GSH

REPORT
GEOTECHNICAL STUDY
LOTS 46R, 47R, AND 48R, SUMMIT AT SKI LAKE NO. 12
SUMMIT PEAK CIRCLE
HUNTSVILLE, UTAH

Submitted To:

Valley Enterprise Investment Company
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Submitted By:

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Job No. 2207-02N-16

November 21, 2016
Job No. 2077-02N-16

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Re: Report
Geotechnical Study
Lots 46R, 47R, and 48R, Summit at Ski Lake No. 12
Summit Peak Circle
Huntsville, Utah

1. INTRODUCTION

1.1 GENERAL

This report presents the results of our geotechnical study performed for the proposed structures on Lots 46R, 47R, and 48R of the Summit at Ski Lake No. 12 located on Summit Peak Circle in Weber County, near Huntsville, Utah. The general location of the site with respect to major roadways, as of 1998, is presented on Figure 1, Vicinity Map. A more detailed layout of the site showing the proposed improvements is presented on Figure 2, Site Plan. The locations of the borings/test pits/trenches excavated in conjunction with this study are also presented on Figure 2.

1.2 OBJECTIVES AND SCOPE

The objectives and scope of our study were planned in discussions between Mr. Ray Bowden of Valley Enterprise Investment Company and Mr. Andrew Harris of GSH Geotechnical, Inc. (GSH).

In general, the objectives of this study were to:

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

2. Provide appropriate foundation, earthwork, and slope stability recommendations as well as geoseismic information to be utilized in the design and construction of the proposed home.

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

1. A field program consisting of the drilling/excavating, logging, and sampling of 2 borings, 2 test pits, and 3 trenches.

2. A laboratory testing program.

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

1.3 AUTHORIZATION

Authorization was provided by returning a signed copy of our Professional Services Agreement No. 16-0471N dated May 2, 2016.

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/test pits/trenches, 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

The proposed project consists of constructing single-family residences for Lots 46R, 47R, and 48R of the Summit at Ski Lake No. 12 in Huntsville, Utah. Construction will likely consist of reinforced concrete spread footings and basement foundation walls supporting 1 to 2 wood-framed levels above grade. Projected maximum column and wall loads are on the order of 10 to 25 kips and 1 to 3 kips per lineal foot, respectively.

Site development will require a moderate amount of earthwork in the form of site grading. We estimate in general that maximum cuts and fills to achieve design grades will be on the order of 2 to 8 feet. Larger cuts and fills may be required in isolated areas and must be planned to maintain stability of the site slopes.

To facilitate site grading for the proposed homes, engineered retaining walls will likely be required. Retaining walls must be engineered based on the site-specific site grading plans. At the time of this report, site-specific grading plans are not available.

3. INVESTIGATIONS

3.1 FIELD PROGRAM

In order to define and evaluate the subsurface soil and groundwater conditions at the site, 2 borings, 2 test pits, and 3 trenches were explored to depths of about 4.0 to 51.5 feet below existing grades. The borings were drilled using a truck-mounted drill rig equipped with hollow-stem augers, and the test pits were excavated using a 20-ton track-mounted excavator. Refusal with the excavator was encountered in the test pit and trench excavations. Locations of the borings and test pits/trenches 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 and excavating operations, a log of the subsurface conditions encountered was maintained. In addition, relatively undisturbed and small disturbed 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 representations of the subsurface conditions encountered are 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). Additional information related to the soil conditions encountered in the test pits and trenches are presented within the attached geological study.

A 3.0-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 in the subsurface soil sampling 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.

A 2.42-inch inside diameter thin-wall drive sampler was utilized in the subsurface sampling at the site.

Following completion of drilling operations, 1.25-inch diameter slotted PVC pipe was installed in Borings B-1 and B-2 in order to provide a means of monitoring potential groundwater fluctuations. The borings were backfilled with auger cuttings. Following completion of excavating and logging, each test pit/trench was backfilled. Although an effort was made to compact the backfill with the trackhoe, backfill was not placed in uniform lifts and compacted to a specific density. Consequently, the backfill soils must be considered as non-engineered and settlement of the backfill with time is likely to occur.

3.2 LABORATORY TESTING

3.2.1 General

In order to provide data necessary for our engineering analyses, a laboratory testing program was performed. The program included moisture, density, Atterberg limits, partial gradations, consolidation, direct shear, and residual direct shear tests. The following paragraphs describe the tests and summarize the test data.

3.2.2 Moisture and Density

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

3.2.3 Atterberg Limits Tests

To aid in classifying the soils, Atterberg limits tests were performed on samples of the fine-grained cohesive soils. Results of the tests are tabulated below:

Boring/Test Pit/Trench No.	Depth (feet)	Liquid Limit (percent)	Plastic Limit (percent)	Plasticity Index (percent)	Soil Classification
B-1	12.5	43	26	17	CL
B-1	17.5	50	30	20	MH
B-1	35.0	50	27	23	CL
B-1	45.0	43	30	13	ML
B-2	20.0	54	27	27	CH
B-2	30.0	78	37	41	MH

3.2.4 Partial Gradation Tests

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

Boring/Test Pit/Trench No.	Depth (feet)	Moisture Content Percent	Percent Passing No. 200 Sieve	Soil Classification
B-1	12.5	26.7	55.2	CL/SC
B-1	17.5	19.2	70.3	CL/ML
B-2	35.0	21.1	71.8	CL/ML

3.2.5 Consolidation Tests

To provide data necessary for our settlement analyses, consolidation tests were performed on a representative sample of the silty clay soils encountered at the site. Based upon data obtained from the consolidation tests, the silty clay/clayey silt soils are moderately over-consolidated and will exhibit moderate strength and compressibility characteristics under the anticipated loadings. Additionally, the silty clay/clayey silt soils exhibit a moderate expansive potential and swell pressure of about 400 to 800 psf. Detailed results of the tests are maintained within our files and can be transmitted, at the Client's request.

