REPORT
PRELIMINARY GEOTECHNICAL STUDY
1810 GIBSON SUBDIVISION
APPROXIMATELY 1810 GIBSON AVENUE
OGDEN UTAH, UTAH

Submitted To:

Ogden City Community Development
2549 Washington Boulevard, Suite 120
Ogden, Utah 84401

Submitted By:

GSH Geotechnical, Inc.
473 West 4800 South
Salt Lake City, Utah 84123

September 19, 2013

Job No. 1461-01N-13

September 19, 2013
Job No. 1461-01N-13

Ogden City Community Development
2549 Washington Boulevard, Suite 120
Ogden, Utah 84401

Attention: Mr. Jeremy Smith

Gentlemen:

Re: Report
Preliminary Geotechnical Study
1810 Gibson Subdivision
Approximately 1810 Gibson Avenue
Ogden Utah, Utah
(41.2328; -111.98389)

1. INTRODUCTION

1.1 GENERAL

This report presents the results of our preliminary geotechnical study performed at the 4-acre site located at approximately 1810 Gibson Avenue in Ogden City, Utah. The general location of the site with respect to major topographic features and existing facilities, as of 1998 and 1999, is presented on Figure 1, Vicinity Map. An aerial photo of the site is shown on Figure 2, Aerial View. A more detailed layout of the site property and surrounding properties in Plat form is shown on Figure 3, Site Plan. The locations of the 3 borings drilled in conjunction with this study are also presented on Figures 2 and 3.

1.2 OBJECTIVES AND SCOPE

The objectives and scope of the preliminary study were planned in discussions between Mr. Jeremy Smith of Ogden City Community Development and Mr. Andrew Harris of GSH Geotechnical, Inc. (GSH).

In general, the objectives of this preliminary study were to:

1. Generally define and evaluate the subsurface soil and groundwater conditions at the site.

GSH Geotechnical, Inc.
473 West 4800 South
Salt Lake City, Utah 84123
Tel: (801) 685-9190 Fax: (801) 685-2990
www.gshgeo.com

2. Provide general earthwork, foundation, and pavement recommendations and geoseismic information to be utilized in future development.

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

1. A field program consisting of the drilling, logging, and sampling of 3 exploration borings.

2. A laboratory testing program.

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

1.3 AUTHORIZATION

Authorization was provided by returning a signed copy of our Professional Services Agreement No. 13-0911N dated September 6, 2013.

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 borings, projected groundwater conditions, and the layout and design data discussed in Section 2, Proposed Construction, of this report. 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

At this time, it is our understanding that proposed construction will consist of subdividing the property into a residential subdivision for single-/multiple-family homes. The exact configuration and building types have not yet been determined. It is projected that construction will include 1- to 3-level structures constructed with concrete spread foundations supporting wood framing with either partial-depth or no below-grade levels.

Projected maximum real column and wall loads are on the order of 40 to 90 kips and 1 to 4 kips per lineal foot, respectively. Floor slab loads will be light and are projected to have an average uniform pressure of less than 100 to 150 pounds per square foot.

Paved parking and roadways will also be part of the site development. We anticipate that parking areas will be subjected to traffic consisting of a light to moderate volume of automobiles and light trucks and occasional medium-weight trucks. In roadways, traffic is anticipated to consist of a moderate volume of automobiles and light trucks and occasional medium- to heavy-weight trucks.

Anticipated maximum site grading cuts/fill are expected to be on the order of 1 to 4 feet.

3. SITE INVESTIGATIONS

3.1 FIELD PROGRAM

In order to define and evaluate the subsurface soil and groundwater conditions across the site, 3 borings were explored to depths ranging from 16 to 36 feet below existing grade. The borings were drilled using a truck-mounted drill rig equipped with hollow-stem augers. Locations of the borings are presented on Figures 2 and 3.

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 have been supplemented by subsequent inspection and testing in our laboratory. Detailed graphical representation of the subsurface conditions encountered is presented on Figures 4A through 4C, Log of Borings. Soils were classified in accordance with the nomenclature described on Figure 4, Key to Boring Log (USCS).

A 3.25-inch outside diameter, 2.42-inch inside diameter drive sampler (Dames & Moore) and a 2.0-inch outside diameter, 1.38-inch inside diameter drive sampler (SPT) were utilized at select locations. The blow counts recorded on the boring logs were those required to drive the sampler 12 inches with a 140-pound hammer dropping 30 inches.

3.2 LABORATORY TESTING

3.2.1 General

In order to provide data necessary for our engineering analyses, a laboratory testing program was initiated. The program included moisture and density, partial gradation, consolidation, and chemical tests. The following paragraphs describe the tests and summarize the test data.

3.2.2 Moisture and Density Tests

To aid in classifying the soils and to help correlate other test data, moisture and density tests were performed on selected undisturbed samples. The results of these tests are presented on the boring logs, Figures 4A through 4C.

