Geotechnical Evaluation Report – Update

Proposed Logan Seminary
110 West 100 South
Logan, Utah (41.7292°, -111.8380°)
LDS Property No.: 502-245323010101

Prepared for:
The Church of Jesus Christ of Latter-day Saints

Utah North PM Office

435 North Wall Avenue, Suite D
Ogden, Utah 84404

GSH

Prepared by
GSH Geotechnical
May 29, 2024

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May 29, 2024
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The Church of Jesus Christ of Latter-day Saints
Utah North PM Office
435 North Wall Avenue, Suite D
Ogden, Utah 84404

Mr. Brian Childs:

Re: Geotechnical Evaluation Report – Update
Proposed Logan Seminary
110 West 100 South
Logan, Utah (41.7292°, -111.8380°)
LDS Property Number: 502-245323010101

1. EXECUTIVE SUMMARY

This report presents the results of the geotechnical study performed at the site of the proposed Logan Seminary to be located at 110 West 100 South in Logan, Utah.

The soils across the site were generally similar at the boring locations. Borings were completed to depths ranging from 16.5 to 46.5 feet. The borings were performed within existing grassy lawn areas and encountered up to approximately 3 inches of topsoil. Topsoil thickness is frequently erratic and thicker zones of topsoil should be anticipated. Non-engineered fills soils were encountered in both borings to depths of up to 6.5 feet below the existing ground surface. The non-engineered fill soil primarily consisted of clay with varying silt, sand, gravel, and cobble content. Natural soils were encountered below the non-engineered fill in each boring. The natural soils primarily consisted of sand and gravel with varying silt content overlying clay with varying silt, sand, and gravel content.

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

The natural clay soils were soft to very stiff, saturated, and gray in color.

Groundwater was measured within the borings at a depth as shallow as 8.2 feet. Based on the anticipated cuts necessary to reach design subgrades, we do not anticipate significant groundwater

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control problems during mass grading operations. However, temporary dewatering may be required for deeper excavations, such as those for utility construction and/or for the removal of non-engineered fills.

The most significant geotechnical aspects of the site are the existing structure and utilities that are to be demolished/relocated, the existing non-engineered fills encountered throughout the site, the relatively shallow depth to groundwater, and the potentially liquifiable soils.

Initial site preparation will consist of the demolition and removal of the existing structures, slabs, foundations, pavements, associated debris, non-engineered fills, 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.

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 consists of the central section of the East Cache fault zone located 2.3 miles to the east of the site.

Due to liquefiable soils being present, the site has been determined to be Site Class F (in accordance with Section 20.3.1, Site Class F of ASCE 7-16). According to ASCE 7-16, a site-specific response analysis is required unless the structure meets the requirements of the exception provided in Section 20.3.1. GSH understands that the proposed structure will have a fundamental period of vibration of less than 0.5 seconds and will therefore meet the exception and a site-specific response analysis is not required.

Based on our analysis, the loose to medium dense, saturated sand layers encountered in Boring B-2 could liquefy during the design seismic event. Calculated settlement associated with the liquefaction within the boring was less than 1.5 inches. This magnitude of settlement must be evaluated by the structural engineer to design for life safety. Additionally, lateral spread and ground rupture are unlikely to occur.

2. INTRODUCTION

This report presents the results of the geotechnical study performed at the site of the proposed Logan Seminary located at 110 West 100 South in Logan, Utah. The general location of the site with respect to existing roadways, as of 2024, is presented on Figure 1, Vicinity Map. A more detailed aerial image of the site showing the existing facilities and roadways is presented on Figure 2, Site Plan. The approximate locations of the borings completed in conjunction with this study are also presented on Figure 2.

3. AUTHORIZATION

Authorization was provided by the client returning a signed "Agreement Between Client and Geotechnical Consultant" in accordance with our Professional Services Agreement No. 23-0908.