3.2.6 Laboratory Direct Shear Tests

To determine the shear strength of the soils encountered at the site, laboratory direct shear tests were performed on samples of the site soils. The results of the tests are tabulated below:

Test Pit/ Trench/ Boring No.	Depth (feet)	Soil Type	In-Situ Moisture Content (percent)	Dry Density (pcf)	Internal Friction Angle (degrees)	Apparent Cohesion (psf)
B-1	7.5	CL/FILL	38	75	27	50
B-2	27.5	CL/ML	34	84	31	505
B-2	30.0	CL/ML	---	---	27	175

4. SITE CONDITIONS

4.1 GEOLOGIC SETTING

A geologic study dated November 10, 2016[1] was prepared for the subject property by GSH and a copy of that report is included in the attached Appendix.

4.2 SURFACE

The subject site consists of 3 residential lots within the existing Summit at Ski Lakes Development located on Summit Peak Circle in Huntsville, Utah. The topography of the site slopes downward to the west/northwest with an overall change in elevation of about 125 feet across the site. Vegetation at the site consists primarily of native weeds, grasses, and a number of mature trees. The site is bordered on the north and west by residential development and on the south and east by undeveloped property.

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1 "Report, Geological Study, Lots 46R, 47R, and 48R, The Summit at Ski Lake Phase 12, Weber County, Utah," GSH Geotechnical, Inc., GSH Job No. 2077-02N-16, November 10, 2016.

4.3 SUBSURFACE SOIL

Subsurface conditions encountered at the boring, test pit, and trench locations varied slightly across the site. Fill material consisting of silty clay was encountered at both of the boring locations extending to about 10.0 to 12.5 feet below existing site grades. Topsoil and disturbed soils were observed in the upper 3 to 12 inches at the test pit and trench locations. Natural soils were observed beneath the fill material and topsoil/disturbed soils to the full depth penetrated, about 4.0 to 51.5 feet below surrounding grades and consisted of silty clay, clayey silt, fine to coarse sand with varying amounts of silt, weathered bedrock (weathered sandstone/claystone/siltstone), and occasional mixture of these soils.

The natural sand soils encountered were medium dense to very dense, slightly moist to moist, light brown to reddish-brown in color, and will generally exhibit moderately high strength and low compressibility characteristics under the anticipated loading.

The natural clay and silt soils encountered were medium stiff to hard, slightly moist to moist, light brown to gray in color, and will generally exhibit moderate strength and compressibility characteristics under the anticipated loading.

The siltstone and sandstone bedrock soils were dry to slightly moist, light brown to brown in color, and weathered

For a more detailed description of the subsurface soils encountered, please refer to Figures 3A and 3B, Boring Logs, and test pit/trench logs within the referenced geological study. The lines designating the interface between soil types on the boring/trench/test pit logs generally represent approximate boundaries. In situ, the transition between soil types may be gradual.

4.4 GROUNDWATER

Groundwater was not encountered in the borings, test pits, and trenches at the time of our field exploration. Groundwater is anticipated to be at significant depths in the area. Seasonal "perched" groundwater conditions may develop atop the shallow bedrock encountered at the site. Seasonal and longer-term groundwater fluctuations on the order of 1.0 to 2.0 feet should be anticipated, with the highest levels occurring during the late spring and summer months. Landscape irrigation on this and surrounding areas may also create additional seasonal groundwater fluctuations. The limitations of landscape irrigation at the site are discussed further in Section 5.9, Site Irrigation, and measures to reduce infiltration of surface water at the site are discussed further in Section 5.8, Subdrains.

5. DISCUSSIONS AND RECOMMENDATIONS

5.1 SUMMARY OF FINDINGS

The results of our analyses indicate that the proposed structures on Lots 46R, 47R, and 48R upon conventional spread and/or continuous wall foundations established upon a minimum of 18 inches of granular structural fill extending to suitable natural soils.

The most significant geotechnical aspect of the site are the shallow bedrock at the site and maintaining stability of the slopes at the property.

The on-site soils are not appropriate to be used as structural site grading fill; however, they may be used as general grading fill in landscape areas.

A geotechnical engineer from GSH will need to verify that all fill material (if encountered) and topsoil/disturbed soils have been completely removed and suitable natural soils encountered prior to the placement of structural site grading fills, floor slabs, foundations, or rigid pavements.

In the following sections, detailed discussions pertaining to earthwork, foundations, lateral pressure and resistance, floor slabs, slope stability, and the geoseismic setting of the site are provided.

5.2 EARTHWORK

5.2.1 Site Preparation

Initial site preparation will consist of the removal of surface vegetation, topsoil, and any other deleterious materials from beneath an area extending out at least 3 feet from the perimeter of the proposed building and 2 feet beyond pavements and exterior flatwork areas.

All non-engineered fills must be removed below all structures. In-situ, non-engineered fills may remain below pavements if the owner accepts the risk of movement, if free of debris and deleterious materials, if less than 4 feet in thickness, and if properly prepared. Proper preparation will consist of the scarification of the upper 12 inches below asphalt concrete (flexible pavement) and 24 inches below rigid pavement followed by moisture preparation and re-compaction to the requirements of structural fill. The thicker sequence of prepared soils below rigid pavements would require the temporary removal of 12 inches of fill soils, scarifying, moisture conditioning, and recompacting the underlying 12 inches and backfilling with 12 inches of compacted suitable fills.

Even with proper preparation, pavements established overlying non-engineered fill soil may encounter some long-term movements unless the non-engineered fill soils are completely removed. Installing reinforcement in slabs over fills may help reduce potential displacement cracking.

It must be noted that from a handling and compaction standpoint, on-site soils containing high amounts of fines (silts and clays) are inherently more difficult to rework and are very sensitive to changes in moisture content, requiring very close moisture control during placement and compaction. This will be very difficult, if not impossible, during wet and cold periods of the year. Additionally, the on-site soils are likely above optimum moisture content for compacting at present and would require some drying prior to recompacting. As an alternative, the fills may be removed and replaced with imported granular structural fill over unfrozen, proof rolled subgrade.

Subsequent to stripping and prior to the placement of structural site grading fill, pavements, driveway, and parking slabs on grade, the prepared subgrade must be proof rolled by passing moderate-weight rubber tire-mounted construction equipment over the surface at least twice. If excessively soft or loose soils are encountered, they must be removed to a maximum depth of 2 feet and replaced with structural fill. Beneath footings, all loose and disturbed soils must be totally removed. Fill soils must be handled as described above.

