GEOTECHNICAL ENGINEERING REPORT

for Phase II of the proposed

WASILLA AREA SENIOR, INC. WILLOW HOUSE DEVELOPMENT
WASILLA, ALASKA

Prepared for:

Spark Design, LLC
5401 Cordova Street, Suite 301
Anchorage, Alaska 99518

Prepared by:

Northern Geotechnical Engineering, Inc. *d.b.a.* Terra Firma Testing

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NOVEMBER 2022

November 7, 2022 NGE-TFT Project #6520-22

Spark Design, LLC
6401 Cordova Street, Suite 301
Anchorage, Alaska 99518

Attn: Deanna Wlad, AIA

RE: GEOTECHNICAL ENGINEERING ASSESSMENT OF THE PROPOSED IMPROVEMENTS FOR PHASE II OF THE WASILLA AREA SENIORS, INC. WILLOW HOUSE DEVELOPMENT – WASILLA, ALASKA

Deanna,

We (Northern Geotechnical Engineering, Inc. *d.b.a.* Terra Firma Testing) have completed a geotechnical engineering assessment for the aforementioned project. Our assessment suggests that the subgrade soils at the project site are generally suitable to support the proposed improvements, provided that proper engineering controls are incorporated into the design and construction of the proposed site improvements.

We detail the findings from our exploration efforts and laboratory testing efforts in the following report. Additionally we provided our conclusions and recommendations for earthworks, foundations, and pavement sections.

Subsurface conditions can vary across a project site. As such, we recommend that The Observational Method (described in more detail in Appendix B of this report) be followed.

We greatly appreciate the opportunity to provide you with our professional service. Please contact us directly with any questions or comments you may have regarding the information that we present in this report, or if you have any other questions, comments, and/or requests.

Sincerely,
Northern Geotechnical Engineering, Inc. *d.b.a.* Terra Firma Testing

Josselynn P. Schneider-Curry, EIT
Project Engineer

STATE OF ALASKA
49TH
7 Nov 2022
Keith F. Mobley
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REGISTERED PROFESSIONAL ENGINEER

Keith F. Mobley, P.E.
President

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Table of Contents

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List of Figures

List of Tables

List of Appendices

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1.0 INTRODUCTION

Project Site: Tract 2 of the Willow House 1 Subdivision

Client: Spark Design, LLC

Service Fee Proposal: 20-124.R1

Authorization: Signature of Service Fee Proposal on September 27, 2022

Scope:

- Provide foundation design values
- Provide pavement design recommendations
- Provide general foundation and earthworks engineering and construction recommendations

2.0 PROJECT OVERVIEW

Project Site Location: 1661 Frank Smith Way (Figure 1)

Legal Description of Project Site: Tract 2 of the Willow House 1 Subdivision

Project Name: Wasilla Area Senior, Inc. (WASI) Willow House Senior Housing Development

Current Site Conditions:

- Project site is relatively flat and clear, with some vegetation along S. Knik-Goose Bay Road
- Developed with a three-story, 40-unit senior housing structure that was built during Phase I (PH I) of the project

Proposed Improvements to Site: Figure 2

- Construction of Phase II (PH II) of the project which consists of:
    - One three-story, 40-unit senior housing structure to the west of the existing structure
    - Associated paved access road, driveways, and vehicle parking lots
    - Associated underground utilities

3.0 PREVIOUS WORK

We conducted a geotechnical engineering assessment for PH I and detailed our findings in the report titled "Geotechnical Engineering Report for Phase I of the proposed Wasilla Area Seniors, Inc. Housing Development, Wasilla, Alaska" (NGE-TFT Project #5659-20), dated March 25, 2020.

For the PH I assessment we advanced eight soil borings at the project site referred to as Borings 1 through 8 (B1 through B8). Graphical exploration logs for these borings can be found in the 2020 report.

4.0 SITE CHARACTERIZATION ACTIVITIES

Subsurface Exploration Contractor: Discovery Drilling, Inc. (DDI)

Number and Type of Soil Explorations: Six hollow-stem auger soil borings (B9 through B14)

Exploration Locations: Figure 2 of this report

Depths: Approximately 21.5 to 31.5 feet below the ground surface (bgs)

Sampling Method: Modified Penetration Test (MPT)

Drop-Hammer Correction Factor: 1.1

Field Blow Count Correction: Figure 3 of this report

Graphical Borehole Logs: Appendix A of this report

Groundwater Readings: Appendix A of this report

For more details regarding field activities refer to Appendix B (Section 1.0) of this report.

5.0 LABORATORY TESTING

We tested select soil samples in general accordance with the respective ASTM standard test methods including:

- moisture content analysis (ASTM D-2216);
- determination of fines content (a.k.a. P200 – ASTM D-1140); and
- grain size sieve and hydrometer analysis (ASTM D-6913 & D-7928) *(See Appendix B (Section 2.0) for an important note about these test methods*).

Laboratory Test Results: Appendices A (graphical exploration logs) and C (laboratory data sheets)

6.0 DESCRIPTION OF SUBSURFACE CONDITIONS

We compiled our field observations with the results from our laboratory analyses to produce graphical logs of each subsurface exploration (Appendix A). The graphical exploration logs depict the subsurface conditions that we identified at each exploration location and help us to interpret/extrapolate the subsurface conditions for areas adjacent to, and immediately surrounding, each exploration location across the project site.

6.1 General Subsurface Profile

The project site is relatively clear of organics; however, we did encounter some thin (less than 0.5 feet) surface organics at some borehole locations. The subgrade at the project site primarily consists of gravel and sand layers with relatively low (less than 9 percent by weight) silt content. The sand and gravel layers are relatively dense. Cobbles were encountered in most boreholes at varying depths and as shallow as less than 3 feet below the ground surface.

We encountered layers of silt around 20 to 25 feet bgs in three of six boreholes.

6.2 Groundwater

Indications of groundwater were observed at approximately 10 to 15 feet bgs during our subsurface exploration program. Groundwater was measured at 9 to 11 feet bgs during our subsequent groundwater monitoring efforts.

6.3 Frozen Soils

We did not observe any indications of frozen soils during our subsurface exploration program. We do not expect permafrost to occur across the project site.

7.0 ENGINEERING CONCLUSIONS

Based on the findings of our field, laboratory testing, and engineering analysis efforts, it is our conclusion that:

General:

1. The dense sand/gravel soils are generally suitable to support the proposed improvements provided that our concerns and recommendations are addressed by the design and construction processes.

Earthworks:

2. Any organic rich material should be excavated out to its horizontal and vertical extent within the footprint of the proposed improvements.
3. Coarse-grained material may be re-used on-site as structural fill assuming that the material is free of any organic material (or other deleterious debris) and that the material is
4. Excavations below the groundwater table will necessitate dewatering efforts for structural fill placement.

Foundations:

5. A conventional shallow foundation is suitable for the project site.
6. There is a low potential for soil liquefaction and earthquake-induced lateral spreading and pressure ridges are unlikely.
    a. Low liquefaction potential can be maintained by properly placing structural fill as discussed in Section 8.1 and 9.1 of this report.

Underground Utilities:

7. Underground utilities can be founded directly onto the existing subgrade soils.
8. Bedding may be required per manufacturer's recommendations.

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Pavement:

9. The pavement section design needs to consider the possible to somewhat frost susceptible (PFS to S1) U.S. Army Corps of Engineers (ESACOE) frost classification of the near surface subgrade soils.

Settlements:

10. Total settlement for shallow concrete foundations placed on recommended bearing materials (defined in Section 8.1) is anticipated to be less than three-quarters (3/4) of an inch, with differential settlements comprising about one-half (1/2) of the total anticipated settlement.
    a. Settlement amounts could increase substantially if the structural fill material used to bring any foundation pads to grade is not properly compacted.
    b. Most of the settlements should occur as the building loads are applied, such that additional long-term settlements should be relatively small and within tolerable limits.
11. Settlements under driveways and parking areas are expected to vary more than under any buildings, especially where utility trenches are located.
    a. The settlement potential can be reduced by performing all utility excavation and backfill efforts as early in the construction schedule as possible and placing any pavement as last in the construction schedule as possible.

8.0 DESIGN RECOMMENDATIONS

We have presented our design recommendations in the general order that the project site will most likely be developed. Our design recommendations can be used in parts (as needed) for the final design configuration.

8.1 Earthworks

Our general recommendations for earthworks are:

- Foundations should be placed on recommended bearing materials.
    - Recommended bearing materials: undisturbed sand/gravel deposits or properly compacted structural fill above undisturbed sand/gravel deposits
- Structural fill materials should be compacted to a minimum of 95 percent of the modified Proctor density.
- Excavated coarse-grained material must have less than approximately 15 percent passing the #200 sieve and not contain any organic/deleterious material to be used as structural fill.

Slopes at the project site should:

- not exceed a 2:1 slope (if constructed);
- have properly keyed in fill; and

- have erosion control.

We recommend the following quality control inspections:

- bottom-of-hole inspections;
- fill gradation classification; and
- in-situ compaction testing.

A bottom-of-hole inspection should be conducted (by a qualified geotechnical engineer, geologist, or special inspector) before any foundation construction begins.

8.2 Seismic Design Parameters

The International Building Code (IBC) 2018 is slowly being adopted by various state and local governmental regulatory agencies throughout Alaska. However, the on-line seismic site design query tool that we use to estimate seismic site design parameters has not been updated from IBC 2015 to IBC 2018. Additionally, IBC 2018 does not explicitly state that any changes have been made to the 2015 IBC seismic design code for locations with site specific geotechnical information. As such, we feel comfortable using the seismic site design parameters using IBC 2015.

Assumptions: IBC 2018 and Seismic Risk Category II

Seismic Site Classification: D

SEAOC Design Map Report: Appendix D

8.3 Shallow Foundations

For the purposes of this report, we consider a shallow foundation to be any foundation which is shallower than ten (10) feet bgs. We have separated our recommendations for warm (i.e., heated) and cold (i.e., unheated) shallow foundations into Sections 8.3.1 and 8.3.2 of this report.

8.3.1 Warm Shallow Foundations

For the purposes of this report, we consider a warm shallow foundation to be any shallow foundation located within an enclosed, climate-controlled space that maintains an internal ambient air temperature above 40°F.

8.3.1.1 Soil Bearing Capacity

Concrete foundations placed on recommended bearing materials (defined in Section 8.1) and at the burial depths of a perimeter footing as described in Section 8.3.1.3 may be designed with a:

- 5,000 pounds per square foot (psf) soil bearing capacity; and
- one-third (1/3) increase to accommodate short-term wind and/or seismic loads.

8.3.1.2 Continuous Strip Footings and Spread Footings

The minimum horizontal dimensions for continuous strip footings and/or spread footings founded directly onto recommended bearing materials (defined in Section 8.1) are:

- 16 inches for continuous strip footings
- 24 inches for individual spread footings

8.3.1.3 Footing Burial Depths

For the project site, the minimum burial depth for any uninsulated shallow foundation footings should be as follows (measured from the bottom of the foundation footing):

1. 12 inches (D_1 in Figure 4) for interior footings located entirely within an enclosed, continuously heated space* (measured from the bottom of the footing to the surface of the interior finished grade or bottom of the floor slab) and
2. 42 inches (D_2 in Figure 4) for foundation footings located along the perimeter of an enclosed, continuously heated space* (measured from the bottom of the footing to the exterior finished grade).

**The temperature of an enclosed, continuously heated space must be maintained above 40 ℉ and allow for adequate heat transfer to foundation soils in order for our recommendations to apply.*

We have provided our recommended insulation configurations Figure 5 of this report. We should be consulted if alternative foundation insulation configurations are to be utilized for this project so that we can evaluate their suitability as it pertains to the existing site conditions and proposed foundation design.

If foundation burial depths are reduced through the use of insulation, then the allowable bearing capacity of the foundation may also be reduced. As such, we should be consulted to re-evaluate our minimum allowable bearing capacities if foundation depths are to be shallower than those which we recommend above.

We provide more details about frost development and protection in Appendix B (Section 3.1) of this report.

8.3.1.4 Thickened Edge Slab Foundations and Floor Slabs

Thickened slab edges (i.e., perimeter slab footings) should extend a minimum of 16 inches below the finished exterior grade to achieve the recommended allowable soil bearing capacity and help resist any lateral forces. Warm thickened edge slab foundations and/or floor slabs can be founded directly onto the recommended bearing materials (defined in Section 8.1) with a pad that consists of:

- relatively free draining sands and gravels with less than about 15% of the fill material passing through a #200 sieve for the upper structural fill material (at or above the footing grade); and
- free draining material with less than 3% passing the #200 sieve for the top four to six inches beneath the slabs.

Concrete slabs constructed directly on the recommended bearing materials (defined in Section 8.1, may be designed using a modulus of subgrade reaction of k_1=280 pci (k_1 is the value for a 1-ft × 1-ft rigid plate) and the equations presented in Appendix B (Section 3.2) for modulus of subgrade reaction for load footprints.

8.3.2 Cold Shallow Foundations

For the purposes of this report, we consider a cold shallow foundation to be any shallow foundation whose subgrade is subjected to freezing temperatures for any amount of time. We do not recommend the construction of a cold shallow foundations. However, in the event that cold shallow foundations cannot be avoided, we provide cold shallow foundations recommendations in the following Subsections of this report.

Deep foundation can serve as an alternative means of cold foundation support. Cost and constructability will typically be the driving forces behind which type of cold foundation system is ultimately selected for a given project.

We provide more details about frost development and protection as well as deep foundations system alternatives in Appendix B (Section 3.1) of this report.

8.3.2.1 Soil Bearing Capacity

The bearing capacity of cold shallow foundations will be a function of both the configuration (i.e., dimensions) and burial depth of the foundation. The warm shallow foundation bearing capacity may be used for a cold shallow foundation.

8.3.2.2 Footing Burial Depths

For the project site, the minimum burial depth (measured from the bottom of the footing to the lowest elevation of either the interior or exterior finished grade – including any floor slabs) for any uninsulated cold shallow foundation footings should be 96 inches (D3 in Figure 4).

The minimum footing burial depth for any cold shallow foundation may be reduced, if the foundation is placed onto a granular structural pad constructed of NFS fill material where:

- the NFS material has less than 3% of the material finer than 0.02 mm in diameter;
- the NFS fill subgrade extends a minimum of 96 inches below the planned finished grade (interior or exterior - whichever is lower); and

- the minimum foundation burial for a cold shallow foundation bearing onto a structural NFS fill pad should is the same as our minimum recommended burial depth for a warm shallow foundation (D2 in Figure 4).

Artificial insulation may be used in lieu of some of the NFS backfill where:

- a minimum of 18 inches of NFS fill is present between the bottom of any shallow foundation footing and the top of any insulation; and
- one inch of rigid foam board insulation is considered equivalent to one foot of NFS fill (in terms of insulating properties).

We detail our recommended insulation configurations for cold shallow foundations in Figure 5 of this report. We should be consulted if alternative shallow foundation insulation configurations are to be utilized for this project so that we can evaluate their suitability.

We provide more details about frost development and protection in Appendix B (Section 3.1) of this report.

8.3.2.3 Grade-level Design Elements

Any cold shallow foundation design elements which are to exist at (or very close to) grade level (e.g., grade beams, connecting structural members, exterior siding, etc.) should be designed to accommodate a minimum of six inches of vertical ground movement

We can evaluate the frost heaving pressures that may develop (for use in the structural design) if the design cannot accommodate our recommended air gap. If planned grade-level design elements cannot withstand any vertical movements, then they should not be used with a cold shallow foundation system.

8.3.3 Shallow Foundation Uplift Resistance

The uplift capacity of a foundation is a function of its weight, configuration, and depth and can be determined using:

- 80 percent of the weight of the foundation plus 80 percent of the weight of the effective soil mass (Figure 6) located above the footing;
- an effective unit weight of 130 pcf for granular structural backfill material; and
- no increase in uplift capacity for short-term loading, as the ultimate uplift load includes any short-term load factors.

Shallow foundation footings should extend laterally a minimum of one-eighth (1/8) of the footing width beyond any foundation walls to help resist any anticipated uplift/overturning forces (Figure 6).

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We can calculate the uplift capacity for other foundation configurations upon request and once we have been provided with a general foundation design.

8.3.4 Lateral Loads for Foundation and Retaining Walls

Retaining walls (such as perimeter foundation stem walls for buildings with basements or crawl spaces) must be designed to resist lateral earth pressures. The magnitude of the pressure exerted on a retaining wall is dependent upon several factors, including:

1) whether the top of the wall is allowed to deflect after placement of backfill;
2) the type of backfill used;
3) compaction effort; and
4) wall drainage provisions.

Any foundation stem walls that are not designed to carry lateral loads should be backfilled on both sides simultaneously to prevent differential lateral loading of the foundation stem wall.

The lateral soil pressures can be represented by equivalent fluid pressures. The pressure distribution is a function of wall restraint, seismic loading, and drainage conditions. In Table 1 of this report, we provide the unit weights to be used with the pressure distribution diagrams for various loading conditions provided in Figure 7 of this report. We assumed that structural fill (containing less than ten percent fines) is used as backfill, and that the fill is compacted to at least 90 percent of the modified Proctor density.

Table 1: Equivalent Fluid Specific Weight for Lateral Loading Design

LOADING CONDITION	DRAINED EQUIVALENT FLUID SPECIFIC WEIGHT		UN-DRAINED EQUIVALENT FLUID SPECIFIC WEIGHT	
	SPECIFIC WEIGHT (pcf)	**SYMBOL**	**SPECIFIC WEIGHT (pcf)**	**SYMBOL**
ACTIVE	40	t_1	23	t_2
AT-REST	62	t_3	37	t_4
PASSIVE	495	t_5	295	t_6
SEISMIC	30 **(UNRESTRAINED)**	t_7	18 **(RESTRAINED)***	t_8

* For wall heights less than 8 ft

Lateral forces may also be resisted by friction between the concrete foundations and the underlying soil. The frictional resistance may be calculated using a coefficient of friction of 0.4 between the concrete and soil.

We provide more details about lateral earth pressure in Appendix B (Section 3.3) of this report.

8.4 Insulation

Any subgrade insulation used should:

- consist of extruded polystyrene such as DOW Styrofoam™ Highload or UC Industries Foamular;
- not absorb more than 2% water per ASTM Test Method C-272;
- not have a thermal conductivity (k) that exceeds 0.25 BTU-in/hr-ft2-°F when tested at 75°F;
- be installed with proper bedding material that provides a flat, smooth surface; and
- be closed cell, board stock with a minimum compressive strength of:
    - 60 psi (at 5% deflection) for use under structural slabs.
    - 25 psi (at 5% deflection) for use around the exterior of any foundations.

8.5 Underground Utilities

In general, the soils in which deep utility trenches (6-10 feet bgs) are to be constructed are composed of relatively dense sand/gravel deposits. Any gravity-fed utility trenches extending into the relatively dense sand/gravel should be a minimum of three feet wide at the bottom with the utility piping located in the center of the trenches. Structural fill should be used to bring the gravity-fed utilities to the proper installation grade. Utilities that are not sensitive to settlement may be placed in the existing sand/gravel deposits.

Underground utilities which are susceptible to damage from freezing:

- Need to be frost-protected by sufficient amounts of backfill, insulation, and/or active freeze protection systems (e.g., heat tape, thaw wire, etc.); or some combination of the above.
- Need to contain some level of additional frost-protection (e.g., insulation, active freeze protection systems, or a combination of both) if they are planned to be constructed less than eight feet below the planned finished grade.
- Should not be constructed within four feet of the planned finished grade (regardless of insulation measures or active freeze-protection systems).

Any insulation used should:

- conform to the specifications detailed in Section 8.4 of this report; and
- extend a minimum of two feet (and a maximum of four feet) perpendicular to either side of the proposed utility alignment.

The thickness of the insulation used will be a function of the burial depth. In general, one inch of insulation is equal to approximately 12 inches of compacted NFS backfill.

8.6 Pavement Sections

<u>Design Considerations:</u>

- The near surface subgrade soils classify as PFS to S1 on the USACOE frost classification scale.
- The lack of relatively available water to contribute to frost development

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We provide more details about frost development in pavement sections in Appendix B (Section 3.4) of this report.

S1 subgrades (or better) will only require a bases course (a.k.a. leveling course) layer, as there is little to no potential for ice lens development in the subgrade soils at the project site. Any structural fill used to bring the pavement section to grade should be S1 (or better) with a maximum particle size of three inches (within the first 14 inches below pavement grade).

8.6.1 Confirmation Testing

Confirmation frost classification testing of the subgrade soils located along the proposed pavement areas should be conducted after the completion of all overburden removal and any utility installation activities.

The results of the confirmation frost classification testing can be used to ensure that the proper pavement section is used for the soil conditions exposed. If the conformation testing indicates that the frost classification of the subgrade soils is higher than USACOE S1, then alternative pavement section designs, including thicker structural sections and/or the use of artificial insulation may be required.

8.6.1 Material Specifications

A permeable geotextile fabric is optional, but not required for this project. For the project site, we recommend a separation geotextile fabric. The geotextile fabric may be either: 1) woven, or 2) non-woven with perforations. We have provided the various strengths for both a woven and non-woven geotextile fabric in Table 2 of this report.

Table 2: Geotextile Fabric Strengths

FABRIC PROPERTY	ASTM STANDARD USED TO DETERMINE STRENGTH	WOVEN FABRIC STRENGTH	NON-WOVEN FABRIC STRENGTH
GRAB STRENGTH	D4632	250	160
SEWN SEAM STRENGTH	D4632	225	140
TEAR STRENGTH	D4533	90	56
PUNCTURE STRENGTH	D6241	495	310

Note: Units in lbs per foot.

The leveling course materials used should conform to the specifications we provide in Figure 8 of this report and be placed in thin lifts compacted to a minimum of 95 % of the modified Proctor density.

Any leveling course used should be NFS; however, it is our experience that the "D-1" leveling course material currently available in Matanuska-Susitna Borough may not be NFS following compaction, and as such we recommend:

- using two inches of recycled asphalt pavement (RAP) for the leveling course; or
- keeping the leveling course thickness to two inches or less.

We provide more details about pavement material specifications in Appendix B (Section 3.4) of this report.

8.7 Surface Drainage

After the property is brought to grade it should be relatively flat, such that storm water will tend to accumulate and flow off the site slowly.

Water accumulation will have a detrimental effect on foundations, retaining structures, and pavement sections and as such we recommend:

1) grading the ground surface around the proposed developments such that surface runoff is channel away from foundations/retaining structures/pavement sections;
2) tightly compacting the surface soils;
3) diverting roof, parking lot and driveway drainage away from foundation; and
4) making tight-line connections from roof drain collectors to storm sewer (if available).

