GSH

REPORT
GEOTECHNICAL STUDY
LOTS 22 AND 23
THE LEGENDS AT HAWKINS CREEK
6564 AND 6585 EAST CHAPARRAL ROAD
NEAR EDEN, WEBER COUNTY, UTAH

Submitted To:

Mr. Victor Holtreman
1172 East Benchview Drive
Ogden, Utah

Submitted By:

GSH Geotechnical, Inc.
1596 West 2650 South
Ogden, Utah 84401

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Job No. 2129-01N-16

GSH

August 15, 2016
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Mr. Victor Holtreman
1172 East Benchview Drive
Ogden, Utah 84404

Re: Report
Geotechnical Study
Lots 22 and 23 The Legends at Hawkins Creek
6564 and 6585 East Chaparral Road
Near Eden, Weber County, Utah
(41.2371° N; 111.7930° W)

1. INTRODUCTION

1.1 GENERAL

This report presents the results of our geotechnical study performed for Lots 22 and 23 The Legends at Hawkins Creek located at 6564 and 6585 East Chaparral Road near Eden in Weber County, Utah. The general location of the site with respect to major roadways, as of 2014, 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 drilled and test pits and 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. Victor Holtreman 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, logging, and sampling of 2 borings, and the excavating, logging, and sampling of 1 test pit and 2 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. 16-0444N dated April 19, 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/boring, 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 a single-family residence on Lots 22 and 23 The Legends at Hawkins Creek near Eden in Weber County, 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.

3. INVESTIGATIONS

3.1 FIELD PROGRAM

In order to define and evaluate the subsurface soil and groundwater conditions at the site, 2 borings were drilled to depths of about 31.5 to 39.0 feet below existing grade. The borings were drilled using a truck-mounted drill rig equipped with hollow-stem augers and mud rotary. Additionally, 1 test pit and 2 trenches were excavated to depths of about 5.0 to 22.0 feet below existing grade. The test pits/trenches were excavated using a track-mounted excavator. Boring and test pit/trench locations 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 excavating and drilling operations, a continuous log of the subsurface soil conditions encountered was maintained. In addition, samples of the typical soils encountered were obtained and placed in sealed bags and plastic containers for subsequent laboratory testing and examination. The soils were classified in the field based upon visual and textural examination. These classifications have been supplemented by subsequent inspection and testing in our laboratory. Detailed graphical representation of the subsurface conditions encountered is presented on Figure 3A and 3B, Boring Log, and on Figures 4A through 4C, Test Pit Log. Soils were classified in accordance with the nomenclature described on Figure 5, Key to Boring Log (USCS) and on Figure 6, Key to Test Pit Log (USCS).

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 within the boring. 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 of the test pit and trenches at the site.

Following completion of drilling and excavation operations, one and one-quarter-inch diameter slotted PVC pipe was installed in borings B-1 and B-2 in order to provide a means of monitoring the groundwater fluctuations. The borings were backfilled with auger cuttings. Following completion of excavating and logging, each test pit 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 log, Figures 3A and 3B, and on the test pit logs, Figure 4A through 4C.

3.2.3 Atterberg Limit Tests

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

Boring No.	Depth (feet)	Liquid Limit (percent)	Plastic Limit (percent)	Plasticity Index (percent)	Soil Classification
B-1	22.5	Non-Plastic	Non-Plastic	Non-Plastic	SP
B-1	25.0	54	34	20	MH
B-2	15.0	66	53	13	MH
B-2	27.5	46	32	14	ML
B-2	30.0	63	32	31	MH
B-2	32.5	71	36	35	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 No.	Depth (feet)	Percent Passing No. 200 Sieve	Soil Classification
B-2	15.0	56	CH/MH
B-2	30.0	57	MH/ML
B-2	32.5	64	MH/ML

3.2.5 Consolidation Tests

To provide data necessary for our settlement analyses, consolidation tests were performed on each of 2 representative samples of the fine grained 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. Detailed results of the test are maintained within our files and can be transmitted, at the client's request.

3.2.6 Laboratory Direct Shear Test

To determine the shear strength of the soils encountered at the site, a laboratory direct shear test was performed on a sample of the site soils. The results of the test are tabulated below:

Boring No.	Depth (feet)	Soil Type	In-Situ Moisture Content (percent)	Dry Density (pcf)	Internal Friction Angle (degrees)	Apparent Cohesion (psf)
B-1	22.5	SP	29	92	26	10
B-1	25.0	CH/MH	29	86	29	370
B-2	30.0	MH/ML	22	91	32	590
B-2	32.5	MH/ML	24	93	27	320

3.2.7 Laboratory Residual Direct Shear Test

To determine the residual shear strength of the soils encountered at the site, a laboratory residual direct shear test was performed on a sample of the site soils. The results of the test are tabulated on below:

Boring No.	Depth (feet)	Soil Type	In-Situ Moisture Content (percent)	Dry Density (pcf)	Internal Friction Angle (degrees)	Apparent Cohesion (psf)
B-1	22.5	SP	29	92	18	215
B-2	30.0	MH/ML	22	91	22	485

4. SITE CONDITIONS

4.1 GEOLOGIC SETTING

A geologic study[1] dated August 15, 2016 was prepared for the subject property by GSH Geotechnical, Inc., and a copy of that report is included in the attached Appendix.

4.2 SURFACE

The subject property is a vacant, rectangular-shaped lot located at 6564 and 6585 East Chaparral Road near Eden in Weber County, Utah. The topography of the site slopes downward to the north at grades of about 10H:1V (Horizontal:Vertical) to about 2.5H:1V (Horizontal:Vertical) with an overall change in elevation of about 75 feet across the site. Vegetation at the site consists primarily of native weeds, grasses, brush, and numerous mature trees, particularly over the slope area. The site is bordered on the north and east by undeveloped property, and on the west and south by Chaparrel Road followed by undeveloped property.

4.3 SUBSURFACE SOIL

Subsurface conditions encountered at the boring and test pit locations varied across the site. Topsoil and disturbed soils were observed in the upper 6 inches at the boring, test pit, and trench locations. In the borings, test pit, and trenches, mass movement soil deposits were encountered below the topsoil and disturbed soils extending to depths of up to about 32.5 feet below surrounding site grades. The mass movement deposits were comprised of a mixture of silty sand, clayey silt, silty clay, and degraded/weathered claystone/sandstone/siltstone. At depth within the borings and in the eastern portions of the test pit/trenches, natural soils were observed beneath the mass movement soils to the full depth penetrated, about 5.0.0 to 39.0 feet below surrounding grades and consisted of clayey silty with varying fine to coarse sand content, silty clay with varying fine to coarse sand content, fine to coarse sand with varying amounts of silt, fine and coarse gravelly clay, silty clayey gravel, and occasional mixture of these soils.

The natural granular soils encountered were dense, dry to saturated, reddish-gray to grayish-white to brown in color, and will generally exhibit moderately high strength and low compressibility characteristics under the anticipated vertical loading.

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

For a more detailed description of the subsurface soils encountered, please refer to Figures 3A and 3B, Boring Log, and Figures 4A through 4C, Test Pit Log. The lines designating the

[1] "Report, Geological Study, Lots 22 and 23 The Legends at Hawkins Creek Huntsville Area, Weber County, Utah, (Parts of the SW 1/4 Section 24, Township 6 North, Range 1 East, Salt Lake base and meridian)," GSH Geotechnical, Inc., GSH Job No. 2129-01N-16, August 15, 2016.

interface between soil types on the test pit/trench and boring logs generally represent approximate boundaries. In-situ, the transition between soil types may be gradual.

4.4 GROUNDWATER

Groundwater was encountered in the borings during our field exploration at about 20 to 25 feet below existing site grades. Stabilized groundwater levels were measured at 20.2 and 21.7 feet below existing site grades in borings B-1 and B-2, respectively. Seasonal and longer-term groundwater fluctuations of 1 to 2 feet shall be anticipated. The highest seasonal levels will generally occur 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. The contractor must be prepared to dewater excavations as needed.

5. DISCUSSIONS AND RECOMMENDATIONS

5.1 SUMMARY OF FINDINGS

The results of our analyses indicate that the proposed structure may be supported upon conventional spread and/or continuous wall foundations established upon a minimum of 2 feet of granular structural fill extending to suitable natural soils. Under no circumstance should the proposed structure or associated structural fill be placed directly on mass movement/landslide deposits noted at the site. A 20 foot setback from the mass movement/landslide deposits is recommended, as discussed in the referenced geologic study. If encountered, mass movement/landslide deposits must be removed in their entirety from beneath the proposed home and extending a minimum of 10 feet outside the home area.

The most significant geotechnical aspects of the site are:

1. The surficial non-engineered fills encountered at borings and test pits;
2. The proximity of the proposed structure to mass movement soil deposits; and
3. Maintaining stability of the slope at the property.

A 20 foot setback from the mass movement/landslide deposits is recommended, as discussed in the referenced geologic study. If encountered, mass movement/landslide deposits must be removed in their entirety from beneath the proposed home and extending a minimum of 10 feet outside the home area. If this is not feasible, GSH must be contacted to provide additional recommendations for foundation support.

A subdrain system must be installed upslope of the home and near the head of the mass movement deposit soils below the home to reduce the potential for surface water infiltration, as discussed further within this report.

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 mass movement deposit soils, 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 other deleterious materials from beneath an area extending out at least 3 feet from the perimeter of the proposed building, pavements, and exterior flatwork areas.

Additional site preparation will consist of the removal of existing non-engineered fills (if encountered) from an area extending out at least 3 feet from the perimeter of residential structures and 1 foot beyond rigid pavements. Mass movement/landslide deposits must be removed in their entirety from beneath the proposed home and extending a minimum of 10 feet outside the home area.

Non-engineered fills/disturbed soil may remain in asphalt pavement and sidewalk areas as long as they are free of deleterious materials and properly prepared. Below rigid pavements non-engineered fills/disturbed soils must be removed. Additionally, the surface of any existing engineered fills must be prepared prior to placing additional site grading fills.

Proper preparation shall consist of scarifying, moisture conditioning, and re-compacting the upper 12 inches to the requirements for structural fill. As an option to proper preparation and recompaction, the upper 12 inches of non-engineered fill (where encountered) may be removed and replaced with granular subbase over unfrozen proofrolled subgrade. Even with proper preparation, pavements established overlying non-engineered fills may encounter some long-term movements unless the non-engineered fills are completely removed.

It must be noted that from a handling and compaction standpoint, onsite 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 onsite soils are likely above optimum moisture content for compacting at present and would require some drying prior to recompacting.

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 proofrolled 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 10 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 10 feet are not anticipated at the site.

Temporary excavations up to 10 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 3/4 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 below:

Location	Total Fill Thickness (feet)	Minimum Percentage of Maximum Dry Density
Beneath an area extending at least 5 feet beyond the perimeter of the structure	0 to 10	95
Site Grading Fills outside area defined above	0 to 5	90
Site Grading Fills outside area defined above	5 to 10	95
Trench Backfill	--	96
Pavement granular base/subbase	--	96

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

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

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 proofrolled and/or properly compacted prior to the construction of any exterior flatwork over a backfilled trench. Proofrolling 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 proofrolling, 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.

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:

Material	Internal Friction Angle (degrees)	Apparent Cohesion (psf)	Saturated Unit Weight (pcf)
Colluvium/Bedrock	28	300	120
Fill	28	75	120
Landslide	18	215	115

For the seismic analysis, a peak horizontal ground acceleration of 0.261 using IBC 2012 guidelines and adjusted for Site Class effects (for Site Class D soils) was obtained for site (grid) locations of 41.2371 degrees latitude (north) and 111.7930 degrees longitude (west). To model sustained accelerations at the site, one-half of this value is typically used. Accordingly, a value of 0.131 was used as the pseudostatic coefficient in the seismic analyses.

5.3.2 Stability Analyses

We evaluated the global stability of the existing slope 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 A-A' consisted of slopes north of the proposed home within the mass movement deposits. Cross-section B-B' consisted of natural soil slopes at the southern end of the site within the proposed home area. Slopes between 10H:1V (Horizontal:Vertical) to 2H:1V (Horizontal:Vertical) with an overall change in elevation of about 78 feet across the site. In addition, a phreatic surface was included in our analyses to account for groundwater at the site.

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 existing onsite slope configurations analyzed will meet both these requirements provided our recommendations are followed (see Figures 7 through 10); however, the steeper offsite slopes within the mass movement deposits do not meet the required factor of safety, thus structures should not be constructed within the mass movement deposits (see Figure 11).

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 home and at the western limit of the landslide deposit onsite 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 proposed structure may be supported upon conventional spread and continuous wall foundations established upon a minimum of 2 feet of structural fill extending to suitable natural soils. For design, the following parameters are provided:

Minimum Recommended Depth of Embedment for Frost Protection	- 30 inches
Minimum Recommended Depth of Embedment for Non-frost Conditions	- 15 inches
Recommended Minimum Width for Continuous Wall Footings	- 16 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

Footings shall not be installed upon mass movement soil deposits, soft or disturbed soils, non-engineered fill, construction debris, frozen soil, or within ponded water. If the granular structural fill upon which the footings are to be established becomes disturbed, it shall be recompacted to the requirements for structural fill or be removed and replaced with structural fill.

The width of structural fill, where placed below footings, shall extend laterally at least 6 inches beyond the edges of the footings in all directions for each foot of fill thickness beneath the footings. For example, if the width of the footing is 2 feet and the thickness of the structural fill beneath the footing is 2.0 feet, the width of the structural fill at the base of the footing excavation would be a total of 4.0 feet, centered below 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 1 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 granular structural fill. Passive resistance provided by properly placed and compacted granular structural fill above the water table may be considered equivalent to a fluid with a density of 300 pounds per cubic foot. Below the water table, this granular soil should be considered equivalent to a fluid with a density of 150 pounds per cubic foot.

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

5.6 LATERAL PRESSURES

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 39 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 table on the following page.

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 2 feet of structural fill extending to suitable natural soils. Under no circumstances shall floor slabs be established over mass movement deposit soils, 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 100 to 150 pounds per square foot or less) is anticipated to be less than 1/4 inch.

The tops of all floor slabs in habitable areas must be established at least 4 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

We recommend that the perimeter foundation subdrains and a cutoff drain above the home and near the head of the mass movement deposit soils 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 home and near the western extent of the onsite mass movement deposit soils near the home. Final location of the required cutoff drains must be reviewed by GSH prior to construction. 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 drilled to a depth of at least 15 feet below existing grade 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 wrapped in 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 top of 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 in a manner such that watering is a minimum of 30 feet back from the crest of 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) 2012. The IBC 2012 code determines the seismic hazard for a site based upon 2008 mapping of bedrock accelerations prepared by the United States Geologic Survey (USGS) and the soil site class. The USGS values are presented on maps incorporated into the IBC code and are also available based on latitude and longitude coordinates (grid points).

The structure must be designed in accordance with the procedure presented in Section 1613, Earthquake Loads, of the IBC 2012 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 7.0 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 2012) can be utilized.

5.10.4 Ground Motions

The IBC 2012 code is based on 2008 USGS mapping, which provides values of short and long period accelerations for the Site Class B 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 D soil profile. Based on the site latitude and longitude (41.2371 degrees north and -111.7930 degrees west, respectively), the values for this site are tabulated on the following page.

Spectral Acceleration Value, T	Site Class B Boundary [mapped values] (% g)	Site Coefficient	Site Class D [adjusted for site class effects] (% g)	Design Values (% g)
Peak Ground Acceleration	33.7	F_a = 1.163	39.2	26.1
0.2 Seconds (Short Period Acceleration)	S_S = 84.2	F_a = 1.163	S_{MS} = 97.9	S_{DS} = 65.3
1.0 Second (Long Period Acceleration)	S_1 = 28.4	F_v = 1.832	S_{M1} = 52	S_{D1} = 34.7

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 mass movement deposit soils, 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) 393-2012.

Respectfully submitted,

GSH Geotechnical, Inc.