4. PROJECT DESCRIPTION, PURPOSE OF EVALUATION, & SCOPE OF WORK

The objectives and scope of our study were planned in discussions between Mr. Brian Childs of The Church of Jesus Christ of Latter-day Saints and Mr. Mike Huber of GSH Geotechnical, Inc. (GSH).

In general, the objectives of this study were to:

1. Define and evaluate the subsurface soil and groundwater conditions.
2. Provide appropriate foundation, earthwork, and geoseismic recommendations to be utilized in the design and construction of the proposed facility.

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

1. A field program consisting of the drilling, logging, and sampling of 2 borings.
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.

5. 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 6, Design Criteria, 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.

6. DESIGN CRITERIA

The seminary structure will be constructed on an approximately 0.5-acre parcel and have a footprint of approximately 4,500 square feet. The structure is anticipated to be 1- to 1-extended level of wood-frame construction, established slab-on-grade, and supported over conventional spread and continuous wall footings.

Maximum real column and wall loads are anticipated to be up to 60 kips and up to 3 kips per lineal foot, respectively. Real loads are defined as the total of all dead plus frequently applied (reduced) live loads.

At-grade paved parking and drive lane areas will be part of the overall site development. Projected traffic in the parking areas is anticipated to consist of a light volume of automobiles and light trucks with no medium-weight or heavyweight trucks. In primary drive areas within the church parking lot, traffic is projected to consist of a light volume of automobiles and light trucks with occasional medium-weight and heavyweight trucks (mainly garbage trucks).

Maximum site grading cuts and fills are anticipated to be on the order of 1 to 2 feet.

7. SITE CONDITIONS

The site is located at 110 West 100 South in Logan, Utah. The site is currently developed with an existing seminary church structure and associated pavements. The site is relatively flat with a slight slope to the south with a total relief of 10 to 12 feet. Site vegetation consists of grassy landscaped areas and mature trees surrounding the existing structure.

The site is bounded to the north by 100 South Street followed by a single-family residential structure; to the east by 100 West Street followed by a multi-family apartment structure; and to the south and west by Logan High School.

8. FIELD STUDY

In order to define and evaluate the subsurface soil and groundwater conditions across the site, 2 borings were extended to depths ranging from 16.5 to 46.5 feet below existing grades. The borings were drilled using a truck-mounted drill rig equipped with hollow-stem augers. The approximate locations of the borings are presented on Figure 2.

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 properties. These classifications were later supplemented by subsequent inspection and testing in our laboratory. Detailed graphical representation of the subsurface conditions encountered is presented on

Figures 3A and 3B, Boring Logs. 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 (Dames & Moore) and a 2.0-inch outside diameter, 1.38-inch inside diameter drive sampler (SPT) were utilized at select locations and depths. 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.

Following completion of exploration operations, 1.25-inch diameter slotted PVC pipe was installed in each boring to provide a means of monitoring the groundwater fluctuations. The borings were backfilled with auger cuttings.

9. SUBSURFACE CONDITIONS AND GROUNDWATER

The following paragraphs provide generalized descriptions of the subsurface profiles and soil conditions encountered within the borings conducted during this study. Soil conditions may vary in unexplored locations.

The borings were completed to depths ranging from 16.5 to 46.5 feet. The soil conditions encountered in each of the borings, to the depths completed, were generally similar across the boring locations.

The borings were performed within existing grassy lawn areas and encountered up to approximately 3 inches of topsoil. Topsoil thickness is frequently erratic and thicker zones of topsoil should be anticipated. Non-engineered fills soils were encountered in both borings to depths of up to 6.5 feet below the existing ground surface. The non-engineered fill soil primarily consisted of clay with varying silt, sand, gravel, and cobble content. Natural soils were encountered below the non-engineered fill in each boring. The natural soils primarily consisted of sand and gravel with varying silt content overlying clay with varying silt, sand, and gravel content.

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

The natural clay soils were soft to very stiff, saturated, and gray in color.

For additional details pertaining to the subsurface conditions encountered, please refer to Figures 3A and 3B, Boring Logs. 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.

