Great Lakes Water Supply Program

GREAT WATER ALLIANCE

6-120 D5 Geotechnical Report, Contract Packages 3 and 3A, Booster Pumping Station and Water Tower, Waukesha, WI

September 2020

Waukesha Water Utility
SERVING WAUKESHA SINCE 1886

GREELEY AND HANSEN

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

PROGRAM TEAM MEMBER CONSULTANTS:

intertek
Total Quality. Assured.
psi

EXECUTIVE SUMMARY

This report is a geotechnical evaluation of the subsurface conditions encountered at the borings performed for the proposed Booster Pumping Station (BPS) and Water Tower site for the Great Water Alliance (Program). The BPS and Water Tower fall under Contract Packages 3 and 3A, respectively. The purpose of this geotechnical report was to evaluate the subsurface conditions at 19 boring locations and two test pit locations and provide recommendations regarding construction of the new pumping station building, two reservoirs, water tower, stormwater management area, and adjacent pavements. The borings performed indicate that the subsurface conditions are generally considered to be suitable for support of the proposed construction.

Based on the size of the reservoir tanks, and the estimated loading, in order to limit the magnitude of settlement of the reservoirs, it is recommended that any near surface lean clay soils present below planned tank subgrade be removed to expose the underlying medium dense to dense natural granular soils. Subsequent Select Fill placement must be performed as recommended in the Reservoir Tank Subgrade Preparation section of this report. It is estimated that where the recommendations within this report are followed, the settlement tolerances as specified by ACI 372R-13 will not be exceeded.

Water was encountered within all the test locations during drilling or excavation (for test pits), with the exception of the test pit BPSRN-B-18, at elevations ranging from about EL. 873 feet to EL. 850 feet. Some of these observed levels may represent perched conditions while others may represent the actual groundwater level. Excavations for the preparation of the subgrade for the reservoirs are generally anticipated to remain above these levels; however, variations in the water levels present during construction should be anticipated and reservoir subgrade preparation may encroach upon or extend below the water levels at the time of construction. Additionally the mat foundation for the lower level finished floor of the BPS building is estimated to encroach upon or extend below the groundwater levels observed at BPSRN-B-7, 8, and 15. At BPSRN-B-8, the water level observed during drilling was at EL. 865. Based on an estimated 2-foot-thick mat slab and a finished lower level elevation of EL. 866.5, the bottom of the mat slab is estimated to be at about EL. 864.5, which is about 1 foot below the water level at this location. It is generally recommended that the bottom of slabs be placed a minimum of 2 feet above the observed water level. However, it is understood that the lower level mat slab and below grade walls will be designed as necessary to resist any hydrostatic forces which they may be subject to.

Additionally, proper care and considerations must be made where stormwater management basins are constructed in close proximity to basements or other below grade structures. Water from the stormwater management basin could potentially infiltrate the drainage system of the lower level of the BPS building by means of lateral migration through the granular soils. Any free draining granular seams such as medium or coarse sand and gravel present near the stormwater basins which may be continuous with the lower level could also expedite this process. Lateral migration of water may result in water collecting around the basement area. The potential for such conditions to occur can greatly increase when basement floors are below the elevation of basin bottoms and/or when basins are placed in close proximity to structures. In addition, the presence of granular or other generally permeable soils, which is typically necessary in the areas of structures, especially within utility backfill, alongside basement walls, or within other development excavations, can act as channels to carry water from basins into nearby basements. In order to help minimize this, it is recommended that clay or bentonite collars be constructed at the end of utility trenches where they encroach upon the basement backfill.

It should be anticipated that the near surface clayey and silty soils at this site may be in a very moist condition once exposed below the topsoil, which may result in these materials being unstable, due to their sensitivity to moisture and construction disturbance. Where observed during construction, very moist or wet, unstable soils encountered at the surface of the site may either be scarified, dried, and recompacted to a minimum of 95% of the maximum dry density as obtained by the modified Proctor test (ASTM D1557), if feasible, or excavated below subgrade (EBS), and replaced with a select granular material meeting the gradation specified for Select Fill in the Draft Backfill Specifications included in **Appendix C**.

A detailed description of the subsurface conditions and more in-depth recommendations are provided in this report.

SECTION 1 Introduction

1.1 Project Description

The Booster Pumping Station (BPS) and Water Tower are to be constructed to the northeast of the intersection of East Broadway and Rempe Drive in Waukesha, WI, as shown in Figure 1 included in **Appendix A**. The site will include a pumping station building which has a footprint of about 84 by 130 feet. It is understood that the building will include below grade lower levels supported by mat foundations. The building will also include areas which are slab-on-grade and supported by conventional shallow spread footings. The planned finished first floor elevation of the pumping station building is EL. 880.5 feet Mean Sea Level (MSL), and the lower level basement is understood to be about 14 feet deep, with a finished floor elevation of about EL. 866.5 feet MSL; and the other lower level portion of the building is understood to be about 4 feet deep, with a finished floor elevation of about EL. 876.5 feet. The upper mat foundation is understood to be about 53 feet by 64 feet and the lower mat foundation is understood to be about 60 feet by 60 feet. Loading on the mat foundations were not known at the time of this report preparation but are estimated to range from about 1,500 to 3,000 pounds per square foot (psf).

Two large above-grade storage reservoirs (Reservoir No. 1 and No. 2) which are 184.5 feet in outside diameter and 180.5 feet in inside diameter, are planned on either side of the BPS building. These are planned to be supported by approximate 4-inch thick, reinforced membrane slabs with thickened perimeter foundations, 18 inches thick and 6.5 feet wide, cast monolithically with the slab. The finished floor elevation for both reservoirs is EL. 875.0 feet MSL. The planned grades adjacent to the reservoirs to the north and south will be at about EL. 888 feet and EL. 880 feet, which are about 13 and 5 feet above the reservoir finished floor elevation, respectively. Each reservoir will be at least about 45 feet tall. Loading on the membrane slabs and perimeter footing are understood to be 2,860 psf and 4,500 psf, respectively.

The project also includes a water tower which is an elevated tank with a pedestal. The tank base is planned at EL. 885, with the adjacent grade at EL. 881. The high-water level within the tank is EL. 1011.5 with the top of the roof hatch of the tank at about EL. 1020.5. The total height of the tank from the adjacent grade of EL. 881 is about 139.5 feet. The pedestal will be supported by a ring foundation with 8-foot-wide spread footings. Bearing elevation of the ring foundation is estimated to be about 10 feet below the planned adjacent grade or EL. 871.

The project includes the construction of new pavement surrounding the pumping station building and an access drive to the west of the building and reservoirs (see Figure 1). The pavement is estimated to be subjected to standard duty loading conditions with potential heavy-duty loading in areas.

A stormwater management basin is proposed for the planned development to the south of the proposed building. The basin will be designed as a wet pond with a planned bottom elevation of EL. 868 and the forebays will have a bottom elevation of EL. 874.

The parameters which are the basis for the evaluation and recommendations presented in this geotechnical report are provided in **Table 1-1**.

Table 1-1 Project Parameters

Structure	Parameter	Value
Booster Pumping Station Building	Planned Finished First Floor Elevation	EL. 880.5 feet MSL
	Planned Upper Below Grade Finished Floor Elevation	EL. 876.5.5 feet MSL
	Planned Lower Below Grade Finished Floor Elevation	EL. 866.5 feet MSL
	Planned Foundation Type in Lower Below Grade Level	Mat
	Planned Foundation Type in Upper Below Grade Level	Mat
	Estimated Bearing Elevations of Mat Slabs	2 feet below Finished Floor (EL. 874.5 and EL. 864.5, respectively)
	Planned Foundation Type in SOG Areas	Conventional Spread
	Estimated Interior and Perimeter Foundation Bearing Grades in SOG Areas	EL. 879 feet and EL. 876.5 feet MSL
Reservoirs	Outside Diameter	184.5 feet
	Inside Diameter	180.5 feet
	Planned Finished Floor Elevation	EL. 875.0 feet MSL
	Planned Foundation Type	Membrane Floor with Perimeter Foundation
	Estimated Membrane Floor Bearing Grade	EL. 874.5 feet MSL
	Estimated Perimeter Spread Foundation Bearing Grade	EL. 874 feet MSL
	Perimeter Foundation Width	6.5 feet
	Maximum Water Height in the Reservoirs	45 feet
	Contact Pressure Below Perimeter Foundation	4,500 psf
	Contact Pressure Below Tank Floor	2,860 psf
Pavements	Light Duty Pavement 18-kip ESALs for 20 Year Design Period	30,000 ESALs
	Heavy Duty Pavement 18-kip ESALs for 20 Year Design Period	60,000 ESALs
Wet Pond	Planned Bottom Elevation	EL. 868 feet MSL

The geotechnical recommendations presented in this report are based on the available (or estimated) project information, building location, reservoir locations, stormwater management area location, and the subsurface materials described. Where the actual conditions differ from what is shown above, the Program geotechnical engineer must be notified. A re-evaluation or redirection of the results contained herein can then be performed as necessary. The recommendations included herein are based on the most recent plans provided. It is recommended that the Program geotechnical engineer review the final plans, and changes to the recommendations in this report can be provided where necessary.

1.2 Purpose and Scope of Services

The purpose of this study was to explore the subsurface conditions at the site and develop geotechnical design criteria regarding the foundations, floor slabs, below grade walls, pavements, and stormwater management basin for the proposed project. Subgrade preparation recommendations and construction considerations are also provided. PSI's scope of services for Contract Package 3 included drilling 19 soil test borings (BPSRN-B-1 through 16, 19, and WTRN-B-1 through 2), performing 2 test pits excavations (BPSRN-B-17 and 18), select laboratory testing, and preparation of this geotechnical report. The borings were performed in locations based on the original site layout. The most recent site layout has changed significantly from the original, resulting in some of the borings being outside of structure footprints. Borings were generally performed to planned depths of 30, 40, or 100 feet. However, mud rotary refusal was encountered at boring BPS-B-6 at a depth of about 92 feet (EL. 788 feet) and BPSRN-11 at a depth of about 67.5 feet (EL. 813.5), on possible cobbles, boulders, or bedrock. BPSRN-B-17 and 18 test pits were performed to a planned depth of 12 feet below existing grade. Borings BPSRN-B-1 and 10 were performed for a potential retaining wall and BPSRN-11 was performed to evaluate the subsoils at the top of the slope for potential global stability evaluation. Several permanent and temporary retaining walls are planned for the development. It is understood that the wall designers will be responsible for evaluating both internal and external stability of these walls. A global stability analysis was performed on the proposed geometry and loading through the area of proposed Reservoir 2, including the existing and proposed slopes above and below the reservoir. Boring BPSRN-B-3 fell outside of any structural areas based on the most recent site layout. This boring and BPSRN-B-1, 10, and 11 were therefore not used to evaluated specific structures but were used for general site information.

The scope of services did not include an environmental assessment for determining the presence or absence of wetlands, or hazardous or toxic materials in the bedrock, surface water, groundwater, or air on or below, or around this site.

With respect to the potential stormwater management area, the field and laboratory work for classification of the subgrade soils was performed to provide information for use by the basin design personnel when considering requirements of Chapter NR151 of the Wisconsin Administrative Code, and of WDNR Technical Standard 1002, "Site Evaluation for Stormwater Infiltration" guidelines. The design of the proposed stormwater management area was beyond the scope of services for this project.

SECTION 2 Site and Subsurface Conditions

2.1 Site Location and Description

The project site (see Figure 1 in **Appendix A**) is located to the northeast of the intersection of East Broadway and Rempe Drive in Waukesha, WI. The area of the project was generally vacant but contained dense brush and trees within most of the area of the project. Based on the plans provided, a delineated wetland area is present to the east of the site. The existing grades across the project area varied from about EL. 870 to EL. 885, generally sloping up to the north.

2.2 Field Testing Procedures

The soil test borings were performed with an all-terrain vehicle (ATV) mounted rotary drilling rig utilizing continuous flight hollow stem augers and mud rotary methods to advance the holes. Extensive brush and tree removal were necessary to gain access to the boring locations. Representative samples were obtained by the Standard Penetration Test (SPT) method using split-spoon sampling procedures in general accordance with ASTM D1586 procedures. Samples were collected at 2.5-foot intervals to 10 feet, and at 5-foot intervals thereafter, to the termination depths of the borings. The standard penetration value (N-value) is defined as the number of blows of a 140-pound hammer, falling 30 inches, required to advance the split-spoon sampler one foot into the soil. The sampler is lowered to the bottom of the drill hole and the number of blows recorded for each of three successive increments of six-inch penetrations. The N-value is obtained by adding the second and third incremental numbers. The SPT provides a means of estimating the relative density of granular soils and comparative consistency of cohesive soils, thereby providing a method of evaluating the relative strength and compressibility characteristics of the subsoils. Upon completion, the borings were backfilled with bentonite.

The SPT soil samples were transferred to clean glass jars immediately after retrieval and returned to the laboratory upon completion of the field operations. All soil samples were visually classified by a soil engineer in general accordance with the Unified Soil Classification System (ASTM D2488-75).

The eastern portion of the stormwater management area was evaluated with the use of two test pit excavations (BPSRN-B-17 and 18). The test pits were excavated with a backhoe to a depth of about 12 feet below existing grade as specified.

2.3 Laboratory Procedures

PSI conducted laboratory testing on select soil samples to aid in identifying and describing the physical characteristics of the soils and to aid in defining the site soil stratigraphy. The results of the field exploration and laboratory tests were used in PSI’s engineering analysis and in the formulation of our engineering recommendations. All laboratory testing was performed in general accordance with ASTM procedures or appropriate standards. Laboratory testing included moisture content testing. Atterberg Limits determination testing was performed on composite samples from BPSRN-B-2 (38.5 to 50 feet) and BPSRN-B-15 (43.5 to 50 feet). The test results are indicated in the table below.

Table 2-1 Atterberg Limits Testing Results

Boring	Depths (feet)	Liquid Limit	Plastic Limit	Plasticity Index	USCS Classification
BPSRN-B-2	38.5-40 43.5-45 48.5-50	26	14	12	CL
BPSRN-B-15	43.5-45 48.5-50	23	12	11	CL

2.4 Subsurface Conditions

The subsurface conditions were explored within borings BPSRN-B-1 through 19, and WTRN-B1 and 2. The borings were generally performed to planned depths of 40 feet or 100 feet. As an exception, stormwater management basin boring BPSRN-B-9 was performed to a planned depth of 30 feet. Additionally, mud rotary refusal was encountered at borings BPSRN-B-6 and 11 at depths of about 92 and 67.5 feet (EL. 788 feet and EL. 813.5 feet), respectively, on possible cobbles, boulders, or bedrock. The borings were located in the field by Ayres Associates. The surface elevations shown on the boring logs were interpolated from the site plan which included one-foot contour intervals. The elevations have been rounded to the nearest foot for ease of interpretation and are relative to National Geodetic Vertical Datum of 1929 (NGVD 29). Borings which were 40 feet deep or less were performed using hollow stem auger drilling to the boring termination depths. The remaining borings were advanced using hollow-stem auger drilling methods to depths of about 20 to 35 feet below existing grades where water was encountered, and then mud rotary drilling thereafter, to the termination depths of the borings. Mud rotary drilling methods use an approximate four-inch diameter tri-cone drilling bit along with circulated bentonite drilling fluid which helps the advancement of the drill bit below water levels, helps maintain borehole stability, and helps remove soil cuttings to the ground surface. Soil samples were routinely obtained during the drilling process. Drilling and sampling techniques were generally accomplished in accordance with ASTM procedures.

Representative soil samples were obtained from the soil borings and were returned to PSI’s laboratory where they were visually classified using the Unified Soil Classification System (USCS) as a guideline. The soil samples from the stormwater management area borings (BPSRN-B-9, 17, and 18) were visually classified in accordance with the United States Department of Agriculture (USDA) Textural Soil Classification System in order to help estimate infiltration rates for stormwater management area design. Further, PSI conducted limited laboratory testing on select soil samples to aid in identifying and describing the physical characteristics of the soils and to aid in defining the site soil stratigraphy. The results of the field exploration and laboratory tests were used in PSI’s engineering analysis and in the formulation of our engineering recommendations.

2.4.1 USCS Classification

The surficial material at the borings consisted of about 3 to 18± inches of topsoil. However, some variation should be expected, and topsoil thickness can increase encroaching upon wetland areas. Below the surface topsoil at BPSRN-B-1, 4, and 14 were fill materials comprised of lean clay, sand and gravel, or silty sand and gravel with lean clay pockets, to a depth of about 5.5 feet (EL. 874.5 feet to EL. 900.5 feet). Standard Penetration Tests on these possible fill materials indicated N-values ranging from about of 12 to 27 blows per foot (bpf) and estimated unconfined compressive strengths ranging from about 1.25 to 2.0 tons per square foot (tsf).

Beneath the fill at the above locations, and below the surface topsoil at the remaining locations, were natural soils generally comprised of brown lean clay to depths of about 3 to 8 feet (EL. 898 feet to EL. 869 feet) below existing grades. These cohesive soils were stiff to very stiff with estimated unconfined compressive strengths ranging from about 1.25 to 4.0 tsf. Some of these upper cohesive soils displayed higher moisture contents ranging from about 21 to 26%. Below the upper lean clay soils were natural granular soils comprised of sand, silty sand, sandy silt, or silt with varying gravel content, to depths of about 17 to 47 feet (EL. 862 feet to EL. 830 feet). Strength tests on these natural granular soils indicated loose to very dense relative density with N-values ranging from about 6 bpf to 50 blows for 4 inches of split spoon sampler penetration, but generally greater than about 15 bpf. Below the natural granular soils was brown or grayish brown lean clay or sandy lean clay, with occasional granular layers, to the termination depths of the borings. These cohesive soils were stiff to very hard with estimated unconfined compressive strengths of about 1.0 to 10.31 tsf, but generally greater than about 3.0 tsf.

2.4.2 USDA Classification

The soils at the stormwater management area borings BPSRN-B-9, 17, and 18 were also classified by the USDA Textural Soil Classification System for the purpose of estimating the infiltration rates of the soils at these locations. At BPSRN-9, below the surface topsoil, natural gravelly sand, gravelly sandy loam, and loamy sand were encountered to the maximum depths explored. At BPSRN-17 and 18, below the surface topsoil, natural brown clay soils were encountered to depths of 3 and 5 feet (EL. 879 feet and EL. 874 feet), respectively. Below the clay at BPSRN-B-17 and 18 was natural gravelly sand soils to the termination depths of the borings

The subsurface description is of a generalized nature to highlight the major subsurface stratification features and material characteristics. The boring logs included in **Appendix B** should be reviewed for specific information at the individual boring locations. These records include soil descriptions, stratifications, penetration resistances, locations of the samples and laboratory test data. The logs represent the conditions at the actual boring locations only, and variations may occur and should be expected between/beyond the boring locations. The stratification represents the approximate boundaries between subsurface materials and the actual transitions may be gradual. Water level information obtained during and at the completion of drilling operations is also shown on these boring logs. The samples which were not altered by laboratory testing will be retained for 60 days from the date of this geotechnical report and then will be discarded.

2.5 Groundwater Information

No water was observed in the test pit performed at BPSRN-B-18. Water was encountered at all the remaining borings/test pit at depths ranging from about 8.5 to 38.5 feet (EL. 873 feet and EL. 850 feet) below existing grade during drilling. Upon completion of drilling and removal of the augers, no water was encountered above the caved soils at any of the borings. Accurate water level readings were not possible upon completion of drilling when mud rotary drilling methods are used due to the drilling fluid which is introduced into the borehole. The table below indicates the estimated water levels encountered during drilling/excavation at each of the boring/test pit locations.

Table 2-2 Estimated Water Levels During Drilling/Excavating (Test Pits)

Boring/Test Pit	Approximate Water Depth Below Existing Grade (feet)	Approximate Elevation of Water (feet)
BPSRN-B-1	38.5	EL. 867.5
BPSRN-B-2	22	EL. 866
BPSRN-B-3	12	EL. 873
BPSRN-B-4	13.5	EL. 868.5
BPSRN-B-5	12	EL. 866
BPSRN-B-6	12	EL. 868
BPSRN-B-7	18.5	EL. 862.5
BPSRN-B-8	12	EL. 865
BPSRN-B-9	12	EL. 868
BPSRN-B-10	33.5	EL. 862.5
BPSRN-B-11	27	EL. 854
BPSRN-B-12	28.5	EL. 859.5
BPSRN-B-13	12	EL. 861
BPSRN-B-14	22	EL. 858
BPSRN-B-15	12	EL. 862
BPSRN-B-16	22	EL. 850
BPSRN-B-17	10	EL. 872
BPSRN-B-18	-	-
BPSRN-B-19	18.5	EL. 866.5
WTRN-B-1	12	EL. 867
WTRN-B-2	8.5	EL. 870.5

The water levels observed may represent perched conditions in some cases, and in other cases they may represent the actual groundwater level. Additional longer-term monitoring through the installation of water monitoring wells and/or piezometers is recommended for a more accurate estimate of the groundwater level at the site.

Gray soils were encountered at BPSRN-B-9 at a depth of about 17 feet (EL. 585 feet). No other redoximorphic features were encountered at the stormwater management boring/test pits.

Fluctuations in the groundwater level, as well as perched water levels and volumes, should be anticipated throughout the year depending on variations in climatological conditions and other factors not apparent at the time the borings were performed. The water level may also fluctuate with the level of the nearby wetland area. The possibility of groundwater level fluctuation should be considered when developing the design and construction documents for the project.

SECTION 3 Evaluation and Recommendations

3.1 Geotechnical Discussion

Based upon the results of PSI's exploration, there are four primary geotechnical-related concerns at this site which will affect the design, development, and performance of the planned project. These should be considered in context with this complete geotechnical report. The following sections summarize these concerns.

3.1.1 Reservoir Tank Subgrade Preparation

The reservoir subgrade should be prepared in general accordance with American Water Works Association (AWWA) document D110-13 and the American Concrete Institute (ACI) 372R-13. Based on the size of the reservoir tanks and the large area being loaded, it is recommended that any lean clay soils present directly below planned membrane slab and perimeter spread foundation subgrade, be removed to expose the underlying medium dense to dense natural granular soils, to limit the magnitude of settlement below the reservoirs. Based on the borings performed within the reservoir areas (BPSRN-B-2, 4 through 6, 12 through 16, and 19), about 1 to 7 feet of over-excavation is anticipated to be necessary to remove these soils in at least some areas. A representative of the project geotechnical engineer must be present during subgrade preparation to offer recommendations on necessary over-excavation of the subgrade. Over-excavation/preparation of the subgrade should extend laterally beyond the reservoir foundation perimeters a minimum distance equal to the depth of fill necessary to reach the membrane slab bearing grade plus an additional 5 feet. Care must be taken not to disturb the silty soils which will be exposed within the tank subgrade areas at planned bearing grades or at the over-excavated grades. The use of a coarse crushed stone mat may be necessary to protect the sensitive subgrade in at least some areas.

Additionally, any existing fill materials present below planned bearing grades at the tanks (EL. 874 feet to EL. 874.5) must be removed to expose medium dense natural underlying granular soils. In the areas of BPSRN-B-4 and 14, at least some limited over-excavation may be necessary to remove existing fill and expose suitable underlying natural granular soils.

Subsequent structural fill placement within the area of the reservoirs should be performed as indicated in the Site Preparation section. Structural fill should meet the gradation for Select Fill as specified in the Draft Backfill Specifications included in **Appendix C,** or Dense Grade Base as specified in Wisconsin Department of Transportation (WisDOT) Standard Specifications for Highway and Structure Construction Section 305 - 1.25 inch. Select Fill must be placed in loose lifts which are 8 inches or less in thickness and compacted to a minimum of 95% of the maximum dry density as specified by the modified Proctor (ASTM D1557). Compaction of the subgrade soils and subsequent Select Fill materials to a minimum of 95% of the maximum dry density as determined by the modified Proctor (ASTM D1557) in the reservoir areas will require achieving moisture contents which are very close to optimum along with a high degree of compactive effort. Therefore, moisture conditioning by drying or wetting, as appropriate, will likely be necessary.

3.1.2 Reservoir Construction Sequencing

It is recommended that exterior utility connections be made after the reservoirs are filled with water to help prevent misalignment of the exterior utility lines with the reservoirs. Where this in not possible, the connections should be designed to tolerate the settlement anticipated. Further details regarding the reservoir construction sequencing are provided later in this report.

3.1.3 Groundwater Level

Water was encountered within all the test locations during drilling or excavation (for test pits), with the exception of the test pit BPSRN-B-18, at elevations ranging from about EL. 873 feet to EL. 850 feet. Excavations for the preparation of the subgrade for the reservoirs are generally anticipated to remain above these levels; however, variations in the water levels present during construction should be anticipated. Depending upon the water levels present during construction, reservoir subgrade preparation may encroach upon or extend below the water levels. Additionally the mat foundation for the lower level finished floor of the BPS building is estimated to encroach upon or extend below the groundwater levels observed at BPSRN-B-7, 8, and 15. At BPSRN-B-8, the water level observed during drilling was at EL. 865. Based on an estimated 2-foot-thick mat slab and a finished lower level elevation of EL. 866.5, the bottom of the mat slab is estimated to be at about EL. 864.5, which is about 1 foot below the water level at BPSRN-B-8. It is generally recommended that the bottom of slabs be placed a minimum of 2 feet above the observed water level. Consideration should be made to raising the bottom of the lower level mat slab to a minimum of 2 feet above the observed water levels. Otherwise, the slab and walls must be designed to resist hydrostatic pressures, especially where a drainage system is not included in the building design. In order to better estimate the groundwater level, additional longer-term observations of the water levels in the area of the BPS building can be done using monitoring wells and/or piezometers.

In the lower level area of the BPS building, it is recommended that the design include a drainage system where the water level can be maintained at least 3 feet below the bottom of the slab. This can consist of a perimeter drain tile system placed at or below the bottom of the mat slab, that drains to a collection area(s) where the water can be removed by a sump pump; or this can consist of a permanent dewatering system. However, prior to any drainage design, additional observations within water monitoring wells and/or piezometers must be made to better estimate the water level. A specialty dewatering contractor must be engaged for proper design of the drainage system. Where the below grade level of the BPS building does not include drainage, it is recommended that the basement walls and mat slab be designed to resist hydrostatic pressures.

The below grade reservoir walls should also include an exterior perimeter drain tile placed near the slab subgrade elevation. A procedure should be used to discharge water from the drain tile by gravity to an appropriate area of the site, which would not allow reverse flow into the system. Water should be properly discharged in accordance with all state and local discharge requirements.

Additionally, proper care and considerations must be made where stormwater management basins are constructed in close proximity to basements or other below grade structures. Water from the stormwater management basins could potentially infiltrate the drainage system of the lower level of the BPS building by means of lateral migration through the granular soils. Any free draining granular seams such as medium or coarse sand and gravel present near the stormwater basin which may be continuous with the lower level could also expedite this process. Lateral migration of water may result in water collecting around the basement area. The potential for such conditions to occur can greatly increase when basement floors are below the elevation of basin bottoms and/or when basins are placed in close proximity to structures. In addition, the presence of granular or other generally permeable soils, which is typically necessary in the areas of structures, especially within utility backfill, alongside basement walls, or within other development excavations, can act as channels to carry water from basins into nearby basements. In order to help minimize this, it is recommended that clay or bentonite collars be constructed at the end of utility trenches where they encroach upon the basement backfill.

The Contractor must make a determination of the groundwater level prior to bidding and construction to determine the need for dewatering, and the appropriate means and methods for effective dewatering where necessary. Observations of test pit excavations in the area of the lower level of the BPS building may be beneficial to identify the presence of any water, and if water is encountered, approximate the infiltration rate of water into the excavation. Where the lower level excavation extends only several inches into the groundwater or into low volume perched water, sumps with filtered pumps should be able to provide suitable groundwater control during construction. Where the excavation extends to greater depths below the groundwater or into large volumes of perched water, comprehensive, prolonged dewatering with a series of sumps or well-points and high capacity pumps will likely be necessary throughout the construction process. Where necessary, dewatering is recommended to be performed to a depth of at least two feet below the lowest excavation depth. Where excavations extend below the groundwater, care must also be exercised to prevent “boiling” of granular soils due to an unbalanced hydrostatic head.

Additionally, it must be recognized that severe caving and sidewall instability can be expected with increasing depth due to the predominance of granular soils, especially where excavations encroach upon or extend below groundwater or perched conditions. Therefore, the use of sloping, shoring, bracing, or trench boxes may be required for open cut trench excavations.

Fluctuations in the groundwater level should be anticipated throughout the year depending on variations in climatological conditions and other factors not apparent at the time the borings were performed. Groundwater levels may be temporarily affected by flooding in the area of the adjacent wetland. The possibility of groundwater level fluctuation and perched water conditions should be considered when developing the design and construction plans for the project.

3.1.4 Unstable Near Surface Subgrade

It should be anticipated that the near surface clayey and silty soils at this site may be in a very moist condition once exposed below the topsoil, which may result in these materials being unstable, due to their sensitivity to moisture and construction disturbance. The natural lean clay soils at BPSRN-B-8 and 15 were in a very moist condition during the exploration, with moisture contents ranging from about 21 to 26%. The moisture contents of some of the near surface silty fine sand and sandy silt were also very moist during the exploration with moisture contents ranging from about 9 to 21%. In addition, moisture contents during construction may be elevated depending upon recent rainfall, thaw, or snow melt. High moisture contents can cause clayey and silty soils to be unstable, especially when subjected to construction traffic, and can result in subgrade instability in floor slab, pavement, and other structural areas. Where observed during construction, very moist or wet, unstable soils encountered at the surface of the site may either be scarified, dried, and recompacted to a minimum of 95% of the maximum dry density as obtained by the modified Proctor test (ASTM D1557), if feasible, or excavated below subgrade (EBS), and replaced with properly placed and compacted Select Fill. In unstable areas requiring EBS, over-excavation to a depth of about 1 to 2 feet and the placement of Select Fill, along with the placement of a geogrid, if necessary, can generally be used to improve the stability of the subgrade. However, a representative of the geotechnical engineer must be present during construction to provide recommendations regarding necessary stabilization efforts. Also, as indicated above, any clay soils present within the area of the reservoirs must be removed to expose underlying medium dense to dense granular soils. Unstable soils which cannot be improved in-place can be placed in non-structural areas or removed from the site.

It must be recognized that soil stability can be dependent on such factors as soil type and moisture content, weather conditions at the time of construction, and construction disturbance. Thus, the need to perform EBS, or not, must be determined by the Program geotechnical engineer based upon field observations made during subgrade preparation.

The following geotechnical related recommendations have been developed on the basis of the subsurface conditions encountered and PSI's understanding of the proposed development. Should changes in the project criteria occur, a review must be made by the Program geotechnical engineer to determine if modifications to the recommendations included herein will be required.

3.2 General Site Preparation

Prior to the placement of any new fill or preparation of the subgrade, PSI recommends that the topsoil, vegetation, roots, soft, organic, frozen, and otherwise unsuitable soils in the construction areas be stripped from within and to a minimum lateral distance of 10 feet beyond the perimeter of the proposed building, reservoirs, pavement, or other structural areas, or to a distance equal to the thickness of Select Fill necessary to reach the planned foundation, floor slab, or pavement subgrade, whichever is greater. These materials should be discarded or reused in non-structural areas. About 3 to 18 inches of topsoil were present at the surface of the borings. However, topsoil thickness should be anticipated to vary across the site and may increase encroaching upon wetland areas.

