REPORT
GEOTECHNICAL STUDY
PROPOSED KENT SUBDIVISION
2463 SOUTH 3500 WEST
OGDEN, UTAH

Submitted To:

Mr. Tony Kent

Submitted By:

GSH Geotechnical, Inc.
473 West 4800 South
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October 22, 2021

Job No. 3403-001-21

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Mr. Tony Kent

Re: Report
Geotechnical Study
Proposed Kent Subdivision
2463 South 3500 West
Ogden, Utah

1. INTRODUCTION

1.1 GENERAL

This report presents the results of our geotechnical study performed at the site of the proposed Kent Subdivision to be located at 2463 South 3500 West in Ogden, Utah. The general location of the site with respect to existing roadways, as of 2021, is presented on Figure 1, Vicinity Map. A more detailed layout of the site showing an aerial layout, existing roadways, and the test pits excavated in conjunction with this study is presented on Figure 2, Site Plan.

1.2 OBJECTIVES AND SCOPE

The objectives and scope of the study were planned in discussions between Mr. Tony Kent and Mr. Robert Gifford of GSH Geotechnical, Inc. (GSH).

In general, the objectives of this study were to:

1. Define and evaluate the subsurface soil and groundwater conditions across the site.

2. Provide appropriate foundation, earthwork, pavement, stormwater percolation, and geoseismic recommendations to be utilized in the design and construction of the proposed facilities.

In accomplishing these objectives, our scope has included the following:

1. A field program consisting of the excavating, logging, and sampling of 4 exploration test pits, as well as performing a stormwater percolation test.

2. A laboratory testing program.

3. An office program consisting of the correlation of available data, engineering analysis, and the preparation of this summary report.

1.3 AUTHORIZATION

Authorization was provided by returning a signed copy of the Professional Services Agreement No. 21-0930 dated September 20, 2021.

1.4 PROFESSIONAL STATEMENTS

Supporting data upon which our recommendations are based are presented in subsequent sections of this report. Recommendations presented herein are governed by the physical properties of the soils encountered in the exploration test pits, projected groundwater conditions, and the layout and design data discussed in Section 2, Proposed Construction. If subsurface conditions other than those described in this report are encountered and/or if design and layout changes are implemented, GSH must be informed so that our recommendations can be reviewed and amended, if necessary.

Our professional services have been performed, our findings developed, and our recommendations prepared in accordance with generally accepted engineering principles and practices in this area at this time.

2. PROPOSED CONSTRUCTION

The approximately 6.5-acre parcel is proposed to be developed for the construction of a 5-lot residential subdivision with associated pavements. The structures are anticipated to be constructed with wood-framing, likely placed slab-on-grade but may have full- or partial-depth basements, supported upon conventional spread and continuous wall footings.

Maximum real column and wall loads are anticipated to be on the order of 40 to 60 kips and 2 to 4 kips per lineal foot, respectively. Real loads are defined as the total of all dead plus frequently applied (reduced) live loads.

Paved residential roadways planned around the structures. Projected traffic in these areas is anticipated to consist of a light volume of automobiles and light trucks, occasional medium-weight trucks, and occasional heavy-weight trucks (school buses).

Site development will require some earthwork in the form of minor cutting and filling. At this time, we anticipate that maximum site grading cuts and fills, excluding utilities, will be on the order of 1 to 3 feet.

3. SITE INVESTIGATIONS

3.1 GENERAL

Subsurface conditions in unexplored locations or at other times may vary from those encountered at specific test pit locations. If such variations are noted during construction or if project development plans are changed, GSH must review the changes and amend our recommendations, if necessary.

Test pit locations were established by estimating distances and angles from site landmarks. If increased accuracy is desired by the client, we recommend that the test pit locations and elevations be surveyed.

3.2 FIELD PROGRAM

To define and evaluate the subsurface soil and groundwater conditions across the site, 4 test pits were excavated within the accessible areas. These test pits were completed to depths ranging from 8.5 to 10.0 feet with a moderate-sized rubber track-mounted excavator. The approximate locations of the test pits are presented on Figure 2. Additionally, a stormwater percolation test to determine the percolation rate was performed in Test Pit TP-4 at a depth of 5 feet.

The field portion of our study was under the direct control and continual supervision of an experienced member of our geotechnical staff. During the course of the drilling operations, a continuous log of the subsurface conditions encountered was maintained. In addition, samples of the typical soils encountered were obtained for subsequent laboratory testing and examination. The soils were classified in the field based upon visual and textural examination. These classifications were supplemented by subsequent inspection and testing in our laboratory. Graphical representation of the subsurface conditions encountered is presented on Figures 3A through 3D, Test Pit Logs. Soils were classified in accordance with the nomenclature described on Figure 4, Key to Test Pit Log (USCS).

A 2.42-inch inside diameter thin-wall drive sampler was utilized at select locations and depths within the test pit excavations to collect soil samples for further examination and laboratory testing.

Following completion of excavation operations, 1.25-inch diameter slotted PVC pipe was installed in each test pit to provide a means of monitoring the groundwater fluctuations. The test pits were then backfilled. Although an effort was made to compact the backfill with the excavator, backfill was not placed in uniform lifts and compacted to a specific density. Consequently, settlement of the backfill with time is likely to occur.

3.3 LABORATORY TESTING

3.3.1 General

To provide data necessary for our engineering analysis, a laboratory testing program was performed. This program included moisture, density, partial gradation, and chemical tests. The following paragraphs describe the tests and summarize the test data.

3.3.2 Moisture and Density Tests

To provide index parameters and to correlate other test data, moisture and density tests were performed on selected samples. The results of these tests are presented on the test pit logs, Figures 3A through 3D.

3.3.3 Partial Gradation Tests

To aid in classifying the granular soils, partial gradation tests were performed. Results of the tests are tabulated below and presented on the test pit logs, Figures 3A through 3D.