Surface vegetation, debris, and other deleterious materials shall generally be removed from the site. Topsoil, although unsuitable for utilization as structural fill, may be stockpiled for subsequent landscaping purposes.

A representative of GSH must verify that suitable natural soils and/or proper preparation of existing fills have been encountered/met prior to placing site grading fills, footings, slabs, and pavements.

5.2.2 Excavations

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:1V). 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. Excavations deeper than 8 feet are not anticipated at the site.

Temporary excavations up to 8 feet deep in fine-grained cohesive soils (if encountered), above or below the water table, may be constructed with sideslopes no steeper than one-half horizontal to one vertical (0.5H:1V).

To reduce disturbance of the natural soils during excavation, it is recommended that smooth edge buckets/blades be utilized.

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 will be required as site grading fill, as backfill over foundations and utilities, and possibly as replacement fill beneath some footings. All structural fill must be free of sod, rubbish, construction debris, frozen soil, and other deleterious materials.

Structural site grading fill is defined as fill placed over fairly large open areas to raise the overall site grade. The maximum particle size within structural site grading fill should generally not exceed 4 inches; although, occasional particles up to 6 to 8 inches may be incorporated provided that they do not result in "honeycombing" or preclude the obtainment of the desired degree of compaction. In confined areas, the maximum particle size should generally be restricted to 2.5 inches.

Only granular soils are recommended in confined areas such as utility trenches, below footings, etc. Generally, we recommend that all imported granular structural fill consist of a well-graded mixture of sands and gravels with no more than 20 percent fines (material passing the No. 200 sieve) and less than 30 percent retained on the three-quarter-inch sieve. The plasticity index of import fine-grained soil shall not exceed 18 percent.

To stabilize soft subgrade conditions or where structural fill is required to be placed closer than 1.0 foot above the water table at the time of construction, a mixture of coarse 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 native ground if 1.5- to 2.0-inch gravel is used as stabilizing fill.

On-site soils are not recommended as structural fill but may be used as non-structural grading fill in landscape areas. 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 ASTM[2] D-1557 (AASHTO[3] T-180) compaction criteria in accordance with the table on the following page.

[2] American Society for Testing and Materials
[3] American Association of State Highway and Transportation Officials

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 8	95
Site Grading Fills outside area defined above	0 to 5	90
Site Grading Fills outside area defined above	5 to 8	95
Trench Backfill	--	96
Pavement granular base/subbase	--	96

Structural fills greater than 8 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.

If utilized for stabilizing fill, coarse gravel and cobble mixtures should 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 fill may be compacted by passing moderately heavy construction equipment or large self-propelled compaction equipment at least twice. Subsequent fill material placed over the coarse gravels and cobbles shall be adequately compacted so that the “fines” are “worked into” the voids in the underlying coarser gravels and cobbles.

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 proof rolled and/or properly compacted prior to the construction of any exterior flatwork over a backfilled trench. Proof rolling may 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 must be removed (to a maximum depth of 2 feet below design finish grade) and replaced with structural fill.

Most utility companies and City-County governments are now requiring that Type A-1-a/A-1-b (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. We recommend that as the major utilities continue onto the site that these compaction specifications are followed.

The natural or imported silt/clay soils are not recommended for use as trench backfill, particularly in structurally loaded areas.

5.3 SLOPE STABILITY

5.3.1 Parameters

The properties of the soils at this site were estimated using the results of our laboratory testing, published correlations, and our experience with similar soils. Accordingly, we estimated the following parameters for use in the stability analyses:

Accordingly, we estimated the following parameters for use in the stability analyses:

Material	Internal Friction Angle (degrees)	Apparent Cohesion (psf)	Saturated Unit Weight (pcf)
Silt/Clay (Colluvium)	27	150	115
Fill	27	50	110
Bedrock	31	500	120

For the seismic analysis, a peak horizontal ground acceleration of 0.237*g* using IBC 2015 guidelines and adjusted for Site Class effects (for Site Class C soils) was obtained for site (grid) locations of 41.2430 degrees latitude (north) and 111.7826 degrees longitude (west). To model sustained accelerations at the site, one-half of this value is typically employed. Accordingly, a value of 0.13g was used as the pseudostatic coefficient for the stability analysis.

5.3.2 Stability Analyses

We evaluated the global stability of the existing slopes using the computer program *SLIDE*. This program uses a limit equilibrium (Simplified Bishop) method for calculating factors of safety against sliding on an assumed failure surface and evaluates numerous potential failure surfaces, with the most critical failure surface identified as the one yielding the lowest factor of safety of those evaluated. We analyzed the following configurations based on cross-sections provided in the referenced geologic study (see geological study in Appendix for cross-section information and location):

- Cross-section consisting of a relatively flat roadway area grading downward to the proposed home location and slope at grades ranging from about 3H:1V (Horizontal to Vertical) to 4H:1V (Horizontal:Vertical). To simulate the load imposed on the slope by the proposed home, a load of 1,500 psf was modeled over the proposed building area. In addition, a phreatic surface was conservatively included above the bedrock contact.

Typically, the required minimum factors of safety are 1.5 for static conditions and 1.0 for seismic (pseudostatic) conditions. The results of our analyses indicate that the slope configuration analyzed will meet both these requirements provided our recommendations are followed (see Figures 5 and 6).

Slope movements or even failure can occur if the slope soils are undermined or become saturated. Groundwater was not encountered during the course of our field investigation; however, saturation of the slope soils can adversely affect the stability of the slope. Measures must be implemented to reduce the potential for saturation of the soils at the site. Surface drainage at the bottom and top of the slope should be directed to prevent ponding at the toe or crest of the slope, and a cut-off drain on the slope above the homes is recommended to reduce the potential for infiltration of surface water at the site, as discussed further in Section 5.8, Subdrains. Landscape irrigation on this and surrounding areas may also create additional seasonal groundwater fluctuations. The limitations of landscape irrigation at the site are discussed further in Section 5.9, Site Irrigation. The property owner and the owner's representatives should be made aware of the risks should these or other conditions occur that could saturate or erode/undermine the slope soils.

