcf
			⊠	26-30-32 (62) 12"		26	LL=47, PL=22, PI=25
		15	⊠	18-26-42 (68) 14"		24	
		20	⊠	8-21-24 (45) 10"		20	
		25	⊠	8-18-26 (44) 12"		19	DD=102 pcf
		30	⊠	7-21-30 (51) 12"		19	LL=57, PL=26, PI=31

Continued on next page

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2207530
Geotechnical Evaluation
Treehouse Apartments
2319 7th Street West
Saint Paul, Minnesota

BORING:	**ST-2**		
LOCATION: See attached sketch			
DATUM: NAD 1983 HARN Adj MN Ramsey (US Feet)			
NORTHING:	141639	EASTING:	556512
DRILLER: M. Hoppe	LOGGED BY: R. Jett	START DATE: 10/13/22	END DATE: 10/13/22
SURFACE ELEVATION: 840.5 ft	RIG: 7504	METHOD: 3 1/4" HSA	
SURFACING:	Grass	WEATHER:	Clear, 42°F

Elev./ Depth ft	Water Level		Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)		Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
		▤	SHALE, bluish gray, moist, decomposed to highly weathered, hand deformed sample classified as "FAT CLAY (CH)" (APPARENT BEDROCK)	35	⧗	36-50/4" (REF) 10"			Water not observed while drilling.
804.7 35.8			END OF BORING Boring then grouted						
				40					
				45					
				50					
				55					
				60					

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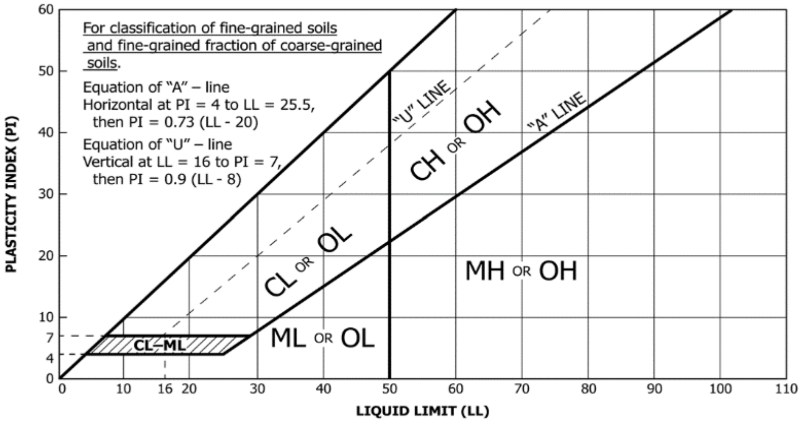
Descriptive Terminology of Soil

Based on Standards ASTM D2487/2488
(Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name[B]
Coarse-grained Soils (more than 50% retained on No. 200 sieve)	**Gravels** (More than 50% of coarse fraction retained on No. 4 sieve)	**Clean Gravels** (Less than 5% fines[C])	$C_u \geq 4$ and $1 \leq C_c \leq 3$[D]	GW	Well-graded gravel[E]
			$C_u < 4$ and/or ($C_c < 1$ or $C_c > 3$)[D]	GP	Poorly graded gravel[E]
		Gravels with Fines (More than 12% fines[C])	Fines classify as ML or MH	GM	Silty gravel[E F G]
			Fines Classify as CL or CH	GC	Clayey gravel[E F G]
	Sands (50% or more coarse fraction passes No. 4 sieve)	**Clean Sands** (Less than 5% fines[H])	$C_u \geq 6$ and $1 \leq C_c \leq 3$[D]	SW	Well-graded sand[I]
			$C_u < 6$ and/or ($C_c < 1$ or $C_c > 3$)[D]	SP	Poorly graded sand[I]
		Sands with Fines (More than 12% fines[H])	Fines classify as ML or MH	SM	Silty sand[F G I]
			Fines classify as CL or CH	SC	Clayey sand[F G I]
Fine-grained Soils (50% or more passes the No. 200 sieve)	**Silts and Clays** (Liquid limit less than 50)	Inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K L M]
			PI < 4 or plots below "A" line[J]	ML	Silt[K L M]
		Organic	$\frac{\text{Liquid Limit – oven dried}}{\text{Liquid Limit – not dried}}$ <0.75	OL	Organic clay [K L M N] Organic silt [K L M O]
	Silts and Clays (Liquid limit 50 or more)	Inorganic	PI plots on or above "A" line	CH	Fat clay[K L M]
			PI plots below "A" line	MH	Elastic silt[K L M]
		Organic	$\frac{\text{Liquid Limit – oven dried}}{\text{Liquid Limit – not dried}}$ <0.75	OH	Organic clay [K L M P] Organic silt [K L M Q]
Highly Organic Soils		Primarily organic matter, dark in color, and organic odor		PT	Peat