Groundwater was measured as shallow as 8.2 feet below the existing ground surface. Based on the anticipated cuts necessary to reach design subgrades, we do not anticipate significant groundwater control problems during mass grading operations. However, temporary dewatering may be required for deeper excavations, such as those for utility construction and/or for the removal of non-engineered fills.

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

10. LABORATORY TESTING

10.1 General

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

10.2 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 samples. The results of these tests are presented on the logs, Figures 3A and 3B.

10.3 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 boring logs, Figures 3A and 3B:

Boring/ No.	Depth (feet)	Percent Passing No. 200 Sieve	Moisture Content Percent	Soil Classification
B-1	2.5	5.5	4.5	GP/GM
	7.5	5.5	3.5	GP/GM
B-2	10.0	6.3	16.8	SP/SM
	15.0	27.2	25.6	SM
	20.0	25.0	25.0	SM

10.4 Atterberg Limits Test

To aid in classifying the soils, an Atterberg limits test is being performed on a sample of the fine-grained cohesive soils. Results of the test will be transmitted to you upon completion.

GSH

10.6 Chemical Tests

A representative soil sample was collected and sent for laboratory analysis for pH and sulfate content. As of the date of this report, results are still pending and will be transmitted when available and with corresponding cement recommendations, if applicable.

10.7 Topsoil Tests

A series of topsoil tests are being performed on a representative surface sample. The results of the tests will be transmitted to you upon completion.

11. RECOMMENDATIONS AND CONCLUSIONS

11.1 SUMMARY OF FINDINGS

The results of the study indicate that the proposed structure may be supported upon conventional spread and continuous wall foundations established upon suitable natural granular soils or granular structural fill extending to suitable natural granular soils.

The most significant geotechnical aspects at the site are:

1. The existing structure and utilities on the site that are to be demolished/relocated.

2. The existing non-engineered fills encountered to depths of up to 6.5 feet below the ground surface.

3. The relatively shallow depth to groundwater with respect to utilities and non-engineered fills.

4. The potentially liquefiable sand layers encountered in Boring B-2.

Prior to proceeding with construction, demolition and removal of the existing structure, slabs, foundations, pavements, surface vegetation, root systems, topsoil, non-engineered fill, 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, additional 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 8.2 feet below the ground surface. GSH recommends placing floor slabs no closer than 4 feet from the highest groundwater elevation. 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 (if necessary).

Proof rolling of the natural subgrade must not be completed if cuts extend to within 1 foot of the groundwater surface. In areas where cuts are to extend to within 1 foot of the groundwater surface, stabilization must 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.

Loose, saturated sand layers were encountered in Boring B-2. Due to liquefiable soils being present, the site has been determined to be Site Class F (in accordance with Section 20.3.1, Site Class F of ASCE 7-16). According to ASCE 7-16, a site-specific response analysis is required unless the structure meets the requirements of the exception provided in Section 20.3.1. GSH understands that the proposed structure will have a fundamental period of vibration of less than 0.5 seconds and will therefore meet the exception and a site-specific response analysis is not required.

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

11.2 EARTHWORK

11.2.1 Site Preparation

Initial site preparation will consist of the demolition and removal of the existing structures, slabs, foundations, pavements, associated debris, non-engineered fills, 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.

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 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 topsoil, loose/disturbed soils, and non-engineered fills have been completely removed.

11.2.2 Temporary Excavations

Temporary excavations up to 8 feet deep in fine-grained cohesive soils (not anticipated at this site), above or below the water table, may be constructed with side slopes 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, shall 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 shall 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 8.2 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.

11.2.3 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, including existing non-engineered fills, 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. <u>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.</u>

Only granular soils are recommended as structural fill in confined areas, such as around foundations, within utility trenches, and as replacement fill below foundations.

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.

11.2.4 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 table on the following page.

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

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 5	95
	5 to 10*	100
Site grading fills outside area defined above	0 to 5	90
	5 to 10*	100
Utility trenches within structural areas	--	96
Road base	--	96

* For structural fill sequences greater than 5 feet thick and up to 10 feet thick, the entire fill sequence must be compacted to 100 percent of the maximum dry density and compaction shall be performed at 0- to 3-percent over the optimum moisture content.