9.0 CONSTRUCTION RECOMMENDATIONS

We have presented our construction recommendations in the general order that the project site will most likely be developed. Our construction recommendations are intended to aid the construction contractor(s) during the construction process.

9.1 Earthwork

Structural fill should be:

- compacted to a minimum of 95 percent of the modified Proctor density as determined by ASTM D-1557 (unless specifically stated otherwise in other sections of this report); and
- placed in individual lifts of less than one-foot in thickness (typical);
    - thickness will be determined based on the equipment used, the soil type, and existing soil moisture content.

All earthworks should be completed with quality control inspection.

Excavated coarse-grained material should:

- have less than approximately 10 to 15 percent passing the #200 sieve and not contain any organic/deleterious material to be used as structural fill; and
- be protected from additional moisture inputs (precipitation, etc.) through the use of plastic tarps, etc. if stockpiled on-site.

Soils with higher silt contents can be used within the foundation footprint. However, the effort required to achieve proper compaction of silt-rich soils may be more costly than purchasing better grade materials. The time of year, existing moisture content, rainfall, air temperature, and fill temperature can all have an impact on the effort required to adequately compact silt-rich material.

9.2 Shallow Foundations

Care should be taken during foundation excavation activities to limit the disturbance of the bottom of any foundation excavations. The bottom of any foundation excavation should be moisture conditioned and proof-rolled as necessary to return the exposed soils to their original in-situ density.

In general, the soils in which the proposed foundation pads are to be constructed consist primarily of sand and gravel deposits. As such, any surface water (*e.g.*, from precipitation, snowmelt, etc.) that enters into foundation excavations will tend likely dissipate. However, excess water will have a negative impact on any backfill and compaction efforts. Therefore, if surface water does accumulate in any open foundation excavations it can be controlled by excavating a shallow drainage trench around the perimeter of the excavation. The drainage trench will collect surface water and direct it to a sump area, which should be located outside of the foundation footprint. The excess water can then be pumped from the sump area and be discharged at an appropriate location away from the excavation and any other existing foundations.

9.2.1 Warm Shallow Foundations

Warm shallow building foundation must remain thawed continuously through construction;

- if construction occurs during the winter months tenting (temporary enclosures) and heat should be applied to keep the building thawed
- consequences of freezing are described in Section 4.1 of Appendix A

9.2.2 Cold Shallow Foundations

We do not recommend the construction of any cold (unheated) shallow foundations without freeze protection, as they may experience ice lens development and/or thaw-weakening, which could result in damages to the proposed foundations. As we mention in Section 8.3.2.2 of this report, the minimum cold foundation burial depth (D_3) can be reduced, if the foundation is placed on a structural pad constructed of NFS fill. The NFS structural pad thickness may be reduced by using insulation at a rate of one inch of insulation to one foot of NFS material.

9.3 Underground Utilities

We expect that utility trench wall stability in the relatively dense sand/gravel soils to be moderate. The contractor should be responsible for trench safety and regulation compliance. If groundwater is encountered during utility trench excavation then dewatering efforts may be required to facilitate proper utility installation and trench backfill.

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All piping should be bedded per the manufacturer's recommendations, with the bedding material compacted to provide pipe support. Above the bedding materials, the backfill should be similar to, and compacted to the approximate density of, the surrounding soils.

9.4 Pavement

All of the earthwork within any areas to be paved should be completed as early in the construction schedule as possible, and the pavement placed as late in the construction schedule as possible. This will give the subgrade soils time to settle, compress, and stabilize prior to placement of the pavement. Any structural fill used should be placed in thin lifts (less than one foot in thickness) and each lift should be compacted to a minimum of 95 percent of the modified Proctor density. Prior to paving, any surface fill material should be re-leveled and re-compacted. All backfill and paving materials should be inspected and tested for material specification compliance and compaction.

Underground utility piping should be installed prior to construction of any pavement sections such that trenching is done through the subgrade soils only. This will help ensure that a uniform pavement section is maintained, which will reduce the potential for differential settlements along underground utility trench alignments.

The minimum thickness for any asphalt concrete (AC) pavement surfaces is two inches. The minimum thickness of any Portland cement concrete (PCC) pavement surfaces will be a function of the reinforcement required. All applicable ACI and IBC standards should be followed.

9.5 Insulation

The satisfactory performance of any subsurface insulation is in part controlled by the details of construction including: 1) the care taken to ensure that the board stock lies flat on a smooth, level surface; and 2) the adjoining ends of the insulation are closely butted together. Any vertical joints should be staggered where more than one layer of insulation is used.

9.6 Winter Construction

Proper placement and compaction of structural fill is not possible when fill material is frozen, and as such, frozen fill material should never be used for structural support unless it has been subsequently thawed and compacted to 95 percent of the modified Proctor density (throughout its vertical extent). Furthermore, subgrade soils (fill or native) need to be completely thawed prior to the placement and compaction of additional lifts of thawed fill material. In our professional experience, ambient soil temperatures need to be above 37 °F in order to achieve efficient compaction. It is extremely difficult to achieve compaction levels equal to 95 percent of the modified Proctor density in fill material that is between 32 °F to 37 °F.

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10.0 CLOSURE

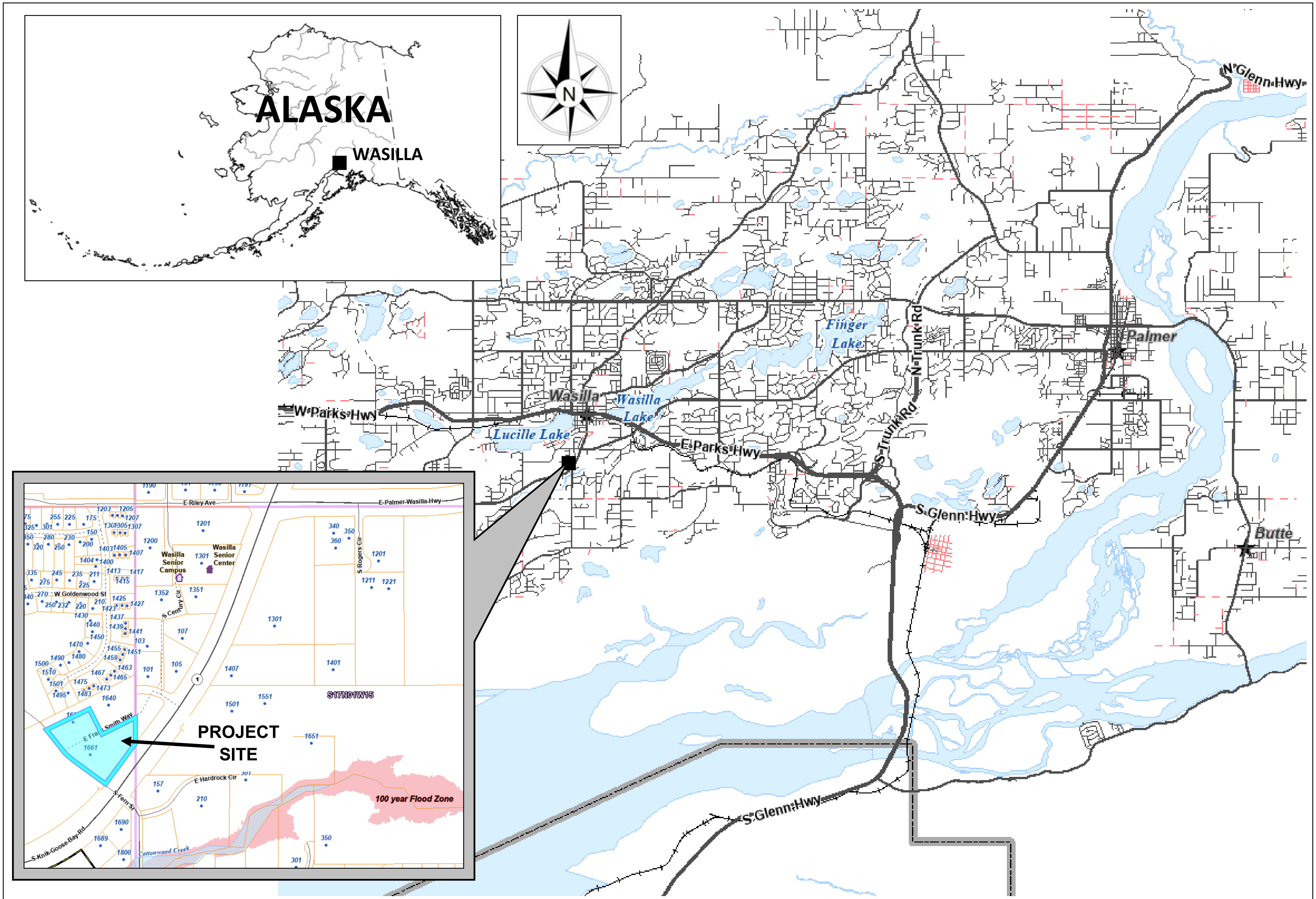
We (Northern Geotechnical Engineering, Inc. d.b.a. Terra Firma Testing) prepared this report exclusively for the use Spark Design, LLC and their consultants/contractors/etc. for use in the design and construction of the proposed improvements. We should be notified if significant changes are to occur in the nature, design, or location of the proposed improvements in order that we may review our conclusions and recommendations that we present in this report and, if necessary, modify them to satisfy the proposed changes.

This report should always be read and/or distributed in its entirety (including all figures, exploration logs, appendices, etc.) so that all of the pertinent information contained within is effectively disseminated. Otherwise, an incomplete or misinterpreted understanding of the site conditions and/or our engineering recommendations may occur. Our recommended best practice is to make this report accessible, in its entirety, to any design professional and/or contractor working on the project. Any part of this report (e.g., exploration logs, calculations, material values, etc.) which is presented in the design/construction plans and/or specifications for the project should have an adequate reference which clearly identifies where the report can be obtained for further review.

Due to the natural variability of earth materials, variations in the subsurface conditions across the project site may exist other than those we identified during the course of our geotechnical assessment. Therefore, a qualified geotechnical engineer, geologist, and/or special inspector be on-site during construction activities to provide corrective recommendations for any unexpected conditions revealed during construction (see our discussion of the Observational Method in Section 5.0 of Appendix B of this report for more detail). Furthermore, the construction budget should allow for any unanticipated conditions that may be encountered during construction activities.

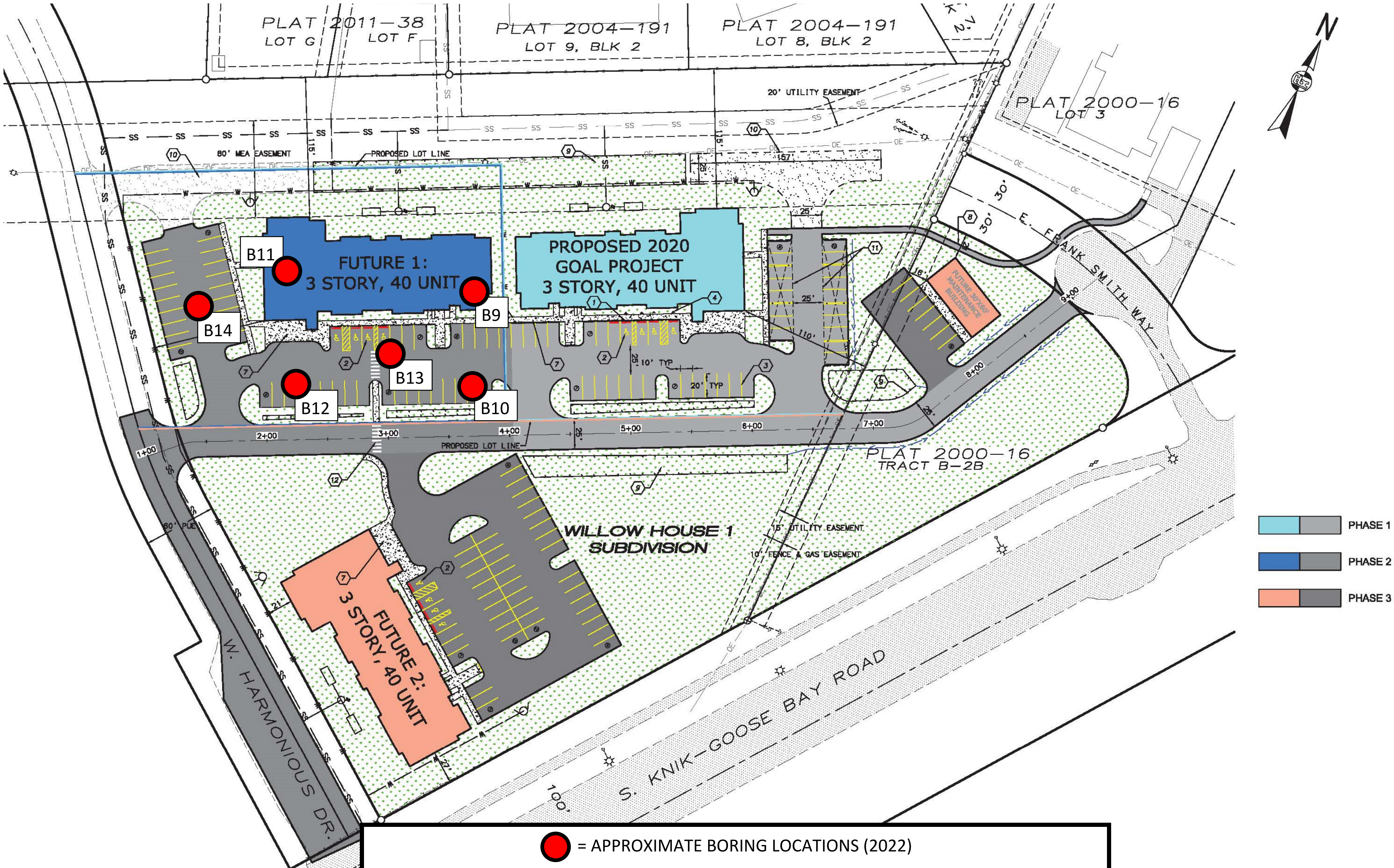
We conducted this evaluation following the standard of care expected of professionals undertaking similar work in the State of Alaska under similar conditions. No warranty, expressed or implied, is made.

REPORT FIGURES



NORTHERN GEOTECHNICAL ENGINEERING, INC.
TERRA FIRMA TESTING

FIGURE TITLE: PROJECT SITE LOCATION MAP	
PROJECT NAME: PH II WASI WILLOW HOUSE DEVELOPMENT	PROJECT ID: 6520-22
PROJECT LOCATION: WASILLA, ALASKA	FIGURE NUMBER: 1



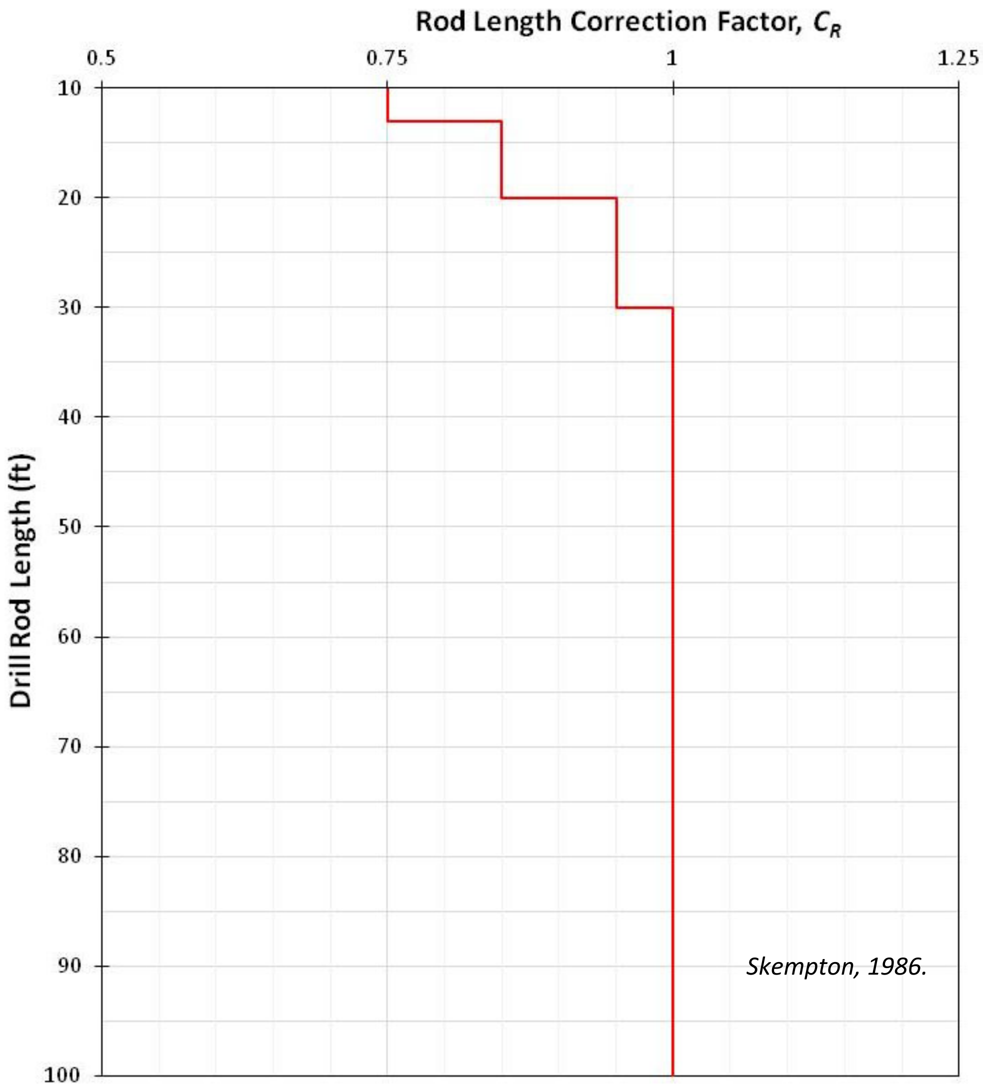
= APPROXIMATE BORING LOCATIONS (2022)

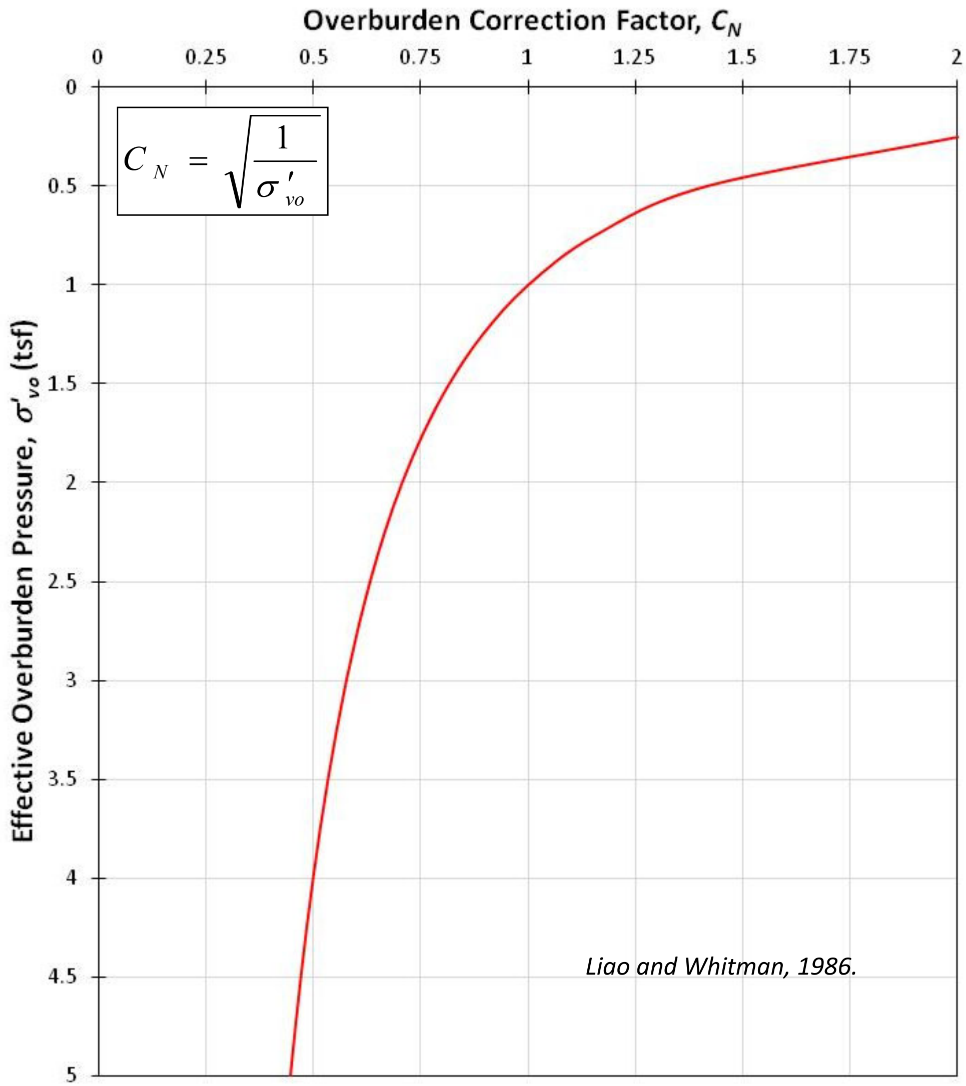
DETAILS FOR BORINGS B1 THROUGH B8 CAN BE FOUND IN THE PH I GEOTECH REPORT (2020)

BASE IMAGE OBTAINED FROM CIVIL SITE & UTILITY IMPROVEMENTS FROM THE WILLOW HOUSE 1 OVERALL SITE PLAN (MARCH 2020)

NORTHERN GEOTECHNICAL ENGINEERING, INC.
TERRA FIRMA TESTING

FIGURE TITLE: PRELIMINARY SITE PLAN AND APPROXIMATE BORING LOCATIONS	
PROJECT NAME: PH II WASI WILLOW HOUSE DEVELOPMENT	PROJECT ID: 6520-22
PROJECT LOCATION: WASILLA, ALASKA	FIGURE NUMBER: 2



