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GEOTECHNICAL STUDY
LOT 19R SKI LAKE ESTATES NO. 4
6672 EAST 1100 SOUTH
HUNTSVILLE, UTAH

Project No. 11-1305G

December 28, 2011

Prepared For:

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1.0 EXECUTIVE SUMMARY

This report presents the results of our geotechnical study for the proposed single family residence on Lot 19R of the Ski Lake Estates No. 4 to be constructed at 6672 East 1100 South in Huntsville, Utah. We understand the proposed building, as currently planned, will consist of a one to two-story structure founded on spread footings with a full basement.

For the field exploration, we excavated a total of two test pits to depths of 10 to 11 feet below the existing ground surface. Groundwater was not encountered within the depths explored. The subsurface soils encountered generally consisted of topsoil overlying near-surface medium dense (estimated) sands, followed by stiff to very stiff (estimated) clay. The topsoil should be removed beneath the entire building footprint and beneath exterior flatwork and pavement areas.

Based on the results of our field exploration, laboratory testing and engineering analyses, it is our opinion that the subject site is suitable for the proposed development, provided the recommendations presented herein are followed and implemented during design and construction. Conventional strip and spread footings may be used to support the structure, with foundations placed entirely on native soils or entirely on properly placed and compacted structural fill.

This executive summary provides a general synopsis of our recommendations. Details of our findings, conclusions, and recommendations are provided within the body of this report. Failure to consult with Earthtec regarding any changes made during design and/or construction of the project from those discussed above in Section 3.0 relieves Earthtec from any liability arising from changed conditions at the site. We also strongly recommend that Earthtec observe the building excavations to verify the adequacy of our recommendations presented herein, and that Earthtec perform materials testing and special inspections for this project to provide consistency during construction.

2.0 INTRODUCTION

This report presents the results of our geotechnical study for the proposed single-family residence constructed on Lot 19R of the Ski Lake Estates No. 4 to be located at 6672 East 1100 South in Huntsville, Utah. The general location of the site is shown on Figure 1, Vicinity Map, at the end of this report.

The purposes of this study were to

- Evaluate the subsurface soil conditions at the site,
- Assess the engineering characteristics of the subsurface soils, and
- Provide geotechnical recommendations for general site grading and the design and construction of foundations, concrete floor slabs, and miscellaneous concrete flatwork.

The scope of work completed for this study included field reconnaissance, subsurface exploration, field and laboratory soil testing, geotechnical engineering analysis, and the preparation of this report.

3.0 PROPOSED CONSTRUCTION

We understand that a single-family residence will be constructed at the 1.1 acre site. We understand that the proposed home will be conventionally framed, one to two stories in height. The home will likely be founded on spread footings with a full basement. We have based our recommendations in this report on the assumption that foundation loads for the proposed home will not exceed 3,000 pounds per linear foot for bearing walls, 25,000 pounds for column loads, and 100 pounds per square foot for floor slabs. If structural loads will be greater our office should be notified so that we may review our recommendations and, if necessary, make modifications.

In addition to the construction described above, we anticipate that utilities will be installed to service the proposed residence, and that exterior concrete flatwork will be placed in the form of walkways and a driveway.

4.0 GENERAL SITE DESCRIPTION

At the time of our subsurface investigation, the subject property consisted of an undeveloped lot that was heavily vegetated with native grasses, weeds, and underbrush. The subject property slopes downward to the north at an approximate 30 percent grade. There is an approximate change in elevation of 90 feet across the property. The subject site is bounded on the north and west by undeveloped land, on the east by a residential construction, and on the south by 1100 South.

5.0 SUBSURFACE EXPLORATION

Under the direction of a qualified member of our geotechnical staff, subsurface explorations were conducted at the site on November 7, 2011 by excavating two exploratory test pits to depths of about 10 to 11 feet below the existing ground surface using a track-mounted excavator. The approximate locations of the test pits are shown on Figure 2, *Site Plan and Location of Test Pits*. Graphical representations and detailed descriptions of the soils encountered are shown on Figures 3 through 4, *Test Pit Log* at the end of this report. The stratification lines shown on the logs represent the approximate boundary between soil units; the actual transition may be gradual. Due to potential natural variations inherent in soil deposits, care should be taken in interpolating between and extrapolating beyond exploration points. A key to the symbols and terms on the logs is presented on Figure 5, *Legend*.

The subsurface soils exposed in the test pits were classified by visual examination using the guidelines of the Unified Soil Classification System (USCS). Disturbed bag samples and relatively undisturbed thin-walled "Shelby" tube samples and block samples were collected at various depths in each test pit. Samples were transported to our Ogden, Utah laboratory for further analysis. Samples will be retained in our laboratory for 30 days following the date of this report and then discarded unless a written request for additional holding time is received prior to the disposal date.

6.0 LABORATORY TESTING

Representative soil samples collected during our field exploration were tested in the laboratory to assess pertinent engineering properties and to aid in refining field classifications, if needed. Tests performed included natural moisture content and dry density tests, liquid and plastic limits determinations, mechanical (partial) gradation analyses, one-dimensional consolidation tests, and a direct shear test. The following table summarizes the laboratory test results, which are also included on the attached test pit logs at the respective sample depths, on Figure Nos. 6 and 7, *Consolidation-Swell Test,* and on Figure No. 8, *Direct Shear Test.*

Table 1: Laboratory Test Results

Test Hole No.	Depth (ft.)	Natural Moisture (%)	Natural Dry Density (pcf)	Atterberg Limits		Grain Size Distribution (%)			*Soil Type
				Liquid Limit	Plasticity Index	Gravel (+ #4)	Sand	Silt/Clay (- #200)	
TP-1	4	12	81	38	8	0	55	45	SM
TP-1	10½	34	56	54	28	0	46	54	CH
TP-2	6½	24	88	41	21	0	22	78	CL
TP-2	9	30	---	37	12	1	42	57	CL

*Detailed descriptions of the soils encountered are presented on the test pit logs

As part of the consolidation test procedure, water was added to the samples to assess moisture sensitivity when the samples were loaded to an equivalent pressure of approximately 1,000 psf. This part of the consolidation test indicated a negligible potential (less than ¼ percent) for collapse (settlement) under increased moisture and load conditions.

7.0 SUBSURFACE CONDITIONS

7.1 Soil Types

On the surface of the site, we encountered topsoil which we estimated to extend about 1½ to 5 feet in depth at the test pit locations. Below the topsoil we encountered silty sand (SM), sandy fat clay (CH), lean clay with sand (CL), and sandy lean clay (CL) extending to the maximum depth explored of about 10 to 11 feet below the existing ground surface. Based on our experience and observations during field exploration, the sandy soils visually appeared to be medium dense in consistency and the clay soils visually ranged from stiff to very stiff in consistency. Consolidation test results indicate the clay soils are moderately compressible and have a low potential for moisture-related collapse (settlement).

7.2 Groundwater Conditions

Groundwater was not encountered in any of the test pit locations. Groundwater levels will fluctuate in response to the season, precipitation and snow melt, irrigation, and other on and off-site influences. Precisely quantifying these fluctuations would require long term monitoring. The contractor should be prepared to dewater excavations as needed.

8.0 SITE GRADING

8.1 General Site Grading

Unsuitable soils and vegetation should be removed from below foundation, floor slab, and exterior concrete flatwork areas. Unsuitable soils consist of topsoil, organic soils, undocumented fill, soft, loose, or disturbed native soils, and any other inept materials. We encountered topsoil materials on the surface extending from 1½ to 5 feet in depth at the test pit locations. The topsoil (including soil with roots larger than about ¼ inch in diameter) should be completely removed beneath all structures, concrete flatwork, and pavement, even if found to extend deeper, along with any other unsuitable soils that may be encountered.