3.2.3 Partial Gradation Tests

To aid in classifying the granular soils, moisture content and partial gradation tests were performed. Results of the tests are tabulated below:

Boring No.	Depth (feet)	Moisture Content Percent	Percent Passing No. 200 Sieve	Soil Classification
B-1	9.5	13.4	16.2	GC
B-1	24.5	11.2	4.8	SP
B-2	14.5	12.2	9.4	SP-SM/GP-GM
B-3	9.5	13.2	6.7	SM-SP

3.2.4 Consolidation Test

To provide data necessary for our settlement analyses, a consolidation test was performed upon each of 2 representative samples of the fine-grained clay soils encountered between 2 and 8 feet in Boring B-1 and B-2. The results indicate that the finer-grained soils are moderately over-consolidated and will exhibit moderate compressibility characteristics when loaded below the over-consolidation pressure. Detailed results of the test are maintained within our files and can be transmitted to you, upon your request.

3.2.5 Chemical Tests

To provide data used in determining whether the site soils will react detrimentally with concrete, pH and water soluble sulfate tests were performed. The results of the tests are tabulated below:

Boring No.	Depth (feet)	Soil Classification	pH	Total Water Soluble Sulfate (mg/L)
B-3	2.0	SM	8.39	27.9

4. SITE CONDITIONS

4.1 SURFACE

At the northwest corner of the site, there are the remains of a concrete structure and scattered debris/trash. The remaining portions of the site are vacant with much of the site appearing to have been brought up in grade with fill soils. This is evident by surface fills encountered in each of the 3 borings completed. Vegetation varies from very little in some areas to tree and grass/weed cover.

The site is bordered by the Ogden River along the south and east, an old single-family residential structure to the north, and an unpaved extension of Gibson Lane followed by vacant property to the west. Site grading across the site is relatively flat with minor overall sloping to the southeast.

4.2 SUBSURFACE SOIL

The subsurface soils encountered in each of the borings were similar. Non-engineered fills blanket the surface at each boring location ranging from 2 feet in Boring B-3 to as deep as 5.5 feet in Boring B-1. The surface fills consist primarily of sandy gravels with varying silt content. However, a layer of silty clay fill was observed between 1.5 and 2.5 feet in Boring B-2.

Below the surface fill in Borings B-1 and B-2, there exists a layer of natural silty and fine sandy clay extending to 8 feet. This clay layer is stiff, moist grading saturated with depth, brown to dark brown in color, and moderately over-consolidated.

Below the surface fill in Boring B-3 and from 8 feet in Boring B-2 extending to the full depths penetrated, 16 feet, and from 8 to 29 feet in Boring B-1, subsurface soils consisted of natural sands and gravels with varying silt and clay content. These sands and gravels are predominately medium dense, moist to saturated, brown and gray in color, and will exhibit moderately high strength and low compressibility characteristics.

From 29 feet to the full depth penetrated, 36 feet, in Boring B-1, silty clay was encountered. This deeper clay layer is soft to medium stiff, saturated, and brown.

The lines designating the interface between soil types on the boring logs generally represent approximate boundaries. In-situ, the transition between soil types may be gradual.

4.3 GROUNDWATER

Groundwater was measured individually following drilling and 5 days after. Groundwater measurements are tabulated on the following page.

Boring No.	Groundwater Depth (feet)	
	September 12, 2013*	**September 17, 2013**
B-1	10.0	9.2
B-2	8.0	7.8
B-3	9.5	8.1

* During drilling, not stabilized.

Seasonal and longer-term groundwater fluctuations on the order of 1.0 to 1.5 feet are projected with the highest seasonal levels generally occurring during the late spring and early summer months.

5. DISCUSSIONS AND RECOMMENDATIONS

5.1 SUMMARY OF FINDINGS

The results of our analysis indicate that the proposed residential structures may be supported upon conventional spread and continuous wall foundations established upon suitable natural soils and/or granular structural fill extending to suitable natural soils. The clay soils encountered to 8 feet will control allowable bearing pressure.

Fills were encountered at the surface in each of the borings ranging to depth of 2.0 to 5.5 feet. Without proper documentation of fill placement, these fills must be considered as non-engineered. The fills were predominately granular in nature and may be re-utilized as structural site grading fill as long as they meet the requirements for such in this report.

Non-engineered fills must be removed below the proposed structure and rigid pavements but may remain below flexible pavements and lightly loaded flatwork if properly prepared as outlined later in this report.

Groundwater was encountered in each of the borings ranging from 7.8 to 9.2 feet below existing grade.

Preliminary detailed discussions pertaining to foundation, earthwork, preliminary pavement recommendations, and the geoseismic setting of the site are discussed in the following sections. Once planned construction is finalized, additional specific geotechnical sampling will likely be required to verify the recommendations provided herein with respect to specific construction types and locations.