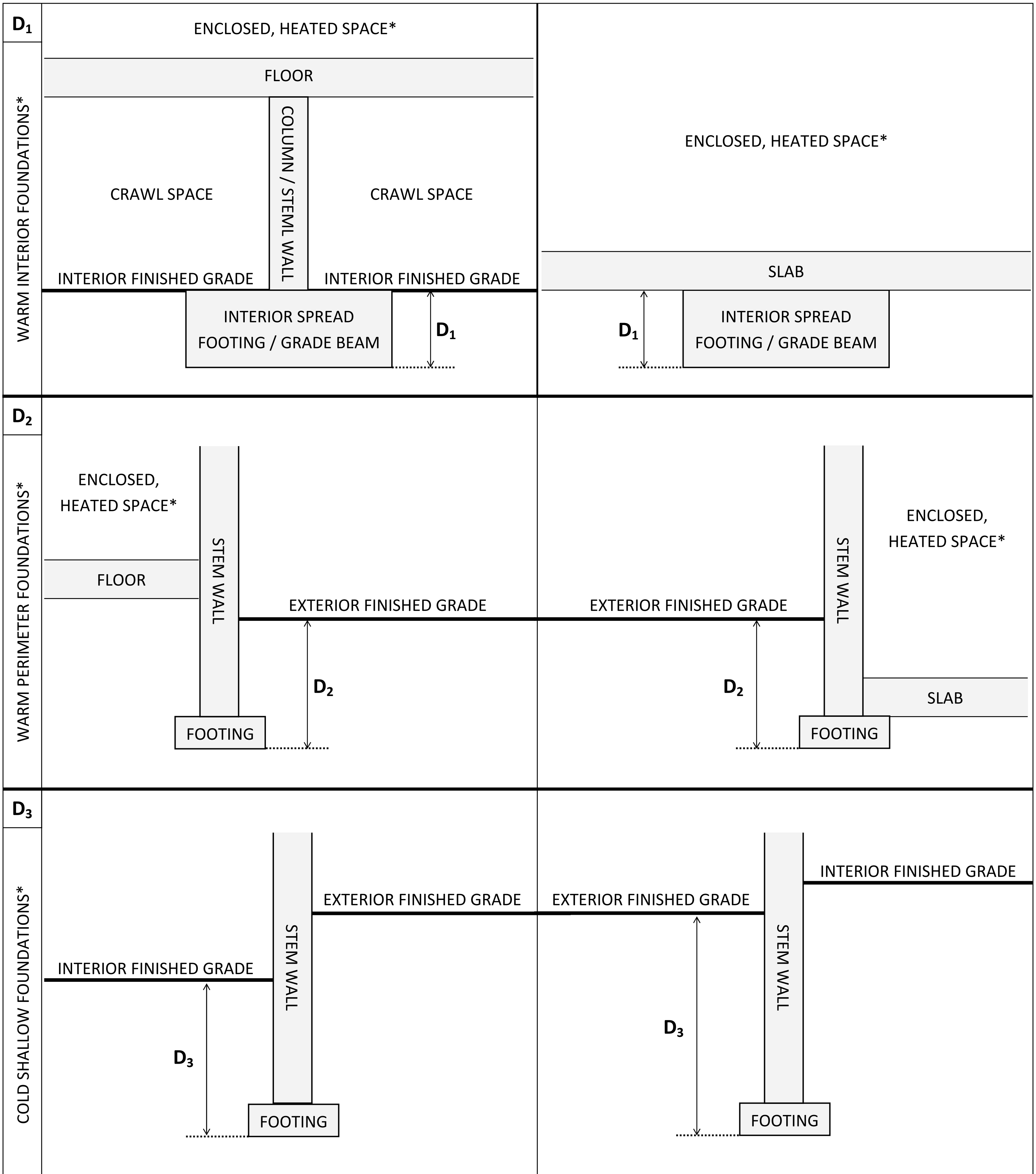


NOTES:

- OVERBURDEN CORRECTION FACTOR IS USED ONLY FOR COHESIONLESS SOILS
- C_N IS THE RATIO OF THE MEASURED BLOW COUNT TO WHAT THE BLOW COUNT WOULD BE AT AN OVERBURDEN PRESSURE OF 1 TON/FT^2
- Σ'_{VO} IS THE EFFECTIVE OVERBURDEN PRESSURE AT THE POINT OF MEASUREMENT (TON/FT^2)

NORTHERN GEOTECHNICAL ENGINEERING, INC.
TERRA FIRMA TESTING

FIGURE TITLE: BLOW COUNT CORRECTIONS	
PROJECT NAME: PH II WASI WILLOW HOUSE DEVELOPMENT	PROJECT ID: 6520-22
PROJECT LOCATION: WASILLA ALASKA	FIGURE NUMBER: 3



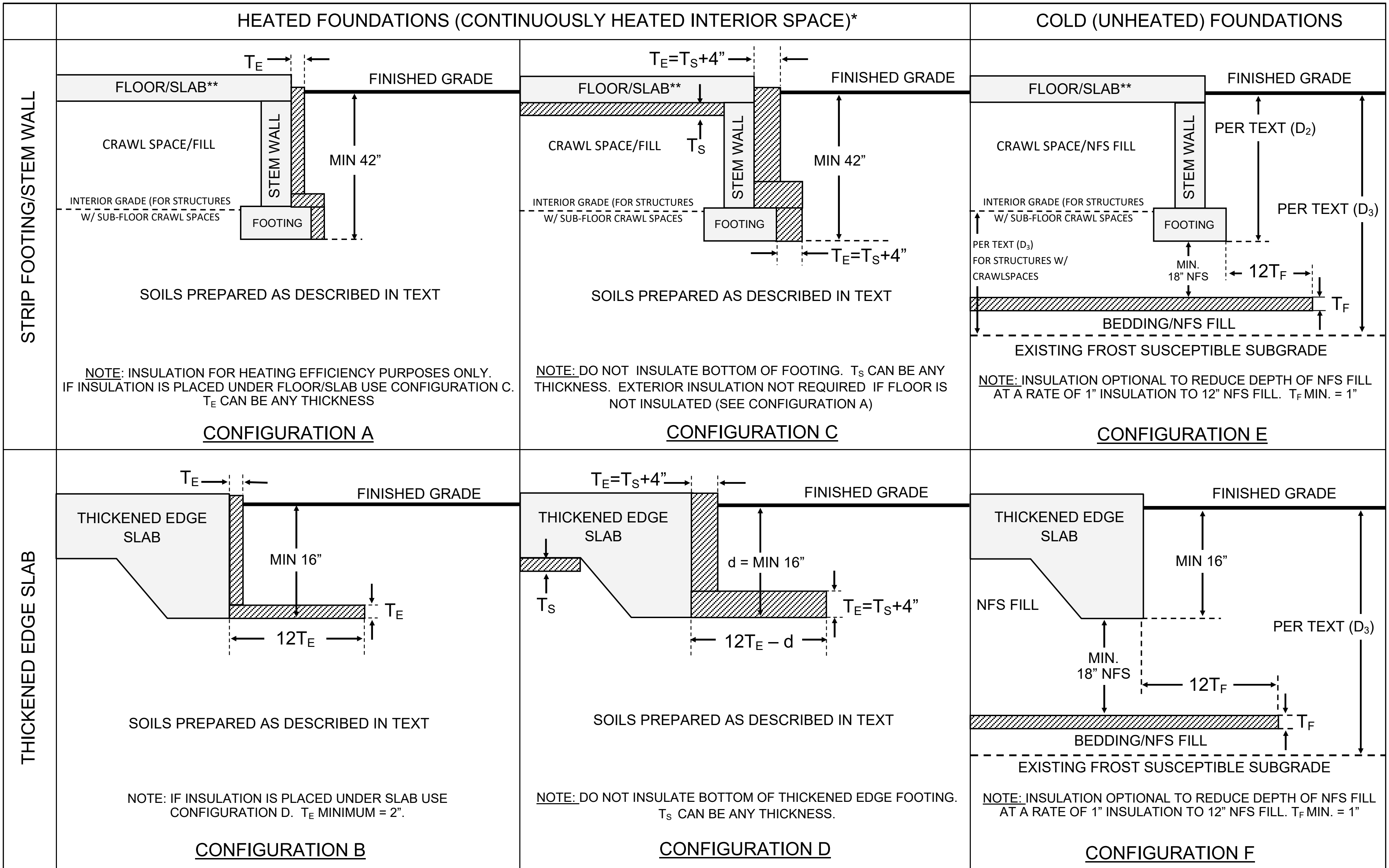
NOTES:

DRAWINGS NOT TO SCALE
MINIMUM DEPTHS PROVIDED IN REPORT

* ENCLOSED HEATED SPACES MUST BE CONTINUOUSLY MAINTAINED AT/ABOVE 40°F

NORTHERN GEOTECHNICAL ENGINEERING, INC.
TERRA FIRMA TESTING

FIGURE TITLE: UNINSULATED SHALLOW FOUNDATION CONFIGURATIONS	
PROJECT NAME: PH II WASI WILLOW HOUSE DEVELOPMENT	PROJECT ID: 6520-22
PROJECT LOCATION: WASILLA, ALASKA	FIGURE NUMBER: 4



T_F = INSULATION THICKNESS UNDER ENTIRE FOUNDATION (INCHES)
T_S= INSULATION THICKNESS UNDER FLOOR/SLAB ONLY (INCHES)
T_E = INSULATION ALONG EXTERIOR OF FOUNDATION (INCHES)

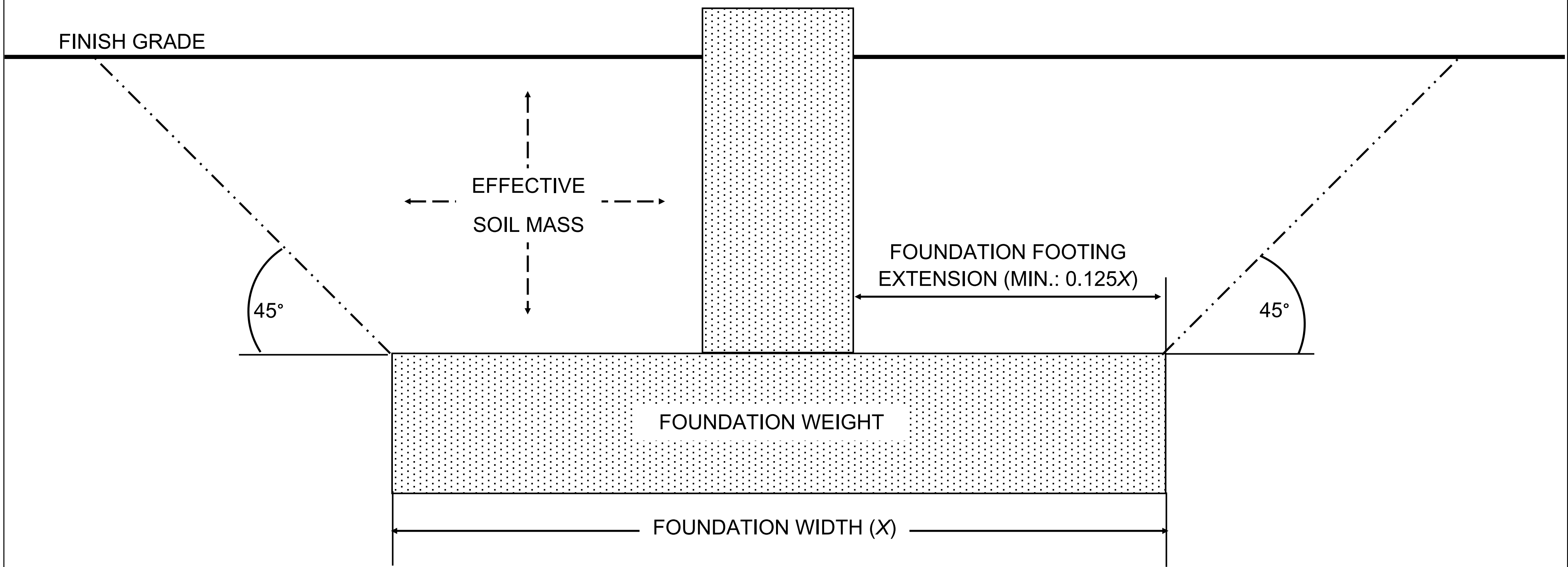
*HEATED FOUNDATION TEMPERATURE MUST BE CONTINUOUSLY MAINTAINED AT/ABOVE 40°F
**FLOOR SYSTEM CAN BE STRUCTURAL (W/ CRAWLSPACE) OR SLAB-ON-GRADE
▨ = RIGID BOARD INSULATION

DRAWING NOT TO SCALE

NORTHERN GEOTECHNICAL ENGINEERING, INC.
TERRA FIRMA TESTING

FIGURE TITLE: INSULATED SHALLOW FOUNDATION CONFIGURATIONS	
PROJECT NAME: PH II WASI WILLOW HOUSE DEVELOPMENT	PROJECT ID: 6520-22
PROJECT LOCATION: WASILLA, ALASKA	FIGURE NUMBER: 5

UPLIFT CAPACITY = 0.8 × (EFFECTIVE SOIL WEIGHT + WEIGHT OF FOUNDATION)



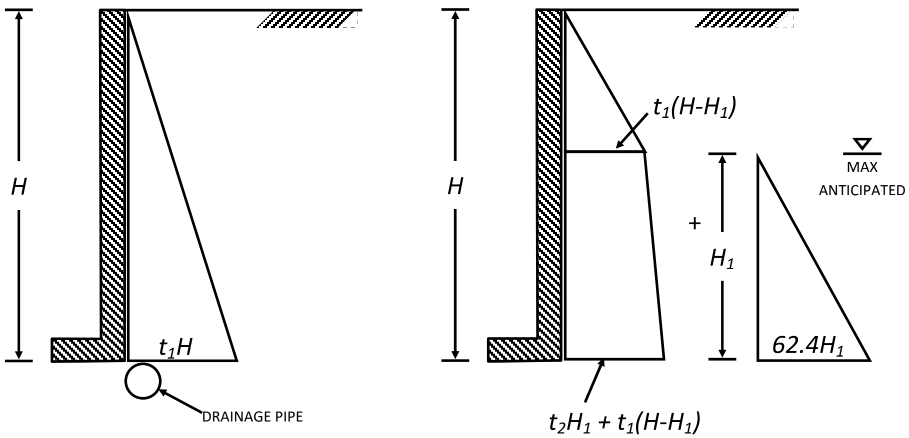
= FOOTING / STEM WALL

DRAWING NOT TO SCALE

NORTHERN GEOTECHNICAL ENGINEERING, INC.
TERRA FIRMA TESTING

FIGURE TITLE: FOOTING UPLIFT CAPACITY DIAGRAM	
PROJECT NAME: PH II WASI WILLOW HOUSE DEVELOPMENT	PROJECT ID: 6520-22
PROJECT LOCATION: WASILLA, ALASKA	FIGURE NUMBER: 6

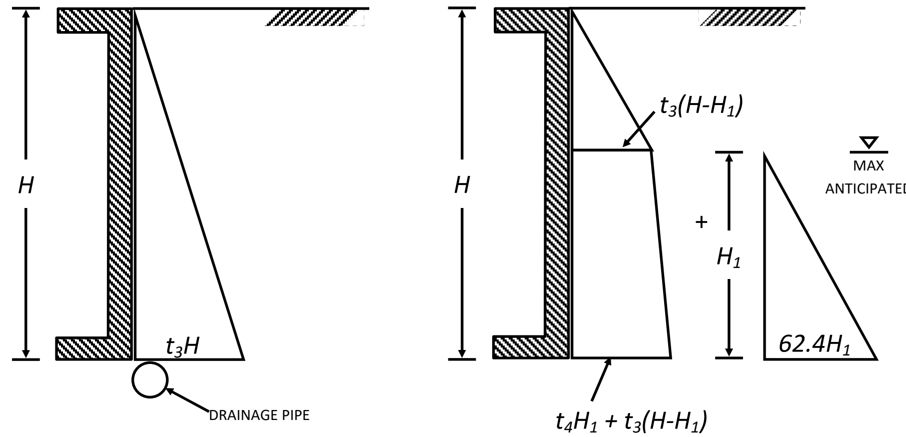
ACTIVE PRESSURE CONDITION



WITH DRAINAGE

WITHOUT DRAINAGE

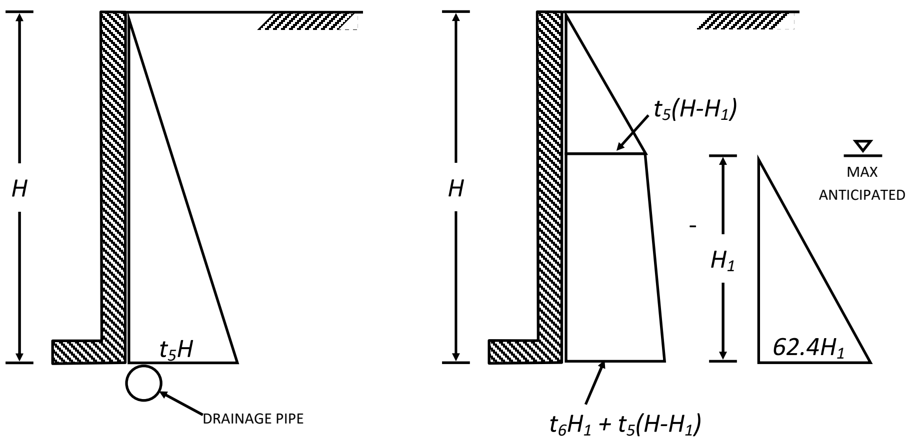
AT-REST PRESSURE CONDITION



WITH DRAINAGE

WITHOUT DRAINAGE

PASSIVE PRESSURE CONDITION

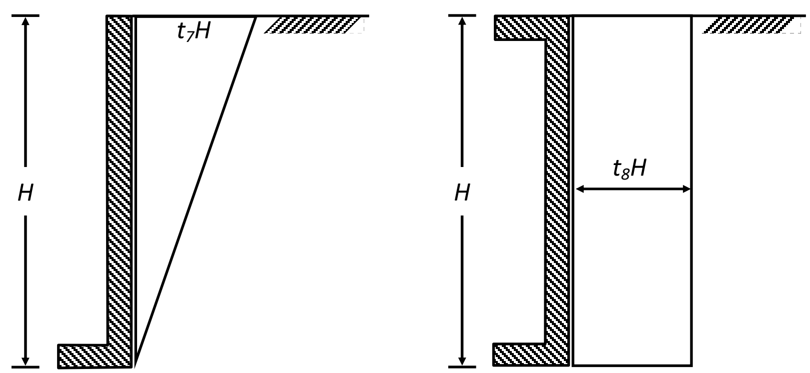


WITH DRAINAGE

WITHOUT DRAINAGE

NOTE: WALLS CAN BE EITHER FREE OR RESTRAINED AT THE TOP FOR THE PASSIVE PRESSURE CONDITION. EQUATIONS ARE ONLY VALID FOR UNITS OF $t_{1\text{-}8}$ (PCF) AND H-H_1(FT).

SEISMIC



UNRESTRAINED

RESTRAINED

NOTE: SEISMIC LOADS ARE VALID FOR WALLS RETAINING LESS THAN 8 FEET VERTICAL OF EARTH. THE SEISMIC LOAD IS ADDED TO ACTIVE OR AT-REST CONDITIONS AND IS SUBTRACTED FROM PASSIVE CONDITIONS.

NORTHERN GEOTECHNICAL ENGINEERING, INC.
TERRA FIRMA TESTING

FIGURE TITLE: LATERAL RETAINING WALL PRESSURE SCHEMATICS	
PROJECT NAME: PH II WASI WILLOW HOUSE DEVELOPMENT	PROJECT ID: 6520-22
PROJECT LOCATION: WASILLA, ALASKA	FIGURE NUMBER: 7

AGGREGATE GRADATION FOR BASE AND SURFACE COURSE

SIEVE SIZE	GRADATION - % BY MASS PASSING			
	BASE - (C-1)	BASE - (D-1)	SURFACE - (E-1)	SURFACE - (F-1)
1-1/2"	100			
1"	70-100	100	100	100
3/4"	60-90	70-100	70-100	85-100
3/8"	45-75	50-80	50-85	60-100
#4	30-60	35-65	35-65	50-85
#8	22-52	20-50	20-50	40-70
#50	6-30	6-30	15-30	25-45
#200	0-6	0-6	8-15	8-20
0.02	0-3	0-3	0-3	0-3

MATERIALS LISTED ABOVE MUST CONSIST OF CRUSHED STONE OR CRUSHED GRAVEL CONSISTING OF SOUND, TOUGH, DURABLE PEBBLES OR ROCK FRAGMENTS OF UNIFORM QUALITY. MUST BE FREE FROM CLAY BALLS, VEGTABLE MATTER AND OTHER DELETERIOUS MATERIALS.

SELECTED MATERIAL

TYPE A. AGGREGATE CONTAINING NO MUCK, FROZEN MATERIAL, ROOTS, SOD OR OTHER DELETERIOUS MATTER AND WITH A PLASTICITY INDEX NOT GREATER THAN 6 AS TESTED BY ATM 204 AND ATM 205. MEET THE FOLLOWING GRADATION AS TESTED BY ATM 304:

SIEVE	% BY MASS PASSING
#4	20-60
#200*	0-6

TYPE B. AGGREGATE CONTAINING NO MUCK, FROZEN MATERIAL, ROOTS, SOD OR OTHER DELETERIOUS MATTER AND WITH A PLASTICITY INDEX NOT GREATER THAN 6 AS TESTED BY ATM 204 AND ATM 205. MEET THE FOLLOWING GRADATION AS TESTED BY ATM 304:

SIEVE	% BY MASS PASSING
#200*	0-10

TYPE C. EARTH, SAND, GRAVEL, ROCK, OR COMBINATIONS THEREOF CONTAINING NO MUCK, PEAT, FROZEN,MATERIAL, ROOTS, SOD, OR OTHER DELETERIOUS MATTER AND IS COMPACTABLE UNDER THE PROVISIONS OF SUBSECTIONS 203-3.04 OR 203-3.05.

