Staff Report for Administrative Approval – Hillside Review

Weber County Planning Division

Synopsis

Application Information

Application Request: Consideration and action on a request to approve a Hillside Review for the Metcalf Residence on Lot 44-R of The Retreat at Wolf Creek Phase 3.
Applicant: Eric Householder
File Number: HSR 2018-04

Property Information

Approximate Address: 4061 N Mountain Ridge Drive, Eden
Project Area: 19,000 sq. ft.
Zoning: RE-20
Existing Land Use: Vacant
Proposed Land Use: Single Family Residence
Parcel ID: 22-331-0015
Township, Range, Section: 7N 1E Sec 22

Adjacent Land Use

North: Residential
East: Residential
South: Residential
West: Residential

Staff Information

Report Presenter: Felix Lleverino
flleverino@webercountyutah.gov
801-399-8767
Report Reviewer: RG

Applicable Ordinances

- Title 108 (Standards) Chapter 14 (Hillside Development Review)
- Title 108 (Standards) Chapter 22 (Natural Hazards Areas)

Background

The subject lot (44-R) is located in The Retreat at Wolf Creek Phase 3 which was recorded with the Weber County Recorder's office on January 27, 2015. The average slope of the lot exceeds 25 percent, as such, plans for development are required to be reviewed by the Hillside Development Review Board, as outlined in the Uniform Land Use Code of Weber County (LUC) Title108 Chapter 14.

IGES has performed the geologic hazards investigation and Earthtec Engineering has performed a geotechnical study for the entire phase 3 of The Retreat at Wolf Creek. Information related to the construction of the dwelling as outlined in the geologic and geotechnical reports have been distributed to the Hillside Review Board for comment. The reports have been reviewed by all applicable review agencies.

Planning Division Review

The Planning Division Staff has determined that, in compliance with review agency conditions, the requirements and standards provided by the Hillside Review Chapter have been met for the excavation and construction of the dwelling. The following submittals were required:

1. Engineered Plans.
2. Geotechnical Investigation and Geologic Hazards Report (see Exhibit B).
3. Utah Pollution Discharge Elimination System (UPDES) Permit with Stormwater Pollution Prevention Plan. A condition of approval from the Planning Division is that the applicant provides the UPDES Permit and SWPPP with the building permit application.
4. Landscaping plan.

Weber County Hillside Review Board comments

The Weber County Hillside Review Board, on this particular application, made the following comments and conditions:

Weber County Engineering Division: The Engineering Division granted approval on August 15, 2018. The approval is subject to the following comments as conditions of approval:

> *"The Contractor/Homeowner must have the geologist do a site visit when excavated for footing/foundation, to assess for adverse geologic conditions. A letter will be required from the geologist determining the conditions and/or his observation from the visit. (As Per Geologic Hazard Assessment)*

Weber Fire District: The Fire District granted an approval on August 8, 2018, based on the following findings:

> *"The plans for this home included a fire suppression system."*

Weber County Building Inspection Department: The Building Inspection Department granted approval on August 21, 2018. The approval is subject to the following comments as conditions of approval:

1. "The Structural Engineer needs to provide a letter that the design is in accordance with the Geo-Tech Engineers requirements."
2. "The footing excavation will need to be approved by the Geo-Tech Engineer prior to placing footings."

Weber-Morgan Health Department: The Health Department will not impose any requirements or conditions for this application due to the proposed residence connecting to the Wolf Creek Water and Sewer District for culinary and wastewater services.

Weber County Planning Division: The Planning Division has granted approval subject to the applicant complying with all Board requirements and conditions. This approval is also subject to the applicant developing Lot 44-R according to approved plans and in compliance with the geologic hazard assessment (dated December 2nd, 2016) and geotechnical study (dated September 12th, 2008).

Planning Division Findings

Based on-site inspections and review agency comments, the Planning Division Staff is recommending approval subject to the following conditions:

1. Development of the lot must comply with the excavating, grading, and filling standards outlined in LUC §108-14-8 as well as the recommendations outlined in the geologic and geotechnical reports that were provided with the application.
2. The applicant shall provide the UPDES Permit and SWPPP with the building permit application.
3. To minimize the amount of water introduced into the subsurface and to limit the potential for activation of new landslides, the landscaping will consist of xeriscape and landscaping design shall include the use of passive land drains while prohibiting the placement of on-site sewage or storm drain disposal.
4. If any geologic hazards are revealed during the excavation and construction phase of the dwelling, work on Lot 44-R will cease pending the development of appropriate mitigation measures and subsequent approval by the County and the County's contracted geotechnical and/or geological consultant.

The recommendation for approval is based on the following findings:

1. The application was submitted and has been deemed complete.
2. The requirements and standards found in the Hillside Development Review Procedures and Standards Chapter have been met or will be met during the excavation and construction phase of the dwelling.
3. The Hillside Review Board members reviewed the application individually and have provided their comments.
4. The applicant has met or will meet, as part of the building permit process and/or during the excavation and construction phase of the dwelling, the requirements, and conditions set forth by the Hillside Review Board.

Administrative Approval

Administrative approval of Lot 44-R, The Retreat at Wolf Creek Hillside Review (HSR2018-04), is hereby granted based upon its compliance with the Weber County Land Use Code. This approval is subject to the requirements of applicable review agencies and is based on the findings listed in this staff report.

Date of Administrative Approval: 8/27/18

Rick Grover
Weber County Planning Director

Exhibits

A. Approved Plans
B. Geologic Hazards Assessment Rev. 1 and Geotechnical Study

Map 1


Subject Property
SNOWFLAKE DR
Powder Mountain Rd
ASPEN LN
JUNIPER LN
WOLF RIDGE CIR
Wolf Creek Dr
Mountain Ridge Dr
RETREAT DR
ZERMATT ST
ELKRIDGE TRAIL
3850 N ST
MIDDLE FORK RD
Porcupine Ridge Dr
PINEVIEW CT
ELKHORN DR
Elkridge Trl
WOLFCREEK DR
mile 6
Wolf Creek Golf Course
HUNTSMAN PATH
FOXRUN DR
5100 E ST

IGES®
Intermountain GeoEnvironmental Services, Inc.
12429 South 300 East, Suite 100, Draper, Utah 84020
T: (801) 748-4044 ~ F: (801) 748-4045
2702 South 1030 West, Ste. 10, SLC, UT 84119
T: (801) 270-9400 ~ F: (801) 270-9401

August 14, 2018

Wolf Creek Resort
3718 N. Wolf Creek Drive
Eden, Utah 84310
Attn: Mr. Eric Householder

IGES Project No. 02348-002

Subject: Geologic Hazards Assessment Rev. 1
The Retreat Subdivision
Eden, Utah

Mr. Householder:

At your request, IGES has performed a geologic hazards assessment for The Retreat Subdivision, located in the City of Eden in Weber County, Utah. This letter report identifies the nature and associated risk of the applicable geologic hazards associated with the property, based upon the results of the literature review, site reconnaissance, and subsurface investigation conducted as part of this assessment.

This document is a revision to the original letter report dated December 2, 2016 that contained a discrepancy between the landslide hazard assessment rating and the assessment rating as contained in the *Conclusions* section of this document. Aside from modification to Section 7.1 to remedy the discrepancy, no other changes have been made.

1.0 INTRODUCTION

The property is located in the City of Eden, Utah, approximately 2.5 miles north of Pineview Reservoir in the northeastern quarter of Section 22, Township 7 North, Range 1 East (see Appendix A, Figure A-1). The property is bound on the north and west by undeveloped lands, and on the east and south by partially completed residential neighborhoods containing intermittent developed and undeveloped lots. Elkhorn Drive runs along the southern margin of the property. We understand that The Retreat Subdivision consists of 45 lots to be developed as one to two-story wood-framed single-family residences, possibly with basements. It is also our understanding that of the 45 lots, 14 are currently unsold and 3 have already been developed. The development will cover a total of approximately 36 acres, and will include open space, community trails, and residential lots. The subject property is located within an area that is mapped as landslide deposits possibly associated with the Norwood Tuff, and as such is required to have a geologic hazard assessment prior to development in order to adequately meet the requirements of the Weber County Code. The following assessment has been produced to meet these requirements.

2.0 PURPOSE AND SCOPE

This study was initially performed as a reconnaissance-level geologic hazards assessment of the property, which was subsequently expanded to include subsurface investigation. The purpose of this assessment was to identify any surficial or subsurface geologic hazards that may be extant on the property or have the capability to adversely impact the property. Specifically, this study was conducted to:

- Analyze the existing geologic conditions present on the property and relevant adjacent areas;

- Assess the geologic hazards that pose a risk to development across the property, and determine an associated risk for each hazard; and

- Identify the most significant geologic hazard risks, and provide recommendations for appropriate additional studies and/or mitigation practices, if necessary.

In order to achieve the purpose and scope outlined above, the following services were performed as part of this investigation:

- Review of available published geologic reports and maps for the subject property and surrounding areas;

- Stereoscopic review of aerial photographs and analysis of additional available aerial imagery, including LiDAR;

- Site reconnaissance by an engineering geologist licensed in the state of Utah to map the surficial geology, determine site conditions, and assess the property for geologic hazards;

- Geologic logging of subsurface excavations, soil sampling, and slope stability analyses; and

- Preparation of this report, based upon the data reviewed and collected in this investigation.

3.0 REVIEW OF GEOLOGIC LITERATURE

A number of pertinent publications were reviewed as part of this assessment. Sorensen and Crittenden, Jr. (1979) provides the only 1:24,000 scale geologic mapping that covers the area in which the property of interest is located, in the form of the Huntsville Geologic Quadrangle. Coogan and King (2001) provide more recent geologic mapping of the area, but at a regional (1:100,000) scale. An updated Coogan and King (2016) regional geologic map (1:62,500 scale) provides the most recent published geologic mapping that covers the project area. A United States Geological Survey (USGS) topographic map for the Huntsville Quadrangle (2014) provides physiographic and hydrologic data for the project area. A Federal Emergency Management Agency (FEMA) flood map (effective in 2015) that covers the project area was reviewed. Regional-scale geologic hazard maps pertaining to landslides (Elliott and Harty, 2010; Colton, 1991), faults (Christenson and Shaw, 2008a; USGS and Utah Geological Survey (UGS), 2006), debris-flows (Christenson and Shaw, 2008b), liquefaction (Christenson and Shaw, 2008c; Anderson et al., 1994), and radon (Solomon, 1996) that cover the project area were also reviewed. More site-specific, the geotechnical report for the subject property (EarthTec, 2008) was reviewed.

3.1 General Geologic Setting

The Retreat Subdivision property is situated in the northern part of the Ogden Valley, along the foothills of the Wasatch Mountains, between two southwest-flowing unnamed ephemeral drainages. Ogden Valley separates the western part of the Wasatch Range from the Bear River Range to the east, a subgroup of mountains that are part of the parent Wasatch Range. The Wasatch Mountains contain a broad depositional history of thick Precambrian and Paleozoic sediments that have been subsequently modified by various tectonic episodes that have included thrusting, folding, intrusion, and volcanics, as well as scouring by glacial and fluvial processes (Stokes, 1987). The uplift of the Wasatch Mountains occurred relatively recently during the Late Tertiary Period (Miocene Epoch) between 12 and 17 million years ago (Milligan, 2000). Since uplift, the Wasatch Front has seen substantial modification due to such occurrences as movement along the Wasatch Fault and associated spurs, the development of the numerous canyons that empty into the current Salt Lake Valley and Utah Valley and their associated alluvial fans, erosion and deposition from Lake Bonneville, and localized mass movement events (Hintze, 1988). The Wasatch Mountains, as part of the Middle Rocky Mountains Province (Milligan, 2000), were uplifted as a fault block along the Wasatch Fault (Hintze, 1988). Ogden Valley itself is a fault-bounded trough that was occupied by Lake Bonneville (Sorensen and Crittenden, Jr, 1979) before being cut through by the Ogden River and subsequently dammed to form the Pineview Reservoir.