5.2 EARTHWORK

5.2.1 Site Preparation

Initial site preparation will consist of the demolition and removal of the existing structure, associated fills and debris piles, loose surficial soils, surface vegetation, topsoil, root bulbs, sod, and any other deleterious materials from beneath an area extending at least 3 feet beyond the perimeter of proposed buildings and 2 feet beyond pavements and exterior flatwork areas. Trees and their associated root bulbs will require deeper removal depths. Old foundations should be completely removed below new buildings and to a minimum of 1.5 feet below pavement areas. Vegetation and other deleterious materials should be removed from the site. Stripped topsoil will be unsuitable for structural fill but may be stockpiled for subsequent landscaping purposes. Any existing utilities will need to be properly abandoned and/or relocated.

All non-engineered fills must be removed to suitable natural soils below the building footprint and rigid pavements. Where the in-place fills are granular and one foot thick or less, they may be compacted in-place to the requirements for structural fill.

Non-engineered fills may remain below flexible pavements provided these fills are free of deleterious materials and are properly prepared. Proper preparation below flexible pavements will consist of the scarification of the upper 9 inches followed by moisture preparation and re-compacted to the requirements of structural fill. In isolated areas, potential in-situ clay fill soils may be encountered below flexible pavement areas and are likely to be well above optimum moisture content. These clay soils will require significant drying prior to re-compacting and will be very difficult to work with during wet and cold periods of the year. In this case, the upper 9 inches may be removed and replaced with granular subbase over proofrolled subgrade.

Subsequent to the above operations and prior to the placement of footings, structural site grading fill, floor slabs, or pavements, the exposed fills/natural soils must be proofrolled by running moderate-weight rubber tire-mounted construction equipment uniformly over the surface at least 2 times.

If excessively soft or otherwise unsuitable soils are encountered beneath footings, they must be totally removed. Where removal depth is greater than 2 feet thick below footings, GSH must be notified to provide further recommendations. In pavement and outside flatwork areas, unsuitable natural soils/fills must be removed to a maximum depth of 2 feet and replaced with compacted granular structural fill.

5.2.2 Temporary Excavations

Temporary construction excavations in the site soils, not exceeding 4 feet in depth, may be constructed with sideslopes no steeper than one-quarter horizontal to one vertical (0.25H:1.0V).

Static groundwater was measured as shallow as 7.8 feet below the existing surface in Boring B-2. 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 0.5H:1V.

For granular (cohesionless) soils, construction excavations up to 8 feet, in granular soils and above the water table, the slopes should be no steeper than 1H:1V. Excavations encountering saturated cohesionless soils will be very difficult and will require very flat sideslopes and/or shoring, bracing, and dewatering. Excavations deeper than 8 feet are not anticipated at the site.

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 possibly as replacement fill below footings. All structural fill must be free of sod, 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 granular soils may be re-utilized as structural site grading fill if they meet the requirements of such.

All imported granular structural fill shall consist of a fairly well-graded mixture of sand and gravel containing less than 20 percent fines (percent by weight of material passing the U.S. No. 200 sieve) and no more than 30 percent retained on the three-quarter-inch sieve.

Non-structural site grading fill is defined as all fill material not designated as structural fill and may consist of any cohesive or granular soils not containing excessive amounts of degradable material.

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] T-180 (ASTM[2] D-1557) compaction criteria in accordance with the table below:

Location	Total Fill Thickness (feet)	Minimum Percentage of Maximum Dry Density
Beneath an area extending at least 3 feet beyond the perimeter of the structure	0 to 10	95
Outside area defined above	0 to 5	90
Outside area defined above	5 to 10	95
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 shall consist of the removal of all loose or disturbed soils.

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.

5.2.5 Utility Trenches

All utility trench backfill material below structurally loaded facilities (flatwork, floor slabs, roads, 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 proofrolled and/or properly compacted prior to the construction of any exterior flatwork over a backfilled trench. Proofrolling 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 proofrolling, they shall be removed to a maximum depth of 2 feet below design finish grade and replaced with structural fill.

---

1 American Association of State Highway and Transportation Officials

2 American Society for Testing and Materials

Most utility companies and City-County governments are now requiring that Type A-1a or A-1b (AASHTO Designation – basically 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 T-180 (ASTM D-1557) method of compaction.

5.3 SPREAD AND CONTINUOUS WALL FOUNDATIONS

5.3.1 Design Data

The proposed 1- to 3-level structures may be supported upon conventional spread and continuous wall foundations established on suitable undisturbed natural soils and/or granular structural fill extending to suitable natural soils. Clay soils encountered in the upper 8 feet govern design bearing capacity. For design, the following parameters are provided with respect to the projected loading discussed in Section 2, Proposed Construction of this report:

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 Pressure for Real Load Conditions Supported on Suitable Natural Soils*	- 2,000 pounds per square foot
Bearing Pressure Increase for Seismic Loading	- 30 percent

* Based on in-situ clay soils encountered in Borings B-1 and B-2 to 8 feet. Higher bearing pressure may be provided as needed if supported on some thickness of natural granular soils or imported granular structural fills.