Test Pit No.	Depth (feet)	Percent Passing No. 200 Sieve	Moisture Content Percent	Soil Classification
TP-1	5.0	8.7	22.1	SP/SM
TP-2	7.0	19.5	27.7	SM
TP-2	9.0	65.8	31.3	CL
TP-4	7.0	48.9	23.5	SM*
TP-4	8.5	34.0	23.1	SM*

*sample contained thin layers of clay

3.3.4 Atterberg Limits Test

To aid in classifying the soils, an Atterberg limits test was performed on a sample of the fine-grained cohesive soils. Results of the test are tabulated below and presented on the test pit logs, Figures 3A through 3D:

Test Pit No.	Depth (feet)	Liquid Limit (percent)	Plastic Limit (percent)	Plasticity Index (percent)	Soil Classification
TP-2	30.0	26	19	7	CL

3.3.5 Chemical Tests

To determine if the site soils will react detrimentally with concrete, chemical tests were performed on a representative sample of the near-surface soil encountered at the site. The results of the chemical tests are tabulated below:

Test Pit No.	Depth (feet)	Soil Classification	pH	Total Water Soluble Sulfate (mg/kg-dry)
TP-4	2.5	SM	8.76	92.6

4. SITE CONDITIONS

4.1 SURFACE

The site is located at 2463 South 3500 West in Ogden, Utah. The site is currently vacant/undeveloped brush/grass land. The topography of the site is relatively flat, grading down to the east with a total relief of approximately 2 to 4 feet. Site vegetation consists of various weeds and brush/grass with sparse mature trees in the southwest portion of the site.

The site is bounded to the north by similar vacant/undeveloped brush/grass land along with single-family residential structures; to the east by single-family residential structures along with 3500 West Street; to the south by similar vacant/undeveloped brush/grass land along with single-family residential structures; and to the west by similar vacant/undeveloped brush/grass land along with single-family residential structures as well as 3600 West Street.

4.2 SUBSURFACE SOIL

The following paragraphs provide generalized descriptions of the subsurface profiles and soil conditions encountered within the test pits conducted during this study. As previously noted, soil conditions may vary in unexplored locations.

The test pits were excavated to depths ranging from 8.5 to 10.0 feet. The soil conditions encountered in each of the test pits, to the depths explored, were generally similar across the test pit locations.

- Approximately 4 to 18 inches of topsoil was encountered in each test pit. Topsoil thickness is frequently erratic and thicker zones of topsoil should be anticipated.

- Natural soils were encountered below the ground surface in each test pit. The natural soils consisted primarily of sand with varying clay and silt content. Test Pit TP-2 encountered clay with silt and sand at a depth of approximately 8 feet.

The natural sand soils were loose to dense, slightly moist to saturated, and gray, tan, and brown in color. The natural sand soils are anticipated to exhibit moderately high strength and moderately low compressibility characteristics under the anticipated load range.

The natural clay soils were medium stiff, saturated, brown in color, and moderately over-consolidated.

For a more descriptive interpretation of subsurface conditions, please refer to Figures 3A through 3D, Test Pit Logs. The lines designating the interface between soil types on the test pit logs generally represent approximate boundaries. In situ, the transition between soil types may be gradual.

4.3 GROUNDWATER

On October 20, 2021 (20 days following excavation), groundwater was measured within the PVC pipes installed as tabulated below:

Test Pit No.	Groundwater Depth (feet)
	October 20, 2021
TP-1	Pipe Damaged*
TP-2	Pipe Damaged*
TP-3	3.0
TP-4	Pipe Damaged*

*Pipe damaged by livestock

Groundwater levels vary with changes in season and rainfall, construction activity, irrigation, snow melt, surface water run-off, and other site-specific factors.

5. DISCUSSIONS AND RECOMMENDATIONS

5.1 SUMMARY OF FINDINGS

The proposed structures may be supported upon conventional spread and continuous wall foundations supported upon suitable natural soils and/or structural fill extending to suitable natural soils.

The most significant geotechnical aspects at the site are:

1. The potential to encounter existing non-engineered fills at the site.

2. The relatively shallow depth to groundwater.

Prior to proceeding with construction, removal of any existing debris, surface vegetation, root systems, topsoil, non-engineered fill (if encountered), and any deleterious materials from beneath an area extending out at least 5 feet from the perimeter of the proposed structure footprints and 3 feet beyond pavements and exterior flatwork areas will be required. All existing utility locations should be reviewed to assess their impact on the proposed construction and abandoned and/or relocated as appropriate.

Due to the developed nature of this site and the surrounding area, non-engineered fills may exist in unexplored areas of the site. Based on our experience, non-engineered fills are frequently erratic in composition and consistency. All surficial loose/disturbed soils and non-engineered fills must be removed below all footings, floor slabs, and pavements.

Groundwater was measured as shallow as 3.0 feet below the ground surface. GSH recommends placing floor slabs no closer than 4 feet from the highest groundwater elevation or 1.5 feet if a foundation subdrain system is utilized. Foundation subdrain recommendations are discussed in Section 5.3.1, Subdrains. As an alternative, site grading fill may be utilized to raise the overall grade to achieve the required separation between the floor slab and the highest groundwater elevation.

To reduce disturbance of the natural soils during excavation, it is recommended that low-impact, track-mounted equipment with smooth edge buckets/blades be utilized.

Detailed discussions pertaining to earthwork, foundations, pavements, and the geoseismic setting of the site are presented in the following sections.

5.2 EARTHWORK

5.2.1 Site Preparation

Initial site preparation will consist of the removal of any existing debris, non-engineered fills (if encountered), surface vegetation, root systems, topsoil, and any deleterious materials from beneath an area extending out at least 5 feet from the perimeter of the proposed structure footprint and 3 feet beyond pavements and exterior flatwork areas. All existing utility locations should be reviewed to assess their impact on the proposed construction and abandoned and/or relocated as appropriate.

It must be noted that from a handling and compaction standpoint, soils containing high amounts of fines (silts and clays) are inherently more difficult to rework and are very sensitive to changes in moisture content, requiring very close moisture control during placement and compaction. This will be very difficult, if not impossible, during wet and cold periods of the year. Additionally, the on-site soils are likely above optimum moisture content for compacting at present and would require some drying prior to re-compacting.

Subsequent to stripping and prior to the placement of floor slabs, foundations, structural site grading fills, exterior flatwork, and pavements, the exposed subgrade must be proof rolled by passing moderate-weight rubber tire-mounted construction equipment over the surface at least twice. If excessively soft or otherwise unsuitable soils are encountered beneath footings, they must be completely removed. If removal depth required is greater than 2 feet below footings, GSH must be notified to provide further recommendations. In pavement, floor slab, and outside flatwork areas, unsuitable natural soils should be removed to a maximum depth of 2 feet and replaced with compacted granular structural fill.

Subgrade preparation as described must be completed prior to placing overlying structural site grading fills.

Due to the relatively high groundwater, site grading cuts should be kept to a minimum. Cuts extending to within 1 foot of the groundwater elevation will likely disturb the natural clay soils and proof rolling must not be completed. Stabilization must be anticipated in areas where cuts are to extend to within 1 foot of the groundwater surface.

To reduce disturbance of the natural soils during excavation, it is recommended that low-impact, track-mounted equipment with smooth edge buckets/blades be utilized.