In order to help minimize the magnitude of settlement of the reservoirs, it is recommended that any lean clay or existing fill soils present below planned subgrade be removed to expose the underlying medium dense to dense natural granular soils. Based on the borings performed within the reservoir areas (BPSRN-B-2, 4 through 6, 12 through 16, and 19), up to about 1 to 7 feet of over-excavation is anticipated to be necessary in some of the reservoir areas to remove these lean clay soils. Over-excavation or preparation of the subgrade should extend laterally beyond the perimeter of the foundation a minimum distance equal to the depth of fill necessary to reach the membrane slab bearing grade plus an additional 5 feet. A representative of the project geotechnical engineer must be present during subgrade preparation to help determine the necessary methods of achieving a suitable subgrade prior to any Select Fill placement.

The subgrade in surficial structural areas (slab-on-grade portions of the proposed building, reservoir areas, and pavement areas) should be thoroughly proof rolled to detect unstable, yielding soils, which must be properly remediated. Proof rolling should consist of overlapping passes in a perpendicular grid pattern of a fully-loaded tandem-axle dump truck, or other equipment of similar size and weight. However, care must be used on this site to avoid disturbing the near surface fine-grained soils during proof rolling, especially during periods of precipitation or spring thaw. At least some unstable areas of subgrade should be expected due to the presence of very moist near surface clayey or silty soils. Scarification, drying, and compaction of very moist or wet soils, or removal and replacement with Select Fill, are two methods which can be considered, but this should be determined by the project geotechnical engineer at the time of construction. Low areas may then be raised to the planned grades with suitable properly compacted fill. Compaction of the subgrade soils should be performed to a minimum of 95% of the maximum dry density as determined by the modified Proctor (ASTM D1557). The subgrade of existing slopes must be benched with horizontal steps to allow for an appropriate bond between the existing slope and new fill soils.

The near surface clayey and silty soils on this site are considered moisture and disturbance sensitive and subject to softening. Therefore, equipment and worker traffic must be kept to a minimum on subgrade bearing surfaces, especially during times of precipitation or following spring thaw. Difficulty with subgrade preparation can be expected, especially in wet or cold weather conditions. Removal of unsuitable portions of the near surface soils and replacement with Select Fill will likely be required in areas, especially if earthwork is not carried out during periods of relatively warm, dry weather, which provide more favorable conditions for drying of these soils. Soft zones which cannot be improved by scarification and aeration, must be removed and replaced with properly compacted Select Fill, such as coarse crushed stone, possibly in conjunction with the use of a geogrid. Substantial construction delays and difficulty with subgrade stabilization should be expected during periods of wet and/or cool weather. Site grading runoff should be directed to catch basins, so that the potential for the softening of the foundation subgrade soils is reduced.

Newly placed engineered fill required to establish site grades should be free of organic, frozen, or other deleterious materials, and have a maximum particle size less than 3 inches. Structural fill should meet the specified gradation for Select Fill as specified in the Draft Backfill Specifications in **Appendix C** (or WisDOT Standard Specification for Highway and Structure Construction Section 305 - 1.25 inch). Select Fill should be placed in lifts of loose material, no thicker than 8 inches, and should be compacted to at least 95% of the maximum dry density and within a few percent of the optimum moisture content as determined by the modified Proctor test (ASTM D1557). If water is to be added, it should be uniformly applied and thoroughly mixed into the soil by disking or scarifying. Each lift of compacted engineered fill should be observed and tested by a qualified construction testing firm prior to placement of subsequent lifts. The minimum lateral extent of the over-excavation of poor soil and subsequent placement and compaction of engineered fill should be 10 feet beyond the perimeter of the proposed building, reservoirs, pavement, or other structural areas, or to a distance equal to the thickness of Select Fill necessary to reach the planned foundation, floor slab, or pavement subgrade, whichever is greater.

Compaction of the subgrade soils and subsequent Select Fill materials to a minimum of 95% of the maximum dry density as determined by the modified Proctor (ASTM D1557) will require achieving moisture contents which are very close to optimum in addition to applying a high level of compactive effort. Therefore, moisture conditioning by drying or wetting, as appropriate, will likely be necessary.

It is recommended that backfill in new utility trenches follow the specifications from the Draft Backfill Specifications indicated in **Appendix C**. Select Fill as described in the Draft Backfill Specifications (or WisDOT Standard Specification for Highway and Structure Construction Section 305 - 1.25 inch) should be used as backfill alongside below grade walls to reduce the potential for consolidation and settlement of the fill. Select Fill should also be used in any areas of foundation subgrade, where the subgrade is over-excavated and then backfilled back up to planned grade. All fill soils must be placed and compacted under engineered, controlled conditions, to provide suitable support for overlaying structures. Additional guidance can be provided at the time of construction in the selection process for grade-raising fill and trench backfill.

When excavations encroach upon or extend below groundwater or perched zones, and into soft clay, silt, or fine sands, subgrade instability and sloughing/caving of sidewalls can occur. Some over-excavation of softened or loosened soils, in conjunction with the use of a crushed stone working mat, may be necessary. Additionally, significantly widened excavations may result, or be required for stability.

The selection of fill materials for various applications should be done in consultation with the project construction testing firm. Similarly, the evaluation of the subgrade and placement and compaction of fill for structural applications should be monitored and tested by a qualified testing firm as well.

3.3 Foundation Recommendations - Building Mat Foundations and Reservoir Slabs

It is understood that the pumping station building design includes two mat foundations, one about 53 feet by 64 feet estimated to be placed at about EL. 874.5 (2 feet below finished mat floor EL. 876.5), and the other deeper mat about 60 feet by 60 feet estimated to be placed at about EL. 864.5 (2 feet below finished mat floor EL. 866.5). Other portions of the building are understood to include slab-on-grade construction with shallow spread footings. Where the pumping station building mat foundations are placed upon the existing stiff lean clay soils, medium dense granular soils or new Select Fill placed as recommended in the Site Preparation section, the mat foundations can be designed for a bearing pressure ranging from about 1,500 to 3,000 psf, with the estimated maximum settlements and subgrade moduli indicated in **Table 3-1**.

Table 3-1 Pumping Station Building Mat Foundation Recommendations

Mat Bearing Pressure (psf)	Maximum Estimated Settlement (in)	Subgrade Modulus (pci)
1,500	0.6	17.4
2,000	1.0	13.9
2,500	1.3	13.4
3,000	1.7	12.3

The maximum settlements will generally occur below the upper mat foundation. However, specific locations of the mats and slab-on-grade areas within the building have not been provided. When the configuration of the various foundations and loading has been determined, PSI should be provided with this information in order to do a more refined evaluation of the estimated settlement. The maximum estimated settlement will occur near the center of the mat, and settlement will decrease moving towards the perimeter of the foundation.

The reservoirs can be supported as planned by the membrane slabs and perimeter spread foundations. Based on the borings performed, and proper preparation of the subgrade (including over-excavation of any surficial lean clay soils), the subgrade is estimated to consist of medium dense to dense natural granular soils with varying gravel content or new Select Fill. The membrane slabs bearing at about EL. 874.5 feet and the perimeter 6.5 foot wide foundation bearing at about EL. 874, within the medium dense to dense natural soils or Select Fill placed as recommended in the Site Preparation section of this report can be designed for bearing pressures of 2,860 psf and 4,500 psf, respectively, with an estimated maximum settlement at the center of the slab of about 3.2 inches and a subgrade modulus of 6.2 pci. The maximum estimated settlement of the perimeter foundation is about 1.5 inches with a maximum differential settlement from the tank edge to the center of about 1.7 inches. The maximum net allowable bearing capacity of the perimeter foundation is 4,500 psf. Potential vertical rise (PVR) is estimated to be less than 1 inch.

It should be noted that the above estimated settlements were based upon the soils' index values and laboratory testing performed on similar soils in the area. Where more refined estimates are desired, consolidation testing should be performed to provide information specific to the subsoils present on this site.

The building mats and reservoir membrane slab foundation designs should ultimately be designed to have zones of varying subgrade moduli. The subgrade moduli on a large foundation will not be constant across the entire foundation and will increase moving toward the perimeter. It is generally recommended that the perimeter footing portion of the reservoirs be designed for a soil bearing pressure near the planned bearing pressure below the slab area to reduce localized distortion settlement at the transition between the slab and connected thickened perimeter spread footing.

It is recommended that the reservoirs be filled with water to allow the settlement to occur prior to making the connection to external utilities, or as recommended in ACI 372R-13, exterior piping connections must be designed to tolerate the estimated settlement. The magnitude of settlement can be monitored by surveying before and after loading of the foundation, to determine when the settlement has occurred, and when the exterior utility connections can be made.

3.4 Foundation Recommendations - Spread Foundations in Building SOG and Water Tower

Based on the exploration, the slab-on-grade portion of the pumping station building can be supported by a conventional spread foundation as planned. Based on the planned finished first floor elevation of EL.880.5 feet and the estimated interior and perimeter foundation bearing grades of EL. 879 and EL. 876.5, respectively, the soils anticipated to be present at these grades are natural medium dense granular soils, stiff to very stiff lean clay, or new Select Fill. Spread foundations placed upon the natural soils or new Select Fill placed and compacted as recommended in the Site Preparation section, can be designed for a net allowable soil bearing pressure of 3,000 psf.

The natural lean clay soils were generally in a very moist condition at the time of the exploration and may be in a very moist to wet condition during construction. These soils are susceptible to a substantial loss in strength when the confining effect of the overburden is removed. A significantly softened subgrade will likely develop. To stabilize and protect these soils during construction, undercutting on the order of about 12 to 18 inches, and the placement a crushed stone working mat can be performed to establish a stable bearing grade.

The water tower can be supported by a conventional ring foundation as planned. Based on the planned foundation bearing grade of about EL.871 feet, the soils anticipated to be present at these grades are natural medium dense to very dense granular soils. Ring foundations placed upon these natural soils or new Select Fill placed and compacted as recommended in the Site Preparation section, can be designed for a net allowable soil bearing pressure of 5,000 psf. However, in order to use this bearing capacity, any lean clay soils present below planned bearing grade will need to be removed to expose the underlying medium dense to very dense natural granular soils.

3.5 General Foundation Recommendations

The suitability of the existing soils for support of the proposed foundations and membrane slab must be determined by testing by a qualified representative of the Program geotechnical engineer during construction, utilizing dynamic cone penetrometer tests for the granular soils. Where unsuitable bearing soils are encountered, the excavation should be deepened to competent bearing soil, and the footing could be lowered or an over-excavation and backfill procedure could be performed. An over-excavation and backfill treatment would require widening the deepened excavation in all directions at least 12 inches beyond the edge of the footing for each 12 inches of over-excavation depth. The over-excavation should then be backfilled up to footing base elevation in maximum 8 inches thick loose lifts with Select Fill material (as specified in the Draft Backfill Specifications) compacted to at least 95% of maximum dry density and within a few percent of the optimum moisture content as determined by modified Proctor (ASTM D1557). As an alternative, to limit lateral over-excavation, the excavation could extend a minimum of 6 inches beyond the plan footing width to suitable bearing soil and then backfilled with lean (500 to 1000 psi) concrete mix to planned footing grade to reduce lateral over-excavation.

After opening, PSI recommends that the foundation subgrade be observed and tested by a qualified representative of the Program geotechnical engineer prior to concrete placement, to evaluate the suitability and uniformity of the bearing materials for support of the design foundation loads. Once the support soils are observed and tested, the concrete should be placed as quickly as possible to avoid exposure of the footing bottoms to wetting and drying. Surface run-off water should be drained away from the excavations and not be allowed to pond.

Exterior footings and footings in unheated areas should be located at a depth of at least 48 inches below the final exterior grade to provide adequate frost protection. If the structures are to be constructed during the winter months or if footings will likely be subjected to freezing temperatures after foundation construction, then the footings and concrete should be adequately protected from freezing.

It is recommended that the footings supporting individual columns have a minimum width of 24 inches, and continuous footings have a minimum width of 18 inches, even if the maximum recommended allowable bearing pressure is not fully utilized. To minimize the effects of any slight differential movement that may occur due to variations in the character of the supporting soils and any variations in seasonal moisture contents, it is recommended that all footings be suitably reinforced to make them as rigid as needed.

3.6 Global Stability Analysis

The global stability analysis was performed through the approximate center of Reservoir 2, which was considered the critical section due to the slope below the reservoir. The construction information provided by the client was utilized, along with the soil information, in defining the parameters used in this evaluation. The proposed slope configuration was analyzed based on:

- The soils information obtained from the borings performed;
- The laboratory testing performed, including moisture contents;
- The geometry of the proposed slope depicted on the cross section and plan provided;
- Loading at the top of the slope;
- Estimations of soil strength and density parameters;
- Groundwater conditions; and
- A variety of other factors.

Data from these sources was entered into the analytical software (STABL6H). The calculations of the factors of safety against instability of a slope are performed by a method of slices. The following tables list the physical parameters assigned to each soil and material type used. Soil parameters were estimated based upon:

- Published correlations between N-values and angles of internal friction;

- Actual laboratory data; and
- Past experience.

The laboratory and field data supporting these parameters can be found on the boring logs and on the lab test results included in the appendix. The following tables list the soil parameters assigned to each soil type/material used in the stability analysis.

Table 3-2 Global Stability Soil Parameters

Soil Layer No.	Soil Type	Moist Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Friction Angle Φ (degrees)	Effective Friction Angle Φ' (degrees)	Total Cohesion (psf)	Effective Cohesion (psf)
1	Lean Clay	125	130	0	28	800	0
2	Select Backfill	130	133	34	34	0	0
3	Sand, Silty Sand	130	133	30	30	0	0
4	Lean Clay	125	130	0	28	2,000	0

The unit weights shown were estimated by published correlations. Parameters were estimated from prior experience and tables such as that from Peck, Hanson, and Thornburn (1974) relating N-values and friction angle. The laboratory and field data supporting these parameters can be found on the boring logs and laboratory test reports included in the appendix. The phreatic surface used in the analysis was estimated from the water levels encountered in the borings at the time of the exploration. New structural fill was estimated to consist of a select granular material such as a crushed sand and gravel.

The global stability analysis performed on the proposed geometry of the new slope, new reservoir, and existing slope, for the soil conditions estimated (utilizing the Modified Bishop Method for both total and effective stress conditions) results in a minimum factor of safety of about 2.0, which reduces to 1.3 with a factor of 0.65, as specified by AASHTO for slopes supporting structures. A minimum factor of safety of 1.0 is typically required. So, this is generally an acceptable minimum factor of safety. This evaluation is based on the new fill materials having a friction angle of at least 34 degrees. This minimum friction angle can only be achieved where the new structural fill soils are properly placed on a prepared existing slope as recommended below in the New Fill Placement section. Where the recommendations presented herein are not adhered to, friction angles of the new fill may be less than 34 degrees, resulting in a minimum factor of safety of less than 1.0, and the potential for instability.

3.7 Below Grade Walls and Lower Level Drainage Design Considerations

The below grade walls for the lower levels of the pumping station building and the below grade portions of the reservoirs will be required to resist lateral earth pressures. The actual earth pressure on the walls will vary according to material types and backfill materials used, how the backfill is compacted, drainage conditions, the grade above the top of wall, and surcharge loads (i.e. traffic or other surface loads). If the walls are restrained from movement in each direction, the at-rest condition applies. For walls that are not restrained from movement, the active condition will apply. The design parameters presented in **Table 3-3** are recommended for the Select Fill material as described in the Draft Backfill Specifications indicated in **Appendix C** (or WisDOT Standard Specifications for Highway and Structure Construction Section 305 - 1.25 inch)**,** for both drained and undrained conditions.

Table 3-3 Equivalent Fluid Pressures

Parameters	Select Backfill
Moist Unit Weight (pcf)	130
Friction Angle (degrees)	35
Coefficient of Active Pressure (K_a)	0.27
Coefficient of At-Rest Pressure (K_o)	0.43
Coefficient of Passive Pressure (K_p)	3.69

Notes: 1. Ultimate passive pressure typically requires large strains to be fully mobilized, therefore, PSI recommends using 50% or less of the ultimate passive pressure to limit the strain on the structure.
2. These values may be used for design only if the Select Backfill extends a lateral distance from the back of the walls approximately equal to or greater than half the total height of the wall at the surface or six feet, whichever is less.
3. Earth pressure coefficients valid for level backfill conditions with no surcharge.

Conditions applicable to the above values include:

- For passive earth pressure, walls must move horizontally to mobilize resistance;
- In-situ soil backfill weight a maximum of 130 pcf for granular soils;
- Horizontal backfill, compacted to at least 95% of modified Proctor maximum dry density;
- Loading from heavy compaction equipment not included;
- No safety factor included; and
- Ignore passive pressure in frost depth zone

An “equivalent fluid” pressure can be obtained from the above chart by multiplying the appropriate K-factor times the moist unit weight of the soil. This applies to unsaturated conditions only. If a saturated (submerged) “equivalent fluid” pressure is needed, the effective unit weight (total unit weight minus unit weight of water) should be multiplied times the appropriate K-factor and the unit weight of water then added to that resultant. Where the lower levels of the pumping station building are designed without a continuous drainage system, the walls and floors must be designed to resist hydrostatic pressures.

The above values are ultimate values and do not include the influence of foundation or surface loads in or adjacent to the wall backfill, which must be appropriately added. Loads applied at the ground surface will exert a resultant horizontal load on the walls. The magnitude of this and other surcharge loads, acting within the zone that begins at the base of a new foundation and extends upward and outward at a 1H:1V ratio can be determined by multiplying the load by the appropriate lateral earth pressure coefficient. Heavy equipment should not operate within a distance closer than the retained height of the walls to prevent lateral pressures more than those provided. To calculate the resistance to sliding, a value of 0.3 should be used as the allowable coefficient of friction between the footing and the underlying soils.

Passive resistance should be neglected to a depth of 4 feet below exterior grade due to seasonal softening from freeze-thaw. In addition, the passive earth pressure values given above are based upon the concrete for the structure being placed in direct contact with the naturally deposited soils. If forms will be used to cast the concrete structure, backfill material within the excavations surrounding the structure must be placed in layers that are less than 8 inches (measured loose) and near the optimum moisture content determined by the modified Proctor compaction test (ASTM D1557).

It is recommended that the pump station building, and reservoir designs include drainage systems. A gravel or crushed stone Drainage Fill as described in the Draft Backfill Specifications indicated in **Appendix C** (or WisDOT Standard Specifications for Highway and Structure Construction Section 310 - Open Graded Base) should be placed beneath the building mat slabs, building slab-on-grade, and reservoir slabs for a minimum thickness of six inches; and alongside the below grade walls of the lower levels of the building and the reservoirs for a width of at least 12 inches, to alleviate hydrostatic uplift pressure beneath the mat/slab and excessive lateral pressure on the walls. The gravel or crushed stone backfill should have less than five percent passing the No. 200 sieve and a maximum particle size less than three inches. Drain tile must be placed at the exterior of and near the bottom of the mat foundation in the lower levels and on the exterior of the below grade areas of the reservoir near the slab subgrade. Drain tile should have a minimum diameter of four inches and should be wrapped with an appropriate filter fabric. Drainage pipes should be surrounded by the free draining Drainage Fill. The Drainage Fill should be used to backfill the walls to within two feet of final grade. The remaining upper portion of the excavations should be backfilled with cohesive soils to reduce infiltration of surface water into the drain system. A non-woven geotextile should be placed along the sides of the wall excavation adjacent to the existing soils and directly below a minimum 2-foot thick clay cap to filter protect the free-draining material and help prevent migration of fines. In addition, the ground surface should be sloped to drain surface water away from the structures. The drain tile system must be connected to adequate sumps for drainage and be properly discharged in accordance with all state and local discharge requirements. It is recommended that a battery backup be included in the pump design.

The below grade reservoir walls should also include an exterior perimeter drain tile placed near the slab subgrade elevation. A procedure should be used to discharge water from the drain tile by gravity to an appropriate area of the site, which would not allow reverse flow into the system. Water should be properly discharged in accordance with all state and local discharge requirements. Where the reservoirs are properly designed with drain tile near the floor slab subgrade elevation which drains by gravity to an appropriate area of the site, the below grade reservoir walls can be designed for drained fluid pressures.

PSI recommends that backfill directly behind the walls be compacted with light, hand-held compactors. Heavy compactors and grading equipment should not be allowed to operate within five to 10 feet of the walls during backfilling to avoid developing excessive temporary or long-term lateral soil pressures. PSI recommends that a representative of a qualified geotechnical engineer be present to monitor foundation excavations and fill placement.

3.8 Floor Slab Recommendations

Based on the borings performed, and provided the recommendations within this report are followed, the mat slabs and slab-on-grade area of the pumping station building and the membrane slabs within the reservoir areas are estimated to be supported by natural soils comprised of medium dense to very dense natural sand or silty sand, stiff to very stiff lean clay, or new properly placed Select Fill. As indicated in the Site Preparation section of this report, it is recommended that any natural lean clay soils be removed from the membrane slab areas of the reservoirs and replaced with properly placed and compacted Select Fill. The floor slab subgrade must be prepared as indicated in the Site Preparation section, which will likely include at least some over-excavation of unstable fill materials and replacement with new Select Fill. The reservoir floor slab subgrade should be prepared in general accordance with AWWA document D110-13 and the ACI 372R-13.

Within the BPS Building, based on an estimated 2-foot-thick mat slab and a finished lower level elevation of EL. 866.5, the bottom of the mat slab is estimated to be at about EL. 864.5, which is below the water level observed at some of the borings in this area. It is generally recommended that the bottom of slabs be placed a minimum of 2 feet above the observed water level. Consideration should be made to raising the bottom of the lower level mat slab to a minimum of 2 feet above the observed levels. Otherwise, the slab and walls must be designed to resist hydrostatic pressures, especially where a drainage system is not included in the building design. It is also recommended that additional longer-term observations of the water levels in the area of the BPS building be done using monitoring wells and/or piezometers to better estimate the water levels.

PSI recommends that a minimum six-inch thick free draining granular mat as specified for Drainage Fill in the Draft Backfill Specifications indicated in **Appendix C** (or WisDOT Standard Specifications for Highway and Structure Construction Section 310 - Open Grade Base) be placed beneath the floor slabs to enhance drainage. Polyethylene sheeting should be placed to act as a vapor retarder where the floors will be in contact with moisture sensitive equipment or products such as tile, wood, carpet, etc., as directed by the design engineer. The decision to locate the vapor retarder in direct contact with the slabs or beneath the layer of granular fill should be made by the design engineer after considering the moisture sensitivity of subsequent floor finishes, anticipated project conditions, and the potential effects of slab curling and cracking. The proper use of a vapor retarder may not completely prevent moisture beneath or on top of the slabs. As recommended by the AWWA document D110-13, proper measures should be taken to reduce the effects of shrinkage of the reservoir floor slabs. The membrane slabs should also be constructed in as large of sections as possible to reduce the number/length of construction joints, and the potential for leaking. Also, minimum membrane horizontal reinforcement should be provided as recommended by the AWWA.

3.9 Exterior/Unheated Slabs

Entry slabs, sidewalks, aprons, and other slabs in exterior or unheated areas may bear upon clayey or silty materials. Such materials are moderately frost susceptible and somewhat to poorly drained. Slabs placed directly upon such soils are subject to heaving and subsequent settlement due to freeze/thaw cycles. This can result in cracking, misalignment, and other related effects (especially at joints). It is recommended that consideration be given to limited undercutting of the lean clay frost susceptible materials to a depth of 1 to 2 feet below the slabs, and replacement with well graded, properly placed and compacted Select Fill as described in the Draft Backfill Specifications indicated in **Appendix C** (or WisDOT Standard Specifications for Highway and Structure Construction Section 305 - 1.25 inch). Where possible, the granular base should be daylighted to adjacent areas to allow for drainage. Otherwise, where this is not possible, a properly designed underdrain system connected to the municipal sewer (if permissible) or directed to on-site stormwater management areas or properly daylighted should be incorporated to reduce the potential effects of freeze/thaw cycles.

3.10 Seismic Site Class

The 2015 International Building Code requires a site class for the calculation of earthquake design forces. This class is a function of soils type (i.e. depth of soil and strata types). Based on the estimated density of the soils observed within the boring locations, Site Class “D” is recommended.

3.11 Pavement Recommendations

PSI understands that the project includes the construction of paved areas surrounding the proposed pumping station building. Based upon the borings performed, PSI anticipates that the subgrade soils within pavement area will generally consist of natural lean clay soils or new properly placed and compacted Select Fill. The materials can be used for support of new pavements where properly prepared in accordance with the Site Preparation section of this report, which will likely include at least some limited undercutting (possibly in conjunction with the placement of a geotextile), and the placement of a coarse crushed stone, to create a stable subgrade condition. At least some difficulty is anticipated in creating a stable subgrade within areas of higher silt content and moisture contents.

A detailed traffic analysis was not performed as part of this exploration; however, based upon the proposed construction, the light and heavy-duty pavement sections presented in **Table 3-5** are based on a 20-year design life of 30,000 and 60,000 equivalent 18,000-pound single axle loads (ESALs), respectively. If these traffic loads are not indicative of the actual loads, PSI must be contacted immediately to review this data. The soils anticipated to be present below the pavement areas are estimated to have an approximate California Bearing Ratio (CBR) value of 3 when properly prepared. Engineered fill material used to raise existing grades within parking and drive areas should meet or exceed this CBR value. The design factors presented in **Table 3-4** were used in developing the recommended pavement sections:

Table 3-4 Pavement Design Parameters

Design Factor	Asphalt	Concrete
Design Life	20 years	20 years
Reliability	0.85	0.85
Overall Deviation	0.45	0.35
Modulus of Rupture	-	600 (4,000 psi concrete)
Modulus of Elasticity	-	4,000,000 psi
Load Transfer Coefficient	-	3.2
Drainage Coefficient	1	1
Modulus of Subgrade Reaction	125 pci	125 pci
CBR/Resilient Modulus	3/2,800	3/2,800

Design Factor	Asphalt	Concrete
Initial Serviceability	4.2	4.5
Terminal Serviceability	2.0	2.0
Assumes standard pick-up truck used for snow plowing		

If during the final design phase these values are determined to be incorrect, PSI must be contacted to provide revised pavement recommendations. Based upon the estimation that lean clay soils will generally comprise the subgrade for the proposed pavements and provided the subgrade soils are properly prepared as outlined in this report, the following flexible pavement sections are recommended for standard duty and heavy-duty areas.

Table 3-5 Recommended Pavement Section Thicknesses

Pavement Components	Standard Duty Areas*	Heavy Duty Areas	WisDOT Structural Coefficients
Hot Mix Asphalt Surface Course	1½”	1½”	WisDOT FDM 14-10, Attach. 5.1 (a=0.44)
Hot Mix Asphalt Binder Course	2”	2½”	WisDOT FDM 14-10, Attach. 5.1 (a=0.44)
Aggregate Base Course	8”	10”	WisDOT FDM 14-10, Attach. 5.1 1.25” Crushed Stone (a=0.14)

*If a front-end loader is used to clear snow, PSI recommends placing a BX1200 geogrid below the base course or adding 2 inches of base course to the section.

Where the pavement subgrade soils consist of materials other than lean clay, PSI should be informed, and revised recommendations can be provided where necessary. The granular base course should consist of well-graded crushed stone meeting the requirements of Select Fill as described in the Draft Backfill Specifications indicated in **Appendix C** (or WisDOT Standard Specifications for Highway and Structure Construction Section 305 - 1.25 inch). The granular base course material should be placed and compacted to a minimum of 95% of the maximum dry density as determined by ASTM D1557 (modified Proctor) and within 2 to 3%± of the optimum moisture content value. Also, a representative of a qualified construction testing firm should test the base course material prior to, and during, placement.

Asphaltic binder and surface courses should meet the requirements from Section 460 of the State of Wisconsin Standard Specifications for Highway and Structure Construction. Asphaltic courses should be placed and compacted to the minimum required density contained within Section 460 of the Standard Specifications. An adequate number of in-place density tests should be performed during construction to document the placement and compaction of the asphalt.

Where rigid pavement is elected to be used, based upon the anticipated traffic volumes, PSI recommends a concrete pavement section consisting of 6 inches of crushed aggregate base course and 6 inches of Portland cement concrete. The concrete must be properly reinforced and must have appropriately spaced control joints.

The pavements should be sloped to provide positive surface drainage. Water should not be allowed to pond on or adjacent to the pavement as this could saturate the subgrade and cause premature pavement deterioration. The granular base course should be protected from water inflow along drainage paths. Additionally, the granular base course should extend beyond the edges of the pavement in low areas to allow any water that enters the base course stone a path for exit. The pavements are recommended to be constructed with attention to final grades to facilitate drainage. Construction of the subgrade and pavements should be in accordance with the project specifications.

Due to the presence of clay soils on the site, PSI recommends that subsurface drains be installed in pavement areas. If placed properly, subsurface drains will greatly reduce the amount of trapped water under the pavement surfaces. Trapped water leads to subgrade degradation and increases pavement heave during winter months. It is recommended that underdrains be placed within the subgrade, just below the granular base. Minimally, these drains should be placed in low spots in the pavement, at the toe of slopes that are draining toward pavement surfaces, undercuts that have been filled with granular fill, and as finger drains. Finger drains should consist of an adequate number of drain tiles extending radially outward an appropriate distance from each interior catch basin. In addition, drain tiles should extend along curb lines, an appropriate distance up the slope from curb inlets. The drain tile should be directly connected to the storm sewer manholes or catch basins. The drain tile should consist of perforated PVC pipe placed beneath the base layer, extending at least 8 inches into the subgrade. The pipe should be surrounded by 1-inch size clean stone, with the pipe and stone being wrapped with a geotextile filter fabric to reduce the potential of soils from migrating into and obstructing the pipe. It is also recommended that roof drains be connected to the stormwater collection system to minimize the potential for this water to enter the base and subgrade. Additionally, the drain tile should be installed with a positive slope (minimum 0.5 to 1%) throughout the length of the tile.

Periodic pavement maintenance is required to keep a pavement, under normal traffic and environmental conditions, as near as possible to its constructed condition. Maintenance is necessary to reduce the effects of pavement stress caused by changes in temperature and moisture, repetitive traffic loadings, and movement of the subgrade soils. As pavement distress is observed, it should be repaired as quickly as possible. Unrepaired areas will generally lead to more severe and widespread distress, and eventually, pavement disintegration. Therefore, routine maintenance consisting of annual crack sealing, seal coating on a regular basis as necessary, and other necessary repairs at least annually, will be required.

3.12 Stormwater Management Area Recommendations

The subgrade soils encountered within the stormwater management borings (BPSRN-B-9, 17, and 18) have been classified in general accordance with the USDA textural soil classification system. Estimated infiltration rates for various soil types according to Table 2 of the Site Evaluation for Stormwater Infiltration (1002) document, which is published by the Wisconsin Department of Natural Resources are shown in **Table 3-6** in the second column. The infiltration rates published by the Natural Resources Conservation Service (NRCS) which are used by Waukesha County to determine if the soils are exempt from infiltration are also listed in the third column.