Andrew M. Harris, P.E.
State of Utah No. 740456
Senior Geotechnical Engineer

Reviewed by:

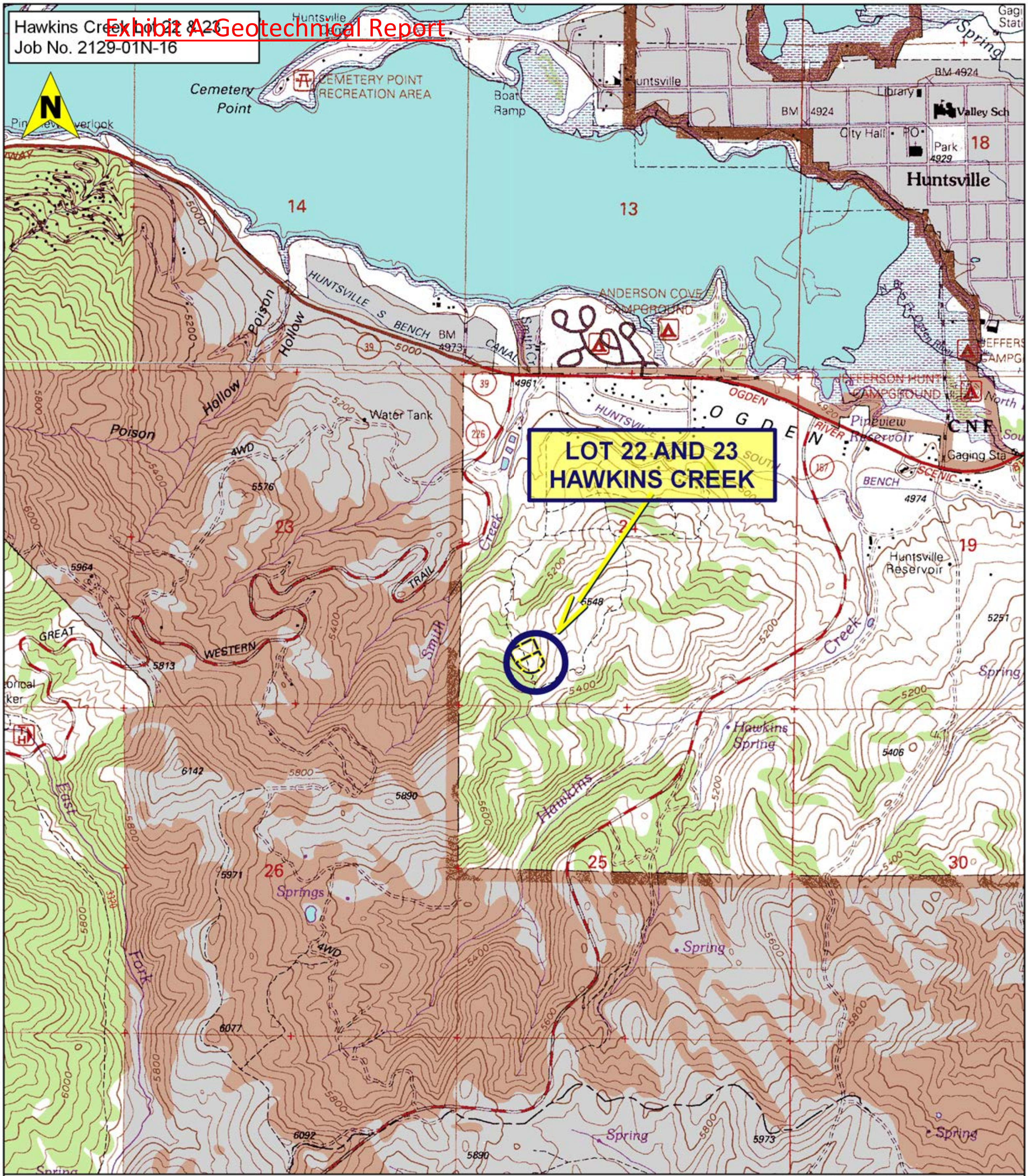
Michael S. Huber, P.E.
State of Utah No. 343650
Senior Geotechnical Engineer

AMH/ADS:mmh

Encl.	Figure	1,	Vicinity Map
	Figure	2,	Site Plan
	Figures	3A	Boring Log
	Figures	4A	through 4C, Test Pit Logs
	Figure	5,	Key to Boring Log (USCS)
	Figure	6,	Key to Test Pit Log (USCS)
	Figures	7	through 11, Stability Results
	Appendix,		Geologic Study

Addressee (email)

Hawkins Creek Lot 22 & 23
Job No. 2129-01N-16

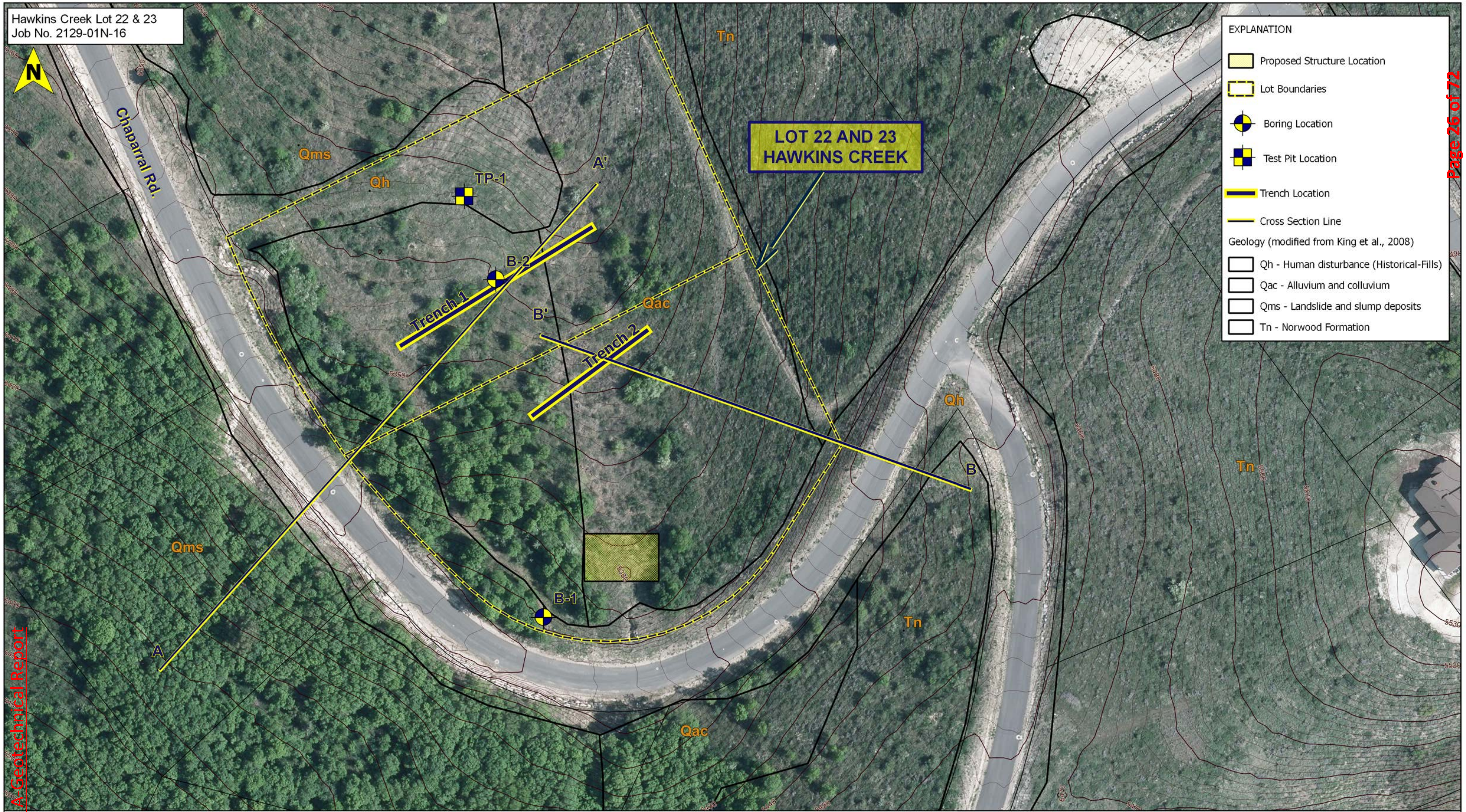


Base:
1998 7.5 Minute USGS Toporgraphic Maps Titled
Snowbasin, Utah, and Huntsville, Utah.

0 2000 4000 ft
1:24,000

FIGURE 1
VICINITY MAP

GSH



Base:
2012 0.5ft Color Orthoimagery
from Utah AGRC, http://gis.utah.gov/
Elevation:
2006 2.0m Geoprocessed LiDAR
from Utah AGRC, http://gis.utah.gov/

0 80 160 240 320 ft

1:960

FIGURE 2
SITE PLAN

GSH

GSH

BORING LOG

BORING: B-1

CLIENT: Victor Holtreman | PROJECT NUMBER: 2129-01N-16

PROJECT: Lots 22 and 23 The Legends at Hawkins Creek | DATE STARTED: 5/17/16 | DATE FINISHED: 5/17/16

LOCATION: 6564 and 6585 East Chaparral Road, Near Eden, Weber County, Utah | GSH FIELD REP.: JM/AA

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

GROUNDWATER DEPTH: Not Encountered (5/17/16), 20.2' (7/12/16) | ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface									
		GRADING FOR DRILL PAD	0								
			5								
	CL	SILTY CLAY with trace fine to coarse sand; siltstone fragments; brownish-gray	10	33	X						moist very stiff
				82	X	21	109				
			15	50+	X						
		grades claystone; reddish-brown									hard
				50+	X						
			20	80+	X						
	SP	FINE TO COARSE SAND with trace silt; gray		76	X	29	92		NP	NP	moist dense
	CH/ MH	SILTY CLAY/CLAYEY SILT with trace fine sand; claystone; reddish-brown	25		X						moist hard

See Subsurface Conditions section in the report for additional information.

FIGURE 3A

GSH

BORING LOG

Page: 2 of 2

BORING: B-1

CLIENT: Victor Holtreman | PROJECT NUMBER: 2129-01N-16

PROJECT: Lots 22 and 23 The Legends at Hawkins Creek | DATE STARTED: 5/17/16 | DATE FINISHED: 5/17/16

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
			25	86+		29	86		54	20	
				50+							
	SP	FINE TO COARSE SAND with trace silt; sandstone; reddish-gray									moist dense
			30	76							
		End of Exploration at 31.5' No groundwater encountered at time of drilling Installed 1.25" diameter slotted PVC pipe to 30.0'									
			35								
			40								
			45								
			50								

See Subsurface Conditions section in the report for additional information.

FIGURE 3A
(continued)

GSH

BORING LOG

Page: 1 of 2

BORING: B-2

CLIENT: Victor Holtreman | PROJECT NUMBER: 2129-01N-16

PROJECT: Lots 22 and 23 The Legends at Hawkins Creek | DATE STARTED: 5/17/16 | DATE FINISHED: 5/17/16

LOCATION: 6564 and 6585 East Chaparral Road, Near Eden, Weber County, Utah | GSH FIELD REP.: JM/AA

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

GROUNDWATER DEPTH: Not Encountered (5/17/16), 21.7' (7/12/16) | ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface									
	CH/ MH	SILTY CLAY/CLAYEY SILT with some fine to coarse sand; some organics; dark brown	0								moist stiff
				12							
			5	32							
		siltstone fragments; light brown		86+							
			10	50+							
				46		35	83				
			15	31				56	66	13	
		reddish-brown		32							
	SP/ SM	FINE TO COARSE SAND with some silt; some clay; brown	20	54							dry dense
	SP	FINE TO COARSE SAND with trace silt; sandstone; grayish-white		53							dry dense
	MH/	CLAYEY SILT	25								

See Subsurface Conditions section in the report for additional information.

FIGURE 3B

GSH

BORING LOG

BORING: B-2

CLIENT: Victor Holtreman | PROJECT NUMBER: 2129-01N-16

PROJECT: Lots 22 and 23 The Legends at Hawkins Creek | DATE STARTED: 5/17/16 | DATE FINISHED: 5/17/16

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
	MH/ ML	CLAYEY SILT with some fine to coarse sand; siltstone fragments; gray	25	38	X						moist very stiff
				30	X	21	105		46	14	
			30	22	X	22	91	57	66	31	
				50+	X	24	93	64	71	35	hard
			35	50+	X						
				50+	X						
		End of Exploration at 39.0' No groundwater encountered at time of drilling Installed 1.25" diameter slotted pipe to 37.5'	40								
			45								
			50								

See Subsurface Conditions section in the report for additional information.

FIGURE 3B
(continued)

GSH

TEST PIT LOG

Page: 1 of 1

TEST PIT: TP-1

CLIENT: Victor Holtreman | PROJECT NUMBER: 2129-01N-16

PROJECT: Lots 22 and 23 The Legends at Hawkins Creek | DATE STARTED: 5/17/16 | DATE FINISHED: 5/17/16

LOCATION: 6564 and 6585 East Chaparral Road, Near Eden, Weber County, Utah | GSH FIELD REP.: DD/GS

EXCAVATING METHOD/EQUIPMENT: HITACHI - Trackhoe

GROUNDWATER DEPTH: Not Encountered (5/17/16) | ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0							
	ML FILL	CLAYEY SILT, FILL major roots (topsoil) to 6"; dark brown								slightly moist soft to medium stiff
					29	83				
			5							
	CL	SILTY CLAY with gravel; cobbles and boulders; siltstone; yellowish-brown								slightly moist dense
	CL	FINE AND COARSE GRAVELLY CLAY yellowish-brown								slightly moist stiff
			10							
			15							
		End of Exploration at 20.0' No significant sidewall caving No groundwater encountered at time of excavation	20							
			25							

See Subsurface Conditions section in the report for additional information.

FIGURE 4A

GSH

TEST PIT LOG

Page: 1 of 1

TEST PIT: TR-1

CLIENT: Victor Holtreman | PROJECT NUMBER: 2129-01N-16

PROJECT: Lots 22 and 23 The Legends at Hawkins Creek | DATE STARTED: 5/17/16 | DATE FINISHED: 5/17/16

LOCATION: 6564 and 6585 East Chaparral Road, Near Eden, Weber County, Utah | GSH FIELD REP.: DD/GS

EXCAVATING METHOD/EQUIPMENT: HITACHI - Trackhoe

GROUNDWATER DEPTH: Not Encountered (5/17/16) | ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0							
	ML/CL	SILTY CLAY major roots (topsoil) to 12"; vertical cracking; brown	0							slightly moist stiff to very stiff
			4–5	▮						
	GC/GM	SILTY CLAYEY GRAVEL with angular cobbles and boulders; siltstone clasts; brown	11							slightly moist dense
	CL	FINE AND COARSE GRAVELLY CLAY dark olive	14.5							slightly moist stiff
		End of Exploration at 22.0' No significant sidewall caving No groundwater encountered at time of excavation	22							

See Subsurface Conditions section in the report for additional information.

FIGURE 4B

GSH

TEST PIT LOG

Page: 1 of 1

TEST PIT: TR-2

CLIENT: Victor Holtreman
PROJECT NUMBER: 2129-01N-16
PROJECT: Lots 22 and 23 The Legends at Hawkins Creek
DATE STARTED: 5/17/16
DATE FINISHED: 5/17/16
LOCATION: 6564 and 6585 East Chaparral Road, Near Eden, Weber County, Utah
GSH FIELD REP.: DD/GS
EXCAVATING METHOD/EQUIPMENT: HITACHI - Trackhoe
GROUNDWATER DEPTH: Not Encountered (5/17/16)
ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface								
	ML	CLAYEY SILT dark brown	0							slightly moist medium stiff
	CL	SILTY CLAY light olive	5	▮	23	98				slightly moist stiff
				▮						
			10							
	ML	CLAYEY SILT pinholes; light brown								slightly moist to moist stiff
				◢						
			15							
			20							
				◢						
		End of Exploration at 22.0' No significant sidewall caving No groundwater encountered at time of excavation								
			25							

See Subsurface Conditions section in the report for additional information.

FIGURE 4C

CLIENT: Victor Holtreman
PROJECT: Lots 22 and 23 The Legends at Hawkins Creek
PROJECT NUMBER: 2129-01N-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

FIGURE 5

GSH

CLIENT: Victor Holtreman
PROJECT: Lots 22 and 23 The Legends at Hawkins Creek
PROJECT NUMBER: 2129-01N-16

KEY TO TEST PIT LOG

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

COLUMN DESCRIPTIONS

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

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

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

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

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

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

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

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

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

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

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

CEMENTATION:	MODIFIERS:	MOISTURE CONTENT (FIELD TEST):
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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.