GSH must be notified prior to the placement of structural site grading fills, floor slabs, footings, and pavements to verify that all loose/disturbed soils and non-engineered fills (if encountered) have been completely removed.

5.2.2 Temporary Excavations

Temporary excavations up to 8 feet deep in fine-grained cohesive soils, above or below the water table, may be constructed with sideslopes no steeper than one-half horizontal to one vertical (0.5H:1.0V). Excavations deeper than 8 feet are not anticipated at the site.

For granular (cohesionless) soils, construction excavations above the water table, not exceeding 4 feet, should be no steeper than one-half horizontal to one vertical (0.5H:1.0V). For excavations up to 8 feet, in granular soils and above the water table, the slopes should be no steeper than one horizontal to one vertical (1H:1V). Excavations encountering saturated cohesionless soils will be very difficult and will require very flat sideslopes and/or shoring, bracing, and dewatering.

To reduce disturbance of the natural soils during excavation, it is recommended that low-impact, track-mounted equipment with smooth edge buckets/blades be utilized.

The static groundwater table was encountered as shallow as 3.0 feet below the existing surface and may be shallower with seasonal fluctuations. Consideration for dewatering of utility trenches, excavations for the removal of non-engineered fill, and other excavations below this level should be incorporated into the design and bidding process.

All excavations must be inspected periodically by qualified personnel. If any signs of instability or excessive sloughing are noted, immediate remedial action must be initiated.

5.2.3 Structural Fill

Structural fill is defined as all fill which will ultimately be subjected to structural loadings, such as imposed by footings, floor slabs, pavements, etc. Structural fill will be required as backfill over foundations and utilities, as site grading fill, and as replacement fill below footings. All structural fill must be free of surface vegetation, root systems, rubbish, topsoil, frozen soil, and other deleterious materials.

Structural site grading fill is defined as structural fill placed over relatively large open areas to raise the overall grade. For structural site grading fill, the maximum particle size shall not exceed 4 inches; although, occasional larger particles, not exceeding 8 inches in diameter, may be incorporated if placed randomly in a manner such that "honeycombing" does not occur and the desired degree of compaction can be achieved. The maximum particle size within structural fill placed within confined areas shall be restricted to 2 inches.

On-site soils may be re-utilized as structural site grading fill if they do not contain construction debris or deleterious material and meet the requirements of structural fill. Fine-grained soils will require very close moisture control and may be very difficult, if not impossible, to properly place and compact during wet and cold periods of the year.

Imported structural fill below foundations and floor slabs shall consist of a well graded sand and gravel mixture with less than 30 percent retained on the three-quarter-inch sieve and less than 20 percent passing the No. 200 Sieve (clays and silts).

To stabilize soft subgrade conditions (if encountered) or where structural fill is required to be placed closer than 2.0 feet above the water table at the time of construction, a mixture of coarse angular gravels and cobbles and/or 1.5- to 2.0-inch gravel (stabilizing fill) should be utilized. It may also help to utilize a stabilization fabric, such as Mirafi 600X or equivalent, placed on the natural ground if 1.5- to 2.0-inch gravel is used as stabilizing fill.

5.2.4 Fill Placement and Compaction

All structural fill shall be placed in lifts not exceeding 8 inches in loose thickness. Structural fills shall be compacted in accordance with the percent of the maximum dry density as determined by the AASHTO[1] T180 (ASTM[2] D1557) compaction criteria in accordance with the following table:

Location	Total Fill Thickness (feet)	Minimum Percentage of Maximum Dry Density
Beneath an area extending at least 5 feet beyond the perimeter of the structure	0 to 10	95
Site grading fills outside area defined above	0 to 5	90
Site grading fills outside area defined above	5 to 10	95
Utility trenches within structural areas	--	96
Road base	--	96

Structural fills greater than 10 feet thick are not anticipated at the site.

Subsequent to stripping and prior to the placement of structural site grading fill, the subgrade shall be prepared as discussed in Section 5.2.1, Site Preparation, of this report. In confined areas, subgrade preparation should consist of the removal of all loose or disturbed soils.

Coarse angular gravel and cobble mixtures (stabilizing fill), if utilized, shall be end dumped, spread to a maximum loose lift thickness of 15 inches, and compacted by dropping a backhoe bucket onto the surface continuously at least twice. As an alternative, the stabilizing fill may be compacted by passing moderately heavy construction equipment or large self-propelled compaction equipment at least twice. Subsequent fill material placed over the coarse gravels and cobbles shall be adequately compacted so that the "fines" are "worked into" the voids in the underlying coarser gravels and cobbles. Where soil fill materials are to be placed directly over more than about 18 inches of clean gravel, a separation geofabric, such as Mirafi 140N or equivalent, is recommended to be placed between the gravel and subsequent soil fills.

Non-structural fill may be placed in lifts not exceeding 12 inches in loose thickness and compacted by passing construction, spreading, or hauling equipment over the surface at least twice.

1 American Association of State Highway and Transportation Officials
2 American Society for Testing and Materials

5.2.5 Utility Trenches

All utility trench backfill material below structurally loaded facilities (footings, floor slabs, flatwork, pavements, etc.) shall be placed at the same density requirements established for structural fill. If the surface of the backfill becomes disturbed during the course of construction, the backfill shall be proof rolled and/or properly compacted prior to the construction of any exterior flatwork over a backfilled trench. Proof rolling shall be performed by passing moderately loaded rubber tire-mounted construction equipment uniformly over the surface at least twice. If excessively loose or soft areas are encountered during proof rolling, they shall be removed to a maximum depth of 2 feet below design finish grade and replaced with structural fill.

Many utility companies and City-County governments are now requiring that Type A-1a or A-1b (AASHTO Designation – granular soils with limited fines) soils be used as backfill over utilities. These organizations are also requiring that in public roadways, the backfill over major utilities be compacted over the full depth of fill to at least 96 percent of the maximum dry density as determined by the AASHTO T180 (ASTM D1557) method of compaction. GSH recommends that as the major utilities continue onto the site that these compaction specifications are followed.

Fine-grained soils, such as silts and clays, are not recommended for utility trench backfill in structural areas.

The static groundwater table was encountered as shallow as 3.0 feet below the existing surface and may be shallower with seasonal fluctuations. Dewatering of utility trenches and other excavations below this level should be anticipated.

To reduce disturbance of the natural soils during excavation, it is recommended that low-impact, track-mounted equipment with smooth edge buckets/blades be utilized.