Table 3-6 Design Static Infiltration Rates for Soil Textures Receiving Stormwater

Soil Texture	WDNR 1002 Table 2, Design Infiltration Rate Without Measurement (In/Hr)	NRCS Infiltration Rates (In/Hr)
Coarse sand or coarser (COS)	3.60	>20
Loamy coarse sand (LCOS)	3.60	>20
Sand (S)	3.60	>20
Loamy sand (LS)	1.63	6.3-20.0
Sandy loam (SL)[1]	0.50	2.0-6.3
Loam (L)	0.24	0.63-2.0
Silt loam (SIL)	0.13	0.63-2.0
Sandy clay loam (SCL)	0.11	0.63-2.0
Clay loam (CL)	0.03	0.63-2.0
Silty Clay loam (SICL)	0.04	0.63-2.0
Sandy clay (SC)	0.04	0.63-2.0
Silty clay (SIC)	0.07	0.06-0.20
Clay (C)	0.07	0.06-0.20

[1] Use sandy loam design infiltration for fine sand, very fine sand, and loamy fine sand soil textures.

PSI understands that a stormwater management basin, located to the south of the proposed BPS building and reservoirs, is planned for the development. The basin will be a wet pond with a bottom elevation of EL. 868 feet and forebays to the east of the wet pond will have a bottom elevation of EL. 874. Other design details were not provided. NR-151 guidelines indicate infiltration rates shall be based on the least permeable soil horizon within 5 feet of the bottom elevation of the proposed infiltration system.

Boring BPSRN-B-9 was performed in the area of the wet pond and BPSRN-B-17 and 18 were performed within the forebay areas as requested. The soils encountered in the basin area generally consisted of natural sand, loamy sand, or sandy loam with varying gravel content to the maximum depths explored. At BPSRN-B-17 and 18, natural clay soils were encountered above the granular soils to depths of about 3 and 5 feet (EL. 879 and EL. 874), respectively. The natural clay soils have an estimate infiltration rate of approximately 0.06 to 0.2 inches per hour, based on the NCRS infiltration rates above. These infiltration rates are less than 0.6 inches per hour, and these soils are therefore exempt from the infiltration requirements of NR151.124(4)(c)1.

The natural sand, loamy sand, and sandy loam soils encountered, have estimated infiltration rates of approximately 2.0 to greater than 20 inches per hour, based on based on the NRCS infiltration rates. These rates are greater than 0.6 inches per hour, and these soils would therefore not be considered exempt from the infiltration requirements of NR151.12(5)(c) under NR151.12(5)(c)6a.

It must be recognized that areas of the site may also be exempt or excluded from the infiltration requirements of NR151.124 under other provisions, such as NR151.124(4)(b), due to insufficient separation distance between the bottom of basin and the groundwater, or due to the lack of a layer of sufficient thickness containing soils with sufficient fines content between the bottom of the basin and the groundwater. This layer of sufficient thickness containing soils with sufficient fines content is denoted by NR151.124(4)(b) as a “filtering layer”. As indicated in NR151.002(14r), a “filtering layer” is defined as a layer at least 3 feet thick, with at least 20 percent fines; or at least 5 feet thick, with at least 10 percent fines. Water was encountered during drilling at BPSRN-B-9 and 17 at depths of 12 and 10 feet (EL. 863 and EL. 872), respectively.

The design infiltration rates from DNR 1002, Table 2 which are to be used for basin design purposes are indicated in the middle column of **Table 3-6.** The preceding infiltration rate estimates and groundwater elevations are based on the subgrade conditions encountered in the borings, and soil characterization in accordance with the USDA Classification system and NR-151 guidelines. They are intended only for use in preliminary planning. It is recommended that the basin bottoms be observed by qualified geotechnical engineering personnel at the time of construction to verify the soil types. In-situ testing, such as with a double ring infiltrometer, are recommended to provide more representative infiltration rates for the design. The type of basin, and intended use, such as being “wet” or “dry”, must be carefully considered when evaluating infiltration rates.

It should be noted that the soil profile on this site is relatively variable, and estimated infiltration rates that vary significantly. In addition, relatively shallow groundwater and perched zones may be present in some areas. Such varying conditions can have a substantial effect on the actual infiltration rates at the bottoms and along the sidewalls of any management area. It is strongly recommended that in-situ testing be performed on this site as part of design planning, for use in proper evaluation with respect to the type, size, bottom elevations, intended use and other factors related to the various stormwater management devices.

It must be recognized that some local building codes or municipal regulations require that basement floor elevations be a specified distance above the water level of nearby basins. It is therefore recommended that the project civil engineer review applicable city or town requirements, and if necessary, verify the design normal and design high water elevations of the stormwater basin with respect to planned basement slab elevation. If raising of slabs is then required, the corresponding effect on final yard grades (and resulting changes in surface drainage patterns), for this and adjacent parcels must be considered.

Care must be exercised in construction of basements in the vicinity of stormwater management basins. The presence of granular or other generally permeable soils, which is typically necessary in the areas of structures, especially within utility backfill, alongside basement walls, or within other development excavations, can act as channels to carry water from basins into nearby basements. In order to help minimize this, it is recommended that clay or bentonite collars be constructed at the end of utility trenches where they encroach upon the basement backfill. In addition, stormwater lines entering the basin should be provided with impermeable clay collars to prevent water from traveling away from the basin toward the basement in granular utility line backfill.

Concerning embankment slopes surrounding basins, it is PSI’s opinion that properly constructed slopes as steep as 2 horizontal to 1 vertical would generally be stable, but would be susceptible to erosion and difficult to maintain or construct with rubber-tired mowing or grading equipment. Therefore, embankment slopes of 3 horizontal to 1 vertical or flatter are recommended.

It should be recognized that actual infiltration rates would be somewhat variable depending upon the uniformity, the in-place density and/or grading of the subsoils below and along the sidewalls of the basin footprint. It should also be recognized that the performance of the basins could be affected by other factors such as soil densification by construction equipment and sedimentation. A maintenance program must be developed to address the removal of sedimentation and/or organic materials, should they develop. It is recommended that an experienced civil engineering firm perform all basin design, and that thorough review of applicable codes (especially NR-151) and regulations be performed. Proper design and construction of clay liners, sidewalls and berms will also be essential for proper basin performance.

SECTION 4 Construction Considerations

4.1 Moisture Sensitive Soils/Weather Related Concern

The clay soils encountered at this site near the surface are expected to be very sensitive to disturbances caused by construction traffic and changes in moisture content. Increases in the moisture content of the soil can cause reduction in the soil strength and support capabilities. In addition, soils that become wet may be slow to dry and thus significantly retard the progress of grading and compaction activities. It will, therefore, be advantageous to perform earthwork and foundation construction activities during dry weather.

Water should not be allowed to collect in the foundation excavation, on floor slab areas, or on prepared subgrades during or after construction. Areas should be sloped to facilitate removal of collected rainwater, groundwater, or surface runoff. Positive site drainage should be provided to reduce infiltration of surface water around the perimeter of buildings, and beneath floor slabs. The grades should be sloped away from buildings and surface drainage should be collected and discharged such that water is not permitted to infiltrate the backfill and floor slab areas of the building.

4.2 Drainage and Groundwater Concerns

Water was encountered within all the test locations during drilling or excavation (for test pits), with the exception of the test pit BPSRN-B-18, at elevations ranging from about EL. 873 feet to EL. 850 feet. Excavations for the preparation of the subgrade for the reservoirs are generally anticipated to remain above these levels; however, variations in the water levels present during construction should be anticipated. Depending upon the water levels present during construction, reservoir subgrade preparation may encroach upon or extend below the water levels. Additionally the mat foundation for the lower level finished floor of the BPS building is estimated to encroach upon or extend below the groundwater levels observed at BPSRN-B-7, 8, and 15. At BPSRN-B-8, the water level observed during drilling was at EL. 865. Based on an estimated 2-foot-thick mat slab and a finished lower level elevation of EL. 866.5, the bottom of the mat slab is estimated to be at about EL. 864.5, which is about 1 foot below the water level at BPSRN-B-8. It is generally recommended that the bottom of slabs be placed a minimum of 2 feet above the observed water level. Consideration should be made to raising the bottom of the lower level mat slab to a minimum of 2 feet above the observed water levels. Otherwise, the slab and walls must be designed to resist hydrostatic pressures, especially where a drainage system is not included in the building design. In order to better estimate the groundwater level, it is also recommended that additional longer-term observations of the water levels in the area of the BPS building be done using monitoring wells and/or piezometers.

In the lower level area of the BPS building, it is recommended that the design include a drainage system where the water level can be maintained at least 3 feet below the bottom of the slabs. This can consist of a perimeter drain tile system placed at or below the bottom of the mat slab, that drains to a collection area(s) where the water can be removed by a sump pump; or this can consist of a permanent dewatering system. However, prior to any drainage design, additional observations within water monitoring wells and/or piezometers must be made to better estimate the water level. A specialty dewatering contractor must be engaged for proper design of the drainage system. Where the below grade level of the BPS building does not include drainage, it is recommended that the basement walls and mat slab be designed to resist hydrostatic pressures.

The below grade reservoir walls should also include an exterior perimeter drain tile placed near the slab subgrade elevation. A procedure should be used to discharge water from the drain tile by gravity to an appropriate area of the site, which would not allow reverse flow into the system. Water should be properly discharged in accordance with all state and local discharge requirements.

Where excavations extend several inches into the groundwater or into low volume perched conditions, gravity drainage with sumps and filtered sump pumps should be sufficient. Where larger volumes of perched water are encountered, or where excavations extend below the groundwater, a series of sumps or well points, along with high capacity pumps, will likely be necessary.

Where excavations encroach upon or extend below the groundwater or perched zones and into fine sand, silt, or soft clay, they may become substantially unstable when the confining effect of the overburden is removed. Significant sloughing or caving of sidewalls will also occur. Some over-excavation of softened or loosened soils, in conjunction with the use of a crushed stone working mat, may be necessary to establish a stable bearing subgrade.

Fluctuations in the groundwater level, as well as perched water levels and volumes, should be anticipated throughout the year depending on variations in climatological conditions and other factors not apparent at the time the borings were performed. Groundwater elevations may also be influenced by the level of the adjacent wetland area. The possibility of groundwater level fluctuation should be considered when developing the design and construction plans for the project.

4.3 Excavations

Sloping, shoring, or bracing of the excavation sidewalls will be necessary. Trenching in granular soils may be difficult due to the instability of vertical slopes, and will therefore require a flattening of trench sides, or some other means of protection, to facilitate construction and to protect life and property. Substantial sloughing and caving should be expected within unprotected excavations. The degree of excavation instability problems is dependent upon the depth and length of time that excavations remain open, excavation bank slopes, water levels and the effectiveness of any dewatering systems. All excavation work must be performed in accordance with Occupational Safety and Health Administration (OSHA) and local building code requirements.

It must be recognized that severe caving and sidewall instability can be expected with increasing depth, and especially where excavations encroach upon or extend below the groundwater or perched water. The use of sloping, shoring, bracing, or trench boxes will be required for open cut trench excavations.

Where excavations encroach upon or extend below any groundwater or perched zones and into fine sand, silt, or soft clay, they may become substantially unstable when the confining effect of the overburden is removed. Significant sloughing or caving of sidewalls may also occur. Some over-excavation of softened or loosened soils, in conjunction with the use of a crushed stone working mat, may be necessary to establish a stable bearing subgrade. Additionally, significantly widened excavations may result, or be required to maintain or achieve sidewall stability.

It is mandated that excavations, whether they be for utility trenches or footing excavations, be constructed in accordance with current OSHA guidelines to protect workers and others during construction. PSI recommends that these regulations be strictly enforced; otherwise, workers could be in danger and the owner(s) and the contractor(s) could be liable for substantial penalties.

The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom.

The contractor's "responsible person", as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations.

PSI is providing this information solely as a service to the project team. PSI does not assume responsibility for construction site safety or the contractor's or other parties' compliance with local, state, and federal safety or other regulations.

4.4 Utility Trenching

In general, the on-site soils can be used for support of utility lines. However, some undercutting of loosened, unstable, or otherwise unsuitable soils, in conjunction with the placement of crushed stone or other suitable granular backfill, may be necessary in isolated areas to establish a stable working mat and/or bearing subgrade. A representative of the geotechnical engineer should be present during construction to help identify areas requiring over-excavation and the over-excavation depths necessary to reach suitable and stable subgrade soils. Where over-excavation is performed, the trench should be widened laterally beyond the pipe in each direction, a minimum distance equal to the depth of over-excavation below planned grade.

Difficulty with the stability of utility trenches should be expected due to the predominance of granular soils across the site, especially in the presence of water. The use of shoring, bracing, or trench boxes will be required. Utility construction should be performed in accordance with "The Standard Specifications for Sewer and Water Line Construction" for the State of Wisconsin.

Proper selection and compaction of the pipe bedding and cover materials is essential to reduce the amount of pipe deflection and settlement of the trench backfill in open cut installation areas. This should be done in general accordance with Wisconsin state codes and requirements. Based on the Draft Backfill Specifications included in **Appendix C**, Pipe Bedding material must exhibit a well-defined moisture density relationship whereby 95% or more is retained on the No. 8 sieve, 100% of the material passes the one-inch sieve, and the material is well graded between these limits. As an alternative, material meeting WisDOT Standard Specifications for Highway and Structure Construction Section 608.2.2.2 Foundation Backfill can be used for pipe bedding materials. Bedding of the pipe should be performed in accordance with normally accepted procedures for the class of pipe being used. The bedding material must be compacted to 95% of the maximum dry density as determined by the modified Proctor method.

Backfilling of the excavation should be done in such a way as to provide relatively uniform lateral support to the pipe until the backfill extends over the pipe. This can be accomplished by performing even fill placement at approximately one-foot intervals simultaneously on both sides of the pipe until reaching the top of the pipe. The backfill materials over the top of the pipe and up to several feet above the pipe must be compacted to a minimum of 90% of the maximum dry density as determined by the modified Proctor method. Care must be taken not to damage the pipe during placement and compaction of the Select Fill backfill materials directly over the pipe.

Backfill for utility trenches is as important as the original subgrade preparation or engineered fill placed to support either a foundation or slab. Therefore, it is imperative that the trench backfill be placed to meet the Program specifications. Two types of materials have been specified for use as backfill as indicated in the Draft Backfill Specifications. This includes Select Fill and Common Fill, for structural and non-structural areas, respectively. Select Fill is defined as gravel, crushed stone, or other similar material which meets the gradation specified and can be compacted to a minimum of 95% of the maximum dry density as determined by the modified Proctor method. Select Fill is generally considered to be an imported, processed material. Very fine sand or uniformly graded granular materials are not acceptable as use for Select Fill. Common Fill materials are generally considered to be excavation spoils which meet the specified gradation ranges indicated for granular materials, and Liquid Limit and Plasticity Indices of less than or equal to 40 and 20, respectively, for cohesive materials. Grainsize testing on some of the near surface on-site soils indicated fines contents ranging from about 24 to 42%. Therefore, the on-site soils are generally not considered to be suitable for use as Select Fill, which has a maximum specified fine content of 15%. It is recommended that a representative of the geotechnical engineer be present during construction to help estimate the suitability of excavation spoils for use as Common Fill. Additional laboratory testing including modified Proctor testing, grainsize determination by mechanical and hydrometer methods, and Atterberg Limits determination will likely be necessary prior to and during construction to verify whether the material properties meet the specifications.

Select Fill must be used within all areas up to at least one foot above the top of the pipe. Then, within the pavement, sidewalk, or other structural areas, Select Fill (or slurry) must be placed and compacted in uniform lifts which are sufficient to achieve a minimum density of 95% of the maximum density as determined by the modified Proctor method. In non-structural areas, such as landscape areas, Common Fill materials can be compacted to a minimum of 90% of the maximum dry density as determined by the modified Proctor method.

Specifications for compaction testing should assign an appropriate frequency of testing to account for the length of trench and the depth of the trench backfill, as well as consider the sensitivity of surface features to settlement. Backfill of trenches should not be performed with water standing in the trench.

It is recommended that mechanical compaction be used to achieve uniform consolidation of the backfill material. Proper moisture control is essential to reduce the amount of compactive effort necessary to achieve the specified density. This is especially true of clayey soils, where drying may be required to achieve near optimum moisture levels prior to compaction. A sheepsfoot roller is generally required for compaction of clayey soils, whereas a vibratory smooth drum roller or backhoe mounted vibratory plate compactor is preferred for granular material. Where cohesive Common Fill soils are being used as backfill, it will likely be necessary to widen the trench in order to allow for the access of a sheepsfoot roller, in order to achieve the compaction specified. Compaction of cohesive soils within a narrow trench with a vibratory plate is typically not adequate to achieve 90% compaction relative to the modified Proctor dry density.

Where controlled low-strength materials (CLSM) are to be used for backfilling, the Standard Specifications for Sewer & Water Construction in Wisconsin should be followed. The CLSM should be thoroughly mixed and delivered with concrete trucks. The CLSM must not be placed within a trench containing water, and the maximum amount of water recommended in the mix must not be exceeded. A maximum design compressive strength of 200 psi should not be exceeded in order to allow for excavation of the slurry backfill by backhoe methods where necessary in the future to expose the pipelines.

The selection of backfill materials for various applications should be done in consultation with the soils engineer. Similarly, the evaluation of the subgrade and placement and compaction of fill for structural applications should be monitored and tested by a qualified representative of the soils engineer. Additional guidance can be provided at the time of construction in the selection process for grade-raising fill and trench backfill.

SECTION 5 Geotechnical Risk

5.1 Geotechnical Risk

The concept of risk is an important aspect of the geotechnical evaluation. The primary reason for this is that the analytical methods used to develop geotechnical recommendations do not comprise an exact science. The analytical tools that geotechnical engineers use, are generally empirical and must be used in conjunction with engineering judgment and experience. Therefore, the solutions and recommendations presented in the geotechnical evaluation should not be considered risk-free, and more importantly, are not a guarantee that the interaction between the soils and the proposed pipelines will perform as planned. The engineering recommendations, presented in the preceding sections, constitute PSI's professional estimate of the necessary measures for the proposed BPS to perform according to the proposed design based on the information generated and referenced during this evaluation, and PSI's experience in working with these conditions.

SECTION 6 Report Limitations

6.1 Report Limitations

The recommendations submitted are based on the available subsurface information obtained by PSI and design details furnished by the Program team. If there are revisions to the plans, or if deviations from the subsurface conditions noted in this report are encountered during construction, PSI should be notified immediately to determine if changes in the recommendations are required. If PSI is not retained to perform these functions, PSI will not be responsible for the impact of those conditions on the Program.

The geotechnical engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted professional geotechnical engineering practices in the local area. No other warranties are implied or expressed.

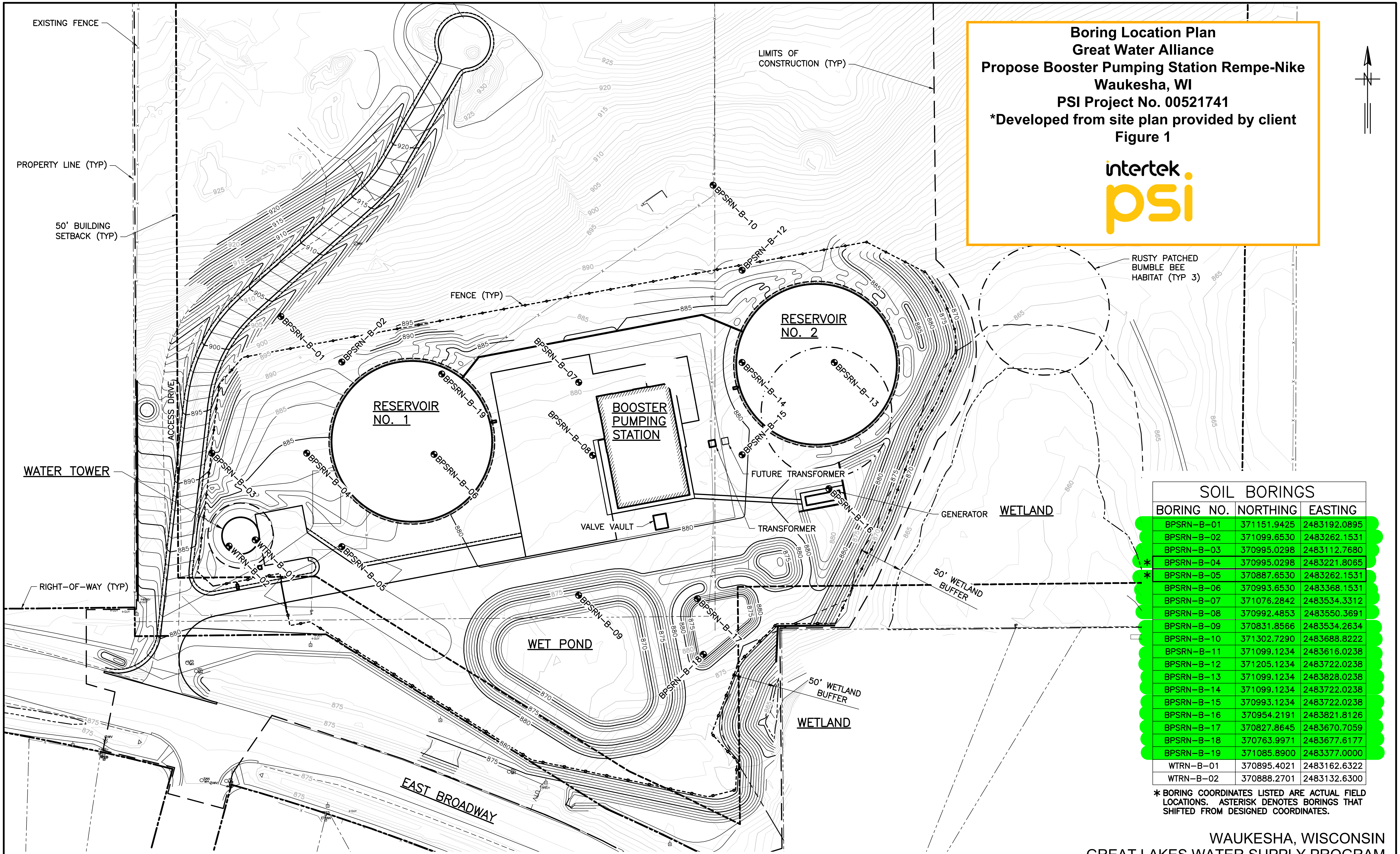
After the plans and specifications are more complete, the geotechnical engineer should be retained and provided the opportunity to review the final design plans and specifications to check that our engineering recommendations have been properly incorporated into the design documents. At that time, it may be necessary to submit supplementary recommendations.

Appendix A - Boring Location Plan

G:\15310-WAUKESHA GREAT LAKES WATER SUPPLY PM-CM\21 CADD\21.03 RPT FIGURES\01 - PUMPING STATIONS\CONTRACT PACKAGE 3 - BPSF\GLWSP-P3-BPSF-REMPE-NIKE-BORING 2020/05/26 4:23 PM MARCOTTE, TIM

Boring Location Plan
Great Water Alliance
Propose Booster Pumping Station Rempe-Nike
Waukesha, WI
PSI Project No. 00521741
***Developed from site plan provided by client**
Figure 1

intertek psi



SOIL BORINGS		
BORING NO.	NORTHING	EASTING
BPSRN-B-01	371151.9425	2483192.0895
BPSRN-B-02	371099.6530	2483262.1531
BPSRN-B-03	370995.0298	2483112.7680
* BPSRN-B-04	370995.0298	2483221.8065
* BPSRN-B-05	370887.6530	2483262.1531
BPSRN-B-06	370993.6530	2483368.1531
BPSRN-B-07	371076.2842	2483534.3312
BPSRN-B-08	370992.4853	2483550.3691
BPSRN-B-09	370831.8566	2483534.2634
BPSRN-B-10	371302.7290	2483688.8222
BPSRN-B-11	371099.1234	2483616.0238
BPSRN-B-12	371205.1234	2483722.0238
BPSRN-B-13	371099.1234	2483828.0238
BPSRN-B-14	371099.1234	2483722.0238
BPSRN-B-15	370993.1234	2483722.0238
BPSRN-B-16	370954.2191	2483821.8126
BPSRN-B-17	370827.8645	2483670.7059
BPSRN-B-18	370763.9971	2483677.6177
BPSRN-B-19	371085.8900	2483377.0000
WTRN-B-01	370895.4021	2483162.6322
WTRN-B-02	370888.2701	2483132.6300

* BORING COORDINATES LISTED ARE ACTUAL FIELD LOCATIONS. ASTERISK DENOTES BORINGS THAT SHIFTED FROM DESIGNED COORDINATES.

100 0 100 200 FT
1"=100'

Waukesha Water Utility
SERVING WAUKESHA SINCE 1886

GREELEY AND HANSEN

WAUKESHA, WISCONSIN
GREAT LAKES WATER SUPPLY PROGRAM
BOOSTER PUMPING STATION REMPE-NIKE
PRELIMINARY SOIL BORING PLAN - DRAFT
2020-05-26

Appendix B - Log of Borings and Soil Evaluation - Storm Forms

BORING LOG

BORING No BPSRN-B-01

PROJECT NAME: **GWA - Alternative BPS Site 2**
PROJECT No: **00521741**
PAGE No: **1 of 1**
CONSULTANT: **Greeley-Hansen**
CONSULTANT PROJECT No:
DATE STARTED: **4/15/20**
HORIZONTAL DATUM:
VERTICAL DATUM:
DRILLING CONTRACTOR: **PSI**
DRILLING CONTRACTOR PROJECT No:
DATE COMPLETED: **4/15/20**
LATITUDE:
CREW CHIEF: **P. Rotaru**
DRILLING RIG: **HD ATV #419**
BORING OFFSET:
LONGITUDE:
FIELD LOG BY: **D. Buchman**
DRILLING METHOD / HOLE SIZE:
ROADWAY NAME:
NORTHING:
LOG QC BY:
HAMMER TYPE:
EFFICIENCY:
STATION:
OFFSET:
EASTING:
COUNTY:
TOWNSHIP:
RANGE:
SECTION:
1/4 SECTION:
1/4 SECTION:
SURFACE ELEVATION: **906 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
					905	Topsoil (12"± Thick), Dark Brown Silty Clay, Very Moist 0.99 (905.01)	OL							27	
1 SS	8	4 13 14	27			Fill, Brown Silty Sand With Gravel and Dark Brown Lean Clay Pockets, Moist 5.5 (900.5)								5	
2 SS	12	4 7 10	17		900									7	
3 SS	7	4 4 5	9			Brown Sandy Lean Clay, Trace Gravel, Moist 8 (898)	CL			2.0	1.81			15	
4 SS	14	5 7 10	17	10	895	Brown Sandy Silt With Gravel, Moist	ML							7	
5 SS		4 7 7	14		890	17 (889)								7	
6 SS	14	18 15 13	28	20	885	Brown Silt, Moist 22 (884)	ML								
7 SS	12	4 14 24	38		880	Brown Sandy Silt With Gravel, Very Moist 27 (879)	ML							15	
8 SS	12	12 20 31	51	30	875	Brown Sand, Trace Gravel, Moist	SP							4	
9 SS	18	21 31 40	71		870	37 (869)								4	
10 SS	12	23 29 32	61	40		▽ Brown Silty Fine Sand, Wet 40 (866)	SM							6	

End of Boring at 40.0 ft.

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 38.5ft.
▼ WATER LEVEL AT COMPLETION: NE
▼ WATER LEVEL AFTER 0 HOURS: N/A
CAVE DEPTH AT COMPLETION: 22ft. WET ☐ DRY ☐
■ CAVE DEPTH AFTER 0 HOURS: N/A WET ☐ DRY ☐
NE = Not Encountered; NMR = No Measurement Recorded

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

BORING LOG

BORING No BPSRN-B-02

PAGE No 1 of 2

PROJECT NAME: GWA - Alternative BPS Site 2			
PROJECT No: 00521741			
CONSULTANT: Greeley-Hansen	CONSULTANT PROJECT No:	DATE STARTED: 3/31/20	HORIZONTAL DATUM: / VERTICAL DATUM:
DRILLING CONTRACTOR: PSI	DRILLING CONTRACTOR PROJECT No:	DATE COMPLETED: 3/31/20	LATITUDE:
CREW CHIEF: P. Rotaru	DRILLING RIG: HD ATV #419	BORING OFFSET:	LONGITUDE:
FIELD LOG BY: R. Sayles	DRILLING METHOD / HOLE SIZE:	ROADWAY NAME:	NORTHING:
LOG QC BY:	HAMMER TYPE: / EFFICIENCY:	STATION: / OFFSET:	EASTING:
COUNTY:	TOWNSHIP: / RANGE: / SECTION:	1/4 SECTION: / 1/4 SECTION:	SURFACE ELEVATION: 888 ft

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_r (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
						Topsoil (15"± Thick), Dark Brown Silty Clay, Very Moist 1.1 (886.9)	OL							32	
1 SS	6	3 3 3	6		885	Light Brown Silty Sand and Gravel, Very Moist	ML							8	
2 SS	4	4 4 4	8			5.5 (882.5)								9	
3 SS	10	23 17 12	29		880	Brown Medium Sand and Gravel, Moist to Wet	SP							5	
4 SS	8	19 19 16	35	10										4	
					875										
5 SS	9	23 23 19	42											2	
					870										
6 SS	4	50/4"	R	20										1	
					865	▽									
7 SS	11	35 34 42	76											9	
					860										
8 SS	8	32 38 50	88	30										15	
					855										
9 SS	5	50/5"	R			37 (851)								17	
					850	Brown Lean Clay, Trace Gravel, Moist	CL								
10 SS	10	22 20 29	49	40						4.5+	7.63			12	
					845										
11 SS	11	23 22 47	69							4.5	4.33			12	
					840										
12 SS		18 38 42	80	50						4.5+	7.21			12	
					835										
13	17		71												

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 22ft.		CAVE DEPTH AT COMPLETION: N/A WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE		CAVE DEPTH AFTER 0 HOURS: N/A WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

PROJECT NAME **GWA - Alternative BPS Site 2**	**GREAT WATER ALLIANCE**	**BORING LOG**	**BORING No BPSRN-B-02**
PROJECT No **00521741**			PAGE No **2 of 2**

CONSULTANT **Greeley-Hansen**	CONSULTANT PROJECT No	DATE STARTED **3/31/20**	HORIZONTAL DATUM	VERTICAL DATUM
DRILLING CONTRACTOR **PSI**	DRILLING CONTRACTOR PROJECT No	DATE COMPLETED **3/31/20**	LATITUDE	
CREW CHIEF **P. Rotaru**	DRILLING RIG **HD ATV #419**	BORING OFFSET	LONGITUDE	
FIELD LOG BY **R. Sayles**	DRILLING METHOD / HOLE SIZE	ROADWAY NAME	NORTHING	
LOG QC BY	HAMMER TYPE / EFFICIENCY	STATION / OFFSET	EASTING	
COUNTY	TOWNSHIP / RANGE / SECTION	1/4 SECTION / 1/4 SECTION	SURFACE ELEVATION **888 ft**	

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
SS		18 28 43				Brown Lean Clay, Trace Gravel, Moist		▨		4.5+	2.23			12	
					830			▨							
14 SS	15	17 28 45	73	60				▨		4.5+	6.39			11	
					825			▨							
15 SS	18	16 26 34	60					▨		3.75	3.79			13	
					820			▨							
16 SS	18	21 24 28	52	70				▨		4.5+	4.95			12	
					815			▨							
17 SS	18	23 31 39	70					▨		4.5+	6.39			12	
					810		CL	▨							
18 SS	15	24 38 50	88	80				▨		4.5+	8.24			11	
					805			▨							
19 SS	2	50/2"	R					▨		4.5+	5.98			12	
					800			▨							
20 SS	4	50/4"	R	90				▨		4.5+	5.56			13	
					795			▨							
21 SS	2	50/2"	R					▨		4.5+					
					790			▨							
22 SS	2	50/2"	R	100		100 (788)		▨		4.5+				10	

Boring offset 13' to the West due to large trees
Started mud rotary drilling at a depth of about 30'
End of Boring at 100.0 ft.