3.2 Surficial and Subsurface Geology

According to Sorensen and Crittenden, Jr. (1979), the property is located entirely on Holocene-aged (~11,700 years ago to the present) colluvium[1] and slopewash (Qcs) deposits (Figure A-2). The Qcs unit is underlain by the Norwood Tuff (Tn) across the property, and outcrops of the Norwood Tuff are present approximately 0.15 miles west of the property and 0.3 miles east of the property. Though two unnamed ephemeral drainages bound eastern and western margin of the property, no alluvial deposits were mapped in association with these drainages. Approximately 0.14 miles north of the northern margin of the property, an outcrop of the Lower Member of the Geertsen Canyon Quartzite (Cgcl) is present. A single northwest-southeast trending fault was mapped in the southern portion of the property near the southern margin. Additionally, a number of northwest-southeast trending faults were mapped to the south and east of the property, all within ¼ mile of the property, with some projecting onto the property (Sorensen and Crittenden, Jr., 1979).

Coogan and King (2001) denoted the area underlying the subject property entirely as Qmso, older (Pleistocene-aged; between 11,700 and 2.6 million years old) landslide and slump deposits, which are described as “poorly sorted clay to boulder-sized material; locally includes

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[1] Colluvium: A general term applied to any loose, heterogeneous, and incoherent mass of soil material and/or rock fragments deposited by rainwash, sheetwash, or slow continuous downslope creep, usually collecting at the base of gentle slopes or hillsides. (AGI, 2005)

flow deposits." In contrast to Sorensen and Crittenden, Jr. (1979), Coogan and King (2001) do not show the faults on, near, or projecting onto the property.

Most recently, Coogan and King (2016) displays the subject property to be predominantly underlain by a large lobe of old (Pleistocene-aged) landslide deposits (Qmso), with some younger (Holocene-aged) landslide deposits (Qms) mapped along the southern and southeastern portion of the property (Figure A-3). This map reinserts some of the linear features to the south and east of the property identified as faults by Sorensen and Crittenden, Jr. (1979), but reinterprets most of them to be landslide scarps, including the one near the southern margin of the property. One Holocene-aged normal fault is mapped as passing northwest-southwest approximately 0.1 miles south of the southern margin of the property. Older eroded alluvial fan deposits (Qafoe) are found adjacent to the Qmso deposits near the western margin of the property, in association with the larger of the two ephemeral drainages that bound the property.

As part of the geotechnical assessment for the property, EarthTec excavated a total of 7 test pits (EarthTec, 2008). The property was found to be largely devoid of topsoil, no groundwater was encountered in any of the test pits, and the soils largely consisted of dense clayey gravel with sand overlying elastic silt produced by the weathering of Norwood Tuff bedrock. A single occurrence of fat clay was noted in a test pit near the eastern margin of the property. Norwood Tuff bedrock was noted in only 2 of the 7 test pits.

3.3 Hydrology

The USGS topographic map for the Huntsville Quadrangle (2014) shows that The Retreat Subdivision project area is situated within the broad northwest-southeast trending Ogden Valley and straddled by two northeast-southwest trending ephemeral stream drainages which form the eastern and western margins of the property, respectively (see Figure A-1). Neither of these drainages were found to contain flowing water during the site reconnaissance. Multiple generally northeast-southwest trending gullies pass onto and across the property from the upslope area to the northeast. No springs are known to occur on the property, though it is possible that springs may occur on various parts of the property during peak spring runoff. A number of springs are found within ¼ mile downslope of the property.

Baseline groundwater depths for The Retreat Subdivision property are currently unknown, but are anticipated to fluctuate both seasonally and annually. Groundwater was not encountered in any of the test pits excavated by EarthTec (2008) for the geotechnical investigation of the property, conducted in late August.

The FEMA flood map that covers the project area shows that the property is in Zone X, located outside of the 500-year flood floodplain for any nearby drainage (FEMA, 2015).

3.4 Geologic Hazards

Based upon the available geologic literature, regional-scale geologic hazard maps that cover The Retreat Subdivision project area have been produced for landslide, fault, debris-flow, liquefaction, and radon hazards. The following is a summary of the data presented in these regional geologic hazard maps.

3.4.1 Landslides

Two regional-scale landslide hazard maps have been produced that cover the project area. Colton (1991) shows the property to be partially located within a large area that is queried as a possible landslide deposit. More recent mapping by Elliott and Harty (2010) refined the area queried by Colton (1991) and show the property to be located within an area classified as a "Deep or unclassified landslide," with individual landslide deposits generally greater than 10 feet thick and exhibiting characteristic landslide morphology.

3.4.2 Faults

Neither Christensen and Shaw (2008a) nor the Quaternary Fault and Fold Database of the United States (USGS and UGS, 2006) show any Quaternary-aged (~2.6 million years ago to the present) faults to be present on or projecting towards the subject property. The Ogden Valley North Fork Fault is located approximately 1.7 miles to the southwest of the property, and the Ogden Valley Northeastern Margin Fault is located approximately 0.8 miles to the northeast of the property. These faults represent the closest Quaternary-aged faults to the property (UGS, 2016a). The Weber County Natural Hazards Overlay Districts defines an active fault to be "a fault displaying evidence of greater than four inches of displacement along one or more of its traces during Holocene time (about 11,000 years ago to the present)" (Weber County, 2015). The closest active fault to the property is the Weber Segment of the Wasatch Fault Zone, located approximately 6.1 miles west of the western margin of the property (USGS and UGS, 2006). Coogan and King (2016) map a northwest-trending, southwest-dipping normal fault approximately 0.1 miles south of the southern margin of the property, though this fault is not included in either the Utah Quaternary Fault and Fold Database (UGS, 2016a) or the Quaternary Fault and Fold Database of the United States (USGS and UGS, 2006).

3.4.3 Debris-Flows

Christensen and Shaw (2008b) do not show the project area to be located within a debris-flow hazard special study area.

3.4.4 Liquefaction

Anderson, et al. (1994) and Christensen and Shaw (2008c) both show the project area to be located in an area with very low potential for liquefaction.

3.4.5 Radon

Solomon (1996) has part of the project area located in an area with moderate radon levels.

4.0 REVIEW OF AERIAL IMAGERY

A series of aerial photographs that cover project area were taken from the UGS Aerial Imagery Collection (UGS, 2016b) and analyzed stereoscopically for the presence of adverse geologic conditions across the property. This included a review of photos collected from the years 1946 and 1963 that were taken prior to the development of the nearby neighborhoods. A table displaying the details of the aerial photographs reviewed can be found in the *References* section at the end of this report.

No geologic lineaments, fault scarps, landslide headscarps, or landslide deposits were observed in the aerial photography on the subject property. However, upslope of the property to the northeast a prominent landslide headscarp and associated highly irregular, hummocky topography was observed. This is consistent with the older landslide deposit mapped by Coogan and King (2001 and 2016) and Elliott and Harty (2010).

Google Earth imagery of the property from between the years of 1993 and 2016 were also reviewed. No clear landslide scarps or deposits or other geological hazard features were noted in the imagery on the property, though the property was seen to be slightly hummocky in places. Most of the project area was observed to be covered in grasses and small bushes with a mantling of scattered cobbles and boulders; few trees were observed on the property. The southern part of the property exhibited the most irregular, possibly hummocky topography. Northeast of the property, the prominent landslide headscarp and associated landslide deposits noted in the aerial photographs were readily observed. The headscarp is located approximately 0.6 miles northeast of the northern margin of the property, and the two ephemeral drainages that bound the property were seen to originate (at least in part) from the edges of the scarp. Approximately ¼ mile northeast of the property in the vicinity of a water tank, the ground becomes noticeably hummocky, with the hummocky topography extending upslope to the northeast to the headscarp. The area between the hummocky topography near the water tank and the northern margin of the property was observed to be highly gullied, though generally with a consistent slope.

Utah Geological Survey 1 meter LiDAR data (UGS, 2011) for the project area was reviewed. The property was shown to contain a number of the gullies evident in the Google Earth imagery, though the property was largely not observed to be irregular or hummocky. The most irregular ground surface was observed near the northern margin of the property.

5.0 SITE RECONNAISSANCE

Mr. Peter E. Doumit, P.G., C.P.G., of IGES conducted reconnaissance of the site and the immediate adjacent properties on September 8, 2016. The site reconnaissance was conducted with the intent to assess the general geologic conditions present across the property, with specific interest in those areas identified in the geologic literature and aerial imagery reviews as potential geologic hazard areas. Additionally, the site reconnaissance provided the opportunity to geologically map the surficial geology of the area. Figure A-4 is a site-specific geologic map of The Retreat Subdivision property and adjacent areas, and Figure A-5 depicts the surficial geology on an aerial image, with reference to the landslide referenced above.

Much of the property was found to have been disturbed by human activity, largely in the form of existing asphalted roads and cul-de-sacs, and differentiating between the natural and human-altered modern topography was difficult to discern in places. In general, the existing terrain was largely sloping to the southwest and covered with quartzite cobbles and boulders. Road cuts in cul-de-sacs displayed as much as 10 feet of what appeared to be colluvial cover overlying weathered Norwood Tuff bedrock. The colluvial cover was observed to decrease in thickness downslope towards the southern parts of the property. The colluvium consisted of subangular to subrounded rock clasts up to 5 feet in diameter, though the mode average size was generally between 1 and 1.5 feet in diameter.

Three distinct lithologies were observed in the colluvial clasts:

1. Tan to white to orange, massive to banded quartzite; cherty in places. This lithology constituted approximately 80% of the clasts on the property.
2. Medium light gray pebbly conglomeratic quartzite. This lithology constituted approximately 15% of the clasts on the property.
3. Medium gray to dark yellow orange, well-indurated sandstone; largely oxidized, though still very hard and competent. This lithology constituted approximately 5% of the clasts on the property.

It should be noted that while it was originally assumed that weathered Norwood Tuff bedrock was seen in the cul-de-sac road cuts, Norwood Tuff clasts were not observed on the surface in association with the colluvium and neither Norwood Tuff clasts nor Norwood Tuff bedrock were encountered in any of the test pits excavated as part of this investigation.

The highly hummocky topography northeast of the property near the water tank was observed to contain a number of internal scarps and small landslide toes. However, none of the landslide scarps were observed to display evidence of recent or historic movement (the soil profile was not freshly exposed at the scarps). Between the hummocky topography and the northern margin of the property, a notable geomorphic change was observed in which the highly irregular, hummocky ground gave way downslope to generally even, consistently-sloping ground.

Four surficial geologic units were differentiated on and adjacent to the property (see Figures A-4 and A-5), as well as areas that have been modified by human activity. Each of these units are discussed in turn below.

Qal (Recent alluvium)

This unit was mapped along the western and eastern margins of the property in association with the unnamed northeast-southwest trending ephemeral drainages. The unit is characterized by the presence of abundant subrounded to subangular quartzite and sandstone clasts as described above, up to 5 feet in diameter, which litter the base and banks of the drainage. It is possible that some of this unit was deposited via a series of debris-flows during major storm events. This surficial alluvial unit was not observed in the subsurface, but the unit is likely to be less than 10 feet thick.

Qc (Holocene-Pleistocene colluvium)

This unit underlies nearly all of The Retreat property, and is found to extend from approximately the water tank north of the property to Elkhorn Drive to the south. The unit was observed in the subsurface in all 5 of the test pits, and consists of abundant cobbles and boulders of quartzite up to 2 feet in diameter loosely consolidated within a topsoil matrix comprised of a lean clay gradational to fat clay. The USCS classification of this unit graded between gravelly lean clay (CL) to lean clay with gravel (CL), and was found to be between 1 and 3 feet thick.

Qlso (Holocene to Pleistocene landslide deposits)

This unit was mapped to the northeast of the property, extending northeast from the approximate location of the water tank to the prominent headscarp at the head of the valley. In the area underlain by this unit, the surface was characterized by significant hummocky, irregular topography exhibiting several internal scarps. However, the subdued nature of the headscarp and the absence of internal scarps exhibiting recent movement suggest a Late Pleistocene/Early Holocene age for these deposits. In the subsurface, this unit was found underlying the Qc unit in 4 of the 5 test pits, and consisted of fat clay with gravel (CH) that commonly exhibited a basal shear zone. The unit was found range between 2.5 and 12 feet thick.