A. Based on the material passing the 3-inch (75-mm) sieve.
B. If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
C. Gravels with 5 to 12% fines require dual symbols:
    GW-GM well-graded gravel with silt
    GW-GC well-graded gravel with clay
    GP-GM poorly graded gravel with silt
    GP-GC poorly graded gravel with clay
D. $C_u = D_{60} / D_{10}$ $C_c = (D_{30})^2 / (D_{10}\ x\ D_{60})$
E. If soil contains ≥ 15% sand, add "with sand" to group name.
F. If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
G. If fines are organic, add "with organic fines" to group name.
H. Sands with 5 to 12% fines require dual symbols:
    SW-SM well-graded sand with silt
    SW-SC well-graded sand with clay
    SP-SM poorly graded sand with silt
    SP-SC poorly graded sand with clay
I. If soil contains ≥ 15% gravel, add "with gravel" to group name.
J. If Atterberg limits plot in hatched area, soil is CL-ML, silty clay.
K. If soil contains 15 to < 30% plus No. 200, add "with sand" or "with gravel", whichever is predominant.
L. If soil contains ≥ 30% plus No. 200, predominantly sand, add “sandy” to group name.
M. If soil contains ≥ 30% plus No. 200 predominantly gravel, add “gravelly” to group name.
N. PI ≥ 4 and plots on or above “A” line.
O. PI < 4 or plots below “A” line.
P. PI plots on or above “A” line.
Q. PI plots below “A” line.



Laboratory Tests

DD	Dry density, pcf	**q_p**	Pocket penetrometer strength, tsf
WD	Wet density, pcf	**q_U**	Unconfined compression test, tsf
P200	% Passing #200 sieve	**LL**	Liquid limit
MC	Moisture content, %	**PL**	Plastic limit
OC	Organic content, %	**PI**	Plasticity index

Particle Size Identification

Boulders............. over 12"
Cobbles............... 3" to 12"
Gravel
    Coarse............ 3/4" to 3" (19.00 mm to 75.00 mm)
    Fine................ No. 4 to 3/4" (4.75 mm to 19.00 mm)
Sand
    Coarse............. No. 10 to No. 4 (2.00 mm to 4.75 mm)
    Medium........... No. 40 to No. 10 (0.425 mm to 2.00 mm)
    Fine................. No. 200 to No. 40 (0.075 mm to 0.425 mm)
Silt........................ No. 200 (0.075 mm) to .005 mm
Clay..................... < .005 mm

Relative Proportions[L, M]

trace............................ 0 to 5%
little............................. 6 to 14%
with............................. ≥ 15%

Inclusion Thicknesses

lens.............................. 0 to 1/8"
seam............................ 1/8" to 1"
layer............................. over 1"

Apparent Relative Density of Cohesionless Soils

Very loose .... 0 to 4 BPF
Loose .... 5 to 10 BPF
Medium dense............. 11 to 30 BPF
Dense........................... 31 to 50 BPF
Very dense................... over 50 BPF

Consistency of Cohesive Soils	Blows Per Foot	Approximate Unconfined Compressive Strength
Very soft..................	0 to 1 BPF..................	< 0.25 tsf
Soft..........................	2 to 4 BPF..................	0.25 to 0.5 tsf
Medium...................	5 to 8 BPF	0.5 to 1 tsf
Stiff..........................	9 to 15 BPF................	1 to 2 tsf
Very Stiff..................	16 to 30 BPF..............	2 to 4 tsf
Hard.........................	over 30 BPF...............	> 4 tsf

Moisture Content:

Dry: Absence of moisture, dusty, dry to the touch.
Moist: Damp but no visible water.
Wet: Visible free water, usually soil is below water table.

Drilling Notes:

Blows/N-value: Blows indicate the driving resistance recorded for each 6-inch interval. The reported N-value is the blows per foot recorded by summing the second and third interval in accordance with the Standard Penetration Test, ASTM D1586.

Partial Penetration: If the sampler could not be driven through a full 6-inch interval, the number of blows for that partial penetration is shown as #/x" (i.e. 50/2"). The N-value is reported as "REF" indicating refusal.

Recovery: Indicates the inches of sample recovered from the sampled interval. For a standard penetration test, full recovery is 18", and is 24" for a thinwall/shelby tube sample.

WOH: Indicates the sampler penetrated soil under weight of hammer and rods alone; driving not required.

WOR: Indicates the sampler penetrated soil under weight of rods alone; hammer weight and driving not required.

Water Level: Indicates the water level measured by the drillers either while drilling (▽), at the end of drilling (▼), or at some time after drilling (▼).

Sample Symbols

☒	Standard Penetration Test	▮	Rock Core
⧗	Modified California (MC)	■	Thinwall (TW)/Shelby Tube (SH)
⬇	Auger	▽	Texas Cone Penetrometer
✋	Grab Sample	▽	Dynamic Cone Penetrometer