Fill placed over large areas, even if only a few feet in depth, can cause consolidation in the underlying native soils resulting in settlement of the fill. If additional grading fill will be placed above the existing surface (to raise site grades), Earthtec should be notified so that we may assess potential settlement and make additional recommendations if needed. Such recommendations may include placing the fill several weeks prior to construction to allow settlement to occur.

8.2 Temporary Excavations

For temporary excavations less than 5 feet in depth into the native soils or into structural fill, slopes should not be made steeper than ½H:1V (Horizontal:Vertical). Temporary excavations extending up to 10 feet in depth should not be made steeper than 1H:1V. If unstable conditions or groundwater seepage are encountered, flatter slopes, shoring, or bracing may be required. All excavations should be conducted in accordance with all applicable OSHA requirements.

8.3 Fill Material Composition

The native soils encountered at the site are not suitable for use as structural fill. Excavated soils, including clays and sands, may be stockpiled for use as fill in landscape areas. We recommend that a professional engineer or geologist verify that the structural fill to be used on this project meets our requirements, given below.

Structural fill is defined as fill material that will ultimately be subjected to any kind of structural loading, such as those imposed by footings, floor slabs, pavement, etc. We recommend that structural fill consist of imported sandy/gravelly soils meeting the following requirements:

Table 2: Structural Fill Recommendations

Sieve Size/Other	Percent Passing (by weight)
4 inches	100
3/4 inches	70 – 100
No. 4	40 – 80
No. 40	15 – 50
No. 200	0 – 15
Liquid Limit	35 maximum
Plasticity Index	15 maximum

In some situations, particles larger than 4 inches and/or more than 30 percent coarse gravel may be acceptable, but would likely make compaction more difficult and/or significantly reduce the possibility of successful compaction testing. Consequently, more strict quality control measures than normally used may be required, such as using thinner lifts and increased or full time observation of fill placement.

We recommend that utility trenches below any structural load be backfilled using structural fill. Note that most local governments and utility companies require Type A-1-a or A-1-b (AASHTO classification) soils (which overall is stricter than our recommendation for structural fill) be used as backfill above utilities in certain areas. In other areas or situations, utility trenches may be backfilled with the native soil, but the contractor should be aware that native clayey soils (as observed in the explorations) may be time consuming to compact due to potential difficulties in controlling the moisture content needed to obtain optimum compaction. All backfill soil should have a maximum particle size of 4 inches, a maximum Liquid Limit of 35 and a maximum Plasticity Index of 15.

Where needed (submerged areas), we recommend that free draining granular material (clean sand and/or gravel) meet the following requirements:

Table 3: Free-Draining Fill Recommendations

Sieve Size/Other	Percent Passing (by weight)
3 inches	100
No. 10	0 – 25
No. 40	0 – 15
No. 200	0 – 5
Plasticity Index	Non-plastic

Three inch minus washed rock (sometimes called river rock or drain rock) and pea gravel materials usually meet these requirements and may be used as free draining fill. If free draining fill will be placed adjacent to soil containing a significant amount of sand or silt/clay, precautions should be taken to prevent the migration of fine soil into the free draining fill. Such precautions should include either placing a filter fabric between the free draining fill and the adjacent material, or using a well graded, clean filtering material approved by the geotechnical engineer.

8.4 Fill Placement and Compaction

Fill should be placed on level, horizontal surfaces. Where fill will be placed on existing slopes steeper than 5H:1V, the existing ground should be benched prior to placing fill. We recommend bench heights of 1 to 4 feet, with the lowest bench being a minimum 3 feet below adjacent grade and at least 10 feet wide.

The thickness of each lift should be appropriate for the compaction equipment that is used. We recommend a maximum lift thickness of 4 inches for hand operated equipment, 6 inches for most "trench compactors", and 8 inches for larger rollers, unless it can be demonstrated by in-place density tests that the required compaction can be obtained throughout a thicker lift. The full thickness of each lift of structural fill placed should be compacted to at least the following percentages of the maximum dry density, as determined by ASTM D-1557:

In landscape areas not supporting structural loads:	90%
Less than 5 feet of fill below foundations, flatwork and pavements:	95%
Five or more feet of fill below foundations, flatwork and pavements:	98%

Generally, placing and compacting fill at a moisture content within 2% of the optimum moisture content, as determined by ASTM D-1557, will facilitate compaction. Typically, the further the moisture content is from optimum the more difficult it will be to achieve the required compaction.

Fill should be tested frequently during placement and early testing is recommended to demonstrate that placement and compaction methods are achieving the required compaction. It is the contractor's responsibility to ensure that fill materials and compaction efforts are consistent so that tested areas are representative of the entire fill.

8.5 Stabilization Recommendations

Near surface layers of clay were encountered during our field exploration. These soils may rut and pump during grading and construction. The likelihood of rutting and/or pumping, and the depth of disturbance, is proportional to the moisture content in the soil, the load applied to the ground surface, and the frequency of the load. Consequently, rutting and pumping can be minimized by avoiding concentrated traffic, minimizing the load applied to the ground surface by using lighter equipment and/or partial loads, by working in dry times of the year, or by providing a working surface for equipment.

During grading the soil in any obvious soft spots should be removed and replaced with granular material. If rutting or pumping occurs traffic should be stopped in the area of concern. The soil in rutted areas should be removed and replaced with granular material. In areas where pumping occurs the soil should either be allowed to sit until pore pressures dissipate (several hours to several days) and the soil firms up, or be removed and replaced with granular material. Typically, we recommend removal to a minimum depth of 24 inches.

For granular material, we recommend using angular well-graded gravel, such as pit run, or crushed rock with a maximum particle size of four inches. We suggest that the initial lift be approximately 12 inches thick and be compacted with a static roller-type compactor. A finer granular material such as sand, gravelly sand, sandy gravel or road base may also be used. The more angular and coarse the material, the thinner the lift that will be required. We recommend that the fines content (percent passing the No. 200 sieve) be less than 15%, the liquid limit be less than 35, and the plasticity index be less than 15.

Using a geosynthetic fabric, such as Mirafi 600X or equivalent, may also reduce the amount of material required and avoid mixing of the granular material and the subgrade. If a fabric is used, following removal of disturbed soils and water, the fabric should be placed over the bottom and up the sides of the excavation a minimum of 24 inches. The fabric should be placed in accordance with the manufacturer's recommendations, including proper overlaps. The granular material should then be placed over the fabric in compacted lifts. Again, we suggest that the initial lift be approximately 12 inches thick and be compacted with a static roller-type compactor.

9.0 SLOPE STABILITY

We evaluated the overall stability of the existing slope. The properties of the clayey soils at the site were determined using direct shear testing, which indicated the clay soils have an internal friction angle of 30 degrees and an apparent cohesion of 200 psf. Accordingly, we used an internal friction angle of 30 degrees, an apparent cohesion of 200 psf and a unit weight of 120 pcf.

For the seismic (pseudostatic) analysis, a peak horizontal ground acceleration of 0.18g for the 10% probability of exceedance in 50 years was obtained for site (grid) locations of 42.241 degrees north latitude and -111.804 degrees west longitude. Accordingly, a value of 0.18 was used as the pseudostatic coefficient for the stability analysis. We also evaluated the global stability of the site using the computer program XSTABL. This program uses a limit equilibrium (Bishop's modified) 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. The configuration analyzed consisted of a 90-foot high slope inclined at approximately 3.5H:1V (Horizontal:Vertical). 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 slope meets both these requirements. The slope stability data are attached as Figures 9 and 10. Any modifications to the slope, including the construction of retaining walls, should be properly designed and engineered.