Cgcl (Cambrian Geertsen Canyon Quartzite, Lower Member)

This bedrock unit was found to outcrop northwest of the property, on the western side of the unnamed ephemeral drainage that bounds the western margin of the property. The unit consisted of a white to brown, amorphous to sugary quartzite that commonly exhibited an orange weathering rind. In contrast to the Coogan and King (2016) bedding orientation, which displays a northerly strike and dip of approximately 26°E for this bedrock outcrop, the outcrop was observed to display a strike of S70°E and dip of between 65 and 77°SW, based on internal bedding and laminations. This bedrock unit was not encountered in any of the test pits, though as much as 15 feet of outcrop was exposed at the surface.

5.1 Surface Water/Groundwater

At the time of the site visit, neither of the ephemeral stream drainages that bound the property were observed to be presently transporting surface water, though the surficial soils in the drainages were observed to be slightly moist.

No springs were identified on the property, and an absence of hydrophilic plants on the property suggests that groundwater is not shallow.

5.2 Geologic Hazards

Based on the fact that the property is located within a mapped landslide deposit and is possibly underlain by the landslide-prone Norwood Tuff, combined with the observation of significant landslide deposits upslope of the property and some uneven ground on the property, it was determined that there is substantial reason to believe that a landslide hazard exists for the property. As such, a subsurface component of the geologic hazard assessment was required to assess the nature and extent of the landslide deposits and associated hazard.

6.0 SUBSURFACE INVESTIGATION

A subsurface investigation of the property was performed between October 7 and 10, 2016. Five test pits were excavated by way of a Komatsu PC300LC tracked excavator to depths between 13 and 16 feet below existing grade (see Figures A-4 and A-5). The subsurface excavations were logged and photographed in detail; the logs are displayed in Figures A-6 through A-10. Practical refusal in hard bedrock was not encountered in any of the excavations. Additionally, groundwater was not observed in any of the test pits.

The common stratigraphic section encountered in the test pits included a thin topsoil between 3 inches and 1 foot thick, weathering upon a colluvial unit between 1 and 3 feet thick. The colluvial unit was overlying a shallow landslide deposit between 2.5 and 12 feet thick, and the shallow landslide unit was underlain by an alluvial deposit consisting of gravelly sand (SW). Both TP-1 and TP-2 were found to have a 3- to 5-foot-thick transitional unit between the shallow landslide and alluvial unit, consisting of sandy fat clay with gravel (CH). TP-3 was found to contain a sandy gravel (GW) fluvial deposit at least 2 feet thick in the base of the test pit, representing an ancient river channel that passed through the property. TP-4 was anomalous in that it contained two distinct landslide units situated upon a thin shear plane, though the basal landslide deposit was a gravelly sand with clay (SC-GC) that appeared similar to both the transitional unit observed in TP-1 and TP-2, as well as the alluvial unit observed in the other test pits underlying the upper landslide clay. No landslide deposits were encountered in TP-5, as the colluvial unit was found to be underlain by gravelly sand gradational to sandy gravel (SW-GW) in what resembled the Wasatch Formation, but may be alluvial deposits.

6.1 Laboratory Testing

Geotechnical laboratory tests were conducted on selected soil samples obtained during our subsurface investigation. The laboratory testing program was designed to evaluate the engineering characteristics of onsite earth materials and to assist in classification. Laboratory tests conducted during this investigation included:

- In situ moisture content (ASTM D7263)
- Atterberg Limits (ASTM D4318)
- Fines Content (% passing the #200 sieve) (ASTM D1140)
- Gradation (ASTM D6913)
- Direct Shear and Residual Shear Test (ASTM D3080)

Results of the laboratory testing are included with this report in Appendix B.

7.0 GEOLOGIC HAZARD ASSESSMENT

Geologic hazard assessments are necessary to determine the potential risk associated with particular geologic hazards that are capable of adversely affecting a proposed development area. As such, they are essential in evaluating the suitability of an area for development and provide critical data in both the planning and design stages of a proposed development. The geologic hazard assessment discussion below is based upon a qualitative assessment of the risk associated with a particular geologic hazard, based upon the data reviewed and collected as part of this investigation.

A “low” hazard rating is an indication that the hazard is either absent, is present in such a remote possibility so as to pose limited or little risk, or is not anticipated to impact the project in an adverse way. Areas with a low-risk determination for a particular geologic hazard generally do not require additional site-specific studies or associated mitigation practices with regard to the geologic hazard in question. A “moderate” hazard rating is an indication that the hazard has the capability of adversely affecting the project at least in part, and that the conditions necessary for the geologic hazard are present in a significant, though not abundant, manner. Areas with a moderate-risk determination for a particular geologic hazard may require additional site-specific studies and associated mitigation practices in the areas that have been identified as the most prone to susceptibility to the particular geologic hazard. A “high” hazard rating is an indication that the hazard is very capable of adversely affecting the project, that the geologic conditions pertaining to the particular hazard are present in abundance, and/or that there is geologic evidence of the hazard having occurred at the area in the historic or geologic past. Areas with a high-risk determination generally always require additional site-specific hazard investigations and associated mitigation practices. For areas with a high-risk geologic hazard, simple avoidance is often considered.

The following are the results of the geologic hazard assessment for The Retreat Subdivision property.

7.1 Landslides/Mass Movement

Landslides and mass movement hazards pose the greatest risk to The Retreat Subdivision property. The property is entirely within an area previously mapped as an older (Pleistocene-aged) landslide (Coogan and King, 2016), aerial and LiDAR imagery indicated some hummocky topography, and the site reconnaissance observed hummocky topography northeast of the property and some irregular ground on the property (see Figures A-4 and A-5). This data was the basis for a subsequent subsurface investigation to assess the nature and extend of the landslide hazard on the property.

A correlative landslide unit approximately 2.5 to 6.5 feet thick consisting of brownish gray fat clay with gravel (CH) was observed in all test pits except TP-5. This unit commonly exhibited a heavily slickensided basal shear zone and occasional slickensides in the rest of the unit in TP-1 and TP-2, though the basal shear zone was absent and slickensides were less common in TP-3 and TP-4. In general, the landslide unit exhibited well-developed shear in the upslope (northeastern) test pits, while evidence of shear was significantly less common in the downslope (southwestern) test pits, and was altogether absent in the southeasternmost test pit (TP-5). These features are indicative of a translational slide, but may also represent post-deposition soil creep. A second landslide unit observed in TP-4, underlying the aforementioned correlative landslide unit, contained slickensides in clayey portions of the unit, but was generally much more granular than the overlying landslide deposit. This unit was more indicative of a debris-flow type landslide deposit, and represents a small, localized landslide that occurred prior to the more wide-spread, largely translational failure that subsequently covered most of the property.

Given the geologic data alone, the landslide risk associated with the property was preliminarily considered to be high for the unsold lots located in the northern ~1/3 of the property, including Lots 30, 31, 34, 38, 39, 42, 43, 44, and 45. The subsurface data indicate that these lots are most susceptible to mass movement, and are also at risk of the potential downslope movement from the large landslide deposit mapped northeast of the property above the water tank. The landslide risk associated with the remaining unsold lots (Lots 16, 19, 24, 28, and 29) was preliminarily considered to be moderate, as the subsurface data indicate that less-developed and discontinuous shear planes are present within the shallow landslide deposit, and a well-developed basal shear zone was not observed in the test pits in this area.

In both cases, the granular nature of the subsurface materials, including the generally high proportion of cobbles found in the shallow landslide unit (~15-20%), aids in reducing the propensity for mass movement. Additionally, slope stability analyses have indicated that the older landslide mass is stable under current conditions (see Section 7.2); as such, the hazard classifications have been reduced to moderate for Lots 30, 31, 34, 38, 39, 42, 43, 44, and 45, and low to moderate for Lots 16, 19, 24, 28, and 29 (see Section 8.0).

7.2 Slope Stability Analysis

The stability of the existing natural slope has been assessed in general accordance with methodologies set forth in Blake, et al. (2002) with respect to Section A-A', illustrated on Figures A-4 and C-1. The stability of the slope was modeled using SLIDE, a computer application incorporating (among others) Spencer's Method of analysis. Calculations for stability were developed by searching for the minimum factor of safety for both a translational-type and rotational-type failures. Homogeneous earth materials (colluvium, older landslide deposits) and both arcuate and planar failure surfaces were assumed. Analysis was performed for the following cases:

a) Static analysis of existing slope
b) Pseudo-static analysis of existing slope

Strength of earth materials was estimated based on direct observation of site earth materials (coarse granular colluvium and clayey landslide deposits) and the results of direct shear tests performed on representative remolded specimens. The results of the direct shear tests are presented in Appendix B, and are summarized in Table 1:

Table 1
Summary of Laboratory Soil Strength Testing

Sample	Description	Test	Friction Angle (deg.)	Cohesion (psf)
TP-2 at 9'	Colluvium, Clayey Sand (SC)	Direct Shear	33	673
TP-1 at 10'	Landslide, Sandy Clay (CH)*	Direct Shear, Residual	11.1	286

*sample obtained from landslide basal shear zone

Based on these test results, appropriate and reasonable soil strength parameters were selected.

Pseudo-static (seismic screening) analysis of the proposed slope was performed in general conformance with Blake, et al. (2002). The design seismic event was taken as the ground motion with a 2 percent probability of exceedance in 50 years (2PE50). Based on information provided in the geotechnical report (Earthtec, 2008), the Peak Ground Acceleration (PGA) associated with a 2PE50 event is taken as 0.44g. Half of the PGA was taken as the horizontal seismic coefficient (k_h = 0.22g) (Hynes and Franklin, 1984), and used in the pseudo-static seismic screen analysis.

Groundwater was not encountered during our investigation, and therefore was not modeled in our analysis.

Our slope stability analysis indicates that the subject property meets the minimum acceptable factors-of-safety of 1.5 (static) and 1.0 (seismic or pseudo-static). The results of the stability analyses are presented in Appendix C.

7.3 Rockfall

No bedrock is exposed upslope of the property. As such, the rockfall hazard associated with the property is considered to be low.

7.4 Surface-Fault-Rupture and Earthquake-Related Hazards

No faults are known to be present on or projecting towards the property, and the closest active fault to the property is the Weber Segment of the Wasatch Fault Zone, located approximately 6.1 miles to the west of the western margin of the property (USGS and UGS, 2006). Given this information, the risk associated with surface-fault-rupture on the property is considered low.

The entire property is subject to earthquake-related ground shaking from a large earthquake generated along the active Wasatch Fault. Given the distance from the Wasatch Fault, the hazard associated with ground shaking is considered to be moderate. Proper building design according to appropriate building code and design parameters can assist in mitigating the hazard associated with earthquake ground shaking.

7.5 Liquefaction

Given the generally clayey, though granular and dry nature of the surficial materials, and consistent with the existing geologic literature for the area, the risk associated with earthquake-induced liquefaction is expected to be low. However, we cannot preclude the possibility for liquefaction to occur onsite. A liquefaction study, which would include borings and/or CPT soundings to a depth of at least 50 feet or bedrock, whichever is shallower, was not performed for this project and is not a part of our scope of work.

7.6 Debris-Flows and Flooding Hazards

No alluvial fan deposits have been mapped on the property, though the property is flanked by ephemeral stream drainages. However, no active stream drainages pass through the property, and all lots on the property are elevated at least approximately 10 feet above the adjacent ephemeral drainages. The basal landslide deposit observed in TP-4 may have been deposited by way of a debris-flow, given its proximity to the ephemeral stream drainage. If so, it likely represents a Pleistocene-aged debris-flow produced under much wetter conditions and a larger available volume of source material than currently exists. Given this information, the debris-flow hazard for the property is considered to be low.

The FEMA flood map that covers the area (FEMA, 2015) shows the entire property to be located outside of the 500-year floodplain for any nearby drainage. Additionally, all of the lots are situated at least approximately 10 feet above the adjacent ephemeral drainages. Given this information, the flooding hazard for the property is considered to be low.