5.3 GROUNDWATER

On October 20, 2021 (20 days following excavation), groundwater was measured within the PVC pipes installed as tabulated below:

Test Pit No.	Groundwater Depth (feet)
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TP-1	Pipe Damaged*
TP-2	Pipe Damaged*
TP-3	3.0
TP-4	Pipe Damaged*

*Pipe damaged by livestock

Based on the anticipated cuts necessary to reach design subgrades, we anticipate temporary and permanent dewatering will be necessary. Floor slabs must be placed a minimum of 4 feet from the stabilized groundwater elevation or 1.5 feet if a perimeter subdrain system is utilized. Foundation subdrain recommendations are discussed in Section 5.3.1, Subdrains. As an alternative, site grading fill may be utilized to raise the overall grade to achieve the required separation between the floor slab and the highest groundwater elevation.

The groundwater measurements presented are conditions at the time of the field exploration and may not be representative of other times or locations. Groundwater levels may vary seasonally and with precipitation, as well as other factors including irrigation. Evaluation of these factors is beyond the scope of this study. Groundwater levels may, therefore, be at shallower or deeper depths than those measured during this study, including during construction and over the life of the structure.

The extent and nature of any dewatering required during construction will be dependent on the actual groundwater conditions prevalent at the time of construction and the effectiveness of construction drainage to prevent run-off into open excavations.

5.3.1 Stormwater Percolation Test

A stormwater percolation test was performed at a depth of approximately 5 feet in the representative natural sand soils at Test Pit TP-4. The measured percolation rate was 20 minutes per inch. This design percolation rate should be considered typical for the soils at the site.

5.3.2 Subdrain

A subdrain system, if utilized, should consist of a perimeter foundation/chimney subdrain and an under-slab subdrain. The perimeter subdrain would consist of a 4-inch diameter slotted or perforated PVC or other durable material pipe installed with an invert at least 18 inches below the top of the lowest adjacent slab. The drain pipe should slope at least 0.25 percent to a suitable point of gravity discharge, such as an inside or outside sump. The 4-inch diameter slotted PVC pipe should be encased in a one-half to three-quarter-inch clean gap-graded gravel extending 2 inches below laterally and continuously up at least 12 inches above the top of the lowest adjacent slab. The gravels must be separated from the adjacent soils with a geotextile fabric, such as Mirafi 140N or equivalent. Extending up from the top of the foundation subdrain to within 1 foot of final grade should be a synthetic drain board or a zone of "free-draining" permeable fill, also separated from all adjacent soils with a geotextile fabric. Prior to the placement of the perimeter foundation subdrain, the outside subgrade walls should be appropriately waterproofed.

In addition to the perimeter foundation/chimney subdrain, an under-slab drain is recommended. This should consist of a minimum of 8 inches of "free-draining" one-half to three-quarter-inch minus clean gap-graded gravel placed over properly prepared suitable natural subgrade soils and/or structural fill extending to suitable natural soil. The "free-draining" gravel shall be hydraulically connected to the perimeter drain. In addition, we recommend 4-inch diameter slotted PVC pipes be installed laterally and spaced approximately 50 feet apart beneath the below-grade level slab of the structure with an invert elevation of at least 12 inches below the top of the lowest adjacent slab. This subdrain would be similarly encased in the one-half- to three-quarter-inch clean gap-graded gravel, separated from the natural soils with a geotextile fabric, extending up to the 6-inch layer of gravel underneath the at-grade slab. This subdrain line would discharge to the perimeter subdrain.

GSH also recommends that a minimum of 10.0 inches of free-draining gravel material be placed below the floor slab and that this gravel be hydraulically tied to the perimeter foundation drain. This may be accomplished by placing footings on a minimum of 6.0 inches of similar free-draining gravel material. Lateral drains must also be placed approximately every 50 feet and tied to the subdrain system.

Water collected by the subdrain system would be gravity discharged or pumped to a suitable discharge point such as area subdrains, storm drains, or other suitable down-gradient location (see attached Figure 5, Typical Foundation/Chimney Subdrain Detail 18”). A back-up power and back-up pump would need to be incorporated against failure if a suitable gravity discharge system is unavailable.

5.4 SPREAD AND CONTINUOUS WALL FOUNDATIONS

5.4.1 Design Data

The results of our analysis indicate that the proposed structures may be supported upon conventional spread and continuous wall foundations established upon suitable natural soils and/or structural fill extending to suitable natural soils. Under no circumstances shall foundations be established over non-engineered fills, loose or disturbed soils, topsoil, surface vegetation, root systems, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water. For design, the following parameters are provided:

Minimum Recommended Depth of Embedment for Frost Protection	- 30 inches
Minimum Recommended Depth of Embedment for Non-frost Conditions	- 15 inches
Recommended Minimum Width for Continuous Wall Footings	- 18 inches
Minimum Recommended Width for Isolated Spread Footings	- 24 inches
Recommended Net Bearing Capacity for Real Load Conditions	- 1,500 pounds per square foot
Bearing Capacity Increase for Seismic Loading	- 50 percent

The term "net bearing capacity" refers to the allowable pressure imposed by the portion of the structure located above lowest adjacent final grade. Therefore, the weight of the footing and backfill to lowest adjacent final grade need not be considered. Real loads are defined as the total of all dead plus frequently applied live loads. Total load includes all dead and live loads, including seismic and wind.

5.4.2 Installation

Under no circumstances shall the footings be installed upon non-engineered fills, loose or disturbed soils, topsoil, surface vegetation, root systems, rubbish, construction debris, or other deleterious materials. If unsuitable soils are encountered, they must be removed and replaced with compacted granular fill. If granular soils become loose or disturbed, they must be recompacted prior to pouring the concrete.

The width of structural replacement fill below footings should be equal to the width of the footing plus one foot for each foot of fill thickness.

5.4.3 Settlements

Based on column loadings, soil bearing capacities, and the foundation recommendations as discussed above, we expect primary total settlement beneath individual foundations to be less than one inch.

The amount of differential settlement is difficult to predict because the subsurface and foundation loading conditions can vary considerably across the site. However, we anticipate differential settlement between adjacent foundations could vary from 0.5 to 0.75 inch. The final deflected shape of the structure will be dependent on actual foundation locations and loading.

5.5 LATERAL RESISTANCE

Lateral loads imposed upon foundations due to wind or seismic forces may be resisted by the development of passive earth pressures and friction between the base of the footings and the supporting soils. In determining frictional resistance, a coefficient of friction of 0.35 may be utilized for the footing interface with in situ natural clay soils and 0.40 for footing interface with natural granular soils or granular structural fill. Passive resistance provided by properly placed and compacted granular structural fill above the water table may be considered equivalent to a fluid with a density of 300 pounds per cubic foot. Below the water table, this granular soil should be considered equivalent to a fluid with a density of 150 pounds per cubic foot.