10.0 SEISMIC CONSIDERATIONS

10.1 Seismic Design

The residential structures should be designed in accordance with the International Residential Code (IRC). The IRC designates this area as a seismic design class D_1.

The site is located at approximately 41.247 degrees latitude and -111.787 degrees longitude. The IRC site value for this property is 0.70g. The design spectral response acceleration parameters are given below in Table 4.

Table No. 4: Design Acceleration for Short Period

S_S	F_a	Site Value (S_{DS})
		2/3 S_S*F_a
0.94g	1.12	0.70g

S_S = Mapped spectral acceleration for short periods
F_a = Site coefficient from Table 1613.5.3(1)
S_{DS} = ⅔S_{MS}= ⅔ (F_a·S_s) = 5% damped design spectral response acceleration for short periods

10.2 Faulting

Based upon published geologic maps, no active faults traverse through or immediately adjacent to the site and the site is not located within local fault study zones. The nearest mapped fault trace is the Ogden Valley Southwestern Margin Fault located about 1.70 miles (2.74 kilometers) southwest of the site.

10.3 Liquefaction Potential

Liquefaction is a phenomenon where soils lose their intergranular strength due to an increase of pore pressures during a dynamic event such as an earthquake. The potential for liquefaction is based on several factors, including 1) the grain size distribution of the soil, 2) the plasticity of the fine fraction of the soil (material passing the No. 200 sieve), 3) relative density of the soil, 4) earthquake strength (magnitude) and duration, and 5) overburden pressures. In addition, the soils must be near saturation for liquefaction to occur. Liquefaction can occur when saturated subsurface soils below groundwater lose their intergranular strength due to an increase in soil pore water pressures during a dynamic event such as an earthquake.

Loose, saturated sands are most susceptible to liquefaction, but some loose, saturated gravels and relatively sensitive silt to low-plasticity silty clay soils can also liquefy during a seismic event. Subsurface soils were composed of unsaturated sands and clays. The soils encountered are typically not liquefiable, but the liquefaction susceptibility of underlying soils (deeper than our explorations) is not known and would require deeper explorations to quantify.

11.0 FOUNDATIONS

11.1 General

The foundation recommendations presented in this report are based on the soil conditions encountered during our field exploration, the results of laboratory testing of samples of the native soils, the site grading recommendations presented in this report, and the foundation loading conditions presented in Section 3.0, *Proposed Construction*, of this report. If loading conditions are significantly different, Earthtec should be notified so that we can re-evaluate our design parameters and estimates (higher loads may cause more settlement), and to provide additional recommendations if necessary.

Conventional strip and spread footings may be used to support the proposed residences after appropriate removals as outlined in Section 8.1. Foundations should not be installed on topsoil, undocumented fill, debris, combination soils, organic soils, frozen soil, or in ponded water. If foundation soils become disturbed during construction they should be removed or recompacted.

11.2 Strip/Spread Footings

We recommend that conventional strip and spread foundations be constructed entirely on firm, undisturbed, uniform soils (i.e. completely on clay soils or completely on silty sand soils), or entirely on a minimum 24 inches of structural fill placed on undisturbed native soils. For foundation design we recommend the following:

- Footings founded entirely on native clay soils or entirely on the native sand soils may be designed using a maximum allowable bearing capacity of 1,500 pounds per square foot. Footings founded on a minimum 24 inches of structural fill may be designed using a maximum allowable bearing capacity of 2,000 pounds per square foot. These bearing pressures may be increased by 33 percent for transient loadings.

- Continuous and spot footings should be uniformly loaded and should have a minimum width of 20 and 30 inches, respectively.

- Exterior footings should be placed below frost depth which is determined by local building codes. Generally 30 inches of cover is adequate for this site. Interior footings, not subject to frost, should extend at least 18 inches below the lowest adjacent grade.

- Foundation walls on continuous footings should be well reinforced. We suggest a minimum amount of steel equivalent to that required for a simply supported span of 12 feet.

- The bottom of footing excavations should be compacted with at least 4 passes of an approved non-vibratory roller prior to erection of forms or placement of structural fill to densify soils that may have been loosened during excavation and to identify soft spots. If soft areas are encountered, they should be allowed to firm up or be stabilized as recommended in Section 8.5.

- Footing excavations should be observed by the geotechnical engineer prior to beginning footing construction to evaluate whether suitable bearing soils have been exposed and whether excavation bottoms are free of loose or disturbed soils.

- Structural fill used below foundations should extend laterally a minimum of 6 inches for every 12 vertical inches of structural fill placed. For example, if 24 inches of structural fill are required to bring the excavation to footing grade, the structural fill should extend laterally a minimum of 12 inches beyond the edge of the footings on both sides.

11.3 Estimated Settlements

If the proposed foundations are properly designed and constructed using the parameters provided above, we estimate that total settlements will not exceed one inch and differential settlements will be one-half of the total settlement over a 25-foot length of foundation, for non-earthquake conditions. Additional settlement could occur during an earthquake due to ground shaking, if any additional grading fill is placed above the existing ground surface, and/or if foundation soils are allowed to become wetted.

11.4 Lateral Earth Pressures

Below grade walls act as soil retaining structures and should be designed to resist pressures induced by the backfill soils. The lateral pressures imposed on a retaining structure are dependant on the rigidity of the structure and its ability to resist rotation. Most retaining walls that can rotate or move slightly will develop an active lateral earth pressure condition. Structures that are not allowed to rotate or move laterally, such as subgrade basement walls, will develop an at-rest lateral earth pressure condition. Lateral pressures applied to structures may be computed by multiplying the vertical depth of backfill material by the appropriate equivalent fluid density. Any surcharge loads in excess of the soil weight applied to the backfill should be multiplied by the appropriate lateral pressure coefficient and added to the soil pressure. For either static or seismic conditions the resultant forces occur at about 1/3 the height of the wall, measured from the bottom of the wall. The lateral pressures presented in the table below are based on drained, horizontally placed structural fill (as outlined in this report) soils as backfill material using a 28° friction angle and a dry unit weight of 120 pcf.

Table 5: Lateral Earth Pressures

Condition	Lateral Pressure Coefficient	Equivalent Fluid Pressure (pcf)*
Active	0.36 0.47	43 (Static) 56 (Seismic)
At-Rest (Rankine)	0..53 0.69	64 (Static) 83 (Seismic)
Passive (Rankine)	2.77 3.64	332 (Static) 437 (Seismic)

*Seismic values combine the static and dynamic values

These pressure values do not include any surcharge, and are based on a relatively level ground surface at the top of the wall and drained conditions behind the wall. It is important that water is not allowed to build up (hydrostatic pressures) behind retaining structures. Retaining walls should incorporate drainage behind the walls as appropriate, and surface water should be directed away from the top and bottom of the walls.

Resistance to sliding may incorporate the friction acting along the base of foundations, which may be computed using a coefficient of friction of 0.45 for native clay and 0.70 for structural fill meeting the recommendations presented herein. These values may be increased by one-third for transient wind and seismic loads.

The friction and lateral earth pressure values given above are ultimate, and appropriate factors of safety should be applied, particularly when utilizing both the coefficient of friction and passive earth pressure to resist sliding.

12.0 FLOOR SLABS AND FLATWORK

Concrete floor slabs and exterior flatwork may be supported on native soils or on a minimum of 6 inches of properly placed and compacted structural fill after appropriate removals and grading as outlined in Section 8.1 are completed. We recommend placing a minimum 4 inches of free-draining fill material (see Section 8.3) beneath floor slabs to facilitate construction, act as a capillary break, and aid in distributing floor loads. For flatwork, we recommend placing a minimum 4 inches of roadbase material. Prior to placing the free-draining fill or roadbase materials, the native subgrade should be proof-rolled to identify soft spots, which should be stabilized as discussed above in Section 8.5.