7.7 Shallow Groundwater

Groundwater was not encountered in any of the 7 test pits excavated as part of the original geotechnical investigation for the property (EarthTec, 2008), nor in the 5 test pits excavated as part of this investigation. The geotechnical test pits were excavated in late August, and the geologic hazard test pits were excavated in early to mid-October, so groundwater levels were likely to be dropping toward seasonal lows. The absence of surface water, springs, groundwater in the test pits, and hydrophilic plants on the property suggests that shallow groundwater conditions are not sustained across the property. As such, the risk associated with shallow groundwater hazards is considered to be low for the property. Nevertheless, it is expected that groundwater levels will fluctuate both seasonally and annually across the property. If present, shallow groundwater issues can be mitigated through appropriate grading measures and/or the avoidance of the construction of structures with basements (except where foundation drains are utilized), or through the use of land-drains.

7.8 Radon

Limited data is available to address the radon hazard across the property. However, at least one study (Solomon, 1996) shows the site situated within an area designated as having a moderate radon hazard. To be conservative, the radon hazard associated with the property is considered to be moderate. A site-specific radon hazard assessment is recommended to adequately address radon concerns across the property.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Based upon the data collected and reviewed as part of this assessment, IGES makes the following conclusions regarding the geological hazards present at The Retreat Subdivision project area:

- **The Retreat Subdivision project area does appear to have geological hazards that could potentially adversely affect significant portions of the development as currently proposed. Geological hazards in the form of landslides and other mass-movement processes, including soil creep, are capable of adversely affecting all of the remaining unsold lots on the property. IGES concludes, however, that the geologic conditions are such that appropriate mitigation practices (discussed in the *Recommendations* section below) can reduce the level of landslide/mass movement hazard risk to an acceptable level for development.**

- Landslide hazards are considered to be moderate for the northernmost ~1/3 of the property, including for unsold Lots 30, 31, 34, 38, 39, 42, 43, 44, and 45. This designation is based upon the presence of a shallow landslide unit exhibiting extensive shearing, and the proximity to the visible landslide deposits near the water tank northeast of the property. Landslide hazards are considered to be low to moderate for the remaining unsold lots on the property, including Lots 16, 19, 24, 28, and 29. Though the shallow landslide unit was observed in the test pits excavated near these lots, the shearing was found to be less prevalent and discontinuous.

- The preexisting landslide appears to be stable based on the current location of the slide, measured soil strengths, and limit equilibrium slope stability analysis performed for the existing conditions. Anticipated grading (construction of homes with basements, moderate cuts and fills for grading around the homes, etc.) is not expected to alter the stability of the slope in a meaningful way. Consequently, **the site is considered suitable for the proposed development of single-family residences across the property, provided the recommendations presented in the following paragraphs are followed.**

- Debris-flow and flooding, shallow groundwater, rockfall, and surface-fault-rupture hazards are all considered to be low for the property.

- Earthquake ground shaking and radon are the only hazards that may potentially affect all parts of the project area, while other hazards have the potential to affect only limited portions of the project area, or pose minimal risk.

- Published literature, the site-specific geotechnical report (EarthTec, 2008), and the laboratory results in this geologic hazard assessment indicate that the liquefaction potential for the site is appropriately considered low. However, due to the presence of some granular soils and the possibility of shallow groundwater, the potential for liquefaction occurring at the site cannot be ruled out.

Given the conclusions listed above, IGES makes the following recommendations:

- Foundations shall be placed on competent alluvial soils or structural fill extending to competent alluvial soils; this will require over-excavating below the base of the landslide (where present). Over-excavation need only be performed under exterior continuous foundation elements, not the entire building footprint. Prior to placement of steel or concrete, IGES should observe the foundation excavation to assess compliance with this recommendation and the recommendations for foundation subgrade preparation presented in the geotechnical report (EarthTec, 2008).

- Excavated foundation soils may be utilized for structural fill provided the soils meet the requirements of the referenced geotechnical report by EarthTec (2008). Over-size earth materials (more than 8 inches in greatest dimension) should not be incorporated into structural fill.

- All other recommendations presented in the referenced geotechnical report by EarthTec (2008) should be followed as applicable, except where superseded by site-specific recommendations presented in this report.

- It is recommended that the landscaping for this development consist of xeriscape, so as to minimize the amount of water introduced into the subsurface in these areas. Landscaping that requires intensive watering (e.g. grass or hydrophilic plants) should be avoided or minimized.

- It is critical to minimize the introduction of water into the subsurface to limit the potential for activation of new landslides or the re-activation of existing landslides. To this end, the inclusion of passive land drains as a part of the civil plans would be beneficial. On-site sewage or storm-drain disposal should not be allowed.

- To adequately address the radon hazard for the property, a site-specific radon assessment is recommended. This could be conducted either on a property-wide basis or a lot-by-lot basis.

- The property as a whole may be largely underlain by the Norwood Tuff, which is a known landslide-prone unit. Additionally, landslide deposits have been mapped on and near the property. Therefore, it is recommended that an IGES engineering geologist observe the foundation excavations for all of the proposed residences to assess the absence of landslide evidence or other adverse geologic conditions in these areas, and to assess compliance with the recommendations contained in this report.

9.0 LIMITATIONS

The conclusions and recommendations presented in this report are based on limited geologic literature review, site reconnaissance, subsurface investigation, laboratory testing, and our understanding of the proposed construction and landslide geometry. The subsurface data used in the preparation of this report were obtained from the explorations made for this investigation and the preceding geotechnical investigation for the property (Earthtec, 2008). It is possible that variations in the soil, geologic structure, and groundwater conditions exist between the points explored. The nature and extent of variations may not be evident until construction occurs. If any conditions are encountered at this site that are different from those described in this report, our firm should be immediately notified so that we may make any necessary revisions to recommendations contained in this report. In addition, if the mitigation measures described herein are altered from that described in this report, our firm should also be notified.

This report was prepared in accordance with the generally accepted standard of practice at the time the report was written; no warranty, expressed or implied, is made. Development of property on or adjacent to documented landslide deposits involves an inherent level of risk, regardless of recommended mitigation practices. In our professional opinion, the mitigation practices recommended in this report will reduce the landslide hazard risk to a reasonable level; however, development in a landslide-prone area always assumes some level of risk, and consequently the Client should understand and accept this risk and develop on this site at their own risk and option. It is not possible to predict whether or not other landslide slip surfaces within the landslide masses upon which the property is partially located will reactivate for currently unknown reasons.

Additional geologic hazards and/or geologic hazards initially concluded to pose low risk may be present that may not be identified until construction activities expose adverse geologic conditions. Therefore, the geologic hazard classifications as denoted in this report are potentially subject to change with data collected from additional excavations across the property.

It is the Client's responsibility to see that all parties to the project including the Contractor, Subcontractors, etc. are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the Contractor's option and risk.

10.0 CLOSURE

We appreciate the opportunity to provide you with our services. If you have any questions, please contact the undersigned at your convenience at (801) 748-4044.

Respectfully Submitted,
IGES, Inc.

9325094-2250
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Senior Geologist

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Attachments:

Section 11.0	References	
Appendix A	Figure A-1	General Location Map
	Figure A-2	Regional Geology Map 1
	Figure A-3	Regional Geology Map 2
	Figure A-4	Local Geology Map 1
	Figure A-5	Local Geology Map 2
	Figures A-6 to A-10	Exploration Logs
Appendix B		Laboratory Results
Appendix C		Slope Stability Analysis – Summary

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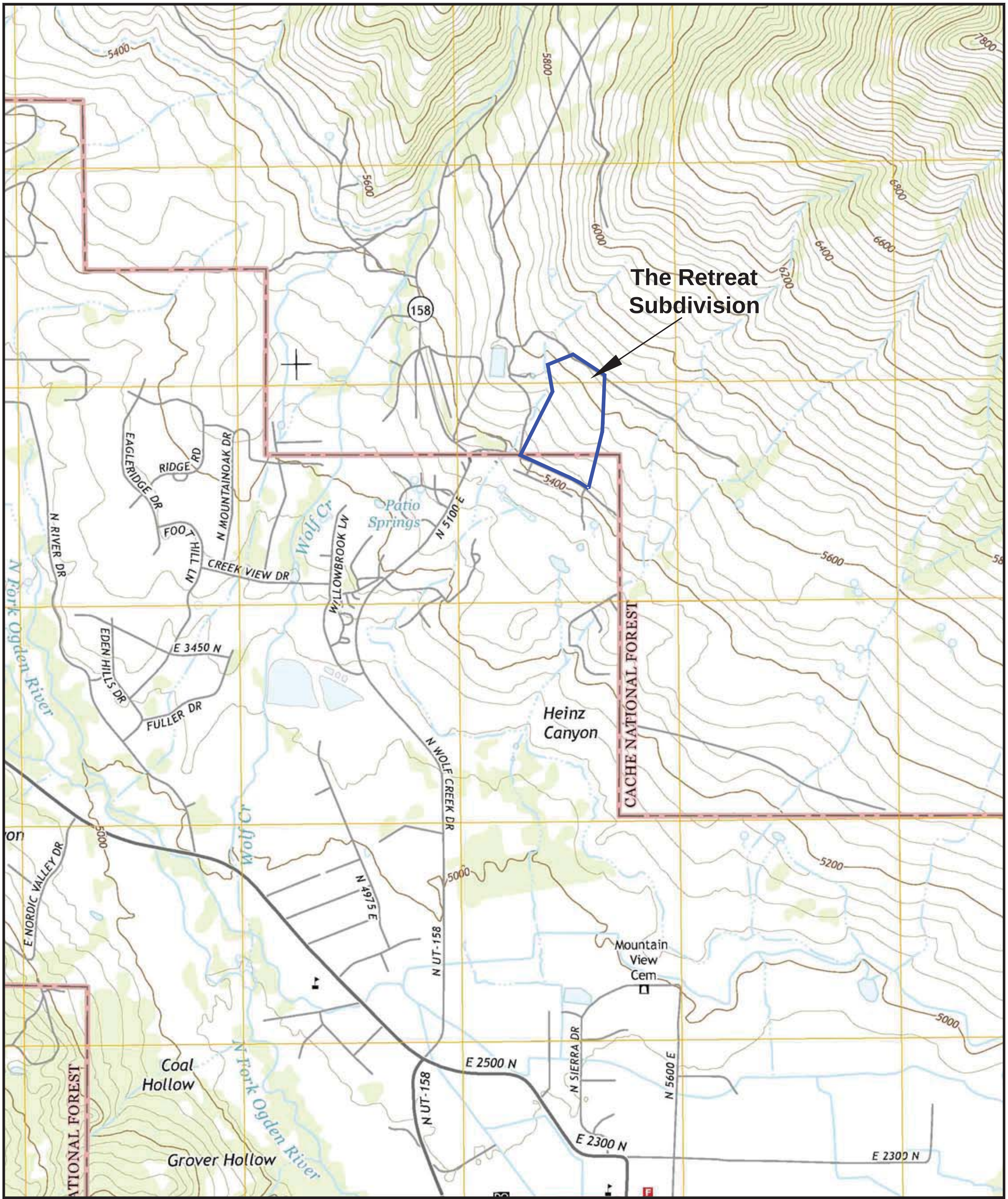
Weber County, 2015, Natural Hazards Overlay Districts, Chapter 27 of Title 104 of the Weber County Code of Ordinances, adopted on December 22, 2015.