Changes to the grading at the site and any retaining walls must be properly engineered to maintain stability of the slopes. GSH must review the final grading plans for the project prior to initiation of any construction.

5.4 SPREAD AND CONTINUOUS WALL FOUNDATIONS

5.4.1 Design Data

The results of our analyses indicate that the proposed structures may be supported upon conventional spread and/or continuous wall foundations established upon a minimum of 18 inches of granular structural fill extending to suitable natural soils. For design, with respect to the proposed construction and anticipated loading given in Section 2.0, Proposed Construction, the following parameters are recommended:

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	- 1,500 pounds per square foot
Bearing Pressure Increase for Seismic Loading	- 50 percent

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.

5.4.2 Installation

Practical refusal of excavating equipment (20-ton trackhoe with 36-inch bucket) was encountered at shallow depths within the test pit and trench excavations. Shallow bedrock at the site will require large excavating equipment, chipping, and possible light blasting to penetrate the bedrock for home and utility excavations. Under no circumstances shall the footings be established upon non-engineered fills, loose or disturbed soils, topsoil, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water. If unsuitable soils are encountered, they must be completely removed and replaced with compacted structural fill.

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. For instance if the footing width is 2 feet and the structural fill depth beneath the footing is 1.5 feet, the fill replacement width should be 3.5 feet, centered beneath the footing.

5.4.3 Settlements

Maximum settlements of foundations designed and installed in accordance with recommendations presented herein and supporting maximum anticipated loads as discussed in Section 2, Proposed Construction, are anticipated to be one inch or less.

Approximately 40 percent of the quoted settlement should occur during construction.

5.5 LATERAL RESISTANCE

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

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

5.6 LATERAL PRESSURES

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 8 feet in height, granular backfill may be considered equivalent to a fluid with a density of 45 pounds per cubic foot. The above values assume that the surface of the soils slope behind the wall is no steeper than 4 horizontal to 1 vertical and that the granular fill within 3 feet of the wall will be compacted with hand-operated compacting equipment.

For seismic loading, a uniform pressure shall be added. The uniform pressures based on different wall heights are provided in the following table:

Wall Height (feet)	Seismic Loading Active Case (psf)	Seismic Loading Moderately Yielding (psf)
4	25	55
6	40	85
8	55	115

5.7 FLOOR SLABS

Floor slabs may be established upon a minimum of 18 inches of structural fill extending to suitable natural soils. Under no circumstances shall floor slabs be established over non-engineered fills, loose or disturbed soils, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water. In order to provide a capillary break and facilitate curing of the concrete, 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 inch.

The tops of all floor slabs in habitable areas must be established at least 3 feet above the highest anticipated normal water level or 1.5 feet above the maximum groundwater level controlled by land drains.

5.8 SUBDRAINS

5.8.1 General

Groundwater was not encountered at the site; however, we recommend that the perimeter foundation subdrains and a cutoff drain upslope of all the homes be installed as indicated below.

5.8.2 Foundation Subdrains

Foundation subdrains should consist of a 4-inch diameter perforated or slotted plastic or PVC pipe enclosed in clean gravel. The invert of a subdrain should be at least 2 feet below the top of the lowest adjacent floor slab. The gravel portion of the drain should extend 2 inches laterally and below the perforated pipe and at least 1 foot above the top of the lowest adjacent floor slab. The gravel zone must be installed immediately adjacent to the perimeter footings and the foundation walls. To reduce the possibility of plugging, the gravel must be wrapped with a geotextile, such as Mirafi 140N or equivalent. Above the subdrain, a minimum 4-inch-wide zone of "free-draining" sand/gravel should be placed adjacent to the foundation walls and extend to within 2 feet of final grade. The upper 2 feet of soils should consist of a compacted clayey cap to reduce surface water infiltration into the drain. As an alternative to the zone of permeable sand/gravel, a prefabricated "drainage board," such as Miradrain or equivalent, may be placed adjacent to the exterior below-grade walls. Prior to the installation of the footing subdrain, the below-grade walls should be dampproofed. The slope of the subdrain should be at least 0.3 percent. The gravel placed around the drain pipe should be clean 0.75-inch to 1.0-inch minus gap graded gravel and/or "pea" gravel. The foundation subdrains can be discharged into the area subdrains, storm drains, or other suitable down-gradient location.

We recommend final site grading slope away from the structures at a minimum 2 percent for hard surfaces (pavement) and 5 percent for soil surfaces within the first 10 feet from the structures.

5.8.3 Cutoff Drain

To reduce potential infiltration of surface water and groundwater into the subsurface soils at the site, a cutoff drain should be installed upslope of the homes. The drain should consist of a perforated 4-inch minimum diameter pipe wrapped in fabric and placed near the bottom of a minimum 24-inch wide trench excavated to a depth of at least 15 feet below existing grade or competent bedrock and lined in filter fabric. The pipe should daylight at one or both ends of the drain and discharge to an appropriate drainage device or area. Clean gravel up to 2 inches in maximum size, with less than 10 percent passing the No. 4 sieve and less than 5 percent passing the No. 200 sieve, should be placed around the drain pipe. A fabric, such as Mirafi 140N or equivalent, should be placed between the clean gravel and the adjacent soils. A zone of clean gravel and fabric at least 24 inches wide should also extend above the drain, to within 2 feet of the ground surface, with fabric placed over the gravel. The upper 2 feet of soils should consist of a compacted clayey cap to reduce surface water infiltration into the drain.

5.9 SITE IRRIGATION

Proper site drainage is important to maintaining slope stability at the site. Saturation of soils at the site may result in slope movement or failure. Therefore, we recommend that no irrigation lines should be placed on the slope. Landscaping at the site should be planned to utilize drought resistant plants that require minimal watering. Plants or lawn may be placed on the slope, with plants watered using direct drip systems targeted only for each plant, and any lawn areas watered using sprinklers placed a minimum of 30 feet from the slope. Overwatering should be strictly avoided. The surface of the site should be graded to prevent the accumulation or ponding of surface water at the site. The property owner and the owner's representatives should be made aware of the risks should these or other conditions occur that could saturate or erode/undermine the slope soils.