For slab design, we recommend using a modulus of subgrade reaction of 120 pounds per cubic inch. To help control normal shrinkage and stress cracking, we recommend that floor slabs have adequate reinforcement for the anticipated floor loads with the reinforcement continuous through interior floor joints, frequent crack control joints, and non-rigid attachment of the slabs to foundation and bearing walls. Special precautions should be taken during placement and curing of all concrete slabs and flatwork. Excessive slump (high water-cement ratios) of the concrete and/or improper finishing and curing procedures used during hot or cold weather conditions may lead to excessive shrinkage, cracking, spalling, or curling of slabs. We recommend all concrete placement and curing operations be performed in accordance with American Concrete Institute (ACI) codes and practices.

13.0 DRAINAGE

13.1 Surface Drainage

As part of good construction practice, precautions should be taken during and after construction to reduce the potential for water to collect near foundation walls. Accordingly, we recommend the following:

- Adequate compaction of foundation backfill should be provided i.e. a minimum of 90% of ASTM D-1557. **Water consolidation methods should not be used.**

- The ground surface should be graded to drain away from the building in all directions. We recommend a minimum fall of 8 inches in the first 10 feet.

- Roof runoff should be collected in rain gutters with downspouts designed to discharge well outside of the backfill limits, or at least 10 feet from foundations, whichever is greater.

- Sprinklers should be aimed away, and all sprinkler components (valves, lines, sprinkler heads) should be placed at least 5 feet from foundation walls. Sprinkler systems should be well maintained, checked for leaks frequently, and repaired promptly. Overwatering at any time should be avoided.

- Any additional precautions which may become evident during construction.

13.2 Subsurface Drainage

Section R405.1 of the 2009 International Residential Code states, "Drains shall be provided around all concrete and masonry foundations that retain earth and enclose habitable or usable spaces located below grade." An exception is allowed when the foundation is installed on well drained ground consisting of Group 1 soils, which include those defined by the Unified Soil Classification System as GW, GP, SW, SP, GM, and SM. The majority of the native soils encountered in the explorations (CL, CH) were not Group 1 soils. The recommendations presented below should be followed during design and construction of the foundation drain:

- A perforated 4-inch minimum diameter pipe should be enveloped in at least 12 inches of free-draining gravel and placed adjacent to the perimeter footings. The perforations should be oriented such that they are not located on the bottom side of the pipe, as much as possible. The free-draining gravel should consist of primarily ¾- to 2-inch size gravel having less than 5 percent passing the No. 4 sieve, and should be wrapped with a separation fabric such as Mirafi 140N or equivalent.

- The highest point of the perforated pipe bottom should be equal to the bottom elevation of the footings. The pipe should be uniformly graded to drain to an appropriate outlet (storm drain, land drain, other gravity outlet, etc.) or to one or more sumps where water can be removed by pumping.

- To facilitate drainage beneath basement floor slabs we recommend that the minimum thickness of free-draining fill beneath the slabs be increased to at least 10 inches (approximately equal to the bottom of footing elevations). A separation fabric such as Mirafi 140N or equivalent should be placed beneath the free-draining gravel. Connections should be made to allow any water beneath the slabs to reach the perimeter foundation drain (i.e. placing at least 10 inches of free-draining fill beneath footings).

- The drain system should be periodically inspected and clean-outs should be installed for the foundation drain to allow occasional cleaning/purging, as needed. Proper drain operation depends on proper construction and maintenance.

14.0 GENERAL CONDITIONS

The exploratory data presented in this report was collected to provide geotechnical design recommendations for this project. The test pits may not be indicative of subsurface conditions outside the study area or between points explored and thus have a limited value in depicting subsurface conditions for contractor bidding. Variations from the conditions portrayed in the test pits may occur and which may be sufficient to require modifications in the design. If during construction conditions are different than presented in this report, please advise us so that the appropriate modifications can be made.

The findings and recommendations presented in this geotechnical report were prepared in accordance with generally accepted geotechnical engineering principles and practice in this area of Utah at this time. No other warranty or representation, either expressed or implied, is intended in our proposals, contracts or reports.

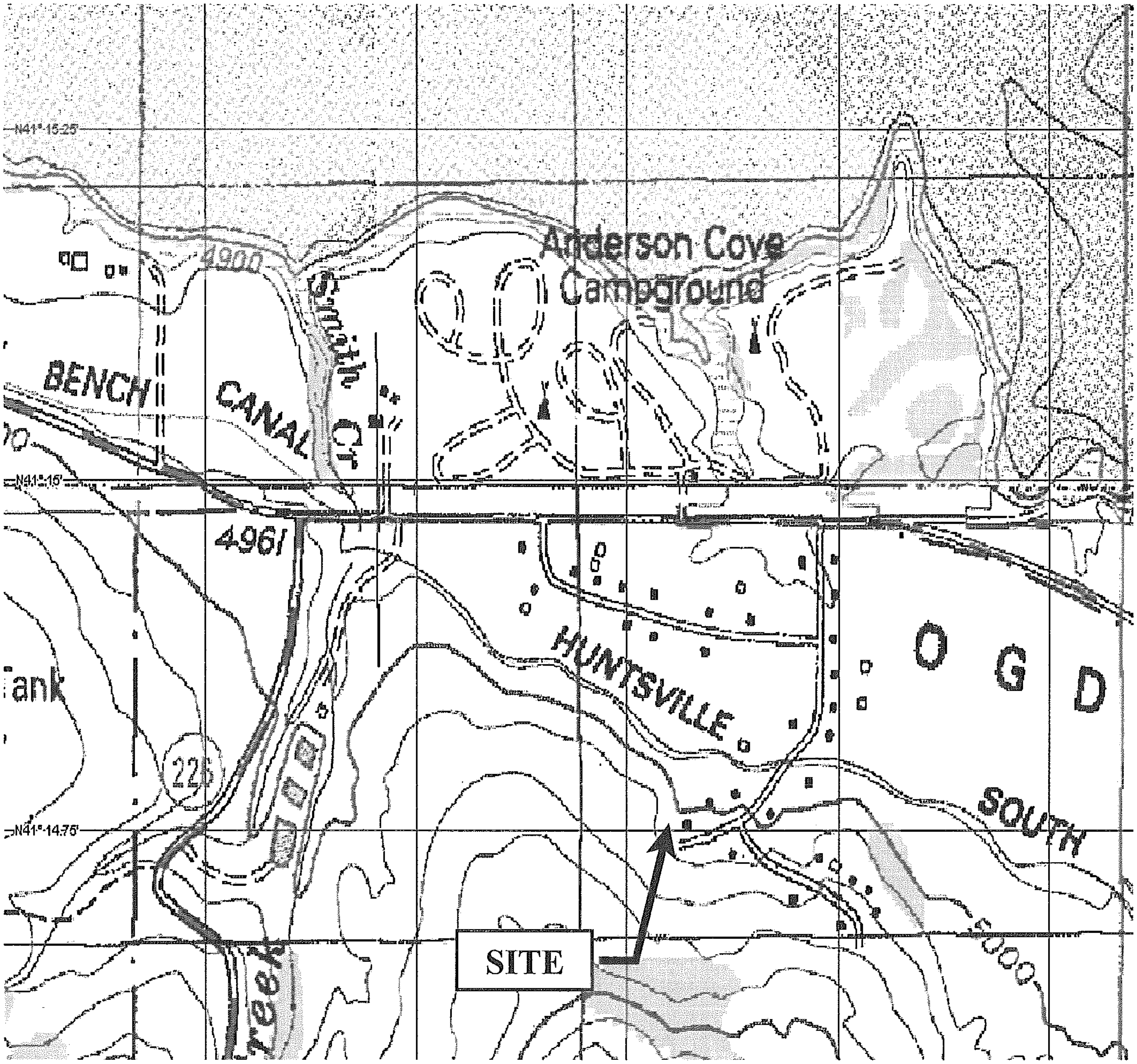
This geotechnical report is based on relatively limited subsurface explorations and laboratory testing. Subsurface conditions may differ in some locations of the site from those described herein, which may require additional analyses and possibly modified recommendations. Thus we strongly recommend consulting with Earthtec Engineering, Inc. regarding any changes made during design and construction of the project from those discussed above in Section 3.0. Failure to consult with Earthtec regarding any such changes relieves Earthtec from any liability arising from changed conditions at the site.