AERIAL PHOTOGRAPHS

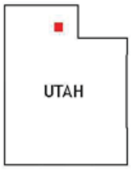
Data Set	Date	Flight	Photographs	Scale
1947 AAJ	August 10, 1946	2B	46, 47	1:20,000
1963 ELK	June 25, 1963	2	169, 170	1:15,840

*https://geodata.geology.utah.gov/imagery/

APPENDIX A



BASE MAP:
USGS Huntsville 7.5-Minute Topographic Quadrangle Map (2014)



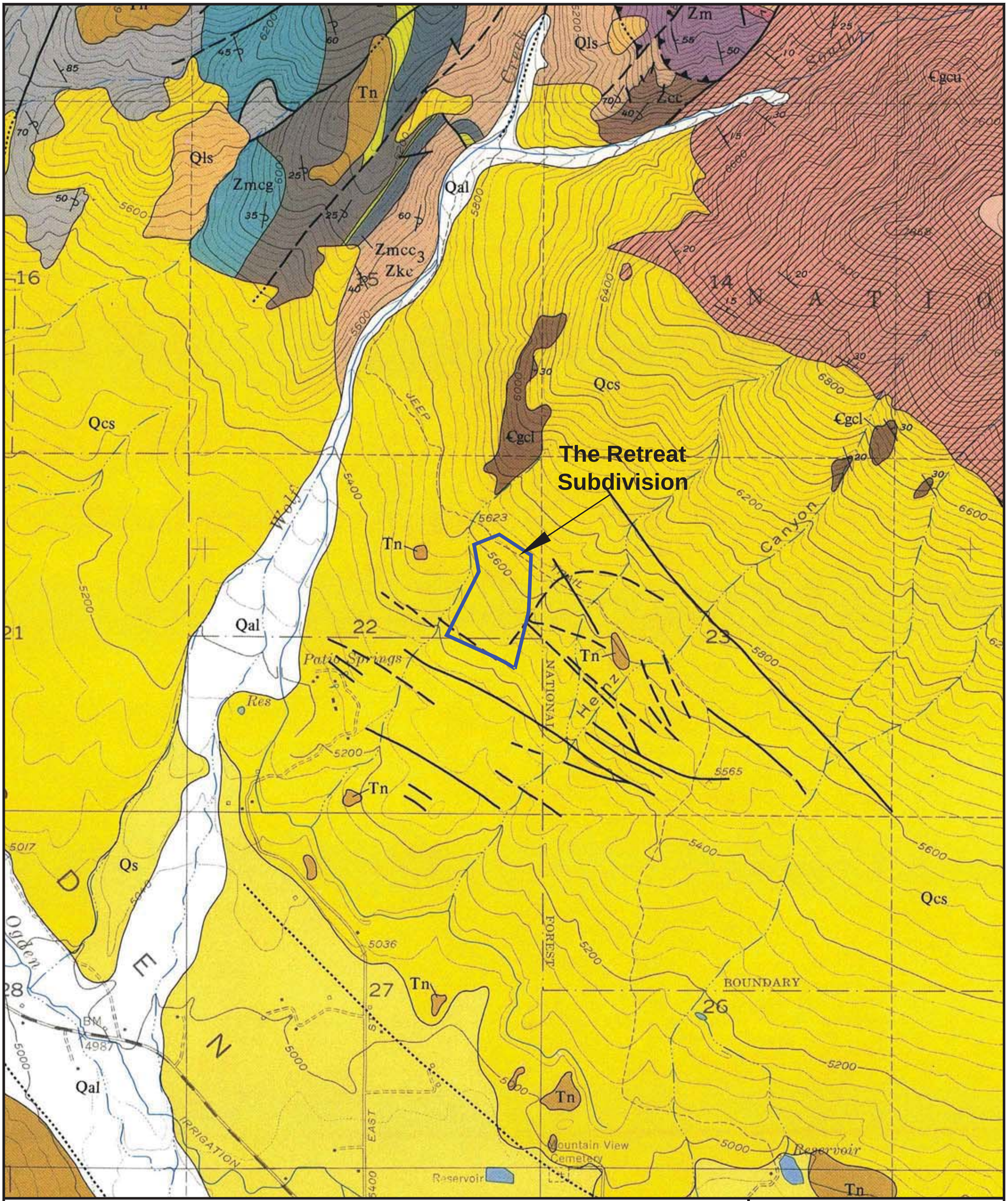
QUADRANGLE LOCATION

FIGURE A-1

GENERAL LOCATION MAP

THE RETREAT SUBDIVISION
WOLF CREEK RESORT
GEOLOGIC HAZARDS ASSESSMENT

DATE: 11/17/2016
PROJECT:02348–002
SCALE: 1"=2,000'
IGES



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USGS Huntsville 7.5-Minute
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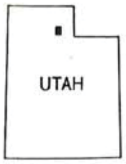
Sorensen and Crittenden, Jr., 1979



QUADRANGLE LOCATION

N

0 1000 2000 3000

FEET

FIGURE A-2a

REGIONAL GEOLOGY MAP 1

THE RETREAT SUBDIVISION
WOLF CREEK RESORT
GEOLOGIC HAZARDS ASSESSMENT

DATE: 11/17/2016
PROJECT:02348-002
SCALE: 1"=2,000'

IGES

MAP LEGEND

Qal	ALLUVIAL DEPOSITS, UNDIFFERENTIATED (Holocene) – Unconsolidated gravel, sand, and silt deposits in presently active stream channels and floodplains; thickness 0-6 m
Qcs	COLLUVIUM AND SLOPEWASH (Holocene) – Bouldery colluvium and slopewash chiefly along eastern margin of Ogden Valley; in part, lag from Tertiary units; thickness 0-30 m
Qf	ALLUVIAL FAN DEPOSITS (Holocene) – Alluvial fan deposits; postdate, at least in part, time of highest stand of former Lake Bonneville; thickness 0-30 m
Qls	LANDSLIDE DEPOSITS (Holocene) – thickness 0-6 m
Qt	TALUS DEPOSITS (Holocene) – thickness 0-6 m
Qtd	TERRACE AND DELTA(?) DEPOSITS (Pleistocene) – In North Fork Ogden River, gravel, sand, and silt in stream terraces graded to high stand of former Lake Bonneville; at mouth of Middle and South Fork Ogden River, pinkish-tan sand and silt in delta(?) remnants deposited during high stands of Lake Bonneville; thickness 0-45 m
Qs	SILT DEPOSITS (Pleistocene) – Tan silt and sand forming extensive flats in Ogden Valley; deposited during high stands of Lake Bonneville, but may include older alluvial units; thickness 0-60 m
Qg	GRAVEL AND COBBLE DEPOSITS (Pleistocene) – In Ogden Canyon, gravel and cobble terrace remnants, probably deposited after time of highest stand of Lake Bonneville; thickness 0-3 m
Qog	OLDER GRAVEL DEPOSITS (Pleistocene) – North of Huntsville, cobble, gravel, and sand deposit that probably predates high stands of Lake Bonneville; thickness 21 m
Tn	NORWOOD TUFF (lower Oligocene and upper Eocene) – Fine- to medium-bedded, fine-grained, friable, white- to buff-weathering tuff and sandy tuff, probably waterlain and in part reworked; thickness 0-450+(?) m

BASE MAP:

USGS Huntsville 7.5-Minute Geologic Quadrangle Map (GQ-1503), Sorensen and Crittenden, Jr. (1979)

QUADRANGLE LOCATION

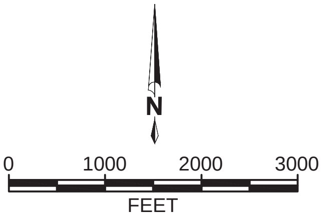


FIGURE A-2b

REGIONAL GEOLOGY MAP 1

THE RETREAT SUBDIVISION
WOLF CREEK RESORT
GEOLOGIC HAZARDS ASSESSMENT

DATE: 11/17/2016
PROJECT:02348–002
SCALE: 1"=2,000'

IGES

MAP LEGEND

GEERTSEN CANYON QUARTZITE (Lower Cambrian) – Includes:

Ꞓgcu Upper member – Pale-buff to white or flesh-pink quartzite, locally streaked with pale red or purple. Coarse-grained; small pebbles occur throughout unit and increase in abundance downward. Base marked by zone 30-60 m thick of cobble conglomerate in beds 30 cm to 2 m thick; clasts, 5-10 cm in diameter, are mainly reddish vein quartz or quartzite, sparse gray quartzite, or red jasper; thickness 730-820 m

Ꞓgcl Lower member – Pale-buff to white and tan quartzite with irregular streaks and lenses of cobble conglomerate decreasing in abundance downward. Lower 90-120 m strongly arkosic, streaked greenish or pinkish. Feldspar clasts increase in size to 0.6-1.3 cm in lower part of unit; thickness 490-520 m

Zkc **ls** **KELLEY CANYON FORMATION** (Precambrian Z) – Upper part interbedded olive-drab siltstone and thin-bedded, tan- or brown-weathering quartzite, generally in wavy or contorted beds cut by small sandstone dikelets; contact with overlying unit may be marked by zone of thin-bedded quartzite (0.5-2-cm beds) with red-weathering wavy laminae of shale and siltstone. Middle part is gray to lavender argillite enclosing and intercalated with thin-bedded pinkish-gray silty limestone (at Middle Fork Ogden River, shown on map as ls). Lower part is lavender-gray, purple-gray, or olive-drab shale, with thin beds of greenish fine-grained sandstone at top. Base of unit marked by 3-m thin-bedded to laminated, tan-weathering, fine-grained dolomite; thickness 600 m

MAPLE CANYON FORMATION (Precambrian Z) – Includes:

Zmcc Conglomerate member – Total thickness 30-150 m. Includes:

Zmcc$_3$ Upper conglomerate – Coarse-grained, locally conglomeratic, white quartzite

Recently active normal fault – Dashed where inferred. Ticks on downthrown side

Pre-Tertiary normal fault – Dotted where concealed Bar and ball on downthrown side

Thrust fault – Dashed where inferred Sawteeth on upper plate

BASE MAP:

USGS Huntsville 7.5-Minute Geologic Quadrangle Map (GQ-1503), Sorensen and Crittenden, Jr. (1979)

QUADRANGLE LOCATION

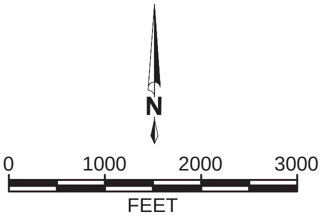
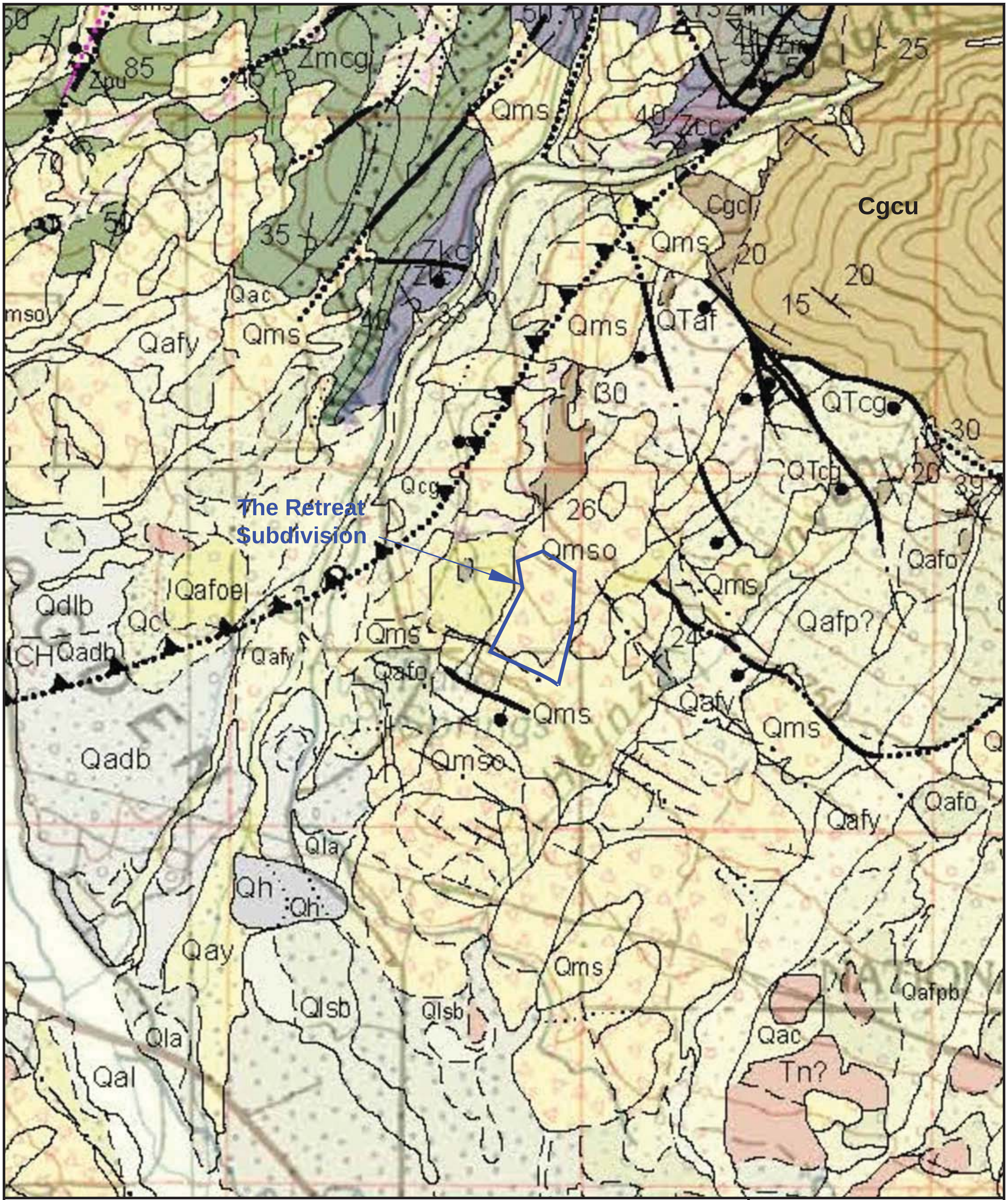