A combination of passive earth resistance and friction may be utilized provided that the friction component of the total is divided by 1.5.

5.6 LATERAL PRESSURES

Parameters, as presented within this section, are for backfills which will consist of drained soil placed and compacted in accordance with the recommendations presented herein.

The lateral pressures imposed upon subgrade facilities will, therefore, be basically dependent upon the relative rigidity and movement of the backfilled structure. For active walls, such as retaining walls which can move outward (away from the backfill), drained backfill may be considered equivalent to a fluid with a density of 40 pounds per cubic foot in computing lateral pressures. For more rigid subgrade walls that are not more than 10 inches thick, granular backfill may be considered equivalent to a fluid with a density of 50 pounds per cubic foot. For very rigid non-yielding walls, granular backfill should be considered equivalent to a fluid with a density of at least 60 pounds per cubic foot. The above values assume that the surface of the soils slope behind the wall is horizontal and that the granular fill within 3 feet of the wall will be compacted with hand-operated compacting equipment.

For seismic loading of below-grade walls, the uniform lateral pressures on the following page, in pounds per square foot (psf), should be added based on wall depth and wall case:

Uniform Lateral Pressures			
Wall Height (Feet)	**Active Pressure Case (psf)**	**Moderately Yielding Case (psf)**	**At Rest/Non-Yielding Case (psf)**
4	24	51	78
6	36	77	117
8	48	102	156
10	61	128	195

5.7 FLOOR SLABS

Floor slabs may be established upon suitable natural subgrade soils or structural fill extending to suitable natural soils. Under no circumstances shall floor slabs be established directly over non-engineered fills, loose or disturbed soils, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water.

Additionally, GSH recommends that floor slabs be constructed a minimum of 4.0 feet from the stabilized groundwater elevation or 1.5 feet if a foundation subdrain system is utilized. Foundation subdrain recommendations are discussed in Section 5.3.1, Subdrains. As an alternative, site grading fill may be utilized to raise the overall grade to achieve the required separation between the floor slab and the highest groundwater elevation.

To facilitate curing of the concrete and to provide a capillary moisture break, it is recommended that floor slabs be directly underlain by at least 4 inches of "free-draining" fill, such as "pea" gravel or three-quarters to one inch minus clean gap-graded gravel.

Settlement of lightly loaded floor slabs designed according to previous recommendations (average uniform pressure of 200 pounds per square foot or less) is anticipated to be less than one-quarter of an inch.

5.8 PAVEMENTS

The natural sand soils will exhibit moderate pavement support characteristics when saturated. All pavement areas must be prepared as previously discussed (see Section 5.2.1, Site Preparation). Under no circumstances shall pavements be established over non-engineered fills, loose or disturbed soils, topsoil, surface vegetation, root systems, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water. With the subgrade soils and the projected traffic as discussed in Section 2, Proposed Construction, the following pavement sections are recommended:

Paved Areas

(Light Volume of Automobiles and Light Trucks,
Occasional Medium-Weight Trucks,
and No Heavyweight Trucks)
[1-3 equivalent 18-kip axle loads per day]

Flexible Pavements:
(Asphalt Concrete)

3.0 inches	Asphalt concrete
9.0 inches	Aggregate base
Over	Properly prepared natural subgrade soils and/or structural site grading fill extending to properly prepared natural subgrade soils

Rigid Pavements:
(Non-reinforced Concrete)

5.0 inches	Portland cement concrete (non-reinforced)
5.0 inches	Aggregate base
Over	Properly prepared natural subgrade soils, and/or structural site grading fill extending to properly prepared natural subgrade soils

For dumpster pads, we recommend a pavement section consisting of 8 inches of Portland cement concrete, 12 inches of aggregate base, over properly prepared natural subgrade or site grading structural fills. Dumpster pads should not be constructed overlying non-engineered fills under any circumstances.

These above rigid pavement sections are for non-reinforced Portland cement concrete. Concrete should be designed in accordance with the American Concrete Institute (ACI) and joint details should conform to the Portland Cement Association (PCA) guidelines. The concrete should have a minimum 28-day unconfined compressive strength of 4,000 pounds per square inch and contain 6 percent ±1 percent air-entrainment.

The crushed stone should conform to applicable sections of the current Utah Department of Transportation (UDOT) Standard Specifications. All asphalt material and paving operations should meet applicable specifications of the Asphalt Institute and UDOT. A GSH technician shall observe placement and perform density testing of the base course material and asphalt.

Please note that the recommended pavement section is based on estimated post-construction traffic loading. If the pavement is to be constructed and utilized by construction traffic, the above pavement section may prove insufficient for heavy truck traffic, such as concrete trucks or tractor-trailers used for construction delivery. Unexpected distress, reduced pavement life, and/or premature failure of the pavement section could result if subjected to heavy construction traffic and the owner should be made aware of this risk. If the estimated traffic loading stated herein is not correct, GSH must review actual pavement loading conditions to determine if revisions to these recommendations are warranted.

5.9 CEMENT TYPES

The laboratory tests indicate that the natural soils tested contain a negligible amount of sulfates. Based on our test results, concrete in contact with the on-site soil will have a low potential for sulfate reaction (ACI 318, Table 4.3.1). Therefore, all concrete which will be in contact with the site soils may be prepared using Type I or IA cement.

5.10 GEOSEISMIC SETTING

5.10.1 General

Utah municipalities have adopted the International Building Code (IBC) 2018. The IBC 2018 code refers to ASCE 7-16 Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE 7-16) determines the seismic hazard for a site based upon mapping of bedrock accelerations prepared by the United States Geologic Survey (USGS) and the soil site class. The USGS values are presented on maps incorporated into the IBC code and are also available based on latitude and longitude coordinates (grid points).

5.10.2 Faulting

Based on our review of available literature, no active faults pass through or immediately adjacent to the site. The nearest active mapped fault consists of the Weber Section of the Wasatch Fault, located about 6.9 miles to the east of the site.

5.10.3 Soil Class

For dynamic structural analysis, the Site Class D – Stiff Soil Profile as defined in Chapter 20 of ASCE 7-16 (per Section 1613.3.2, Site Class Definitions, of IBC 2018) can be utilized.

5.10.4 Ground Motions

The IBC 2018 code is based on USGS mapping, which provides values of short and long period accelerations for average bedrock values for the Western United States and must be corrected for local soil conditions. The following table summarizes the peak ground and short and long period accelerations for the MCE event and incorporates the appropriate soil amplification factor for a Site Class D – Stiff Soil Profile. Based on the site latitude and longitude (41.2218 degrees north and 112.0657 degrees west, respectively), the values for this site are tabulated below.