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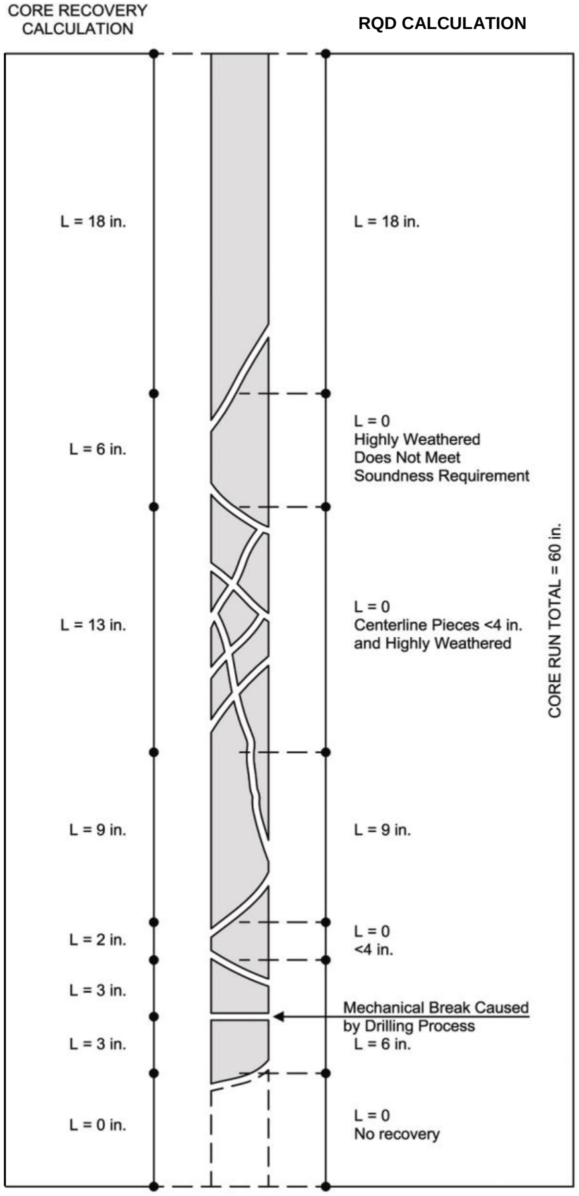
Descriptive Terminology of Rock

Based on U.S. Army Corps of Engineers EM 1110-1-2908



Example Calculations

$$\text{Core Recovery, CR} = \frac{\text{Total length of rock recovered}}{\text{Total core run length}}$$

$$\text{Example:CR} = \frac{(18 + 6 + 13 + 9 + 2 + 3 + 3)}{(60)}$$

CR = 90%

$$\text{RQD} = \frac{\text{Sum of sound pieces 4 inches or larger}}{\text{Total core run length}}$$

RQD Percent	Rock Quality
< 25	very poor
25 < 50	poor
50 < 75	fair
75 < 90	good
90 < 100	excellent

$$\text{Example: RQD} = \frac{(18 + 9 + 6)}{(60)}$$

RQD = 55%

Weathering

Unweathered: No evidence of chemical or mechanical alteration.

Slightly weathered: Slight discoloration on surface, slight alteration along discontinuities, less than 10% of rock volume altered.

Moderately Weathered: Discoloration evident, surface pitted and altered with alteration penetrating well below rock surfaces, weathering halos evident, 10% to 50% of the rock altered.

Highly Weathered: Entire mass discolored, alteration pervading nearly all of the rock, with some pockets of slightly weathered rock noticeable, some mineral leached away.

Decomposed: Rock reduced to a soil consistency with relict rock texture, generally molded and crumbled by hand.

Hardness

Very soft:	Can be deformed by hand
Soft:	Can be scratched with a fingernail
Moderately hard:	Can be scratched easily with a knife
Hard:	Can be scratched with difficulty with a knife
Very hard:	Cannot be scratched with a knife

Texture

Sedimentary Rocks:	Grain Size
Coarse grained	2 – 5 mm
Medium grained	0.4 – 2 mm
Fine grained	0.1 – 0.4 mm
Very fine grained	< 0.1 mm
Igneous and Metamorphic Rocks:	
Coarse grained	5 mm
Medium grained	1 – 5 mm
Fine grained	0.1 – 1 mm
Aphanitic	< 0.1 mm

Thickness of Bedding

Massive:	3 ft. thick or greater
Thick bedded:	1 to 3 ft. thick
Medium bedded:	4 in. to 1 ft. thick
Thin bedded:	4 in. thick or less

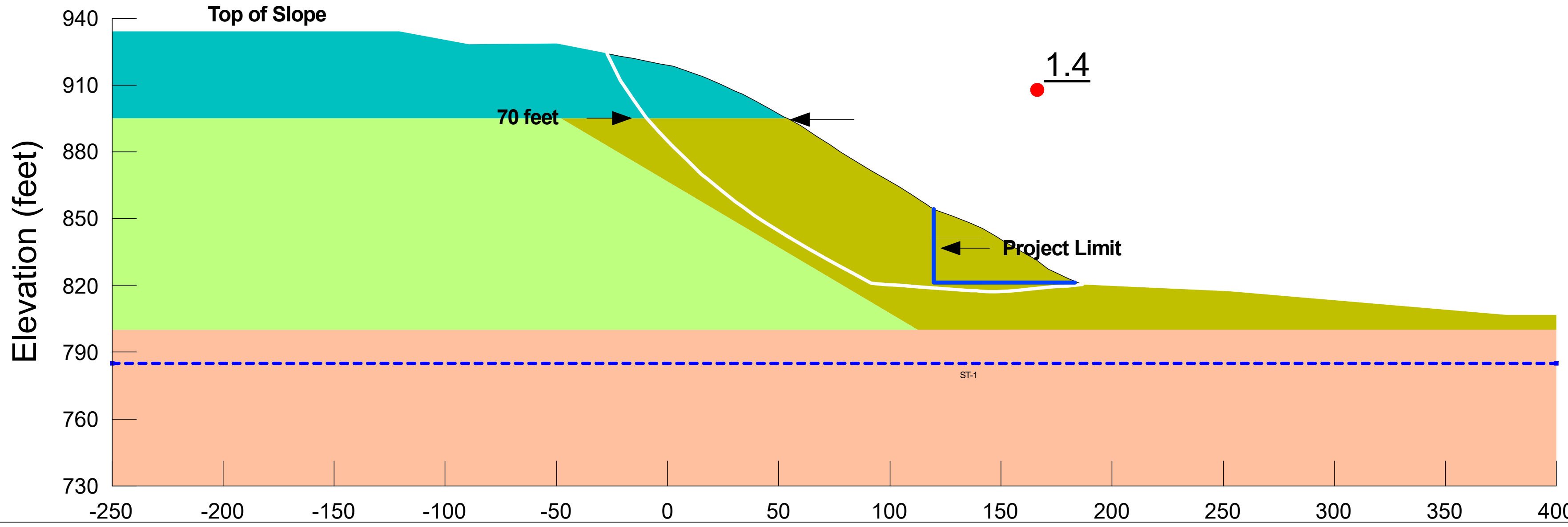
Degree of Fracturing (Jointing)