FIGURE A-2c

REGIONAL GEOLOGY MAP 1

THE RETREAT SUBDIVISION
WOLF CREEK RESORT
GEOLOGIC HAZARDS ASSESSMENT

DATE: 11/17/2016
PROJECT:02348-002
SCALE: 1"=2,000'



BASE MAP:

UGS Ogden 30-Minute x 60-Minute Geologic Quadrangle Map (OFR-653) Coogan and King, 2016

N

0 1000 2000 3000
FEET

FIGURE A-3a

REGIONAL GEOLOGY MAP 2

THE RETREAT SUBDIVISION
WOLF CREEK RESORT
GEOLOGIC HAZARDS ASSESSMENT

DATE: 11/17/2016	SCALE:	IGES
PROJECT:02348-002	1"=2,000'	

MAP LEGEND

Qaf1, Qaf2, Qaf2?, Qafy, Qafy?

Younger alluvial-fan deposits (Holocene and uppermost Pleistocene) – Like undivided alluvial fans, but all of these fans are unconsolidated and should be considered active; height above present drainages is low and is within certain limits; generally less than 40 feet (12 m) thick; near former Lake Bonneville, fans are shown as Qafy where Qaf1 and Qaf2 cannot be separated, and all contain well-rounded recycled Lake Bonneville gravel. Younger alluvial fan deposits are queried where relative age is uncertain (see Qaf for details).

Qaf1 fans are active because they impinge on and deflect present-day drainages. Qaf2 fans appear to underlie Qaf1 fans but may be active. Qafy fans are active, impinge on present-day floodplains, divert active streams, overlie low terraces, and/or cap alluvial deposits (Qap) related to the Provo and regressive shorelines. Therefore, Qafy fans are younger than the Provo shoreline and likely mostly Holocene in age, but may be as old as latest Pleistocene and may be partly older than Qaf1 fans.

Qms, Qms?, Qmsy, Qmsy?, Qmso, Qmso?

Landslide deposits (Holocene and upper and middle? Pleistocene) – Poorly sorted clay- to boulder-sized material; includes slides, slumps, and locally flows and floods; generally characterized by hummocky topography, main and internal scarps, and chaotic bedding in displaced blocks; composition depends on local sources; morphology becomes more subdued with time and amount of water in material during emplacement; Qms may be in contact with Qms when landslides are different/distinct; thickness highly variable, up to about 20 to 30 feet (6-9 m) for small slides, and 80 to 100 feet (25-30 m) thick for larger landslides. Qmsy and Qmso queried where relative age uncertain; Qms queried where classification uncertain. Numerous landslides are too small to show at map scale and more detailed maps shown in the index to geologic mapping should be examined.

Qms without a suffix is mapped where the age is uncertain (though likely Holocene and/or late Pleistocene), where portions of slide complexes have different ages but cannot be shown separately at map scale, or where boundaries between slides of different ages are not distinct. Estimated time of emplacement is indicated by relative-age letter suffixes with: Qmsy mapped where landslides deflect streams or failures are in Lake Bonneville deposits, and scarps are variably vegetated; Qmso typically mapped where deposits are "perched" above present drainages, rumpled morphology typical of mass movements has been diminished, and/or younger surficial deposits cover or cut Qmso. Lower perched Qmso deposits are at Qao heights above drainages (95 ka and older) and the higher perched deposits may correlate with high level alluvium (QTa_) (likely older than 780 ka) (see table 1). Suffixes y and o indicate probable Holocene and Pleistocene ages, respectively, with all Qmso likely emplaced before Lake Bonneville transgression. These older deposits are as unstable as other slides, and are easily reactivated with the addition of water, be it irrigation or septic tank drain fields.

— Contact, approximately located
— Contact, approximately located, queried
— Contact, concealed
— Contact, concealed, queried
— Contact, scratch, used where map units combined
— Contact, well located

— Fault, uncertain sense of movement, approximately located
— Fault, uncertain sense of movement, approximately located, queried
— Fault, uncertain sense of movement, concealed
— Fault, uncertain sense of movement, concealed, queried
— Fault, uncertain sense of movement, well located
— Scarp, landslide
— Scarp, terrace
— Scarp, undefined

BASE MAP:

UGS Ogden 30-Minute x 60-Minute
Geologic Quadrangle Map (OFR-653)
Coogan and King, 2016

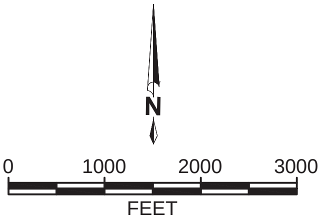
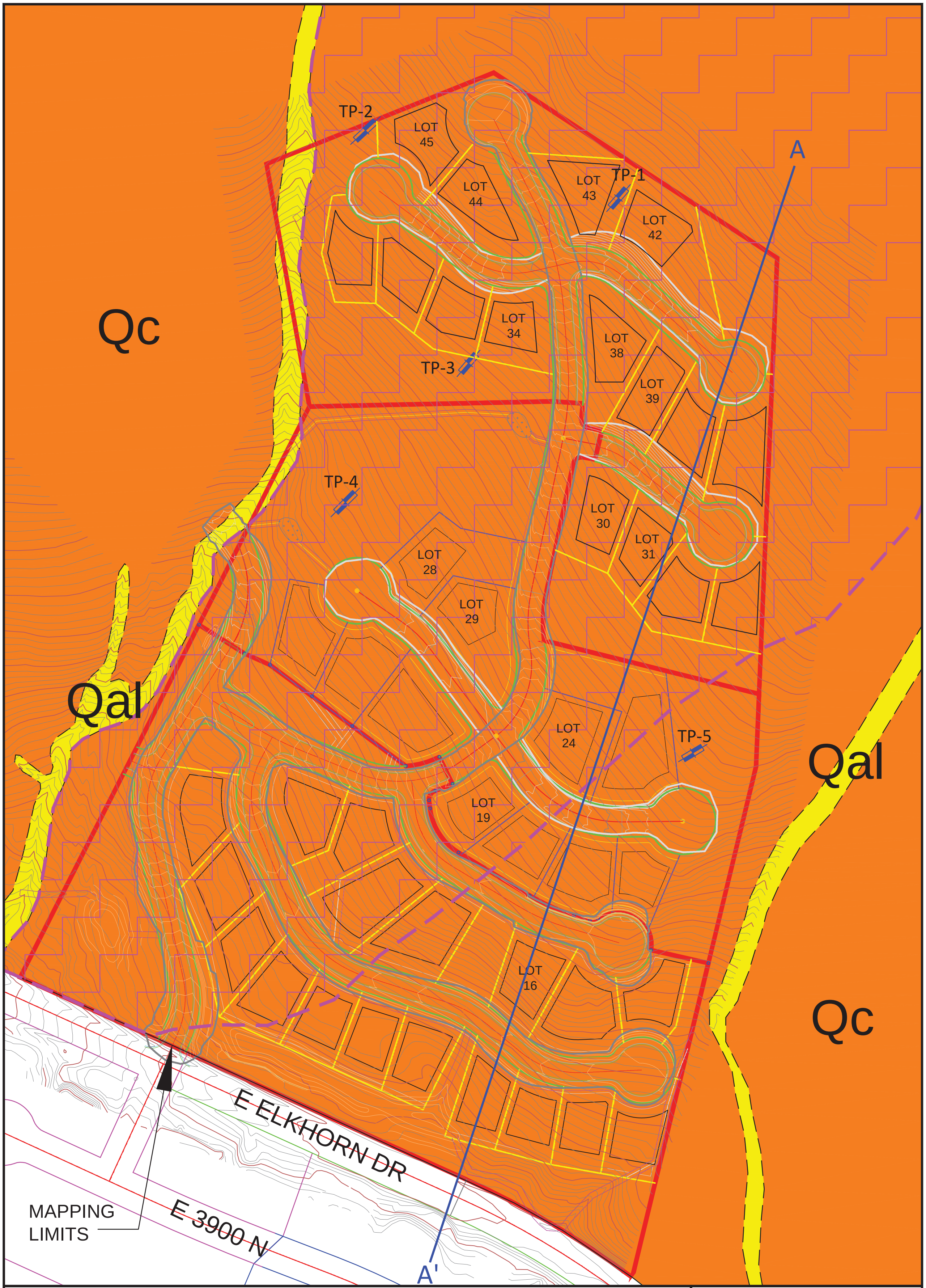


FIGURE A-3b

REGIONAL GEOLOGY MAP 2

THE RETREAT SUBDIVISION
WOLF CREEK RESORT
GEOLOGIC HAZARDS ASSESSMENT

DATE: 11/17/2016
PROJECT:02348–002
SCALE: 1"=2,000'
IGES



LEGEND

🟨 Qal RECENT ALLUVIUM

🟧 Qc COLLUVIUM (HOLOCENE-PLEISTOCENE)