To reduce the potential for saturation of the site soils, overwatering at the site should be strictly avoided. Watering at the site should be limited to a maximum equivalent rainfall of 0.5 inches per week. Irrigation at the site should be strictly avoided during periods of natural precipitation.

5.10 GEOSEISMIC SETTING

5.10.1 General

Utah municipalities have adopted the International Building Code (IBC) 2015. The IBC 2015 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 structure must be designed in accordance with the procedure presented in Section 1613, Earthquake Loads, of the IBC 2015 edition.

5.10.2 Faulting

Based upon our review of available literature, no active faults are known to pass through the site. The nearest active fault is the Wasatch Fault Zone Weber Section, approximately 7.2 miles west of the site.

5.10.3 Soil Class

For dynamic structural analysis, the Site Class D – Stiff Soil Profile as defined in Chapter 20 of ASCE 7 (per Section 1613.3.2, Site Class Definitions, of IBC 2015) can be utilized.

5.10.4 Ground Motions

The IBC 2015 code is based on 2008 USGS mapping, which provides values of short and long period accelerations for the Site Class B boundary for the Maximum Considered Earthquake

(MCE). This Site Class B boundary represents average bedrock values for the Western United States and must be corrected for local soil conditions. The following table summarizes the peak ground and short and long period accelerations for the MCE event and incorporates the appropriate soil amplification factor for a Site Class C soil profile. Based on the site latitude and longitude (41.2430 degrees north and 111.7826 degrees west, respectively), the values for this site are tabulated on the following table:

Spectral Acceleration Value, T	Site Class B Boundary [mapped values] (% g)	Site Coefficient	Site Class C [adjusted for site class effects] (% g)	Design Values (% g)
Peak Ground Acceleration	33.2	F_a = 1.068	35.5	23.7
0.2 Seconds (Short Period Acceleration)	S_S = 83.0	F_a = 1.068	S_{MS} = 88.6	S_{DS} = 59.1
1.0 Second (Long Period Acceleration)	S_1 = 27.9	F_v = 1.521	S_{M1} = 42.4	S_{D1} = 28.3

5.10.5 Liquefaction

The site is located in an area that has been identified by the Utah Geologic Survey as having "very low" liquefaction potential. Liquefaction is defined as the condition when saturated, loose, finer-grained sand-type soils lose their support capabilities because of excessive pore water pressure which develops during a seismic event. Clay soils, even if saturated, will generally not liquefy.

Liquefaction of the site soils is not anticipated during the design seismic event due to the unsaturated nature of the site soils.

5.11 SITE OBSERVATIONS

As stated previously, prior to placement of foundations, floor slabs, pavements, and site grading fills, a geotechnical engineer from GSH must verify that all non-engineered fill materials, topsoil, and disturbed soils have been removed and/or properly prepared and suitable subgrade conditions encountered. Additionally, GSH must observe fill placement and verify in-place moisture content and density of fill materials placed at the site.

5.12 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.	Reviewed by:
Andrew M. Harris, P.E.	Michael S. Huber, P.E.
State of Utah No. 7420456	State of Utah No. 343650
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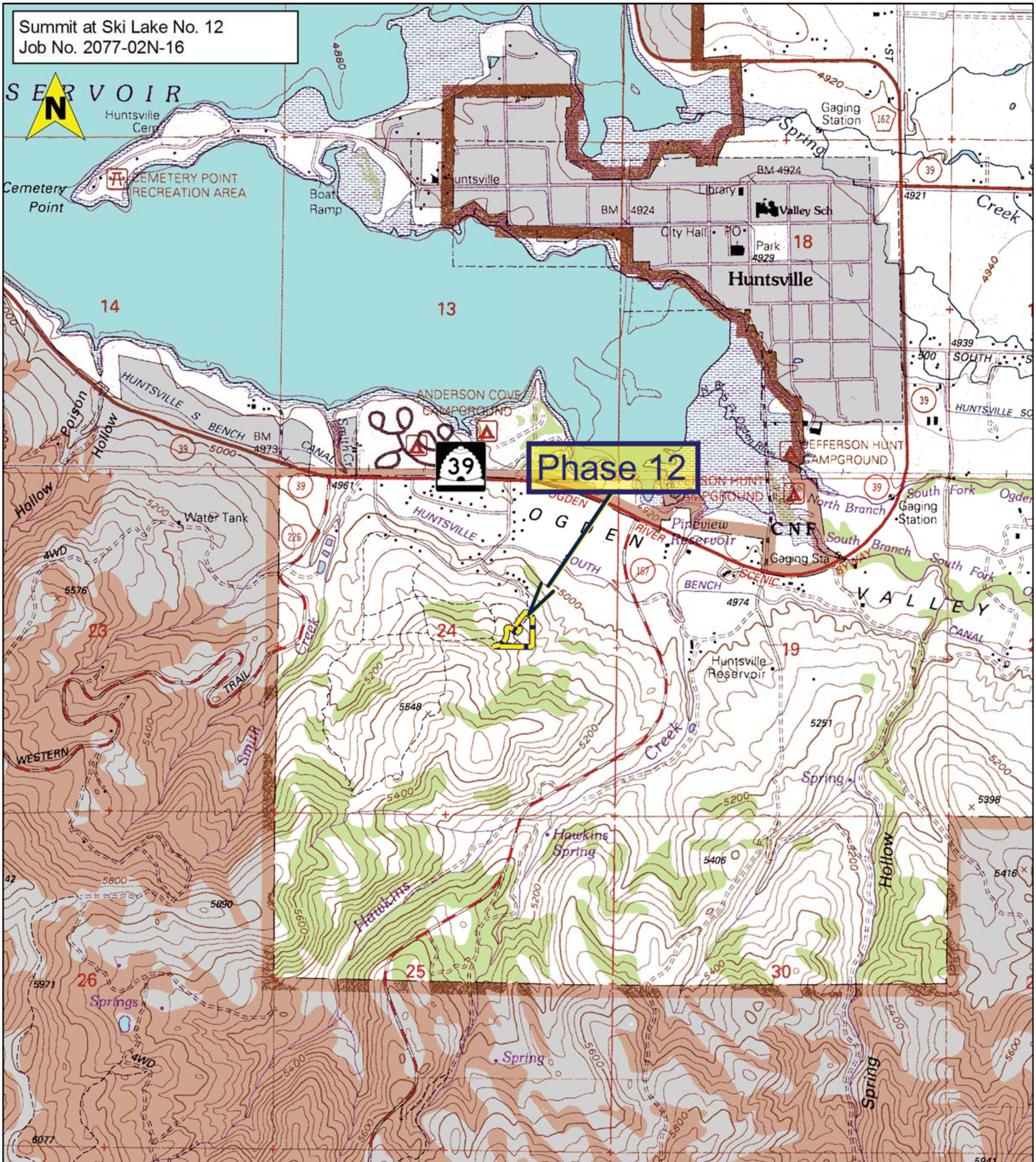
LICENSED PROFESSIONAL ENGINEER ANDREW MICHAEL HARRIS No. 7420456 STATE OF UTAH