Spectral Acceleration Value, T	**Bedrock Boundary [mapped values] (% g)**	**Site Coefficient**	**Site Class D [adjusted for site class effects] (% g)**	**Design Values* (% g)**
0.2 Seconds (Short Period Acceleration)	S_S = 119.0	F_a = 1.024	S_{MS} = 121.9	S_{DS} = 81.2
1.0 Second (Long Period Acceleration)	S_1 = 42.2	F_v = 1.878	S_{M1} = 79.3	S_{D1} = 52.8

5.10.5 Liquefaction

The site is located in an area that has been identified by the Utah Geological Survey (UGS) as being a "high" liquefaction potential zone. Liquefaction is defined as the condition when saturated, loose, granular soils lose their support capabilities because of excessive pore water pressure, which develops during a seismic event. Clayey soils, even if saturated, will generally not liquefy during a major seismic event.

Liquefaction was not included in the scope of this study and would require a deeper (30+ foot) boring for engineering analysis.

5.11 SITE VISITS

GSH must verify that all topsoil/disturbed soils and any other unsuitable soils have been removed, that non-engineered fills (if encountered) have been removed, and that suitable soils have been encountered prior to placing site grading fills, footings, slabs, and pavements. Additionally, GSH must observe fill placement and verify in-place moisture content and density of fill materials placed at the site.

6. CLOSURE

If you have any questions or would like to discuss these items further, please feel free to contact us at (801) 685-9190.

Respectfully submitted,

GSH Geotechnical, Inc.

REGISTERED PROFESSIONAL ENGINEER
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ALAN D.
SPILKER
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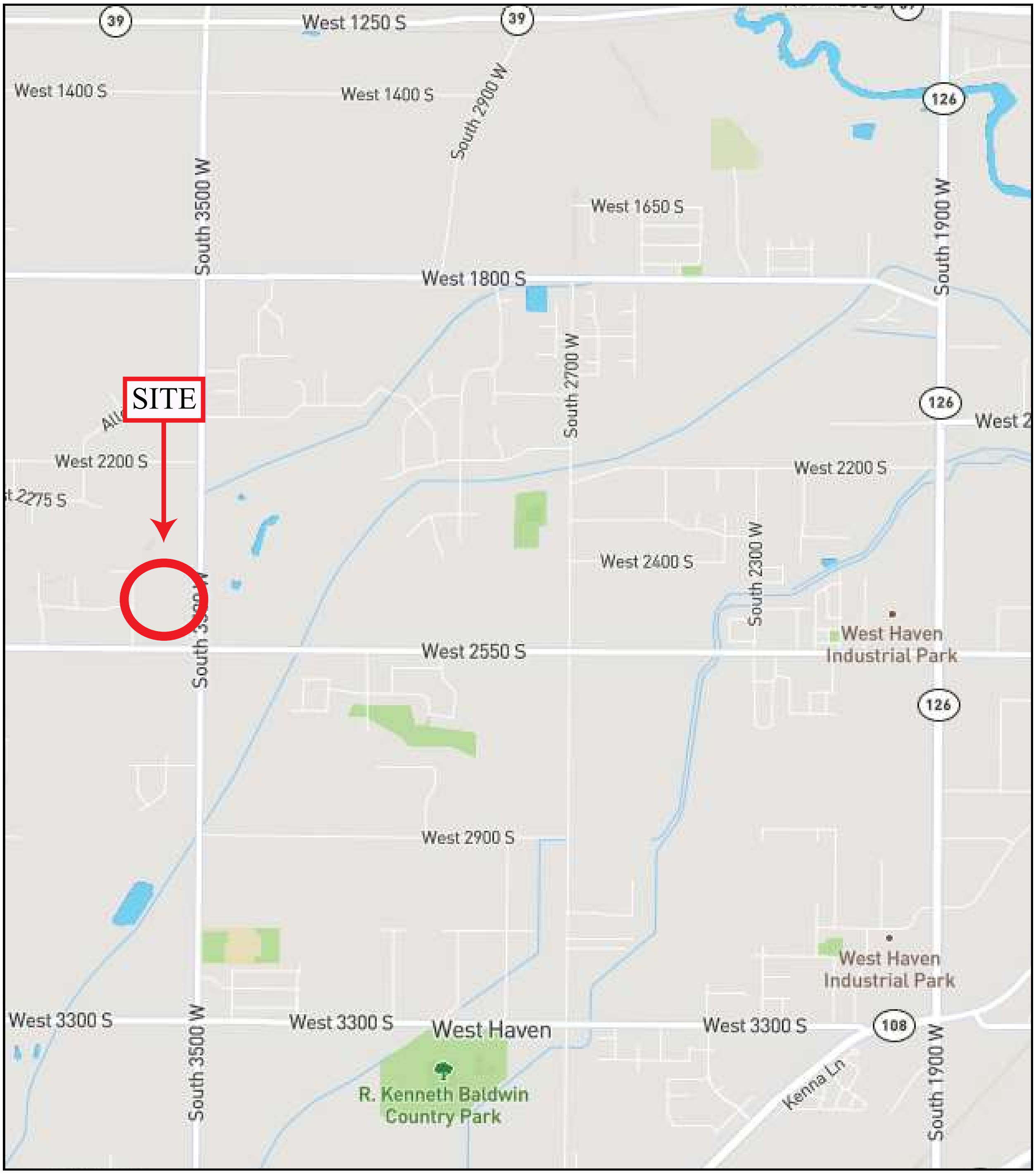
President/Senior Geotechnical Engineer

ADS:ea

Encl.	Figure	1,	Vicinity Map
	Figure	2,	Site Plan
	Figures	3A	through 3D, Test Pit Logs
	Figure	4,	Key to Test Pit Log (USCS)
	Figure	5,	Typical Foundation Chimney Subdrain Detail 18”

Addressee (email)