▨ Qlso SHALLOW LANDSLIDE DEPOSITS (PLEISTOCENE); IN SUBSURFACE ONLY

THE RETREAT PROPERTY BOUNDARY

TP-3 TEST PIT LOCATION

– – – ALL CONTACTS APPROXIMATE

A A' CROSS-SECTION LINE

N

0 150
FEET

Basemap provided by Gardner Engineering

FIGURE A-4

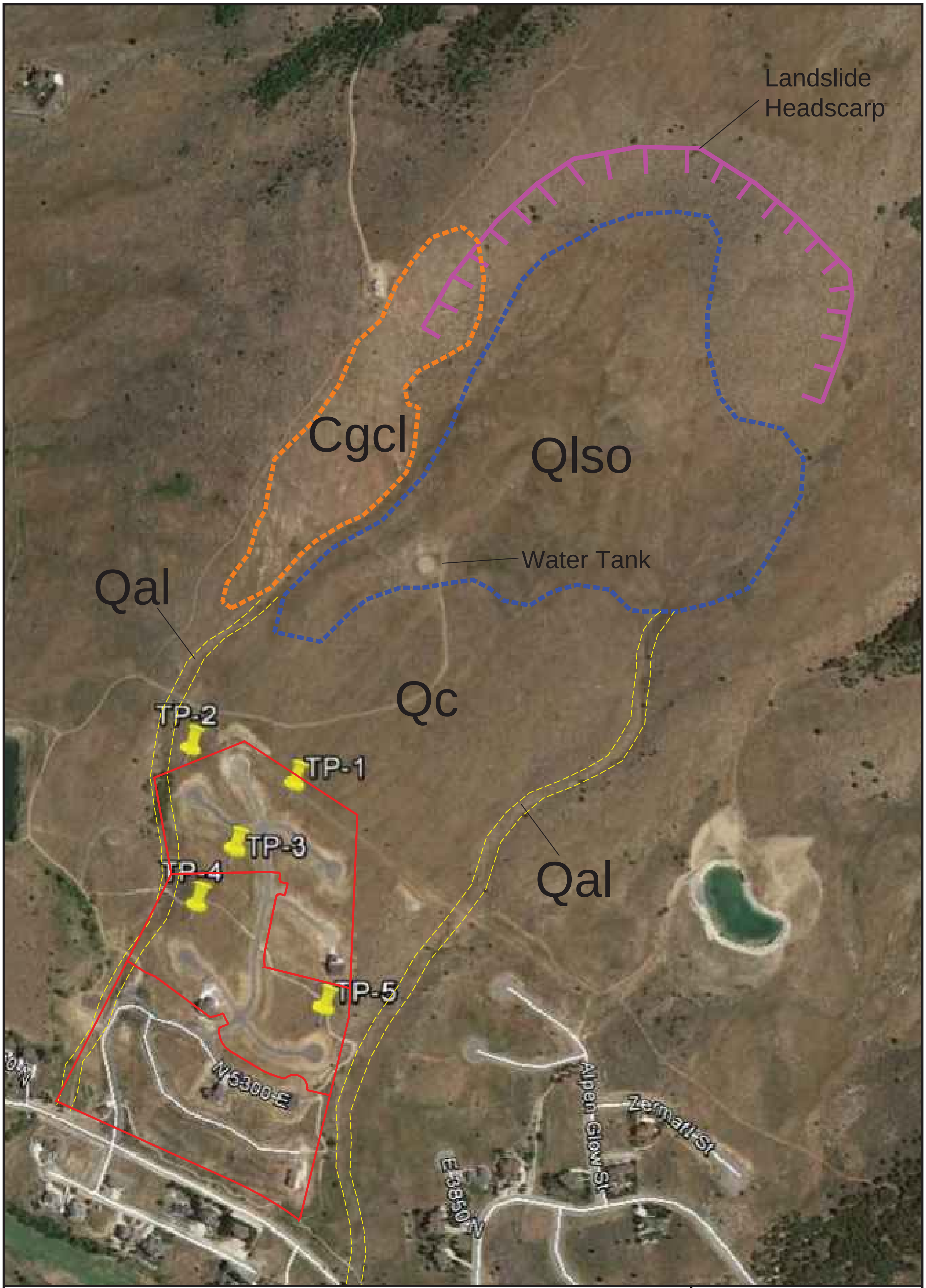
LOCAL GEOLOGY MAP

THE RETREAT SUBDIVISION

GEOLOGIC HAZARD ASSESSMENT
WOLF CREEK RESORT
EDEN, UTAH

DATE: 11/21/2016
PROJECT: 02348-002
SCALE: 1"=150'

IGES



LEGEND

🟨 Qal RECENT ALLUVIUM

Qc COLLUVIUM (HOLOCENE - PLEISTOCENE)

🟦 Qlso SHALLOW LANDSLIDE DEPOSITS
(HOLOCENE - PLEISTOCENE)

🟧 Cgcl GEERTSEN CANYON QUARTZITE,
LOWER MEMEBER (CAMBRIAN)

THE RETREAT
PROPERTY BOUNDARY

– – – ALL CONTACTS
APPROXIMATE

N

0 200 400
FEET

Base image from Google Earth, dated 7/8/16

FIGURE A-5

LOCAL GEOLOGY MAP 2

THE RETREAT SUBDIVISION

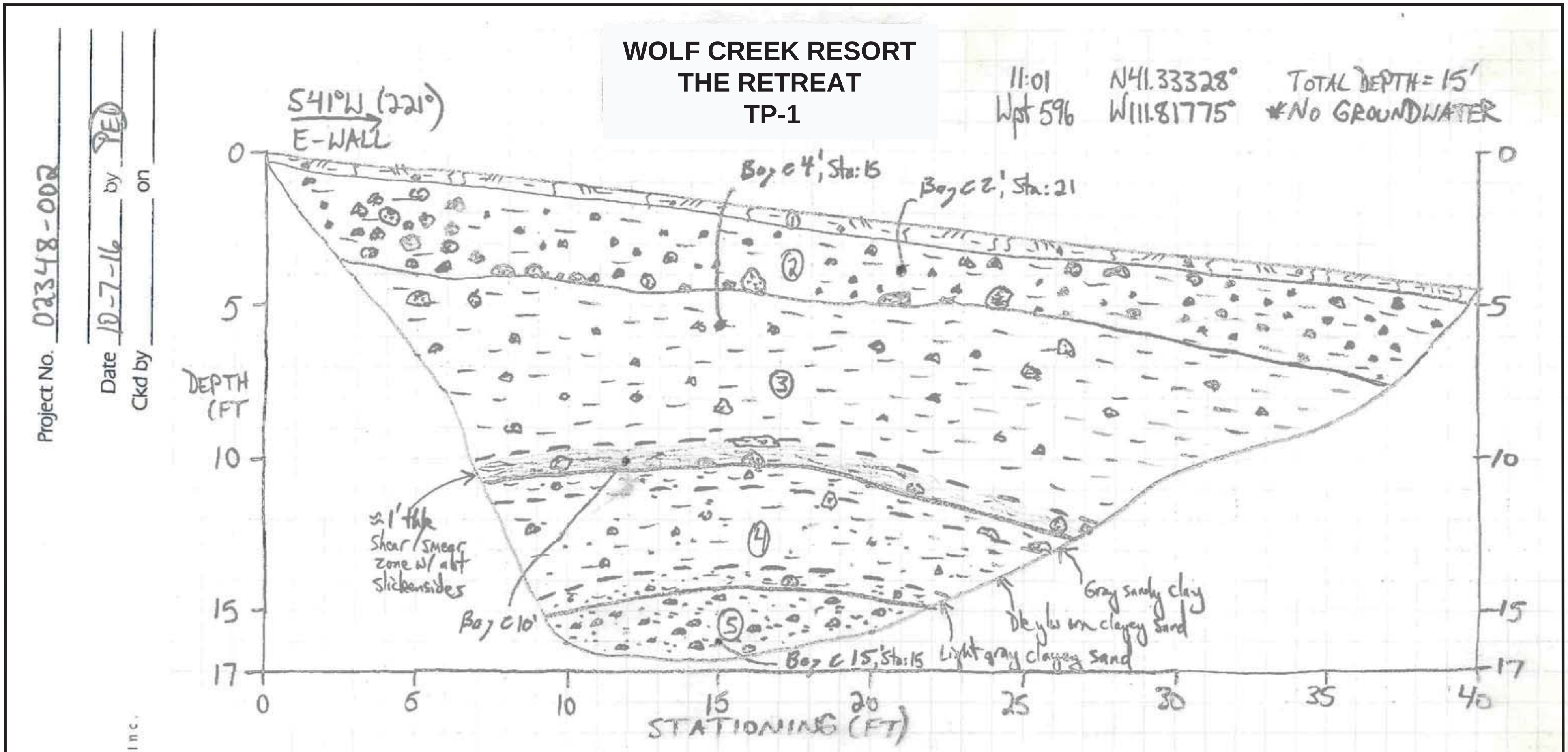
GEOLOGIC HAZARD ASSESSMENT

WOLF CREEK RESORT
EDEN, UTAH

DATE: 11/22/2016
PROJECT: 02348-002
SCALE: 1"=350'

IGES

WOLF CREEK RESORT
THE RETREAT
TP-1



Project No. 02348-002

Date 10-7-16 by PEJ

Ckd by ____ on ____

LITHOLOGIC UNIT DESCRIPTIONS:

1. A/B Soil Horizon: ~3-6" thick; brownish black (5YR 2/1) to grayish brown (5Y 3/2) lean CLAY with gravel (CL), loose, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-20% of unit; clasts entirely subrounded to subangular moderate orange pink (10R 7/4) to medium gray (N5) quartzite up to 9" in diameter; abundant plant and tree roots.

2. Colluvium: ~2-3' thick; dark yellowish brown (10YR 4/2) to grayish brown (5Y 3/2) gravelly lean CLAY (CL) gradational to clayey GRAVEL (GC), loose to medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~40-50% of unit; clasts entirely quartzite as above, up to 14" in diameter, though mode size is ~2-4"; appears to have topsoil between clasts as matrix; matrix-supported, though clasts-supported in places; poorly sorted; basal ~6" of unit is medium stiff and dark reddish brown (10R 3/4), with a low to moderate plasticity; common plant and tree roots; sharp, irregular basal contact with large clasts commonly found at contact.

3. Shallow Landslide: ~6-6.5' thick; light gray (N7) to medium light gray (N6) fat CLAY with gravel (CH), very stiff, slightly moist, high plasticity, massive; basal ~1' is brownish gray (5YR 4/1) and is shear/slide plane littered with natural slickensides and linear shear features, though a single basal slide plane not observed; occasional slickensides noted throughout rest of unit; gravel and larger sized clasts comprise ~30% of unit, and increase in frequency with depth; clasts are predominantly white (N9) to light gray (N7) massive quartzite, though some white possibly hydrothermally altered sandstone; clasts are subangular to subrounded, and up to 1' in diameter, though mode size ~4-6"; sharp, irregular basal contact.

4. Transitional: ~4' thick; medium light gray (N6) to dark yellowish orange (10YR 6/6) to pale yellowish orange (10YR 8/6) sandy fat CLAY with gravel (CH) gradational to clayey SAND with gravel (SC), stiff, slightly moist, moderate plasticity, thickly bedded; gravel and larger sized clasts comprise ~10-15% of unit; clasts as above, up to 7" in diameter, though mode size 3"; becomes sandier with depth; occasional slickensides, though not continuous; sharp, planar basal contact.

5. Alluvium: >2.5' thick; dark yellowish orange (10YR 6/6) to moderate reddish orange (10R 6/6), gravelly SAND (SW), very dense, slightly moist, possibly faintly thinly bedded; gravel and larger sized clasts comprise ~40-50% of unit; clasts entirely quartzite as above, up to 6" in diameter, though mode size 1-3"; moderately sorted; sand is fine to medium-grained.