* GRADATION SHALL BE DETERMINED ON THAT PORTION PASSING THE 3" SCREEN

AGGREGATE GRADATION FOR SUBBASE

SIEVE SIZE	GRADATION - % BY MASS PASSING				
	A	B	C	D	E
4"	100	--	--	--	--
2"	85-100	100	--	--	--
1"	--	--	100	--	--
3/4"	--	--	--	100	--
#4	15-60	15-60	40-75	45-80	--
#16	--	--	20-43	23-50	--
#200*	0-10	0-6	4-10	4-12	0-6
0.02*	0-3	0-3	0-3	0-3	0-3

* GRADATION SHALL BE DETERMINED ON THAT PORTION PASSING THE 3" SCREEN

MODIFIED FROM SECTIONS 703-2.03, 703-2.07 AND 703-2.9 OF AK DOT & PF STANDARD SPECIFICATIONS FOR HIGHWAY CONSTRUCTION - 2015

APPENDIX A

GRAPHICAL EXPLORATION BOREHOLE LOGS

Northern Geotechnical Engineering, Inc.
and Terra Firma Testing
11301 Olive Lane
Anchorage, AK 99515
Telephone: 907-344-5934

EXPLORATION B9

NGE-TFT PROJECT NAME: WASI Housing PH II	**NGE-TFT PROJECT NUMBER:** 6520-22
PROJECT LOCATION: Wasilla, AK	**EXPLORATION CONTRACTOR:** Discovery Drilling, Inc.
EXPLORATION EQUIPMENT: Truck-mounted	**EXPLORATION METHOD:** Hollow Stem Auger
SAMPLING METHOD: MPT w/ 340lb autohammer	**LOGGED BY:** D. Light
DATE/TIME STARTED: 10/10/2022 @ 9:15:00 AM	**DATE COMPLETED:** 10/10/2022
EXPLORATION LOCATION: See report Figure 2	**GROUND ELEVATION:** Not Known
▽ **GROUNDWATER (ATD):** Approx. 15.0 ft bgs	▼ **GROUNDWATER (10/20/2022):** Approx. 8.9 ft bgs
EXPLORATION COMPLETION: See completion comments at end of log	**WEATHER CONDITIONS:** Cloudy

DEPTH (ft bgs)	MATERIAL DESCRIPTION	FIELD SAMPLE ID	RECOVERY (in)	FIELD BLOWS	$(N_1)_{60}$	LAB SAMPLE ID	LAB RESULTS	REMARKS/NOTES
0–4.5	**POORLY GRADED GRAVEL WITH SAND** (GP), medium dense to dense, reddish brown, moist, gravel up to 2" in diameter	S1	18	3 5 7	20*	S1	S1 MC = 3.6% 71.7% gravel, 23.6% sand, 4.7% silt P0.02 = 3.2% FC = S1	*Some freshly fractured rock, blow counts may not be representative.
		S2	10	9 12 16	46	S2	S2 MC = 4.9%	
4.5–9.5	**WELL GRADED GRAVEL WITH SILT AND SAND** (GW-GM), dense, reddish brown, moist, gravel up to 2" in diameter	S3	14	15 10 9	N/A*	S3	S3 MC = 3.8% 53.4% gravel, 38.6% sand, 8.0% silt	*Freshly fractured rock, blow counts not representative.
▼		S4	14	46 21 50	76*	S4	S4 MC = 4.3%	*Some freshly fractured rock, blow counts may not be representative.
9.5–18.5	**POORLY GRADED GRAVEL WITH SILT AND SAND** (GP-GM), dense, light brown, moist, gravel up to 1" in diameter	S5	6	50	N/A*	S5	S5 MC = 2.9%	*Pounding on rock.
▽ 15		S6	18	16 27 25	49	S6	S6 MC = 10.9%	
18.5–	**POORLY GRADED SAND WITH SILT AND GRAVEL** (SP-SM), dense, olive, wet, gravel up to 0.5" in diameter	S7	18	14 21 20	39	S7	S7 MC = 16.4%	

Always refer to our complete geotechnical report for this project for a more detailed explanation of the subsurface conditions at the project site and how they may affect any existing and/or prospective project site development.

(Continued Next Page)

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Telephone: 907-344-5934

EXPLORATION B9

NGE-TFT PROJECT NAME: WASI Housing PH II
NGE-TFT PROJECT NUMBER: 6520-22
PROJECT LOCATION: Wasilla, AK
EXPLORATION CONTRACTOR: Discovery Drilling, Inc.
EXPLORATION EQUIPMENT: Truck-mounted
EXPLORATION METHOD: Hollow Stem Auger
SAMPLING METHOD: MPT w/ 340lb autohammer
LOGGED BY: D. Light
DATE/TIME STARTED: 10/10/2022 @ 9:15:00 AM
DATE COMPLETED: 10/10/2022
EXPLORATION LOCATION: See report Figure 2
GROUND ELEVATION: Not Known
GROUNDWATER (ATD): Approx. 15.0 ft bgs
GROUNDWATER (10/20/2022): Approx. 8.9 ft bgs
EXPLORATION COMPLETION: See completion comments at end of log
WEATHER CONDITIONS: Cloudy

DEPTH (ft bgs)	GRAPHIC LOG	FROZEN SOILS	MATERIAL DESCRIPTION	SAMPLE TYPE	FIELD SAMPLE ID	RECOVERY (in)	FIELD BLOWS	$(N_1)_{60}$	SAMPLE INT. COLLECT	LAB SAMPLE ID	LAB RESULTS	REMARKS/NOTES	WELL DIAGRAM
			POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM), dense, olive, wet, gravel up to 0.5" in diameter *(continued)*										
25			**POORLY GRADED SAND** (SP), wet		S8	18	50	N/A*		S8		*Sand Heave, blow counts not representative. Very dense material indicated by drilling action starting at approx. 26 ft.	
			POORLY GRADED GRAVEL WITH SILT (GP-GM), very dense, gray, moist										
30					S9	8	50	N/A		S9	S9 MC = 13.1%		

Bottom of borehole at 30.5 ft bgs.
Set 1" PVC to BOH. Hand slotted casing bottom 10 ft.
Backfilled with cuttings from 1.5-30.5 ft bgs, bentonite seal from 0.5-1.5 ft bgs, cuttings to ground surface.

Always refer to our complete geotechnical report for this project for a more detailed explanation of the subsurface conditions at the project site and how they may affect any existing and/or prospective project site development.

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Anchorage, AK 99515
Telephone: 907-344-5934

EXPLORATION B10

NGE-TFT PROJECT NAME: WASI Housing PH II
NGE-TFT PROJECT NUMBER: 6520-22
PROJECT LOCATION: Wasilla, AK
EXPLORATION CONTRACTOR: Discovery Drilling, Inc.
EXPLORATION EQUIPMENT: Truck-mounted
EXPLORATION METHOD: Hollow Stem Auger
SAMPLING METHOD: MPT w/ 340lb autohammer
LOGGED BY: D. Light
DATE/TIME STARTED: 10/10/2022 @ 11:27:00 AM
DATE COMPLETED: 10/10/2022
EXPLORATION LOCATION: See report Figure 2
GROUND ELEVATION: Not Known
▽ **GROUNDWATER (ATD):** Approx. 15.0 ft bgs
▼ **GROUNDWATER (10/20/2022):** Approx. 9.4 ft bgs
EXPLORATION COMPLETION: See completion comments at end of log
WEATHER CONDITIONS: Cloudy

DEPTH (ft bgs)	MATERIAL DESCRIPTION	FIELD SAMPLE ID	RECOVERY (in)	FIELD BLOWS	$(N_1)_{60}$	LAB SAMPLE ID	LAB RESULTS	REMARKS/NOTES
0	**ORGANIC SILT WITH SAND** (ML), reddish							
	POORLY GRADED GRAVEL WITH SAND (GP), medium dense to dense, reddish brown, moist, gravel up to 2" in diameter	S1	14	4 5 8	21	S1	S1 MC = 10.5% 60.5% gravel, 34.8% sand, 4.7% silt	
		S2	4	17 18 20	N/A*	S2	S2 MC = 16.4%	*Pounding on rock.
5	**POORLY GRADED GRAVEL WITH SILT AND SAND** (GP-GM), medium dense to dense, brown / olive, moist	S3	14	20 14 10	30*	S3	S3 MC = 3.5% 47.2% gravel, 43.9% sand, 8.9% silt P0.02 = 4.0% FC = S1	*Some freshly fractured rock, blow counts may not be representative.
	POORLY GRADED SAND WITH GRAVEL (SP), dense, moist, gravel up to 1.5" in diameter ▼	S4	17	27 17 19	39	S4	S4 MC = 5.1%	
10	**POORLY GRADED GRAVEL WITH SILT AND SAND** (GP-GM), dense, brown / olive, moist	S5	16	24 25 19	N/A*	S5	S5 MC = 5.0%	*Freshly fractured rock, blow counts not representative.
	WELL GRADED GRAVEL (GW), dense, olive, wet, gravel up to 1" in diameter							
15	▽	S6	14	23 50	N/A*	S6	S6 MC = 6.6%	*Pouding on rock, some fractured rock in sampler.
	POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM), very dense, olive, wet							
20		S7		34 50	N/A	S7	S7 MC = 8.6%	

Bottom of borehole at 21.0 ft bgs.
Set 1" PVC to BOH. Hand slotted casing bottom 10 ft.
Backfilled with cuttings from 1.5-21 ft bgs, bentonite seal from 0.5-1.5 ft bgs, cuttings to ground surface.

Always refer to our complete geotechnical report for this project for a more detailed explanation of the subsurface conditions at the project site and how they may affect any existing and/or prospective project site development.

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Anchorage, AK 99515
Telephone: 907-344-5934

EXPLORATION B11

NGE-TFT PROJECT NAME: WASI Housing PH II
NGE-TFT PROJECT NUMBER: 6520-22
PROJECT LOCATION: Wasilla, AK
EXPLORATION CONTRACTOR: Discovery Drilling, Inc.
EXPLORATION EQUIPMENT: Truck-mounted
EXPLORATION METHOD: Hollow Stem Auger
SAMPLING METHOD: MPT w/ 340lb autohammer
LOGGED BY: D. Light
DATE/TIME STARTED: 10/10/2022 @ 1:45:00 PM
DATE COMPLETED: 10/10/2022
EXPLORATION LOCATION: See report Figure 2
GROUND ELEVATION: Not Known
▽ **GROUNDWATER (ATD):** Approx. 15.0 ft bgs
▼ **GROUNDWATER (10/20/2022):** Approx. 10.7 ft bgs
EXPLORATION COMPLETION: See completion comments at end of log
WEATHER CONDITIONS: Cloudy

DEPTH (ft bgs)	MATERIAL DESCRIPTION	FIELD SAMPLE ID	RECOVERY (in)	FIELD BLOWS	$(N_1)_{60}$	LAB SAMPLE ID	LAB RESULTS	REMARKS/NOTES
0	**POORLY GRADED GRAVEL WITH SILT AND SAND** (GP-GM), medium dense to dense, brown, moist, gravel up to 2" in diameter	S1	16	5 7 8	25	S1	S1 MC = 5.0% 48.1% gravel, 46.2% sand, 5.7% silt P0.02 = 3.0% FC = S1	
		S2	14	11 9 10	31	S2	S2 MC = 7.6%	
5	**WELL GRADED GRAVEL WITH SILT AND SAND** (GW-GM), medium dense, brown, moist, gravel up to 2" in diameter	S3	15	13 13 12	N/A*	S3	S3 MC = 2.3% 55.6% gravel, 39.3% sand, 5.1% silt	*Freshly fractured rock, blow counts not representative.
		S4	15	11 9 10	20*	S4	S4 MC = 3.0%	*Some freshly fracted rock, blow counts may not be representative.
10	**POORLY GRADED SAND WITH SILT AND GRAVEL** (SP-SM), medium dense, brown, moist to wet ▼	S5	17	9 11 12	23	S5	S5 MC = 5.8%	
15	▽ **POORLY GRADED GRAVEL** (GP), medium dense, reddish brown	S6	13	14 13 15	26	S6	S6 MC = 11.3%	
	POORLY GRADED SAND (SP), olive, wet, coarse grained							
20	**POORLY GRADED GRAVEL** (GP), wet, rounded gravel, gravel up to 2" in diameter	S7	17	8 8 8	N/A*	S7	S7 MC = 13.7%	*Sand heave, blow counts not representative.

Always refer to our complete geotechnical report for this project for a more detailed explanation of the subsurface conditions at the project site and how they may affect any existing and/or prospective project site development.

(Continued Next Page)

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Anchorage, AK 99515
Telephone: 907-344-5934

EXPLORATION B11

NGE-TFT PROJECT NAME: WASI Housing PH II
NGE-TFT PROJECT NUMBER: 6520-22
PROJECT LOCATION: Wasilla, AK
EXPLORATION CONTRACTOR: Discovery Drilling, Inc.
EXPLORATION EQUIPMENT: Truck-mounted
EXPLORATION METHOD: Hollow Stem Auger
SAMPLING METHOD: MPT w/ 340lb autohammer
LOGGED BY: D. Light
DATE/TIME STARTED: 10/10/2022 @ 1:45:00 PM
DATE COMPLETED: 10/10/2022
EXPLORATION LOCATION: See report Figure 2
GROUND ELEVATION: Not Known
GROUNDWATER (ATD): Approx. 15.0 ft bgs
GROUNDWATER (10/20/2022): Approx. 10.7 ft bgs
EXPLORATION COMPLETION: See completion comments at end of log
WEATHER CONDITIONS: Cloudy

DEPTH (ft bgs)	GRAPHIC LOG	FROZEN SOILS	MATERIAL DESCRIPTION	SAMPLE TYPE	FIELD SAMPLE ID	RECOVERY (in)	FIELD BLOWS	$(N_1)_{60}$	SAMPLE INT. COLLECT	LAB SAMPLE ID	LAB RESULTS	REMARKS/NOTES	WELL DIAGRAM
			POORLY GRADED SAND (SP), gray / olive, wet, coarse grained										
25					S8	17	19 13 17	31		S8	S8 MC = 19.1%		
			SANDY SILT (ML), very stiff, gray, moist to wet										
			POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM), very dense, gray, wet										
30					S9	10	25 50	N/A		S9	S9 MC = 10.2%		

Bottom of borehole at 31.0 ft bgs.
Set 1" PVC to BOH. Hand slotted casing bottom 10 ft.
Backfilled with cuttings from 1.5-31 ft bgs, bentonite seal from 0.5-1.5 ft bgs, cuttings to ground surface.

EXPLORATION B12

Northern Geotechnical Engineering, Inc.
and Terra Firma Testing
11301 Olive Lane
Anchorage, AK 99515
Telephone: 907-344-5934

NGE-TFT PROJECT NAME: WASI Housing PH II
NGE-TFT PROJECT NUMBER: 6520-22
PROJECT LOCATION: Wasilla, AK
EXPLORATION CONTRACTOR: Discovery Drilling, Inc.
EXPLORATION EQUIPMENT: Truck-mounted
EXPLORATION METHOD: Hollow Stem Auger
SAMPLING METHOD: MPT w/ 340lb autohammer
LOGGED BY: D. Light
DATE/TIME STARTED: 10/10/2022 @ 3:00:00 PM
DATE COMPLETED: 10/10/2022
EXPLORATION LOCATION: See report Figure 2
GROUND ELEVATION: Not Known
▽ **GROUNDWATER (ATD):** Approx. 10.0 ft bgs
▼ **GROUNDWATER ():** N/A
EXPLORATION COMPLETION: Backfilled with cuttings.
WEATHER CONDITIONS: Cloudy

DEPTH (ft bgs)	MATERIAL DESCRIPTION	FIELD SAMPLE ID	RECOVERY (in)	FIELD BLOWS	$(N_1)_{60}$	LAB SAMPLE ID	LAB RESULTS	REMARKS/NOTES
0	**POORLY GRADED GRAVEL WITH SILT AND SAND** (GP-GM), medium dense to dense, red / brown, moist, gravel up to 2" in diameter	S1	16	3 7 10	28	S1	S1 MC = 10.8% 48.9% gravel, 44.1% sand, 7.0% silt P0.02 = 3.2% FC = S1	
		S2	5	26 23 21	N/A*	S2	S2 MC = 6.6%	*Pounding on rock.
5	**POORLY GRADED SAND WITH SILT AND GRAVEL** (SP-SM), medium dense, brown, moist	S3	14	15 13 11	N/A*	S3	S3 MC = 3.6% 30.3% gravel, 62.3% sand, 7.4% silt	*Freshly fractured rock, blow counts not representative.
		S4	15	13 10 11	N/A*	S4	S4 MC = 5.4%	*Freshly fractured rock, blow counts not representative.
10	▽ **POORLY GRADED SAND WITH GRAVEL** (SP), medium dense to dense, brown, wet	S5	7	16 14 10	24	S5	S5 MC = 13.3%	
15		S6	8	28 19 20	40	S6	S6 MC = 12.7%	
20		S7	14	12 21 23	46	S7	S7 MC = 17.6%	
	SILT WITH GRAVEL (ML), hard, gray, moist, gravel up to 1.5" in diameter							

Bottom of borehole at 21.5 ft bgs.

Always refer to our complete geotechnical report for this project for a more detailed explanation of the subsurface conditions at the project site and how they may affect any existing and/or prospective project site development.

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EXPLORATION B13

NGE-TFT PROJECT NAME: WASI Housing PH II

NGE-TFT PROJECT NUMBER: 6520-22

PROJECT LOCATION: Wasilla, AK

EXPLORATION CONTRACTOR: Discovery Drilling, Inc.

EXPLORATION EQUIPMENT: Truck-mounted

EXPLORATION METHOD: Hollow Stem Auger

SAMPLING METHOD: MPT w/ 340lb autohammer

LOGGED BY: D. Light

DATE/TIME STARTED: 10/10/2022 @ 1:00:00 PM

DATE COMPLETED: 10/10/2022

EXPLORATION LOCATION: See report Figure 2

GROUND ELEVATION: Not Known

▽ **GROUNDWATER (ATD):** Approx. 10.0 ft bgs

▼ **GROUNDWATER ():** N/A

EXPLORATION COMPLETION: Backfilled with cuttings.

WEATHER CONDITIONS: Cloudy

DEPTH (ft bgs)	GRAPHIC LOG	FROZEN SOILS	MATERIAL DESCRIPTION	SAMPLE TYPE	FIELD SAMPLE ID	RECOVERY (in)	FIELD BLOWS	$(N_1)_{60}$	SAMPLE INT. COLLECT	LAB SAMPLE ID	LAB RESULTS	REMARKS/NOTES
0			**POORLY GRADED GRAVEL WITH SILT AND SAND** (GP-GM), medium dense, red / brown, moist		S1	16	4 8 10	30*		S1	S1 MC = 5.1% 51.2% gravel, 41.8% sand, 7.0% silt P0.02 = 3.5% FC = S1	*Some freshly fractured rock, blow counts may not be representative.
			POORLY GRADED SAND WITH GRAVEL (SP), dense to very dense, olive, moist to wet		S2	15	18 11 14	41*		S2	S2 MC = 4.1%	*Some freshly fractured rock, blow counts may not be representative.
5					S3	17	17 13 15	35*		S3	S3 MC = 2.8% 46.9% gravel, 49.1% sand, 4.0% silt	*Some freshly fractured rock, blow counts may not be representative.
					S4	16	18 14 43	61		S4	S4 MC = 5.7%	
10		▽			S5	14	48 18 18	36		S5	S5 MC = 9.4%	
15					S6	17	21 32 45	72		S6	S6 MC = 6.9%	
			POORLY GRADED SAND WITH GRAVEL (SP), dense, olive, wet, coarse grained									
20			**SANDY SILT** (ML), hard, olive, moist		S7	17	12 15 22	39		S7	S7 MC = 18.9% P200 = 30.3%	

Bottom of borehole at 21.5 ft bgs.

Always refer to our complete geotechnical report for this project for a more detailed explanation of the subsurface conditions at the project site and how they may affect any existing and/or prospective project site development.

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EXPLORATION B14

NGE-TFT PROJECT NAME: WASI Housing PH II
NGE-TFT PROJECT NUMBER: 6520-22
PROJECT LOCATION: Wasilla, AK
EXPLORATION CONTRACTOR: Discovery Drilling, Inc.
EXPLORATION EQUIPMENT: Truck-mounted
EXPLORATION METHOD: Hollow Stem Auger
SAMPLING METHOD: MPT w/ 340lb autohammer
LOGGED BY: D. Light
DATE STARTED: 10/10/2022
DATE COMPLETED: 10/10/2022
EXPLORATION LOCATION: See report Figure 2
GROUND ELEVATION: Not Known
▽ **GROUNDWATER (ATD):** Approx. 15.0 ft bgs
▼ **GROUNDWATER ():** N/A
EXPLORATION COMPLETION: Backfilled with cuttings.
WEATHER CONDITIONS: Sleet, 33°F

DEPTH (ft bgs)	GRAPHIC LOG	FROZEN SOILS	MATERIAL DESCRIPTION	SAMPLE TYPE	FIELD SAMPLE ID	RECOVERY (in)	FIELD BLOWS	$(N_1)_{60}$	SAMPLE INT. COLLECT	LAB SAMPLE ID	LAB RESULTS	REMARKS/NOTES
0			**POORLY GRADED SAND WITH SILT AND GRAVEL** (SP-SM), loose to dense, brown, moist, gravel up to 1" in diameter		S1	12	2 2 4	10		S1	S1 MC = 5.1%	
					S2	14	10 8 10	30		S2	S2 MC = 4.9% 46.8% gravel, 47.5% sand, 5.7% silt	
5					S3	18	10 13 16	38*		S3	S3 MC = 4.0% 44.0% gravel, 49.2% sand, 6.8% silt P0.02 = 3.5% FC = PFS	*Some freshly fractured rock, blow counts may not be representative.
					S4	17	11 12 15	31*		S4	S4 MC = 3.2%	*Some freshly fractured rock, blow counts may not be representative.
10			**POORLY GRADED GRAVEL** (GP), dense to medium dense, reddish brown, moist to wet		S5	12	11 13 15	N/A*		S5	S5 MC = 2.5%	*Freshly fractured rock, blow counts not representative.
15		▽			S6	13	21 13 19	30		S6	S6 MC = 8.8%	
20					S7	16	5 6 7	12		S7	S7 MC = 11.5%	

Bottom of borehole at 21.5 ft bgs.

Always refer to our complete geotechnical report for this project for a more detailed explanation of the subsurface conditions at the project site and how they may affect any existing and/or prospective project site development.