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			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

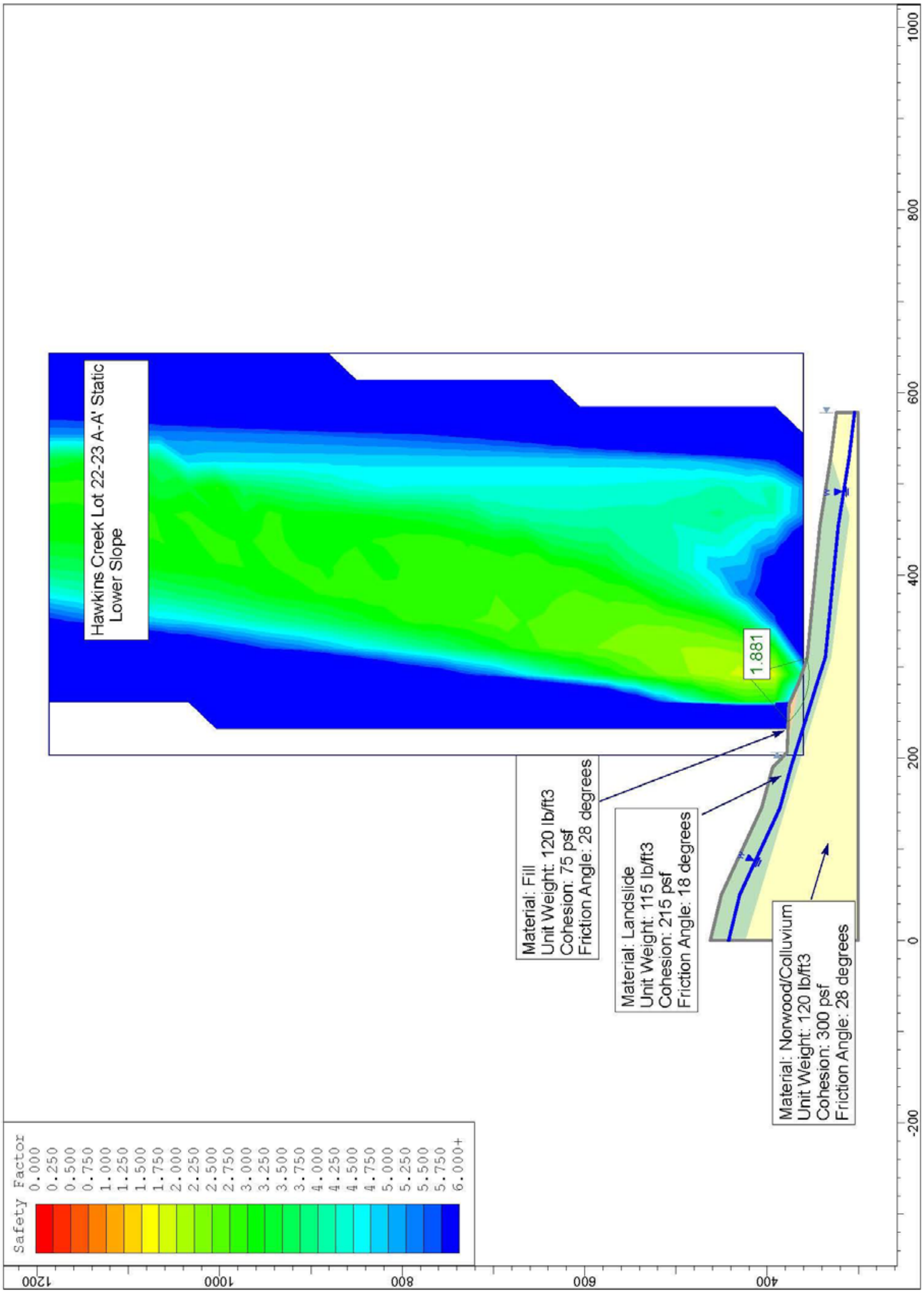
Water Level

FIGURE 6

GSH

STABILITY RESULTS

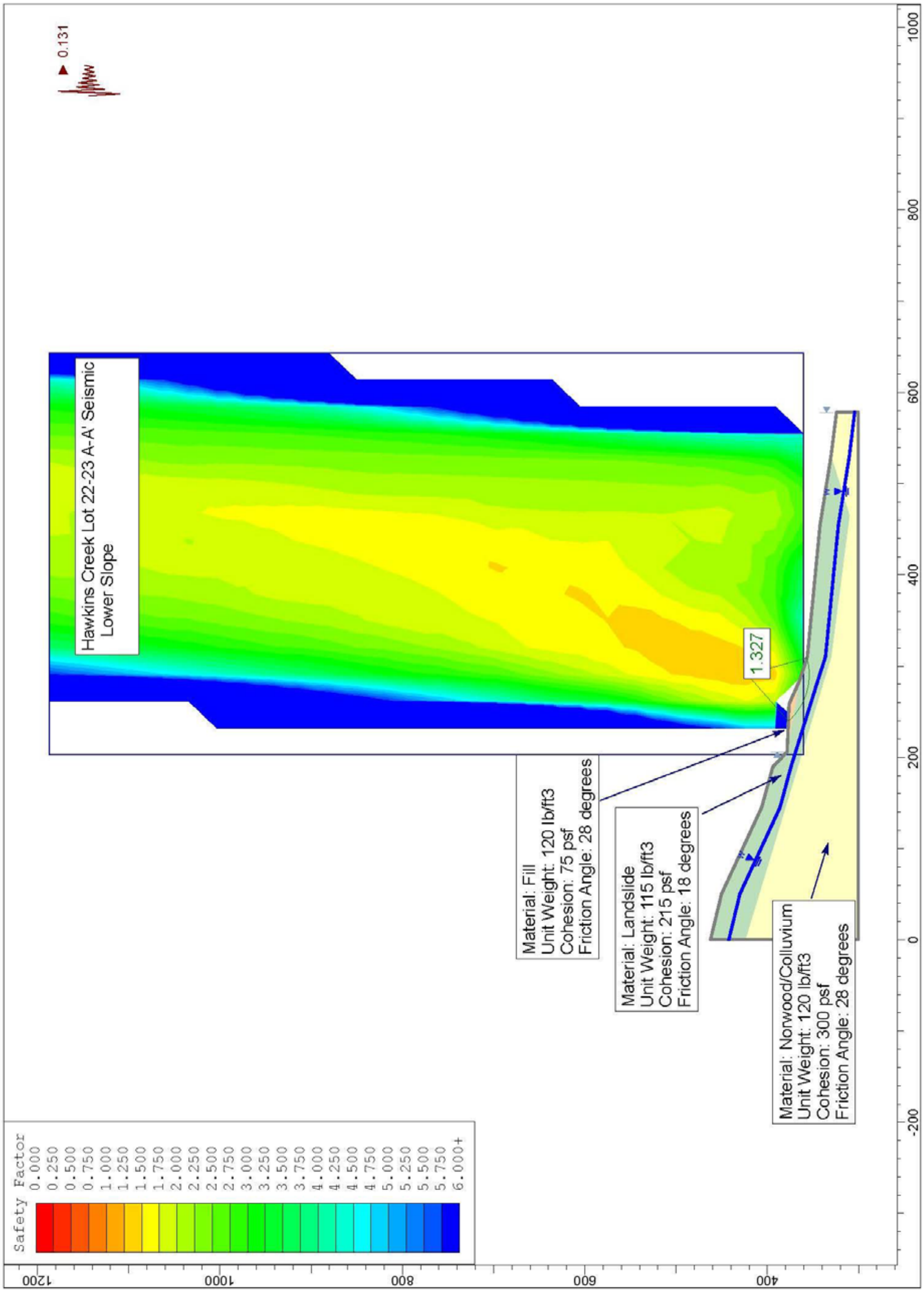
LOTS 22 AND 23 THE LEGENDS AT HAWKINS CREEK



PROJECT NO.: 2129-01N-16	GSH	**FIGURE NO.:** 7

STABILITY RESULTS

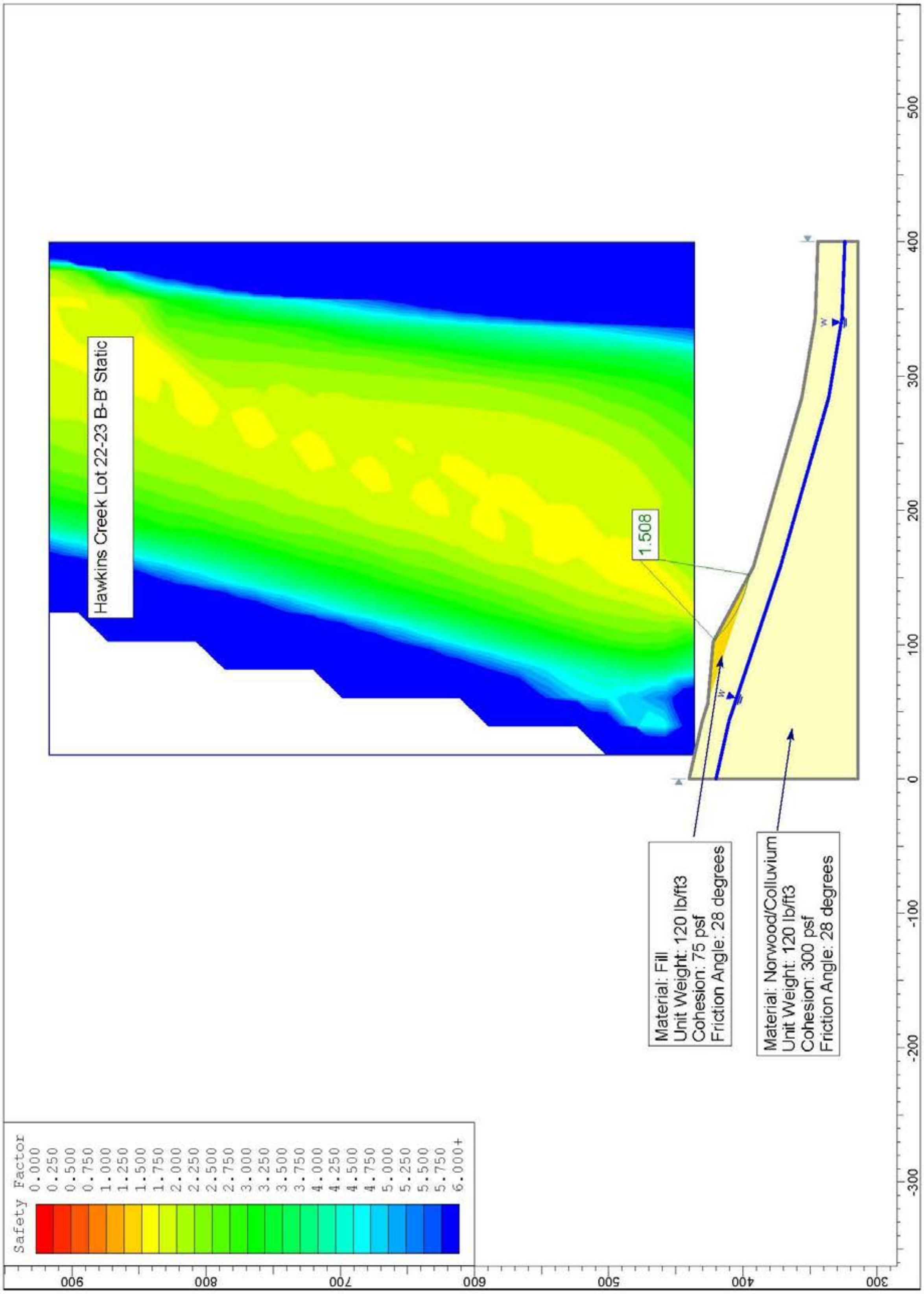
LOTS 22 AND 23 THE LEGENDS AT HAWKINS CREEK



PROJECT NO.: 2129-01N-16	GSH	**FIGURE NO.:** 8

STABILITY RESULTS

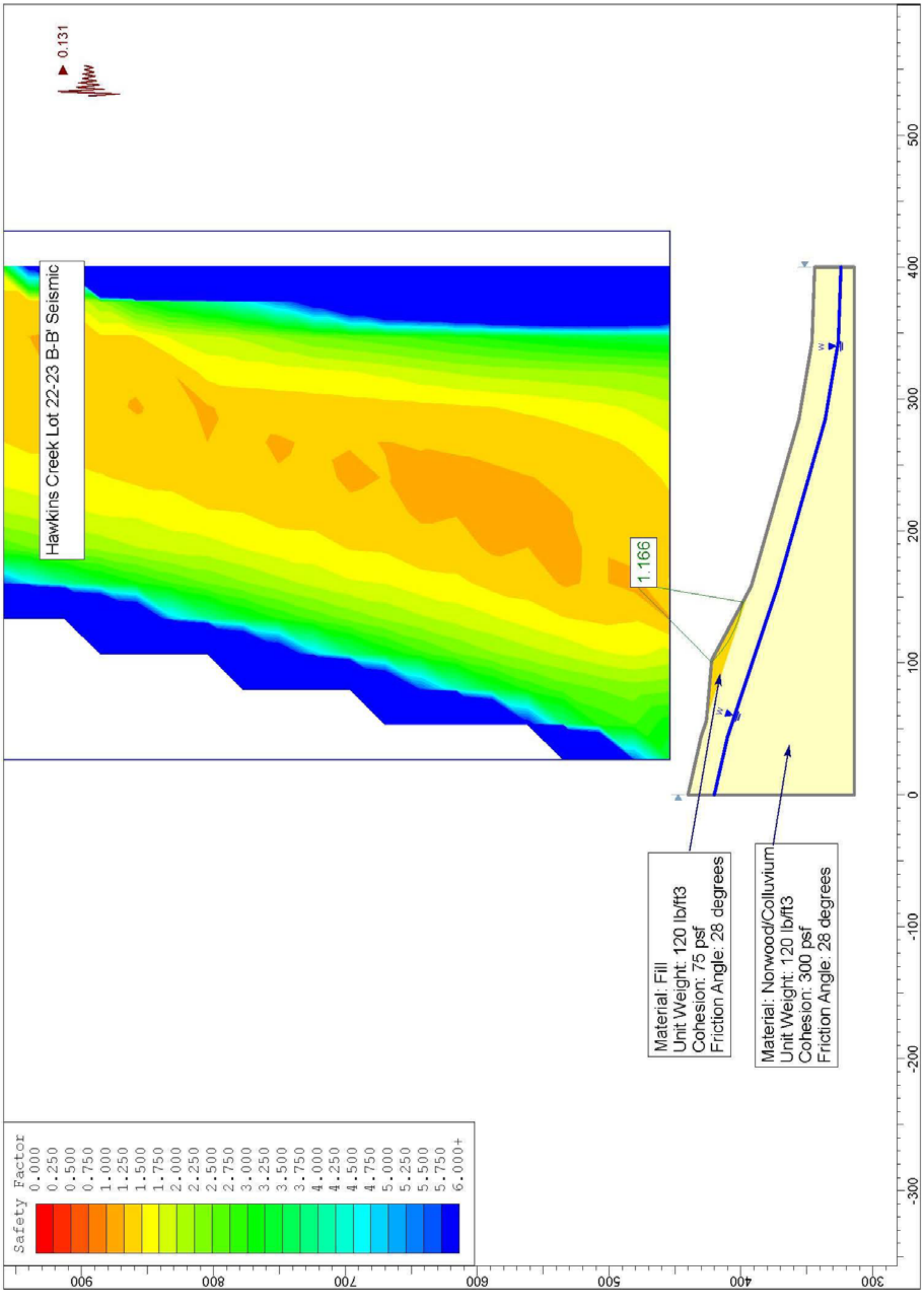
LOTS 22 AND 23 THE LEGENDS AT HAWKINS CREEK



PROJECT NO.: 2129-01N-16	GSH	**FIGURE NO.:** 9

STABILITY RESULTS

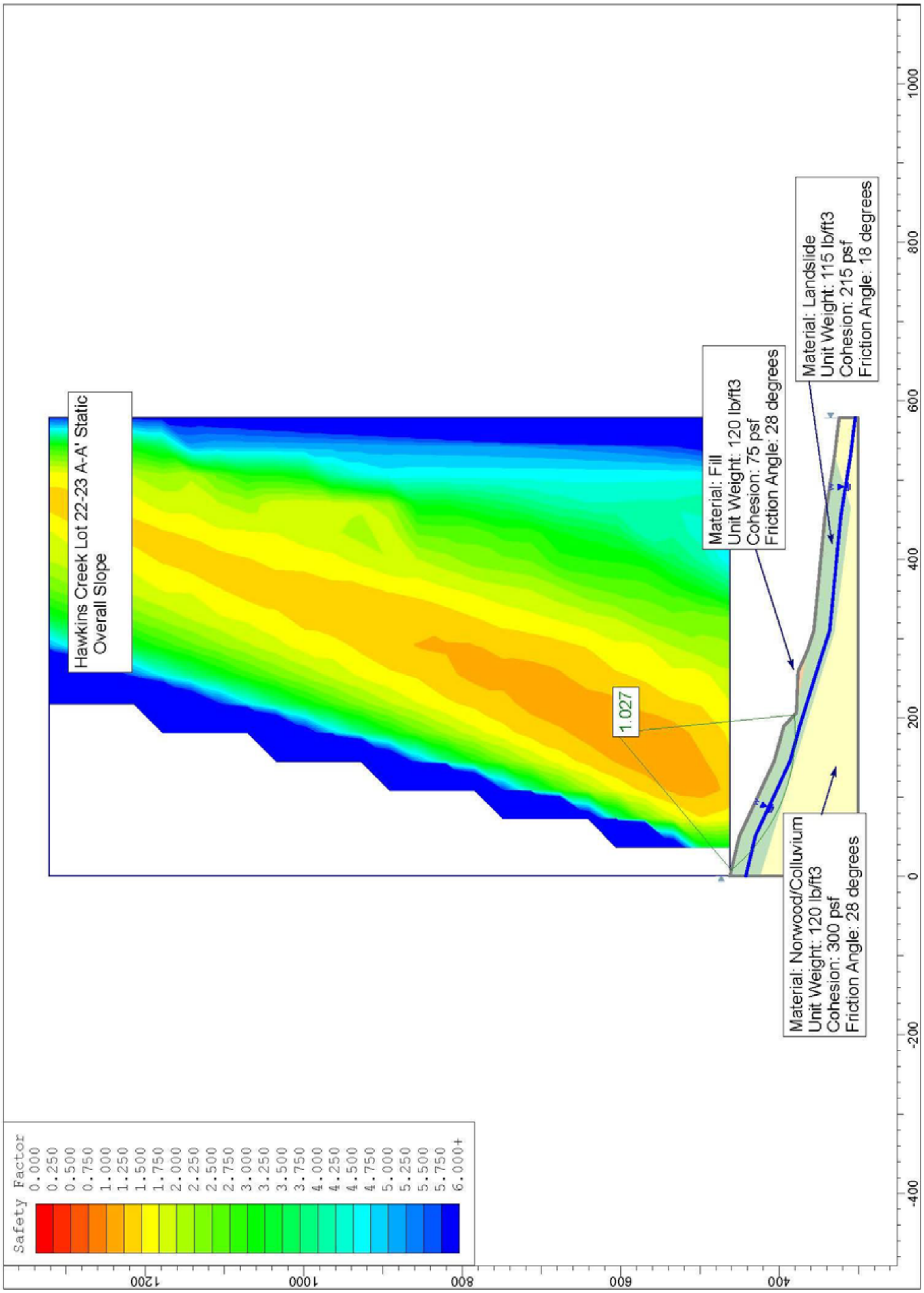
LOTS 22 AND 23 THE LEGENDS AT HAWKINS CREEK



PROJECT NO.: 2129-01N-16	GSH	**FIGURE NO.:** 10

STABILITY RESULTS

LOTS 22 AND 23 THE LEGENDS AT HAWKINS CREEK



PROJECT NO.: 2129-01N-16	GSH	**FIGURE NO.:** 11

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REPORT
GEOLOGICAL HAZARDS STUDY
LOTS 22 AND 23
THE LEGENDS AT HAWKINS CREEK
6564 AND 6585 EAST CHAPARRAL ROAD
NEAR EDEN, WEBER COUNTY, UTAH

Submitted To:

Mr. Victor Holtreman
1172 East Benchview Drive
Ogden, Utah

Submitted By:

GSH Geotechnical, Inc.
1596 West 2650 South
Ogden, Utah 84401

August 15, 2016

Job No. 2129-01N-16

GSH

August 15, 2016
Job No. 2129-01N-16

Mr. Victor Holtreman
1172 East Benchview Drive
Ogden, Utah 84404

Attn: Mr. Holtreman

RE: Geological Study
Lots 22 and 23 The Legends at Hawkins Creek
Huntsville Area, Weber County, Utah
(Parts of the SW 1/4 Section 24, Township 6 North, Range 1 East, Salt Lake base and meridian)

1. INTODUCTION

The Legends at Hawkins Creek Subdivision is located in the vicinity of Huntsville Town, Weber County, Utah (41.22369, -111.7929). The subdivision is a gated cluster community located on the east side of Old Snowbasin Road approximately 0.6 miles south from Utah SR-39 intersection as shown on Figure 1, Vicinity Map. The subdivision consists of forty-one residential development lots roughly one to two acres in area, and covers a total area of approximately 165 acres. Approximately 40-percent of the subdivision area is dedicated to common area. The two lots to be investigated as part of this study include Lot 22 and Lot 23. The two property parcels are adjacent and are located on the east side of Chaparral Road, which is a primary access road that loops through the subdivision as shown on Figure 2, Aerial Coverage. Lot 22 is recorded at 6585 East Chaparral Road, and Lot 23 is recorded at 6564 East Chaparral Road.