Unfractured:	Fracture spacing 6 ft. of more
Slightly fractured:	Fracture spacing 2 to 6 ft.
Moderately fractured:	Fracture spacing 8 in. to 2 ft.
Highly fractured:	Fracture spacing 2 in. to 8 in.
Intensely fractured:	Fracture spacing 2 in. or less

Title: B2207530: Treehouse Apartments
Name: A. Existing Slope
Kind: SLOPE/W

Long-term Stability
Effective Stress Parameter

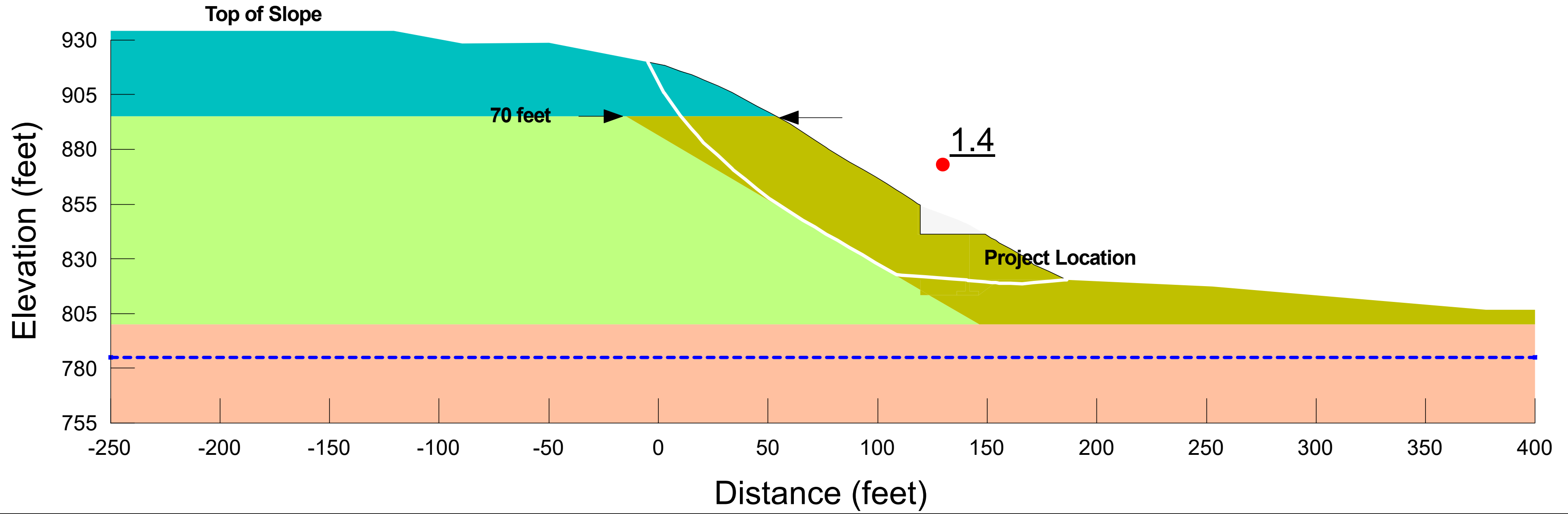
Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-Anisotropic Strength Fn.	C-Anisotropic Strength Fn.	Piezometric Surface
🟨	Anisotropic Shale	115	400	24	Anisotropic Shale Friction	Anisotropic Shale Cohesion	1
🟦	Glacial Till	130	200	32			1
🟩	Isotropic Shale	120	500	30			1
🟧	Sandstone	125	0	38			1