TONY KENT
JOB NO. 3403-001-21



0.5 0 0.5 1 KM 1.5

0.2 0 0.2 0.4 0.6 0.8 1 MI 1.2

FIGURE 1
VICINITY MAP

GSH

REFERENCE:
ALL TRAILS - NATIONAL GEOGRAPHIC TERRAIN
DATED 2021

TONY KENT
JOB NO. 3403-001-21

FIGURE 2
SITE PLAN

GSH

REFERENCE:
ADAPTED FROM AERIAL PHOTOGRAPH
DOWNLOADED FROM GOOGLE EARTH
IMAGERY DATED 5/2021

TEST PIT LOG

Page: 1 of 1

TEST PIT: TP-1

CLIENT: Mr. Tony Kent	PROJECT NUMBER: 3403-001-21
PROJECT: Proposed Kent Subdivision	DATE STARTED: 9/30/21 DATE FINISHED: 9/30/21
LOCATION: 2463 South 3500 West, Ogden, Utah	GSH FIELD REP.: JH
EXCAVATING METHOD/EQUIPMENT: 6-ton Kubota	
GROUNDWATER DEPTH: 5.0' (9/30/21)	ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0							
	SP/SM	FINE TO MEDIUM SAND with some silt; major roots (topsoil) to 4"; tan								slightly moist medium dense
				▮	8.6	96				
										moist
▼ (5.0')			5	◣	22.1		8.7			saturated
	SM	SILTY FINE TO MEDIUM SAND tan/brown		◣						saturated loose
			10	◣						
		End of Exploration at 10.0' Significant sidewall caving at 8.0'.. Installed 1.25" diameter slotted PVC pipe to 10.0'.								
			15							
			20							
			25							

See Subsurface Conditions section in the report for additional information.

FIGURE 3A

TEST PIT LOG

Page: 1 of 1

TEST PIT: TP-2

CLIENT: Mr. Tony Kent | PROJECT NUMBER: 3403-001-21

PROJECT: Proposed Kent Subdivision | DATE STARTED: 9/30/21 | DATE FINISHED: 9/30/21

LOCATION: 2463 South 3500 West, Ogden, Utah | GSH FIELD REP.: JH

EXCAVATING METHOD/EQUIPMENT: 6-ton Kubota

GROUNDWATER DEPTH: 5.5' (9/30/21) | ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0							
	SP/SM	FINE TO MEDIUM SAND with some silt; major roots (topsoil) to 4"; brown								moist medium dense
				▮	15.2	96				
				◢						
▼ (5.5')			5							saturated
	SM	SILTY FINE TO MEDIUM SAND with trace clay; gray								saturated medium dense
				◢	27.7		19.5			
	CL	FINE SANDY CLAY with silt; gray								saturated medium stiff
				◢	31.3		65.8			
		End of Exploration at 10.0' No significant sidewall caving. Installed 1.25” diameter slotted PVC pipe to 10.0’.	10							
			15							
			20							
			25							

See Subsurface Conditions section in the report for additional information.

FIGURE 3B

TEST PIT LOG

Page: 1 of 1

TEST PIT: TP-3

CLIENT: Mr. Tony Kent | PROJECT NUMBER: 3403-001-21

PROJECT: Proposed Kent Subdivision | DATE STARTED: 9/30/21 | DATE FINISHED: 9/30/21

LOCATION: 2463 South 3500 West, Ogden, Utah | GSH FIELD REP.: JH

EXCAVATING METHOD/EQUIPMENT: 6-ton Kubota

GROUNDWATER DEPTH: 3.0' (10/20/21) | ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface								
	SM	SILTY FINE TO MEDIUM SAND major roots (topsoil) to 18"; brown	0							slightly moist dense
					25.6	96				
▼										saturated
			5							
		grades fine to coarse sand								
										loose
		End of Exploration at 8.5' No significant sidewall caving. Installed 1.25” diameter slotted PVC pipe to 8.5’.	10							
			15							
			20							
			25							

See Subsurface Conditions section in the report for additional information.

FIGURE 3C

TEST PIT LOG

Page: 1 of 1

TEST PIT: TP-4

CLIENT: Mr. Tony Kent — PROJECT NUMBER: 3403-001-21

PROJECT: Proposed Kent Subdivision — DATE STARTED: 9/30/21 — DATE FINISHED: 9/30/21

LOCATION: 2463 South 3500 West, Ogden, Utah — GSH FIELD REP.: JH

EXCAVATING METHOD/EQUIPMENT: 6-ton Kubota

GROUNDWATER DEPTH: 4.5' (9/30/21) — ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface								
	SM	SILTY FINE TO MEDIUM SAND major roots (topsoil) to 8"; brown	0							moist medium dense
				▮	13.7	104				
▼				◣						saturated
		grades silty fine to coarse sand; tan/brown	5							
		grades with layers of silty clay up to 2" thick		◣	23.5		48.9			
				◣	23.1		34			
		End of Exploration at 8.5' No significant sidewall caving. Installed 1.25” diameter slotted PVC pipe to 8.5’.	10							
			15							
			20							
			25							

See Subsurface Conditions section in the report for additional information.

FIGURE 3D

CLIENT: Mr. Tony Kent PROJECT: Proposed Kent Subdivision PROJECT NUMBER: 3403-001-21	**KEY TO TEST PIT LOG**

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪

COLUMN DESCRIPTIONS

① **Water Level:** Depth to measured groundwater table. See symbol below.

② **USCS:** (Unified Soil Classification System) Description of soils encountered; typical symbols are explained below.

③ **Description:** Description of material encountered; may include color, moisture, grain size, density/consistency,

④ **Depth (ft.):** Depth in feet below the ground surface.

⑤ **Sample Symbol:** Type of soil sample collected at depth interval shown; sampler symbols are explained below.

⑥ **Moisture (%):** Water content of soil sample measured in laboratory; expressed as percentage of dryweight of

⑦ **Dry Density (pcf):** The density of a soil measured in laboratory; expressed in pounds per cubic foot.

⑧ **% Passing 200:** Fines content of soils sample passing a No. 200 sieve; expressed as a percentage.

⑨ **Liquid Limit (%):** Water content at which a soil changes from plastic to liquid behavior.

⑩ **Plasticity Index (%):** Range of water content at which a soil exhibits plastic properties.

⑪ **Remarks:** Comments and observations regarding drilling or sampling made by driller or field personnel. May include other field and laboratory test results using the following abbreviations:

CEMENTATION:	MODIFIERS:	MOISTURE CONTENT (FIELD TEST):
Weakly: Crumbles or breaks with handling or slight finger pressure.	**Trace** <5%	**Dry:** Absence of moisture, dusty, dry to the touch.
Moderately: Crumbles or breaks with considerable finger pressure.	**Some** 5-12%	**Moist:** Damp but no visible water.
Strongly: Will not crumble or break with finger pressure.	**With** > 12%	**Saturated:** Visible water, usually soil below water table.

Descriptions and stratum lines are interpretive; field descriptions may have been modified to reflect lab test results. Descriptions on the logs apply only at the specific boring locations and at the time the borings were advanced; they are not warranted to be representative of subsurface conditions at other locations or times.