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.

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 over the surface 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.

11.2.5 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 8.2 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.

11.3 GROUNDWATER

On February 28, 2024 (16 days following drilling), groundwater was measured within the PVC pipes installed as tabulated below:

Boring No.	**Groundwater Depth (feet)**
	February 28, 2024
B-1	15.4
B-2	8.2

Based on the anticipated cuts necessary to reach design subgrades, we do not anticipate significant groundwater control problems during mass grading operations. However, temporary dewatering may be required for deeper excavations, such as those for utility construction and/or for the removal of non-engineered fills.

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.

11.4 SPREAD AND CONTINUOUS WALL FOUNDATIONS

11.4.1 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 granular soils and/or structural fill extending to suitable natural granular soils. For design, the following parameters are provided with respect to the projected loading discussed in Section 6, Design Criteria, 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 Capacity for Real Load Conditions for Footings Established Upon Suitable Natural Granular Soils	- 3,000 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.

11.4.2 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.

11.4.3 Settlements

Based on column loadings, soil bearing capacities, and the foundation recommendations as discussed above, settlements are anticipated 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 one-half to three-quarter inch. The final deflected shape of the structure will be dependent on actual foundation locations and loading.

11.5 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 the in situ natural soils and 0.40 for footing interface with 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.

11.6 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. 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 (if necessary).

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.

GSH recommends placing floor slabs no closer than 4 feet from the highest groundwater elevation.

In accordance with the Geotechnical Evaluation Report Template, floor slabs are to be constructed without control or construction joints, are reinforced with No. 4 bars at 18 inches on-center each way and shall include a 15-mil vapor retarder placed directly under the concrete with at least 4 inches of "free-draining" fill, described previously, placed below the vapor retarder.

11.7 PAVEMENTS

The natural granular soils will exhibit moderate pavement support characteristics when saturated. All pavement areas must be prepared as previously discussed (see Section 11.2.1, Site Preparation). Under no circumstances shall pavements be established over loose or disturbed soils, non-engineered soils (if encountered), 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.

<u>Parking Areas</u>

(Light Volume of Automobiles and Light Trucks,
Occasional Medium-Weight Trucks,
No Heavyweight Trucks)
[6 equivalent 18-kip axle loads <u>per week</u>]

<u>Flexible:</u>

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

Rigid:

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 suitable natural subgrade soils

Parking Lot Drive Lanes and Access Driveways

(Moderate Volume of Automobiles and Light Trucks,
Light Volume of Medium-Weight Trucks,
and Occasional Heavyweight Trucks)
[15 equivalent 18-kip axle loads per week]

Flexible:

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

Rigid:

5.5 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 suitable natural subgrade soils

For trash enclosure and associated approach slabs (one 40,000-pound axel load per week), we recommend a pavement section consisting of 8.0 inches of Portland cement concrete, 12.0 inches of aggregate base, over properly prepared and stabilized natural subgrade or site grading structural fills extending to suitable stabilized natural soils.

The 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 shall have a minimum 28-day unconfined compressive strength of 4,500 pounds per square inch, contain 6 percent ±1 percent air-entrainment, and meet the requirements given below in Section 11.8, Cement Types, of this report. In accordance with the Geotechnical Evaluation Report Template, 25 percent fly ash is required in all concrete exposed to freeze-thaw cycles and deicers.

The crushed stone shall conform to applicable sections of the current Utah Department of Transportation (UDOT) Standard Specifications. All asphalt material and paving operations shall 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.

11.8 CEMENT TYPES

A representative soil sample was collected and sent for laboratory analysis for pH and sulfate content. As of the date of this report, results are still pending and will be transmitted when available and with corresponding cement recommendations, if applicable.

11.9 DOWNSPOUTS

It is recommended that all surface water be directed away from the building with positive drainage measures, including downspouts.