The present plans for the development of the two lots calls for the construction of a single residential structure to be located on parts of both lots or alternatively on one of the two lots. The proposed location (footprint) for the structure at the time of this reporting is shown on Figure 2. The footprint for the proposed structure is approximately 5,000 square feet. Although design has not been finalized for this project we expect the proposed structure to consist of reinforced concrete footings and basement foundation walls supporting 1 to 3 wood-framed levels above grade with some stone, brick, or stucco veneer, with maximum column and wall loads projected to be on the order of 10 to 25 kips and 1 to 3 kips per lineal foot, respectively.

1.1 Weber County Natural Hazards Overlay Districts

Because are the lots are located on a sloping hill side area with susceptible expansive soil and rock conditions (Mulvey, 1992), and partially occupy slopes identified as having "Landslide Potential" (Elliott and Harty, 2010), Weber County (Planning Commission) is requesting that geotechnical and geological studies be conducted to evaluate conformance of the proposed development with *Sensitive Lands Overlay District* requirement provisions.

At this time specific guidelines for these studies have not been specified by the County, however Weber County Code Section 104-27-2. - Potential hazards (Weber County Code, 2016), pertaining to Landslide/Tectonic Subsidence provides the following requirements:

> *... any development proposed within a designated landslide hazard area, as delineated on the Sensitive Lands Overlay District maps, shall require the submittal, review and approval by the planning commission, of specific site studies, including grading plans, cut/fill, and plans produced by a qualified engineering geologist and a Utah licensed geotechnical engineer. The site specific study shall address slope stability (including natural or proposed cut slopes), evaluate slope-failure potential, effects of development and recommendations for mitigative measures. Slope stability analysis shall include potential for movement under static, development-induced and earthquake-induced conditions as well as likely groundwater conditions.*

Referenced Sensitive Lands Overlay District maps addressing Landslide/Tectonic Subsidence zones for Weber County are presently not available for the site, and the present determination by County officials as to potential site geological hazard exposure is bassed upon regional hazrad mapping prepared by the Utah Geological Survey (UGS) and U.S Geological Survey (USGS) agencies (Mulvey, 1992; USGS 2006; Elliott and Harty, 2010),

A preliminary review of site geological mapping prepared by Utah Geological Survey (UGS) geologists (King, et al, 2008), show on Figure 3, Geologic Map has indicated that parts of the Lot 22 and 23 parcels (the Site) is within mapped Quaternary landslide and colluvial deposits (Qms and Qmc), that are within an area largely underlain by Tertiary age Norwood Formation (Tn) rocks (King, et al., 2008).

1.2 Scope of Work and Work Plan

On the basis of the Weber County Sensitive Lands Overlay District requrements and our preliminary review of geological conditions of the site, we (GSH consultants) prepared the following scope of work (work plan) for the evaluation of the Site as applicable to the Weber County Natural Hazards Overlay District Code. In our May 2, 2016 Work Plan we (GHS consultants) provided the following scope of work:

> *1) Work Plan and scope of work development and plan implementation and meetings with Weber County Staff*;*
>
> *2) A search and review of previous relevant documentation of site engineering and geologic studies and including UGS mapping (King, et al, 2008); and reports and studies prepared by others (Earthtec Testing & Engineering, 1999);*
>
> *3) A field reconnaissance study including the geologic logging of a single walk-in trench approximately 250 feet in length and as much as 14 feet in depth, three walk-in test pits to as much as 19 feet in depth, and two geotechnical borings to penetrate as deep as 50 feet...*

4) Development of a geological cross section along slope section line A-A' shown on Figure 4 to be used for geotechnical engineering slope stability analysis;

5) Site specific geological mapping and classification to identify critical geological units and exposure to proposed site improvements;
6) Slope analysis from LiDAR DEM geoprocessing identifying critical areas 25-percent or greater across the site and/or surficial features potentially affecting the proposed site improvements;

7) A laboratory geotechnical soils testing program of samples recovered from the test pits, trenches and borings for typical and critical geological units explored and identified in our subsurface evaluation. Laboratory testing program to include but not be limited to the moisture, density, gradation, Atterberg limits, consolidation, vane shear, and direct shear tests of representative soil samples; And

8) Preparation of summary report presenting results of our analysis and findings including:

- *A vicinity map showing the location of the property relative to site vicinity and topographic features.*
- *A geologic map showing the site specific surficial geology of the property and surrounding area.*
- *Aerial photography showing the site and nearby surficial geologic features.*
- *Logs of trenches, test pits and borings.*
- *An assessment of potential geologic hazards in the vicinity of the site and the exposure of the site and proposed site improvements to hazards named in the ordinance including but not limited to: landsliding and recommendations for site specific slope stability analysis; alluvial fan processes including debris-flow; surface fault rupture hazards, strong earthquake ground motion, and liquefaction hazards; rockfall and avalanche hazards, flood hazards, and radon*
- *Cross-sections of slopes depicting encountered geological conditions.*
- *Site development recommendations based upon our findings and professional experience.*
- *Following completion of the geologic study, a geotechnical study will be prepared for the subject property based on the findings of the geologic study and concurrent/subsequent geotechnical evaluations.*

*Planning meetings with Weber County Staff were not held for this project.

2. INVESTIGATIONS

2.1 Literature Review

During the Work Plan development, existing previous reports and geological literature sources were reviewed. Specific to the site and immediate surrounding area, reports and mapping by; Earthtec Testing & Engineering, 1999; King, et al., 2008; and Coogan and King, 2016 were reviewed. The Earthtec Testing & Engineering study involved a general geotechnical assessment with no subsurface observations. Summary geological discussions regarding the 160 acre were provided in the Earthtec report; however no geological hazards were delineated or mapped. The King, et al., 2008 document is an Open-file UGS 1:24,000 scale geological mapping project of the Snow Basin and Huntsville, Utah quadrangles, which includes the location of the Lot 22 and 23 site, and the Coogan & King, 2016 mapping is a 1:100,000 scale regional compilation mapping that that includes the Snow Basin and Huntsville quadrangles.

2.2 Field Program

GSH conducted field operations at the site on the dates May 13, 16, and 17, 2016. The field program involved the excavation and geological logging of two exploration trenches and one test pit, and two borings. The excavations and borings were logged to observe and characterize site subsurface/geologic and groundwater conditions for the site and the proposed residence construction location.

The trenches and test pits were excavated using a 20-ton class excavator with a 36-inch bucket. Trench 1 was located to evaluate the conditions beneath the initial proposed residence structure location, and Trench 2 was located to evaluate an alternative locations on the site, and the Test Pit 1 was located to observe conditions within the building lots, but away from the structure locations. The locations of our trenches and test pits are included on Figure 4, Site Evaluation. Trench 1 was 196.0 feet in length and extended to depths of 8.0 to 10.0 feet for walk-in observations, and deepened to 22.0 feet at Station 160 East for deep sampling and observation. Trench 2 was 125.0 feet in length and extended to depths of 10.0 to 12.0 feet for walk-in observations, and deepened to 20.0 feet at Station 110 East for deep sampling and observation. Test Pit 1 was excavated to a depth of 20 feet. The trenches and test pits were logged so as to illustrate the vertical and lateral characteristics and variations of soil and rock conditions underlying the Site.

The borings were completed using a CME 55 truck-mounted drill rig using hollow-stem auger/rotary wash equipment and methods. Soil and rock samples were recovered at 2.5-foot intervals using driven 2.42-inch inside diameter drive Dames & Moore sampler. Boring 1 was advanced to a depth of 31.5 feet and Boring 2 was advanced to a depth of 39.0 feet.

Our field program was conducted under the supervision of Dr. Greg Schlenker, PG of our geotechnical staff. Mr. Amos Allard, Staff Geologist also of our geotechnical staff assisted Dr. Schlenker and supervised drilling operations. In conjunction with field operations, the general surface of the site and surrounding area was reconnoitered to assess geological and slope conditions, and feature location and elevation data were recorded using a hand-held GPS receiver device.

Detailed graphical representations of the subsurface conditions encountered are presented on Figures 5 through 7, Log of Trench 1, Figures 8 and 9, Log of Trench 2, and Figure 10, Log of Test Pit 1. The boring Logs are included on Figures 11 and 12 Boring Log B-1, and Figures 13 and 14 Boring Log B-2.

Bulk and thin wall samples of representative soil layers encountered in the trenches and test pit were obtained and placed in sealable bags and/or were recovered undisturbed using driven sample tubes, and undisturbed ring samples. In the borings soil and rock samples were recovered at 2.5-foot intervals using driven 2.42-inch inside diameter drive Dames & Moore sampler. The borings were also logged in accordance with the Unified Soil Classification System (USCS). The locations of the sample recovery locations are included on our trench, test pit and boring logs. These classifications were supplemented by subsequent inspection and testing in our laboratory. The results of our laboratory analysis and testing of the soils recovered from the trenches, test pit and borings will be included in forthcoming geotechnical reports. Static groundwater was not observed in any of the excavations or borings during the dates of our field program, however vadose water was observed entering the deep section of Trench 1 at Station 160 East at a depth of about 15 feet.

2.3 LiDAR - Slope Analysis

To asses slope conditions, interpret terrain, and develop site specific geologic cross section for the site, a LiDAR - Slope Analysis was performed for the site. Elevation data consisting of 2.0 meter LiDAR digital elevation data (DEM), for the site was obtained from Utah Automated Geographic Reference Center (AGRC). These data were geo-processed using the QGIS® GIS platform, and using the r.slope, r.shaded.relief and r.contour.level GRASS® (Geographic Resources Analysis Support System) modules, slope percentages, relief renderings and elevation contours for the site area were processed.

Figure 15, LiDAR-Slope Analysis, presents the results of our slope analysis efforts. Shown on Figure 15 is the 25-percent and greater slope gradients across the site. The critical limiting gradient for slope development considerations according to the Weber County Section 108-14-3. (Weber County Code, 2016), includes slopes greater that 25-percent. The shaded relief rendering on Figure 15 also provides a visual basis for landform interpretation mapping, and the contour elevation data shown on Figure 15 was used to develop the Geologic Slope Cross Sections shown on Figure 16 and Figure 17 that will be used for slope stability analysis to be included our geotechnical reporting.

3. SITE CONDITIONS

The site conditions and site geology were interpreted through an integrated compilation of data including a review of literature and mapping from previous studies conducted in the area (Sorensen and Crittenden, 1979; Bryant, 1988; Coogan and King, 2001; and King et al., 2008) including a review previous evaluations discussed previously in the Literature Review Section of this report, photogeologic analyses of 2014 and 2012 imagery shown on Figure 2 and Figure 4, and historical stereoscopic imagery flown in 1946. GIS analyses of elevation and geoprocessed DEM terrain data as discussed in the previous section (LiDAR-Slope Analysis) and shown on Figure 15, field reconnaissance of the general site area, and the interpretation of the trenches, test pit and borings made on the site as part of our field program. Seismic hazards information was developed from United States Geologic Survey (USGS) databases (Peterson, et al., 2008).

3.1 Geologic Setting

The site is located on the eastern flank of Mount Ogden which western flank comprises the Wasatch Front. The Wasatch Front is marked by the Wasatch fault, which is 7.0 miles west of the site, and provides the basis of division between the Middle Rocky Mountain Physiographic on the east and the Basin and Range Physiographic Province on the west. The Basin and Range Physiographic Province is characterized by approximately north-south trending valleys and mountain ranges that have been formed by extensional tectonics and displacement along normal faults, and extends from the Wasatch Range on the east to the Sierra Nevada Range on the west (Hunt, 1967).

The Middle Rocky Mountain province covers parts of Utah, Colorado, Wyoming, Idaho, and Montana. The geology of the province is an assemblage of sedimentary, igneous, and metamorphic rocks that have been folded, faulted, and uplifted. Mountain building (tectonic) activity commenced about 30 million years ago (Cretaceous time) and continues to the present. The province is characterized by mountainous terrain with deep canyons and broad intervening basins, with temperate semi-arid to mesic climatic conditions (Hunt, 1967).

The surficial geology of the site vicinity is the result of the uplift and exposure of older pre-Cambrian rocks which forms the crest of Mount Ogden east of the site. This exposure was the result of movement along high-angle faults during late Tertiary and Quaternary age (Bryant, 1988).

Bounding the east foothill flank of Mount Ogden are mid Teritary units of the Norwood Formation that ramp along the base of the mountains south and west of the Ogden Valley floor. The Norwood Formation is described as "light-gray to light brown, altered tuff (claystone), tuffaceous siltstone, sandstone, and conglomerate" derived from volcanic ash deposition (King, et al., 2008), and has been measured to be as much as 7000 feet thick in the vicinity of the site. The claystone, siltstone and sandstone occurrences of the formation are primarily a result of lacustrine (lake processes) redeposition of the volcanic ash. The site location is largely underlain by Norwood Formation lacustrine rock units which beds appear to slope gently down to the northeast across the site (King et. al, 2008). A previous investigation for the Via Cortina roadway extension approximately 2,000 feet to the north of the site, revealed bedded exposures of lucustrine rock sequences generally consisting of moderate to thick bed units, (one to two feet in thickness) typically fining upward (sandstone-siltstone-claystone), colored light shades of buff, tan red and green and gray, and ranged from *weak* to *strong* in field test competency (GSH Geotechnical Inc., 2015). The existing surface of the site and vicinity appears to have been modified by Quaternary age erosion, and localized late-Quaternary stream, lacustrine (Currey and Oviatt, 1985), residual soil weathering and development, and mass movement processes (King, et al., 2008).

3.2 Surface Conditions

As shown on Figure 2 and Figure 4, the site consists of an area of approximately 3.9 acres in size that is currently vacant and undeveloped. Surface vegetation consists of open areas of grasses, weeds and sage brush with clustered wooded areas of scrub oak, alder and maple trees. The topography of the site consist of a primarily north facing swale with slopes on the property generally facing downward toward the northeast, north and northwest toward Ogden Valley.

Topographically the site is located on base foothills on the northeast side of Mount Ogden, and overlooks Ogden Valley and the South Fork of the Ogden River floodplain, which is inundated by Pineview Reservoir waters, to the north of the site. The site, as shown on Figure 2 and Figure 4 is bordered on the south, west and north by vacant undeveloped residential lots, and on the east and by open-space land uses.

3.3 Subsurface Conditions

The natural rock and soils sequence observed in the trenches, test pits and borings, and illustrated on Figures 5 through 14, generally consisted, from bottom to top of:

1. **Residual Weathered Norwood Formation** consisting of reddish brown claystone (CS); very stiff to hard slightly moist to moist, gray, gray-brown to reddish-brown silty clays (CL), and stiff, slightly moist, dark olive gravelly clays (CL), with beds of dense, slighlty moist, gray, brown and reddish-gray fine to coarse sand (SP). The observed thickness of the residual weathered Norwood Formation deposits extended from the top of the gravelly clay deposits observed from 14.0 feet below the surface at Station 165 East in Trench 1 to the 39.0 foot depth penetrated by Boring 2.