Title: B2207530: Treehouse Apartments
Name: B. Upper Excavation
Kind: SLOPE/W

Long-term Stability
Effective Stress Parameter

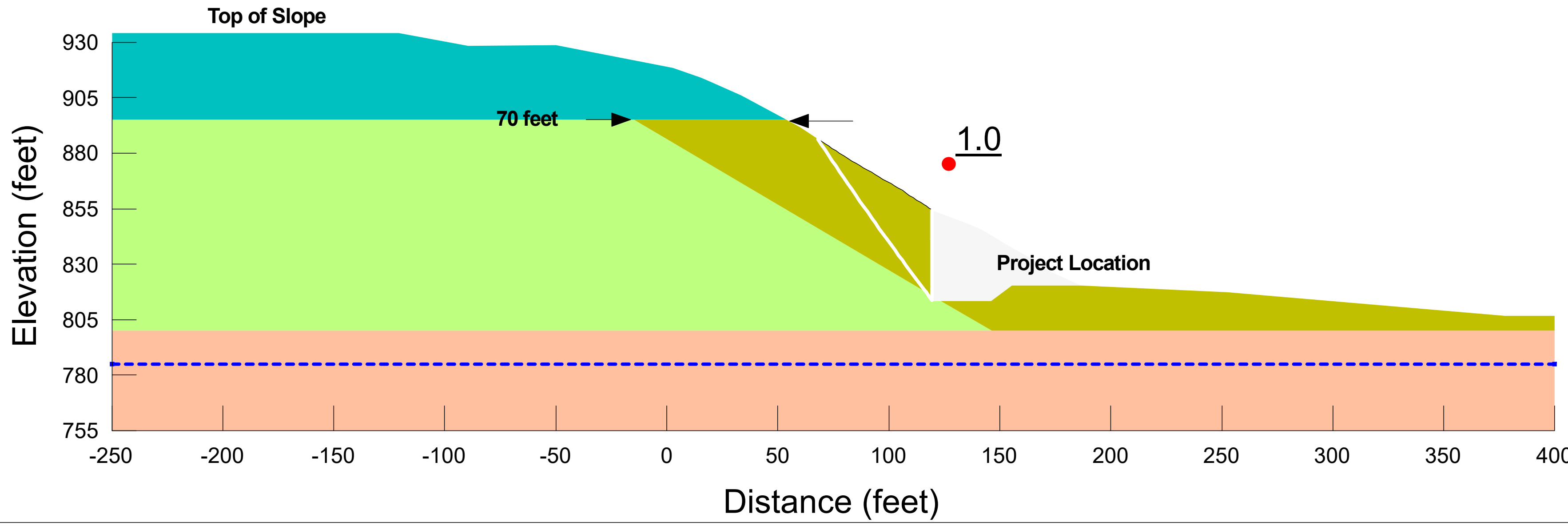
Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-Anisotropic Strength Fn.	C-Anisotropic Strength Fn.	Piezometric Surface
🟨	Anisotropic Shale	115	400	24	Anisotropic Shale Friction	Anisotropic Shale Cohesion	1
🟦	Glacial Till	130	200	32			1
🟩	Isotropic Shale	120	500	30			1
🟧	Sandstone	125	0	38			1



Title: B2207530: Treehouse Apartments
Name: C. Foundation Excavation
Kind: SLOPE/W

Long-term Stability
Effective Stress Parameter

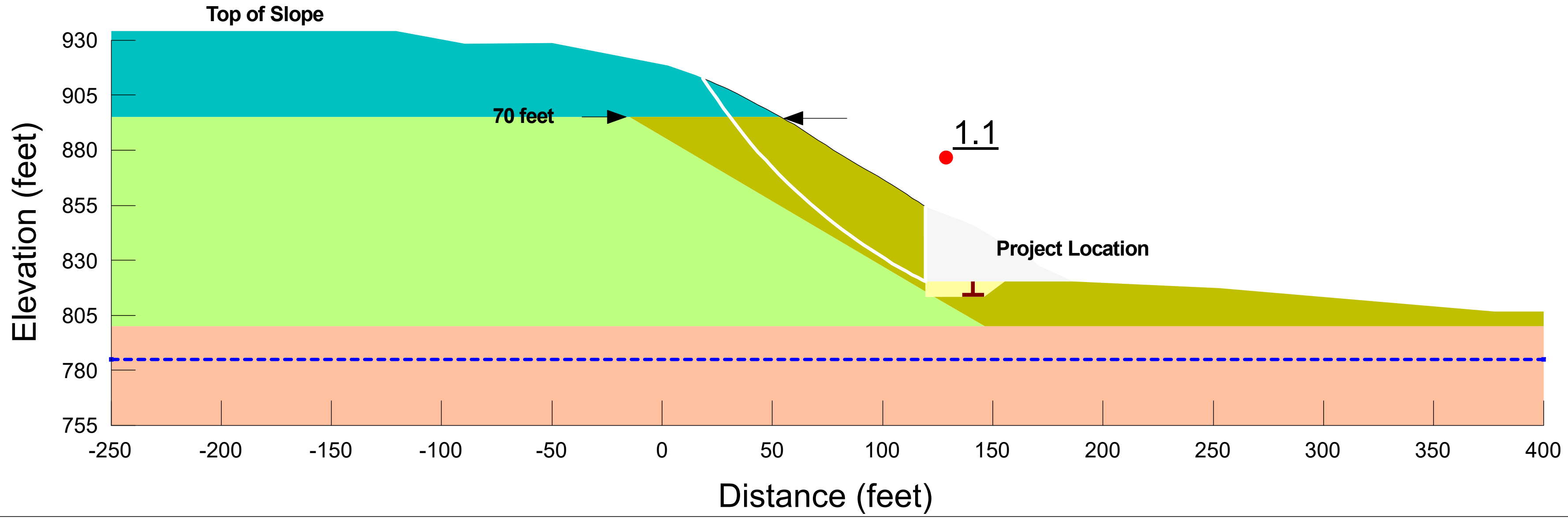
Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-Anisotropic Strength Fn.	C-Anisotropic Strength Fn.	Piezometric Surface
🟨	Anisotropic Shale	115	400	24	Anisotropic Shale Friction	Anisotropic Shale Cohesion	1
🟦	Glacial Till	130	200	32			1
🟩	Isotropic Shale	120	500	30			1
🟧	Sandstone	125	0	38			1