For consistency, Earthtec Engineering Inc. should also perform materials testing and special inspections for this project. The recommendations presented herein are based on the assumption that an adequate program of tests and observations will be followed during construction to verify compliance with our recommendations. We also assume that we will review the project plans and specifications to verify that our conclusions and recommendations are incorporated and remain appropriate (based on the actual design). Earthtec Engineering, Inc. should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Earthtec Engineering, Inc. also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

We appreciate the opportunity of providing our services on this project. If we can answer questions or be of further service, please contact Earthtec at your convenience.

EARTHTEC ENGINEERING, INC

North



EEI Job No. 11-1305G **VICINITY MAP** **Figure 1**

EARTHTEC ENGINEERING, INC

North

SITE PLAN SHOWING LOCATION OF TEST PITS

EEI Job No. 11-1305G

Figure 2

TEST PIT LOG

NO.: TP-1

PROJECT: Lot 19R ski Lake Estates No. 4 — **PROJECT NO.:** 11-1305G
CLIENT: Charlie Wolff — **DATE:** 11/07/11 - 11/07/11
LOCATION: See Figure 2 — **ELEVATION:** Not Measured
OPERATOR: Sundown Construction — **LOGGED BY:** SAS
EQUIPMENT: CAT 303.5C Excavator
DEPTH TO WATER; INITIAL ∇: — **AT COMPLETION ▼:**

Depth (Ft.)	Graphic Log	USCS	Description	Samples	Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0–1.5		TOPSOIL	Topsoil; organic rich, dry, black									
1.5–5.5		SM	Silty Sand, medium dense (estimated), dry, light brown, low pinhole texture, thin rooting									
~3.5				X								
~4.5				■	12	81	38	8	0	55	45	C
5.5–8		SANDSTONE	Sandstone, weakly cemented, tan, dry, 2 to 6 inches in diameter, crumbles with moderate pressure, thin rooting									
8–11		CH	Sandy Fat Clay, very stiff (estimated), dry, light brown, low pinhole texture									
~9				X								
~10.5–11				■	34	56	54	28	0	46	54	C
11			MAXIMUM DEPTH EXPLORED 11 FEET									

Notes: No groundwater encountered.

Tests Key
- CBR = California Bearing Ratio
- C = Consolidation
- R = Resistivity
- DS = Direct Shear
- SS = Soluble Sulfates
- UC = Unconfined Compressive Strength

TEST PIT LOG

NO.: TP-2

PROJECT: Lot 19R ski Lake Estates No. 4
PROJECT NO.: 11-1305G
CLIENT: Charlie Wolff
DATE: 11/07/11 - 11/07/11
LOCATION: See Figure 2
ELEVATION: Not Measured
OPERATOR: Sundown Construction
LOGGED BY: SAS
EQUIPMENT: CAT 303.5C Excavator
DEPTH TO WATER; INITIAL ∇:
AT COMPLETION ▼:

Depth (Ft.)	Graphic Log	USCS	Description	Samples	Water Cont. (%)	Dry Dens. (pcf)	LL	PI	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0–5		TOPSOIL	Topsoil; organic rich, dry, black									
5–7.5		CL	Lean Clay with sand, very stiff (estimated), slightly moist, light brown, thin rooting, low pinhole texture									
7				■	24	88	41	21	0	22	78	DS
7.5–10		CL	Sandy Lean Clay, very stiff (estimated), slightly moist, light brown, thin rooting, low pinhole texture									
9.5				X	30		37	12	1	42	57	
10			MAXIMUM DEPTH EXPLORED 10 FEET									

Notes: No groundwater encountered.

Tests Key
CBR = California Bearing Ratio
C = Consolidation
R = Resistivity
DS = Direct Shear
SS = Soluble Sulfates
UC = Unconfined Compressive Strength

PROJECT NO.: 11-1305G

Earthtec Engineering Inc.

FIGURE NO.: 4

LOG OF TESTPIT 11-1305G.GPJ EARTHTEC.GDT 11/18/11

LEGEND

PROJECT: Lot 19R ski Lake Estates No. 4 **DATE:** 11/07/11 - 11/07/11
CLIENT: Charlie Wolff **LOGGED BY:** SAS

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR SOIL DIVISIONS			USCS SYMBOL	TYPICAL SOIL DESCRIPTIONS
COARSE GRAINED SOILS (More than 50% retaining on No. 200 Sieve)	GRAVELS (More than 50% of coarse fraction retained on No. 4 Sieve)	CLEAN GRAVELS (Less than 5% fines)	GW	Well Graded Gravel, May Contain Sand, Very Little Fines
			GP	Poorly Graded Gravel, May Contain Sand, Very Little Fines
		GRAVELS WITH FINES (More than 12% fines)	GM	Silty Gravel, May Contain Sand
			GC	Clayey Gravel, May Contain Sand
	SANDS (50% or more of coarse fraction passes No. 4 Sieve)	CLEAN SANDS (Less than 5% fines)	SW	Well Graded Sand, May Contain Gravel, Very Little Fines
			SP	Poorly Graded Sand, May Contain Gravel, Very Little Fines
		SANDS WITH FINES (More than 12% fines)	SM	Silty Sand, May Contain Gravel
			SC	Clayey Sand, May Contain Gravel
FINE GRAINED SOILS (More than 50% passing No. 200 Sieve)	SILTS AND CLAYS (Liquid Limit less than 50)		CL	Lean Clay, Inorganic, May Contain Gravel and/or Sand
			ML	Silt, Inorganic, May Contain Gravel and/or Sand
			OL	Organic Silt or Clay, May Contain Gravel and/or Sand
	SILTS AND CLAYS (Liquid Limit Greater than 50)		CH	Fat Clay, Inorganic, May Contain Gravel and/or Sand
			MH	Elastic Silt, Inorganic, May Contain Gravel and/or Sand
			OH	Organic Clay or Silt, May Contain Gravel and/or Sand
HIGHLY ORGANIC SOILS			PT	Peat, Primarily Organic Matter

SAMPLER DESCRIPTIONS

- SPLIT SPOON SAMPLER (1 3/8 inch inside diameter)
- MODIFIED CALIFORNIA SAMPLER (2 inch outside diameter)
- SHELBY TUBE (3 inch outside diameter)
- BLOCK SAMPLE
- BAG/BULK SAMPLE