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 22ft.	☒	CAVE DEPTH AT COMPLETION: N/A	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	■	CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

BORING LOG

BORING No BPSRN-B-03

PROJECT NAME GWA - Alternative BPS Site 2			PAGE No 1 of 2
PROJECT No 00521741			
CONSULTANT Greeley-Hansen	CONSULTANT PROJECT No	DATE STARTED 3/30/20	HORIZONTAL DATUM
			VERTICAL DATUM
DRILLING CONTRACTOR PSI	DRILLING CONTRACTOR PROJECT No	DATE COMPLETED 3/30/20	LATITUDE
CREW CHIEF P. Rotaru	DRILLING RIG HD ATV #419	BORING OFFSET	LONGITUDE
FIELD LOG BY R. Sayles	DRILLING METHOD / HOLE SIZE	ROADWAY NAME	NORTHING
LOG QC BY	HAMMER TYPE EFFICIENCY	STATION OFFSET	EASTING
COUNTY	TOWNSHIP RANGE SECTION	1/4 SECTION 1/4 SECTION	SURFACE ELEVATION 885 ft

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
						Topsoil (12"± Thick), Dark Brown Silty Clay, Very Moist	OL							17	
1 SS	7	3 2 4	6			0.99 (884.01)				4.0				21	
						Brown Sandy Lean Clay, Very Moist to Moist	CL								
2 SS	11	6 5 6	11		880	5.5 (879.5)				2.0				17	
						Brown Sand and Gravel, Moist to Wet									
3 SS	6	4 6 9	15											5	
4 SS	7	43 27 18	45	10	875									2	
						⊠ ▽	SP								
5 SS	5	24 12 6	18		870									15	
						17 (868)									
						Brown Medium Sand, Wet									
6 SS	6	15 18 28	46	20	865		SP							17	
						22 (863)									
						Brown Sand and Gravel, Wet									
7 SS	4	50/4"	R		860		SW								
						27 (858)									
						Brown Lean Clay, Moist to Very Moist									
8 SS	4	21 27 23	50	30	855					4.5+				10	
9 SS	12	14 26 32	58		850					4.5+				11	
10 SS	13	16 21 31	52	40	845					4.5+	6.18			12	
							CL								
11 SS	10	15 23 33	56		840					4.5+	8.24			11	
12 SS	10	19 25 35	60	50	835					4.5+	7.42			10	
13	11		66		830										

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 12ft.	⊠	CAVE DEPTH AT COMPLETION: 11ft.	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	■	CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

BORING LOG

BORING No BPSRN-B-03

PROJECT NAME: GWA - Alternative BPS Site 2
PROJECT No: 00521741
PAGE No: 2 of 2
CONSULTANT: Greeley-Hansen
CONSULTANT PROJECT No:
DATE STARTED: 3/30/20
HORIZONTAL DATUM:
VERTICAL DATUM:
DRILLING CONTRACTOR: PSI
DRILLING CONTRACTOR PROJECT No:
DATE COMPLETED: 3/30/20
LATITUDE:
CREW CHIEF: P. Rotaru
DRILLING RIG: HD ATV #419
BORING OFFSET:
LONGITUDE:
FIELD LOG BY: R. Sayles
DRILLING METHOD / HOLE SIZE:
ROADWAY NAME:
NORTHING:
LOG QC BY:
HAMMER TYPE:
EFFICIENCY:
STATION:
OFFSET:
EASTING:
COUNTY:
TOWNSHIP:
RANGE:
SECTION:
1/4 SECTION:
1/4 SECTION:
SURFACE ELEVATION: 885 ft

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
SS		11 30 36				Brown Lean Clay, Moist to Very Moist	CL	▨		4.5+	4.53			11	
14 SS	13	15 24 46	70	60	825					4.0				12	
15 SS	11	13 24 31	55		820					4.0	3.71			13	
16 SS	13	13 20 31	51	70	815					3.5	2.47			13	
17 SS	12	12 27 35	62		810					4.5	3.96			12	
18 SS	14	15 24 37	61	80	805					3.0	2.89			13	
19 SS	5	50/5"	R		800					3.5	2.14			22	
20 SS	4	50/4"	R	90	795					4.5+	4.53			18	
21 SS	4.5	50/5"	R		790					4.5+	5.36			21	
22 SS		28 28 38	66	100	785	100 (785)				4.5+	9.07			17	

Started mud rotary drilling at a depth of about 25'
End of Boring at 100.0 ft.

WATER & CAVE-IN OBSERVATION DATA

WATER ENCOUNTERED DURING DRILLING: 12ft.		CAVE DEPTH AT COMPLETION: 11ft.	WET ☐ DRY ☐
WATER LEVEL AT COMPLETION: NE		CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

BORING LOG

BORING No BPSRN-B-04

PROJECT NAME GWA - Alternative BPS Site 2			PAGE No 1 of 2
PROJECT No 00521741			
CONSULTANT Greeley-Hansen	CONSULTANT PROJECT No	DATE STARTED 4/07/20	HORIZONTAL DATUM / VERTICAL DATUM
DRILLING CONTRACTOR PSI	DRILLING CONTRACTOR PROJECT No	DATE COMPLETED 4/07/20	LATITUDE
CREW CHIEF P. Rotaru	DRILLING RIG HD ATV #419	BORING OFFSET	LONGITUDE
FIELD LOG BY D. Buchman	DRILLING METHOD / HOLE SIZE	ROADWAY NAME	NORTHING
LOG QC BY	HAMMER TYPE / EFFICIENCY	STATION / OFFSET	EASTING
COUNTY	TOWNSHIP / RANGE / SECTION	1/4 SECTION / 1/4 SECTION	SURFACE ELEVATION 882 ft

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
						Topsoil (11"± Thick), Dark Brown Silt, Very Moist 0.9 (881.1)	OL							25	
1 SS	10	6 4 4	8		880	Fill, Brown and Dark Brown Lean Clay, Trace Sand and Gravel, Very Moist to Moist				1.25				22	
2 SS	10	4 6 5	11			5.5 (876.5)				2.0				15	
3 SS	8	8 39 31	70		875	Brown Sand and Gravel, Damp 8 (874)	SP							5	
4 SS	12	9 12 14	26	10		Brown Fine to Medium Sand, Moist to Wet	SP							9	
					870	▽									
5 SS	10	26 16 19	35		865	17 (865)								21	
6 SS	14	23 10 20	30	20	860	Brown Sand With Gravel, Possible Cobbles, Wet	SP							12	
7 SS	12	20 17 29	46		855									14	
8 SS	14	23 31 50	81	30	850									19	
9 SS	10	23 40 50	90		845	37 (845)									
10 SS	8	12 26 32	58	40	840	Brown Lean Clay, Trace Gravel, Moist	CL			4.25	4.53			12	
11 SS	8	17 26 40	66		835					4.5+	9.48			11	
12 SS	14	20 24 38	62	50	830					4.5+	7.63			10	
13	18		51												

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 13.5ft.

▼ WATER LEVEL AT COMPLETION: NE

▼ WATER LEVEL AFTER 0 HOURS: N/A

CAVE DEPTH AT COMPLETION: NE WET ☐ DRY ☐

CAVE DEPTH AFTER 0 HOURS: N/A WET ☐ DRY ☐

NE = Not Encountered; NMR = No Measurement Recorded

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

PROJECT NAME **GWA - Alternative BPS Site 2**	**BORING LOG**		**BORING No BPSRN-B-04**
PROJECT No **00521741**			PAGE No **2 of 2**
CONSULTANT **Greeley-Hansen**	CONSULTANT PROJECT No	DATE STARTED **4/07/20**	HORIZONTAL DATUM / VERTICAL DATUM
DRILLING CONTRACTOR **PSI**	DRILLING CONTRACTOR PROJECT No	DATE COMPLETED **4/07/20**	LATITUDE
CREW CHIEF **P. Rotaru**	DRILLING RIG **HD ATV #419**	BORING OFFSET	LONGITUDE
FIELD LOG BY **D. Buchman**	DRILLING METHOD / HOLE SIZE	ROADWAY NAME	NORTHING
LOG QC BY	HAMMER TYPE / EFFICIENCY	STATION / OFFSET	EASTING
COUNTY	TOWNSHIP / RANGE / SECTION	1/4 SECTION / 1/4 SECTION	SURFACE ELEVATION **882 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
SS		22 26 25			825	Brown Lean Clay, Trace Gravel, Moist		▨		4.0				12	
14 SS	18	19 24 36	60	60	820			▨		4.5+	6.18			12	
15 SS	18	18 21 32	53		815			▨		4.5+				12	
16 SS	18	16 25 38	63	70	810			▨		4.5+				12	
17 SS	10	15 25 32	57		805		CL	▨		4.5+	4.74			12	
18 SS	12	14 28 40	68	80	800			▨		4.5	4.53			14	
19 SS	12	26 31 33	64		795			▨		4.5+	10.3+			10	
20 SS	18	23 29 32	61	90	790			▨		4.5+				12	
21 SS	18	25 31 34	65		785			▨		4.5+	9.07			9	
22 SS	5	50/5"	R	100		100 (782)		▨		4.0	4.12			19	

Started mud rotary drilling at a depth of about 15'
End of Boring at 100.0 ft.

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 13.5ft.		CAVE DEPTH AT COMPLETION: NE	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	■	CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

PROJECT NAME **GWA - Alternative BPS Site 2**
PROJECT No **00521741**

GREAT WATER ALLIANCE

BORING LOG

Intertek psi

BORING No BPSRN-B-05

PAGE No **1 of 2**

CONSULTANT **Greeley-Hansen**
CONSULTANT PROJECT No
DATE STARTED **4/08/20**
HORIZONTAL DATUM
VERTICAL DATUM
DRILLING CONTRACTOR **PSI**
DRILLING CONTRACTOR PROJECT No
DATE COMPLETED **4/08/20**
LATITUDE
CREW CHIEF **P. Rotaru**
DRILLING RIG **HD ATV #419**
BORING OFFSET
LONGITUDE
FIELD LOG BY **D. Buchman**
DRILLING METHOD / HOLE SIZE
ROADWAY NAME
NORTHING
LOG QC BY
HAMMER TYPE
EFFICIENCY
STATION
OFFSET
EASTING
COUNTY
TOWNSHIP
RANGE
SECTION
1/4 SECTION
1/4 SECTION
SURFACE ELEVATION **878 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
						Topsoil (12"± Thick), Dark Brown Silty Clay, Very Moist	OL								
1 SS	8	3 3 3	6		875	0.99 (877.01)								11	
						Brown Sandy Lean Clay, Very Moist									
2 SS	10	4 5 5	10			3 (875)								10	
						Brown Silty Sand With Gravel, Moist	SM								
3 SS	8	6 5 6	11		870	8 (870)								11	
						Brown Silt, Moist	ML								
4 SS	14	5 7 12	19	10										10	
						▽ 12 (866)									
					865	Brown Sand and Gravel, Wet	SP								
5 SS	12	3 5 13	18											12	
					860										
6 SS	12	9 28 35	63	20		22 (856)								12	
					855	Brown Lean Clay, Trace Gravel, Moist	CL								
7 SS	8	11 22 20	42							3.75	4.53			12	
					850										
8 SS	18	9 17 24	41	30						3.5	2.64			14	
					845										
9 SS	15	9 16 23	39							4.5	4.04			12	
					840										
10 SS	18	11 14 21	35	40						3.75	3.63			12	
					835										
11 SS	18	10 15 26	41							4.25	4.33			13	
					830										
12 SS	18	8 17 27	44	50						4.5+	5.36			12	
					825										
13	18		42												

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 12ft.
▼ WATER LEVEL AT COMPLETION: NE
▼ WATER LEVEL AFTER 0 HOURS: N/A
CAVE DEPTH AT COMPLETION: NE — WET ☐ DRY ☐
CAVE DEPTH AFTER 0 HOURS: N/A — WET ☐ DRY ☐
NE = Not Encountered; NMR = No Measurement Recorded

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

BORING LOG

BORING No BPSRN-B-05

PROJECT NAME **GWA - Alternative BPS Site 2**			PAGE No **2 of 2**
PROJECT No **00521741**			
CONSULTANT **Greeley-Hansen**	CONSULTANT PROJECT No	DATE STARTED **4/08/20**	HORIZONTAL DATUM / VERTICAL DATUM
DRILLING CONTRACTOR **PSI**	DRILLING CONTRACTOR PROJECT No	DATE COMPLETED **4/08/20**	LATITUDE
CREW CHIEF **P. Rotaru**	DRILLING RIG **HD ATV #419**	BORING OFFSET	LONGITUDE
FIELD LOG BY **D. Buchman**	DRILLING METHOD / HOLE SIZE	ROADWAY NAME	NORTHING
LOG QC BY	HAMMER TYPE / EFFICIENCY	STATION / OFFSET	EASTING
COUNTY	TOWNSHIP / RANGE / SECTION / 1/4 SECTION / 1/4 SECTION		SURFACE ELEVATION **878 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
SS		10 18 24				Brown Lean Clay, Trace Gravel, Moist		▨		4.5+	7.21			12	
					820										
14 SS	18	11 19 26	45	60						4.5+	6.39			12	
					815										
15 SS	14	10 16 22	38							4.5	4.53			12	
					810										
16 SS	18	12 14 24	38	70						4.5+	5.15			12	
					805										
17 SS	14	14 38 25	63				CL			4.5+				6	
					800										
18 SS	12	16 42 38	80	80						4.5+				14	
					795										
19 SS	18	18 39 36	75							4.5+				9	
					790										
20 SS	18	14 36 37	73	90						4.5+				5	
						92 (786)									
					785	Brown Clayey Sand and Gravel, Wet		▨							
21 SS	3	50/3"	R				SC							5	
					780										
22 SS	2	50/2"	R	100		100 (778)								19	

Started mud rotary drilling at a depth of about 15'
End of Boring at 100.0 ft.

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 12ft.		CAVE DEPTH AT COMPLETION: NE	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	■	CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

BORING LOG

BORING No BPSRN-B-06

PROJECT NAME: GWA - Alternative BPS Site 2
PROJECT No: 00521741
PAGE No: 1 of 2
CONSULTANT: Greeley-Hansen
CONSULTANT PROJECT No:
DATE STARTED: 4/10/20
HORIZONTAL DATUM:
VERTICAL DATUM:
DRILLING CONTRACTOR: PSI
DRILLING CONTRACTOR PROJECT No:
DATE COMPLETED: 4/10/20
LATITUDE:
CREW CHIEF: P. Rotaru
DRILLING RIG: HD ATV #419
BORING OFFSET:
LONGITUDE:
FIELD LOG BY: D. Buchman
DRILLING METHOD / HOLE SIZE:
ROADWAY NAME:
NORTHING:
LOG QC BY:
HAMMER TYPE:
EFFICIENCY:
STATION:
OFFSET:
EASTING:
COUNTY:
TOWNSHIP:
RANGE:
SECTION:
1/4 SECTION:
1/4 SECTION:
SURFACE ELEVATION: 880 ft

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
						Topsoil (12"± Thick), Dark Brown Silty Clay, Very Moist 0.99 (879.01)	OL							50	
1 SS	8	3 4 5	9			Brown Lean Clay with Sand, Very Moist	CL	▨		4.0				21	
2 SS	8	3 6 12	18		875	5.5 (874.5)		▨						22	
3 SS	8	10 21 29	50			Brown Sand With Gravel, Moist to Wet		⁘						3	
4 SS	11	9 15 20	35	10	870			⁘						4	
						▽		⁘							
5 SS	10	5 7 8	15		865		SP	⁘						14	
6 SS	10	16 17 18	35	20	860	22 (858)		⁘						7	
7 SS	8	10 10 15	25		855	Brown Lean Clay, Moist 27 (853)	CL	▨						13	
8 SS	14	5 12 19	31	30	850	Brown Coarse Sand and Gravel, Wet 32 (848)	SP	⁘						16	
9 SS	15	8 13 19	32		845	Brown Lean Clay, Trace Gravel, Moist		▨		4.5+	7.83			12	
10 SS	15	10 15 22	37	40	840			▨		4.5+	7.01			12	
11 SS	12	16 21 28	49		835		CL	▨		4.5+	5.77			12	
12 SS	14	18 21 30	51	50	830			▨		4.5+	5.15			13	
13	14		51		825			▨							

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 12ft.		CAVE DEPTH AT COMPLETION: NE	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	■	CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

PROJECT NAME **GWA - Alternative BPS Site 2**
PROJECT No **00521741**

BORING LOG

BORING No BPSRN-B-06

PAGE No **2 of 2**

CONSULTANT **Greeley-Hansen**
CONSULTANT PROJECT No
DATE STARTED **4/10/20**
HORIZONTAL DATUM
VERTICAL DATUM
DRILLING CONTRACTOR **PSI**
DRILLING CONTRACTOR PROJECT No
DATE COMPLETED **4/10/20**
LATITUDE
CREW CHIEF **P. Rotaru**
DRILLING RIG **HD ATV #419**
BORING OFFSET
LONGITUDE
FIELD LOG BY **D. Buchman**
DRILLING METHOD / HOLE SIZE
ROADWAY NAME
NORTHING
LOG QC BY
HAMMER TYPE
EFFICIENCY
STATION
OFFSET
EASTING
COUNTY
TOWNSHIP
RANGE
SECTION
1/4 SECTION
1/4 SECTION
SURFACE ELEVATION **880 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
SS		16 20 31				Brown Lean Clay, Trace Gravel, Moist	CL			4.5+	7.01			11	
14 SS	12	15 22 34	56	60	820					4.5+	6.6			11	
15 SS	10	17 27 39	66		815					4.5+	5.98			13	
16 SS	12	18 27 43	70	70	810					4.5+	6.6			13	
17 SS	12	18 30 39	69		805	77 (803)				4.5+	7.21			14	
						Grayish Brown Silty Sand, Very Moist	SM								
18 SS	8	16 18 19	37	80	800									16	
19 SS	6	17 16 15	31		795									16	
20 SS	0.5	50/1"	R	90	790	92 (788)									

End of Boring at 92' Due to Auger Refusal on
Possible Cobbles, Boulders, or Bedrock
Started mud rotary drilling at a depth of about 15'
End of Boring at 92.0 ft.

WATER & CAVE-IN OBSERVATION DATA

∇ WATER ENCOUNTERED DURING DRILLING: 12ft.
▼ WATER LEVEL AT COMPLETION: NE
▼ WATER LEVEL AFTER 0 HOURS: N/A
CAVE DEPTH AT COMPLETION: NE WET ☐ DRY ☐
CAVE DEPTH AFTER 0 HOURS: N/A WET ☐ DRY ☐
NE = Not Encountered; NMR = No Measurement Recorded

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

BORING LOG

BORING No BPSRN-B-07

PROJECT NAME GWA - Alternative BPS Site 2			PAGE No 1 of 1	
PROJECT No 00521741				
CONSULTANT Greeley-Hansen	CONSULTANT PROJECT No	DATE STARTED 4/27/20	HORIZONTAL DATUM	VERTICAL DATUM
DRILLING CONTRACTOR PSI	DRILLING CONTRACTOR PROJECT No	DATE COMPLETED 4/27/20	LATITUDE	
CREW CHIEF V. Jones	DRILLING RIG Marooka #395	BORING OFFSET	LONGITUDE	
FIELD LOG BY N. Canning	DRILLING METHOD / HOLE SIZE	ROADWAY NAME	NORTHING	
LOG QC BY	HAMMER TYPE / EFFICIENCY	STATION / OFFSET	EASTING	
COUNTY	TOWNSHIP / RANGE / SECTION	1/4 SECTION / 1/4 SECTION	SURFACE ELEVATION 881 ft	

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
					880	Topsoil (3"± Thick), Dark Brown Silty Clay With Root Matter, Very Moist 0.3 (880.7)	OL							22	
1 SS	4	50/4"	R			Brown Sand With Gravel and Silt Seams, Moist	SP							5	
2 SS	7	10 10 11	21		875									7	
3 SS	6	12 22 24	46			8 (873)								12	
4 SS	15	11 13 9	22	10	870	Brown Silty Sand, Moist ☒ 12 (869)	SM							16	
						Brown Sand and Gravel, Moist to Wet									
5 SS	9	9 15 22	37		865	▽								3	
6 SS	7	11 7 11	18	20	860		SW							10	
7 SS	13	26 37 25	62		855									6	
8 SS	9	22 30 29	59	30	850	32 (849)								7	
9 SS	11	9 13 16	29		845	Gray Silty Sand and Gravel, Wet 37 (844)	SM							8	
10 SS	9	15 19 24	43	40		Gray Sandy Lean Clay With Gravel, Wet 40 (841)	CL							8	

End of Boring at 40.0 ft.

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 18.5ft.	☒ CAVE DEPTH AT COMPLETION: 12ft.	WET ☐ DRY ☐
▼ WATER LEVEL AT COMPLETION: NE	■ CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼ WATER LEVEL AFTER 0 HOURS: N/A	NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

BORING LOG

BORING No BPSRN-B-08

PROJECT NAME: **GWA - Alternative BPS Site 2**			PAGE No: **1 of 1**
PROJECT No: **00521741**			
CONSULTANT: **Greeley-Hansen**	CONSULTANT PROJECT No:	DATE STARTED: **4/23/20**	HORIZONTAL DATUM: / VERTICAL DATUM:
DRILLING CONTRACTOR: **PSI**	DRILLING CONTRACTOR PROJECT No:	DATE COMPLETED: **4/23/20**	LATITUDE:
CREW CHIEF: **V. Jones**	DRILLING RIG: **Marooka #395**	BORING OFFSET:	LONGITUDE:
FIELD LOG BY: **D. Buchman**	DRILLING METHOD / HOLE SIZE:	ROADWAY NAME:	NORTHING:
LOG QC BY:	HAMMER TYPE: / EFFICIENCY:	STATION: / OFFSET:	EASTING:
COUNTY:	TOWNSHIP: / RANGE: / SECTION:	1/4 SECTION: / 1/4 SECTION:	SURFACE ELEVATION: **877 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
						Topsoil (8"± Thick), Dark Brown Silty Clay, Very Moist 0.6 (876.4)	OL							18	
1 SS	6	3 3 3	6		875	Brown Lean Clay, Very Moist	CL			2.0				21	
2 SS	8	3 4 5	9							2.0				24	
3 SS	12	3 3 3	6		870	8 (869)				1.5				26	
						Brown Silty Sand, Very Moist	SM								
4 SS	12	3 3 9	12	10										14	
					865	12 (865)									
						Brown Sand and Gravel, Wet	SP								
5 SS	10	16 16 14	30											8	
					860										
6 SS	13	4 8 11	19	20										9	
					855	22 (855)									
						Brown Medium Sand, Wet	SP								
7 SS	15	8 6 5	11											16	
					850										
8 SS	9	7 10 12	22	30										22	
					845										
9 SS	12	8 15 22	37											16	
					840										
10 SS	10	9 16 27	43	40		40 (837)								20	

End of Boring at 40.0 ft.

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING:	12ft.	☒	CAVE DEPTH AT COMPLETION:	12ft. WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION:	NE	■	CAVE DEPTH AFTER 0 HOURS:	N/A WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS:	N/A		NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

BORING LOG

BORING No BPSRN-B-09

PROJECT NAME: GWA - Alternative BPS Site 2
PROJECT No: 00521741
PAGE No: 1 of 1
CONSULTANT: Greeley-Hansen
CONSULTANT PROJECT No:
DATE STARTED: 4/23/20
HORIZONTAL DATUM:
VERTICAL DATUM:
DRILLING CONTRACTOR: PSI
DRILLING CONTRACTOR PROJECT No:
DATE COMPLETED: 4/23/20
LATITUDE:
CREW CHIEF: V. Jones
DRILLING RIG: Marooka #395
BORING OFFSET:
LONGITUDE:
FIELD LOG BY: D. Buchman
DRILLING METHOD / HOLE SIZE:
ROADWAY NAME:
NORTHING:
LOG QC BY:
HAMMER TYPE:
EFFICIENCY:
STATION:
OFFSET:
EASTING:
COUNTY:
TOWNSHIP:
RANGE:
SECTION:
1/4 SECTION:
1/4 SECTION:
SURFACE ELEVATION: 875 ft

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_r (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
1 SS	6	3 19 8	27			Topsoil (10"± Thick), Dark Brown Silty Clay, Very Moist 0.8 (874.2)	OL							28 5	
2 SS	6	9 8 9	17		870	Brown Gravelly Sand (S), Moist to Wet	SP							3	
3 SS	8	31 15 16	31											6	
4 SS	10	33 43 22	65	10	865									3	
5 SS	14	19 11 9	20		860	17 (858)								9	
6 SS	8	3 3 8	11	20	855	Gray Gravelly Sandy Loam (SL), Wet 22 (853)	ML							9	
7 SS	8	13 11 13	24		850	Brown Loamy Sand (LS), Wet 27 (848)	SM							18	
8 SS	10	12 21 21	42	30	845	Brown Very Gravelly Sand (S), Wet 30 (845)	SW							7	

End of Boring at 30.0 ft.

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 12ft.	☒	CAVE DEPTH AT COMPLETION: 12ft.	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	■	CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

BORING LOG

BORING No BPSRN-B-10

PROJECT NAME: **GWA - Alternative BPS Site 2**
PROJECT No: **00521741**
PAGE No: **1 of 1**
CONSULTANT: **Greeley-Hansen**
CONSULTANT PROJECT No:
DATE STARTED: **4/27/20**
HORIZONTAL DATUM:
VERTICAL DATUM:
DRILLING CONTRACTOR: **PSI**
DRILLING CONTRACTOR PROJECT No:
DATE COMPLETED: **4/27/20**
LATITUDE:
CREW CHIEF: **V. Jones**
DRILLING RIG: **Marooka #395**
BORING OFFSET:
LONGITUDE:
FIELD LOG BY: **N. Canning**
DRILLING METHOD / HOLE SIZE:
ROADWAY NAME:
NORTHING:
LOG QC BY:
HAMMER TYPE:
EFFICIENCY:
STATION:
OFFSET:
EASTING:
COUNTY:
TOWNSHIP:
RANGE:
SECTION:
1/4 SECTION:
1/4 SECTION:
SURFACE ELEVATION: **896 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_r (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
					895	Topsoil (10"± Thick), Dark Brown Silty Clay, Very Moist 0.8 (895.2)	OL							30	
1 SS	7	3 4 4	8			Brown Sandy Lean Clay, Moist	CL			3.5				23	
2 SS	10	4 3 3	6			5.5 (890.5)				2.0					
3 SS	9	17 18 19	37		890	Brown Sand and Gravel, Moist	SP							5	
4 SS	11	13 12 9	21	10	885	12 (884)								7	
5 SS	13	9 10 12	22		880	Brown Silty Sand With Gravel, Moist	SM							8	
6 SS	12	12 26 35	61	20	875	▨ 22 (874)								14	
7 SS	15	16 23 30	53		870	Brown Silt, Moist	ML							11	
8 SS	12	21 41 50	91	30	865	32 (864)								13	
9 SS	13	16 29 33	62		860	▽ Brownish Gray Coarse Sand and Gravel, Wet	SP							8	
10 SS	16	20 28 37	65	40		40 (856)								7	

End of Boring at 40.0 ft.

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 33.5ft.	▨	CAVE DEPTH AT COMPLETION: 22ft.	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	■	CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

PROJECT NAME **GWA - Alternative BPS Site 2**
PROJECT No **00521741**

BORING LOG

BORING No BPSRN-B-11

PAGE No **1 of 2**

CONSULTANT **Greeley-Hansen**	CONSULTANT PROJECT No	DATE STARTED **5/01/20**	HORIZONTAL DATUM / VERTICAL DATUM
DRILLING CONTRACTOR **PSI**	DRILLING CONTRACTOR PROJECT No	DATE COMPLETED **5/01/20**	LATITUDE
CREW CHIEF **V. Jones**	DRILLING RIG **Marooka #395**	BORING OFFSET	LONGITUDE
FIELD LOG BY **N. Canning**	DRILLING METHOD / HOLE SIZE	ROADWAY NAME	NORTHING
LOG QC BY	HAMMER TYPE / EFFICIENCY	STATION / OFFSET	EASTING
COUNTY	TOWNSHIP / RANGE / SECTION / 1/4 SECTION / 1/4 SECTION		SURFACE ELEVATION **881 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
					880	Topsoil (3"± Thick), Dark Brown Silty With Root Matter and Gravel, Very Moist 0.3 (880.7)	OL							21	
1 SS	9	8 10 11	21			Brown Silty Sand With Gravel, Moist	SM							10	
2 SS	10	8 13 15	28		875									5	
3 SS	14	7 41 50	91											10	
4 SS	13	18 34 47	81	10	870									4	
5 SS	15	18 27 40	67		865									5	
6 SS	12	29 38 50	88	20	860	22 (859)								6	
						Brown Sandy Silt and Gravel, Very Moist to Wet	ML								
7 SS	14	22 28 32	60		855	▽								7	
8 SS	5	50/5"	R	30	850									10	
9 SS	5	50/5"	R		845									9	
10 SS	5	50/5"	R	40	840	42 (839)									
						Brown Silty Sand, Wet	SM								
11 SS	5	50/5"	R		835	47 (834)								15	
						Gray Sandy Silt With Gravel, Wet	ML								
12 SS	5	50/5"	R	50	830									7	
13	1	50/1"	R												

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 27ft.		CAVE DEPTH AT COMPLETION: NE	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	■	CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

PROJECT NAME
GWA - Alternative BPS Site 2
PROJECT No
00521741

BORING LOG

BORING No BPSRN-B-11

PAGE No
2 of 2

CONSULTANT **Greeley-Hansen**	CONSULTANT PROJECT No	DATE STARTED **5/01/20**	HORIZONTAL DATUM / VERTICAL DATUM
DRILLING CONTRACTOR **PSI**	DRILLING CONTRACTOR PROJECT No	DATE COMPLETED **5/01/20**	LATITUDE
CREW CHIEF **V. Jones**	DRILLING RIG **Marooka #395**	BORING OFFSET	LONGITUDE
FIELD LOG BY **N. Canning**	DRILLING METHOD / HOLE SIZE	ROADWAY NAME	NORTHING
LOG QC BY	HAMMER TYPE / EFFICIENCY	STATION / OFFSET	EASTING
COUNTY	TOWNSHIP / RANGE / SECTION	1/4 SECTION / 1/4 SECTION	SURFACE ELEVATION **881 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
SS					825	Gray Sandy Silt With Gravel, Wet 57 (824)	ML							8	
						Brownish Gray Sand and Gravel, Wet									
14 SS	4	50/4"	R	60										11	
					820										
							SP								
15 SS	2	50/2"	R												
					815	67.5 (813.5)									

End of Boring at 67.5' Due to Mud Rotary Refusal on
Possible Cobbles, Boulders, or Bedrock
Started mud rotary drilling at a depth of about 30'
End of Boring at 67.5 ft.