AMH/MSH:jlh

Encl.	Figure	1,	Vicinity Map
	Figure	2,	Site Plan
	Figures	3A	and 3B, Boring Logs
	Figure	4,	Key to Boring Log (USCS)
	Figures	5	and 6, Stability Results
	Appendix,		Geological Study

Addressee (Email)



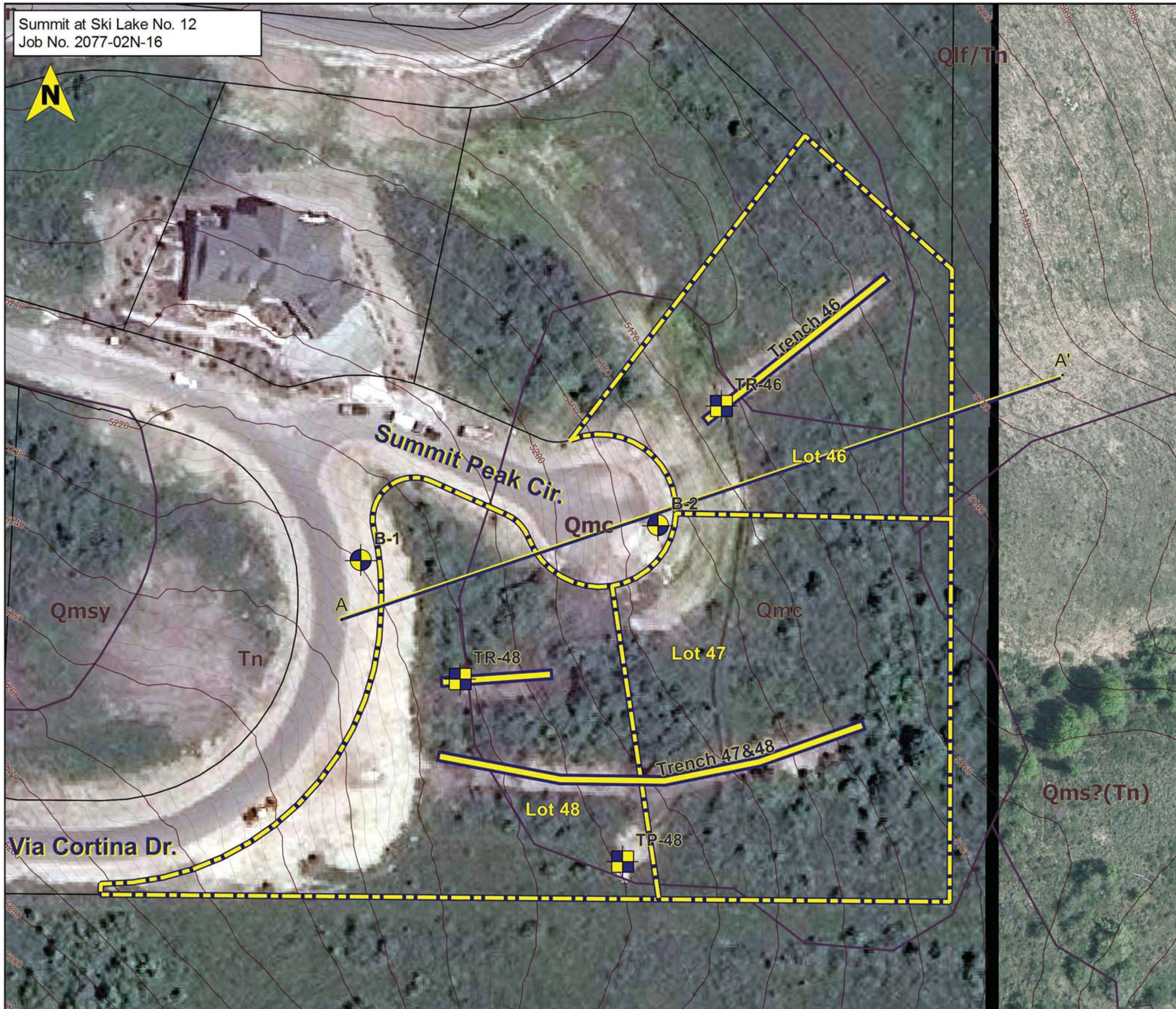
Base:
1998 7.5 Minute USGS Topographic Maps
TitledSnowbasin, Utah, and Huntsville, Utah.
from Utah AGRC; http://gis.utah.gov/

0 2000 4000 ft

1:24,000

FIGURE 1
VICINITY MAP

GSH



Explanation

- Lot Boundaries
- Test Pit Location
- Boring Location
- Trench Location
- Geologic Cross Section Line A-A'

Geology after King, 2008

- Qmc - Landslide and slump, and colluvial deposits undivided
- Qmsy - Landslide and slump deposits (younger)
- Qms - Landslide and slump deposits
- Qms?(Tn) - Landslide and slump deposits over Norwood Formation
- Qlf/Tn - Lake Bonneville fine-grained deposits over Norwood Formation
- Tn - Norwood Formation

Base:
2016 1.5-foot TerraServer Image Overlay
2012 6-inch Color HRO Orthoimagery,
Elevation: 2006 2.0m Geoprocessed LiDAR
from Utah AGRC; http://gis.utah.gov/