WATER SYMBOLS

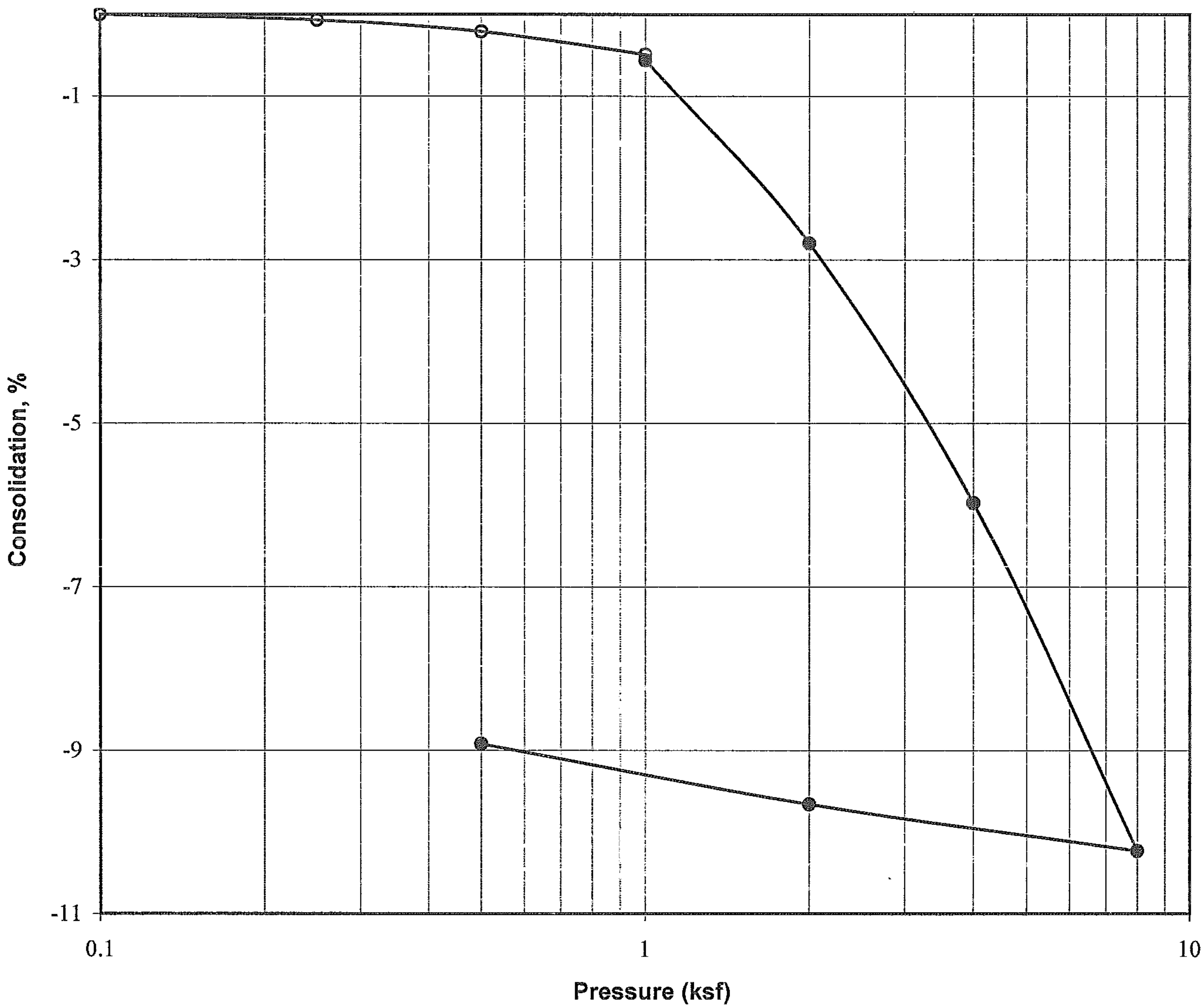
- ▽ Water level encountered during field exploration
- ▼ Water level encountered at completion of field exploration

NOTES:
1. The logs are subject to the limitations, conclusions, and recommendations in this report.
2. Results of tests conducted on samples recovered are reported on the logs and any applicable graphs.
3. Strata lines on the logs represent approximate boundaries only. Actual transitions may be gradual.
4. In general, USCS symbols shown on the logs are based on visual methods only: actual designations (based on laboratory tests) may vary.

PROJECT NO.: 11-1305G | Earthtec Engineering Inc. | **FIGURE NO.:** 5

LEGEND 11-1305G.GPJ EARTHTEC.GDT 11/18/11

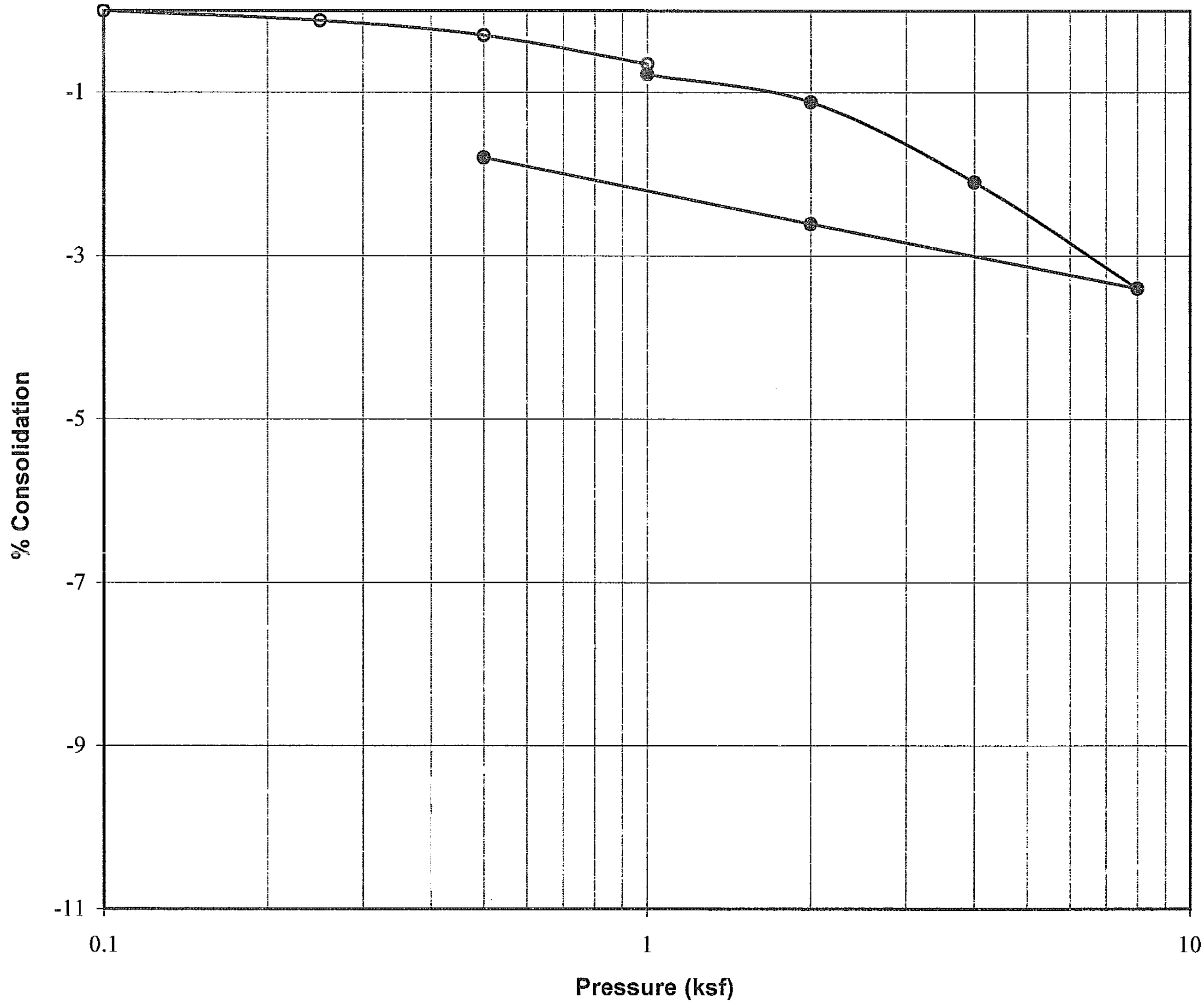
CONSOLIDATION - SWELL TEST



Project:	Lot 19R Ski Lake Estates No. 4
Location:	TP-1
Sample Depth, ft:	4
Description:	Block
Soil Type:	Silty Sand (SM)
Natural Moisture, %:	12
Dry Density, pcf:	81
Liquid Limit:	38
Plasticity Index:	8
Water Added at:	1 ksf
Percent Collapse:	0.1