11.10 GEOSEISMIC SETTING

11.10.1 General

Utah municipalities have adopted the International Building Code (IBC) 2021. The IBC 2021 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).

11.10.2 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 consists of the central section of the East Cache fault zone located 2.3 miles to the east of the site.

11.10.3 Soil Class

Due to liquefiable soils being present, the site has been determined to be Site Class F (in accordance with Section 20.3.1, Site Class F of ASCE 7-16). According to ASCE 7-16, a site-specific response analysis is required unless the structure meets the requirements of the exception provided in Section 20.3.1. GSH understands that the proposed structure will have a fundamental period of vibration of less than 0.5 seconds and will therefore meet the exception and a site-specific response analysis is not required.

The spectral accelerations may be determined by using a Site Class D-Default Soil Profile (in accordance with Section 20.3 and the corresponding values of F_a and F_v determined from Tables 11.4-1 and 11.4-2). If a measured site class in accordance with IBC 2021/ASCE 7-16 is beneficial based on the project structural engineer's review, please contact GSH for additional options for obtaining this measured site class.

11.10.4 Ground Motions

The IBC 2021 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 short and long period accelerations for the MCE event and incorporates the appropriate soil amplification factor for a Site Class D – Default* Soil Profile. Based on the site latitude and longitude (41.7292 degrees north and 111.8380 degrees west, respectively) and Risk Category II, the values for this site are tabulated below:

Spectral Acceleration Value, T	Bedrock Boundary [mapped values] (% g)	Site Coefficient	Site Class D - Default* [adjusted for site class effects] (% g)	Design Values (% g)
0.2 Seconds (Short Period Acceleration)	S_S = 107.2	F_a = 1.200	S_{MS} = 128.6	S_{DS} = 85.7
1.0 Second (Long Period Acceleration)	S_1 = 35.8	F_v = 1.942	S_{M1} = 69.5	S_{D1} = 46.3

* See Section 11.10.3, Soil Class

11.10.5 Liquefaction

The site is located in an area that has been identified by the Utah Geological Survey (UGS) as being a “high to moderate” 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.

Calculations were performed using the procedures described in the 2014 Soil Liquefaction During Earthquakes Monograph by Idriss and Boulanger[3]. Our calculations indicate the loose to medium dense, saturated sand layers encountered in Boring B-2 could liquefy during the design seismic event. Calculated settlement associated with the liquefaction within the boring was less than 1.5 inches. This magnitude of settlement must be evaluated by the structural engineer to design for life safety. Additionally, lateral spread and ground rupture are unlikely to occur.

11.11 SITE VISITS

GSH must verify that all topsoil/disturbed soils and any other unsuitable soils have been removed, that non-engineered fills 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.

[3] Idriss, I. M., and Boulanger, R. W. (2014), Soil liquefaction during earthquakes: Monograph MNO-12, Earthquake Engineering Research Institute, Oakland, CA, 261 pp.

11.12 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.

Michael S. Huber, P.E.
State of Utah No. 343650
Vice President/Senior Geotechnical Engineer