2. **Alluvial Deposits** consisting of slightly moist to moist, reddish brown, clayey silt (ML), and reddish brown and light-olive silty clays (CL). These deposits are believed to have accumulated on the site by means of local sheet flow and colluvial slope wash processes. The observed thickness of the Alluvial Deposits extended from clay deposits observed from a foot or two from the site surface to 14.0 feet below the surface at Station 165 East in Trench 1. Based upon observed stratigraphic relations the deposition of Alluvial deposits appear to both precede and proceed the movement of the Slide Mass deposits.

3. **Slide Mass** landslide deposits. The Slide Mass deposits was observed in Trench 1 (Station 00 to 172 East) and Trench 2 (Station 00 to 45 East), and was likely present in Test Pit 1. These deposits displayed tilted, rotated and disturbed bedding, and a variety of textural classifications including stiff, slightly moist, reddish-brown silty clays (CL), and stiff, slightly moist, dark olive gravelly clays (CL) containing angular fine and coarse gravel and tabular siltstone cobbles and boulders (ST). Beds of slightly moist, dense, light olive fine silty sand (SM) were interbedded with the Slide Mass clay deposits. The Slide Mass deposits also displayed zones of Fe-oxide accumulation and thin wavy beds of clay. The observed thickness of the Slide Mass deposits extended from the uppermost gravelly clay deposits observed from a foot or two from the site surface to 14.0 feet below the surface at Station 160 in Trench. We believe the Slide Mass deposits extend deeper than the 14.0 feet depth observed in Trench 1.

4. **Surficial Pedogenic Soils** including A-B soil vertisol sequences that extended in depth as much as 1.5 to 11 feet in the trenches. These consisted of surficial clayey silt (ML), moist, medium stiff, dark brown, major herb roots to 6' inches, and becoming with depth stiff, brown silty clay (CL), slightly moist, with deep vertical (vertisol) cracking in the two trenches. These soils are believed to be locally derived from weathered rock, slide mass and colluvial sources.

   Deep cumlic clayey silt (ML) soil sequences characterized by abundant organic eluviates 5.0 feet in thickness were observed on the east side of Trench 2, and thick clayey silt (ML) top soil fills 6.5 feet in thickness were observed on the surface of Test Pit 1.

Landslide movement was observed in Trench 1, Trench 2, and possibly in Test Pit 1. The landslide movement observed in the two trenches appears to be downslope in a northward direction, with the lateral right flank boundary observed at Station 170 East in Trench 1, and Station 45 East in Trench 2 believed to be the lateral flanks of a larger landslide feature mapped as **Qms** on Figure 3 that extends both upslope and downslope of the Lot 22 and 23 location.

Static groundwater was not observed in any of the trenches, test pit or borings during our field program, however a vadose zone of water was encountered at a depth of 15 feet in Trench 1.

3.4 Site Engineering Geology

Our interpretation of the site engineering geology is presented on Figure 4 and Figure 15 of this report. The engineering geology shown on the two figures is largely based on previous mapping prepared by King, et al. (2008) which is presented on Figure 3, with amendments to the mapping drawn on the basis of the findings of this and previous studies. A summary of the mapping units identified on the site vicinity are listed below in relative age sequence (youngest-top to oldest bottom):

Qh - Human deposits, deposits and exposures resulting primarily from previous site grading activities.
Qac - Alluvium and colluvium, as found by this study, mapped as **Qmc** - landslide and slump, and colluvial deposits by King, et al., 2008.
Qms - Landslide and slump deposits, resulting fro past landslide movement
Tn; Norwood Formation, rock and residual soils.

4. DISCUSSIONS AND RECOMMENDATIONS

4.1 Summary of Findings

4.1.1 Subsurface Observations: The geology exposed by trenches and test pits were generally found to consists of surficial, upper 1.0 to 1.5 feet of pedogenic soil A horizons, B horizon vertisol sequences that extended in depth (thickness) as much as 11.0 feet, and consisting of stiff silty clays derived from weathered rock and colluvial sources. At depth weathered rock and soil sequences consisting of alluvial deposits, landslide slide mass deposits, and weathered Norwood Formation soils and rock were observed.

4.1.2 Expansive soils. Vertical cracking associated with vertisol development was observed to extend from 1.0 to 6.0 feet below the surface in the two trenches excavated for this study. The vertical cracking demonstrated by these soils is a result of naturally high expansive clay content within these soils (Graham and Southard, 1982). The presence or absence of the vertisol soils should be evaluated where structural loads are to be placed during future development.

4.1.3 Sloping Surfaces. The surface of site slopes developed from our LiDAR analysis range from level to over 55-percent as shown on Figure 5, LiDAR-Slope Analysis. For the two lot Site the slope gradient averaged 23.0-percent, for the general vicinity of the 165 acre subdivision area the slope gradient averaged 29.4-percent. As previously discussed in the LiDAR-Slope Analysis section of this report, the critical gradient for slope development considerations according to the Weber County Code is 25-percent.

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4.1.4 Site Engineering Geology And Mapping. The engineering geology mapping of the site presented on Figure 4 and Figure 15 reveals three issues that pertain to site development planning. These issues include: (1) **Landslide and slump deposits Qms -** the presence of Landslide and slump deposits deposits on the west side of the site; (2) **Norwood Formation (Tn)** - the presence of Norwood Formation **Tn** projected underlie the site; and (3) **Non-Engineered Fills,** mapped as **Qh -** human deposits associated with the placement of thick fill soils on the north side of the site, and observed in Test Pit 1. These issues are addressed in order importance below:

1. Landslide and slump deposits: Presence of mass-movement landslide and slump deposits mapped as **Qms** is based upon developed field observations including; deformation of soils observed in Trench 1 and Trench 2, location of the topographic features evident on the LiDAR imagery on Figure 15 indicating the planform area of movement observed in the trenches and test pits, and the mapping by King et al. (2008).

The area of movement mapped as Qms on Figures 4 and 15 consists of a relatively thick, greater than 14.0-feet in thickness, block of soil and rock that appears to have moved or "creeped" downslope in response to inherent weak and expansive soil characteristics, and the moderately steep slope conditions in this area. Based upon our observations of evident topographic surface expression of this feature, and observed stratigraphic sequences in the trenches, we believe that this movement should be considered active.

2. Norwood Formation (Tn): The Norwood Formation has a notoriety of poor stability performance and geotechnically challenging soils throughout Northern Utah (Mulvey, 1992). Furthermore, we have observed an apparent genetic relationship with the occurrence of the Norwood Formation (and Norwood "Tuff") and surficial vertisol soils (discussed previously in section 4.1.2), which are subject seasonal shrink-swell processes (Graham and Southard, 1982). Based upon our past experience with areas underlain by Norwood Formation rock and soil, we believe that appropriate geological/geotechnical studies should be conducted before structural improvements are made in those areas.

3. Non-Engineered Fills, mapped as **Qh -** human deposits apparently have been placed on the north boundary of the of as part of subdivision site development and grading. Although the area mapped as **Qh** comprises only a small part of the Lot 22 and 23 property, all the non-engineered fills will need to be removed and suitable subgrade conditions prepared for any structural improvements that occur in the areas mapped as **Qh.**

4.1.5 Geoseismic Setting: Utah municipalities have adopted the International Building Code (IBC) 2012. The IBC 2012 code determines the seismic hazard for a site based upon 2008 mapping of bedrock accelerations prepared by the United States Geologic Survey (USGS) and the soil site class (Peterson, et al., 2008). The USGS values are presented on maps incorporated into the IBC code and are also available based on latitude and longitude coordinates (grid points).

Based on probabilistic estimates (Peterson, et al., 2008) queried for the site , the expected peak horizontal ground acceleration on rock from a large earthquake with a ten-percent probability of exceedance in 50 years is as high as 0.16*g*, and for a two-percent probability of exceedance in 50 years is as high as 0.33*g* for the site. Ground accelerations greater than these are possible but will have a lower probability of occurrence.

4.1.6 Active Earthquake Faults: Based upon our review of available literature, no active faults are known to pass through or immediately adjacent to the site. The nearest active (Holocene) fault is the Weber Segment of the Wasatch fault, located 7.0 miles west of the site (Black et al., 2004). The Wasatch Fault Zone is considered capable of generating earthquakes as large as magnitude 7.3 (Arabasz, et al., 1992).

4.1.7 Liquefaction Potential Hazards: In conjunction with the ground shaking potential of large magnitude seismic events as discussed previously, certain soil units may also possess a potential for liquefaction during a large magnitude event. Liquefaction is a phenomenon whereby loose, saturated, granular soil units lose a significant portion of their shear strength due to excess pore water pressure buildup resulting from dynamic loading, such as that caused by an earthquake. Among other effects, liquefaction can result in densification of such deposits causing settlements of overlying layers after an earthquake as excess pore water pressures are dissipated. Horizontally continuous liquefied layers may also have a potential to spread laterally where sufficient slope or free-face conditions exist. The primary factors affecting liquefaction potential of a soil deposit are: (1) magnitude and duration of seismic ground motions; (2) soil type and consistency; and (3) occurrence and depth to groundwater.

Liquefaction commonly occurs in saturated non-cohesive soils such as alluvium, thus no areas in the vicinity of the site appears to be susceptible to liquefaction processes.

4.1.8 Alluvial Fan Deposits: Alluvial fan deposits indicative of processes including flash flooding and debris flow hazard do not occur on the site: The nearest active alluvial fan deposits to the site, mapped as Qafy by King, et al. (2008), are located on a small fan surface (<4.0 acres in area) approximately 500 feet north of the site, and do not appear to represent a potential impact the site.

4.1.9 Flooding Hazards: No significant water ways pass in the vicinity of the site and flood insurance rate mapping by Federal Emergency Management Agency for the site vicinity has not been prepared for this area at this time (FEMA, 2016). Local sheet flow, slope wash, and seasonally perched soil water typical of sloping areas should be anticipated for the site, and site improvements.

4.1.10 Rockfall and Avalanche Hazards: The site is over two miles from steep slope areas where such hazards may originate.

4.1.10 Radon Exposure: Radon is a naturally occurring radioactive gas that has no smell, taste, or color, and comes from the natural decay of uranium that is found in nearly all rock and soil. Radon and has been found occur in the Ogden Valley area, and can be a hazard in buildings because the gas collects in enclosed spaces. Indoor testing following construction to detect and determine radon hazard exposure should be conducted to determine if radon reduction measures are necessary for new construction. The radon-hazard potential mapping has been prepared for most of Ogden Valley by the Utah Geological Survey (Solomon, 1996), however that mapping does not extend far enough to the south to include the Lot 22 and 23 site. The radon-hazard potential is mapped as "Moderate" for the area directly north of the site (250 feet) included in studies by the UGS (Solomon, 1996). For new structures radon-resistant construction techniques as provided by the EPA (EPA 2016) should be considered.

4.2 Conclusions

Based upon our geological studies herein, we believe that the Lot 22/23 Legends at Hawkins Creek is suitable for development, provided that soils identified in our borings, trenches and test pits as subject to past landslide movement (Qms) as discussed in Section 3.3 of this report, are avoided or mitigated. Due to the extensive nature of the past landslide movement soils on the western portion of the site, the proposed structure must be sited within the alluvial/colluvial soils observed over the eastern portion of the site. This will require vacating the existing drainage easement at the site and relocation of the associated drainage channel. Under no circumstance should structures be placed in the landslide deposits or slopes associated with landslide deposits be steepened as part of the development process. <u>We also recommend that structures be setback at least 20 feet from the landslide deposits (Qms) shown on Figure 4 and Figure 15.</u>

The site has been shown to be underlain by Norwood Formation deposits, and expansive vertisol soils were observed in all of the excavations made for this study. Areas where these soils are present or uncovered should be evaluated prior to the placement of structural loads. Additional evaluation of the expansive potential of the soils must be conducted as part of the geotechnical study for the site.

A pinhole texture was observed in the deeper natural soils within Trench 2 excavated at the site. Further evaluation of the collapse potential for the soils containing a pinhole structure must be conducted as part of the site geotechnical study.

Indoor testing following construction to detect and determine radon hazard exposure should be conducted to determine if radon reduction measures are necessary for new construction.

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CLOSURE

If you have any questions or would like to discuss the results of this study further, please feel free to contact us at (801) 393 2012.

Respectfully submitted,

GSH Geotechnical, Inc.

LICENSED PROFESSIONAL GEOLOGIST
8/15/16
GREGORY C. SCHLENKER
5224720-2250
STATE OF UTAH

Gregory Schlenker PhD, P.G.
State of Utah No. 5224720
Senior Geologist

Reviewed by:

Andrew M. Harris, P.E.
State of Utah No. 7420456
Senior Geotechnical Engineer

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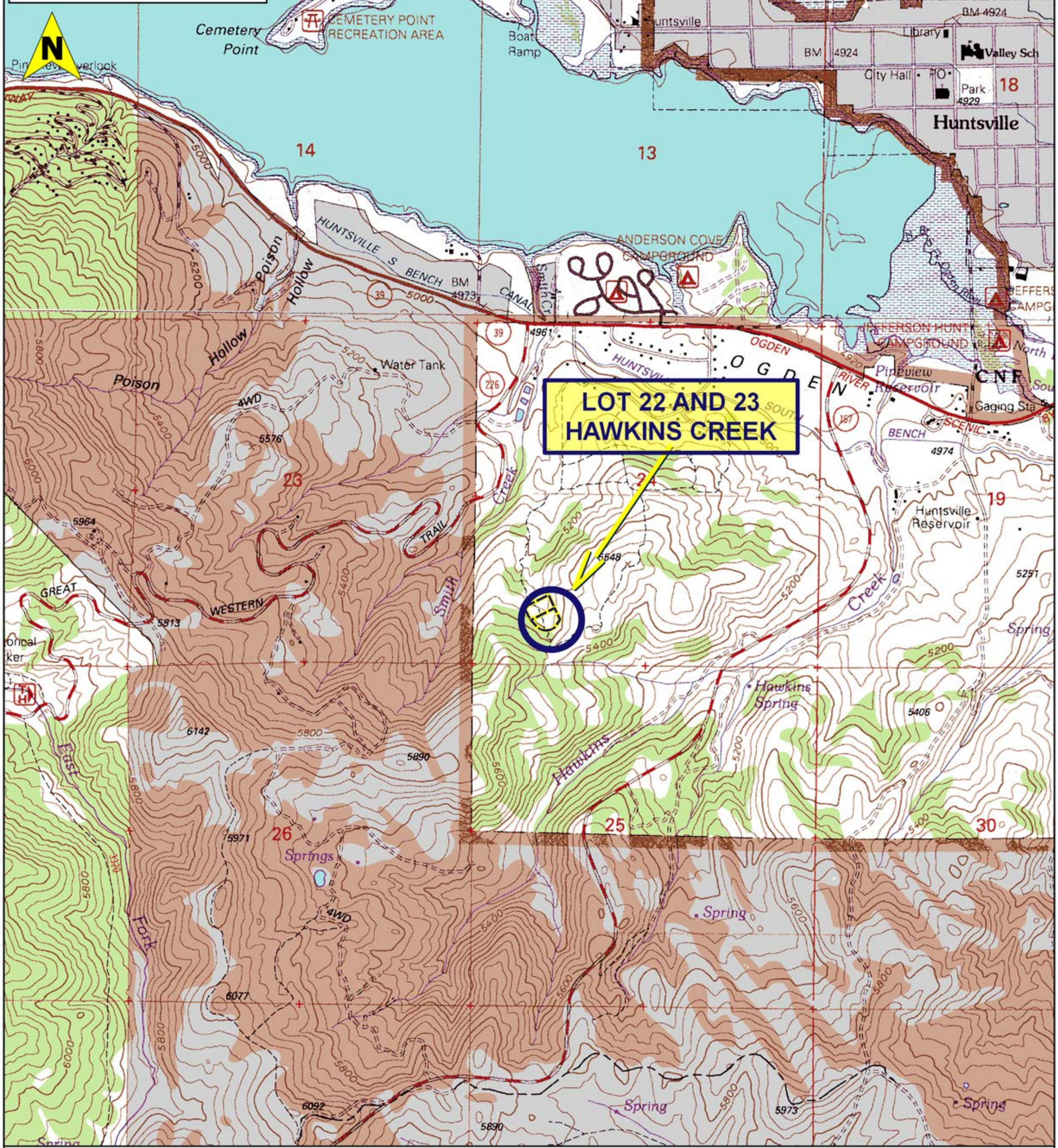
Hawkins Creek Lot 22 & 23
Job No. 2129-01N-16