Title: B2207530: Treehouse Apartments
Name: D. Foundation Installation
Kind: SLOPE/W

Long-term Stability
Effective Stress Parameter

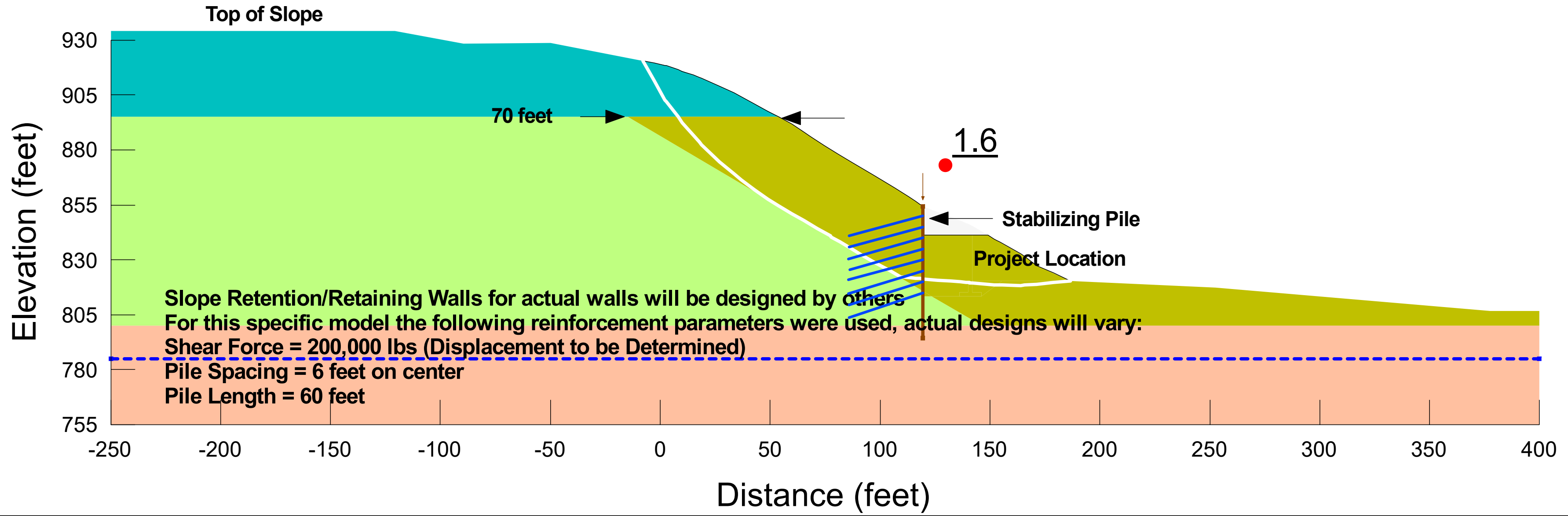
Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-Anisotropic Strength Fn.	C-Anisotropic Strength Fn.	Piezometric Surface
🟫	Anisotropic Shale	115	400	24	Anisotropic Shale Friction	Anisotropic Shale Cohesion	1
🟦	Glacial Till	130	200	32			1
🟩	Isotropic Shale	120	500	30			1
🟨	Sand Fill	120	0	30			1
🟧	Sandstone	125	0	38			1
🟥	Wall	115					1



Title: B2207530: Treehouse Apartments
Name: F. Upper Excavation with Pile
Kind: SLOPE/W

Long-term Stability
Effective Stress Parameter

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-Anisotropic Strength Fn.	C-Anisotropic Strength Fn.	Piezometric Surface
🟨	Anisotropic Shale	115	400	24	Anisotropic Shale Friction	Anisotropic Shale Cohesion	1
🟦	Glacial Till	130	200	32			1
🟩	Isotropic Shale	120	500	30			1
🟧	Sandstone	125	0	38			1