The term "net bearing pressure" refers to the 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.

5.3.2 Installation

Under no circumstances should the footings be installed upon non-engineered fill, loose or disturbed soil, sod, rubbish, construction debris, topsoil, frozen soil, other deleterious materials, or within ponded water. If unsuitable soils are encountered, they must be totally removed and replaced with compacted granular structural fill. If granular soils become loose or disturbed, they must be properly recompacted before the footings are poured.

The width of replacement fill below footings should be equal to the width of the footing plus one foot for each foot of fill thickness. For example, if the width of the footing is 2 feet and the thickness of the structural fill beneath the footing is 2 feet, the width of the structural fill at the base of the footing excavation would be a total of 4 feet.

5.3.3 Settlements

Settlement of foundations designed and installed in accordance with the above recommendations, supporting maximum loads as discussed in Section 2, Proposed Construction, should be less than one inch. It is anticipated that approximately 40 to 60 percent of the quoted settlements may occur during construction.

5.4 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 0.40 should be utilized. 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.

5.5 LATERAL PRESSURES

The lateral pressure parameters, as presented within this section, are for backfills which will consist of drained granular 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), granular backfill may be considered equivalent to a fluid with a density of 35 pounds per cubic foot in computing lateral pressures. For more rigid walls (moderately yielding), generally not exceeding 10 feet in height, granular backfill may be considered equivalent to a fluid with a density of 45 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 retaining/below-grade walls, the uniform lateral pressures tabulated below, 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	30	60	90
6	45	90	135

5.6 FLOOR SLABS

Lightly loaded at-grade floor slabs must be established on suitable natural soils and/or structural fill extending to these soils. Under no circumstance should floor slabs be established upon non-engineered fill, loose or disturbed soils, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water. In order to facilitate construction and curing of the concrete, as well as provide a capillary break, it is recommended that floor slabs be directly underlain by 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 (average uniform pressure of 150 pounds per square foot or less) is anticipated to be less than one-quarter of an inch.

5.7 CEMENT TYPES

Laboratory tests indicate that the site soils contain negligible amounts of water soluble sulfates. Therefore, all concrete which will be in contact with the site soils may be prepared using Type I or IA cement.

5.8 PAVEMENTS

The properly prepared existing granular fills encountered at the site will exhibit moderate to good pavement support characteristics, even when saturated or near saturated. Rigid pavement shall not be placed over non-engineered fills. With the subgrade soils and the projected traffic as discussed in Section 2, Proposed Construction, the pavement sections on the following pages are recommended.

Light Parking Lot
(Light Volume of Automobiles and Light Trucks,
Occasional Medium-Weight Trucks,
and No Heavy-Weight Trucks)
[2 equivalent 18-kip axle loads per day]

Flexible:

3.0 inches	Asphalt concrete
7.0 inches	Aggregate base course
Over	Properly prepared non-engineered fills, natural subgrade soils, and/or structural site grading fill extending to suitable natural subgrade soils/properly prepared non-engineered fills

Rigid:

5.0 inches	Portland cement concrete (non-reinforced)
4.0 inches	Aggregate base course
Over	Suitable natural granular soils or structural site grading fill extending to suitable natural soils

Residential Roadways

(Moderate Volume of Automobiles and Light Trucks,
Occasional Medium- and Heavy-Weight Trucks)
[8 equivalent 18-kip axle loads per day]

Flexible:

3.5 inches	Asphalt concrete
8.0 inches	Aggregate base course
Over	Properly prepared non-engineered fills, natural subgrade soils, and/or structural site grading fill extending to suitable natural subgrade soils/properly prepared non-engineered fills

Rigid:

6.0 inches	Portland cement concrete (non-reinforced)
4.0 inches	Aggregate base course
Over	Suitable natural granular soils or structural site grading fill extending to suitable natural soils

For dumpster pads, we recommend a pavement section consisting of 6.5 inches of Portland cement concrete, 4.0 inches of aggregate base course, over properly prepared natural subgrade or site grading structural fills.

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.

5.9 GEOSEISMIC SETTING

5.9.1 General

Utah municipalities adopted the International Building Code (IBC) 2012 on July 1, 2013. The IBC 2012 code determines the seismic hazard for a site based upon 2008 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).

The structures must be designed in accordance with the procedure presented in Section 1613, Earthquake Loads, of the IBC 2012 edition.

5.9.2 Site Class

For dynamic structural analysis, the Site Class D - Stiff Soil Profile as defined in Table 1613.5.2, Site Class Definitions, of the IBC 2012 can be utilized.

5.9.3 Faulting

Based upon our review of available literature, no active faults are known to pass through or immediately adjacent to the site. The nearest active fault is the Ogden portion of the Wasatch Fault, approximately 3 miles east of the site.