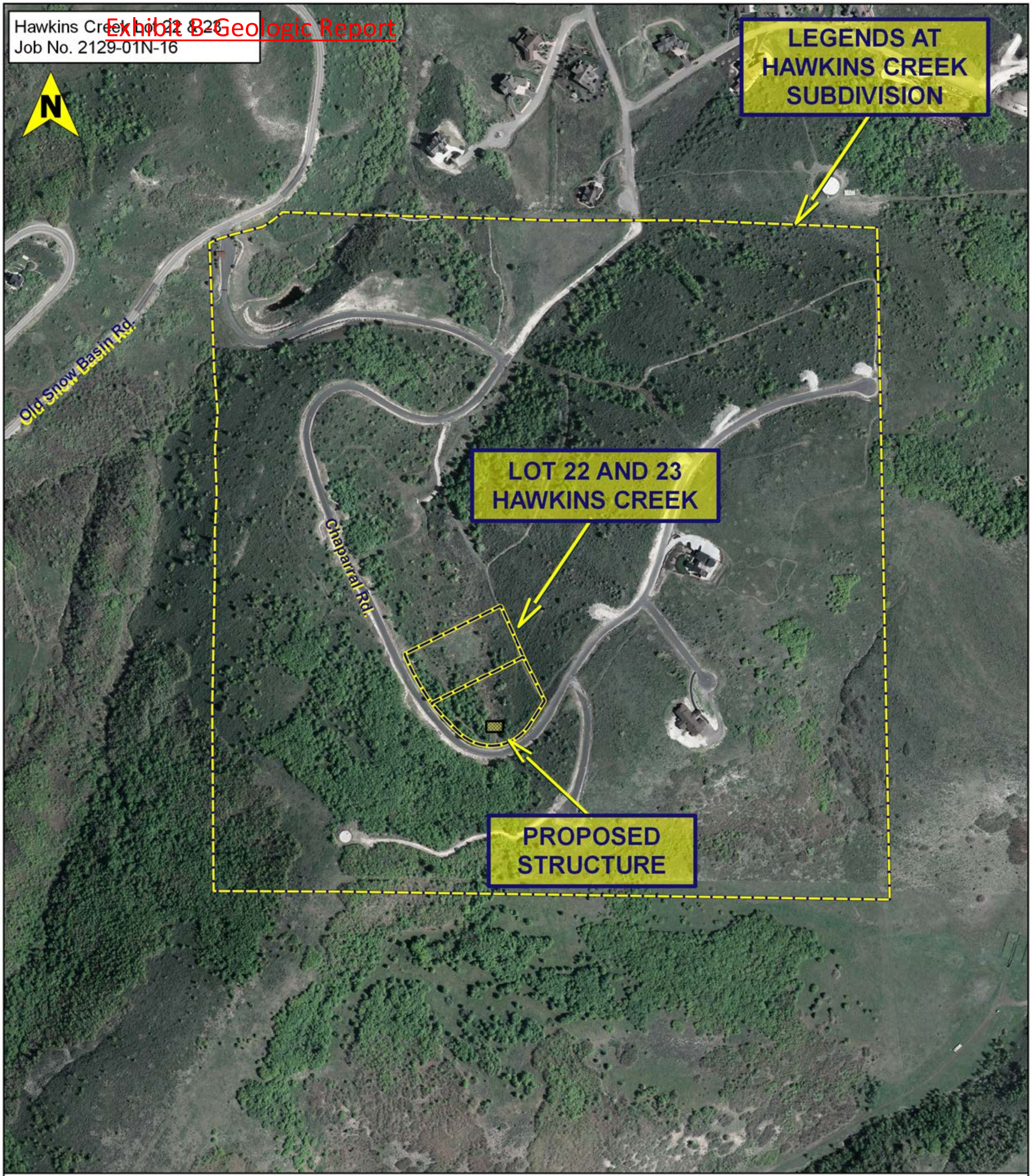


Base:
1998 7.5 Minute USGS Toporgraphic Maps Titled
Snowbasin, Utah, and Huntsville, Utah.

0 2000 4000 ft
1:24,000

FIGURE 1
VICINITY MAP

GSH



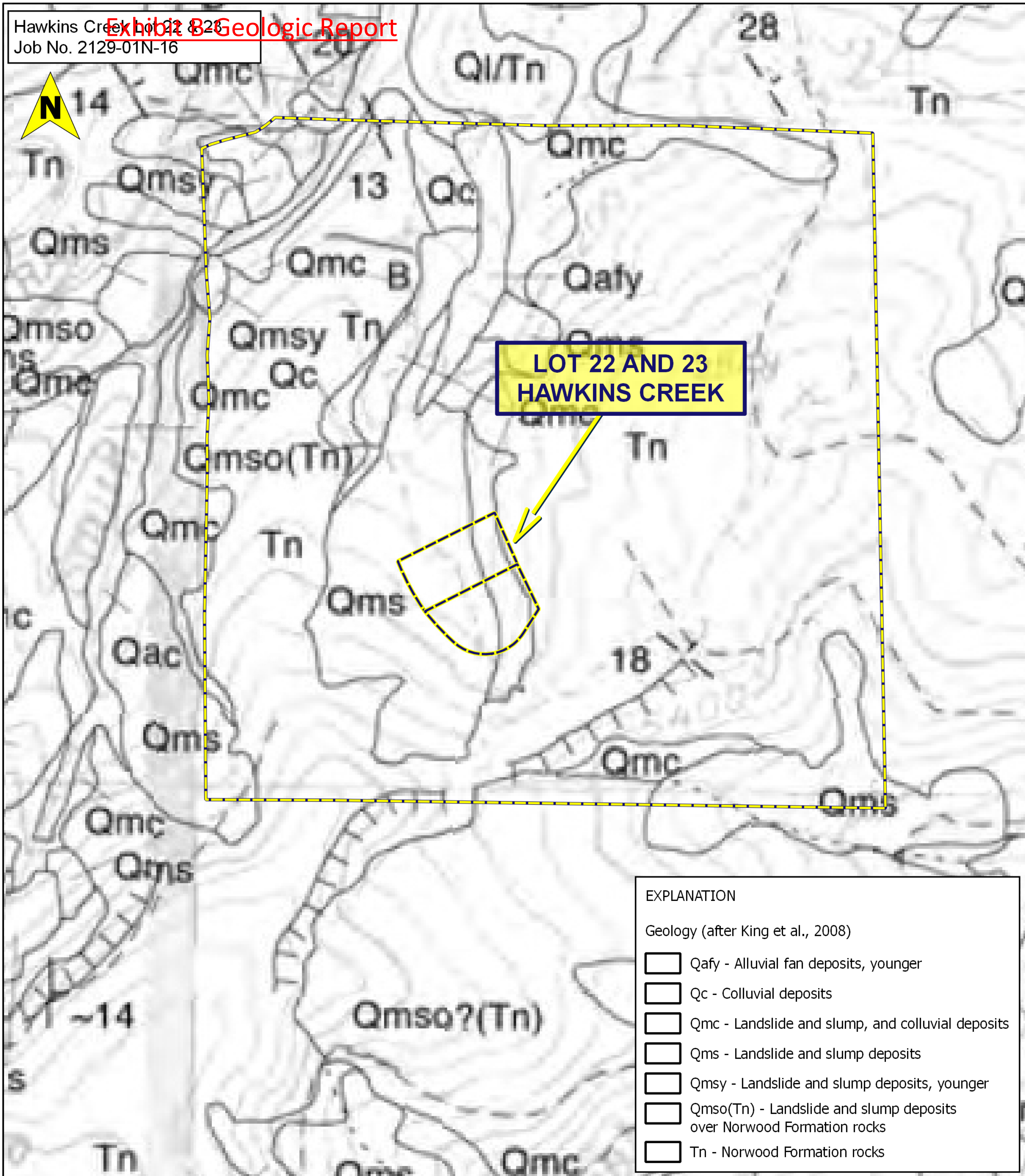
Base:
2012 0.5ft Color Orthoimagery
from Utah AGRC, http://gis.utah.gov/

0 500 1000 ft
1:6,000

FIGURE 2
AERIAL COVERAGE

GSH

Hawkins Creek Lot 22 & 23
Job No. 2129-01N-16



EXPLANATION

Geology (after King et al., 2008)

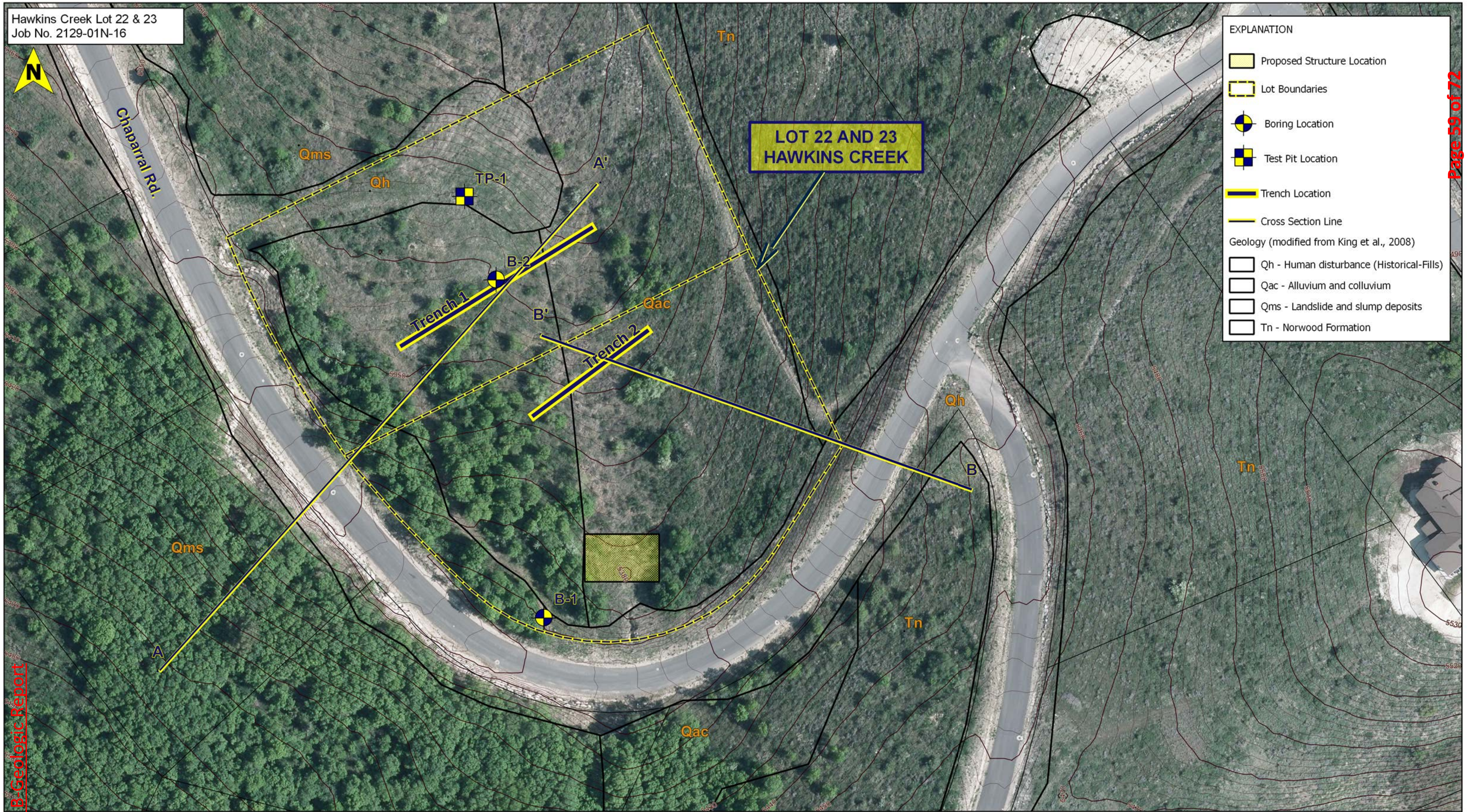
- Qafy - Alluvial fan deposits, younger
- Qc - Colluvial deposits
- Qmc - Landslide and slump, and colluvial deposits
- Qms - Landslide and slump deposits
- Qmsy - Landslide and slump deposits, younger
- Qmso(Tn) - Landslide and slump deposits over Norwood Formation rocks
- Tn - Norwood Formation rocks

Base:
King, J.K., Yonkee, W.A., and Coogan, J.C., 2008, Interim geologic map of the Snow Basin and part of the Huntsville quadrangle, Davis, Morgan, and Weber Counties, Utah: Utah Geological Survey Open-File Report 536, scale 1:24,000.

0 500 1000 ft
1:6,000

FIGURE 3
GEOLOGIC MAP

GSH



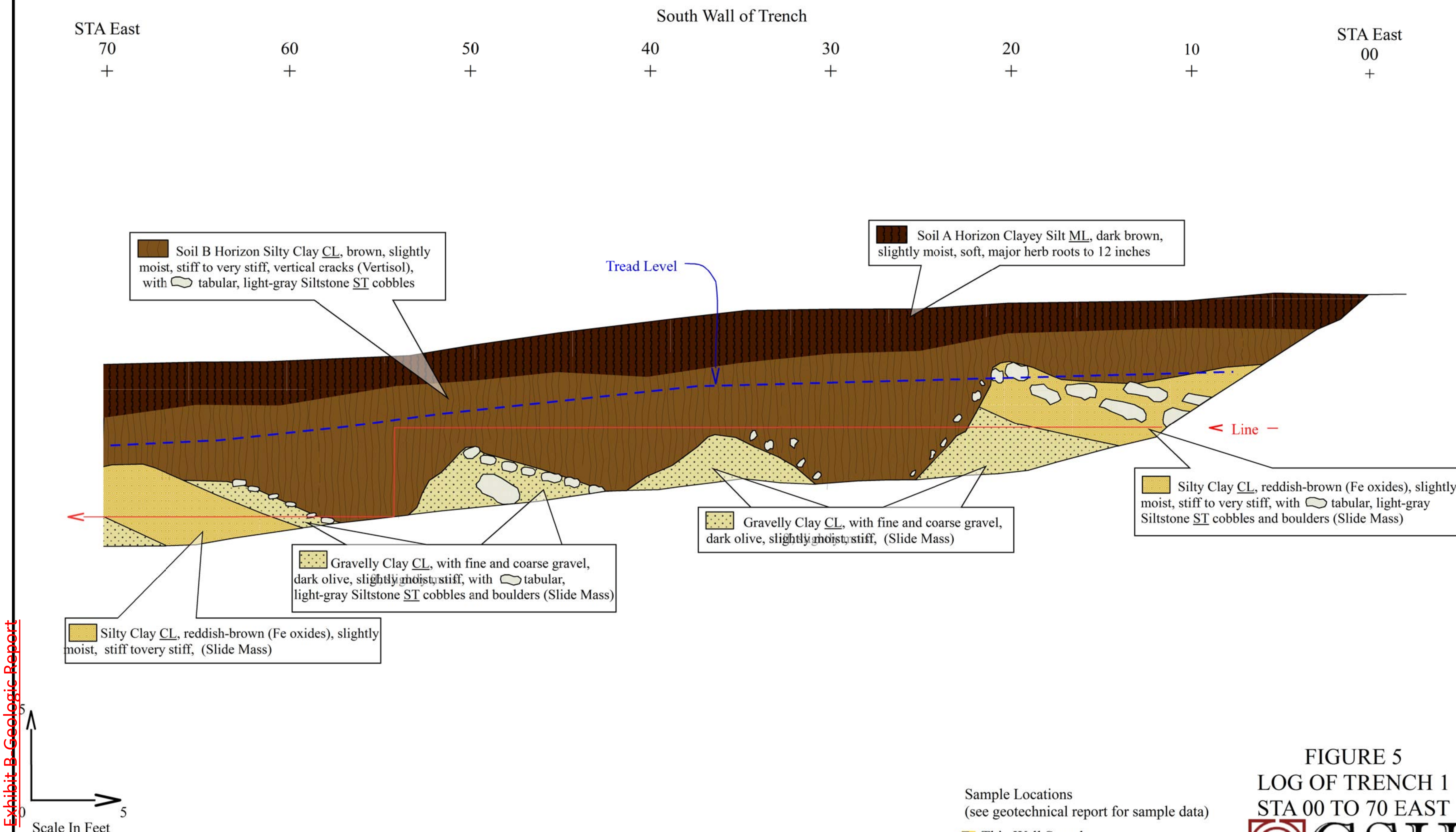
Base:
2012 0.5ft Color Orthoimagery
from Utah AGRC, http://gis.utah.gov/
Elevation:
2006 2.0m Geoprocessed LiDAR
from Utah AGRC, http://gis.utah.gov/

0 80 160 240 320 ft
1:960

FIGURE 4
SITE EVALUATION

GSH

Hawkins Creek Lot 22 & 23
Job No. 2129-01N-16



Sample Locations
(see geotechnical report for sample data)