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EXPLORATION LEGEND

CLIENT Spark Design, LLC

NGE-TFT PROJECT NAME WASI Housing PH II

NGE-TFT PROJECT NUMBER 6520-22

PROJECT LOCATION Wasilla, AK

LITHOLOGIC SYMBOLS (Unified Soil Classification System)

- GP: USCS Poorly-graded Gravel
- GP-GM: USCS Poorly-graded Gravel with Silt
- GPS: Sandy Gravel
- GW: USCS Well-graded Gravel
- GW-GM: USCS Well-graded Gravel with Silt
- MLG: USCS Gravelly Silt
- MLS: Sandy Silt
- SP: USCS Poorly-graded Sand
- SPG: Gravelly Sand
- SP-SM: USCS Poorly-graded Sand with Silt

SAMPLER SYMBOLS

- Modified Penetration Test

WELL CONSTRUCTION SYMBOLS

- Bentonite Seal
- Slough Backfill
- Slotted Pipe Backfilled with Slough

ABBREVIATIONS

LL - LIQUID LIMIT (%)
PI - PLASTIC INDEX (%)
MC - MOISTURE CONTENT (%)
DD - DRY DENSITY (PCF)
NP - NON PLASTIC
P200 - PERCENT PASSING NO. 200 SIEVE
P0.02- PERCENT PASSING 0.02mm SIEVE
PP - POCKET PENETROMETER (tons/ft^2)
S/U - CASING STICK-UP

▽ Water Level at Time Drilling, or as Shown

▼ Water Level After 24 Hours, or as Shown

TV - TORVANE
PID - PHOTOIONIZATION DETECTOR
UC - UNCONFINED COMPRESSION
ppm - PARTS PER MILLION
N/E - NOT ENCOUNTERED
N/R - NOT REPRESENTATIVE
N/A - NOT APPLICABLE

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SOIL CLASSIFICATION CHART

CLIENT Spark Design, LLC

PROJECT NAME WASI Housing PH II

NGE-TFT PROJECT NUMBER 6520-22

PROJECT LOCATION Wasilla, AK

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
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

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS.
DIAGONAL LINES INDICATE UNKNOWN DEPTH OF SOIL TRANSITION.

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EXPLORATION LOG KEY

CLIENT Spark Design, LLC
PROJECT NAME WASI Housing PH II
NGE-TFT PROJECT NUMBER 6520-22
PROJECT LOCATION Wasilla, AK

SAMPLER SYMBOLS

SPT w/ 140# Hammer
30" Drop and 2.0" O.D. Sampler

Modified SPT w/ 340# Hammer
30" Drop and 3.0 O.D. Sampler

Grab Sample

Shelby Tube Sample

Rock Core Sample

Direct Push Sample

No Recovery

N/E Not Encountered

WELL SYMBOLS

1" Slotted Pipe
Backfilled with Silica Sand

1" PVC Pipe
Backfilled with Auger Cuttings

1" PVC Pipe
with Bentonite Seal

Capped Riser

COMPONENT DEFINITIONS

COMPONENT	SIZE RANGE
Boulders	Larger than 12 in
Cobbles	3 in to 12 in
Gravel	3 in to No. 4 (4.5mm)
Coarse gravel	3 in to 3/4 in
Fine gravel	3/4 in to No. 4 (4.5 mm)
Sand	No. 4 (4.5 mm) to No. 200
Coarse sand	No. 4 (4.5 mm) to No. 10 (2.0 mm)
Medium sand	No. 10 (2.0 mm) to No. 40 (0.42 mm)
Fine sand	No. 40 (0.42 mm) to No. 200 (0.074 mm)
Silt and Clay	Smaller than No. 200 (0.074 mm)

COMPONENT PROPORTIONS

DESCRIPTIVE TERMS	RANGE OF PROPORTION
Trace	1-5%
Few	5-10%
Little	10-20%
Some	20-35%
And	35-50%

MOISTURE CONTENT

DRY	Absence of moisture, dusty, dry to the touch
DAMP	Some perceptible moisture; below optimum
MOIST	No visible water; near optimum moisture content
WET	Visible free water, usually soil is below water table

RELATIVE DENSITY OR CONSISTENCY VERSUS SPT N-VALUE

COHESIONLESS SOILS			COHESIVE SOILS		
DENSITY	N (BLOWS/FT)	APPROXIMATE RELATIVE DENSITY (%)	CONSISTENCY	N (BLOWS/FT)	APPROXIMATE UNDRAINED SHEAR STRENGTH (PSF)
VERY LOOSE	0-4	0-15	VERY SOFT	0-1	< 250
LOOSE	5-10	15-35	SOFT	2-4	250-500
MEDIUM DENSE	11-25	35-65	MEDIUM STIFF	5-8	500-1000
DENSE	26-50	65-85	STIFF	9-15	1000-2000
VERY DENSE	> 50	85-100	VERY STIFF	16-30	2000-4000
			HARD	> 30	> 4000

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EXPLORATION LOG KEY

CLIENT Spark Design, LLC

PROJECT NAME WASI Housing PH II

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PROJECT LOCATION Wasilla, AK

FROST DESIGN SOIL CLASSIFICATION

FROST GROUP (USACOE)	FROST GROUP (M.O.A.)	SOIL TYPE	% FINER THAN 0.02mm BY MASS	TYPICAL SOIL TYPES UNDER UNIFIED SOIL CLASSIFICATION SYSTEM
NFS*	NFS*	(A) GRAVELS CRUSHED STONE CRUSHED ROCK (B) SANDS	0 - 1.5 0 - 3	GW, GP SW, SP
PFS+	NFS*	(A) GRAVELS CRUSHED STONE CRUSHED ROCK	1.5 - 3	GW, GP
	F2	(B) SANDS	3 - 10	SW, SP
S1	F1	GRAVELLY SOILS	3 - 6	GW, GP, GW-GM, GP-GM
S2	F2	SANDY SOILS	3 - 6	SW, SP, SW-SM, SP-SM
F1	F1	GRAVELLY SOILS	6 - 10	GM, GW-GM, GP-GM
F2	F2	(A) GRAVELLY SOILS (B) SANDS	10 - 20 6 - 15	GM, GW-GM, GP-GM SM, SW-SM, SP-SM
F3	F3	(A) GRAVELLY SOILS (B) SANDS, EXCEPT VERY FINE SILTY SANDS (C) CLAYS, PI>12	Over 20 Over 15 - - - - - -	GM, GC SM, SC CL, CH
F4	F4	(A) ALL SILTS (B) VERY FINE SILTY SANDS (C) CLAYS, PI<12 (D) VARVED CLAYS AND OTHER FINE GRAINED, BANDED SEDIMENTS	- - - - - - Over 15 - - - - - - - - - - - -	ML, MH SM CL, CL-ML CL & ML; CL, ML, & SM; CL, CH, & ML; CL, CH, ML, & SM

*Non-frost susceptible
+Possibly frost susceptible, but requires lab testing to determine frost design soils classification.

ICE CLASSIFICATION SYSTEM

GROUP	ICE VISIBILITY	DESCRIPTION		SYMBOL	
N	SEGREGATED ICE NOT VISIBLE BY EYE	POORLY BONDED OR FRIABLE		Nf	
		WELL BONDED	NO EXCESS ICE	Nb	Nbn
			EXCESS MICROSCOPIC ICE		Nbe
V	SEGREGATED ICE IS VISIBLE BY EYE AND IS ONE INCH OR LESS IN THICKNESS	INDIVIDUAL ICE CRYSTALS OR INCLUSIONS		Vx	
		ICE COATINGS ON PARTICLES		Vc	
		RANDOM OR IRREGULARY ORIENTED ICE		Vr	
		STRATIFIED OR DISTINCTLY ORIENTED ICE		Vs	
		UNIFORMLY DISTRIBUTED ICE		Vu	
ICE	ICE IS GREATER THAN ONE INCH IN THICKNESS	ICE WITH SOILS INCLUSIONS		ICE + Soil Type	
		ICE WITHOUT SOILS INCLUSIONS		ICE	

APPENDIX B

ADDITIONAL REPORT DETAILS

APPENDIX B – ADDITIONAL REPORT DETAILS

1.0 FIELD ACTIVITIES

We conceived, coordinated, and directed a subsurface exploration program at the project site in an effort to characterize the subsurface conditions of the project site as they currently exist. We subcontracted Discovery Drilling Inc (DDI) to provide the necessary geotechnical exploration services. A qualified representative from our office was present on-site during the entire exploration program to select the exploration locations, direct the exploration activities, log the geology of each exploration, and collect representative samples for further identification and laboratory analysis. Under our direction DDI advanced a total of six soil borings at the project site on October 10, 2022 to depths ranging from approximately 21.5 to 31 feet below the existing ground surface (bgs) using conventional hollow-stem auger drilling and split-spoon sampling methods.

Under our direction, DDI performed a Modified Penetration Test (MPT) at regular intervals during the drilling of each borehole. A MPT can be used to assess the consistency of a soil interval and to collect representative soil samples. A MPT is performed by driving a 3.0-inch O.D. (2.4-inch I.D.) split-spoon sampler at least 18 inches past the bottom of the advancing augers with blows from a 340-lb drop-hammer, free-falling 30 inches onto an anvil attached to the top of the drill rod stem. Our field representative recorded the hammer blows required to drive the modified split-spoon sampler the entire length of each sample interval, or until sampler refusal was encountered. We have provided the field blow count data for each sample interval (in six-inch increments) on the graphical borehole logs contained in Appendix A of this report.

During the course of our subsurface exploration program, we encountered a physical phenomenon common to hollow-stem auger drilling known as “sand-heave” in boring B9 and B11. Sand-heave typically occurs when sampling saturated sand deposits with hollow stem augers/split-spoon samplers, as the increased hydrostatic pressure outside of the hollow-stem augers forces a sand slurry up into the hollow auger flights when the drill stem is removed (to allow for split-spoon sampling). At times, sand-heave can be significant; filling the inside of the hollow-stem auger flights with several feet of densely-packed sand. As a result, sand-heaving forces disturb the in-situ density of the sand deposit at the tip of the advancing augers and can lead to the collection of unrepresentative blow count data (i.e., soil resistance measurements) and a disturbed split-spoon sample.

We corrected the field blow count data for all six boreholes for standard confining pressure, drill rod length, and drop-hammer operation procedure to estimate a standard $(N_1)_{60}$ value for each

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sample interval. *$(N_1)_{60}$* values are a measure of the relative density (compactness) and consistency (stiffness) of cohesionless or cohesive soils, respectively. Our estimate of the *$(N_1)_{60}$* values is based on the drop-hammer blows required to drive the spilt-spoon sampler the final 12-inches of an 18-inch MPT. We have provided our estimated *$(N_1)_{60}$* values for each sample interval on the graphical borehole logs contained in Appendix A of this report. The automatic drop-hammer that DDI used for this project is not standard, so we applied a correction factor of 1.1 to the *$(N_1)_{60}$* values to account for the efficiency of the automatic drop-hammer used. We have provided a graphical plot of the field blow count corrections that we used to correct for confining pressure and drill rod length in Figure 3 of this report.

We did not report the *$(N1)_{60}$* values on the borehole logs where sand-heave occurred, as the *$(N1)_{60}$* values obtained for those sample intervals are not representative of the in-situ material.

Our field representative sealed each sample that they collected during our subsurface exploration program inside of an air-tight bag and/or container, to help preserve the moisture content of each sample, and then submitted each sample to our laboratory for further identification and analysis.

We directed DDI to install one-inch diameter, open-ended PVC pipe from the ground surface down to the bottom of boreholes B9, B10 and B11 in order to provide a conduit (i.e., monitoring wells) for future groundwater level monitoring. Construction diagrams for each groundwater monitoring well are presented on the graphical borehole logs contained in Appendix A of this report.

For the remaining boreholes, we directed DDI to backfill the annulus of each exploration with its respective drill cuttings.

1.1 Groundwater Level Monitoring

We conducted groundwater level monitoring efforts at the project site on October 10, 2022, to help determine what the static groundwater level is. We used an electronic water level meter (with 0.01-foot increments) to measure the relative depth of the groundwater surface (below the existing ground surface) at each monitoring well location. A summary of the groundwater level measurements that we collected at the project site are presented on the graphical borehole logs contained in Appendix B of this report.

2.0 LABORATORY TESTING

It is important to note that ASTM test method D-6913 requires that any soil sample specimen which is to be submitted for gradational analysis (by ASTM D-7928 or other methods) must satisfy a minimum mass requirement based on the maximum particle size of the sample specimen. Split-spoon sampling techniques (standard or modified), as well as other small-diameter soil sampling techniques (e.g., macro-core, etc.), typically recover anywhere from approximately 1 to 10 pounds of sample specimen. The amount of sample specimen recovered can be influenced by (amongst other variables) the soil gradation, soil density, sample interval, sampler tooling, and soil moisture

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content. As a result, samples of coarse-grained soils (with individual soil particles greater than approximately 0.75 inches in diameter) collected with small-diameter sampling methods (e.g., split-spoons, macro-core, etc.) may not meet the minimum mass requirement specified by Table 2 of ASTM D-6913. This may result in gradational and frost classification results which are not representative of the actual (i.e., in-situ) soil gradation and/or frost classification. The use of small-diameter sampling devices in coarse-grained soils (e.g., sand and gravel) can result in the collection of unrepresentative samples due to: the exclusion of oversized particles (larger than the opening of the sampler) from the sample; and the mechanical breakdown/degradation of coarse-grained particles by the sampling process (producing an unrepresentative increase in smaller-diameter particles in the sample). Both of these sampling biases can skew laboratory test results towards the fine-grained end of the gradational spectrum.

3.0 DESIGN RECOMMENDATIONS

3.1 Frost Development and Protection

Frost Heave:

If the subgrade soils are allowed to freeze (for any amount of time), then soil ice can form in the subgrade and result in a phenomena known as “frost heaving”. Frost heaving forces can generate significant uplift loads which can damage foundations or connecting members.

Burial Depths:

Perimeter and exterior shallow foundation footing burial depths will vary, based on whether or not the foundation subgrade will be allowed to freeze during winter months. Additionally, shallow foundations need to be buried sufficiently deep so as to resist any anticipated uplift/overturning forces (e.g. wind, seismic, frost jacking, etc.).

Frost heaving forces can damage shallow foundations. As such, footings need to be buried sufficiently deep and/or be adequately insulated so as to reduce the potential for freezing of the foundation subgrade and any associated frost heaving forces.

Insulation:

Artificial insulation can be used to decrease minimum burial depths for both heated and unheated foundations by helping to reduce the potential for freezing of foundation soils, as well as help increase heating efficiency.

Insulation may be placed beneath of interior floors/slabs. However, no insulation should be placed directly underneath of any perimeter footings, as this can promote freezing of the foundation soils by preventing adequate heat transfer from the interior of the structure to the foundation soils. Alternatively, insulation should be placed along the exterior of the footing/stem wall to prevent

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freezing (and associated frost heaving) of the foundation soils along the perimeter of the foundation.

In terms of insulating properties, one inch of rigid board insulation can be considered equivalent to one foot of NFS fill.

Cold Shallow Foundations

It is difficult to predict the depth of ground frost penetration and extent of ice lens formation at any given site. Therefore, we do not recommend the construction of cold shallow foundations. The formation of ice lenses in the foundation subgrade can damage overlying foundations due to differential movements in the foundation subgrade as a result of soil ice growth and/or subsequent thaw-related losses of soil bearing capacity (due to increased soil moisture contents).

Cold Deep Foundations

Deep foundation systems such as driven piling, helical piers, under-reamed concrete piers, or other deep foundation systems can serve as an alternative means of cold foundation support, as they can provide the uplift resistance needed to counteract any frost heaving/jacking forces (assuming proper embedment depths, footing sizes, etc. are achieved).

Frost heaving forces can damage connecting members of pile foundations and/or result in failures at connections between pile foundations. As such, connecting members need to be above grade with a sufficient air gap or be buried sufficiently deep and/or be adequately insulated so as to reduce the potential for freezing of the foundation subgrade and any associated frost heaving forces.

3.2 Modulus of Subgrade Reaction Calculations

For this project, the following equations can be used (with standard English units) to calculate the appropriate modulus of subgrade reaction for load footprints bearing onto recommended bearing materials (defined in the report):

$$k_{(B\ x\ B)} = k_1 \left(\frac{B+1}{2B}\right)^2 \tag{1}$$

Where:

B = the load footprint width of a square load in feet
k_1 = the modulus of subgrade reaction for a 1-ft × 1-ft rigid plate in pci
$k_{(B\ x\ B)}$ = the modulus of subgrade reaction for a square load footprint of width B in pci

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The following equation (2) can be used for a rectangular load having the dimensions $B \times L$ (in feet) with similar bearing soils as the square footprint loading equation above (1).

$$k_{(B\ x\ L)} = \frac{k_{(B\ x\ B)}\left(1+0.5\frac{B}{L}\right)}{1.5} \qquad (2)$$

Where:

$k_{(B\ x\ B)}$ = the modulus of subgrade reaction for a $B \times B$ square load footprint
$k_{(B\ x\ L)}$ = the modulus of subgrade reaction for $B \times L$ rectangular load footprint
B = the least horizontal dimension of a rectangular load footprint
L = the larger horizontal dimension of a rectangular load footprint

3.3 Lateral Earth Pressures

An active-earth pressure condition will prevail (under static loading) if a retaining wall is allowed to deflect or rotate a minimum of 0.001 times by the wall height. An at-rest pressure condition will prevail if a retaining wall is restrained at the top and cannot move at least 0.002 times the wall height. Lateral forces exerted by wind or seismic activity may be resisted by passive-earth pressures against the sides of the foundation footings, exterior walls (below grade), and grade beams. Therefore, interior footings should extend a minimum of 12 inches below the finished floor grade (assuming a continuously heated building is maintained during winter months) to help resist any lateral forces.

In order to prevent water accumulation against the outside of any foundation or retaining wall, the wall must have a perimeter drainage system connected to an outlet that will not freeze closed at any time of the year. The top of the drainage piping must be located below the top of the footing for the foundation and/or retaining wall. Backfill used against the wall (and extending a minimum of one foot beyond the wall) must be free-draining with less than three percent fines. The top one-foot of backfill against the outside of a foundation and/or retaining wall should consist of relatively impermeable (fine-grained) material and be tightly compacted such that surface water is directed away from the foundation and/or retaining wall. A permeable geotextile fabric may be useful to prevent mixing of the impermeable (fine-grained) overburden and underlying free-draining (coarse-grained) backfill. Furthermore, the finished surface should slope away from any foundation and/or retaining wall with a grade between 1 to 2 percent, such that surface water is directed away from the foundation and/or retaining wall.

Seismic loading on foundation and/or retaining walls generally increases the lateral pressures on the wall and decreases the passive resistance. For foundation systems where the building foundation is continuous, the differential lateral movement between the soil and foundation is very small, and as such, essentially no excess lateral loading on the foundation wall is experienced. Foundation walls with a differential in backfill heights of over six feet (basements, crawl spaces, etc.) will experience seismic lateral loading from the inertial effects of seismic waves passing through the foundation.

3.4 Pavement Sections

Construction of the pavement section for the proposed roads and parking areas will be guided (in part) by the amount of cut/fill needed to achieve the final grade. The composition, structure, and thickness of the pavement section will be further controlled by the frost susceptibility of, and overall potential for ice lens development within, the subgrade soils.

There are three primary factors that influence the potential for ice lens formation at a given site:

1. soil gradation (i.e., ability to draw up moisture through capillary tension);
2. the presence of sufficient volumes of water (surface water, pore water, or groundwater) near the freeze front to foster ice lens development; and
3. the rate and duration of freeze-front advancement due to air temperature and wind variations.

All three factors need to occur simultaneously in order for ice lenses to develop in the subgrade.

Materials:

As we discuss in the report, it is our experience that the “D-1” leveling course material currently available in Anchorage area may not be NFS following compaction, because the compaction with a vibratory compactor further increases the frost susceptibility of the leveling course by increasing the percentage of fine-grained material (due to degradation of the soil particles from the impact of the compaction equipment).

RAP has a low frost susceptibility, making it a suitable alternative for D-1 as the leveling course material.

No Type A materials should be placed within 12 inches of any pavement surfaces to help reduce the risk of pavement dimpling (from oversized particles contained within the Type A material).

4.0 CONSTRUCTION RECOMMENDATIONS

4.1 Warm Shallow Foundations

It is imperative that shallow building foundations for heated structures remain in a thawed state for the entire construction period; even when dealing with soils that have little to no frost susceptibility. Foundation soils that are allowed to freeze during the initial construction (before the building is enclosed and heated) may be compromised by the development of ice lenses. Upon thawing, which may take several weeks or months, potential differential settlements could distort the structure resulting in damaged foundations, cracked sheetrock, skewed door frames, and broken windows.

If construction extends into the winter months, temporary enclosures should be constructed which completely enclose warm foundations and heat should be applied to the enclosure to prevent freezing of the soils located beneath any warm foundation and/or floor slab.

5.0 THE OBSERVATIONAL METHOD

A comprehensive geoprofessional service (e.g., geotechnical, geological, civil, and/or environmental engineering, etc.) should consist of an interdependent, two-part process comprised of:

Part I - pre-construction site assessment, engineering, and design; and

Part II - continuous construction oversight and design support.

This process, commonly referred to in the geoprofessional industry as "The Observational Method", was developed to reduce the costs required to complete a construction project, while simultaneously reducing the overall risk associated with the design and construction of the project.

In geotechnical engineering, Part I of the Observational Method (OM) begins with a geotechnical assessment of the site, which typically consists of some combination of literature research, site reconnaissance, subsurface exploration, laboratory testing, and geotechnical engineering. These efforts are usually documented in a formal report (e.g., such as this report) that summarizes the findings of the geotechnical assessment, and presents provisional geotechnical engineering recommendations for design and construction. Geotechnical assessment reports (and the findings and recommendations contained within) are considered provisional due to the fact that their contents are typically based primarily on limited subsurface information for a site. Most conventional geotechnical exploration programs only physically characterize a very small percentage of a given site, as it is typically cost prohibitive to conduct extensive (i.e. high density/frequency) exploration programs. As an alternative, geoprofessionals use the subsurface information available for a site to extrapolate subsurface conditions between exploration locations and develop appropriate provisional recommendations based on the inferred site conditions. As a result, the geoprofessional of record cannot be certain that the provisional recommendations will be wholly applicable to the site, as subsurface conditions other than those identified during the geotechnical assessment may exist at the site which could present obstacles and/or increased risk to the proposed design and construction.

Part II of the OM is employed by geoprofessionals to help reduce the risk associated with unidentified and/or unexpected subsurface conditions. Geoprofessionals accomplish Part II of the OM by providing construction oversight (e.g., construction observation, inspection, and testing). Part II of the OM is a valuable service, as the geoprofessional of record is available if unexpected conditions are encountered during the construction process (e.g., during excavation, fill placement, etc.) to make timely assessments of the unexpected conditions and modify their design and construction recommendations accordingly; thus reducing considerable cost resulting from potential construction delays and reducing the risk of future problems resulting from inappropriate design and construction practices.