5.9.4 Ground Motions

The IBC 2012 code is based on 2008 USGS mapping, which provides values of short and long period accelerations for the Site Class B-C boundary for the Maximum Considered Earthquake (MCE). This Site Class B-C boundary represents a hypothetical bedrock surface and must be corrected for local soil conditions. The following table summarizes the peak ground and short and long period accelerations for a MCE event and incorporates a soil amplification factor for a Site Class D soil profile in the second column. Based on the site latitude and longitude (41.23285 degrees north and 111.98389 degrees west, respectively), the values for this site are tabulated below:

Spectral Acceleration Value, T Seconds	**Site Class B-C Boundary [mapped values] (% g)**	**Site Class D [adjusted for site class effects] (% g)**
Peak Ground Acceleration	55.3	55.3
0.2 Seconds, (Short Period Acceleration)	S_S = 138.2	S_{MS} = 138.2
1.0 Seconds (Long Period Acceleration)	S_1 = 49.2	S_{M1} = 74.2

The IBC 2012 code design accelerations (S_{DS} and S_{D1}) are based on multiplying the above accelerations (adjusted for site class effects) for the MCE event by two-thirds.

5.9.5 Liquefaction

The site is located in an area that has been mapped as having a "high" liquefaction potential. Liquefaction is defined as the condition when saturated, loose, fine sand-type soils lose their support capabilities because of excessive pore water pressure which develops during a seismic event. Clayey soils, even if saturated, will not liquefy during a major seismic event.

Due to the relative dense nature of the granular soils encountered within the 3 borings completed to depths of 1 to 36 feet, liquefaction is not likely to occur during the design seismic event. Calculations were performed using the procedures described in the 2008 Soil Liquefaction During Earthquakes Monograph by Idriss and Boulanger[3].

5.10 SITE OBSERVATIONS

As previously mentioned, non-engineered fills were encountered at the boring locations and some demolition of the existing structure will be required. Prior to placement of foundations, floor slabs, pavements, and site grading fills, a geotechnical engineer from GSH must verify that all non-engineered fills and debris have been removed and suitable subgrade conditions encountered.

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.

Bryan N. Roberts, P.E.
State of Utah No. 276476
Project Geotechnical Engineer

Reviewed by:

Alan D. Spilker, P.E.
State of Utah No. 334228
President/Senior Geotechnical Engineer

BNR/ADS:jlh

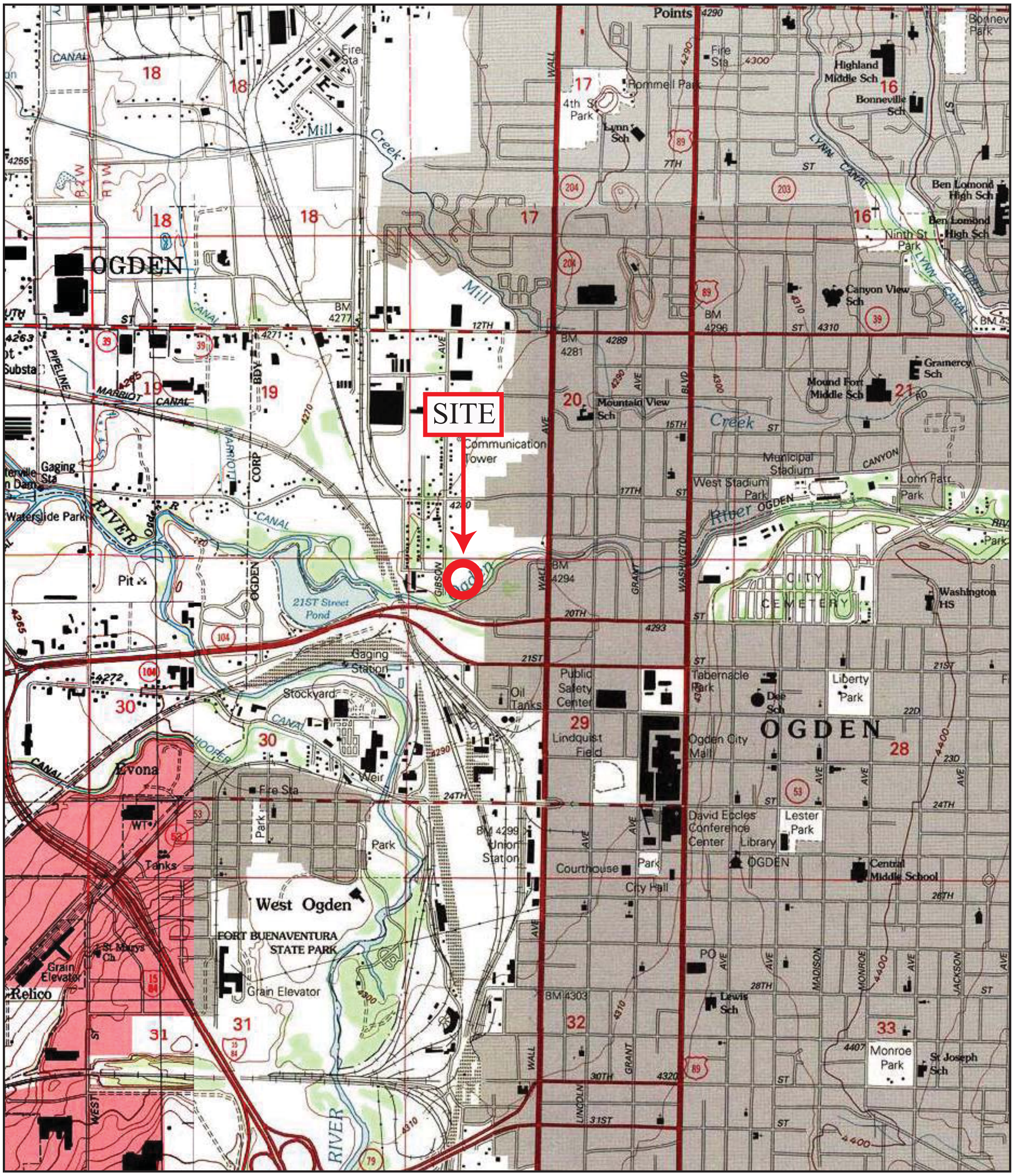
Encl. Figure 1, Vicinity Map
Figure 2, Aerial View
Figure 3, Site Plan
Figures 4A through 4C, Log of Borings
Figure 5, Key to Boring Log (USCS)