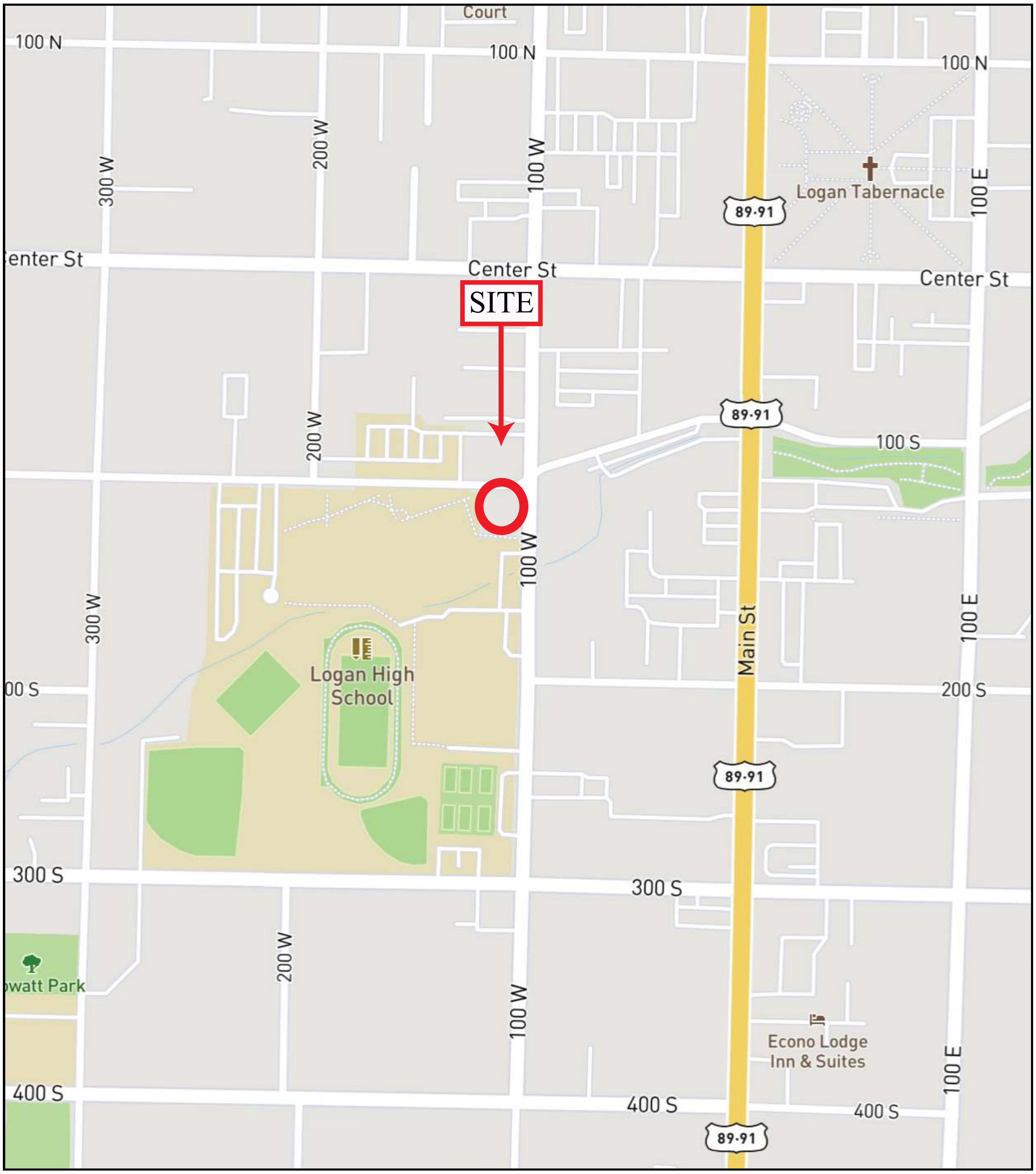
MSH:jmt

Encl.	Figure	1,	Vicinity Map
	Figure	2,	Site Plan
	Figures	3A	and 3B, Boring Logs
	Figure	4,	Key to Boring Logs (USCS)

Addressee: (email)

cc: Matt McBride (mattm@arwengineers.com)
Adam Ferguson (aferguson@ffkr.com)