PROJECT NO.: 11-1305G	Earthtec Engineering Inc.	**FIGURE NO.:** 6

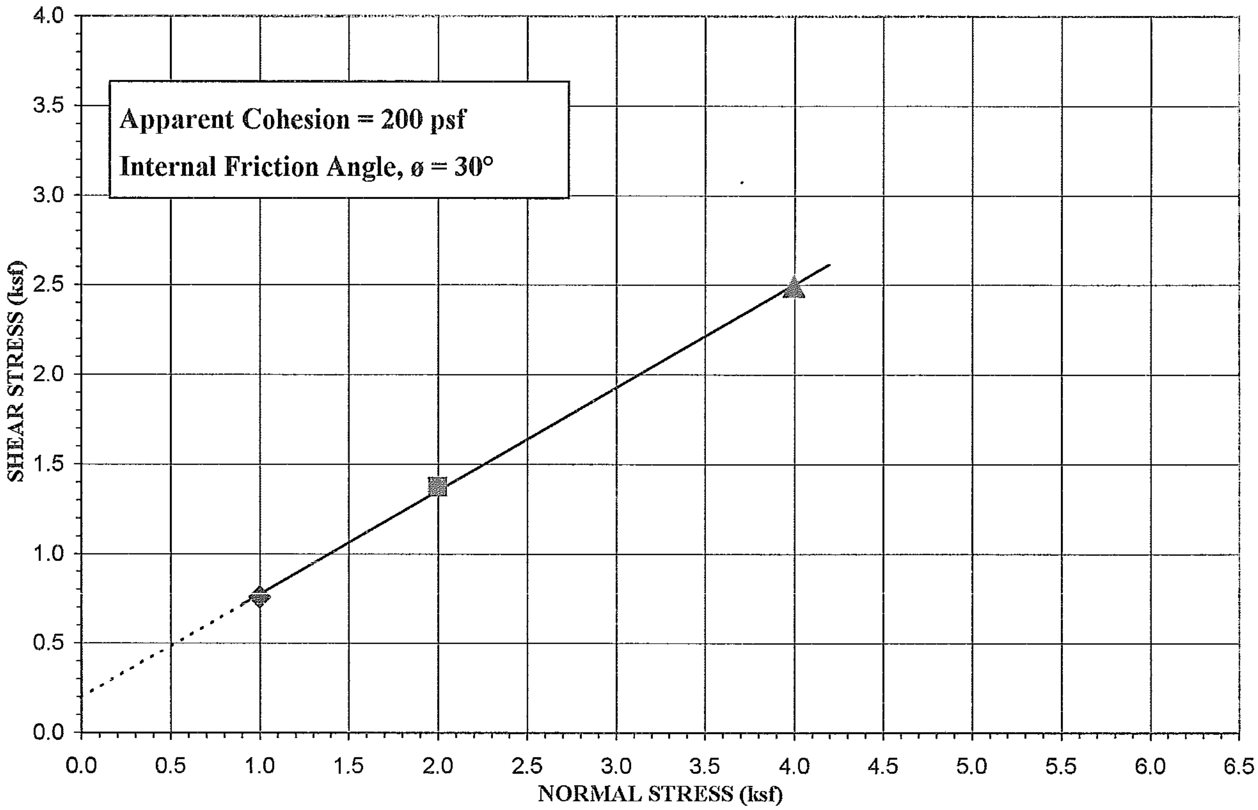
CONSOLIDATION - SWELL TEST

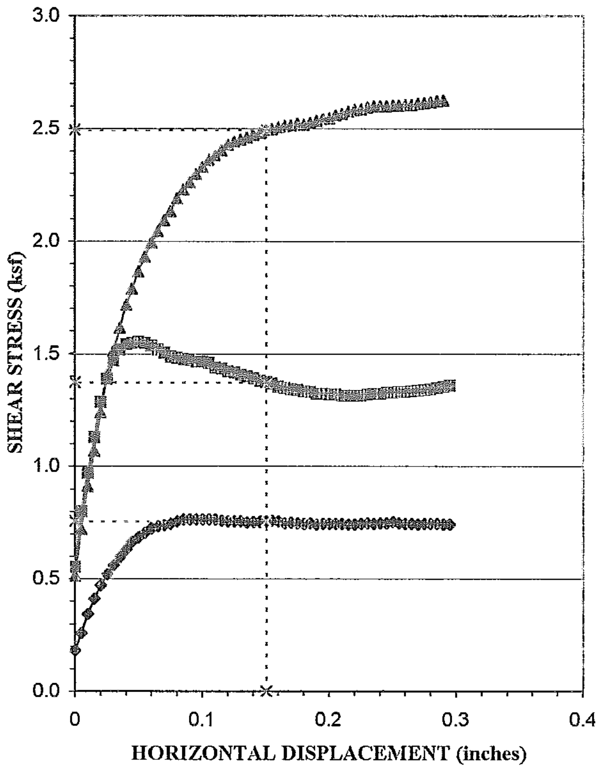


Project:	Lot 19R Ski Lake Estates No. 4
Location:	TP-1
Sample Depth, ft:	10½
Description:	Block
Soil Type:	Sandy Fat Clay (CH)
Natural Moisture, %:	34
Dry Density, pcf:	56
Liquid Limit:	54
Plasticity Index:	28
Water Added at:	1 ksf
Percent Collapse:	0.1

PROJECT NO.: 11-1305G	Earthtec Engineering Inc.	**FIGURE NO.:** 7

DIRECT SHEAR TEST





Source: TP-2	Depth: 6.5 ft		
Type of Test:	Consolidated Drained/Saturated		
Test No. (Symbol)	1 (◆)	2 (■)	3 (▲)
Sample Type	Undisturbed		
Initial Height, in.	1	1	1
Diameter, in.	2.4	2.4	2.4
Dry Density Before, pcf	88.2	89.9	88.1
Dry Density After, pcf	90.6	95.0	90.9
Moisture % Before	24.2	24.2	24.2
Moisture % After	32.8	27.5	31.5
Normal Load, ksf	1.0	2.0	4.0
Shear Stress, ksf	0.76	1.37	2.49
Strain Rate	.0002375 IN/SEC		

Sample Properties	
Cohesion, psf	200
Friction Angle, ϕ	30
Liquid Limit, %	41
Plasticity Index, %	20
Percent Gravel	0
Percent Sand	22
Percent Passing No. 200 sieve	78
Classification	Lean Clay with Sand (CL)