Addressee (3 + email)

---

3 Idriss, I. M., and Boulanger, R. W. (2008), Soil liquefaction during earthquakes: Monograph MNO-12, Earthquake Engineering Research Institute, Oakland, CA, 261 pp.

OGDEN CITY COMMUNITY DEVELOPMENT
JOB NO. 1461-01N-13



SCALE IN FEET
1000 0 1000 2000

FIGURE 1
VICINITY MAP

GSH

REFERENCE:
USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE MAP(S)
ENTITLED “OGDEN, UTAH”, “PLAIN CITY, UTAH”, “NORTH OGDEN, UTAH”
ALL DATED 1998 AND “ROY, UTAH” DATED 1999

OGDEN CITY COMMUNITY DEVELOPMENT
JOB NO. 1461-01N-13

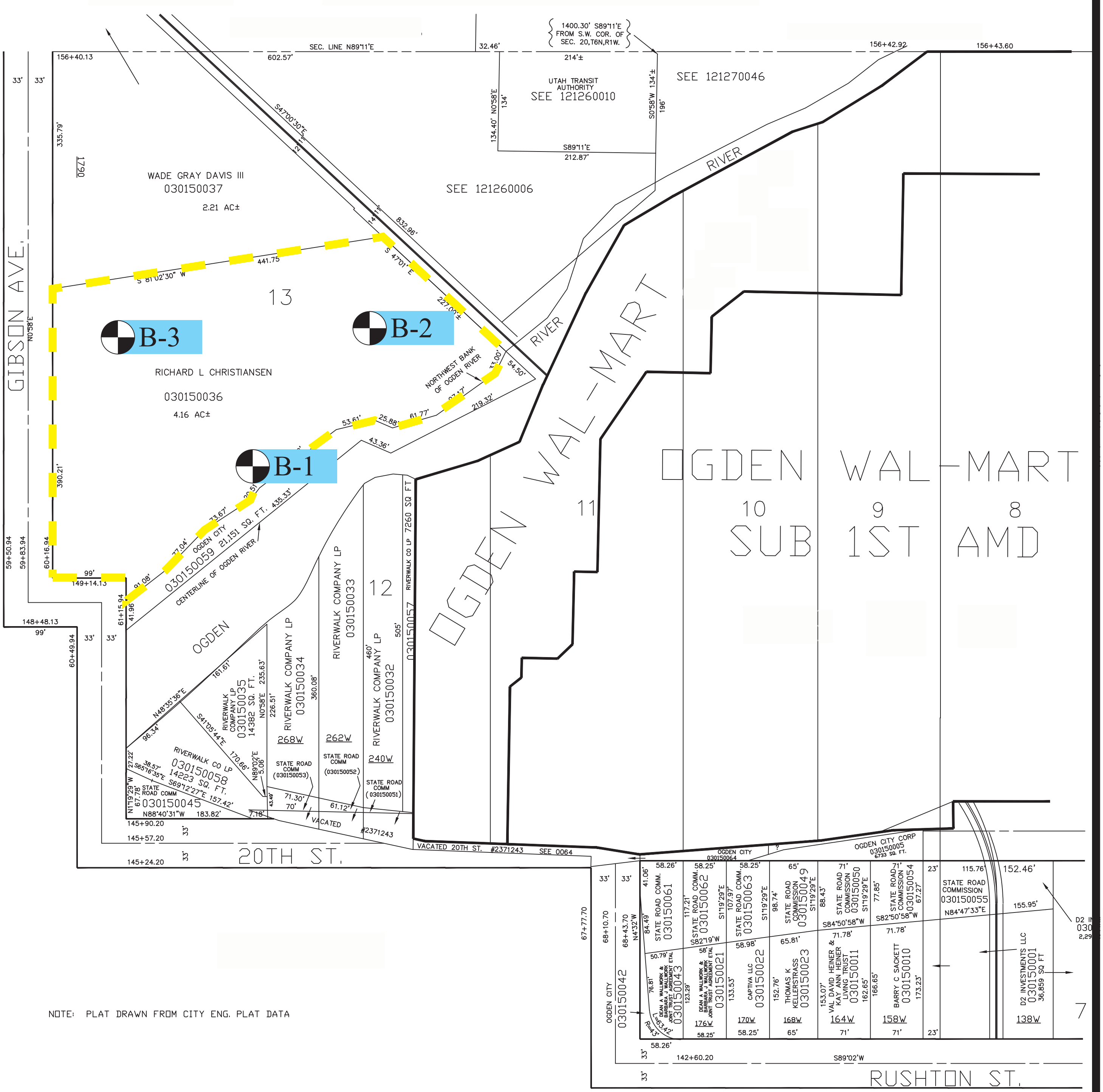
REFERENCE:
ADAPTED FROM AERIAL PHOTOGRAPH
DOWNLOADED FROM GOOGLE EARTH
IMAGERY DATE: 6/17/2010.