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 27ft.		CAVE DEPTH AT COMPLETION: NE	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	■	CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

BORING LOG

BORING No BPSRN-B-12

PROJECT NAME: **GWA - Alternative BPS Site 2**

PROJECT No: **00521741**

PAGE No: **1 of 2**

CONSULTANT: **Greeley-Hansen**

CONSULTANT PROJECT No:

DATE STARTED: **4/29/20**

HORIZONTAL DATUM:

VERTICAL DATUM:

DRILLING CONTRACTOR: **PSI**

DRILLING CONTRACTOR PROJECT No:

DATE COMPLETED: **4/29/20**

LATITUDE:

CREW CHIEF: **V. Jones**

DRILLING RIG: **Marooka #395**

BORING OFFSET:

LONGITUDE:

FIELD LOG BY: **N. Canning**

DRILLING METHOD / HOLE SIZE:

ROADWAY NAME:

NORTHING:

LOG QC BY:

HAMMER TYPE:

EFFICIENCY:

STATION:

OFFSET:

EASTING:

COUNTY:

TOWNSHIP:

RANGE:

SECTION:

1/4 SECTION:

1/4 SECTION:

SURFACE ELEVATION: **888 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
						Topsoil (9"± Thick), Dark Brown Silty Clay, Very Moist 0.8 (887.2)	OL								
1 SS	15	3 3 3	6		885	Brown Lean Clay, Trace to with Sand, Very Moist	CL			2.0	2.14			26 23	
2 SS	15	4 3 4	7			5.5 (882.5)				2.5				19	
3 SS	9	4 5 9	14		880	Brown Sandy Silt With Gravel, Very Moist 8 (880)	ML							11	
4 SS	10	10 14 14	28	10		Brown Medium Sand With Gravel, Moist	SP							4	
					875										
5 SS	13	18 35 34	69			17 (871)								3	
					870	Brown Silty Sand With Gravel, Moist	SM								
6 SS	14	13 18 19	37	20										13	
					865										
7 SS	5	50/5"	R			27 (861)								7	
					860	▽ Brown Medium Sand, Wet	SP								
8 SS	10	20 18 19	37	30		32 (856)								19	
					855	Gray Medium Sand, Wet	SP								
9 SS	12	17 20 20	40			37 (851)								19	
					850	Gray Silt, Wet	ML								
10 SS	15	16 20 25	45	40		42 (846)								22	
					845	Brown Lean Clay, Trace Gravel, Moist	CL								
11 SS	13	23 23 39	62							4.5	5.77			13	
					840										
12 SS	18	17 20 34	54	50						3.5	6.18			13	
					835										
13	15		59												

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 28.5ft.

▼ WATER LEVEL AT COMPLETION: NE

▼ WATER LEVEL AFTER 0 HOURS: N/A

CAVE DEPTH AT COMPLETION: NE — WET ☐ DRY ☐

CAVE DEPTH AFTER 0 HOURS: N/A — WET ☐ DRY ☐

NE = Not Encountered; NMR = No Measurement Recorded

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

PROJECT NAME **GWA - Alternative BPS Site 2**	GREAT WATER ALLIANCE	**BORING LOG** Intertek psi	**BORING No BPSRN-B-12**
PROJECT No **00521741**			PAGE No **2 of 2**

CONSULTANT: **Greeley-Hansen**	CONSULTANT PROJECT No:	DATE STARTED: **4/29/20**	HORIZONTAL DATUM:	VERTICAL DATUM:
DRILLING CONTRACTOR: **PSI**	DRILLING CONTRACTOR PROJECT No:	DATE COMPLETED: **4/29/20**	LATITUDE:	
CREW CHIEF: **V. Jones**	DRILLING RIG: **Marooka #395**	BORING OFFSET:	LONGITUDE:	
FIELD LOG BY: **N. Canning**	DRILLING METHOD / HOLE SIZE:	ROADWAY NAME:	NORTHING:	
LOG QC BY:	HAMMER TYPE: / EFFICIENCY:	STATION: / OFFSET:	EASTING:	
COUNTY:	TOWNSHIP: / RANGE: / SECTION:	1/4 SECTION: / 1/4 SECTION:	SURFACE ELEVATION: **888 ft**	

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_r (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
SS		19 23 36			830	Brown Lean Clay, Trace Gravel, Moist	CL	▨			3.46			13	
14 SS	5	50/5"	R	60	825			▨		4.5	5.56			12	
15 SS	5	50/5"	R		820			▨			9.89			11	
16 SS	5	50/5"	R	70	815			▨			4.95			10	
17 SS	5	50/5"	R		810			▨		4.5+	7.63			12	
18 SS	4	50/4"	R	80		82 (806)		▨		4.5+	10.31			11	
19 SS	5	29 39 49	88		805	Brown Clayey Sand With Gravel, Very Moist 87 (801)	SC	▨						12	
20 SS	4	50/4"	R	90	800 795	Brown Lean Clay, Moist	CL	▨						11	
21 SS	3	50/3"	R		790			▨		4.5+	8.24			10	
22 SS	1	50/1"	R	100		100 (788)		▨		4.5+	10.31			11	

Started mud rotary drilling at a depth of about 35'
End of Boring at 100.0 ft.

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 28.5ft.		CAVE DEPTH AT COMPLETION: NE	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	■	CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

PROJECT NAME **GWA - Alternative BPS Site 2**

PROJECT No **00521741**

BORING LOG

BORING No BPSRN-B-13

PAGE No **1 of 2**

CONSULTANT **Greeley-Hansen**
CONSULTANT PROJECT No
DATE STARTED **4/17/20**
HORIZONTAL DATUM
VERTICAL DATUM

DRILLING CONTRACTOR **PSI**
DRILLING CONTRACTOR PROJECT No
DATE COMPLETED **4/17/20**
LATITUDE

CREW CHIEF **V. Jones**
DRILLING RIG **Marooka #395**
BORING OFFSET
LONGITUDE

FIELD LOG BY **R. Sayles**
DRILLING METHOD / HOLE SIZE
ROADWAY NAME
NORTHING

LOG QC BY
HAMMER TYPE
EFFICIENCY
STATION
OFFSET
EASTING

COUNTY
TOWNSHIP
RANGE
SECTION
1/4 SECTION
1/4 SECTION
SURFACE ELEVATION **873 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
						Topsoil (11"± Thick), Dark Brown Silty Clay, Very Moist 0.9 (872.1)	OL							32	
1 SS	7	3 3 4	7		870	Brown Lean Clay, Moist to Very Moist	CL			3.0				17	
2 SS	10	3 3 3	6			5.5 (867.5)				1.0				23	
3 SS	6	5 11 10	21		865	Brown Silt, Trace Gravel, Moist	ML							12	
4 SS	11	6 10 12	22	10										11	
						▽ 12 (861)									
					860	Brown Sand and Gravel, Wet	SW								
5 SS	7	6 6 7	13											3	
					855										
6 SS	7	6 8 8	16	20										7	
					850										
7 SS	8	14 13 14	27											12	
						27 (846)									
					845	Brown Sandy Lean Clay With Gravel, Very Moist	CL								
8 SS	9	10 16 30	46	30										10	
					840										
9 SS	10	6 15 6	21											7	
						37 (836)									
					835	Brown Silt Sand With Gravel, Very Moist	SM								
10 SS	5	8 16 19	35	40										13	
						42 (831)									
					830	Brown Lean Clay, Trace Gravel, Moist	CL								
11 SS	5	50/5"	R							4.0				9	
					825										
12 SS	14	9 12 26	38	50						4.0	3.13			12	
					820										
13	18		39												

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 12ft.
CAVE DEPTH AT COMPLETION: 75ft. WET ☐ DRY ☐
▼ WATER LEVEL AT COMPLETION: NE
CAVE DEPTH AFTER 0 HOURS: N/A WET ☐ DRY ☐
▼ WATER LEVEL AFTER 0 HOURS: N/A
NE = Not Encountered; NMR = No Measurement Recorded

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

BORING LOG

BORING No BPSRN-B-13

PROJECT NAME GWA - Alternative BPS Site 2			PAGE No 2 of 2
PROJECT No 00521741			
CONSULTANT Greeley-Hansen	CONSULTANT PROJECT No	DATE STARTED 4/17/20	HORIZONTAL DATUM / VERTICAL DATUM
DRILLING CONTRACTOR PSI	DRILLING CONTRACTOR PROJECT No	DATE COMPLETED 4/17/20	LATITUDE
CREW CHIEF V. Jones	DRILLING RIG Marooka #395	BORING OFFSET	LONGITUDE
FIELD LOG BY R. Sayles	DRILLING METHOD / HOLE SIZE	ROADWAY NAME	NORTHING
LOG QC BY	HAMMER TYPE / EFFICIENCY	STATION / OFFSET	EASTING
COUNTY	TOWNSHIP / RANGE / SECTION	1/4 SECTION / 1/4 SECTION	SURFACE ELEVATION 873 ft

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
SS		11 14 25				Brown Lean Clay, Trace Gravel, Moist		▨		3.5	3.71			14	
					815										
14 SS	16	19 32 48	80	60						3.5	4.74			14	
					810										
15 SS	18	22 38 47	85							3.5	4.33			13	
					805										
16 SS	5	50/5"	R	70						4.5	7.01			10	
					800										
17 SS	4	50/4"	R											16	
					795		CL								
18 SS	5	50/5"	R	80						3.5	3.87			2	
					790										
19 SS	2	50/2"	R											17	
					785										
20 SS	1	50/1"	R	90						3.0				15	
					780										
21 SS	3	50/3"	R							3.5	3.63			15	
					775										
22 SS	1	50/1"	R	100		100 (773)				4.5				12	

Started mud rotary drilling at a depth of about 30'
End of Boring at 100.0 ft.

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 12ft.	☒	CAVE DEPTH AT COMPLETION: 75ft. WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	■	CAVE DEPTH AFTER 0 HOURS: N/A WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

BORING LOG

BORING No BPSRN-B-14

PROJECT NAME: GWA - Alternative BPS Site 2
PROJECT No: 00521741
GREAT WATER ALLIANCE
Intertek psi
PAGE No: 1 of 2

CONSULTANT: Greeley-Hansen
CONSULTANT PROJECT No:
DATE STARTED: 4/28/20
HORIZONTAL DATUM:
VERTICAL DATUM:
DRILLING CONTRACTOR: PSI
DRILLING CONTRACTOR PROJECT No:
DATE COMPLETED: 4/28/20
LATITUDE:
CREW CHIEF: V. Jones
DRILLING RIG: Marooka #395
BORING OFFSET:
LONGITUDE:
FIELD LOG BY: N. Canning
DRILLING METHOD / HOLE SIZE:
ROADWAY NAME:
NORTHING:
LOG QC BY:
HAMMER TYPE:
EFFICIENCY:
STATION:
OFFSET:
EASTING:
COUNTY:
TOWNSHIP:
RANGE:
SECTION:
1/4 SECTION:
1/4 SECTION:
SURFACE ELEVATION: 880 ft

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
						Topsoil (10"± Thick), Dark Brown Silty Clay, Very Moist 0.8 (879.2)	OL							33	
1 SS	9	3 5 7	12			Fill, Brown Sand and Gravel, Moist	SP							6	
2 SS	8	5 8 17	25		875	5.5 (874.5)								5	
3 SS	12	9 5 8	13			Light Brown Sandy Silt With Gravel, Moist	ML							11	
4 SS	11	4 9 9	18	10	870	12 (868)								14	
5 SS	7	22 23 24	47		865	Brown Silty Sand With Gravel, Very Moist	SM							9	
6 SS	12	3 4 6	10	20	860	▽ 22 (858)								9	
7 SS	0	6 6 7	13		855	Brown Medium Sand, Wet	SP								
8 SS	10	12 17 19	36	30	850	32 (848)								15	
9 SS	9	18 23 26	49		845	Gray Coarse Sand and Gravel, Wet 37 (843)	SW							10	
10 SS	11	14 16 18	34	40	840	Brown Medium Sand, Very Moist	SP							18	
11 SS	5	50/5"	R		835	47 (833)								12	
12 SS	14	21 30 31	61	50	830	Brown Lean Clay, Trace Gravel, Moist to Very Moist	CL			3.75	4.12			12	
13	16		65		825										

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 22ft.
CAVE DEPTH AT COMPLETION: NE — WET ☐ DRY ☐
▼ WATER LEVEL AT COMPLETION: NE
CAVE DEPTH AFTER 0 HOURS: N/A — WET ☐ DRY ☐
▼ WATER LEVEL AFTER 0 HOURS: N/A
NE = Not Encountered; NMR = No Measurement Recorded

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

PROJECT NAME **GWA - Alternative BPS Site 2**	**BORING LOG**		**BORING No BPSRN-B-14**
PROJECT No **00521741**			PAGE No **2 of 2**
CONSULTANT **Greeley-Hansen**	CONSULTANT PROJECT No	DATE STARTED **4/28/20**	HORIZONTAL DATUM / VERTICAL DATUM
DRILLING CONTRACTOR **PSI**	DRILLING CONTRACTOR PROJECT No	DATE COMPLETED **4/28/20**	LATITUDE
CREW CHIEF **V. Jones**	DRILLING RIG **Marooka #395**	BORING OFFSET	LONGITUDE
FIELD LOG BY **N. Canning**	DRILLING METHOD / HOLE SIZE	ROADWAY NAME	NORTHING
LOG QC BY	HAMMER TYPE / EFFICIENCY	STATION / OFFSET	EASTING
COUNTY	TOWNSHIP / RANGE / SECTION	1/4 SECTION / 1/4 SECTION	SURFACE ELEVATION **880 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_r (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
SS		22 31 34				Brown Lean Clay, Trace Gravel, Moist to Very Moist	CL	▨		3.75	7.42			11	
14 SS	18	21 30 41	71	60	820					4.75	6.18			11	
15 SS	18	26 33 39	72		815					4.25	3.30			10	
16 SS	13	19 39 50	89	70	810					4.5+	9.48			10	
17 SS	5	50/5"	R		805					3.5	4.95			12	
18 SS	5	50/5"	R	80	800					3.75				15	
19 SS	5	50/5"	R		795					4.0	4.95			15	
20 SS	4	50/4"	R	90	790					4.5	3.71			24	
21 SS	5	50/5"	R		785									16	
22 SS	1	50/1"	R	100	780	100 (780)				4.0	4.12			15	

Started mud rotary drilling at a depth of about 25'
End of Boring at 100.0 ft.

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 22ft.		CAVE DEPTH AT COMPLETION: NE	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	■	CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

BORING LOG

BORING No BPSRN-B-15

PROJECT NAME: GWA - Alternative BPS Site 2			PAGE No: 1 of 2
PROJECT No: 00521741			
CONSULTANT: Greeley-Hansen	CONSULTANT PROJECT No:	DATE STARTED: 4/15/20	HORIZONTAL DATUM: / VERTICAL DATUM:
DRILLING CONTRACTOR: PSI	DRILLING CONTRACTOR PROJECT No:	DATE COMPLETED: 4/15/20	LATITUDE:
CREW CHIEF: V. Jones	DRILLING RIG: Marooka #395	BORING OFFSET:	LONGITUDE:
FIELD LOG BY: N. Canning	DRILLING METHOD / HOLE SIZE:	ROADWAY NAME:	NORTHING:
LOG QC BY:	HAMMER TYPE: / EFFICIENCY:	STATION: / OFFSET:	EASTING:
COUNTY:	TOWNSHIP: / RANGE: / SECTION:	1/4 SECTION: / 1/4 SECTION:	SURFACE ELEVATION: 874 ft

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Unconfined Comp. Strength Q_p (tsf)	Moisture Content (%)
					30
1 SS	8	3 3 3	6	2.0	22
2 SS	13	3 3 5	8	3.5	23
3 SS	6	4 11 15	26		5
4 SS	4	14 17 14	31		5
5 SS	8	14 14 10	24		8
6 SS	3	9 7 8	15		
7 SS	7	7 5 4	9		17
8 SS	10	13 12 14	26		20
9 SS	10	16 19 18	37		22
10 SS	6	6 9 6	15		15
11 SS	13	4 6 5	11	1.25	11
12 SS	8	6 5 5	10	1.0	10
13	12		33		

Depth (ft): 10, 20, 30, 40, 50
Elevation (ft): 870, 865, 860, 855, 850, 845, 840, 835, 830, 825, 820

Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO
Topsoil (14"± Thick), Dark Brown Silt, Very Moist — 1.1 (872.9)	OL
Brown Lean Clay, with Silt Lenses, Very Moist — 5.5 (868.5)	CL
Brown Medium to Coarse Sand and Gravel, Moist to Wet — 27 (847)	SW
Brown Silty Fine Sand, Wet — 37 (837)	SM
Brownish Gray Sandy Clay With Gravel, Very Moist to Moist	CL

Well Diagram | Unconfined Comp. Strength Q_u (tsf) | Liquid Limit (%) | Plasticity Index (%) | Notes

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 12ft.		CAVE DEPTH AT COMPLETION: NE	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	■	CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

PROJECT NAME **GWA - Alternative BPS Site 2**	**BORING LOG**		**BORING No BPSRN-B-15**
PROJECT No **00521741**			PAGE No **2 of 2**
CONSULTANT **Greeley-Hansen**	CONSULTANT PROJECT No	DATE STARTED **4/15/20**	HORIZONTAL DATUM / VERTICAL DATUM
DRILLING CONTRACTOR **PSI**	DRILLING CONTRACTOR PROJECT No	DATE COMPLETED **4/15/20**	LATITUDE
CREW CHIEF **V. Jones**	DRILLING RIG **Marooka #395**	BORING OFFSET	LONGITUDE
FIELD LOG BY **N. Canning**	DRILLING METHOD / HOLE SIZE	ROADWAY NAME	NORTHING
LOG QC BY	HAMMER TYPE / EFFICIENCY	STATION / OFFSET	EASTING
COUNTY	TOWNSHIP / RANGE / SECTION	1/4 SECTION / 1/4 SECTION	SURFACE ELEVATION **874 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
SS		9 15 18				Brownish Gray Sandy Clay With Gravel, Very Moist to Moist 57 (817)	CL			3.0				10	
					815	Brown Lean Clay, Trace Gravel, Moist									
14 SS	18	15 20 37	57	60						4.0				14	
					810										
15 SS	13	14 24 35	59							4.5+				16	
					805										
16 SS	18	18 22 20	42	70						4.5+				4	
					800										
17 SS	16	20 26 22	48							4.5+				13	
					795		CL								
18 SS	14	24 30 28	58	80						4.5+				13	
19 SS	2	50/2"	R		790					4.5+				13	
20 SS	3	50/3"	R	90	785					4.5+				15	
21 SS	4	50/4"	R		780					4.5+				14	
22 SS	1	50/1"	R	100	775	100 (774)				4.5+					

Started mud rotary drilling at a depth of about 20'
End of Boring at 100.0 ft.

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 12ft.	CAVE DEPTH AT COMPLETION: NE	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A	NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

BORING LOG

BORING No BPSRN-B-16

PROJECT NAME: **GWA - Alternative BPS Site 2**			PAGE No: **1 of 2**
PROJECT No: **00521741**			
CONSULTANT: **Greeley-Hansen**	CONSULTANT PROJECT No	DATE STARTED: **4/16/20**	HORIZONTAL DATUM / VERTICAL DATUM
DRILLING CONTRACTOR: **PSI**	DRILLING CONTRACTOR PROJECT No	DATE COMPLETED: **4/16/20**	LATITUDE
CREW CHIEF: **V. Jones**	DRILLING RIG: **Marooka #395**	BORING OFFSET	LONGITUDE
FIELD LOG BY: **A. Salinas**	DRILLING METHOD / HOLE SIZE	ROADWAY NAME	NORTHING
LOG QC BY	HAMMER TYPE / EFFICIENCY	STATION / OFFSET	EASTING
COUNTY	TOWNSHIP / RANGE / SECTION	1/4 SECTION / 1/4 SECTION	SURFACE ELEVATION: **872 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
						Topsoil (9"± Thick), Dark Brown Silty Clay, Very Moist 0.8 (871.2)	OL								
1 SS	9	3 3 3	6		870	Brown Sandy Lean Clay, Trace Gravel, Very Moist 3 (869)	CL	▨		1.25				29 22	
2 SS	7	8 9 10	19			Brown Sand and Gravel, Moist		⁙						5	
3 SS	14	8 15 14	29		865			⁙						5	
4 SS	10	8 10 22	32	10				⁙						5	
					860		SP	⁙							
5 SS	12	22 10 7	17					⁙						3	
					855			⁙							
6 SS	3	14 6 9	15	20				⁙							
					850 ▽	22 (850)									
						Brown Medium Sand, Wet		⁙							
7 SS	16	7 9 10	19					⁙						19	
					845			⁙							
8 SS	14	11 11 13	24	30				⁙						17	
					840		SP	⁙							
9 SS	12	8 10 13	23					⁙						20	
					835			⁙							
10 SS	15	11 10 15	25	40				⁙						15	
					830	42 (830)									
						Brown Lean Clay, Trace Gravel, Moist		▨							
11 SS	10	7 9 14	23					▨		3.0				7	
					825		CL	▨							
12 SS	13	21 17 19	36	50				▨		3.5				13	
					820			▨							
13	14		45					▨							

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 22ft.		CAVE DEPTH AT COMPLETION: NE — WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	■	CAVE DEPTH AFTER 0 HOURS: N/A — WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

PROJECT NAME **GWA - Alternative BPS Site 2**	**BORING LOG**			**BORING No BPSRN-B-16**
PROJECT No **00521741**				PAGE No **2 of 2**
CONSULTANT **Greeley-Hansen**	CONSULTANT PROJECT No	DATE STARTED **4/16/20**		HORIZONTAL DATUM / VERTICAL DATUM
DRILLING CONTRACTOR **PSI**	DRILLING CONTRACTOR PROJECT No	DATE COMPLETED **4/16/20**		LATITUDE
CREW CHIEF **V. Jones**	DRILLING RIG **Marooka #395**	BORING OFFSET		LONGITUDE
FIELD LOG BY **A. Salinas**	DRILLING METHOD / HOLE SIZE	ROADWAY NAME		NORTHING
LOG QC BY	HAMMER TYPE / EFFICIENCY	STATION	OFFSET	EASTING
COUNTY	TOWNSHIP / RANGE / SECTION	1/4 SECTION	1/4 SECTION	SURFACE ELEVATION **872 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
SS		15 23 22			815	Brown Lean Clay, Trace Gravel, Moist		▨		4.0	4.12			12	
14 SS	18	18 20 27	47	60	810			▨		4.5+				12	
15 SS	10	28 41 49	90		805			▨		4.5+	6.18			12	
16 SS	12	36 44 50	94	70	800			▨		4.5+	6.18			11	
17 SS	9	30 36 50	86		795		CL	▨		4.5+	4.95			12	
18 SS	11	50/5"	R	80	790			▨		4.5+	6.39			12	
19 SS	7	29 39 50	89		785			▨		4.0	3.71			13	
20 SS	4	50/4"	R	90	780			▨		3.75	3.71			12	
21 SS	4	50/4"	R		775			▨		4.5+				12	
22 SS	5	50/5"	R	100		100 (772)		▨		3.0					

Started mud rotary drilling at a depth of about 25'
End of Boring at 100.0 ft.

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 22ft.		CAVE DEPTH AT COMPLETION: NE	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	■	CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

BORING LOG

BORING No BPSRN-B-17

PROJECT NAME **GWA - Alternative BPS Site 2**			PAGE No **1 of 1**
PROJECT No **00521741**			
CONSULTANT **Greeley-Hansen**	CONSULTANT PROJECT No	DATE STARTED **5/26/20**	HORIZONTAL DATUM / VERTICAL DATUM
DRILLING CONTRACTOR **R&W Trucking, Inc.**	DRILLING CONTRACTOR PROJECT No	DATE COMPLETED **5/26/20**	LATITUDE
CREW CHIEF	DRILLING RIG **Excavator**	BORING OFFSET	LONGITUDE
FIELD LOG BY	DRILLING METHOD / HOLE SIZE	ROADWAY NAME **E Broadway**	NORTHING
LOG QC BY	HAMMER TYPE / EFFICIENCY	STATION / OFFSET	EASTING
COUNTY	TOWNSHIP / RANGE / SECTION	1/4 SECTION / 1/4 SECTION	SURFACE ELEVATION **882 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
1 GRAB						Topsoil, Dark Brown Silty Clay, Very Moist (18"± Thick) 1.49 (880.51)									
2 GRAB				2.5	880	Light Brown Clay (C), Moist 3 (879)				1.5					
3 GRAB				5.0 7.5 10.0	875 870	Brown Gravelly Sand (S) with Cobbles, Moist to Wet ▽ 12 (870)									

End of Pit at 12'

End of Boring at 12.0 ft.

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 10ft.	▨	CAVE DEPTH AT COMPLETION: NE	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	■	CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

BORING LOG

BORING No BPSRN-B-18

PROJECT NAME: **GWA - Alternative BPS Site 2**			PAGE No: **1 of 1**
PROJECT No: **00521741**			
CONSULTANT: **Greeley-Hansen**	CONSULTANT PROJECT No:	DATE STARTED: **5/26/20**	HORIZONTAL DATUM: / VERTICAL DATUM:
DRILLING CONTRACTOR: **R&W Trucking, Inc.**	DRILLING CONTRACTOR PROJECT No:	DATE COMPLETED: **5/26/20**	LATITUDE:
CREW CHIEF:	DRILLING RIG: **Excavator**	BORING OFFSET:	LONGITUDE:
FIELD LOG BY:	DRILLING METHOD / HOLE SIZE:	ROADWAY NAME: **E Broadway**	NORTHING:
LOG QC BY:	HAMMER TYPE: / EFFICIENCY:	STATION: / OFFSET:	EASTING:
COUNTY:	TOWNSHIP: / RANGE: / SECTION:	1/4 SECTION: / 1/4 SECTION:	SURFACE ELEVATION: **879 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_r (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
1 GRAB						Topsoil, Dark Brown Silty Clay, Very Moist (16"± Thick) 1.3 (877.7)									
2 GRAB				2.5		Light Brown Clay (C), Moist				1.5					
					875										
				5.0		5 (874)									
3 GRAB						Brown Very Gravelly Sand (vgS) with Cobbles, Moist									
				7.5											
					870										
				10.0											
						12 (867)									

End of Pit at 12'

End of Boring at 12.0 ft.

WATER & CAVE-IN OBSERVATION DATA

∇	WATER ENCOUNTERED DURING DRILLING: N/A	▨	CAVE DEPTH AT COMPLETION: N/A WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: N/A	■	CAVE DEPTH AFTER 0 HOURS: N/A WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

PROJECT NAME **GWA - Alternative BPS Site 2**	**BORING LOG**		**BORING No BPSRN-B-19**
PROJECT No **00521741**			PAGE No **1 of 2**
CONSULTANT **Greeley-Hansen**	CONSULTANT PROJECT No	DATE STARTED **5/26/20**	HORIZONTAL DATUM / VERTICAL DATUM
DRILLING CONTRACTOR **PSI**	DRILLING CONTRACTOR PROJECT No	DATE COMPLETED **5/26/20**	LATITUDE
CREW CHIEF **P. Rotaru**	DRILLING RIG **HD ATV #419**	BORING OFFSET	LONGITUDE
FIELD LOG BY **A. Salinas**	DRILLING METHOD / HOLE SIZE	ROADWAY NAME	NORTHING
LOG QC BY	HAMMER TYPE / EFFICIENCY	STATION / OFFSET	EASTING
COUNTY	TOWNSHIP / RANGE / SECTION	1/4 SECTION / 1/4 SECTION	SURFACE ELEVATION **885 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
						Topsoil, Dark Brown Silty Clay, Very Moist (12"± Thick) 0.99 (884.01)	OL							35	
1 SS	9	5 4 4	8			Brown Lean Clay with Sand, Very Moist 3 (882)	CL							23	
2 SS	4	50/4"	R		880	Brown Medium Sand With Gravel, Damp 5.5 (879.5)	SP							4	
3 SS	14	10 8 10	18			Brown Silty Sand and Gravel, Moist								8	
4 SS	7	7 9 12	21	10	875		ML							8	
5 SS	12	15 18 25	43		870	17 (868)								6	
						▽ Brown Medium Sand, Wet									
6 SS	16	20 22 23	45	20	865		SP							19	
7 SS	14	27 25 35	60		860	27 (858)								21	
						Brown Silty Fine Sand, Wet									
8 SS	13	25 29 23	52	30	855	32 (853)	SM							20	
						Brown Lean Clay, Moist to Very Moist									
9 SS	14	19 29 47	76		850									12	
10 SS	15	11 21 25	46	40	845					4.5+	6.60			12	
11 SS	18	11 21 27	48		840		CL			4.5+	7.21			11	
12 SS	18	12 25 37	62	50	835						4.12			12	
13	14		54		830										

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 18.5ft.

▼ WATER LEVEL AT COMPLETION: NE

▼ WATER LEVEL AFTER 0 HOURS: N/A

CAVE DEPTH AT COMPLETION: NE — WET ☐ DRY ☐

CAVE DEPTH AFTER 0 HOURS: N/A — WET ☐ DRY ☐

NE = Not Encountered; NMR = No Measurement Recorded

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

PROJECT NAME **GWA - Alternative BPS Site 2**

PROJECT No **00521741**

BORING LOG

Intertek psi

BORING No BPSRN-B-19

PAGE No **2 of 2**

CONSULTANT **Greeley-Hansen**	CONSULTANT PROJECT No	DATE STARTED **5/26/20**	HORIZONTAL DATUM / VERTICAL DATUM
DRILLING CONTRACTOR **PSI**	DRILLING CONTRACTOR PROJECT No	DATE COMPLETED **5/26/20**	LATITUDE
CREW CHIEF **P. Rotaru**	DRILLING RIG **HD ATV #419**	BORING OFFSET	LONGITUDE
FIELD LOG BY **A. Salinas**	DRILLING METHOD / HOLE SIZE	ROADWAY NAME	NORTHING
LOG QC BY	HAMMER TYPE / EFFICIENCY	STATION / OFFSET	EASTING
COUNTY	TOWNSHIP / RANGE / SECTION / 1/4 SECTION / 1/4 SECTION		SURFACE ELEVATION **885 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
SS		15 18 36				Brown Lean Clay, Moist to Very Moist		▨		3.0	3.71			13	
14 SS	18	13 15 29	44	60	825			▨		4.0	5.77			12	
15 SS	16	18 29 37	66		820			▨		3.5	3.22			15	
16 SS	18	20 23 34	57	70	815			▨		2.25	3.22			15	
17 SS	18	14 19 46	65		810		CL	▨		3.25	4.04			16	
18 SS	18	20 25 42	67	80	805			▨		4.5	5.77			11	
19 SS	17	25 26 43	69		800			▨		4.5	5.15			12	
20 SS	18	19 24 38	62	90	795	92 (793)		▨		3.75	3.91			17	
						Gray Sandy Silt, Very Moist									
21 SS	18	22 23 39	62		790		ML							13	
22 SS	18	26 30 41	71	100	785	100 (785)								13	

Started mud rotary drilling at a depth of about 20'

End of Boring at 100.0 ft.