0 80 160 240 ft

1:960

FIGURE 2
SITE PLAN

GSH

GSH

BORING LOG

BORING: B-1

CLIENT: Valley Enterprise Investment Company | PROJECT NUMBER: 2077-02N-16

PROJECT: Lots 46, 47, and 48 Summit at Ski Lake No.12 | DATE STARTED: 5/26/16 | DATE FINISHED: 5/26/16

LOCATION: 6839, 6861, and 6858 Summit Peak Circle, near Huntsville, Weber County, Utah | GSH FIELD REP.: JM

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

GROUNDWATER DEPTH: Not Encountered (5/26/16) | ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface									
	CL FILL	SILTY CLAY, FILL with some fine to coarse sand; some fine and coarse gravel; dark brown	0								moist medium stiff
				8							
			5	3							soft
				8							medium stiff
			10	20							very stiff
	CL/ SC	SILTY CLAY/CLAYEY SAND with trace fine to coarse sand; gray		80		27		55	43	17	moist hard
	ML/ CL	WEATHERED SILTSTONE/CLAYSTONE with some fine to coarse sand; gray	15	60+							moist hard
				50+		19		70	50	20	
			20	50+							
				50+							
	SM	SILTY FINE TO COARSE SAND/WEATHERED SANDSTONE	25								

See Subsurface Conditions section in the report for additional information.

FIGURE 3A

CLIENT: Valley Enterprise Investment Company | PROJECT NUMBER: 2077-02N-16

PROJECT: Lots 46, 47, and 48 Summit at Ski Lake No.12 | DATE STARTED: 5/26/16 | DATE FINISHED: 5/26/16

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
	SM	SILTY FINE TO COARSE SAND/WEATHERED SANDSTONE reddish-brown	25	50+							moist dense
				50+							
		grayish-red	30	50+							
	ML/CL	WEATHERED SILTSTONE/CLAYSTONE with some fine to coarse sand; gray to dark gray		50+							moist hard
			35	62					50	23	
				66							
			40	50+							
				50+							
			45	50+					43	13	
				50+							
			50	50+							
		End of Exploration at 51.5'; No groundwater at time of drilling.									

See Subsurface Conditions section in the report for additional information.

BORING LOG

BORING: B-2

CLIENT: Valley Enterprise Investment Company | PROJECT NUMBER: 2077-02N-16

PROJECT: Lots 46, 47, and 48 Summit at Ski Lake No.12 | DATE STARTED: 5/27/16 | DATE FINISHED: 5/27/16

LOCATION: 6839, 6861, and 6858 Summit Peak Circle, near Huntsville, Weber County, Utah | GSH FIELD REP.: JM

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

GROUNDWATER DEPTH: Not Encountered (5/27/16) | ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface									
	CL FILL	SILTY CLAY, FILL with trace fine to coarse sand; trace fine and coarse gravel; dark brown	0								moist stiff
				10							
			5	7							medium stiff
				7							
	CL	SILTY CLAY with trace fine to coarse sand; brown to black	10	21							moist very stiff
				37		25	97				
			15	46							
				75							hard
			20	47					54	27	
				53							
	CL/	SILTY CLAY/CLAYEY SILT	25								

See Subsurface Conditions section in the report for additional information.

BORING LOG

BORING: B-2

CLIENT: Valley Enterprise Investment Company — PROJECT NUMBER: 2077-02N-16

PROJECT: Lots 46, 47, and 48 Summit at Ski Lake No.12 — DATE STARTED: 5/27/16 — DATE FINISHED: 5/27/16

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
	CL/ ML	SILTY CLAY/CLAYEY SILT with trace fine sand; brown	25	30							moist very stiff
		grades with trace fine and coarse gravel; light brown		13							stiff
		grades with layers of fine to coarse sand up to 1" thick	30	24					78	41	very stiff
	ML/ CL	WEATHERED SILTSTONE/CLAYSTONE with some fine sand; gray		50+							moist hard
			35	50+		18					
				50+							
		grades with some oxidation	40	50+							
				50+		21		72			
		grades with layers of fine to coarse silty sand up to 6" thick	45	50+							
	SM	FINE TO COARSE SILTY SAND/WEATHERED SILTSTONE brown		50+							moist very dense
			50	50+							
		End of Exploration at 51.5'; No groundwater at time of drilling.									

See Subsurface Conditions section in the report for additional information.

FIGURE 3B (continued)

CLIENT: Valley Enterprise Investment Company PROJECT: Lots 46, 47, and 48 Summit at Ski Lake No.12 PROJECT NUMBER: 2077-02N-16	**KEY TO BORING LOG**

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSSING 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