NOT TO SCALE

FIGURE 2
AERIAL VIEW

GSH

OGDEN CITY COMMUNITY DEVELOPMENT
JOB NO. 1461-01N-13



NOT TO SCALE

REFERENCE:
ADAPTED FROM FIGURE
PROVIDED BY CLIENT

FIGURE 3
SITE PLAN

GSH

GSH BORING LOG

BORING: B-1

CLIENT: Ogden City Community Development
PROJECT NUMBER: 1461-01N-13
PROJECT: Preliminary Geotechnical Study 1810 Gibson Subdivision
DATE STARTED: 09/12/13 **DATE FINISHED:** 09/12/13
LOCATION: 1810 Gibson Avenue, Ogden, UT, 84401
GSH Field Rep.: RAG
DRILLING METHOD/EQUIPMENT: 3-3/4" ID Hollow-Stem Auger **HAMMER:** Automatic **WEIGHT:** 140 lbs **DROP:** 30"
GROUNDWATER DEPTH: 10' (09/12/13) 9.2' (09/17/13) **ELEVATION:** ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0								
	GM/GP FILL	**FINE TO COARSE SANDY FINE GRAVEL, FILL** with some silt and clay and asphalt pieces; brown									moist
				30	X						medium dense
			5	15	X						
	CL	**SILTY CLAY** with some fine sand; dark brown									moist stiff
▼	GC	**CLAYEY FINE GRAVEL** with some fine to coarse sand; brown/gray									moist saturated
			10	13	‖	13.4		16.2			medium dense
	GM/GP	**FINE GRAVEL** with some fine to coarse sand and some silt; brown									saturated
			15	17	‖						medium dense
	SM	**SILTY FINE TO COARSE SAND** with some coarse gravel and trace cobbles; brown	20	49	‖						saturated dense
	SP	**FINE TO COARSE SAND** with some gravel and trace silt; brown									
			25		‖						

See Subsurface Conditions section in the report for additional information.

GSH BORING LOG

BORING: B-1

CLIENT: Ogden City Community Development | **PROJECT NUMBER:** 1461-01N-13

PROJECT: Preliminary Geotechnical Study 1810 Gibson Subdivision | **DATE STARTED:** 09/12/13

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
			25	17		11.2		4.8			medium dense
											saturated
	CL	**SILTY CLAY** with occasional layers of clayey fine to medium sand less than 0.5” thick; brown	30	3							soft
		grades with trace fine sand	35	4							soft to medium stiff
		End of exploration at 36.0’. Installed 1-1/4” diameter slotted PVC pipe to 36.0’.	40								
			45								
			50								

See Subsurface Conditions section in the report for additional information.