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 18.5ft.		CAVE DEPTH AT COMPLETION: NE	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	■	CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

GREAT WATER ALLIANCE

BORING LOG

Intertek psi

BORING No WTRN-B-01

PROJECT NAME GWA - Alternative BPS Site 2			BORING No WTRN-B-01
PROJECT No 00521741			PAGE No 1 of 2
CONSULTANT Greeley-Hansen	CONSULTANT PROJECT No	DATE STARTED 5/06/20	HORIZONTAL DATUM / VERTICAL DATUM
DRILLING CONTRACTOR PSI	DRILLING CONTRACTOR PROJECT No	DATE COMPLETED 5/06/20	LATITUDE
CREW CHIEF T. Ebert	DRILLING RIG ASV ATV #420	BORING OFFSET	LONGITUDE
FIELD LOG BY D. Turley	DRILLING METHOD / HOLE SIZE	ROADWAY NAME	NORTHING
LOG QC BY	HAMMER TYPE / EFFICIENCY	STATION / OFFSET	EASTING
COUNTY	TOWNSHIP / RANGE / SECTION	1/4 SECTION / 1/4 SECTION	SURFACE ELEVATION 879 ft

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
						Topsoil, Dark Brown Silty Clay, Very Moist (12"± Thick) 0.99 (878.01)	OL							17	
1 SS	18	4 4 4	8							2.0	2.14			22	
2 SS	6	10 13 14	27		875	Brown Lean Clay, Very Moist 5.5 (873.5)	CL			1.5				24	
3 SS	14	16 21 21	42			Brown Medium Sand With Gravel, Damp								5	
4 SS	5	50/5"	R	10	870		SP								
						▽ 12 (867)									
5 SS	12	18 20 34	54		865	Brown Coarse Sand and Gravel, Wet 17 (862)	SP							12	
6 SS	14	17 25 28	53	20	860	Brown Lean Clay, Trace Gravel, Moist to Very Moist				3.5	4.12			13	
7 SS	16	20 24 34	58		855					4.0				12	
8 SS	14	10 15 24	39	30	850					2.25	2.06			13	
9 SS	12	11 15 24	39		845		CL			3.0	2.72			12	
10 SS	14	10 15 23	38	40	840					2.5	2.31			16	
11 SS	14	12 18 27	45		835					4.25	4.53			12	
12 SS	16	10 15 24	39	50	830					3.5	3.54			13	
13	14		52		825										

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 12ft.	CAVE DEPTH AT COMPLETION: NE	WET ☐ DRY ☐
▼ WATER LEVEL AT COMPLETION: NE	CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼ WATER LEVEL AFTER 0 HOURS: N/A	NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

PROJECT NAME **GWA - Alternative BPS Site 2**	**BORING LOG**		BORING No **WTRN-B-01**
PROJECT No **00521741**			PAGE No **2 of 2**
CONSULTANT **Greeley-Hansen**	CONSULTANT PROJECT No	DATE STARTED **5/06/20**	HORIZONTAL DATUM / VERTICAL DATUM
DRILLING CONTRACTOR **PSI**	DRILLING CONTRACTOR PROJECT No	DATE COMPLETED **5/06/20**	LATITUDE
CREW CHIEF **T. Ebert**	DRILLING RIG **ASV ATV #420**	BORING OFFSET	LONGITUDE
FIELD LOG BY **D. Turley**	DRILLING METHOD / HOLE SIZE	ROADWAY NAME	NORTHING
LOG QC BY	HAMMER TYPE / EFFICIENCY	STATION / OFFSET	EASTING
COUNTY	TOWNSHIP / RANGE / SECTION	1/4 SECTION / 1/4 SECTION	SURFACE ELEVATION **879 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
SS		12 20 32				Brown Lean Clay, Trace Gravel, Moist to Very Moist	CL	▨		3.75	4.53			12	
14 SS	10	28 28 41	69	60	820									17	
15 SS	12	12 14 28	42		815					2.0	2.06			14	
16 SS	14	11 18 28	46	70	810					4.5+	4.74			12	
17 SS	12	12 30 30	60		805					4.25	4.33			12	
18 SS	12	14 25 28	53	80	800					4.25	4.12			12	
19 SS	12	13 28 29	57		795					4.5	4.95			12	
20 SS	12	15 28 34	62	90	790					4.5+				7	
21 SS	10	18 30 38	68		785					4.0	3.13			12	
22 SS	12	21 29 40	69	100	780	100 (779)				4.5+	7.42			12	

Started mud rotary drilling at a depth of about 20'
End of Boring at 100.0 ft.

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 12ft.		CAVE DEPTH AT COMPLETION: NE	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NE	■	CAVE DEPTH AFTER 0 HOURS: N/A	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: N/A		NE = Not Encountered; NMR = No Measurement Recorded	

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

PROJECT NAME: **GWA - Alternative BPS Site 2**
PROJECT No: **00521741**
CONSULTANT: **Greeley-Hansen**
DRILLING CONTRACTOR: **PSI**
CREW CHIEF: **D. Turley**
FIELD LOG BY: **A. Salinas**
LOG QC BY:
COUNTY:

BORING LOG

CONSULTANT PROJECT No:
DRILLING CONTRACTOR PROJECT No:
DRILLING RIG: **ASV ATV #420**
DRILLING METHOD / HOLE SIZE:
HAMMER TYPE:
EFFICIENCY:
TOWNSHIP:
RANGE:
SECTION:
1/4 SECTION:
1/4 SECTION:
DATE STARTED: **5/11/20**
DATE COMPLETED: **5/11/20**
BORING OFFSET:
ROADWAY NAME:
STATION:
OFFSET:

BORING No WTRN-B-02

PAGE No: **1 of 2**
HORIZONTAL DATUM:
VERTICAL DATUM:
LATITUDE:
LONGITUDE:
NORTHING:
EASTING:
SURFACE ELEVATION: **879 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_r (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
						Topsoil, Dark Brown Silt, Very Moist (10"± Thick)	OL								
1 SS	5	4 4 4	8			0.8 (878.2) Brown Lean Clay with Sand, Moist	CL	▨		2.75				33 18	
2 SS	10	4 8 8	16		875	3 (876) Brown Medium to Coarse Sand With Gravel, Moist to Wet		░						10	
3 SS	12	21 21 22	43		870 ▽			░						4	
4 SS	16	25 8 11	19	10				░						11	
5 SS	14	15 11 13	24		865		SP	░						12	
6 SS	12	14 11 30	41	20	860			░						14	
						22 (857) Brown Lean Clay, Trace Gravel, Moist to Very Moist		▨							
7 SS	13	8 16 21	37		855			▨		4.5+				11	
8 SS	12	8 11 18	29	30	850			▨		4.0				14	
9 SS	16	10 14 24	38		845			▨		4.5	4.95			11	
10 SS	16	8 9 20	29	40	840		CL	▨		3.5	4.33			13	
11 SS	18	12 18 32	50		835			▨		2.5	3.30			13	
12 SS	14	8 11 21	32	50	830			▨		4.5+	5.50			12	
13	10		35		825			▨							

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 8.5ft.
▼ WATER LEVEL AT COMPLETION: NE
▼ WATER LEVEL AFTER 0 HOURS: N/A

CAVE DEPTH AT COMPLETION: NE — WET ☐ DRY ☐
CAVE DEPTH AFTER 0 HOURS: N/A — WET ☐ DRY ☐
NE = Not Encountered; NMR = No Measurement Recorded

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

PROJECT NAME: **GWA - Alternative BPS Site 2**

PROJECT No: **00521741**

BORING LOG

BORING No WTRN-B-02

PAGE No: **2 of 2**

CONSULTANT: **Greeley-Hansen**

CONSULTANT PROJECT No:

DATE STARTED: **5/11/20**

HORIZONTAL DATUM:

VERTICAL DATUM:

DRILLING CONTRACTOR: **PSI**

DRILLING CONTRACTOR PROJECT No:

DATE COMPLETED: **5/11/20**

LATITUDE:

CREW CHIEF: **D. Turley**

DRILLING RIG: **ASV ATV #420**

BORING OFFSET:

LONGITUDE:

FIELD LOG BY: **A. Salinas**

DRILLING METHOD / HOLE SIZE:

ROADWAY NAME:

NORTHING:

LOG QC BY:

HAMMER TYPE:

EFFICIENCY:

STATION:

OFFSET:

EASTING:

COUNTY:

TOWNSHIP:

RANGE:

SECTION:

1/4 SECTION:

1/4 SECTION:

SURFACE ELEVATION: **879 ft**

Sample No / Type	Sample Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Graphic	Well Diagram	Unconfined Comp. Strength Q_p (tsf)	Unconfined Comp. Strength Q_u (tsf)	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Notes
SS		12 18 17				Brown Lean Clay, Trace Gravel, Moist to Very Moist		▨		4.5+	7.83			11	
14 SS	16	11 15 21	36	60	820			▨		4.0	5.35			12	
15 SS	12	9 15 18	33		815			▨		3.5	4.12			13	
16 SS	14	10 12 16	28	70	810			▨						13	
17 SS	13	13 21 21	42		805		CL	▨		2.5	3.71			14	
18 SS	16	18 16 20	36	80	800			▨		4.5+	6.18			12	
19 SS	12	21 16 18	34		795			▨		4.5	4.53			12	
20 SS	18	20 24 36	60	90	790	92 (787)		▨		4.5				9	
21 SS	4	50/4"	R		785	Gray Sandy Silt With Gravel, Very Moist	ML							9	
22 SS	3	50/3"	R	100	780	100 (779)								10	

Started mud rotary drilling at a depth of about 30'
End of Boring at 100.0 ft.

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 8.5ft.	CAVE DEPTH AT COMPLETION: NE		WET ☐ DRY ☐
▼ WATER LEVEL AT COMPLETION: NE	■ CAVE DEPTH AFTER 0 HOURS: N/A		WET ☐ DRY ☐
▼ WATER LEVEL AFTER 0 HOURS: N/A	NE = Not Encountered; NMR = No Measurement Recorded		

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

Wis. Dept. of Safety and Professional Services
Division of Industry Services

SOIL EVALUATION - STORM

Page 1 of 2

In accordance with SPS 382.365 & 385, Wis. Adm. Code and WDNR Standard 1002

Attach complete site plan on paper not less that 8 1/2 x 11 inches in size. Plan must include, but not limited to: vertical and horizontal reference point (BM), direction and percent slope, scale or dimensions, north arrow, and BM referenced to nearest road.

Please print all information.

Personal information you provide may be used for secondary purposes [Privacy Law, s. 15.04 (1) (m)].

County: Waukesha
Parcel I.D.:
Reviewed by:
Date:

Property Owner: Waukesha Water Utility
Property Location: W½, SE¼, SE¼, Sec1 T6N R19E
Property Owner's Mailing Address: 115 Delafield Street
Lot #:
Block #:
Subd. Name or CSM#:
City: Waukesha
State: WI
Zip Code: 53188
Phone Number:
☒ City ☐ Village ☐ Town: Waukesha
Nearest Road: East Broadway

Drainage area ___________________ ☐ sq. ft. ☐ acres

Optional:

Test Site Suitable for (check all that apply)

☐ Irrigation ☐ Bioretention trench ☐ Trench(es)

☐ Rain Garden ☐ Grassed swale ☐ Reuse

☐ Infiltration trench ☐ SDS (> 15' wide) ☐ Other __________

Hydraulic Application Test Method:

☒ Morphological Evaluation

☐ Double Ring Infiltrometer

☐ Other (specify)

Soil Moisture

Date of Soil Borings:

USDA-NRCS WETS Value:

☐ **Dry = 1;**

☐ **Normal = 2;**

☒ **Wet = 3.**

1 Obs. #

☒ Boring BPSRN-B-9

☐ Pit Ground surface elevation - EL. 875

Elevation of limiting factor: EL. 863

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture¹	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.¹	% Fines¹˒²	Hydraulic App. Rate Inches/Hr. (WDNR Table 2)
1	0-10	Topsoil								
2	10-204	10YR, 5/3		S	2, vf, sg	ml	g	15-35	0-15	3.6
3	204-264	10YR, 6/1		SL	0, m	mvfr	g	15-35	15-55	0.5
4	264-324	10YR, 5/3		LS	0, m	mvfr	g	<15	10-30	1.63
5	324-360	10YR, 6/4		S	2, vf, sg	ml	g	35-60	0-15	3.6

Comments:

2 Obs. #

☐ Boring Ground surface elevation - EL. 882

☒ Pit BPSRN-B-17

Elevation of limiting factor: EL. 872

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture¹	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.¹	% Fines¹˒²	Hydraulic App. Rate Inches/Hr. (WDNR Table 2)
1	0-18	Topsoil								
2	18-36	10YR, 6/3		C	1, vf, abk	mfi	g	<15	55-100	0.07
3	36-144	10YR, 5/3		S	2, vf, sg	ml	g	15-35	0-15	3.6

Comments:

CST/PSS Name (Please Print): Bradley J. Broback
Signature: Bradley J. Broback
CST/PSS Number: 1411511
Address: 821 Corporate Court, Suite 102, Waukesha, WI 53189
Date Evaluation Conducted: 5/26/2020
Telephone Number: 262-521-2125

3 Obs. #

☐ Boring Ground surface elevation - EL. 879

☒ Pit BPSRN-B-18 Elevation of limiting factor: Not Observed

Horizon	Depth in.	Dominant Color Munsell	Redox Description Qu. Sz. Cont. Color	Texture[1]	Structure Gr. Sz. Sh.	Consistence	Boundary	% Rock Frag.[1]	% Fines[1,2]	Hydraulic App. Rate Inches/Hr. (WDNR Table 2)
1	0-16	Topsoil								
2	16-60	10YR, 6/3		C	1, vf, abk	mfi	g	<15	55-100	0.07
3	60-144	10YR, 5/3		S	2, vf, sg	ml	g	15-35	0-15	3.6

Comments:

---

[1] Estimated based on the visual classification and not based upon laboratory testing.

[2] Based on only the fraction of soil that passes through the No. 10 sieve.

Appendix C - Draft Backfill Specifications

GREELEY AND HANSEN

741 N. Grand Ave., Suite 308
Waukesha, WI 53186

SECTION 31 23 23

BACKFILLING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Backfilling excavation to the original surface of the ground or to such other grades as may be shown or required. For areas to be covered by topsoil, leave or stop backfill 12 inches below the finished grade or as shown. Obtain approval before backfilling against masonry structures. Remove from backfill, any compressible, putrescible, or destructible rubbish and refuse and lumber and braces from the excavated space before backfilling is started. Leave a portion of the sheeting in place as shown.

B. Equipment Limitations: Do not permit construction equipment used to backfill to travel against and over cast-in-place concrete structures until the specified concrete strength has been obtained, as verified by concrete test cylinders. In special cases where conditions warrant, the above restriction may be modified providing the concrete has gained sufficient strength, as determined from test cylinders, to satisfy design requirements for the removal of forms and the application of load.

C. Related Work Specified In Other Sections Includes, but is Not Limited to, the Following:

1. Section 31 10 00 - Site Clearing
2. Section 31 23 16 - Excavation

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. ASTM C94 - Standard Specification for Ready-Mixed Concrete

2. ASTM C143 - Standard Test Method for Slump of Hydraulic-Cement Concrete

3. ASTM C150 - Standard Specification for Portland Cement

4. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))

5. ASTM D2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

6. ASTM D4832 - Standard Test Method for Preparation and Testing of Controlled Low Strength (CLSM) Test Cylinders

7. ASTM D5971 - Standard Practice for Sampling Freshly Mixed Controlled Low-Strength Material

8. ASTM D6023 - Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material (CLSM)

9. ASTM D6024 - Standard Test Method for Ball Drop on Controlled Low-Strength Material (CLSM) to Determine Suitability for Load Application

10. ASTM D6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

11. State of Wisconsin Department of Transportation (WisDOT), Standard Specifications for Highway and Structure Construction, latest Edition, including the latest supplemental specifications and recurring special provisions, referred to as the “State Specifications”

12. Standard Specifications for Sewer and Water Construction in Wisconsin, Sixth Edition, referred to as the “Standard Specifications”

1.3 SUBMITTALS

A. General: Furnish submittals, including the following, as specified in Division 1.

1. Certified laboratory reports of proposed backfill material, including unit weight, specific gravity, soundness and gradations of proposed granular backfill material.

2. Source of backfill material.

3. Flowable fill and flowable fill with cement mix design.

PART 2 PRODUCTS

2.1 BACKFILL MATERIAL - GENERAL

A. General: Backfill with sound materials, free from waste, organic matter, rubbish, boggy or other unsuitable materials.

B. General Materials Requirements: Conform materials used for backfilling to the requirements specified. Follow common fill requirements whenever other fill is not specified. Determine and obtain the approval of the appropriate test method where more than one compaction test method is specified.

C. Frozen Materials: Do not use frozen material for backfilling.

2.2 SELECT FILL

A. Materials for Select Fill: Use gravel, crushed stone, limestone screenings or other granular or similar material as approved which can be readily and thoroughly compacted to not less than 95 percent of the maximum dry density obtainable by ASTM D1557.

1. Suitable Materials for Select Fill:

    a. Grade select fill between the following limits:

U.S. Standard Sieve	Percent Passing by Weight
2 inch	100
1-1/2 inch	90-100
1 inch	75-95
1/2 inch	45-70
#4	25-50
#10	15-40
#200	5-15

    b. Select fill conforming to 1 1/4-inch aggregate defined in Section 305.2.2 of the State Specifications may be used.

2. Unsuitable Materials for Select Fill: Very fine sand, uniformly graded sands and gravels, or other materials that have a tendency to flow under pressure when wet are unacceptable as select fill.

2.3 PIPE BEDDING

A. Material for Pipe Bedding: Use of crushed stone chips made from crushing sound limestone, dolomite ledge rock, or other materials of regional significance, which can be readily and thoroughly compacted to 95 percent of the maximum dry density obtainable by ASTM D1557. The material is to be hard, tough, and durable.

1. Gradation for Small Piping: For pipe 18 inches and smaller in diameter, grade pipe bedding between the following limits:

Gradation Requirements for 3/8-inch Crushed Stone
(Standard Specifications, Table 32)

U.S. Standard Sieve	Percent Passing by Weight
1/2 inch	100
3/8 inch	90-100
#8	0-15
#30	0-3

2. Gradation for Large Piping: For pipe larger than 18 inches in diameter, grade pipe bedding between the following limits:

Gradation Requirements for 3/4-inch Crushed Stone
(Standard Specifications, Table 28, Coarse Aggregate Size No. 1, and Table 33)

U.S. Standard Sieve	Percent Passing by Weight
1 inch	100
3/4 inch	90-100
3/8 inch	20-55
#4	0-10
#8	0-5

2.4 FLOWABLE FILL

A. Materials for Flowable Fill: Use a concrete mixture of aggregate, cement (only for flowable fill with cement), and water that is workable, flowable, compacted to 95 percent of the maximum dry density obtainable by ASTM D1557, and self-leveling meeting the requirements of Sections 8.43.8 and 8.43.9 of the Standard Specifications and ASTM D4832.

B. Thoroughly mix the materials in a clean concrete mixer truck in the following quantities per cubic yard in damp weight.

1. Sand: 1,350 lbs of sand.

2. Coarse Aggregate Size No. 1: 750 lbs of Course Aggregate Size No. 1 conforming to the requirements of this Section.

3. Coarse Aggregate Size No. 2: 1,150 lbs of Coarse Aggregate Size No. 2 graded between the following limits:

Gradation Requirements for 1 1/2-inch Crushed Stone
(Standard Specifications, Table 28, Coarse Aggregate Size No. 2)

U.S. Standard Sieve	Percent Passing by Weight
2 inch	100
1 1/2 inch	90-100
1 inch	20-55
3/4 inch	0-15
1/2 inch	0-5

4. Water: 25 gallons of water. Additional water is not permitted

5. Where flowable fill with cement is shown or required, provide an additional minimum 1 bag per cubic yard of air-entraining Portland Cement meeting the requirements of ASTM C150 and Section 8.32.2 of the Standard Specifications.

    a. Admixtures: Approved chemical admixtures and fly ash that do not contain calcium chloride may be used to obtain the required properties of the flowable fill with cement mix upon approval. Provide admixtures compatible with the cement and other admixtures in the batch.

    b. Air Content: Provide an air content by volume of between 4 and 7 percent.

    c. Slump: Provide a slump of approximately 3 to 4 inches when tested in accordance with ASTM C143.

d. Compressive Strength: Provide flowable fill with a minimum 28 day compressive strength of 100 psi meeting the requirements of ASTM D4832 and based on tests of cylinders made and cured.

C. Water: Provide batch mixing water and mixer washout water meeting the requirements of ASTM C94.

D. Consistency: Provide fill with a consistency such that the material flows easily into voids and openings.

E. COMMON FILL

1. Materials for Common Fill:

a. Material used as common fill is subject to approval.

b. Material from on-site excavation may be used as common fill provided that it can be readily compacted to 90 percent of the maximum dry density obtainable by ASTM D1557, and does not contain unsuitable material as defined below.

c. If there is insufficient suitable material from on-site excavation, then import additional off-site material from sources other than the excavations in this contract conforming to the specifications and at no additional cost. Select fill may be used as common fill at no change in the Contract Price.

2. Suitable Soils for Common Fill: ASTM D2487 soil classification group (Unified Soil Classification System) GW, GP, GM, GC, SW, SP, SM, SC, CL, ML, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

3. Suitable Soils for Granular Common Fill at Structures: ASTM D2487 soil classification group (Unified Soil Classification System) GW, GP, GM, GC, SW, SP, SM, SC, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

4. Unsuitable Soils for Common Fill: ASTM D2487 soil classification group CH, MH, OH, OL and PT; soils which contain rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation or other organic matter, pieces or fragments of concrete larger than 3 inches in any dimension, clumps of clay larger than 6 inches in any dimension, and other deleterious matter.

2.5 GEOTEXTILE FABRIC

A. Provide non-woven, permeable, synthetic fiber material designed to prevent fine soil particles from migrating through the material. Provide geotextile filter fabric in accordance with Section 645 of the State Specifications.

PART 3 EXECUTION

3.1 ELECTRICAL CONDUIT AND PRECAST VAULT BEDDING

A. Bedding Compaction: Bed electrical conduits and precast vaults in well graded, compacted, select fill conforming to the requirements of this Section except as otherwise shown, specified, or required. Where conduit is installed in dedicated trenches, extend electrical conduit bedding a minimum of 6 inches below the bottom of the conduit and above the top of the conduit for the full trench width. Compact bedding thickness no less than 6 inches for precast concrete vault bases.

B. Concrete Work Mats: Cast cast-in-place vault bases and other foundations for structures against a Class D concrete work mat in clean and dry excavations, unless otherwise shown, specified or required.

C. Bedding Placement: Place select fill used for bedding beneath electrical conduits and precast vault bases, in uniform layers not greater than 9 inches in loose thickness on native, undisturbed soil. Thoroughly compact in place with suitable mechanical or pneumatic tools to not less than 95 percent of the maximum dry density as determined by ASTM D1557.

3.2 PIPE BEDDING

A. General: Provide pipe bedding material as specified and shown to proper grade and elevation and for the full width of the trench.

B. Hand Placement: Place pipe bedding by hand from the bottom of the excavation on native, undisturbed soil to 1 foot over the top outside surface of the pipe in uniform layers not greater than 6 inches in loose thickness. Tamp under pipe haunches and thoroughly compact pipe bedding in place with suitable mechanical or pneumatic tools to not less than 95 percent of the maximum dry density as measured by ASTM D1557.

   1. After the pipe is laid to line and grade, place and carefully compact pipe bedding material for the full width of the trench and in even layers on each side of the pipe to the springline of the pipe. Thoroughly hand tamp with approved tamping sticks supplemented by "walking in" and slicing with a shovel to fill voids.

2. Pay particular attention from the flow line to the springline of the pipe to provide firm support and prevent any lateral movement of the pipe during the final placement of cover material.

3. Complete compaction above the pipe when sufficient cover over the pipe has been achieved to prevent damage to the pipe.

4. Provide flowable fill, flowable fill with cement, select fill, or common fill as backfill material above the pipe bedding material as shown.

C. Stone Placement: Do not place stone fragments 3 inches or larger in any dimension in the backfill nearer than 2 feet at any point from any pipe, conduit or concrete wall.

D. Unallowed Materials: Pipe bedding containing very fine sand, uniformly graded sands and gravels, or other materials that have a tendency to flow under pressure when wet is unacceptable.

3.3 GEOTEXTILE FABRIC

A. Provide geotextile fabric completely enveloping pipe bedding material in the following conditions:

1. Along the lengths of pipe shown.

2. Anywhere loose silt, soft clay, or organic soils are encountered.

3. If trench excavation is in unsuitable soils that extend to and above the trench bottom.

4. Where directed by the RESIDENT PROJECT REPRESENTATIVE, protect geotextile during storage from becoming wet, coming in contact with soil, cement, or other foreign materials, and from exposure to sunlight.

5. Lay geotextile fabric along the bottom of the trench and pull up along the side walls of the trench prior to placement of pipe bedding material. Take care to allow the geotextile fabric to conform to the full extent of the trench opening so as to prevent tearing of the geotextile fabric during pipe bedding placement.

6. Keep sufficient geotextile fabric on each side of the trench to allow the geotextile fabric to be folded over and placed on top of the fully installed pipe bedding material and overlapped linearly along the pipeline as shown.

7. Place small quantities of the flowable fill, flowable fill with cement, select fill, or common fill material as shown on the geotextile fabric to keep the fabric and overlap in place.

3.4 EXISTING UNDERGROUND STRUCTURES AND UTITLITES

A. Bed and backfill existing underground structures, tunnels, conduit, or pipe crossing the excavation with material shown. Place bedding material under and around each existing underground structure, tunnel, conduit, or pipe and extend underneath to native, undisturbed soil and on each side to a distance equal to the depth of the trench below the structure, conduit or pipe.

3.5 TRENCH BACKFILL

A. General: Backfill trenches from 1 foot over the top of the pipe, from the top of electrical conduit bedding or as shown to the bottom of pavement base course, subgrade for lawns or lawn replacement, to the top of the existing ground surface or to such other grades as may be shown or required.

B. Backfill simultaneously and evenly on each side of free-standing structures and pipe.

C. Materials: Provide flowable fill, flowable fill with cement, select fill, or common fill, as shown, specified and approved for trench backfill.

D. Depth of Placement - General: Except under pavements, walkways, railroad tracks, and street or highway appurtenances, or as otherwise shown or specified, place trench backfill in uniform layers not greater than 9 inches in loose thickness and thoroughly compact in place using suitable mechanical or pneumatic equipment. Compact backfill to not less than 90 percent of the maximum dry density as determined by ASTM D1557.

E. Depth of Placement - Traffic Areas and Under Utilities: Where pavements, walkways, railroad tracks, and street or highway appurtenances are to be placed over trenches (except in tunnels) and under utilities or utility services crossing the trench, provide trench backfill as shown. Compact backfill to not less than 95 percent of the maximum dry density as determined by ASTM D1557. Place select fill, flowable fill with cement, and flowable fill as follows.

1. Placing Select Fill:

    a. Provide select fill in uniform layers not greater than 9 inches in loose thickness and thoroughly compacted in place with equipment as specified in this Section.

2. Placing Flowable Fill and Flowable Fill with Cement:

    a. Just prior to mixing, run the mixer at full mixing speed for one full minute to provide an even mixture.

b. Place fill directly from the concrete transit mix truck over the pipe bedding material to an elevation equal to the bottom of pavement base course as shown.

c. Use rodding, mechanical vibration, and compaction to assist in consolidating the fill to fill voids and openings.

d. When required to prevent uplift, place fill in 2 stages, allowing sufficient time for the initial set of the first stage before the remainder is placed.

e. Place fill as nearly as practical in its final position. Do not disturb the pipe trench or cause foreign material to become mixed with the fill.

f. Do not place backfill over the flowable fill with cement until it has reached the initial set. If backfill is not to be placed over the flowable fill with cement within 8 hours, place a 6-inch cover of select fill over the flowable fill with cement.

g. At air temperatures lower than 45 degrees Fahrenheit, deliver and place fill at a minimum temperature of 50 degrees Fahrenheit. Maintain a temperature of concrete during production and transportation equal to or less than 90 degrees Fahrenheit.

h. Do not place fill when:

  (1) The trench walls are frozen or contain frozen materials.

  (2) The air temperature is below 40 degrees Fahrenheit, unless the air temperature is 35 degrees Fahrenheit or more and the temperature is rising.

  (3) Weather conditions are otherwise unsuitable.

  (4) Directed by the RESIDENT PROJECT REPRESENTATIVE.

F. Depth of Placement - Undeveloped Areas: In undeveloped areas where flowable or select fill material or hand-placed backfill are not specified, shown, or required, place common fill, or other approved backfill in lifts not exceeding 12 inches in loose thickness. When the trench is full, consolidate the backfill by jetting, spading, tamping or puddling to ensure complete filling of the excavation. Mound the top of the trench approximately 12 inches to allow for consolidation of backfill.

G. Dropping of Material on Work: Do trench backfilling work in such a way as to prevent dropping material directly on top of any conduit or pipe through any great vertical distance that would cause damage to the pipe, coating, polyethylene encasement, any other aspect of the Work, or existing utility or structure. Do not allow backfilling material from a bucket or other source to fall directly on a structure or pipe and lower the bucket or other source so that the shock of falling earth will not cause damage.

H. Distribution of Large Materials: Break lumps up and distribute any stones, pieces of crushed rock or lumps which cannot be readily broken up, throughout the mass so that interstices are solidly filled with fine material.

3.6 STRUCTURE BACKFILL

A. Use of Select Fill: Use select fill underneath structures, and adjacent to structures where pipes, connections, electrical ducts and conduits, and structural foundations are to be located within this fill. Use flowable fill, flowable fill with cement, or select fill beneath pavements, walkways, and railroad tracks (except in tunnels) as shown and extend up to the bottom of pavement base course or ballast.

1. Place backfill in uniform layers not greater than 8 inches in loose thickness and thoroughly compact in place with suitable approved mechanical or pneumatic equipment.

2. Compact backfill to not less than 95 percent of the maximum dry density as determined by ASTM D1557.

B. Use of Common Fill: Use common granular fill adjacent to structures in areas not specified above, unless otherwise shown or specified. Select fill may be used in place of common granular fill at no additional cost.

1. Extend such backfill from the bottom of the excavation or top of bedding to the bottom of subgrade for lawns or lawn replacement, the top of previously existing ground surface or to such other grades as may be shown or required.

2. Place backfill in uniform layers not greater than 8 inches in loose thickness and thoroughly compact in place with suitable equipment, as specified above.