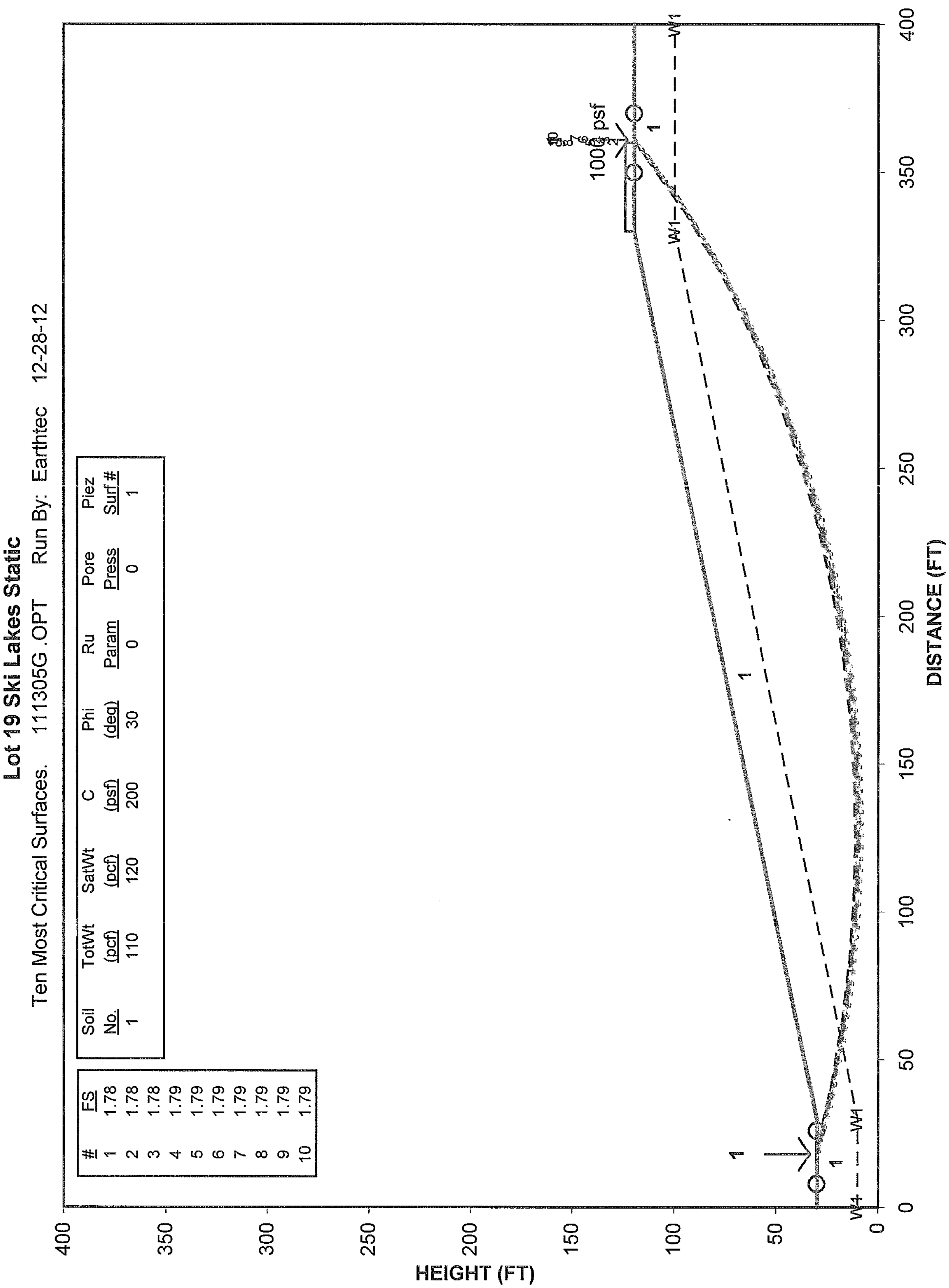
PROJECT: Lot 19R Ski Lake Estates No. 4

PROJECT NO.: 11-1305G

Earthtec Engineering, Inc.

FIGURE NO.: 8

STABILITY RESULTS

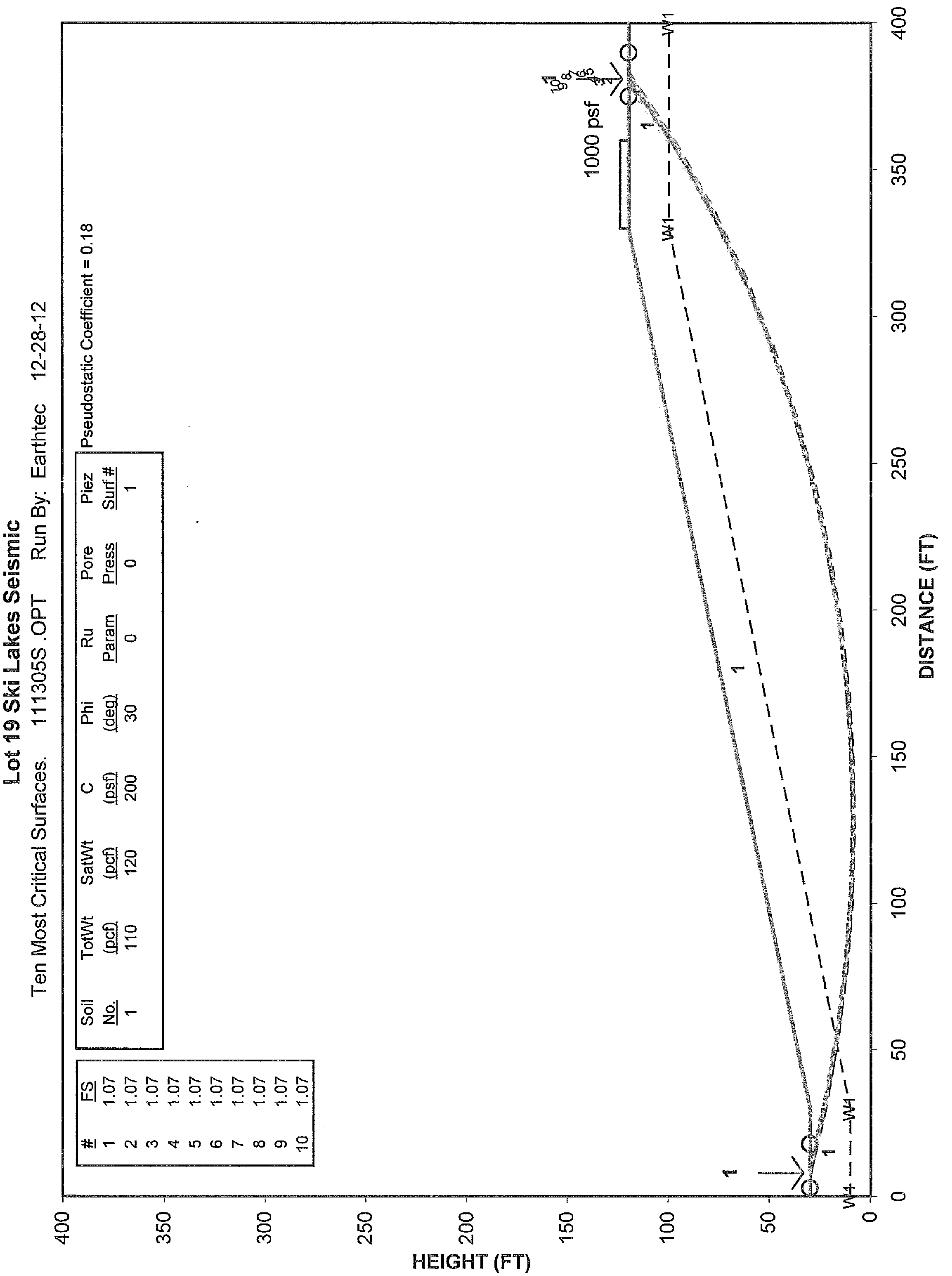


PROJECT NO.: 111305

Earthtec Engineering Inc.

FIGURE NO.: 9

STABILITY RESULTS



PROJECT NO.: 111305	Earthtec Engineering Inc.	FIGURE NO.: 10