TW Thin Wall Sample

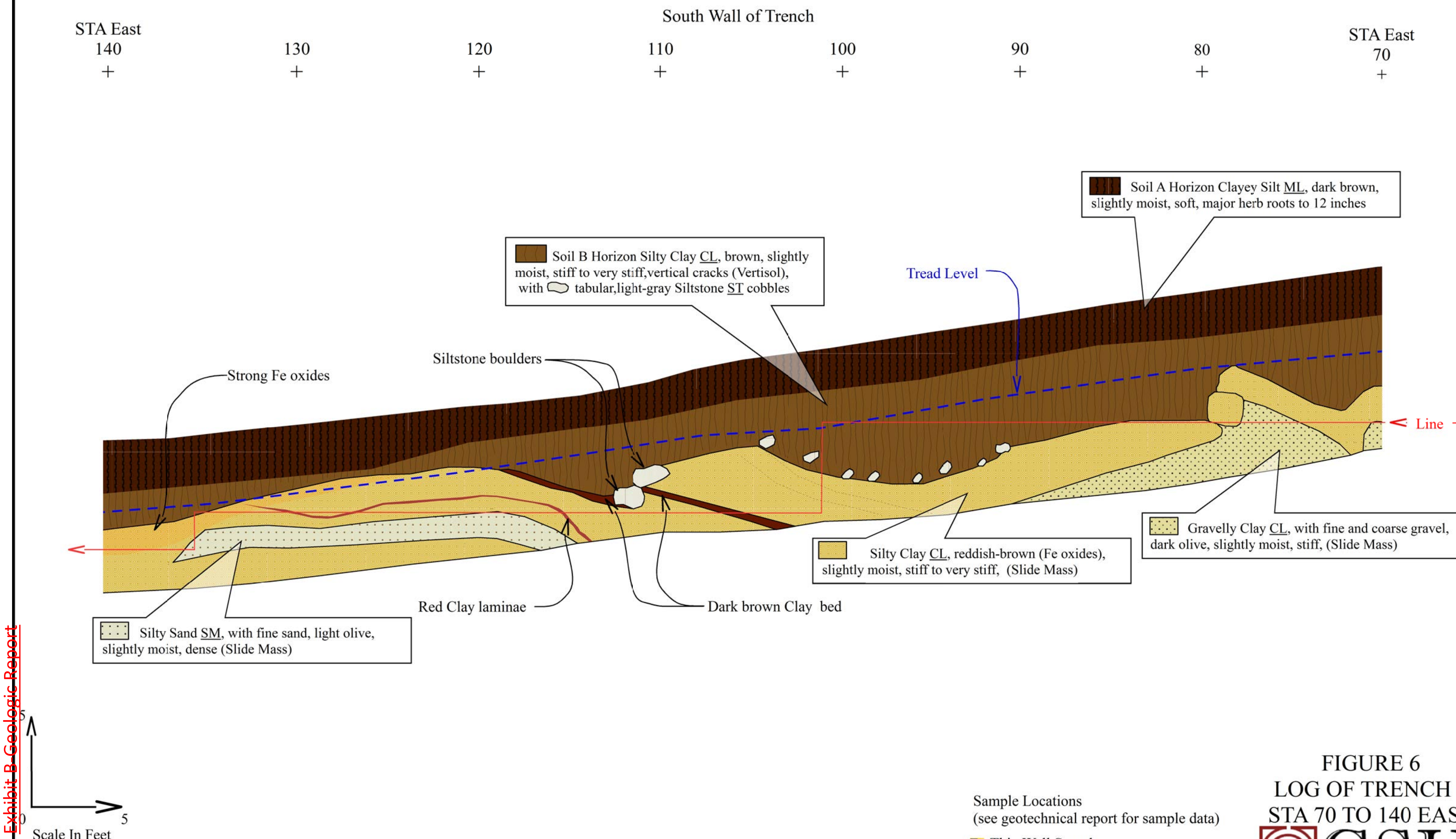
B Bulk Sample

FIGURE 5
LOG OF TRENCH 1
STA 00 TO 70 EAST

GSH

ANALYSIS BY: GCS | CHECKED BY AH | DATE 8/8/16

Hawkins Creek Lot 22 & 23
Job No. 2129-01N-16



Sample Locations
(see geotechnical report for sample data)

TW Thin Wall Sample

B Bulk Sample

FIGURE 6
LOG OF TRENCH 1
STA 70 TO 140 EAST

GSH

ANALYSIS BY: GCS | CHECKED BY AH | DATE 8/8/16

Hawkins Creek Lot 22 & 23
Job No. 2129-01N-16

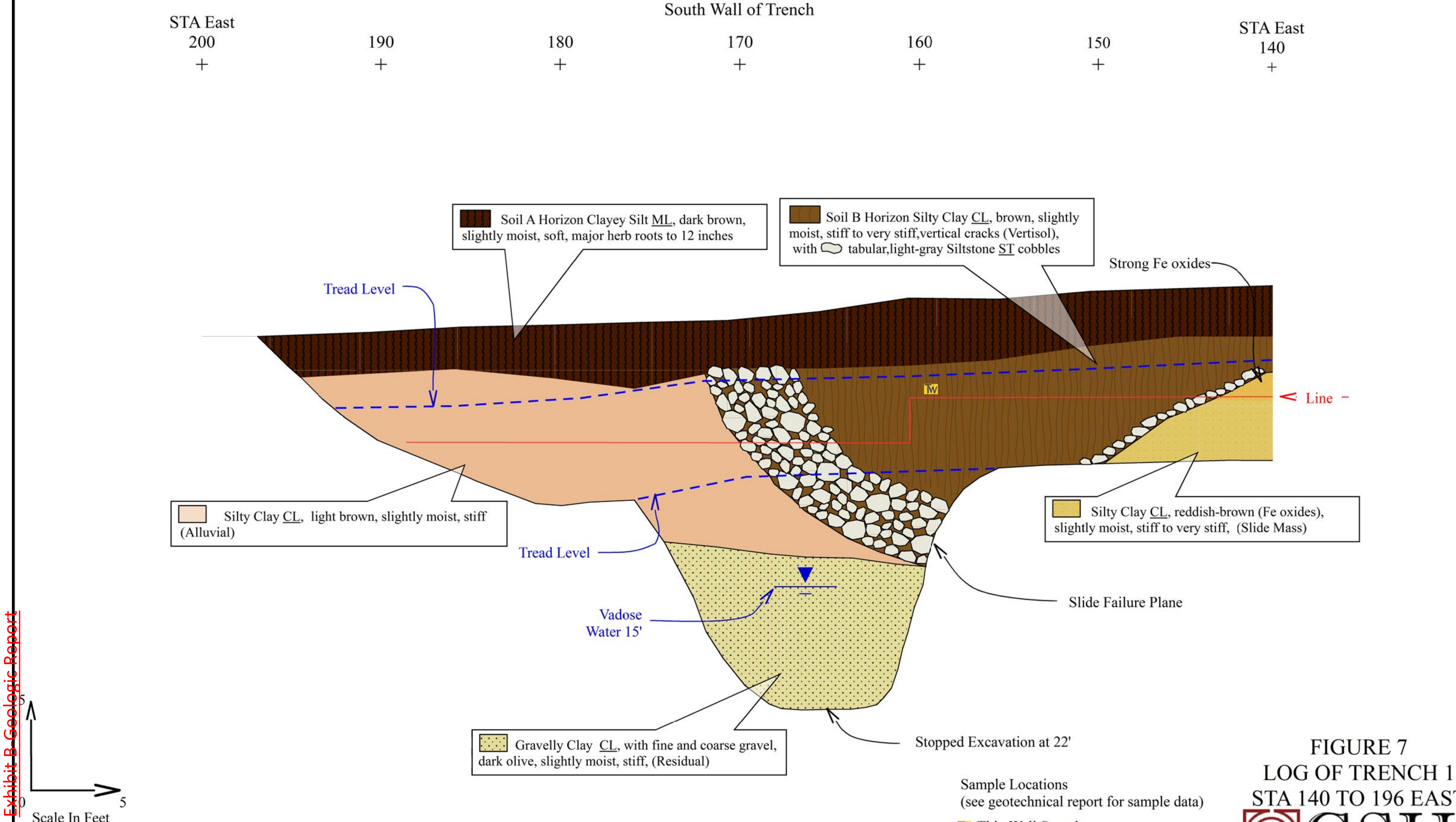


FIGURE 7
LOG OF TRENCH 1
STA 140 TO 196 EAST

GSH

ANALYSIS BY: GCS | CHECKED BY AH | DATE8/8/16

Hawkins Creek Lot 22 & 23
Job No. 2129-01N-16

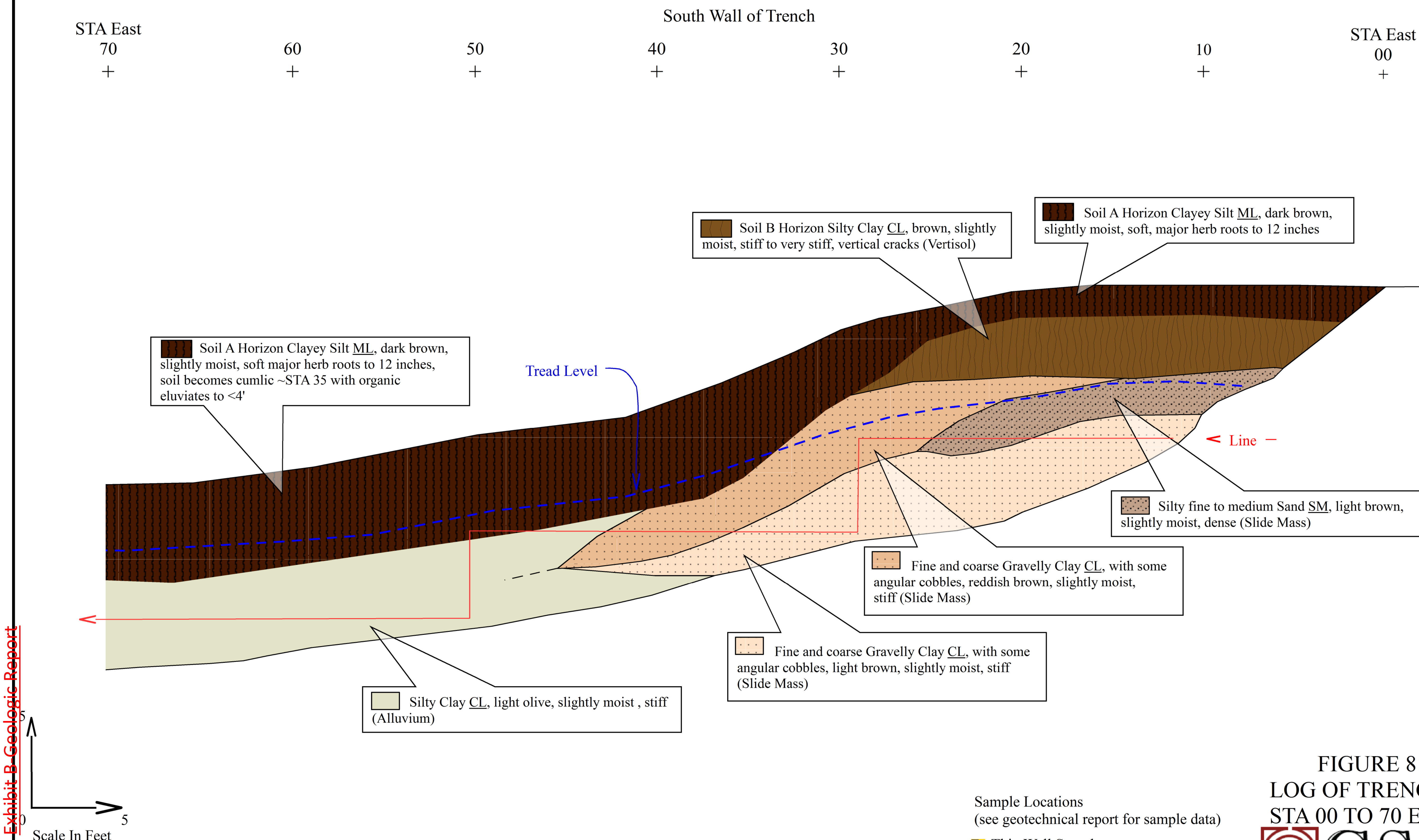


FIGURE 8
LOG OF TRENCH 2
STA 00 TO 70 EAST

GSH

ANALYSIS BY: GCS | CHECKED BY AH | DATE 8/8/16

Hawkins Creek Lot 22 & 23
Job No. 2129-01N-16

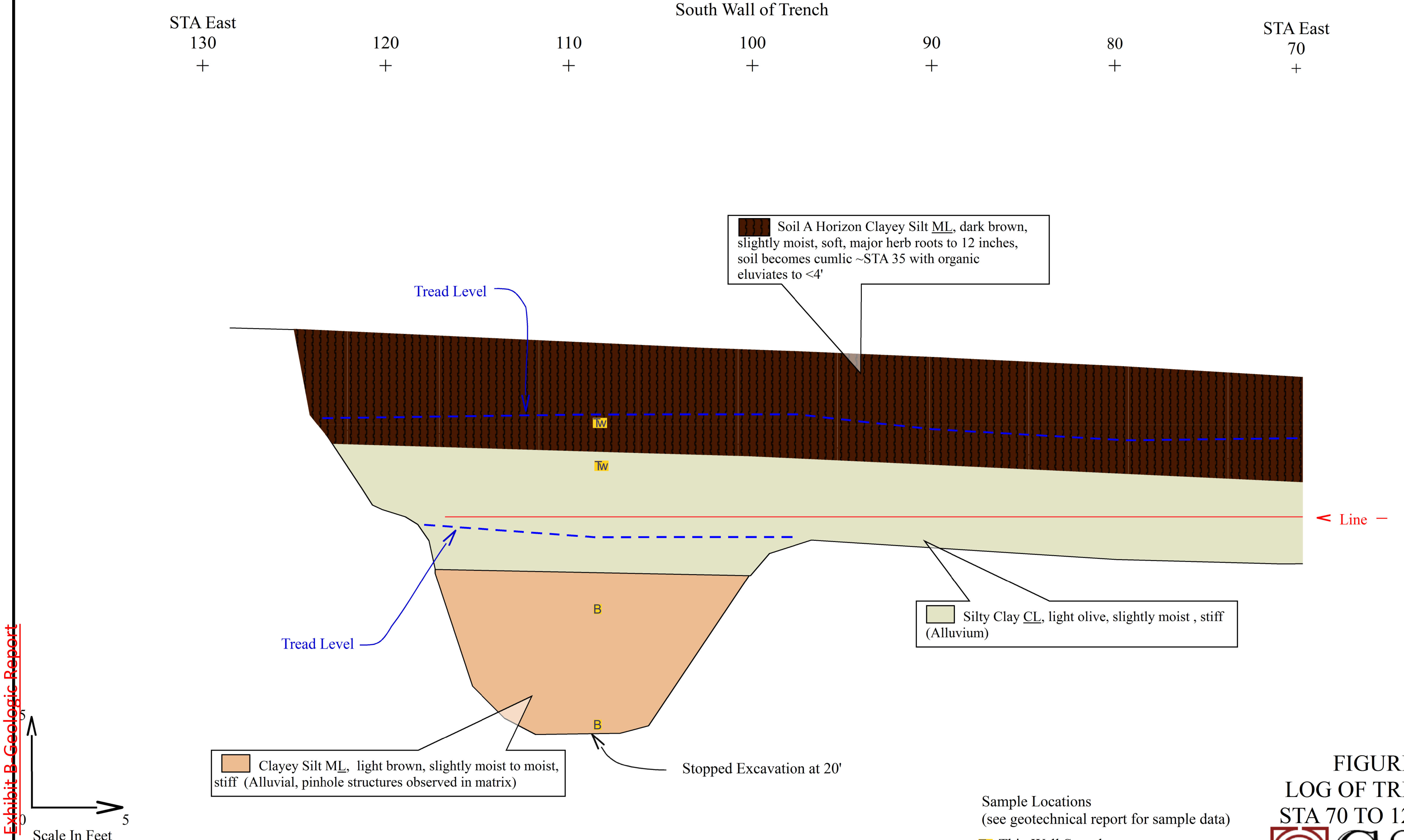


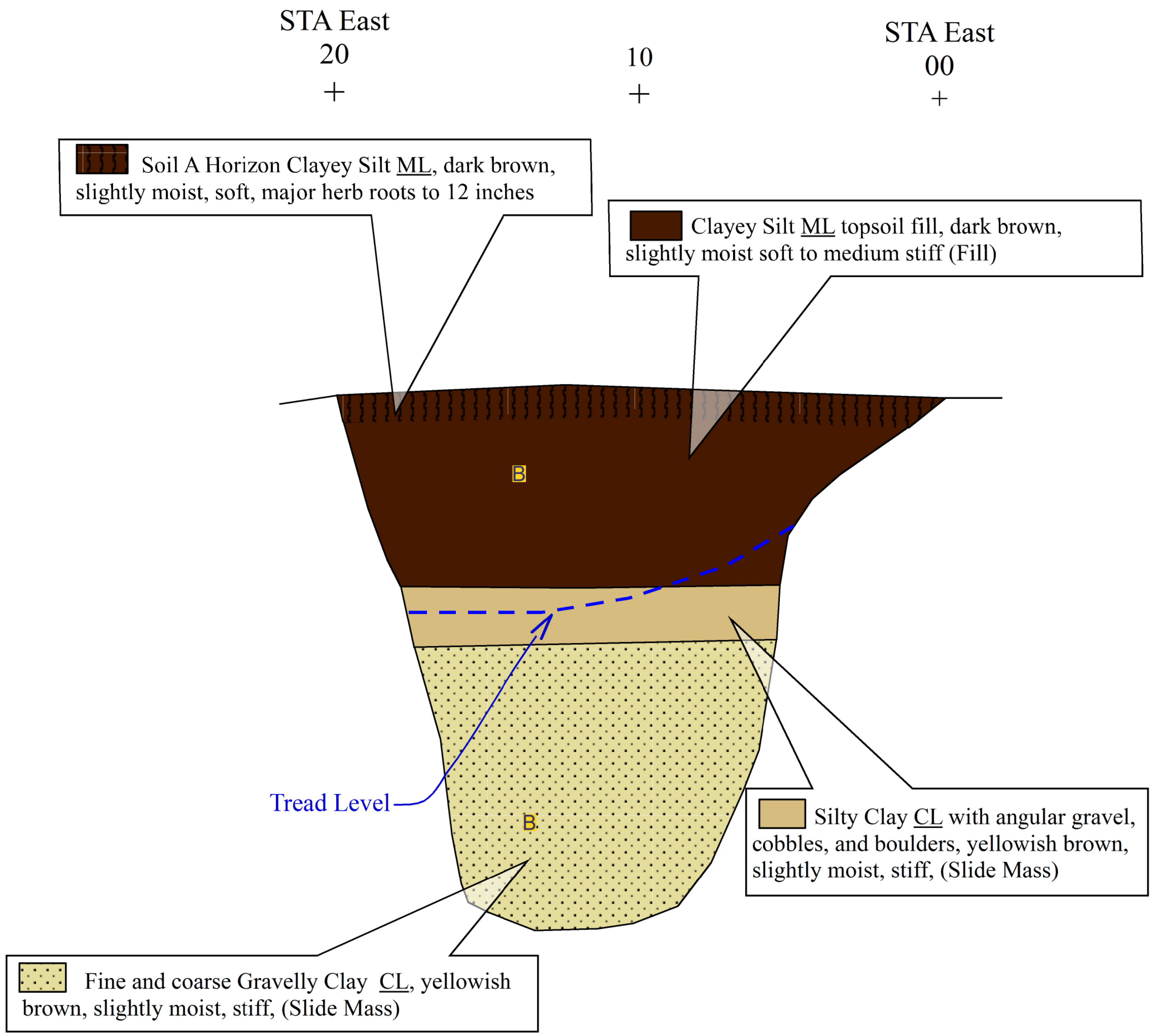
FIGURE 9
LOG OF TRENCH 2
STA 70 TO 125 EAST