3. Compact backfill to not less than 90 percent of the maximum dry density as determined by ASTM D1557.

C. Use of Clay: In unpaved areas adjacent to structures for the top 1 foot of fill directly under lawn subgrades use clay backfill placed in 6-inch lifts. Compact clay backfill to not less than 90 percent of the maximum dry density as determined by ASTM D1557.

1. Use clay having a liquid limit less than or equal to 40 and a plasticity index less than or equal to 20.

3.7 COMPACTION EQUIPMENT

A. Equipment and Methods: Carry out compaction with suitable approved equipment and methods.

1. Compact clay and other cohesive material with sheep's-foot rollers or similar equipment where practicable. Use hand held pneumatic tampers elsewhere for compaction of cohesive fill material.

2. Compact low cohesive soils with pneumatic-tire rollers or large vibratory equipment where practicable. Use small vibratory equipment elsewhere for compaction of cohesionless fill material.

3. Do not use heavy compaction equipment over pipelines or other structures, unless the depth of fill is sufficient to adequately distribute the load.

3.8 FINISH GRADING

A. Final Contours: Perform finish grading in accordance with the completed contour elevations and grades shown and blend into conformation with remaining natural ground surfaces.

1. Leave finished grading surfaces smooth and firm to drain.

2. Bring finish grades to elevations within plus or minus 0.10 foot of elevations or contours shown.

B. Surface Drainage: Perform grading outside of building or structure lines in a manner to prevent accumulation of water within the area. Where necessary or where shown, extend finish grading to ensure that water will be carried to drainage ditches, and the site area left smooth and free from depressions holding water.

3.9 RESPONSIBILITY FOR AFTERSETTLEMENT

A. Aftersettlement Responsibility: Take responsibility for correcting any depression which may develop in backfilled areas from settlement within three years after the work is fully completed. Provide as needed, backfill material, pavement base replacement, permanent pavement, sidewalk, curb and driveway repair or replacement, and lawn replacement, and perform the necessary reconditioning and restoration work to bring such depressed areas to proper grade as approved.

3.10 INSPECTION AND TESTING OF BACKFILLING

A. Sampling and Testing: Sampling and testing of in-place backfill and concrete will be provided by the OWNER as specified in Division 1. If initial testing reveals non-compliance with Contract requirements, all additional testing will be made at the Contractor’s expense.

B. Coordinate required backfill and concrete tests with the OWNER’s testing agency including providing the testing agency a 24-hour notice prior to any required testing.

C. Correction of Work: Correct any areas of unsatisfactory compaction by removal and replacement, or by scarifying, aerating or sprinkling as needed and recompaction and retesting in place prior to placement of a new lift at no cost to OWNER.

END OF SECTION

(NO TEXT FOR THIS PAGE)

Appendix D - General Notes and USDA Classification Charts

GENERAL NOTES

SAMPLE IDENTIFICATION

The Unified Soil Classification System (USCS), AASHTO 1988 and ASTM designations D2487 and D-2488 are used to identify the encountered materials unless otherwise noted. Coarse-grained soils are defined as having more than 50% of their dry weight retained on a #200 sieve (0.075mm); they are described as: boulders, cobbles, gravel or sand. Fine-grained soils have less than 50% of their dry weight retained on a #200 sieve; they are defined as silts or clay depending on their Atterberg Limit attributes. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size.

DRILLING AND SAMPLING SYMBOLS

SFA: Solid Flight Auger - typically 4" diameter flights, except where noted.
HSA: Hollow Stem Auger - typically 3¼" or 4¼ I.D. openings, except where noted.
M.R.: Mud Rotary - Uses a rotary head with Bentonite or Polymer Slurry
R.C.: Diamond Bit Core Sampler
H.A.: Hand Auger
P.A.: Power Auger - Handheld motorized auger

☒ SS: Split-Spoon - 1 3/8" I.D., 2" O.D., except where noted.
█ ST: Shelby Tube - 3" O.D., except where noted.
▯ RC: Rock Core
⇓ TC: Texas Cone
✋ BS: Bulk Sample
▦ PM: Pressuremeter
CPT-U: Cone Penetrometer Testing with Pore-Pressure Readings

SOIL PROPERTY SYMBOLS

N: Standard "N" penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2-inch O.D. Split-Spoon.
N_{60}: A "N" penetration value corrected to an equivalent 60% hammer energy transfer efficiency (ETR)
Q_u: Unconfined compressive strength, TSF
Q_p: Pocket penetrometer value, unconfined compressive strength, TSF
w%: Moisture/water content, %
LL: Liquid Limit, %
PL: Plastic Limit, %
PI: Plasticity Index = (LL-PL),%
DD: Dry unit weight, pcf
▼, ▽, ▼ Apparent groundwater level at time noted

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Relative Density	N - Blows/foot
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	50 - 80
Extremely Dense	80+

ANGULARITY OF COARSE-GRAINED PARTICLES

Description	Criteria
Angular:	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular:	Particles are similar to angular description, but have rounded edges
Subrounded:	Particles have nearly plane sides, but have well-rounded corners and edges
Rounded:	Particles have smoothly curved sides and no edges

GRAIN-SIZE TERMINOLOGY

Component	Size Range
Boulders:	Over 300 mm (>12 in.)
Cobbles:	75 mm to 300 mm (3 in. to 12 in.)
Coarse-Grained Gravel:	19 mm to 75 mm (¾ in. to 3 in.)
Fine-Grained Gravel:	4.75 mm to 19 mm (No.4 to ¾ in.)
Coarse-Grained Sand:	2 mm to 4.75 mm (No.10 to No.4)
Medium-Grained Sand:	0.42 mm to 2 mm (No.40 to No.10)
Fine-Grained Sand:	0.075 mm to 0.42 mm (No. 200 to No.40)
Silt:	0.005 mm to 0.075 mm
Clay:	<0.005 mm

PARTICLE SHAPE

Description	Criteria
Flat:	Particles with width/thickness ratio > 3
Elongated:	Particles with length/width ratio > 3
Flat & Elongated:	Particles meet criteria for both flat and elongated

RELATIVE PROPORTIONS OF FINES

Descriptive Term	% Dry Weight
Trace:	< 5%
With:	5% to 12%
Modifier:	>12%

GENERAL NOTES

(Continued)

CONSISTENCY OF FINE-GRAINED SOILS

Q_U - TSF	N - Blows/foot	Consistency
0 - 0.25	0 - 2	Very Soft
0.25 - 0.50	2 - 4	Soft
0.50 - 1.00	4 - 8	Firm (Medium Stiff)
1.00 - 2.00	8 - 15	Stiff
2.00 - 4.00	15 - 30	Very Stiff
4.00 - 8.00	30 - 50	Hard
8.00+	50+	Very Hard

MOISTURE CONDITION DESCRIPTION

Description	Criteria
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

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term	% Dry Weight
Trace:	< 15%
With:	15% to 30%
Modifier:	>30%

STRUCTURE DESCRIPTION

Description	Criteria
Stratified:	Alternating layers of varying material or color with layers at least ¼-inch (6 mm) thick
Laminated:	Alternating layers of varying material or color with layers less than ¼-inch (6 mm) thick
Fissured:	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided:	Fracture planes appear polished or glossy, sometimes striated

Description	Criteria
Blocky:	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed:	Inclusion of small pockets of different soils
Layer:	Inclusion greater than 3 inches thick (75 mm)
Seam:	Inclusion 1/8-inch to 3 inches (3 to 75 mm) thick extending through the sample
Parting:	Inclusion less than 1/8-inch (3 mm) thick

SCALE OF RELATIVE ROCK HARDNESS

Q_U - TSF	Consistency
2.5 - 10	Extremely Soft
10 - 50	Very Soft
50 - 250	Soft
250 - 525	Medium Hard
525 - 1,050	Moderately Hard
1,050 - 2,600	Hard
>2,600	Very Hard

ROCK BEDDING THICKNESSES

Description	Criteria
Very Thick Bedded	Greater than 3-foot (>1.0 m)
Thick Bedded	1-foot to 3-foot (0.3 m to 1.0 m)
Medium Bedded	4-inch to 1-foot (0.1 m to 0.3 m)
Thin Bedded	1¼-inch to 4-inch (30 mm to 100 mm)
Very Thin Bedded	½-inch to 1¼-inch (10 mm to 30 mm)
Thickly Laminated	1/8-inch to ½-inch (3 mm to 10 mm)
Thinly Laminated	1/8-inch or less "paper thin" (<3 mm)

ROCK VOIDS

Voids	Void Diameter
Pit	<6 mm (<0.25 in)
Vug	6 mm to 50 mm (0.25 in to 2 in)
Cavity	50 mm to 600 mm (2 in to 24 in)
Cave	>600 mm (>24 in)

GRAIN-SIZED TERMINOLOGY

(Typically Sedimentary Rock)

Component	Size Range
Very Coarse Grained	>4.76 mm
Coarse Grained	2.0 mm - 4.76 mm
Medium Grained	0.42 mm - 2.0 mm
Fine Grained	0.075 mm - 0.42 mm
Very Fine Grained	<0.075 mm

ROCK QUALITY DESCRIPTION

Rock Mass Description	RQD Value
Excellent	90 -100
Good	75 - 90
Fair	50 - 75
Poor	25 -50
Very Poor	Less than 25

DEGREE OF WEATHERING

Slightly Weathered:	Rock generally fresh, joints stained and discoloration extends into rock up to 25 mm (1 in), open joints may contain clay, core rings under hammer impact.
Weathered:	Rock mass is decomposed 50% or less, significant portions of the rock show discoloration and weathering effects, cores cannot be broken by hand or scraped by knife.
Highly Weathered:	Rock mass is more than 50% decomposed, complete discoloration of rock fabric, core may be extremely broken and gives clunk sound when struck by hammer, may be shaved with a knife.

SOIL CLASSIFICATION CHART

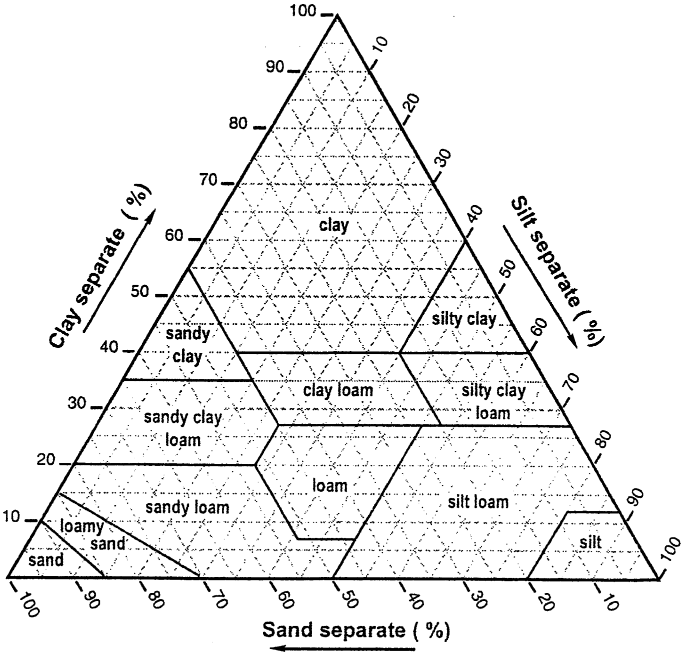
NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	▨	GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
			▨	GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	▨	GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
			▨	GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	▨	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			▨	SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	▨	SM	SILTY SANDS, SAND - SILT MIXTURES
			▨	SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	▨	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			▨	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			▨	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	▨	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
			▨	CH	INORGANIC CLAYS OF HIGH PLASTICITY
			▨	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			▨	PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

intertek
psi

Texture Triangle:

Fine Earth Texture Classes (——)



TEXTURE MODIFIERS - Conventions for using "Rock Fragment Texture Modifiers" and for using textural adjectives that convey the "% volume" ranges for **Rock Fragments - Size and Quantity**.

Fragment Content % By Volume	**Rock Fragment Modifier Usage**
< 15	No texture adjective is used (noun only; e.g., *loam*).
15 to < 35	Use adjective for appropriate size; e.g., *gravelly.*
35 to < 60	Use "very" with the appropriate size adjective; e.g., *very gravelly.*
60 to < 90	Use "extremely" with the appropriate size adjective; e.g., *extremely gravelly.*
≥ 90	No adjective or modifier. If ≤ 10% fine earth, use the appropriate noun for the dominant size class; e.g., *gravel.* Use **Terms in Lieu of Texture.**

(SOIL) TEXTURE

This is the numerical proportion (percent by weight) of sand, silt, and clay in a soil. Sand, silt, and clay content is estimated in the field by hand (or quantitatively measured in the office/lab by hydrometer or pipette) and then placed within the texture triangle to determine **Texture Class**. Estimate the **Texture Class**; e.g., *sandy loam*; or **Subclass**; e.g., *fine sandy loam* of the fine earth (≤ 2 mm) fraction, or choose a **Term in Lieu of Texture**; e.g., *gravel.* If appropriate, use a **Textural Class Modifier**; e.g., *gravelly silt loam.*

NOTE: **Soil Texture** encompasses only the fine earth fraction (≤ 2 mm). **Particle Size Distribution** (PSD) encompasses the whole soil, including both the fine earth fraction (≤ 2 mm; weight %) and rock fragments (> 2 mm; volume %).

TEXTURE CLASS

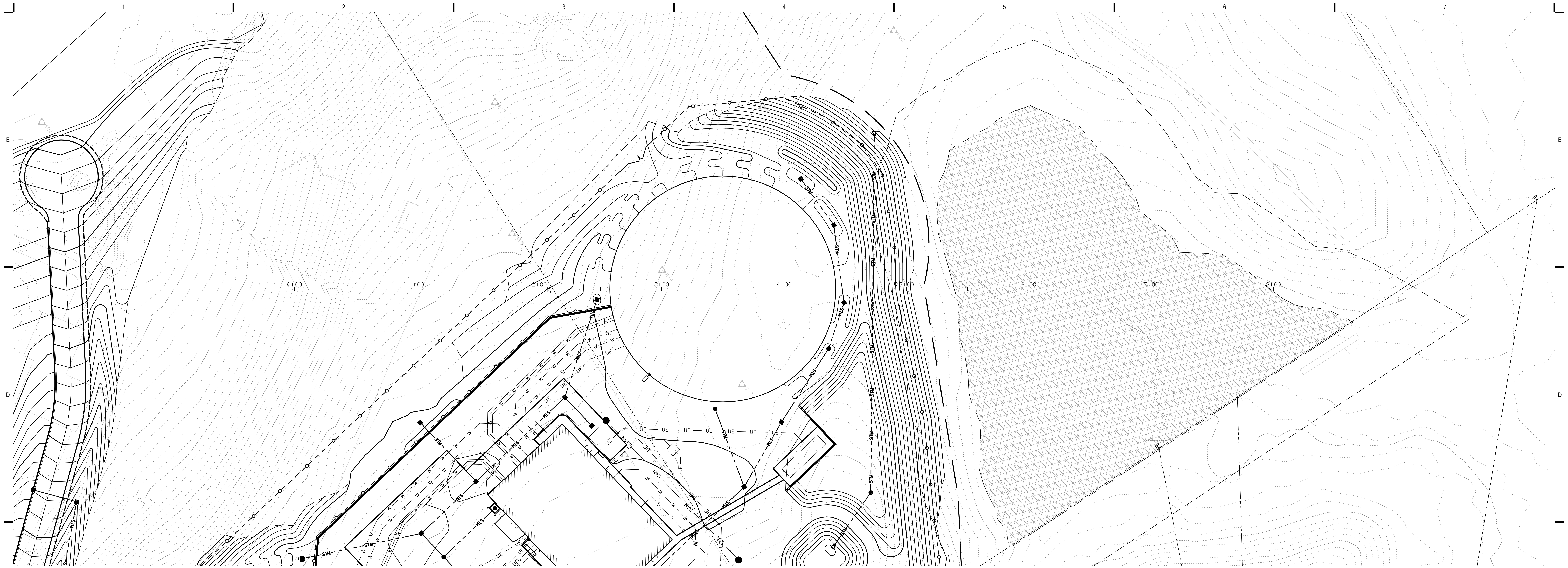
	Code	
Texture Class or Subclass	**Conv.**	**NASIS**
Coarse Sand	cos	COS
Sand	s	S
Fine Sand	fs	FS
Very Fine Sand	vfs	VFS
Loamy Coarse Sand	lcos	LCOS
Loamy Sand	ls	LS
Loamy Fine Sand	lfs	LFS
Loamy Very Fine Sand	lvfs	LVFS
Coarse Sandy Loam	cosl	COSL
Sandy Loam	sl	SL
Fine Sandy Loam	fsl	FSL
Very Fine Sandy Loam	vfsl	VFSL
Loam	l	L
Silt Loam	sil	SIL
Silt	si	SI
Sandy Clay Loam	scl	SCL
Clay Loam	cl	CL
Silty Clay Loam	sicl	SICL
Sandy Clay	sc	SC
Silty Clay	sic	SIC
Clay	c	C

TEXTURE MODIFIERS - *(adjectives)*

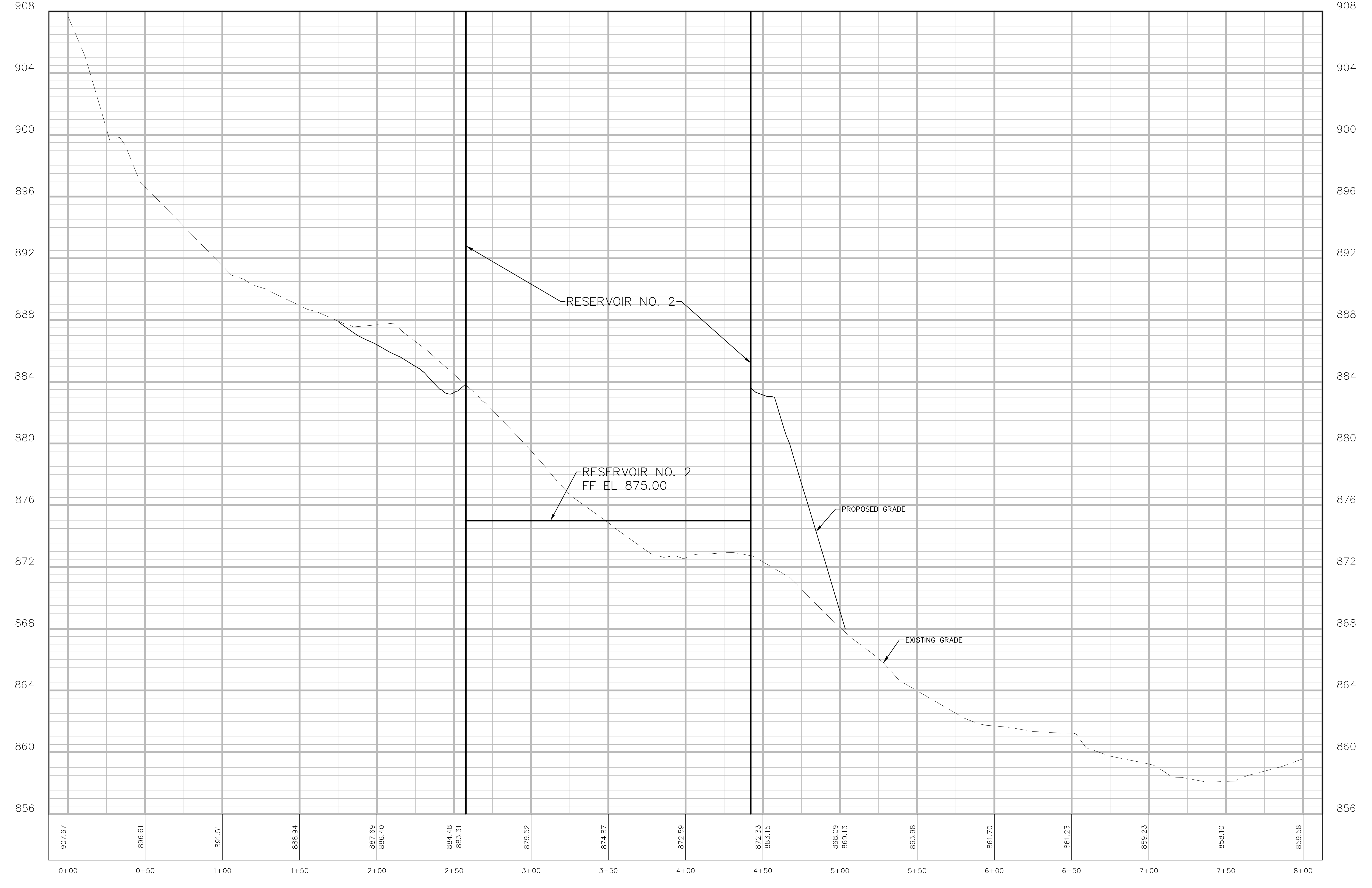
ROCK FRAGMENTS: Size & Quantity [1]	**Code**		**Criteria: Percent (By Volume) of Total Rock Fragments and Dominated By** (*name size*): [1]
	Conv.	**PDP/ NASIS**	
ROCK FRAGMENTS (> 2 mm; ≥ Strongly Cemented)			
Gravelly	GR	GR	≥ 15% but < 35% gravel
Fine Gravelly	FGR	GRF	≥15% but < 35% fine gravel
Medium Gravelly	MGR	GRM	≥15% but < 35% med. gravel
Coarse Gravelly	CGR	GRC	≥ 15% but < 35% coarse gravel
Very Gravelly	VGR	GRV	≥ 35% but < 60% gravel
Extremely Gravelly	XGR	GRX	≥ 60% but < 90% gravel
Cobbly	CB	CB	≥ 15% but < 35% cobbles
Very Cobbly	VCB	CBV	≥ 35% but < 60% cobbles
Extremely Cobbly	XCB	CBX	≥ 60% but < 90% cobbles
Stony	ST	ST	≥ 15% but < 35% stones
Very Stony	VST	STV	≥ 35% but < 60% stones
Extremely Stony	XST	STX	≥ 60% but < 90% stones
Bouldery	BY	BY	≥ 15% but < 35% boulders
Very Bouldery	VBY	BYV	≥ 35% but < 60% boulders
Extremely Bouldery	XBY	BYX	≥ 60% but < 90% boulders
Channery	CN	CN	≥ 15% but < 35% channers
Very Channery	VCN	CNV	≥ 35% but < 60% channers
Extremely Channery	XCN	CNX	≥ 60% but < 90% channers
Flaggy	FL	FL	≥ 15% but < 35% flagstones
Very Flaggy	VFL	FLV	≥ 35% but < 60% flagstones
Extremely Flaggy	XFL	FLX	≥ 60% but < 90% flagstones
PARAROCK FRAGMENTS (> 2 mm; < Strongly Cemented) [2,3]			
Parabouldery	PBY	PBY	(same criteria as bouldery)
Very Parabouldery	VPBY	PBYV	(same criteria as very bouldery)
Extr. Parabouldery	XPBY	PBYX	(same criteria as ext. bouldery)
etc.	etc.	etc.	(same criteria as non-para)

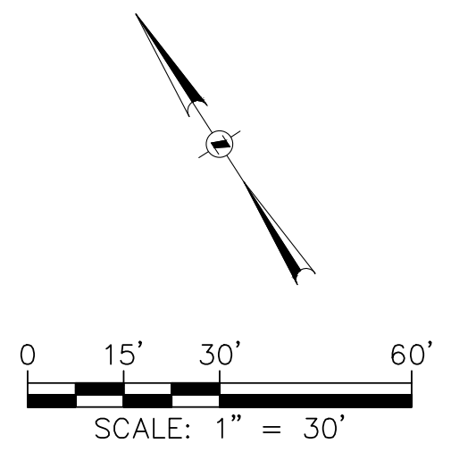
[1] The "Quantity" modifier (e.g., *very*) is based on the total rock fragment content. The "Size" modifier (e.g., *cobbly*) is independently based on the largest, dominant fragment size. For a mixture of sizes (e.g., *gravel and stones*), a smaller size–class is named only if its quantity (%) sufficiently exceeds that of a larger size–class. For field texture determination, a smaller size-class must exceed 2 times the quantity (vol. %) of a larger size class before it is named (e.g., 30% gravel and 14% stones = *very gravelly*, but 20% gravel and 14% stones = *stony*). For more explicit naming criteria see NSSH-Part 618, Exhibit 618.11(Soil Survey Staff, 2001b).

Appendix E - Cross Section for Global Stability



Site Cross Section PROFILE





GRAEF

275 West Wisconsin Avenue, Suite 300
Milwaukee, WI 53203
414 / 259 1500
414 / 259 0037 fax

www.graef-usa.com

[redacted] CONSULTANTS:

[redacted] PROJECT TITLE:

CONTRACT PACKAGE 3: BOOSTER PUMPING STATION

[redacted] ISSUE:

NO.	DATE	REVISIONS	BY

[redacted] PROJECT INFORMATION:

PROJECT NUMBER:	2016-0998.00
DATE:	09/01/2020
DRAWN BY:	TRY
CHECKED BY:	PRE
APPROVED BY:	PRE
SCALE:	AS NOTED

[redacted] SHEET TITLE:

SITE CROSS SECTION

[redacted] SHEET NUMBER:

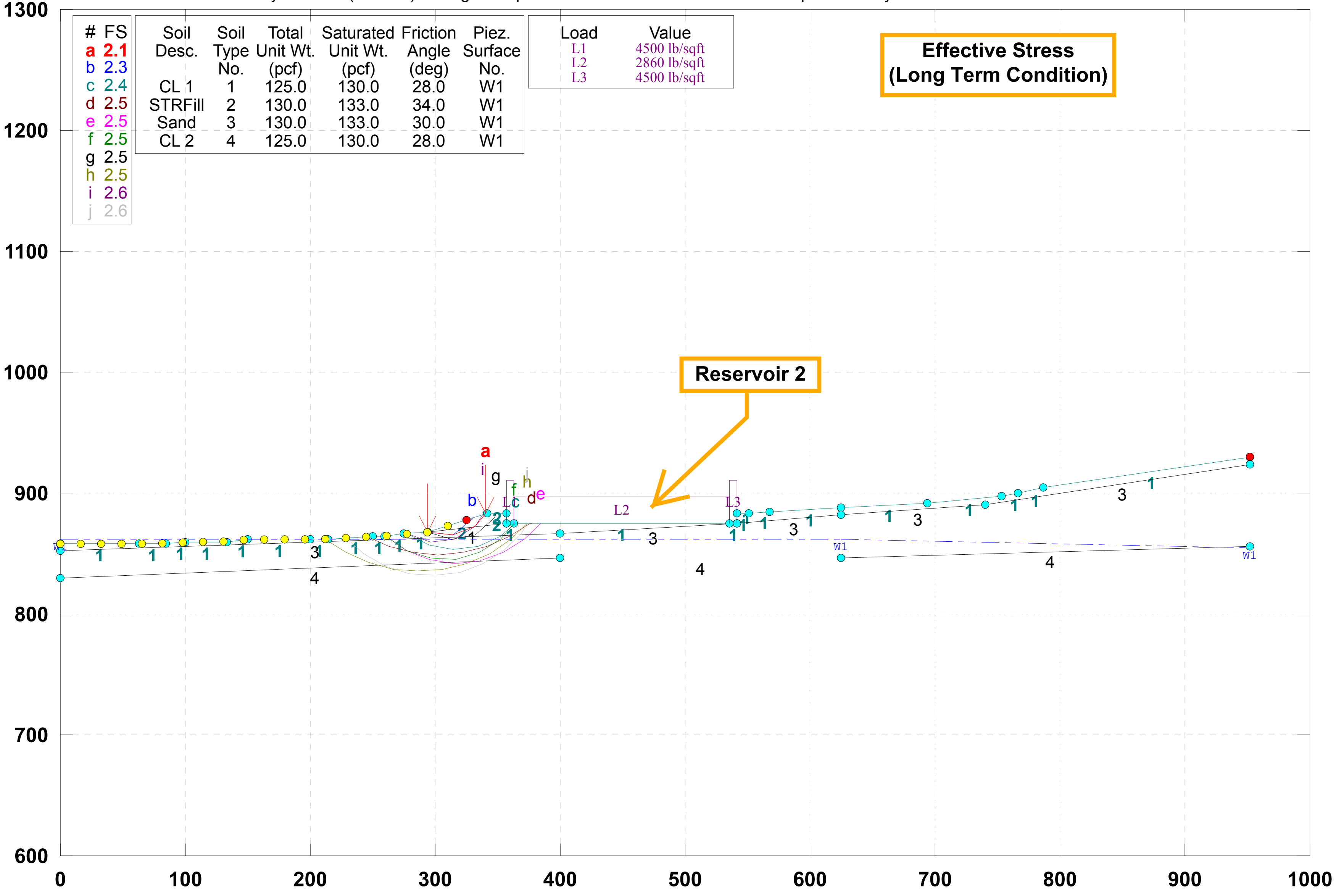
EX-01

X:\ML\2016\20160998\CAD\Site\dwg\misc\C_03_Site Soils Cross Sections_0998
9/1/2020 8:04 AM

Appendix F - Global Stability Runs

GWA - BPS 2 - Reservoir 2 - R1 Overall Waukesha, WI

u:\bradley broback (800014)\stabl\gwa - bps 2 - reservoir 2\reservoir 2r1 overall.pl2 Run By: Brad Broback 9/4/2020 08:54AM



#	FS
a	2.1
b	2.3
c	2.4
d	2.5
e	2.5
f	2.5
g	2.5
h	2.5
i	2.6
j	2.6

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Friction Angle (deg)	Piez. Surface No.
CL 1	1	125.0	130.0	28.0	W1
STRFill	2	130.0	133.0	34.0	W1
Sand	3	130.0	133.0	30.0	W1
CL 2	4	125.0	130.0	28.0	W1

Load	Value
L1	4500 lb/sqft
L2	2860 lb/sqft
L3	4500 lb/sqft

Effective Stress (Long Term Condition)