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

MAJOR DIVISIONS			USCS SYMBOLS	TYPICAL DESCRIPTIONS
COARSE-GRAINED SOILS More than 50% of material is larger than No. 200 sieve size.	**GRAVELS** 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
	SANDS More than 50% of coarse fraction passing through No. 4 sieve.	**CLEAN SANDS** (little or no fines)	SW	Well-Graded Sands, Gravelly Sands, Little or No Fines
			SP	Poorly-Graded Sands, Gravelly Sands, 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 o f Low Plasticity
	SILTS AND CLAYS Liquid Limit greater than 50%		MH	Inorganic Silts, Micacious or Diatomacious Fine Sand or Silty Soils
			CH	Inorganic Clays of High Plasticity, Fat Clays
			OH	Organic Silts and Organic Clays of Medium to High Plasticity
HIGHLY ORGANIC SOILS			PT	Peat, Humus, Swamp Soils with High Organic Contents

Note: Dual Symbols are used to indicate borderline soil classifications.

STRATIFICATION:

DESCRIPTION	THICKNESS
Seam	up to 1/8"
Layer	1/8" to 12"

Occasional:
One or less per 6" of thickness
Numerous;
More than one per 6" of thickness

TYPICAL SAMPLER GRAPHIC SYMBOLS

- Bulk/Bag Sample
- Standard Penetration Split Spoon Sampler
- Rock Core
- No Recovery
- 3.25" OD, 2.42" ID D&M Sampler
- 3.0" OD, 2.42" ID D&M Sampler
- California Sampler
- Thin Wall

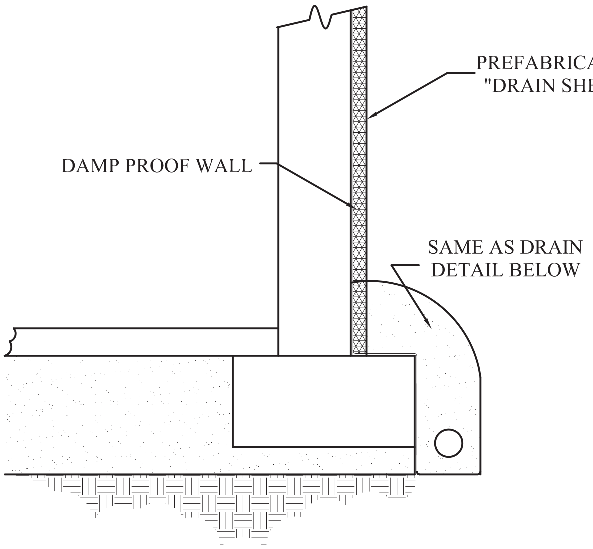
WATER SYMBOL

Water Level

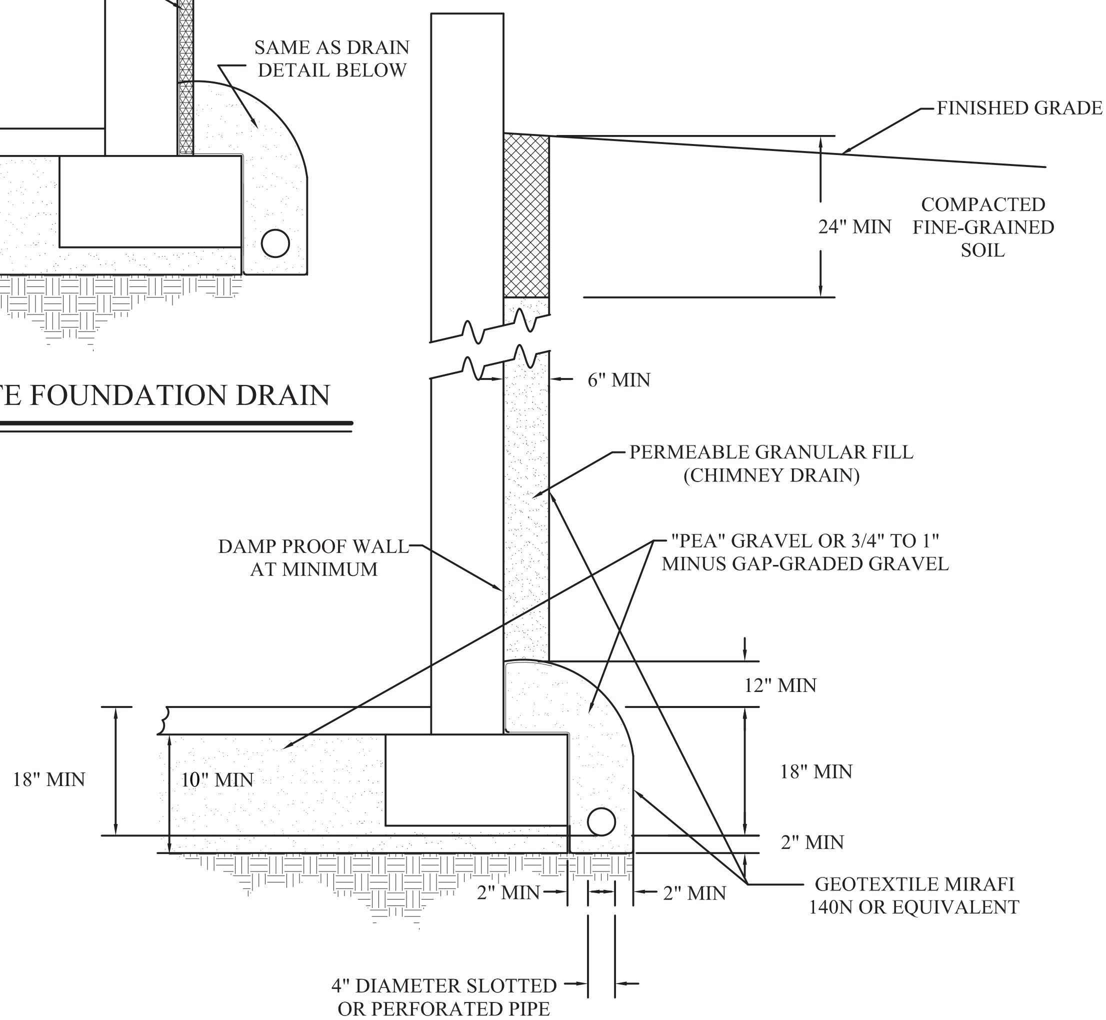
FIGURE 4

GSH

TYPICAL FOUNDATION/CHIMNEY SUBDRAIN DETAIL



ALTERNATE FOUNDATION DRAIN



TYPICAL FOUNDATION DRAIN

(NOT TO SCALE)

GSH

FIGURE 5