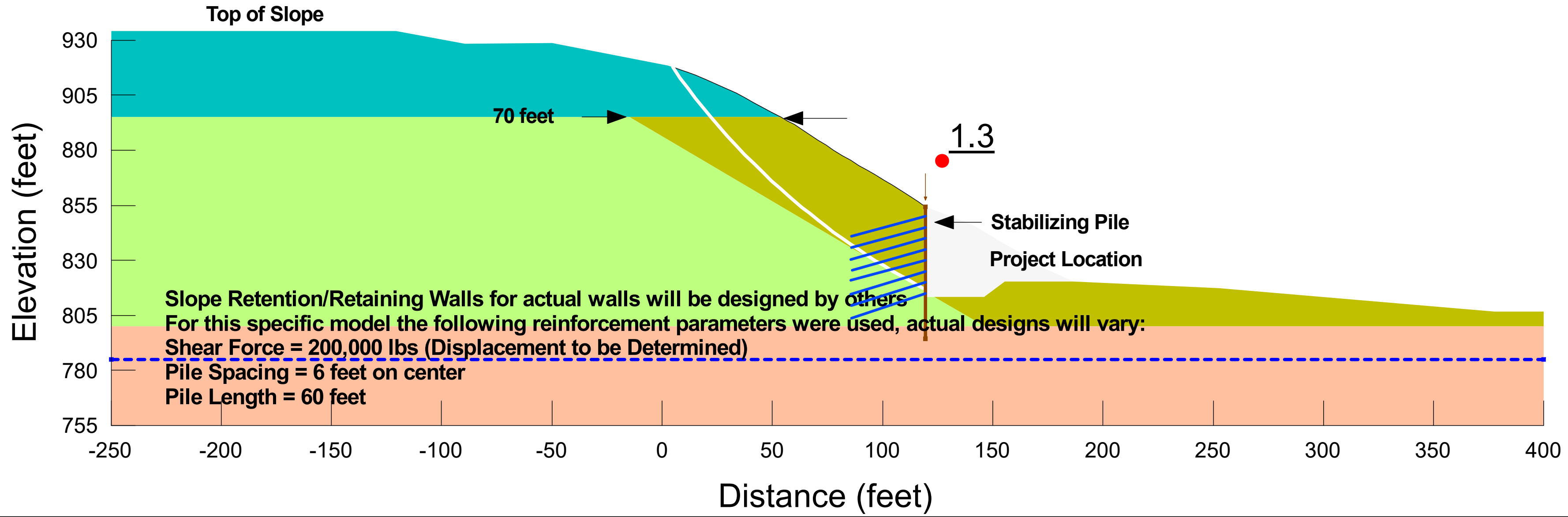


Slope Retention/Retaining Walls for actual walls will be designed by others
For this specific model the following reinforcement parameters were used, actual designs will vary:
Shear Force = 200,000 lbs (Displacement to be Determined)
Pile Spacing = 6 feet on center
Pile Length = 60 feet

Title: B2207530: Treehouse Apartments
Name: G. Foundation Excavation with Pile
Kind: SLOPE/W

Long-term Stability
Effective Stress Parameter

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-Anisotropic Strength Fn.	C-Anisotropic Strength Fn.	Piezometric Surface
🟨	Anisotropic Shale	115	400	24	Anisotropic Shale Friction	Anisotropic Shale Cohesion	1
🟦	Glacial Till	130	200	32			1
🟩	Isotropic Shale	120	500	30			1
🟧	Sandstone	125	0	38			1

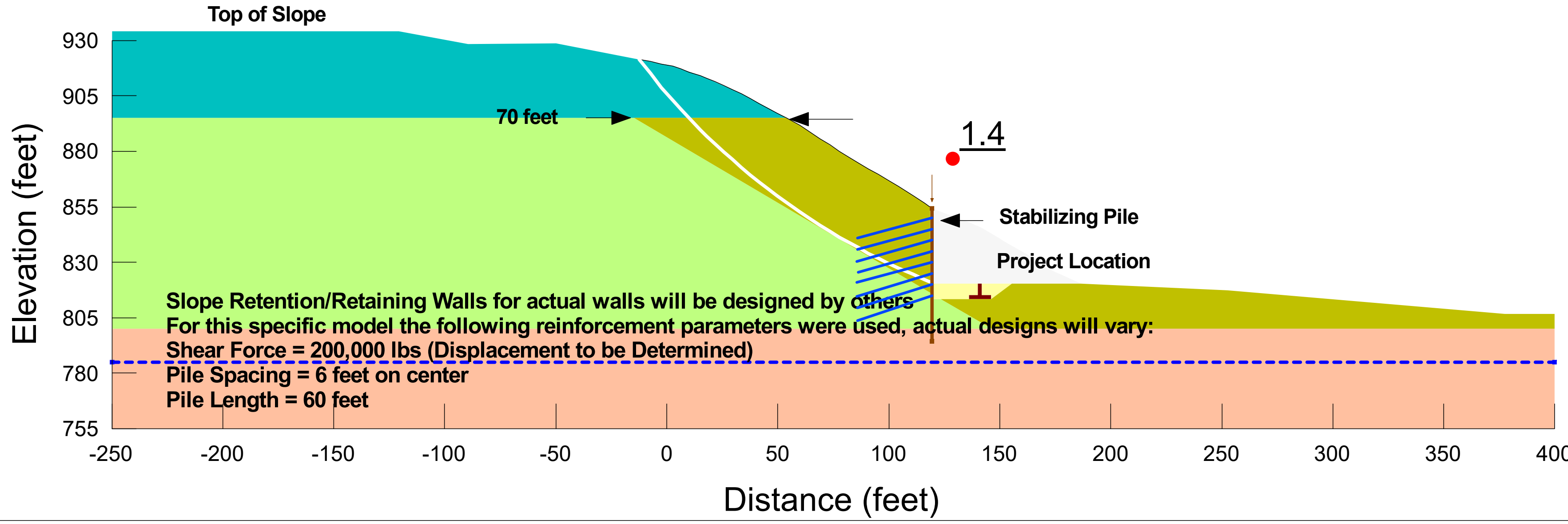


Slope Retention/Retaining Walls for actual walls will be designed by others
For this specific model the following reinforcement parameters were used, actual designs will vary:
Shear Force = 200,000 lbs (Displacement to be Determined)
Pile Spacing = 6 feet on center
Pile Length = 60 feet