FIGURE 4A (cont’d)

BORING LOG

BORING: B-2

CLIENT: Ogden City Community Development — **PROJECT NUMBER:** 1461-01N-13

PROJECT: Preliminary Geotechnical Study 1810 Gibson Subdivision — **DATE STARTED:** 09/12/13 **DATE FINISHED:** 09/12/13

LOCATION: 1810 Gibson Avenue, Ogden, UT, 84401 — **GSH Field Rep.:** RAG

DRILLING METHOD/EQUIPMENT: 3-3/4" ID Hollow-Stem Auger — **HAMMER:** Automatic **WEIGHT:** 140 lbs **DROP:** 30"

GROUNDWATER DEPTH: 8' (09/12/13) 7.8' (09/17/13) — **ELEVATION:** ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0								
	GM FILL	**FINE TO COARSE SANDY FINE AND COARSE GRAVEL, FILL** brown									
	CL FILL	**FINE TO COARSE SANDY CLAY, FILL** with some fine gravel; brown									
	CL	**SILTY CLAY** with trace fine sand and occasional layers of fine to medium silty sand up to 2.0" thick; brown		70		8.3	107				moist very stiff
			5	14							stiff
▼	SP	**FINE GRAVELLY FINE TO COARSE SAND** gray/brown									saturated
			10	19							loose
	SP-SM/GP-GM	**GRAVELLY SAND/ SANDY GRAVEL** with some silt; brown/gray									saturated
			15	19		12.2		9.4			medium dense
		End of exploration at 16.0'. Installed 1-1/4" diameter slotted PVC pipe to 16.0'.	20								
			25								

See Subsurface Conditions section in the report for additional information.

FIGURE 4B

BORING LOG

BORING: B-3

CLIENT: Ogden City Community Development | **PROJECT NUMBER:** 1461-01N-13
PROJECT: Preliminary Geotechnical Study 1810 Gibson Subdivision | **DATE STARTED:** 09/12/13 **DATE FINISHED:** 09/12/13
LOCATION: 1810 Gibson Avenue, Ogden, UT, 84401 | **GSH Field Rep.:** RAG
DRILLING METHOD/EQUIPMENT: 3-3/4" ID Hollow-Stem Auger | **HAMMER:** Automatic **WEIGHT:** 140 lbs **DROP:** 30"
GROUNDWATER DEPTH: 9.5' (09/12/13) 8.1' (09/17/13) | **ELEVATION:** ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0								
	GM FILL	**FINE GRAVEL, FILL** with some sand; brown									
	SM	**SILTY FINE TO COARSE SAND** with occasional layers of silty clay up to 2" thick; brown		31	⧗	13.7	119				moist, medium dense
	SC	**CLAYEY FINE SAND** brown	5	4	⧗						moist, medium dense
▼											saturated
	SM/SP	**FINE GRAVELLY FINE TO COARSE SAND** with some silt; brown	10	10	‖	13.2		6.7			medium dense
			15	15	‖						
		End of exploration at 16.0'. Installed 1-1/4" diameter slotted PVC pipe to 16.0'.	20								
			25								

See Subsurface Conditions section in the report for additional information.

FIGURE 4C

PROJECT: Ogden City Community Development
PROJECT LOCATION: 1810 Gibson Avenue, Ogden, UT
PROJECT NUMBER: 1461-01N-13

KEY TO BORING LOG

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12

COLUMN DESCRIPTIONS

1. **Water Level**: Depth to measure groundwater table. See symbol below.
2. **USCS**: Graphic depiction of subsurface material encountered; typical symbols are explained below.
3. **Description**: Description of material encountered; may include color, moisture, grain size, and density/consistency.
4. **Depth (ft.)**: Depth in feet below the ground surface.
5. **Blow Count**: Number of blows required to advance sampler (12 inches) beyond first. using a 140-lb hammer with a 30 inch drop.
6. **Sample Symbol**: Type of soil sample collected at depth interval shown; sampler symbols are explained below.
7. **Moisture (%)**: Water content of soil sample measured in laboratory; expressed as percentage of dry weight of specimen.
8. **Dry Density (pcf)**: The density of a soil measured in laboratory; expressed as pounds per cubic foot.
9. **% Passing 200:** Fines content of soil sample passing a No. 200 sieve measured in laboratory, expressed as a percentage.
10. **Liquid Limit (%):** Water content at which a soil changes from plastic to liquid behavior.
11. **Placsticity Index (%):** Range of water content at which a soil exhibits plastic properties.
12. **Remarks**: Comments and observations regarding drilling or sampling made by driller or field personnel. Other field and laboratory test results; using the following abbreviations:

CEMENTATION	MODIFIERS	MOISTURE CONTENT (FIELD TEST)
Weakly: Crumbles or breaks with handling of 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

MAJOR DIVISIONS			SYMBOLS Graph	SYMBOLS Letter	TYPICAL DESCRIPTIONS
COARSE-GRAINED SOILS More than 50% of No. 200 sieve size.	**GRAVELS** More than 50% of coarse fraction retained in No. 4 sieve.	**CLEAN GRAVELS** (little or no fines)		GW	Well-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
				GP	Poorly Graded Gravel, 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 of 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 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

STRATIFACTION

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

STRATIFACTION

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

LOG KEY SYMBOLS

- Water Level

FIGURE 4

GSH