THE CHURCH OF JESUS CHRIST OF LATTER-DAY SAINTS
JOB NO. 0153-521-24



0.05 0 0 0 0 0 0.05 0.1 0.15 MI 0.2

100 0 0 100 200 M 300

FIGURE 1
VICINITY MAP

GSH

REFERENCE:
ALL TRAILS - NATIONAL GEOGRAPHIC TERRAIN
DATED 2024

THE CHURCH OF JESUS CHRIST OF LATTER-DAY SAINTS
JOB NO. 0153-521-24

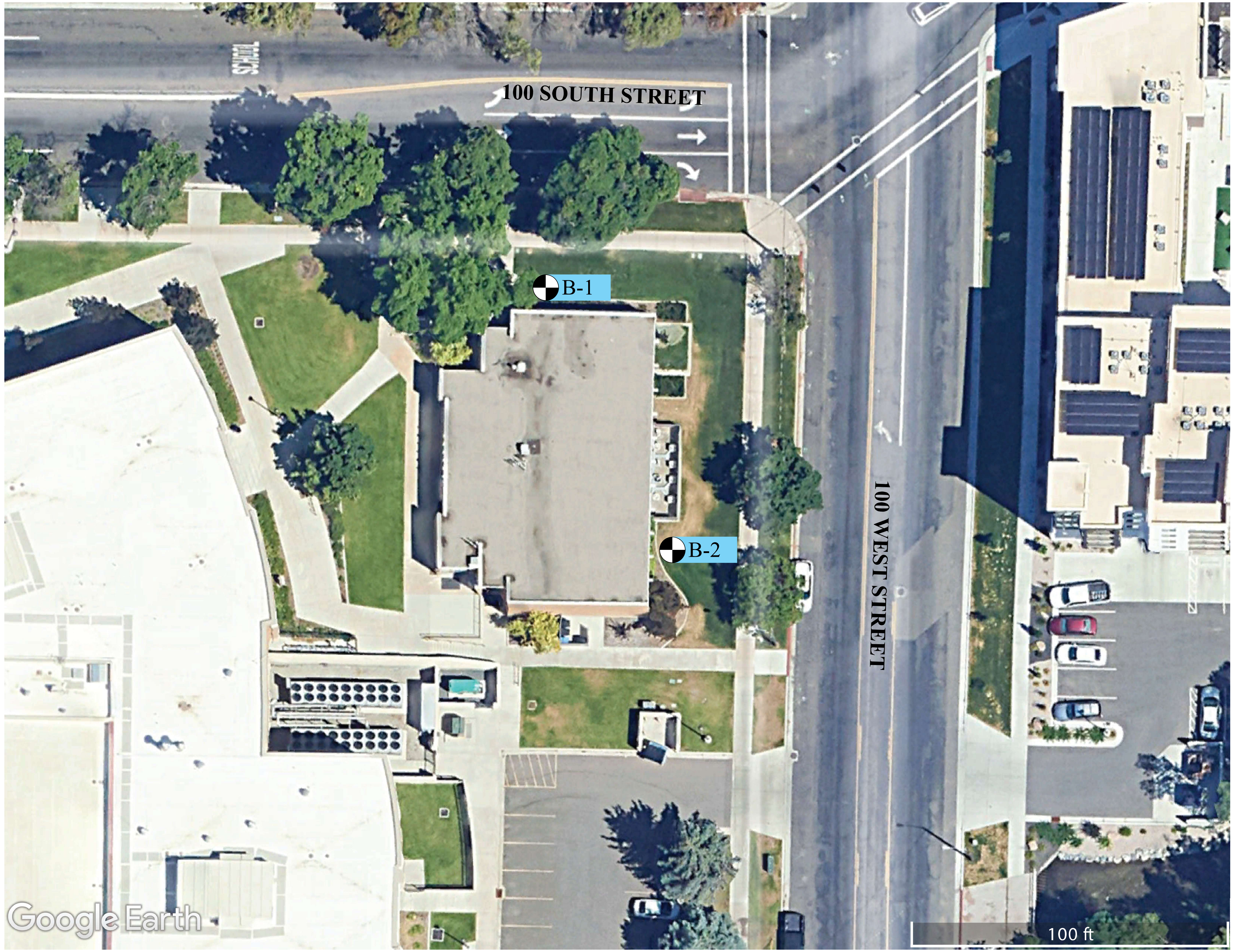


FIGURE 2
SITE PLAN

GSH

REFERENCE:
ADAPTED FROM AERIAL PHOTOGRAPH
DOWNLOADED FROM GOOGLE EARTH
IMAGERY DATED 7/2023

BORING LOG

BORING: B-1

CLIENT: The Church of Jesus Christ of Latter-day Saints	PROJECT NUMBER: 0153-521-24
PROJECT: Proposed Logan Seminary	DATE STARTED: 2/12/24 DATE FINISHED: 2/12/24
LOCATION: 110 West 100 South, Logan, Utah (41.7292°, -111.8380°)	GSH FIELD REP.: JC
DRILLING METHOD/EQUIPMENT: 4-1/4" ID Hollow-Stem Auger	HAMMER: Automatic WEIGHT: 140 lbs DROP: 30"
GROUNDWATER DEPTH: 15.4' (2/28/24)	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								
	CL FILL	FINE TO COARSE SANDY CLAY, FILL with fine and coarse gravel; major roots (topsoil) to 3"; brown									slightly moist medium stiff
	GP/GM	FINE AND COARSE GRAVEL with some silt and fine to coarse sand; brown									slightly moist medium dense
				62		4.5		5.5			
			5	73							moist dense
				37		3.5		5.5			
			10								
▽			15	86		5.5	95				saturated
		End of Exploration at 16.5'. No groundwater encountered at time of drilling. Installed 1.25" diameter slotted PVC pipe to 16.5'.									
			20								
			25								

See Subsurface Conditions section in the report for additional information.

FIGURE 3A

GSH

BORING LOG

BORING: B-2

CLIENT: The Church of Jesus Christ of Latter-day Saints | PROJECT NUMBER: 0153-521-24

PROJECT: Proposed Logan Seminary | DATE STARTED: 2/12/24 | DATE FINISHED: 2/12/24

LOCATION: 110 West 100 South, Logan, Utah (41.7292°, -111.8380°) | GSH FIELD REP.: JC

DRILLING METHOD/EQUIPMENT: 4-1/4" ID Hollow-Stem Auger | HAMMER: Automatic | WEIGHT: 140 lbs | DROP: 30"

GROUNDWATER DEPTH: 8.2' (2/28/24) | ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface									