Title: B2207530: Treehouse Apartments
Name: H. Foundation Installation with Pile
Kind: SLOPE/W

Long-term Stability
Effective Stress Parameter

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-Anisotropic Strength Fn.	C-Anisotropic Strength Fn.	Piezometric Surface
🟫	Anisotropic Shale	115	400	24	Anisotropic Shale Friction	Anisotropic Shale Cohesion	1
🟦	Glacial Till	130	200	32			1
🟩	Isotropic Shale	120	500	30			1
🟨	Sand Fill	120	0	30			1
🟧	Sandstone	125	0	38			1
🟥	Wall	115					1

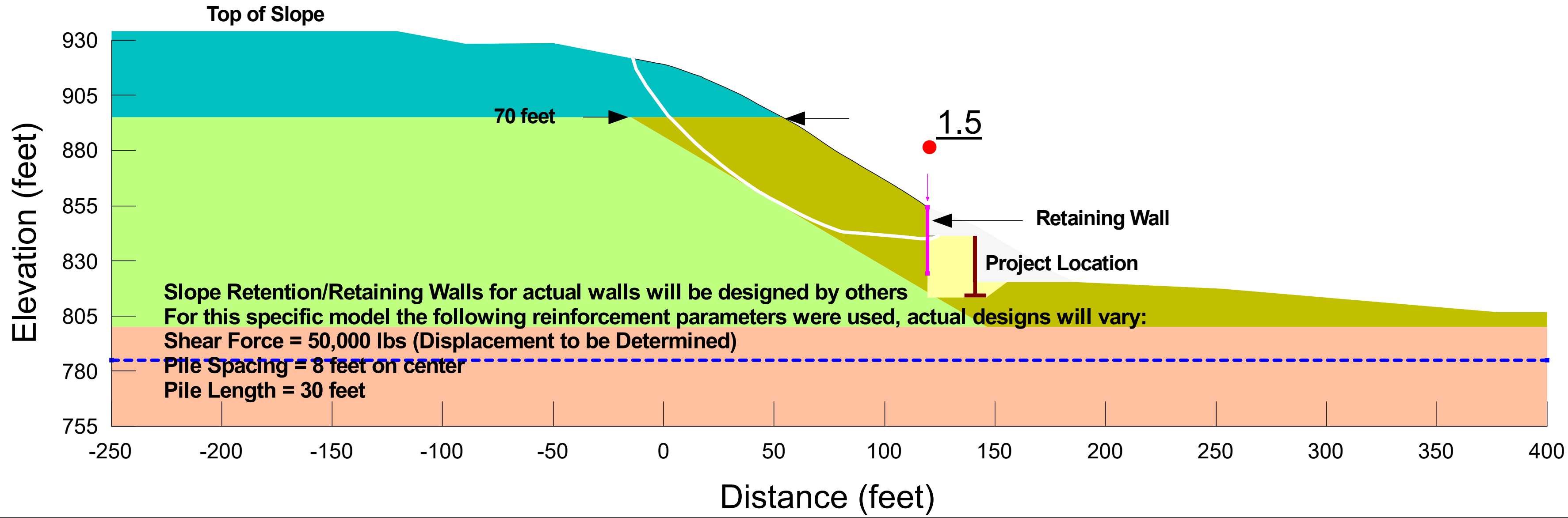


Slope Retention/Retaining Walls for actual walls will be designed by others
For this specific model the following reinforcement parameters were used, actual designs will vary:
Shear Force = 200,000 lbs (Displacement to be Determined)
Pile Spacing = 6 feet on center
Pile Length = 60 feet

Title: B2207530: Treehouse Apartments
Name: E. Final Condition
Kind: SLOPE/W

Long-term Stability
Effective Stress Parameter

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-Anisotropic Strength Fn.	C-Anisotropic Strength Fn.	Piezometric Surface
🟫	Anisotropic Shale	115	400	24	Anisotropic Shale Friction	Anisotropic Shale Cohesion	1
🟦	Glacial Till	130	200	32			1
🟩	Isotropic Shale	120	500	30			1
🟨	Sand Fill	120	0	30			1
🟧	Sandstone	125	0	38			1
🟥	Wall	115					1



Slope Retention/Retaining Walls for actual walls will be designed by others
For this specific model the following reinforcement parameters were used, actual designs will vary:
Shear Force = 50,000 lbs (Displacement to be Determined)
Pile Spacing = 8 feet on center
Pile Length = 30 feet