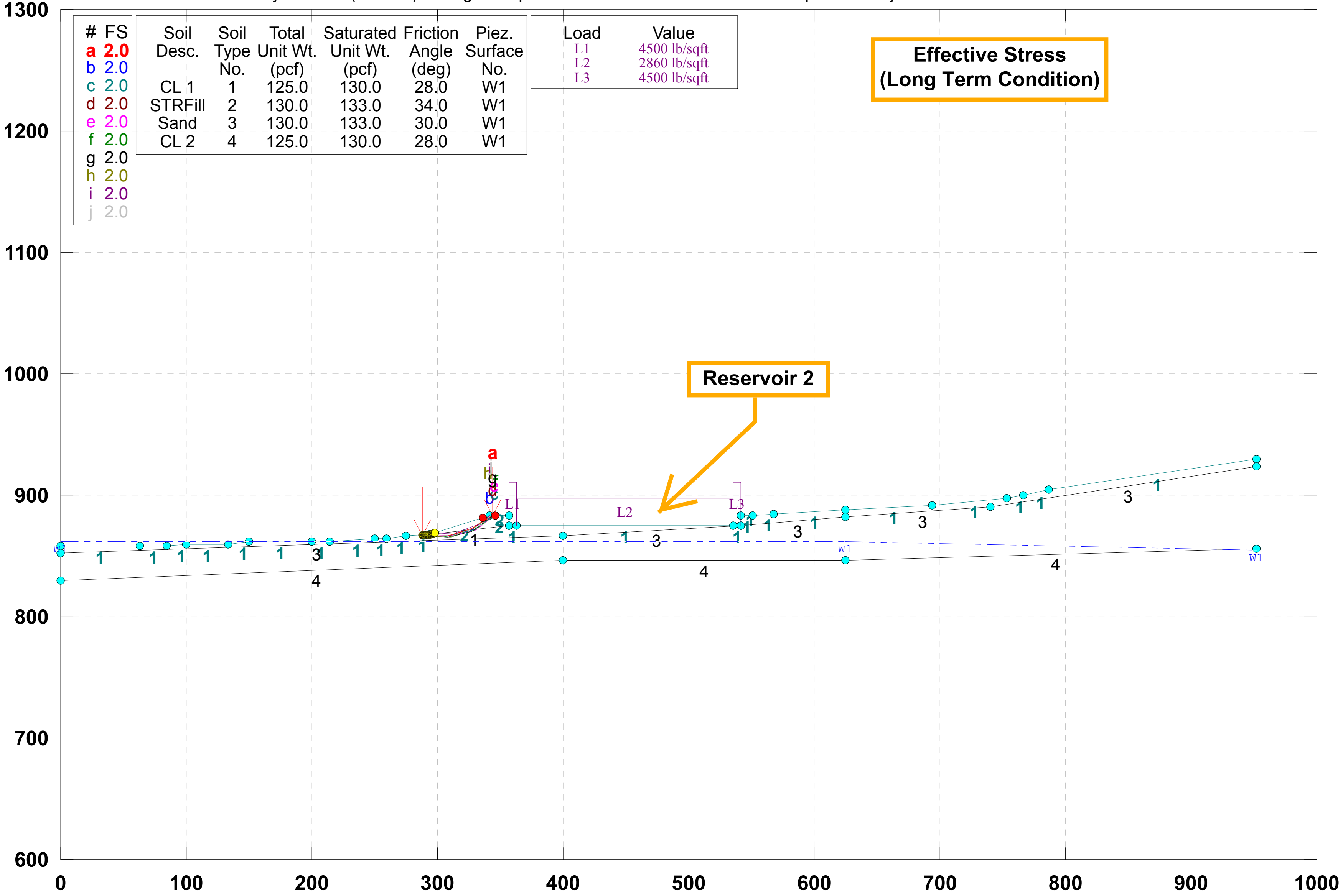
Reservoir 2

STABL6H FSmin=2.1

Safety Factors Are Calculated By The Modified Bishop Method

GWA - BPS 2 - Reservoir 2 - R1 Overall Waukesha, WI

u:\bradley broback (800014)\stabl\gwa - bps 2 - reservoir 2\reservoir 2r1 overall.pl2   Run By: Brad Broback   9/4/2020   08:59AM



#	FS
a	2.0
b	2.0
c	2.0
d	2.0
e	2.0
f	2.0
g	2.0
h	2.0
i	2.0
j	2.0

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Friction Angle (deg)	Piez. Surface No.
CL 1	1	125.0	130.0	28.0	W1
STRFill	2	130.0	133.0	34.0	W1
Sand	3	130.0	133.0	30.0	W1
CL 2	4	125.0	130.0	28.0	W1

Load	Value
L1	4500 lb/sqft
L2	2860 lb/sqft
L3	4500 lb/sqft

Effective Stress (Long Term Condition)

Reservoir 2

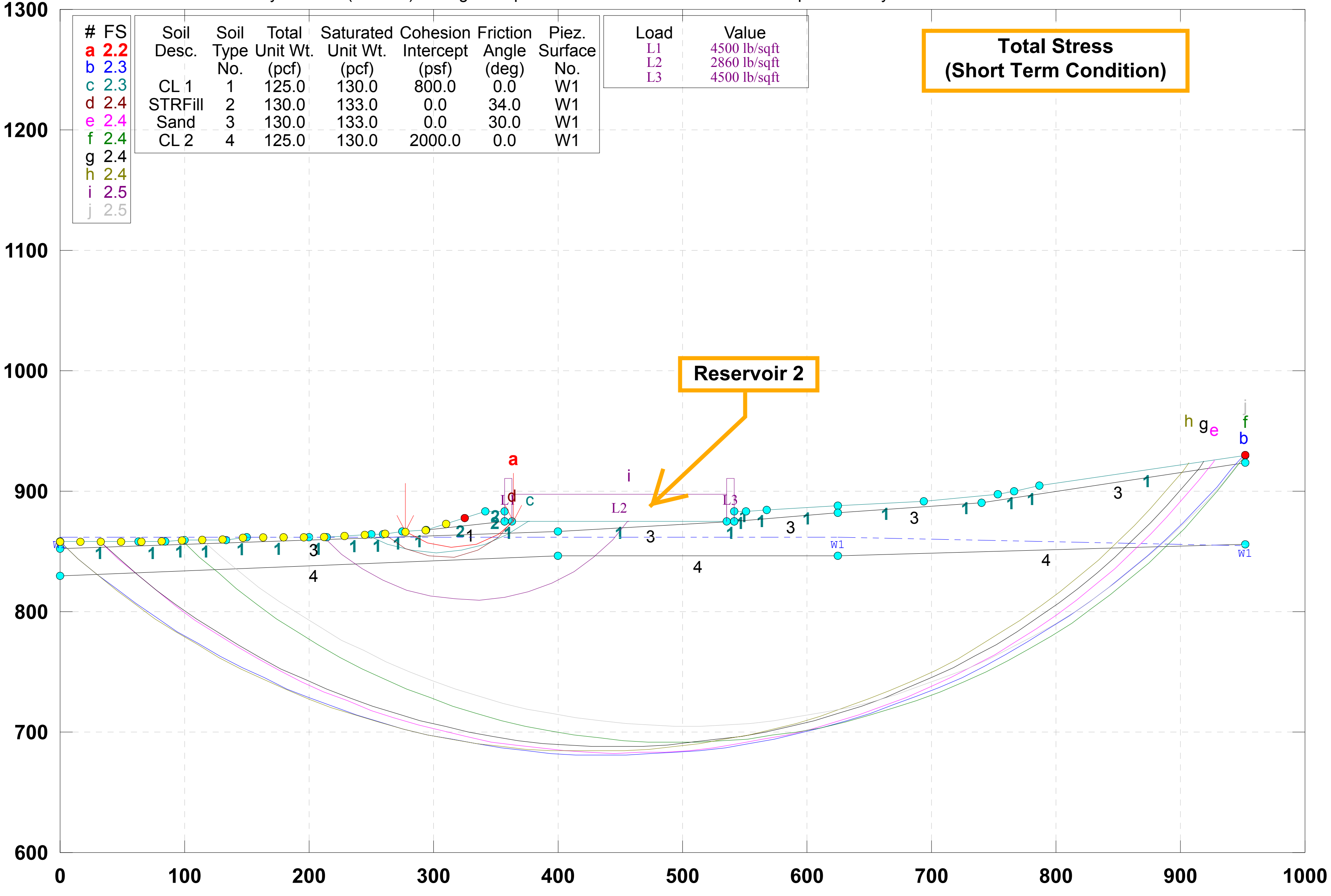
STABL6H FSmin=2.0

Safety Factors Are Calculated By The Modified Bishop Method

intertek psi

GWA - BPS 2 - Reservoir 2 - R1 Overall Waukesha, WI

u:\bradley broback (800014)\stabl\gwa - bps 2 - reservoir 2\reservoir 2r1 overall.pl2 Run By: Brad Broback 9/4/2020 09:01AM



#	FS
a	2.2
b	2.3
c	2.3
d	2.4
e	2.4
f	2.4
g	2.4
h	2.4
i	2.5
j	2.5

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CL 1	1	125.0	130.0	800.0	0.0	W1
STRFill	2	130.0	133.0	0.0	34.0	W1
Sand	3	130.0	133.0	0.0	30.0	W1
CL 2	4	125.0	130.0	2000.0	0.0	W1

Load	Value
L1	4500 lb/sqft
L2	2860 lb/sqft
L3	4500 lb/sqft

Total Stress (Short Term Condition)

Reservoir 2

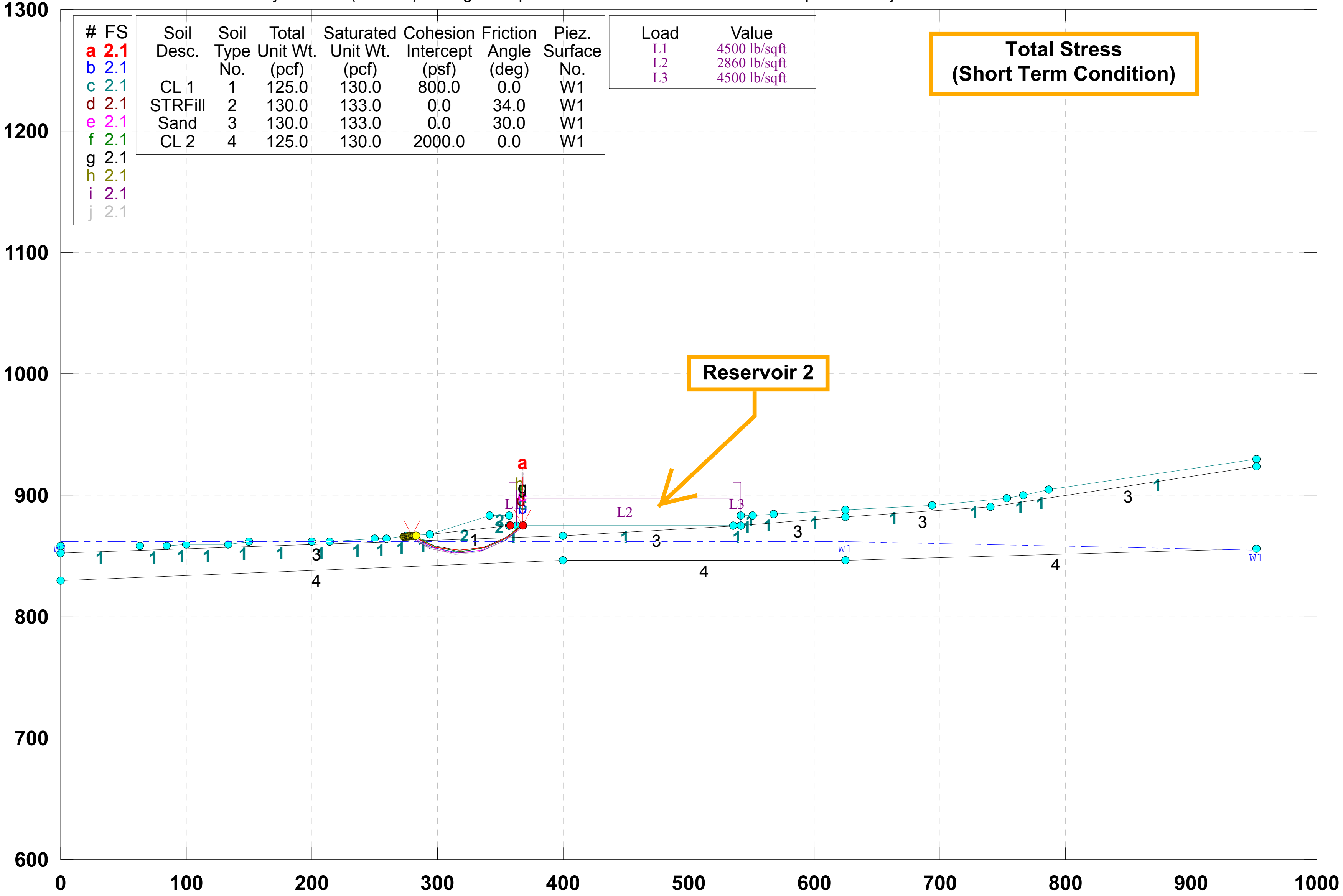
STABL6H FSmin=2.2

Safety Factors Are Calculated By The Modified Bishop Method

intertek psi

GWA - BPS 2 - Reservoir 2 - R1 Overall Waukesha, WI

u:\bradley broback (800014)\stabl\gwa - bps 2 - reservoir 2\reservoir 2r1 overall.pl2   Run By: Brad Broback   9/4/2020   09:02AM



#	FS
a	2.1
b	2.1
c	2.1
d	2.1
e	2.1
f	2.1
g	2.1
h	2.1
i	2.1
j	2.1

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CL 1	1	125.0	130.0	800.0	0.0	W1
STRFill	2	130.0	133.0	0.0	34.0	W1
Sand	3	130.0	133.0	0.0	30.0	W1
CL 2	4	125.0	130.0	2000.0	0.0	W1

Load	Value
L1	4500 lb/sqft
L2	2860 lb/sqft
L3	4500 lb/sqft

Total Stress
(Short Term Condition)

Reservoir 2

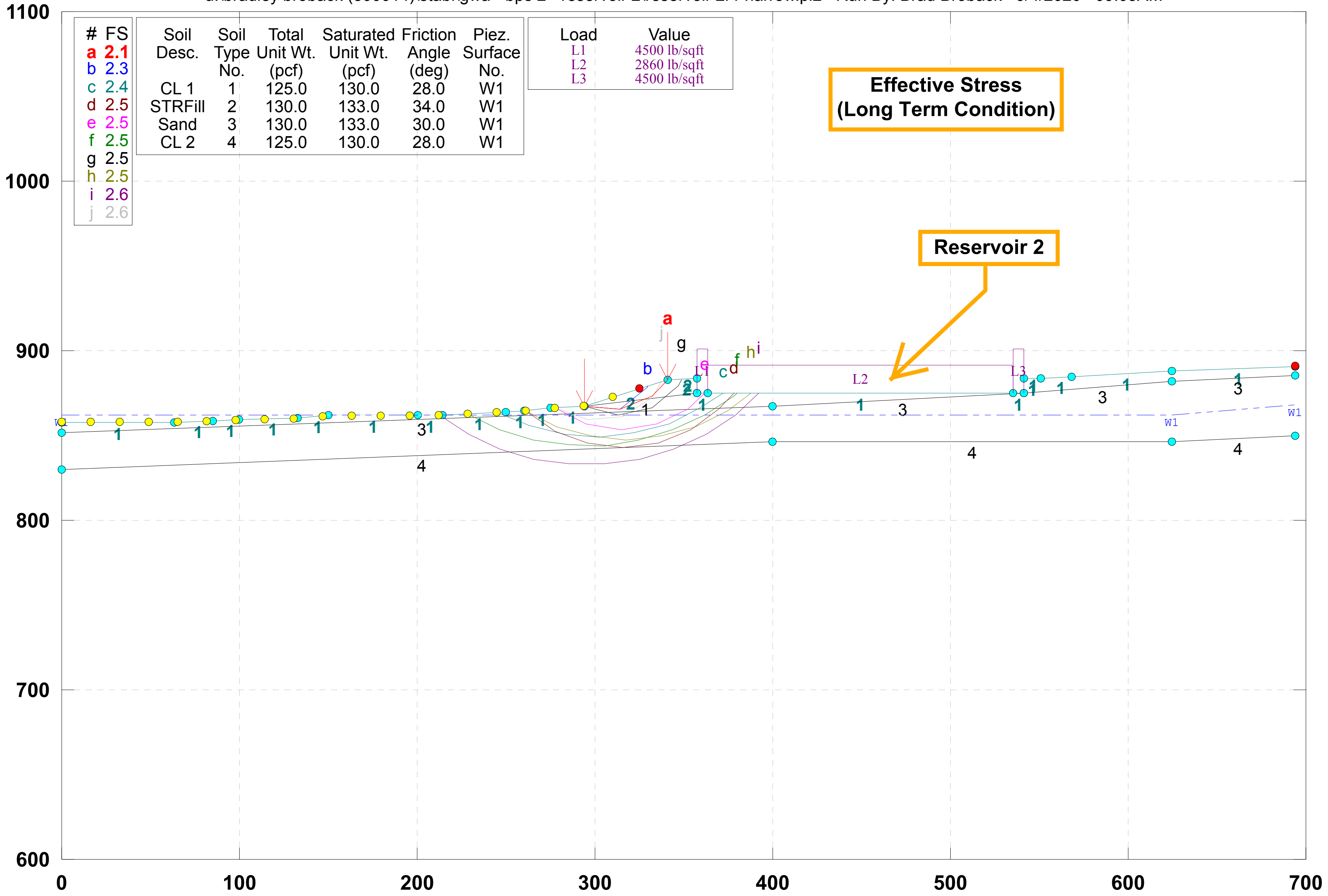
STABL6H FSmin=2.1

Safety Factors Are Calculated By The Modified Bishop Method

intertek
psi

GWA - BPS 2 - Reservoir 2 - R1 Narrow Waukesha, WI

u:\bradley broback (800014)\stabl\gwa - bps 2 - reservoir 2\reservoir 2r1 narrow.pl2 Run By: Brad Broback 9/4/2020 09:03AM



#	FS
a	2.1
b	2.3
c	2.4
d	2.5
e	2.5
f	2.5
g	2.5
h	2.5
i	2.6
j	2.6

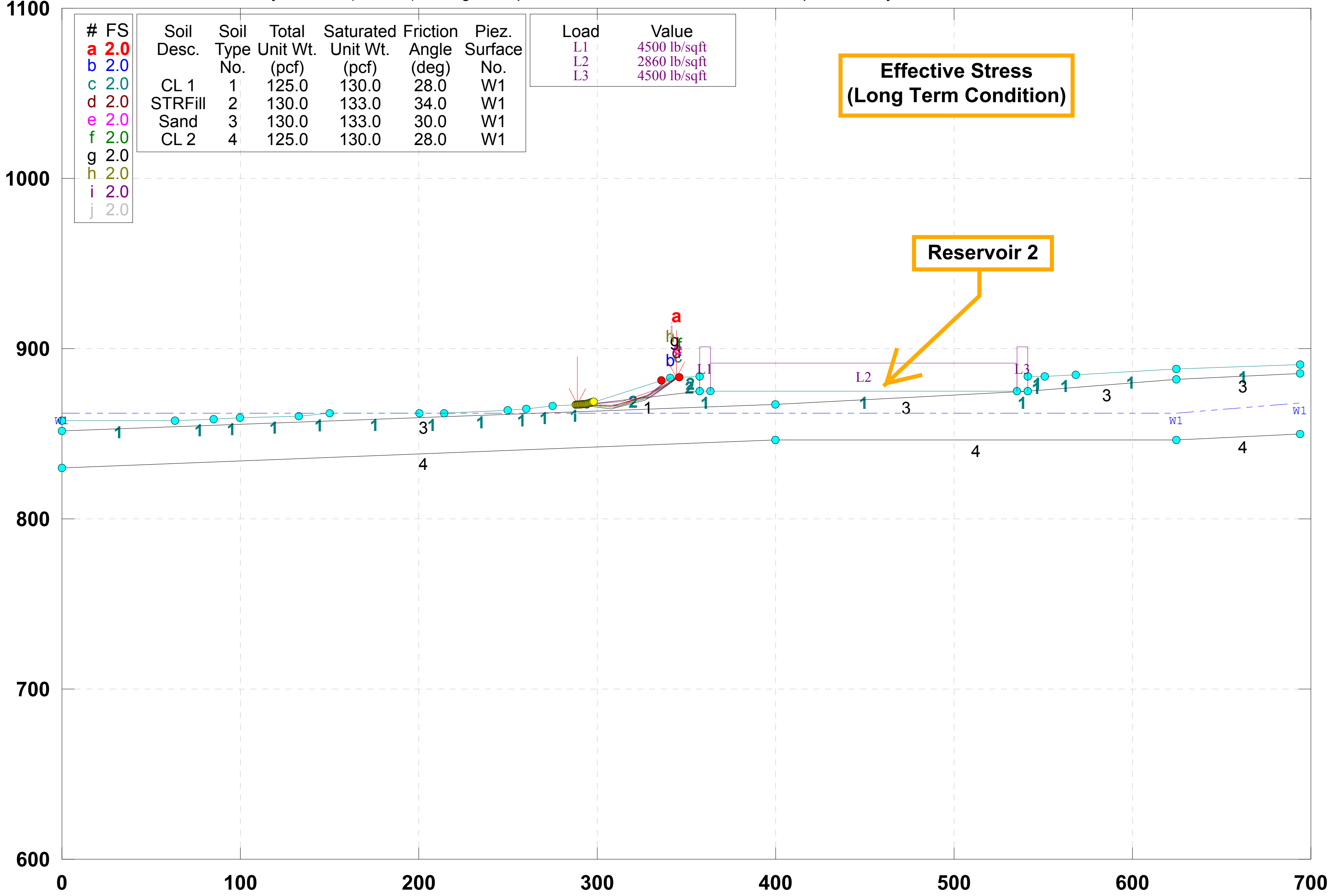
Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Friction Angle (deg)	Piez. Surface No.
CL 1	1	125.0	130.0	28.0	W1
STRFill	2	130.0	133.0	34.0	W1
Sand	3	130.0	133.0	30.0	W1
CL 2	4	125.0	130.0	28.0	W1

Load	Value
L1	4500 lb/sqft
L2	2860 lb/sqft
L3	4500 lb/sqft

STABL6H FSmin=2.1
Safety Factors Are Calculated By The Modified Bishop Method

GWA - BPS 2 - Reservoir 2 - R1 Narrow Waukesha, WI

u:\bradley broback (800014)\stabl\gwa - bps 2 - reservoir 2\reservoir 2r1 narrow.pl2 Run By: Brad Broback 9/4/2020 09:04AM



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Friction Angle (deg)	Piez. Surface No.
CL 1	1	125.0	130.0	28.0	W1
STRFill	2	130.0	133.0	34.0	W1
Sand	3	130.0	133.0	30.0	W1
CL 2	4	125.0	130.0	28.0	W1

Load	Value
L1	4500 lb/sqft
L2	2860 lb/sqft
L3	4500 lb/sqft

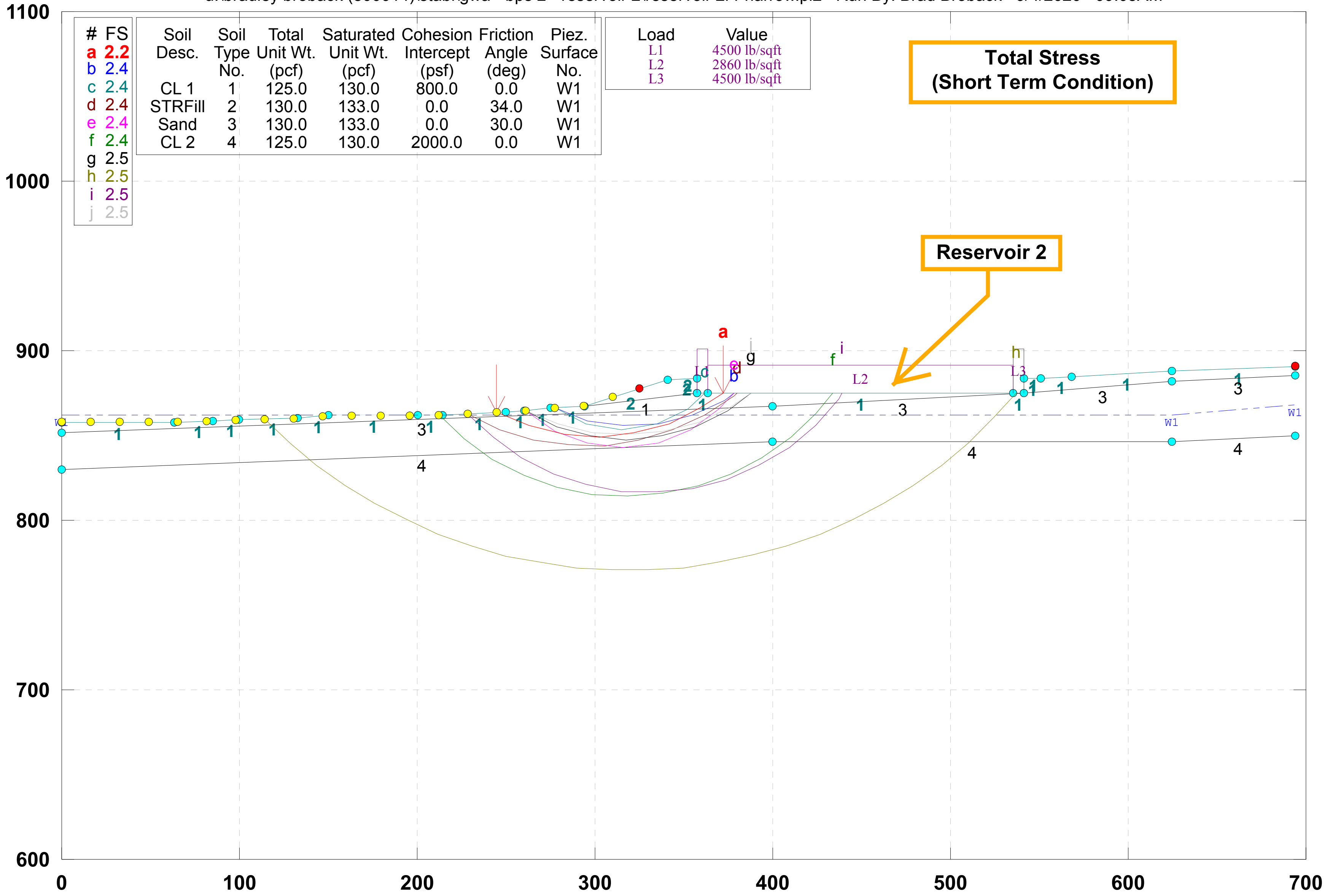
STABL6H FSmin=2.0

Safety Factors Are Calculated By The Modified Bishop Method

intertek psi

GWA - BPS 2 - Reservoir 2 - R1 Narrow Waukesha, WI

u:\bradley broback (800014)\stabl\gwa - bps 2 - reservoir 2\reservoir 2r1 narrow.pl2   Run By: Brad Broback   9/4/2020   09:05AM



#	FS
a	2.2
b	2.4
c	2.4
d	2.4
e	2.4
f	2.4
g	2.5
h	2.5
i	2.5
j	2.5

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CL 1	1	125.0	130.0	800.0	0.0	W1
STRFill	2	130.0	133.0	0.0	34.0	W1
Sand	3	130.0	133.0	0.0	30.0	W1
CL 2	4	125.0	130.0	2000.0	0.0	W1

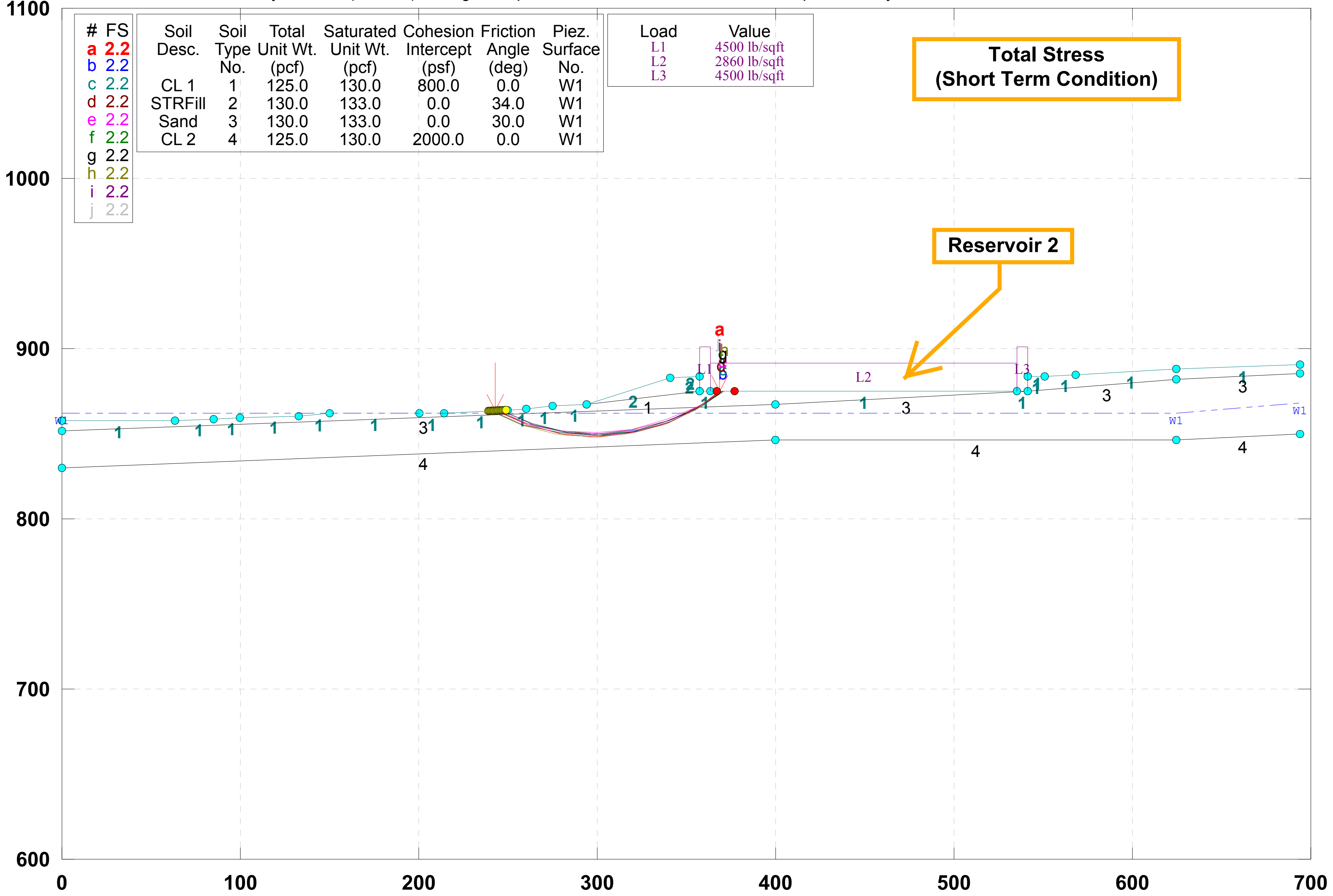
Load	Value
L1	4500 lb/sqft
L2	2860 lb/sqft
L3	4500 lb/sqft

STABL6H FSmin=2.2

Safety Factors Are Calculated By The Modified Bishop Method

GWA - BPS 2 - Reservoir 2 - R1 Narrow Waukesha, WI

u:\bradley broback (800014)\stabl\gwa - bps 2 - reservoir 2\reservoir 2r1 narrow.pl2 Run By: Brad Broback 9/4/2020 09:07AM



#	FS
a	2.2
b	2.2
c	2.2
d	2.2
e	2.2
f	2.2
g	2.2
h	2.2
i	2.2
j	2.2

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
CL 1	1	125.0	130.0	800.0	0.0	W1
STRFill	2	130.0	133.0	0.0	34.0	W1
Sand	3	130.0	133.0	0.0	30.0	W1
CL 2	4	125.0	130.0	2000.0	0.0	W1

Load	Value
L1	4500 lb/sqft
L2	2860 lb/sqft
L3	4500 lb/sqft

Total Stress (Short Term Condition)

Reservoir 2

STABL6H FSmin=2.2

Safety Factors Are Calculated By The Modified Bishop Method

intertek psi

GREELEY AND HANSEN

741 N. Grand Ave., Suite 308
Waukesha, WI 53186