Oftentimes, a client may be persuaded to use an alternative geoprofessional firm to conduct Part II of the OM for a given project; as some geoprofessional firms offer the same services at discounted prices in order to help them obtain the overall construction materials engineering and testing (CoMET) commission. The geoprofessional industry as a whole recommends against this practice. An alternative geoprofessional firm cannot provide the same level of service as the geoprofessional of record. The geoprofessional of record has (amongst other things) a unique familiarity with the project including; an intimate understanding of the subsurface conditions, the proposed design, and the client's unique concerns and needs, as well as other factors that could impact the successful completion of a construction project. An alternative geoprofessional firm is not aware of the inferences made and the judgment applied by the geoprofessional of record in developing the provisional recommendations, and may overlook opportunities to provide extra value during Part II of the geoprofessional service.

Clients that prevent the geoprofessional of record from performing a complete service can be held solely liable for any complications stemming from engineering omissions as a result of unidentified conditions. The geoprofessional of record may not be liable for any resulting complications that occur, as the geoprofessional of record was not able to complete their services. Furthermore, the replacement geoprofessional firm may also be found to have no liability for the same reasons.

We are available at any time to discuss the OM in more detail, or to provide you with an estimate for any additional construction observation and testing services required.

APPENDIX C

LABORATORY TEST RESULTS

Summary of Laboratory Test Results

WASI Housing PH II

NGE-TFT Project #:6520-22

Exploration ID	Sample Number	Depth Interval (ft) Top	(ft) Bottom	Moisture Content ASTM D2216 (% By Dry Mass)	Particle Size Analysis ASTM C136/D7928/D6913 (% By Mass) Gravel	Sand	Silt/Clay	Passing #200 ASTM D1140 (% By Mass)	Passing 0.02mm ASTM D7928 (% By Mass)	Frost Class.	Unified Soil Classification ASTM D2487
B9	B9S1	0.0	1.5	3.6	71.7	23.6	4.7		3.2	S1	(GP) Poorly-graded gravel w/ sand
B9	B9S2	2.5	4.0	4.9							
B9	B9S3	5.0	6.5	3.8	53.4	38.6	8.0				(GW-GM) Well-graded gravel w/ silt and sand
B9	B9S4	7.5	9.0	4.3							
B9	B9S5	10.0	11.5	2.9							
B9	B9S6	15.0	16.5	10.9							
B9	B9S7	20.0	21.5	16.4							
B9	B9S9	30.0	31.5	13.1							
B10	B10S1	0.0	1.5	10.5	60.5	34.8	4.7				(GP) Poorly-graded gravel w/ sand
B10	B10S2	2.5	4.0	16.4							
B10	B10S3	5.0	6.5	3.5	47.2	43.9	8.9		4.0	S1	(GP-GM) Poorly-graded gravel w/ silt and sand
B10	B10S4	7.5	9.0	5.1							
B10	B10S5	10.0	11.5	5.0							
B10	B10S6	15.0	16.5	6.6							
B10	B10S7	20.0	21.5	8.6							
B11	B11S1	0.0	1.5	5.0	48.1	46.2	5.7		3.0	S1	(GP-GM) Poorly-graded gravel w/ silt and sand
B11	B11S2	2.5	4.0	7.6							
B11	B11S3	5.0	6.5	2.3	55.6	39.3	5.1				(GW-GM) Well-graded gravel w/ silt and sand
B11	B11S4	7.5	9.0	3.0							
B11	B11S5	10.0	11.5	5.8							
B11	B11S6	15.0	16.5	11.3							
B11	B11S7	20.0	21.5	13.7							
B11	B11S8	25.0	26.5	19.1							
B11	B11S9	30.0	31.5	10.2							
B12	B12S1	0.0	1.5	10.8	48.9	44.1	7.0		3.2	S1	(GP-GM) Poorly-graded gravel w/ silt and sand
B12	B12S2	2.5	4.0	6.6							
B12	B12S3	5.0	6.5	3.6	30.3	62.3	7.4				(SP-SM) Poorly-graded sand w/ silt and gravel
B12	B12S4	7.5	9.0	5.4							
B12	B12S5	10.0	11.5	13.3							
B12	B12S6	15.0	16.5	12.7							
B12	B12S7	20.0	21.5	17.6							
B13	B13S1	0.0	1.5	5.1	51.2	41.8	7.0		3.5	S1	(GP-GM) Poorly-graded gravel w/ silt and sand
B13	B13S2	2.5	4.0	4.1							
B13	B13S3	5.0	6.5	2.8	46.9	49.1	4.0				(SP) Poorly-graded sand w/ gravel
B13	B13S4	7.5	9.0	5.7							
B13	B13S5	10.0	11.5	9.4							
B13	B13S6	15.0	16.5	6.9							
B13	B13S7	20.0	21.5	18.9				30.3			
B14	B14S1	0.0	1.5	5.1							
B14	B14S2	2.5	4.0	4.9	46.8	47.5	5.7				(SP-SM) Poorly-graded sand w/ silt and gravel
B14	B14S3	5.0	6.5	4.0	44.0	49.2	6.8		3.5	PFS	(SP-SM) Poorly-graded sand w/ silt and gravel
B14	B14S4	7.5	9.0	3.2							
B14	B14S5	10.0	11.5	2.5							
B14	B14S6	15.0	16.5	8.8							
B14	B14S7	20.0	21.5	11.5							

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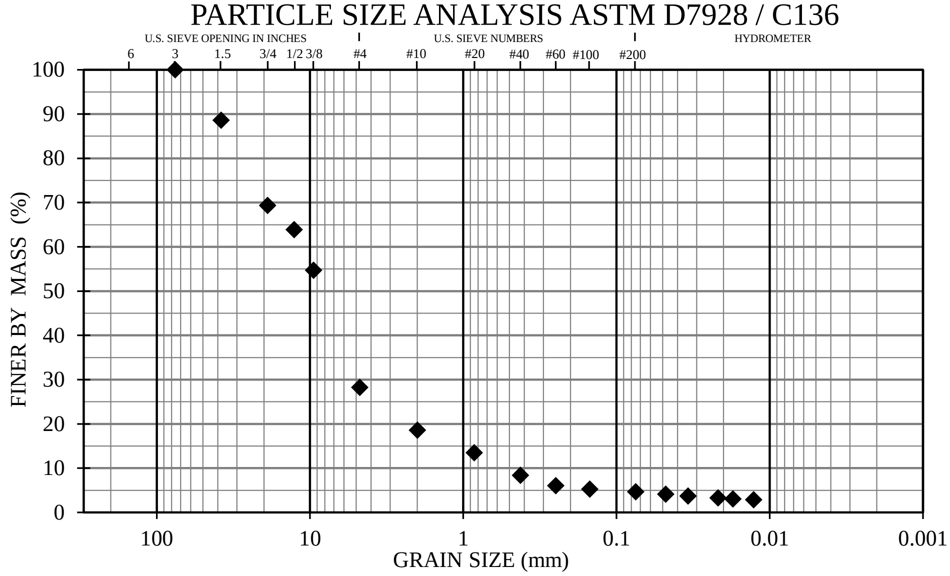
PROJECT CLIENT:	**Spark Design, LLC**
PROJECT NAME:	**WASI Housing PH II**
PROJECT NO.:	**6520-22**
SAMPLE LOC.:	**B9**
NUMBER/ DEPTH:	**B9S1 / 0 - 1.5'**
DESCRIPTION:	**Poorly-graded gravel w/ sand**
DATE RECEIVED:	**10/12/2022**
TESTED BY:	**Sean Totzke**
REVIEWED BY:	**ACS**

% GRAVEL	**71.7**	USCS	**GP**
% SAND	**23.6**	USACOE FC	**S1**
% SILT/CLAY	**4.7**	% PASS. 0.02 mm	**3.2**
% MOIST. CONTENT	**3.6**	% PASS. 0.002 mm	**N/A**
UNIFORMITY COEFFICIENT (C_u)	**20.3**		
COEFFICIENT OF GRADATION (C_c)	**4.0**		
ASTM D1557 (uncorrected)	**N/A**		
ASTM D4718 (corrected)	**N/A**		
OPTIMUM MOIST. CONTENT. (corrected)	**N/A**		

PARTICLE SIZE ANALYSIS ASTM D7928 / C136

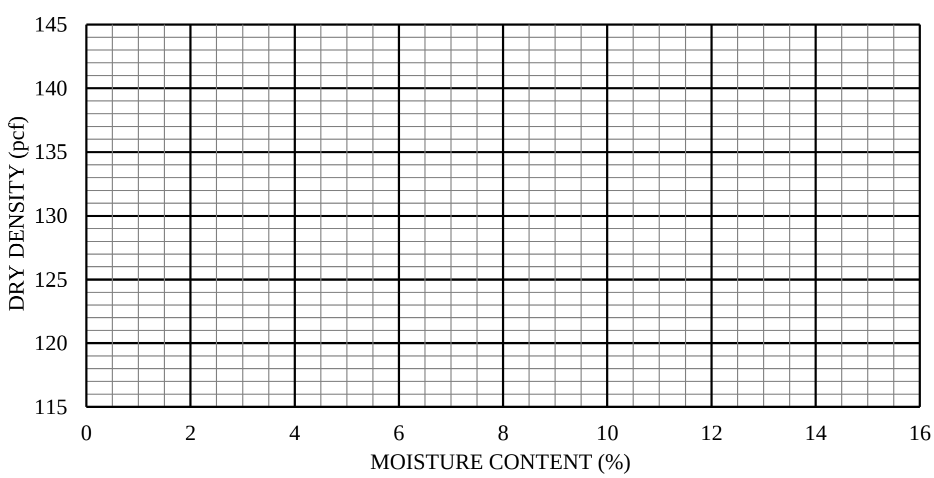


COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"	**100**	
38.10	1.5"	**89**	
19.00	3/4"	**69**	
12.70	1/2"	**64**	
9.50	3/8"	**55**	
4.75	#4	**28**	
2.00	#10	**19**	
0.85	#20	**13**	
0.43	#40	**8**	
0.25	#60	**6**	
0.15	#100	**5**	
0.075	#200	**4.7**	

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
1	0.0478	4.1
2	0.0342	3.7
5	0.0218	3.3
8	0.0174	3.1
15	0.0127	2.9
30		
60		
250		
1440		

HYDRAULIC COND. (ASTM D2434)	**N/A**
DEGRADATION (ATM T-313)	**N/A**
PLASTICITY INDEX ASTM 4318	**N/A**

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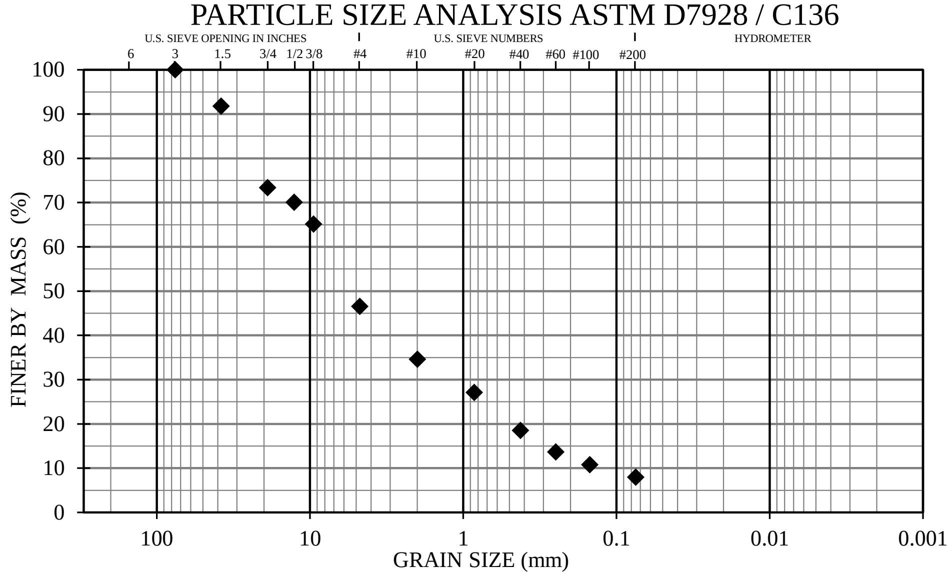
PROJECT CLIENT:	**Spark Design, LLC**
PROJECT NAME:	**WASI Housing PH II**
PROJECT NO.:	**6520-22**
SAMPLE LOC.:	**B9**
NUMBER/ DEPTH:	**B9S3 / 5 - 6.5'**
DESCRIPTION:	**Well-graded gravel w/ silt and sand**
DATE RECEIVED:	**10/12/2022**
TESTED BY:	**PT**
REVIEWED BY:	**ACS**

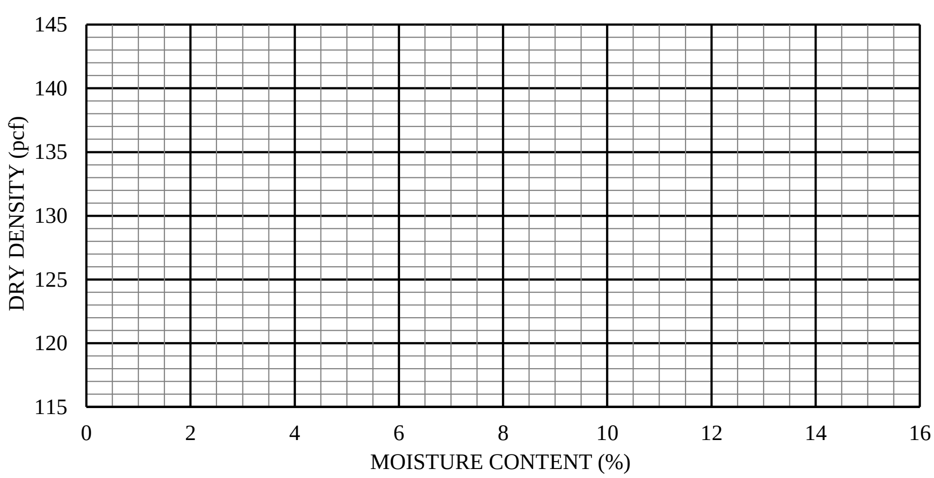
% GRAVEL	**53.4**	USCS	**GW-GM**
% SAND	**38.6**	USACOE FC	**N/A**
% SILT/CLAY	**8.0**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT	**3.7**	% PASS. 0.002 mm	**N/A**
UNIFORMITY COEFFICIENT (C_u)		**63.9**	
COEFFICIENT OF GRADATION (C_c)		**1.6**	
ASTM D1557 (uncorrected)		**N/A**	
ASTM D4718 (corrected)		**N/A**	
OPTIMUM MOIST. CONTENT. (corrected)		**N/A**	

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"	**100**	
38.10	1.5"	**92**	
19.00	3/4"	**73**	
12.70	1/2"	**70**	
9.50	3/8"	**65**	
4.75	#4	**47**	
2.00	#10	**35**	
0.85	#20	**27**	
0.43	#40	**19**	
0.25	#60	**14**	
0.15	#100	**11**	
0.075	#200	**8.0**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
1		
2		
5		
8		
15		
30		
60		
250		
1440		

HYDRAULIC COND. (ASTM D2434)	**N/A**
DEGRADATION (ATM T-313)	**N/A**
PLASTICITY INDEX ASTM 4318	**N/A**

The testing services reported herein have been performed to recognized industry standards, unless otherwise noted. No other warranty is made. Should engineering interpretation or opinion be required, NGE-TFT will provide upon written request.

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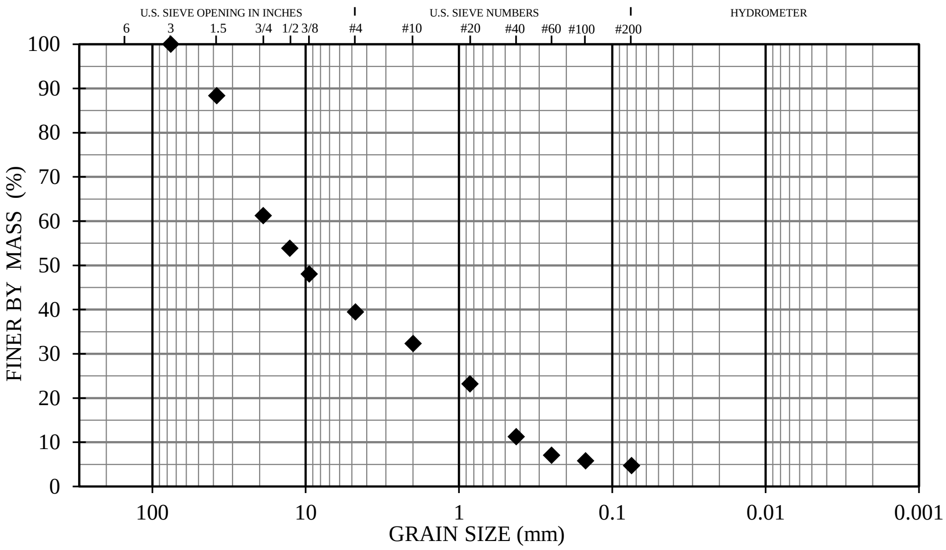
PROJECT CLIENT:	**Spark Design, LLC**
PROJECT NAME:	**WASI Housing PH II**
PROJECT NO.:	**6520-22**
SAMPLE LOC.:	**B10**
NUMBER/ DEPTH:	**B10S1 / 0 - 1.5'**
DESCRIPTION:	**Poorly-graded gravel w/ sand**
DATE RECEIVED:	**10/12/2022**
TESTED BY:	**PT**
REVIEWED BY:	**ACS**

% GRAVEL	**60.5**	USCS	**GP**
% SAND	**34.8**	USACOE FC	**N/A**
% SILT/CLAY	**4.7**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT	**10.5**	% PASS. 0.002 mm	**N/A**
UNIFORMITY COEFFICIENT (C_u)	**48.2**		
COEFFICIENT OF GRADATION (C_c)	**0.4**		
ASTM D1557 (uncorrected)	**N/A**		
ASTM D4718 (corrected)	**N/A**		
OPTIMUM MOIST. CONTENT. (corrected)	**N/A**		

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

SIEVE ANALYSIS RESULT

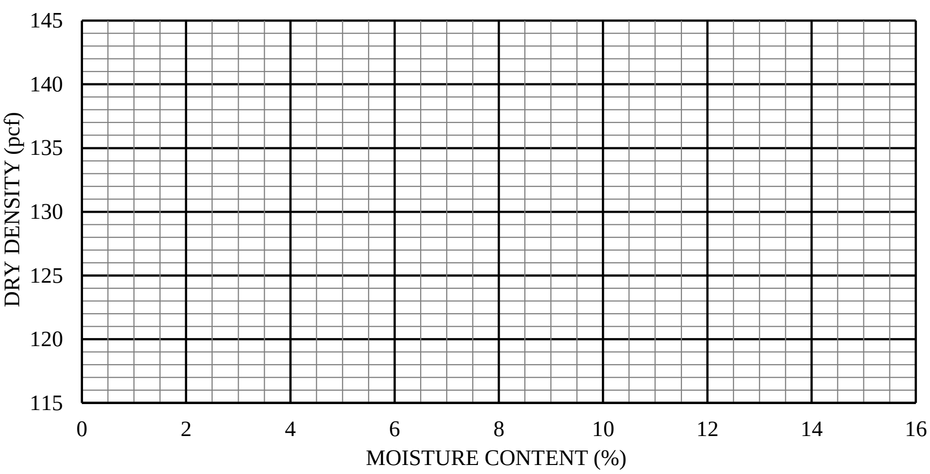
SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"	**100**	
38.10	1.5"	**88**	
19.00	3/4"	**61**	
12.70	1/2"	**54**	
9.50	3/8"	**48**	
4.75	#4	**39**	
2.00	#10	**32**	
0.85	#20	**23**	
0.43	#40	**11**	
0.25	#60	**7**	
0.15	#100	**6**	
0.075	#200	**4.7**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
1		
2		
5		
8		
15		
30		
60		
250		
1440		

HYDRAULIC COND. (ASTM D2434)	**N/A**
DEGRADATION (ATM T-313)	**N/A**
PLASTICITY INDEX ASTM 4318	**N/A**

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



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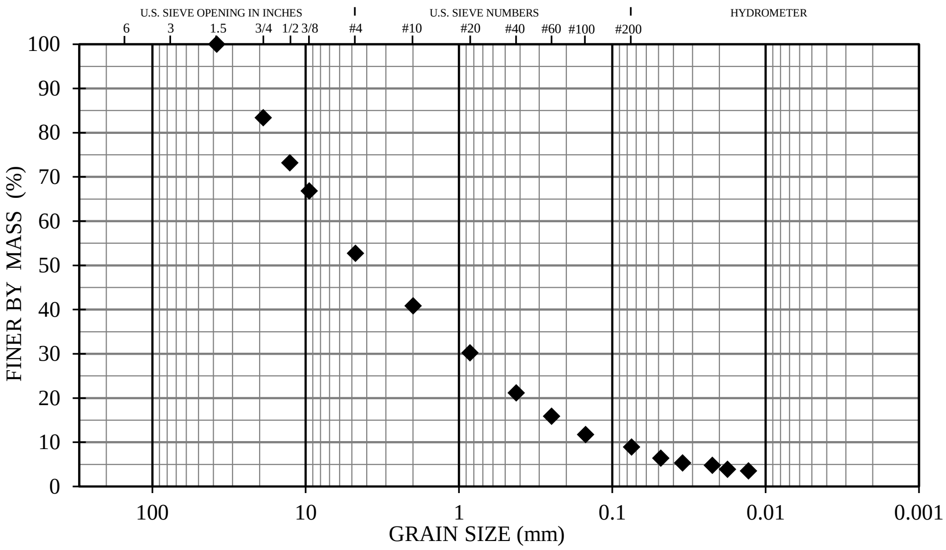
PROJECT CLIENT:	**Spark Design, LLC**
PROJECT NAME:	**WASI Housing PH II**
PROJECT NO.:	**6520-22**
SAMPLE LOC.:	**B10**
NUMBER/ DEPTH:	**B10S3 / 5 - 6.5'**
DESCRIPTION:	**Poorly-graded gravel w/ silt and sand**
DATE RECEIVED:	**10/12/2022**
TESTED BY:	**PT**
REVIEWED BY:	**ACS**