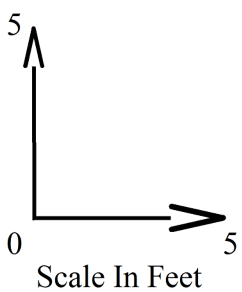
GSH

ANALYSIS BY: GCS | CHECKED BY AH | DATE 8/8/16

Hawkins Creek Lot 22 & 23
Job No. 2129-01N-16

South Wall of Test Pit





Sample Locations
(see geotechnical report for sample data)

TW Thin Wall Sample

B Bulk Sample

FIGURE 10
LOG OF TEST PIT 1

GSH

ANALYSIS BY: GCS | CHECKED BY AH | DATE8/8/16

GSH — BORING LOG — BORING: B-1

CLIENT: Victor Holtreman	PROJECT NUMBER: 2129-01N-16
PROJECT: Lots 22 and 23 The Legends at Hawkins Creek	DATE STARTED: 5/17/16 DATE FINISHED: 5/17/16
LOCATION: 6564 and 6585 East Chaparral Road, Near Eden, Weber County, Utah	GSH FIELD REP.: JM/AA
DRILLING METHOD/EQUIPMENT: 3-3/4" ID Hollow-Stem Auger	HAMMER: Automatic WEIGHT: 140 lbs DROP: 30"
GROUNDWATER DEPTH: Not Encountered (5/17/16), 20.2' (7/12/16)	ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface									
		GRADING FOR DRILL PAD	0								
			5								
	CL	SILTY CLAY with trace fine to coarse sand; siltstone fragments; brownish-gray	10	33							moist very stiff
				82		21	109				
			15	50+							
		grades claystone; reddish-brown									hard
				50+							
			20	80+							
	SP	FINE TO COARSE SAND with trace silt; gray		76		29	92		NP	NP	moist dense
	CH/MH	SILTY CLAY/CLAYEY SILT with trace fine sand; claystone; reddish-brown	25								moist hard

See Subsurface Conditions section in the report for additional information.

GSH

BORING LOG

Page: 2 of 2

BORING: B-1

CLIENT: Victor Holtreman

PROJECT NUMBER: 2129-01N-16

PROJECT: Lots 22 and 23 The Legends at Hawkins Creek

DATE STARTED: 5/17/16

DATE FINISHED: 5/17/16

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
			25	86+	X	29	86		54	20	
				50+	X						
	SP	FINE TO COARSE SAND with trace silt; sandstone; reddish-gray	30	76	X						moist dense
		End of Exploration at 31.5' No groundwater encountered at time of drilling Installed 1.25" diameter slotted PVC pipe to 30.0'	35								
			40								
			45								
			50								

See Subsurface Conditions section in the report for additional information.

FIGURE12

GSH BORING LOG

Page: 1 of 2

BORING: B-2

CLIENT: Victor Holtreman	PROJECT NUMBER: 2129-01N-16
PROJECT: Lots 22 and 23 The Legends at Hawkins Creek	DATE STARTED: 5/17/16 DATE FINISHED: 5/17/16
LOCATION: 6564 and 6585 East Chaparral Road, Near Eden, Weber County, Utah	GSH FIELD REP.: JM/AA
DRILLING METHOD/EQUIPMENT: 3-3/4" ID Hollow-Stem Auger	HAMMER: Automatic WEIGHT: 140 lbs DROP: 30"
GROUNDWATER DEPTH: Not Encountered (5/17/16), 21.7' (7/12/16)	ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0								
	CH/ MH	SILTY CLAY/CLAYEY SILT with some fine to coarse sand; some organics; dark brown									moist stiff
				12	X						
			5	32	X						
		siltstone fragments; light brown		86+	X						
			10	50+	X						
				46	X	35	83				
			15	31	X			56	66	13	
		reddish-brown		32	X						
	SP/ SM	FINE TO COARSE SAND with some silt; some clay; brown	20	54	X						dry dense
	SP	FINE TO COARSE SAND with trace silt; sandstone; grayish-white		53	X						dry dense
	MH/	CLAYEY SILT	25		X						

See Subsurface Conditions section in the report for additional information.

FIGURE 13

GSH

BORING LOG

Page: 2 of 2

BORING: B-2

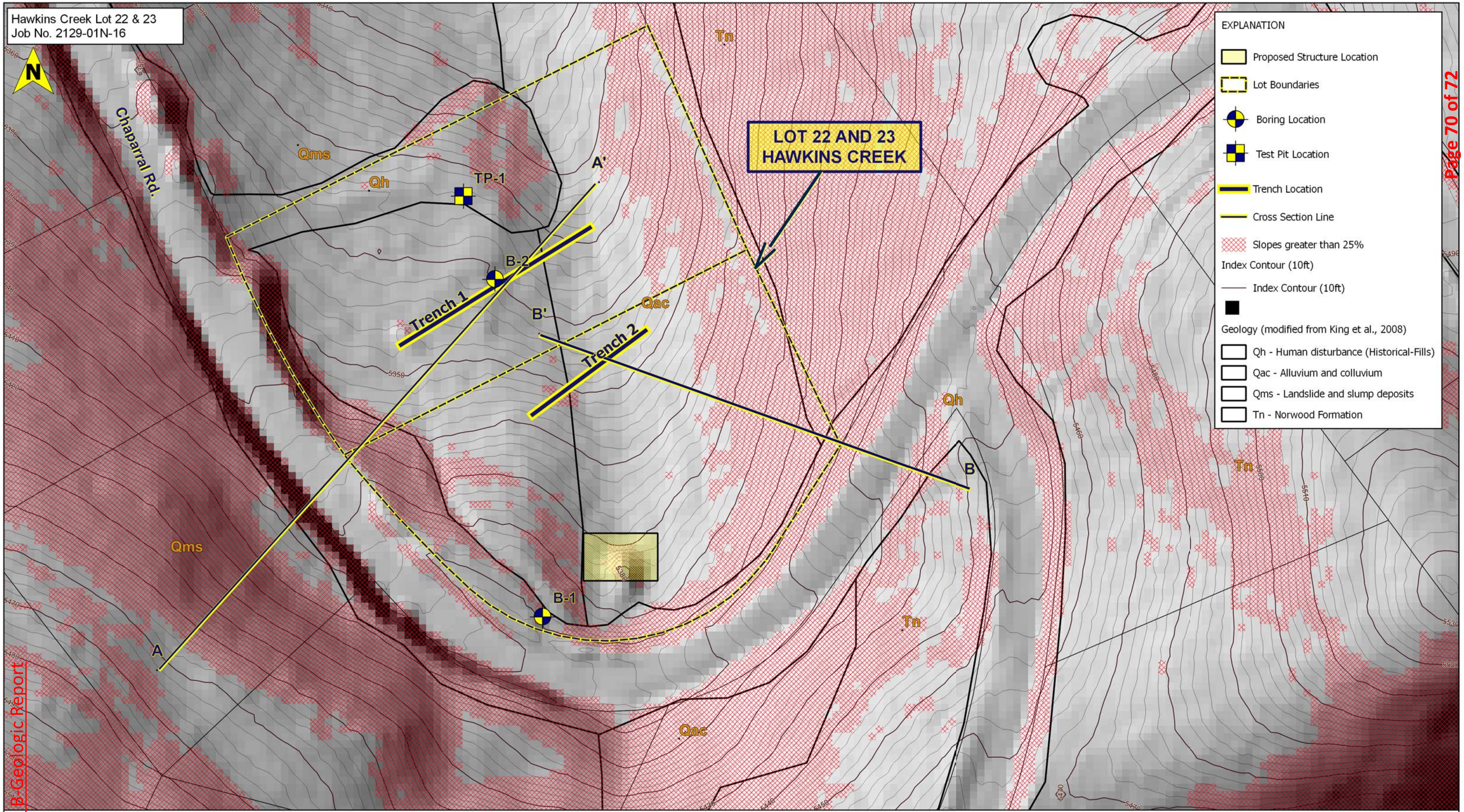
CLIENT: Victor Holtreman | PROJECT NUMBER: 2129-01N-16

PROJECT: Lots 22 and 23 The Legends at Hawkins Creek | DATE STARTED: 5/17/16 | DATE FINISHED: 5/17/16

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
	MH/ ML	CLAYEY SILT with some fine to coarse sand; siltstone fragments; gray	25	38							moist very stiff
				30		21	105		46	14	
			30	22		22	91	57	66	31	
				50+		24	93	64	71	35	hard
			35	50+							
				50+							
		End of Exploration at 39.0' No groundwater encountered at time of drilling Installed 1.25" diameter slotted pipe to 37.5'	40								
			45								
			50								

See Subsurface Conditions section in the report for additional information.

FIGURE 14



Terrain-Elevation:
2006 2.0m Geoprocessed LiDAR
from Utah AGRC, http://gis.utah.gov/

0 80 160 240 320 ft

1:960

FIGURE 15
LiDAR-SLOPE ANALYSIS

GSH

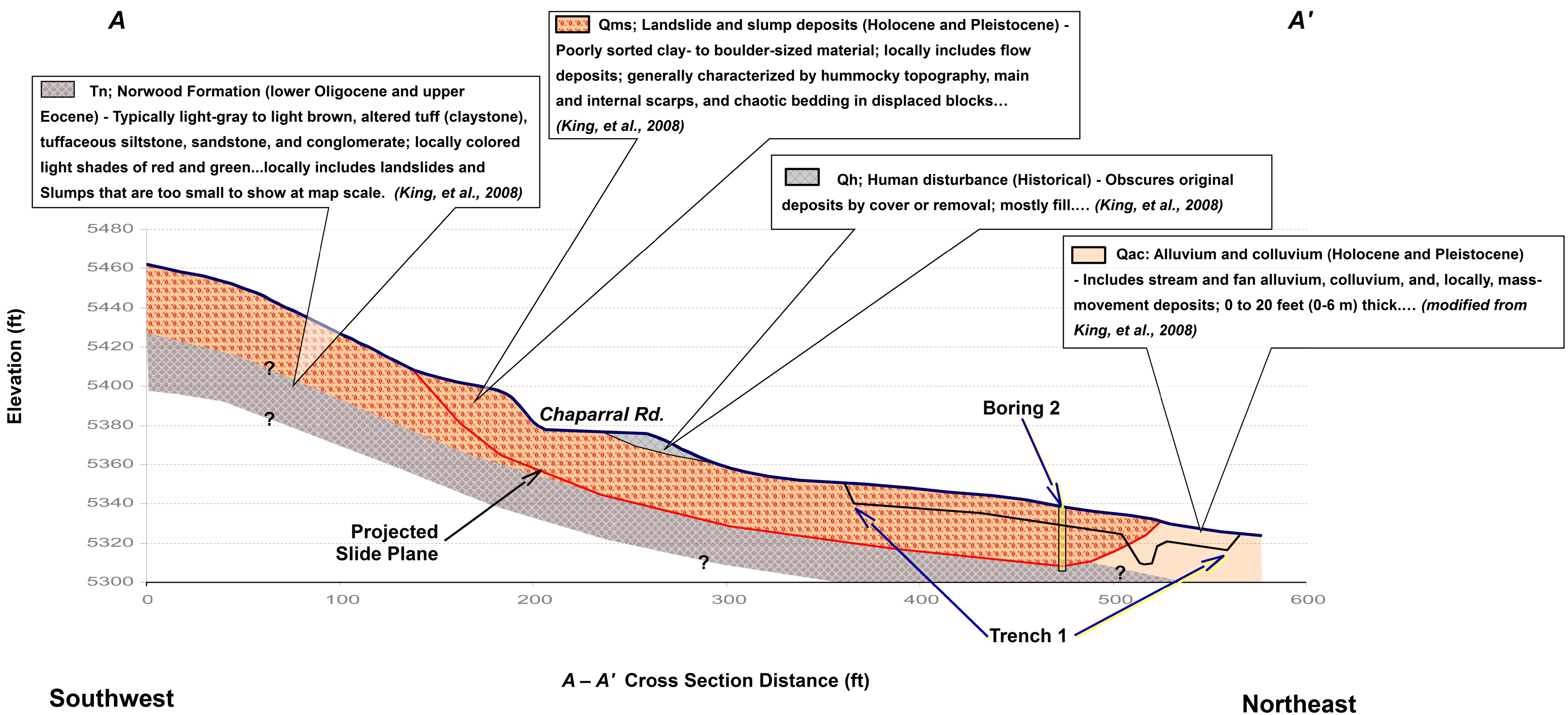


FIGURE 16
SLOPE CROSS
SECTION *A-A'*

GSH

* From Section Shown on Figure 4 and 15

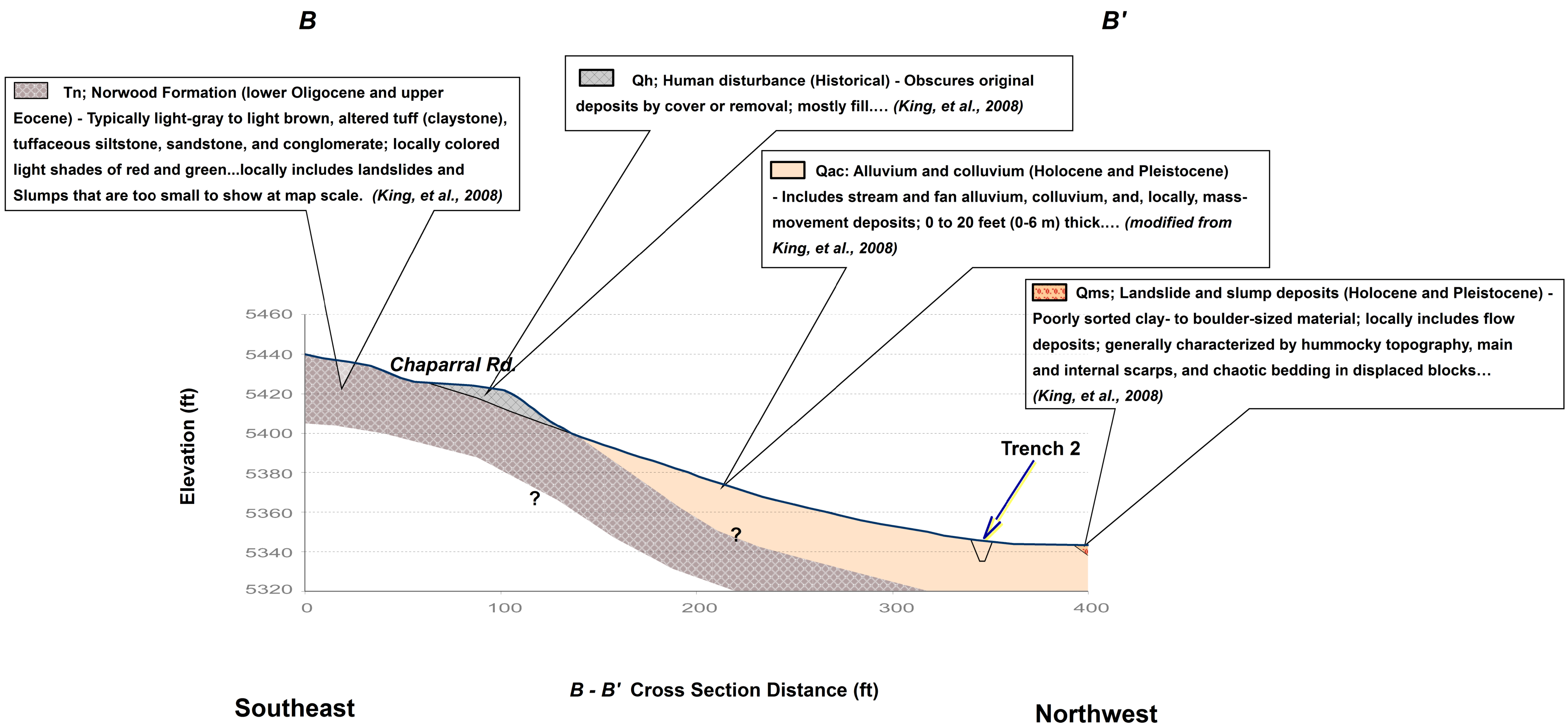


FIGURE 17
SLOPE CROSS
SECTION *B-B'*

GSH

* From Section Shown on Figure 4 and 15