	CL FILL	SILTY CLAY, FILL with fine and coarse gravel, trace fine sand, and cobbles; major roots (topsoil) to 3"; brown	0								moist very stiff
				26							
		grades with trace coarse sand	5	10							
	SP/SM	FINE TO COARSE SAND with fine and coarse gravel and some silt; brown									moist medium dense
▼											saturated
			10	14		16.8		6.3			
	SM	SILTY FINE TO COARSE SAND with layers of clay up to 1/4" thick; brown									saturated loose
			15	9		25.6		27.2			
		grades with layers of clay up to 2" thick	20	7		25.0		25.0			
	CL	SILTY CLAY with trace fine sand; gray									saturated medium stiff
			25								

See Subsurface Conditions section in the report for additional information.

FIGURE 3B

BORING LOG

BORING: B-2

CLIENT: The Church of Jesus Christ of Latter-day Saints — PROJECT NUMBER: 0153-521-24

PROJECT: Proposed Logan Seminary — DATE STARTED: 2/12/24 — DATE FINISHED: 2/12/24

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		grades with trace coarse sand and fine gravel	25	6							
			30								
		gravel grades out		3							soft
			35	12							stiff
			40	24							very stiff
			45	4							medium stiff
		End of Exploration at 46.5'. Installed 1.25" diameter slotted PVC pipe to 46.5'.									
			50								

See Subsurface Conditions section in the report for additional information.

FIGURE 3B (continued)

CLIENT: The Church of Jesus Christ of Latter-day Saints PROJECT: Proposed Logan Seminary PROJECT NUMBER: 0153-521-24	**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 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 **Blow Count:** Number of blows to advance sampler 12" beyond first 6", using a 140-lb hammer with 30" 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 dryweight of

⑧ **Dry Density (pcf):** The density of a soil measured in laboratory; expressed in pounds per cubic foot.

⑨ **% Passing 200:** Fines content of soils sample passing a No. 200 sieve; expressed as a percentage.

⑩ **Liquid Limit (%):** Water content at which a soil changes from plastic to liquid behavior.

⑪ **Plasticity 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. 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