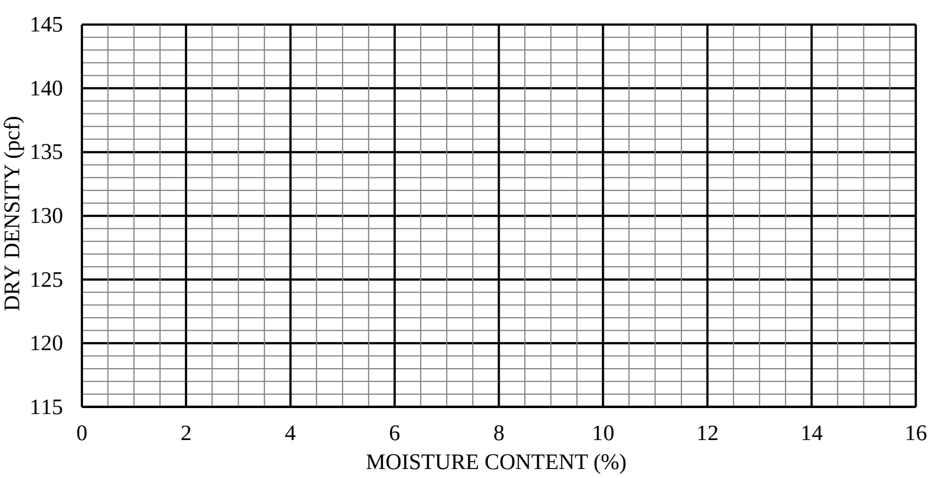
% GRAVEL	**47.2**	USCS	**GP-GM**
% SAND	**43.9**	USACOE FC	**S1**
% SILT/CLAY	**8.9**	% PASS. 0.02 mm	**4.0**
% MOIST. CONTENT	**3.5**	% PASS. 0.002 mm	**N/A**
UNIFORMITY COEFFICIENT (C_u)		**69.4**	
COEFFICIENT OF GRADATION (C_c)		**0.9**	
ASTM D1557 (uncorrected)		**N/A**	
ASTM D4718 (corrected)		**N/A**	
OPTIMUM MOIST. CONTENT. (corrected)		**N/A**	

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"		
38.10	1.5"	**100**	
19.00	3/4"	**83**	
12.70	1/2"	**73**	
9.50	3/8"	**67**	
4.75	#4	**53**	
2.00	#10	**41**	
0.85	#20	**30**	
0.43	#40	**21**	
0.25	#60	**16**	
0.15	#100	**12**	
0.075	#200	**8.9**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
1	0.0484	6.4
2	0.0349	5.4
5	0.0223	4.8
8	0.0178	3.9
15	0.0130	3.5
30		
60		
250		
1440		

HYDRAULIC COND. (ASTM D2434)	**N/A**
DEGRADATION (ATM T-313)	**N/A**
PLASTICITY INDEX ASTM 4318	**N/A**

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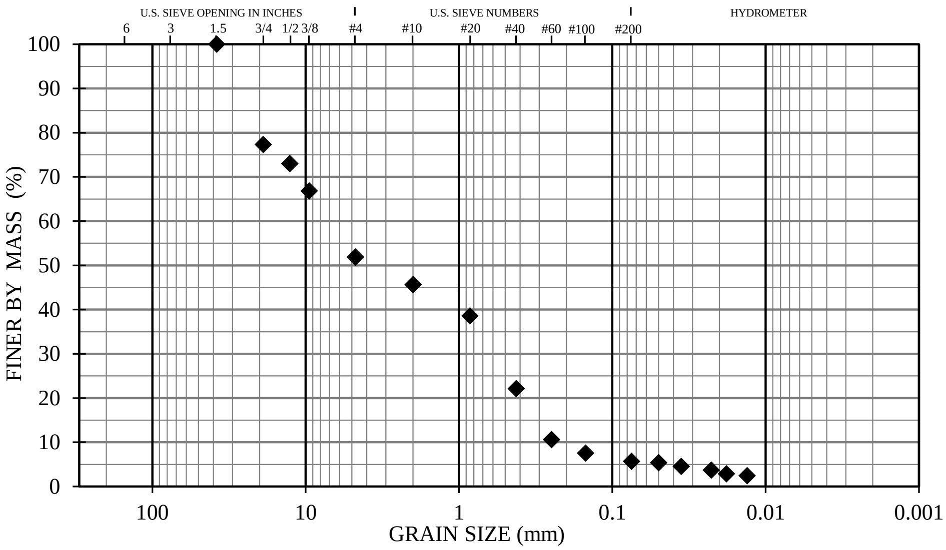
PROJECT CLIENT:	**Spark Design, LLC**
PROJECT NAME:	**WASI Housing PH II**
PROJECT NO.:	**6520-22**
SAMPLE LOC.:	**B11**
NUMBER/ DEPTH:	**B11S1 / 0 - 1.5'**
DESCRIPTION:	**Poorly-graded gravel w/ silt and sand**
DATE RECEIVED:	**10/12/2022**
TESTED BY:	**PT**
REVIEWED BY:	**ACS**

% GRAVEL	**48.1**	USCS	**GP-GM**
% SAND	**46.2**	USACOE FC	**S1**
% SILT/CLAY	**5.7**	% PASS. 0.02 mm	**3.0**
% MOIST. CONTENT	**5.0**	% PASS. 0.002 mm	**N/A**
UNIFORMITY COEFFICIENT (C_u)	**32.0**		
COEFFICIENT OF GRADATION (C_c)	**0.2**		
ASTM D1557 (uncorrected)	**N/A**		
ASTM D4718 (corrected)	**N/A**		
OPTIMUM MOIST. CONTENT. (corrected)	**N/A**		

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

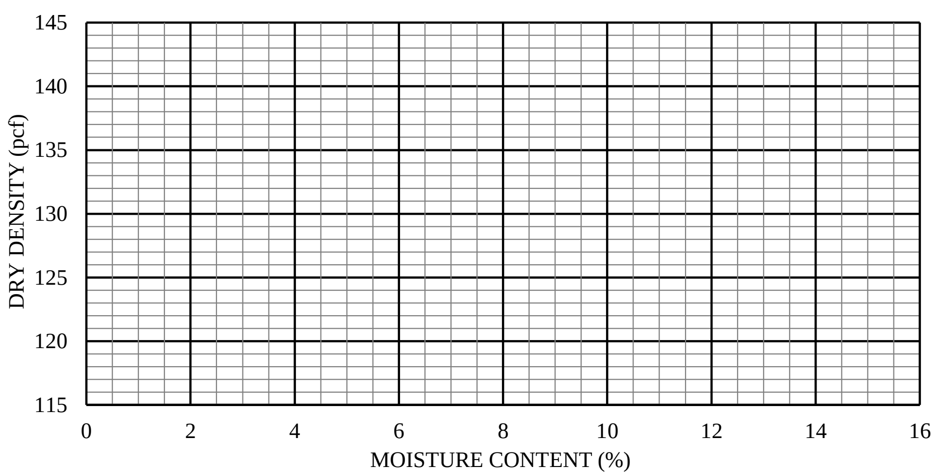
SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"		
38.10	1.5"	**100**	
19.00	3/4"	**77**	
12.70	1/2"	**73**	
9.50	3/8"	**67**	
4.75	#4	**52**	
2.00	#10	**46**	
0.85	#20	**39**	
0.43	#40	**22**	
0.25	#60	**11**	
0.15	#100	**8**	
0.075	#200	**5.7**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
1	0.0499	5.4
2	0.0355	4.6
5	0.0227	3.7
8	0.0181	2.9
15	0.0132	2.5
30		
60		
250		
1440		

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



HYDRAULIC COND. (ASTM D2434)	**N/A**
DEGRADATION (ATM T-313)	**N/A**
PLASTICITY INDEX ASTM 4318	**N/A**

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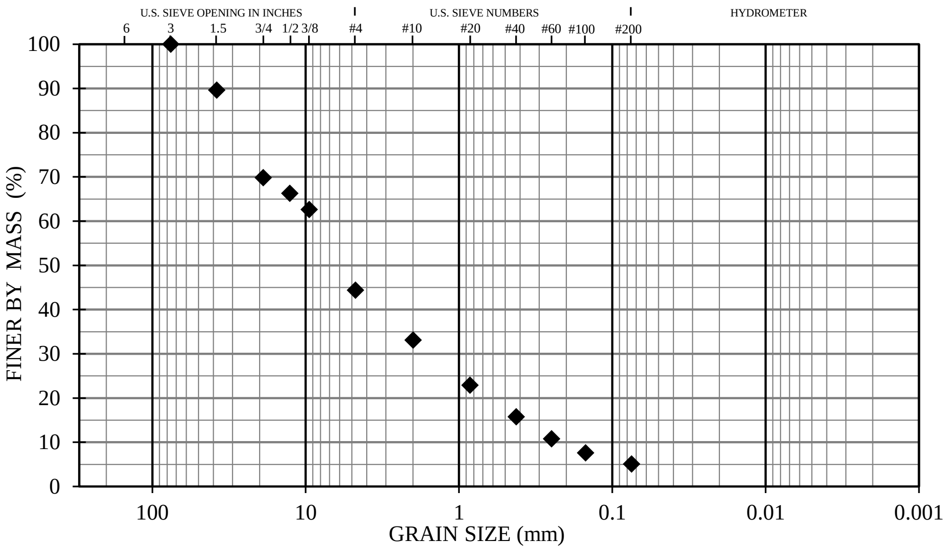
PROJECT CLIENT:	**Spark Design, LLC**
PROJECT NAME:	**WASI Housing PH II**
PROJECT NO.:	**6520-22**
SAMPLE LOC.:	**B11**
NUMBER/ DEPTH:	**B11S3 / 5 - 6.5'**
DESCRIPTION:	**Well-graded gravel w/ silt and sand**
DATE RECEIVED:	**10/12/2022**
TESTED BY:	**PT**
REVIEWED BY:	**ACS**

% GRAVEL	**55.6**	USCS	**GW-GM**
% SAND	**39.3**	USACOE FC	**N/A**
% SILT/CLAY	**5.1**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT	**2.3**	% PASS. 0.002 mm	**N/A**

UNIFORMITY COEFFICIENT (C_u)	**39.2**
COEFFICIENT OF GRADATION (C_c)	**1.4**
ASTM D1557 (uncorrected)	**N/A**
ASTM D4718 (corrected)	**N/A**
OPTIMUM MOIST. CONTENT. (corrected)	**N/A**

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

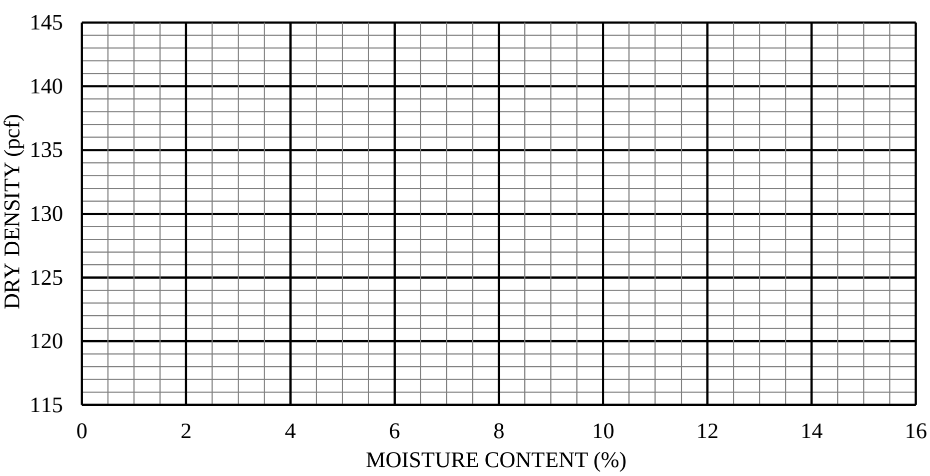
SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"	**100**	
38.10	1.5"	**90**	
19.00	3/4"	**70**	
12.70	1/2"	**66**	
9.50	3/8"	**63**	
4.75	#4	**44**	
2.00	#10	**33**	
0.85	#20	**23**	
0.43	#40	**16**	
0.25	#60	**11**	
0.15	#100	**8**	
0.075	#200	**5.1**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
1		
2		
5		
8		
15		
30		
60		
250		
1440		

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



HYDRAULIC COND. (ASTM D2434)	**N/A**
DEGRADATION (ATM T-313)	**N/A**
PLASTICITY INDEX ASTM 4318	**N/A**

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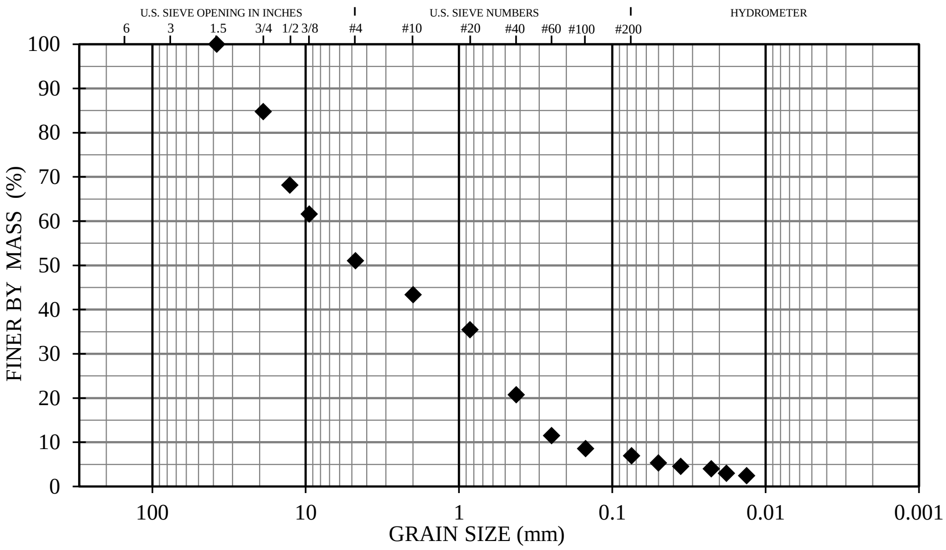
PROJECT CLIENT:	**Spark Design, LLC**
PROJECT NAME:	**WASI Housing PH II**
PROJECT NO.:	**6520-22**
SAMPLE LOC.:	**B12**
NUMBER/ DEPTH:	**B12S1 / 0 - 1.5'**
DESCRIPTION:	**Poorly-graded gravel w/ silt and sand**
DATE RECEIVED:	**10/12/2022**
TESTED BY:	**ST**
REVIEWED BY:	**ACS**

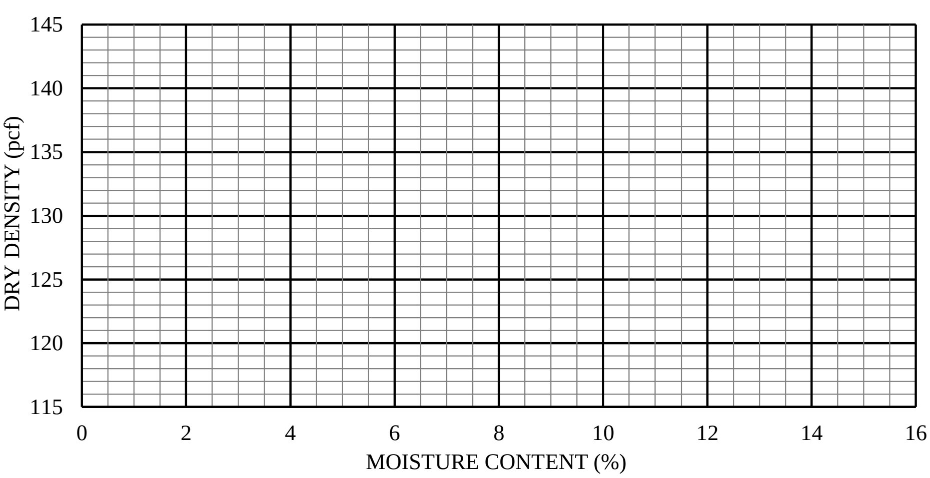
% GRAVEL	**48.9**	USCS	**GP-GM**
% SAND	**44.1**	USACOE FC	**S1**
% SILT/CLAY	**7.0**	% PASS. 0.02 mm	**3.2**
% MOIST. CONTENT	**10.8**	% PASS. 0.002 mm	**N/A**
UNIFORMITY COEFFICIENT (C_u)		**44.3**	
COEFFICIENT OF GRADATION (C_c)		**0.3**	
ASTM D1557 (uncorrected)		**N/A**	
ASTM D4718 (corrected)		**N/A**	
OPTIMUM MOIST. CONTENT. (corrected)		**N/A**	

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"		
38.10	1.5"	**100**	
19.00	3/4"	**85**	
12.70	1/2"	**68**	
9.50	3/8"	**62**	
4.75	#4	**51**	
2.00	#10	**43**	
0.85	#20	**35**	
0.43	#40	**21**	
0.25	#60	**12**	
0.15	#100	**9**	
0.075	#200	**7.0**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
1	0.0503	5.3
2	0.0359	4.5
5	0.0227	4.0
8	0.0181	3.0
15	0.0133	2.5
30		
60		
250		
1440		

HYDRAULIC COND. (ASTM D2434)	**N/A**
DEGRADATION (ATM T-313)	**N/A**
PLASTICITY INDEX ASTM 4318	**N/A**

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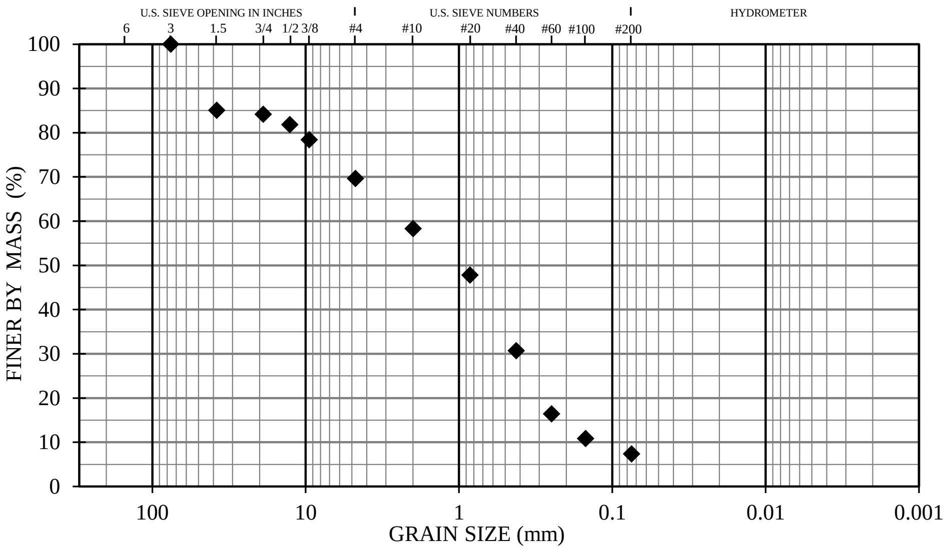
PROJECT CLIENT:	**Spark Design, LLC**
PROJECT NAME:	**WASI Housing PH II**
PROJECT NO.:	**6520-22**
SAMPLE LOC.:	**B12**
NUMBER/ DEPTH:	**B12S3 / 5 - 6.5'**
DESCRIPTION:	**Poorly-graded sand w/ silt and gravel**
DATE RECEIVED:	**10/12/2022**
TESTED BY:	**ST**
REVIEWED BY:	**ACS**

% GRAVEL	**30.3**	USCS	**SP-SM**
% SAND	**62.3**	USACOE FC	**N/A**
% SILT/CLAY	**7.4**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT	**3.6**	% PASS. 0.002 mm	**N/A**
UNIFORMITY COEFFICIENT (C_u)		**18.3**	
COEFFICIENT OF GRADATION (C_c)		**0.5**	
ASTM D1557 (uncorrected)		**N/A**	
ASTM D4718 (corrected)		**N/A**	
OPTIMUM MOIST. CONTENT. (corrected)		**N/A**	

PARTICLE SIZE ANALYSIS ASTM D7928 / C136

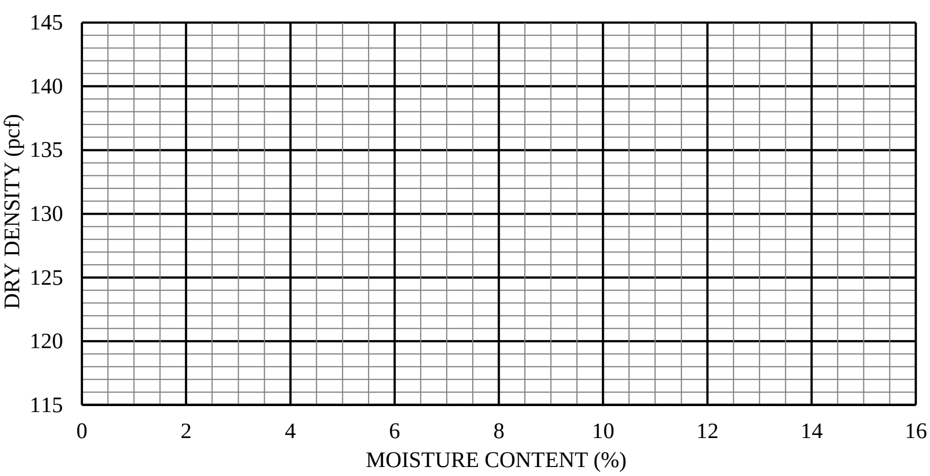


COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"	**100**	
38.10	1.5"	**85**	
19.00	3/4"	**84**	
12.70	1/2"	**82**	
9.50	3/8"	**78**	
4.75	#4	**70**	
2.00	#10	**58**	
0.85	#20	**48**	
0.43	#40	**31**	
0.25	#60	**16**	
0.15	#100	**11**	
0.075	#200	**7.4**	

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
1		
2		
5		
8		
15		
30		
60		
250		
1440		

HYDRAULIC COND. (ASTM D2434)	**N/A**
DEGRADATION (ATM T-313)	**N/A**
PLASTICITY INDEX ASTM 4318	**N/A**

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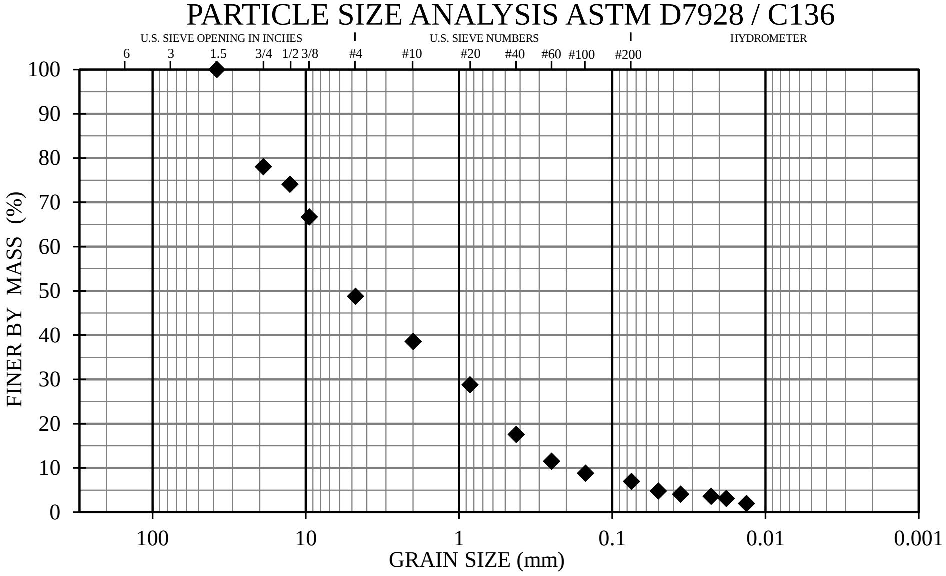
PROJECT CLIENT:	**Spark Design, LLC**
PROJECT NAME:	**WASI Housing PH II**
PROJECT NO.:	**6520-22**
SAMPLE LOC.:	**B13**
NUMBER/ DEPTH:	**B13S1 / 0 - 1.5'**
DESCRIPTION:	**Poorly-graded gravel w/ silt and sand**
DATE RECEIVED:	**10/12/2022**
TESTED BY:	**ST**
REVIEWED BY:	**ACS**