GSH

FIGURE 5
STABILITY RESULTS

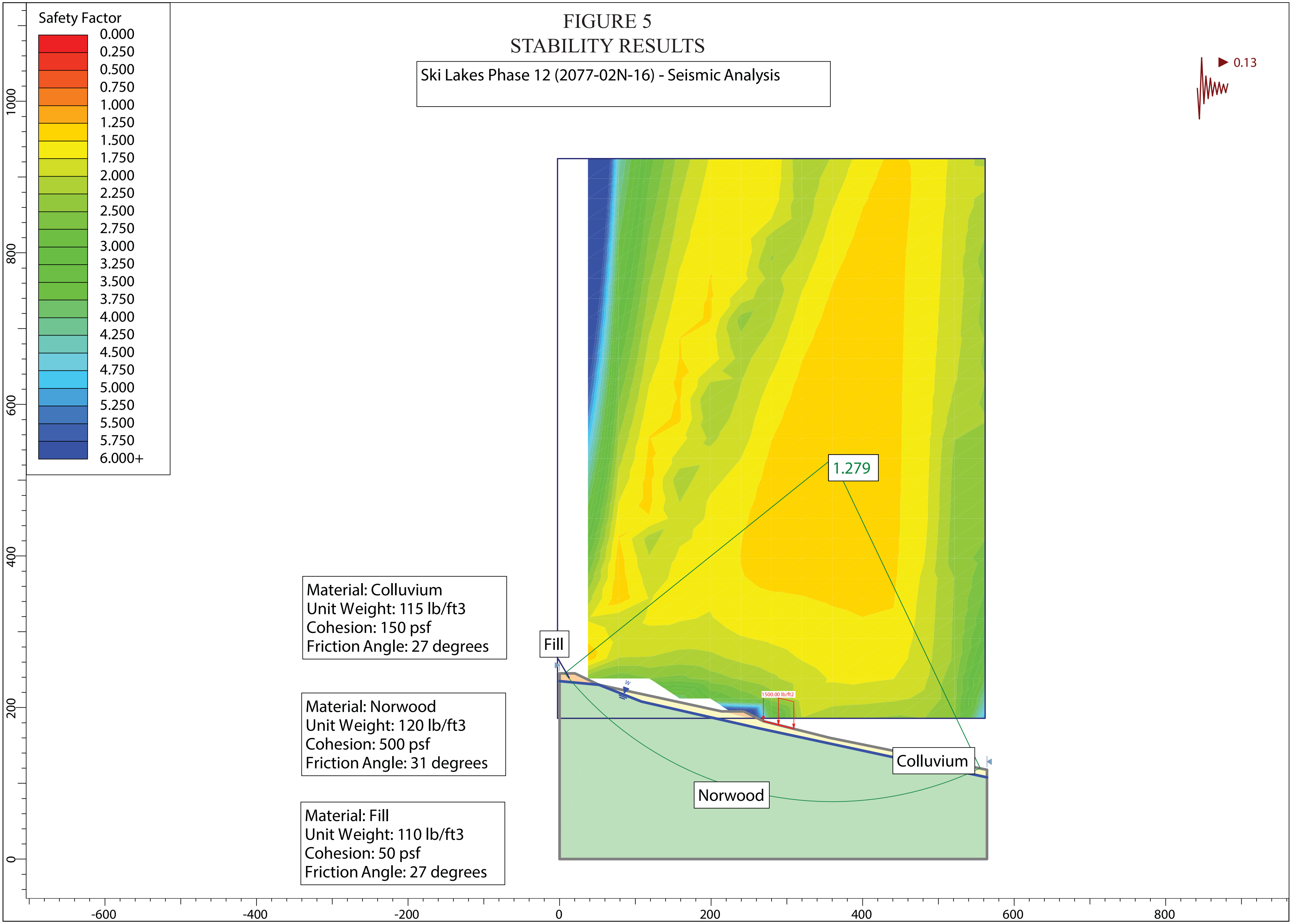
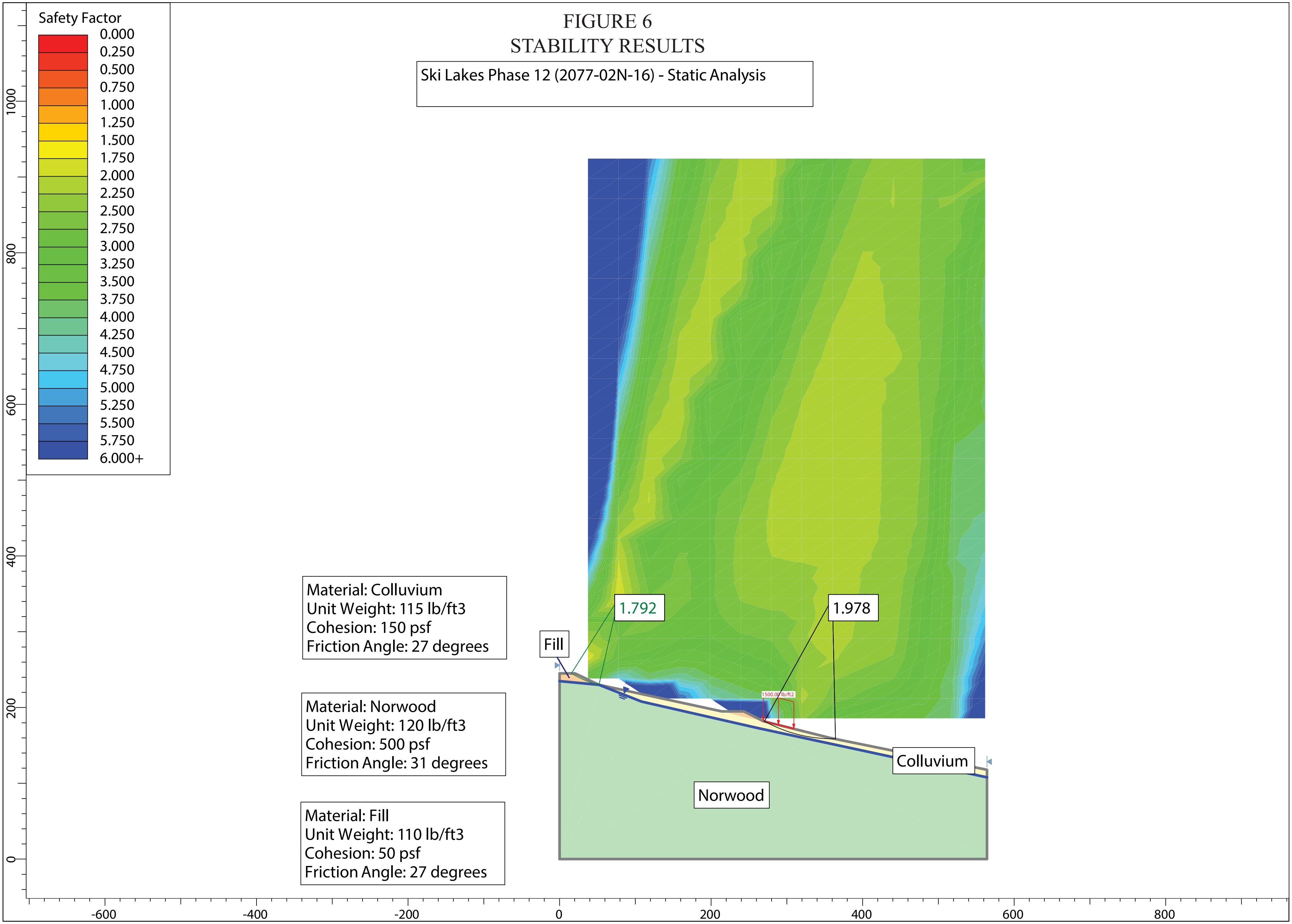


FIGURE 6
STABILITY RESULTS



APPENDIX