% GRAVEL	**51.2**	USCS	**GP-GM**
% SAND	**41.8**	USACOE FC	**S1**
% SILT/CLAY	**7.0**	% PASS. 0.02 mm	**3.5**
% MOIST. CONTENT	**5.1**	% PASS. 0.002 mm	**N/A**
UNIFORMITY COEFFICIENT (C_u)			**39.9**
COEFFICIENT OF GRADATION (C_c)			**0.7**
ASTM D1557 (uncorrected)			**N/A**
ASTM D4718 (corrected)			**N/A**
OPTIMUM MOIST. CONTENT. (corrected)			**N/A**

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

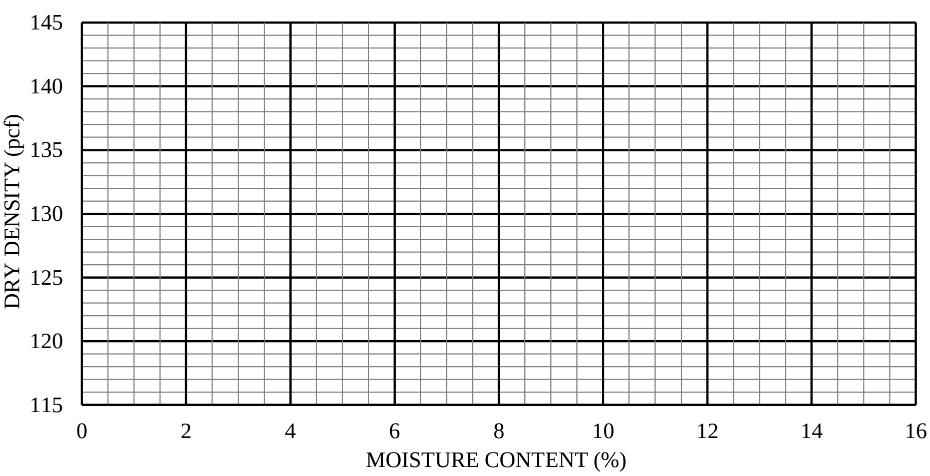
SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"		
38.10	1.5"	**100**	
19.00	3/4"	**78**	
12.70	1/2"	**74**	
9.50	3/8"	**67**	
4.75	#4	**49**	
2.00	#10	**39**	
0.85	#20	**29**	
0.43	#40	**18**	
0.25	#60	**12**	
0.15	#100	**9**	
0.075	#200	**7.0**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
1	0.0503	4.8
2	0.0359	4.1
5	0.0227	3.6
8	0.0181	3.1
15	0.0133	2.0
30		
60		
250		
1440		

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



HYDRAULIC COND. (ASTM D2434)	**N/A**
DEGRADATION (ATM T-313)	**N/A**
PLASTICITY INDEX ASTM 4318	**N/A**

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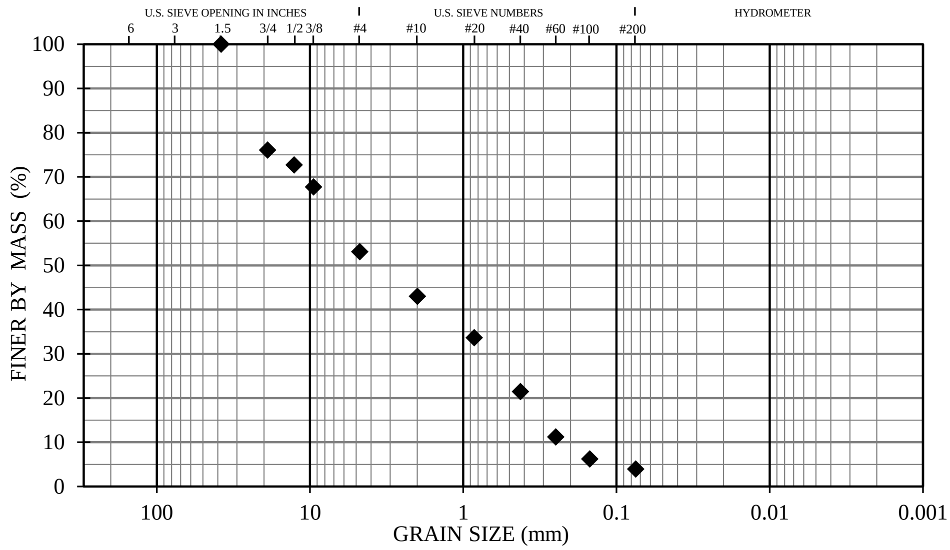
PROJECT CLIENT:	**Spark Design, LLC**
PROJECT NAME:	**WASI Housing PH II**
PROJECT NO.:	**6520-22**
SAMPLE LOC.:	**B13**
NUMBER/ DEPTH:	**B13S3 / 5 - 6.5'**
DESCRIPTION:	**Poorly-graded sand w/ gravel**
DATE RECEIVED:	**10/12/2022**
TESTED BY:	**ST**
REVIEWED BY:	**ACS**

% GRAVEL	**46.9**	USCS	**SP**
% SAND	**49.1**	USACOE FC	**N/A**
% SILT/CLAY	**4.0**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT	**2.8**	% PASS. 0.002 mm	**N/A**
UNIFORMITY COEFFICIENT (C_u)		**31.0**	
COEFFICIENT OF GRADATION (C_c)		**0.3**	
ASTM D1557 (uncorrected)		**N/A**	
ASTM D4718 (corrected)		**N/A**	
OPTIMUM MOIST. CONTENT. (corrected)		**N/A**	

PARTICLE SIZE ANALYSIS ASTM D7928 / C136

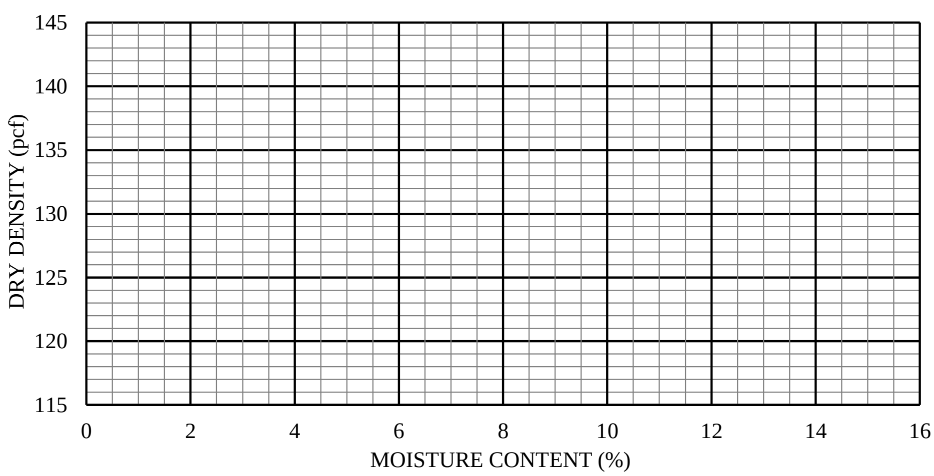


COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"		
38.10	1.5"	**100**	
19.00	3/4"	**76**	
12.70	1/2"	**73**	
9.50	3/8"	**68**	
4.75	#4	**53**	
2.00	#10	**43**	
0.85	#20	**34**	
0.43	#40	**21**	
0.25	#60	**11**	
0.15	#100	**6**	
0.075	#200	**4.0**	

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
1		
2		
5		
8		
15		
30		
60		
250		
1440		

HYDRAULIC COND. (ASTM D2434)	**N/A**
DEGRADATION (ATM T-313)	**N/A**
PLASTICITY INDEX ASTM 4318	**N/A**

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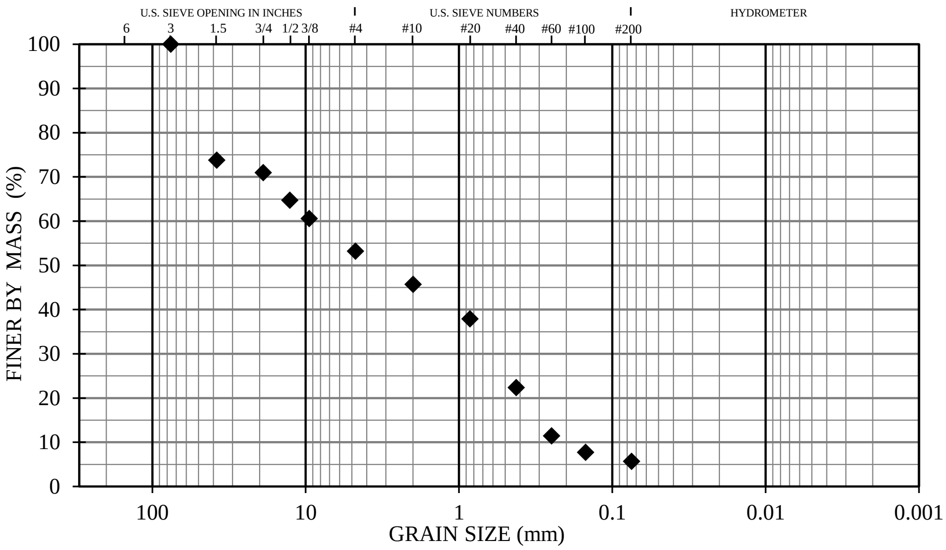
PROJECT CLIENT:	**Spark Design, LLC**
PROJECT NAME:	**WASI Housing PH II**
PROJECT NO.:	**6520-22**
SAMPLE LOC.:	**B14**
NUMBER/ DEPTH:	**B14S2 / 2.5 - 4'**
DESCRIPTION:	**Poorly-graded sand w/ silt and gravel**
DATE RECEIVED:	**10/12/2022**
TESTED BY:	**ST**
REVIEWED BY:	**ACS**

% GRAVEL	**46.8**	USCS	**SP-SM**
% SAND	**47.5**	USACOE FC	**N/A**
% SILT/CLAY	**5.7**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT	**4.9**	% PASS. 0.002 mm	**N/A**
UNIFORMITY COEFFICIENT (C_u)		**43.1**	
COEFFICIENT OF GRADATION (C_c)		**0.2**	
ASTM D1557 (uncorrected)		**N/A**	
ASTM D4718 (corrected)		**N/A**	
OPTIMUM MOIST. CONTENT. (corrected)		**N/A**	

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

SIEVE ANALYSIS RESULT

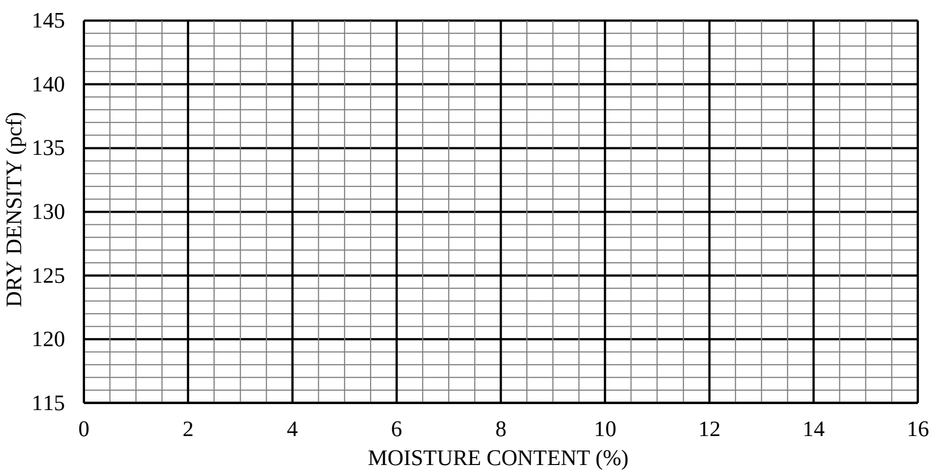
SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"	**100**	
38.10	1.5"	**74**	
19.00	3/4"	**71**	
12.70	1/2"	**65**	
9.50	3/8"	**61**	
4.75	#4	**53**	
2.00	#10	**46**	
0.85	#20	**38**	
0.43	#40	**22**	
0.25	#60	**11**	
0.15	#100	**8**	
0.075	#200	**5.7**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
1		
2		
5		
8		
15		
30		
60		
250		
1440		

HYDRAULIC COND. (ASTM D2434)	**N/A**
DEGRADATION (ATM T-313)	**N/A**
PLASTICITY INDEX ASTM 4318	**N/A**

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



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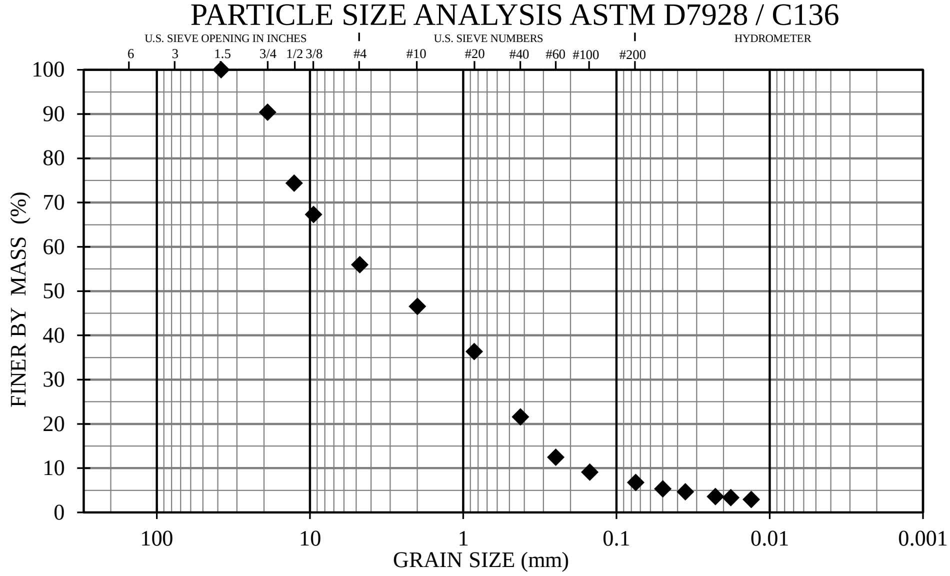
PROJECT CLIENT:	**Spark Design, LLC**
PROJECT NAME:	**WASI Housing PH II**
PROJECT NO.:	**6520-22**
SAMPLE LOC.:	**B14**
NUMBER/ DEPTH:	**B14S3 / 5 - 6.5'**
DESCRIPTION:	**Poorly-graded sand w/ silt and gravel**
DATE RECEIVED:	**10/12/2022**
TESTED BY:	**ST**
REVIEWED BY:	**ACS**

% GRAVEL	**44.0**	USCS	**SP-SM**
% SAND	**49.2**	USACOE FC	**PFS**
% SILT/CLAY	**6.8**	% PASS. 0.02 mm	**3.5**
% MOIST. CONTENT	**4.0**	% PASS. 0.002 mm	**N/A**
UNIFORMITY COEFFICIENT (C_u)		**36.4**	
COEFFICIENT OF GRADATION (C_c)		**0.4**	
ASTM D1557 (uncorrected)		**N/A**	
ASTM D4718 (corrected)		**N/A**	
OPTIMUM MOIST. CONTENT. (corrected)		**N/A**	

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

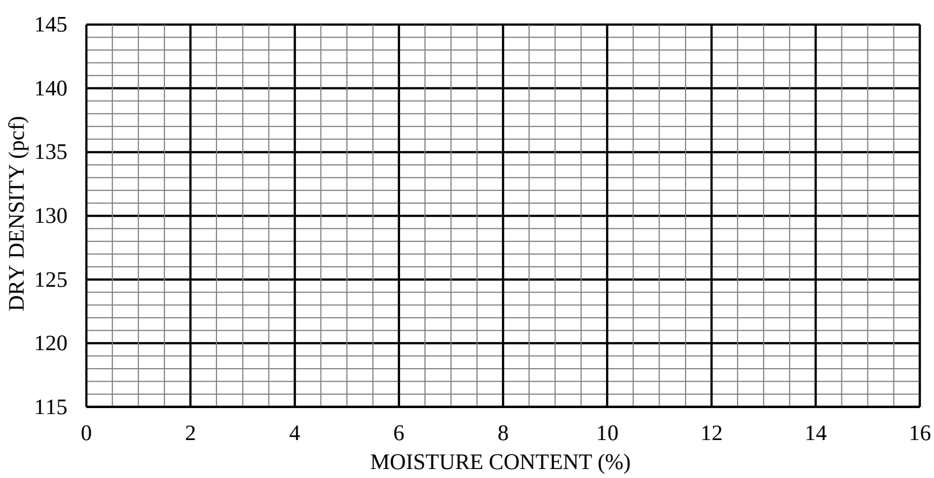
SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"		
38.10	1.5"	**100**	
19.00	3/4"	**90**	
12.70	1/2"	**74**	
9.50	3/8"	**67**	
4.75	#4	**56**	
2.00	#10	**47**	
0.85	#20	**36**	
0.43	#40	**22**	
0.25	#60	**12**	
0.15	#100	**9**	
0.075	#200	**6.8**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
1	0.0499	5.3
2	0.0355	4.7
5	0.0227	3.6
8	0.0180	3.4
15	0.0132	2.9
30		
60		
250		
1440		

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



HYDRAULIC COND. (ASTM D2434)	**N/A**
DEGRADATION (ATM T-313)	**N/A**
PLASTICITY INDEX ASTM 4318	**N/A**

The testing services reported herein have been performed to recognized industry standards, unless otherwise noted. No other warranty is made. Should engineering interpretation or opinion be required, NGE-TFT will provide upon written request.

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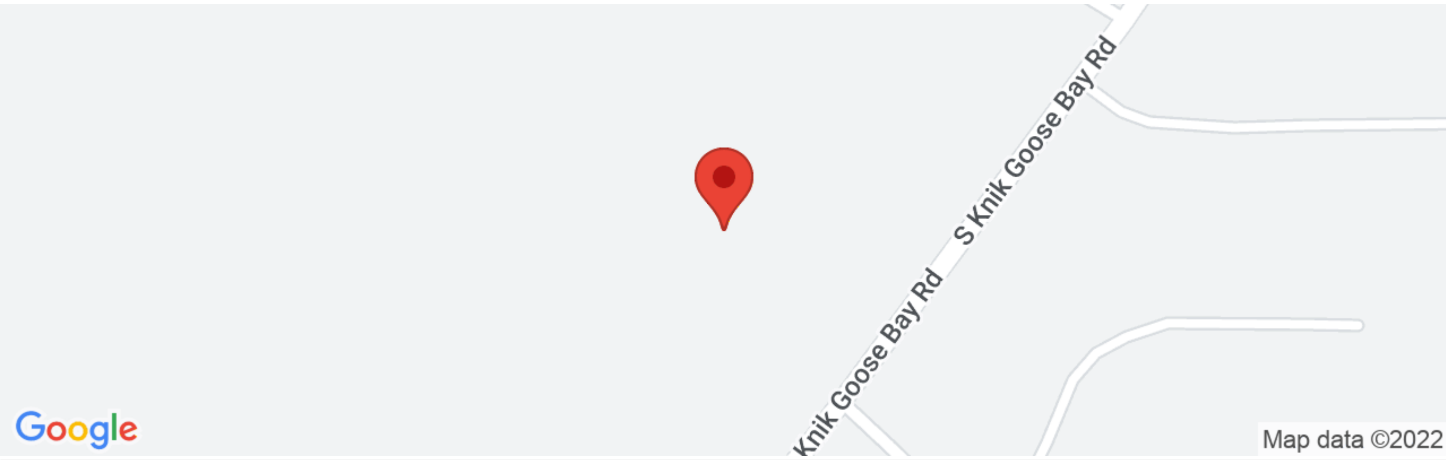
APPENDIX D

SEAOC SITE SPECIFIC SEISMIC LOADS

6520-22

1661 Frank Smith Way, Wasilla, AK 99654, USA

Latitude, Longitude: 61.5655308, -149.4525584



Date	11/3/2022, 12:59:02 PM
Design Code Reference Document	IBC-2015
Risk Category	II
Site Class	D - Stiff Soil

Type	Value	Description
S_S	1.626	MCE_R ground motion. (for 0.2 second period)
S_1	0.828	MCE_R ground motion. (for 1.0s period)
S_{MS}	1.626	Site-modified spectral acceleration value
S_{M1}	1.243	Site-modified spectral acceleration value
S_{DS}	1.084	Numeric seismic design value at 0.2 second SA
S_{D1}	0.828	Numeric seismic design value at 1.0 second SA

Type	Value	Description
SDC	E	Seismic design category
F_a	1	Site amplification factor at 0.2 second
F_v	1.5	Site amplification factor at 1.0 second
PGA	0.659	MCE_G peak ground acceleration
F_{PGA}	1	Site amplification factor at PGA
PGA_M	0.659	Site modified peak ground acceleration
T_L	16	Long-period transition period in seconds
SsRT	2.087	Probabilistic risk-targeted ground motion. (0.2 second)
SsUH	1.873	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration
SsD	1.626	Factored deterministic acceleration value. (0.2 second)
S1RT	0.913	Probabilistic risk-targeted ground motion. (1.0 second)
S1UH	0.897	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration.
S1D	0.828	Factored deterministic acceleration value. (1.0 second)
PGAd	0.659	Factored deterministic acceleration value. (Peak Ground Acceleration)
PGA_{UH}	0.74	Uniform-hazard (2% probability of exceedance in 50 years) Peak Ground Acceleration

Type	Value	Description
C_{RS}	1.114	Mapped value of the risk coefficient at short periods
C_{R1}	1.017	Mapped value of the risk coefficient at a period of 1 s
C_V		Vertical coefficient

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