FIGURE A-6
TP-1 LOG

THE RETREAT SUBDIVISION

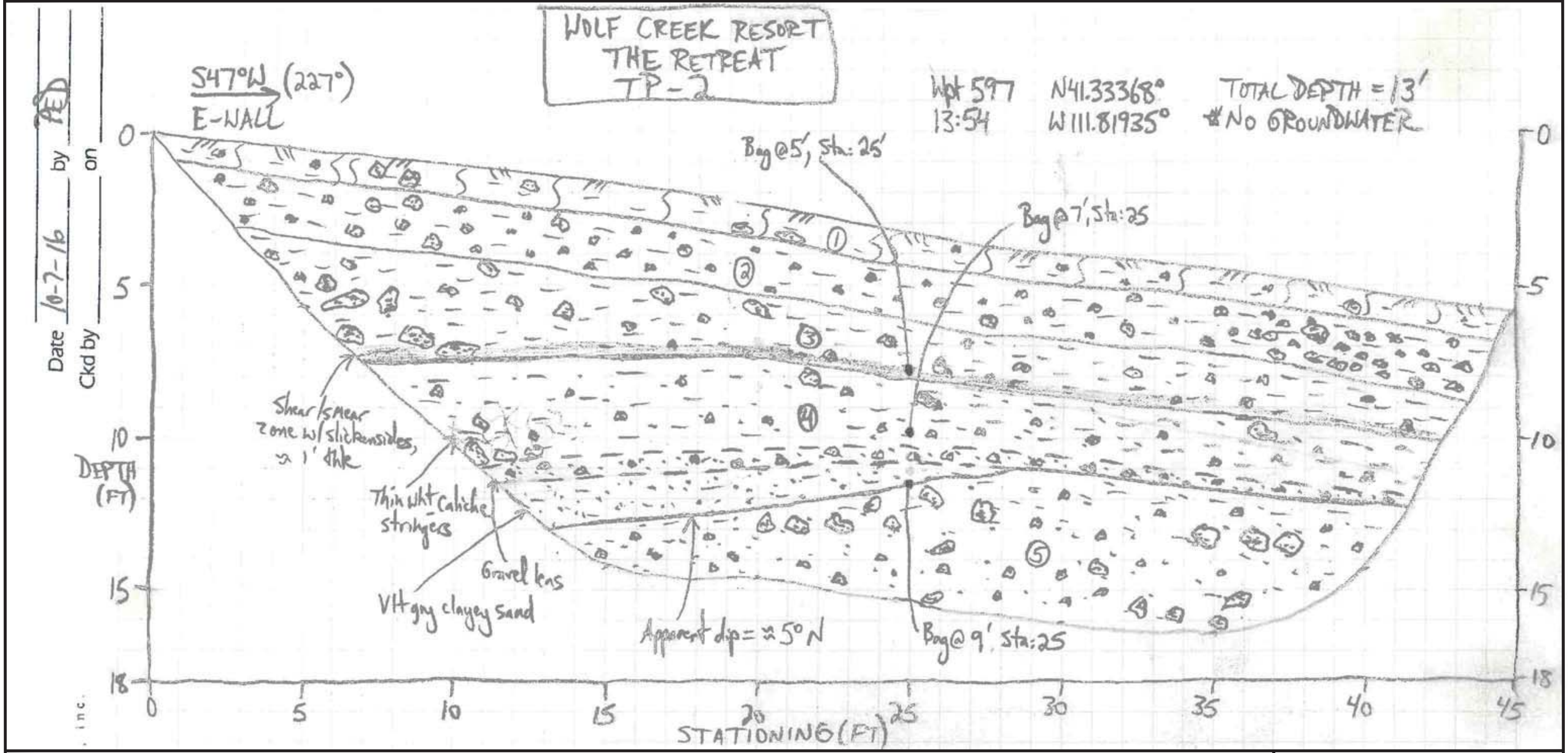
GEOLOGIC
HAZARD ASSESSMENT

WOLF CREEK RESORT

EDEN, UTAH

DATE: 11/17/2016
PROJECT: 02348-002
SCALE: 1"=5'

IGES



LITHOLOGIC UNIT DESCRIPTIONS:

1. A/B Soil Horizon: ~1' thick; brownish black (5YR 2/1) to grayish brown (5Y 3/2) lean CLAY with gravel (CL), loose, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of unit; clasts entirely subrounded to subangular moderate orange pink (10R 7/4) to medium gray (N5) quartzite up to 3' in diameter; abundant plant and tree roots.

2. Colluvium: ~2-2.5' thick; brownish black (5YR 2/1) to dark reddish brown (10R 3/4) gravelly fat CLAY (CH), medium stiff to loose, slightly moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~30-40% of unit; clasts entirely moderate orange pink (10R 7/4) to medium gray (N5) quartzite, subrounded to subangular, up to 16" in diameter, though mode size ~3-4"; largely same as seen in TP-1, except clay is fatter and red component comprises basal ~1-1.5' of unit, with topsoil matrix above; sharp, irregular basal contact.

3. Shallow Landslide: ~2.5-3.5' thick; brownish gray (5YR 4/1) to dark yellowish brown (10YR 4/2) fat CLAY with gravel (CH), very stiff, slightly moist, high plasticity, massive; as seen in TP-1, except darker colored, thinner, and exhibits less prevalent slickensides; shear/smear zone seen in basal ~1' of unit; gravel and larger sized clasts comprise ~15-20% of unit; clasts are entirely subangular to subrounded quartzite as above, up to 14" in diameter; irregularly sorted and largely variable clasts sizes; unit thins downslope; sharp, largely planar basal contact.

4. Transitional: ~3-5' thick; dark yellowish orange (10YR 6/6) to very light gray (N8); uppermost ~1.5-3' is dark yellowish orange sandy fat CLAY with gravel (CH), stiff to very stiff, slightly moist, moderate to high plasticity, massive; contains occasional natural slickensides, though highly variable clay and sand component and slickensides are discontinuous; gravel and larger sized clasts comprise ~5% of this uppermost subunit; middle of the unit is ~4-6" of dark yellowish orange, coarse-grained gravelly SAND (SP) that appears alluvial in origin; basal ~1-1.5' of unit is very light gray fine-grained clayey SAND (SC) that pinches out downslope; this basal subunit contains no clasts, though it appears like a slab of highly weathered quartzite bedrock.

5. Alluvium: >7' thick; dark yellowish orange (10YR 6/6) gravelly SAND (SW), very dense, slightly moist, massive to finely bedded; sand is coarse-grained and largely derived from weathered quartzite; appears generally reversely-graded; gravel and larger sized clasts comprise ~40-50% of unit; clasts entirely subrounded to subangular quartzite up to 13" in diameter, though mode size ~1-3"; slightly clayey in uppermost ~6" of unit; becomes less gravelly (sandier) and finely bedded with depth.

FIGURE A-7
TP-2 LOG

THE RETREAT SUBDIVISION

GEOLOGIC
HAZARD ASSESSMENT

WOLF CREEK RESORT

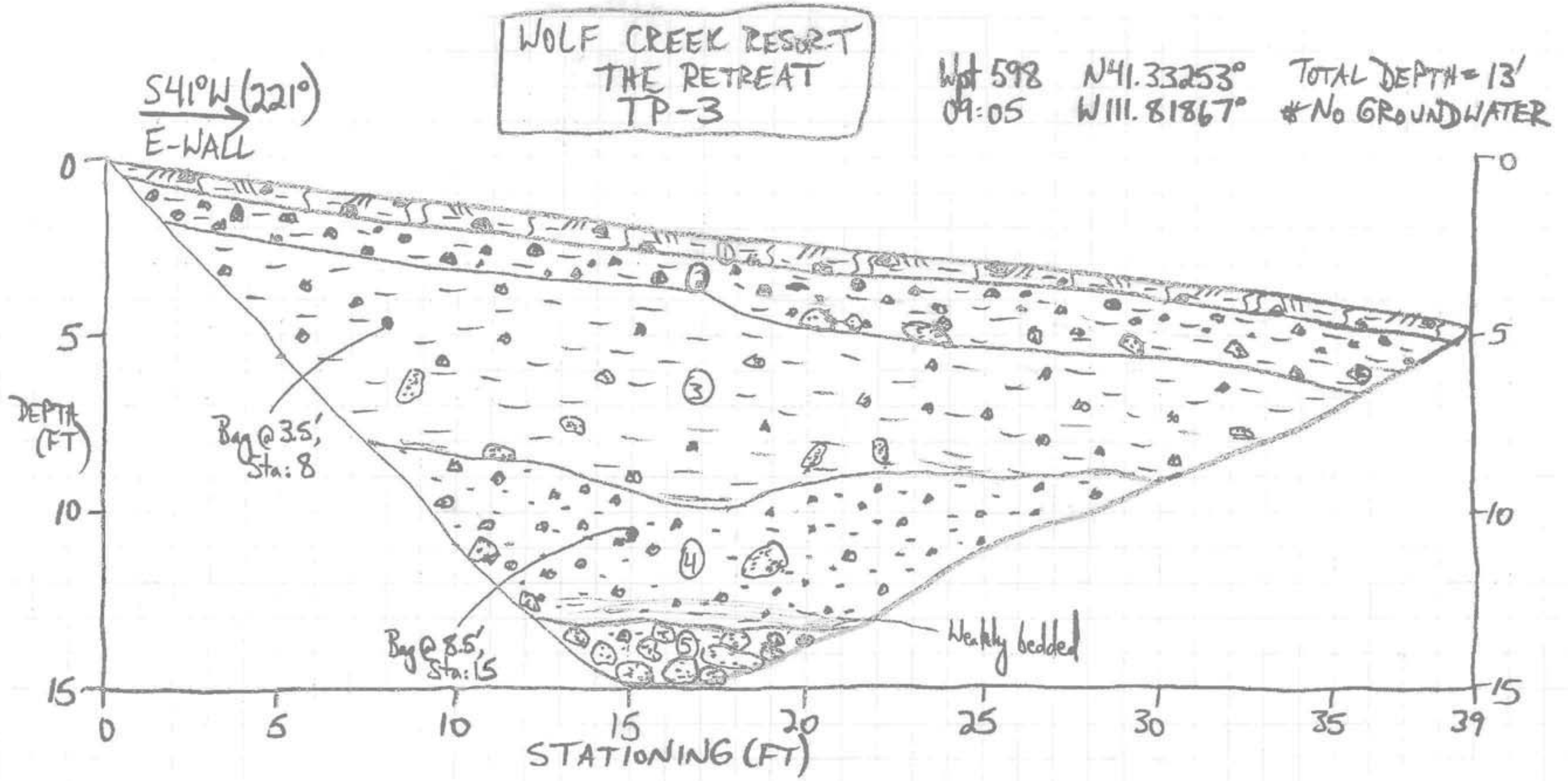
EDEN, UTAH

DATE: 11/18/2016
PROJECT: 02348-002
SCALE: 1"=5'
IGES

Project No. 02348-002

Date 10-10-16 by PED

Ckd by ______ on ______



LITHOLOGIC UNIT DESCRIPTIONS:

1. A/B Soil Horizon: ~3-6" thick; brownish black (5YR 2/1) to grayish brown (5Y 3/2) gravelly lean CLAY (CL), loose, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of unit; clasts entirely subrounded to subangular pale yellowish orange (10YR 8/6) to medium gray (N5) quartzite up to 1.5' in diameter, though mode size ~3-6"; silty; abundant plant and tree roots.

2. Colluvium: ~1-2' thick; dark reddish brown (10R 3/4) to dark yellowish brown (10YR 4/2) gravelly fat CLAY (CH), stiff to medium-stiff, slightly moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~40% of unit; clasts entirely quartzite as above up to 1.5' in diameter, though mode size ~2-4"; matrix-supported; uppermost ~6"-1' matrix is topsoil, though becomes clayey with depth and clay component is fat; poorly sorted; thickens downslope; occasional plant and tree roots; sharp, irregular basal contact.

3. Shallow Landslide: ~3-5' thick; light gray (N7) to light brownish gray (5YR 6/1) fat CLAY with gravel (CH), very stiff to stiff, slightly moist, high plasticity, massive; gravel and larger sized clasts comprise ~20% of unit; clasts consist of medium gray (N5) to moderate orange pink (10R 7/4) to pale yellowish orange (10YR 8/6) quartzite and white (N9), possibly hydrothermally altered sandstone; clasts are subrounded to subangular and up to 2' in diameter, though mode size ~3-6"; blocky texture; occasional natural slickensides, though no clear basal shear zone as seen in TP-1 and TP-2; thins downslope; sharp, irregular basal contact.

4. Alluvium: ~3-4' thick; mottled dark yellowish orange (10YR 6/6) to moderate reddish brown (10R 4/6) to white (N9) gravelly SAND (SW), very dense to dense, slightly moist, finely bedded in basal ~1', otherwise massive; gravel and larger sized clasts comprise ~30-40% of unit and increase in frequency with depth; clasts are roughly equal proportion of medium light gray (N6) massive quartzite and white (N9) hydrothermally altered fine-grained to medium-grained sandstone; clasts are subangular to subrounded and up to 14" in diameter, though mode size ~1-2"; poorly sorted, though basal ~1' is dark reddish brown (10R 3/4) sandy gravel bed with minor clay and is moderately sorted; sand is medium-grained to fine-grained; sharp, wavy basal contact.

5. Fluvial: >2' thick; very light gray (N8) sandy GRAVEL (GW), dense to very dense, dry, possibly faintly bedded; river channel gravel deposits, clast-supported; gravel and larger sized clasts comprise ~85-90% of unit; clasts are a combination of quartzite and sandstone as above up to 2' in diameter, though mode size ~1-3"; clasts are subrounded to subangular; moderately sorted; matrix is fine-grained sand and unit is largely devoid of fines.

FIGURE A-8
TP-3 LOG

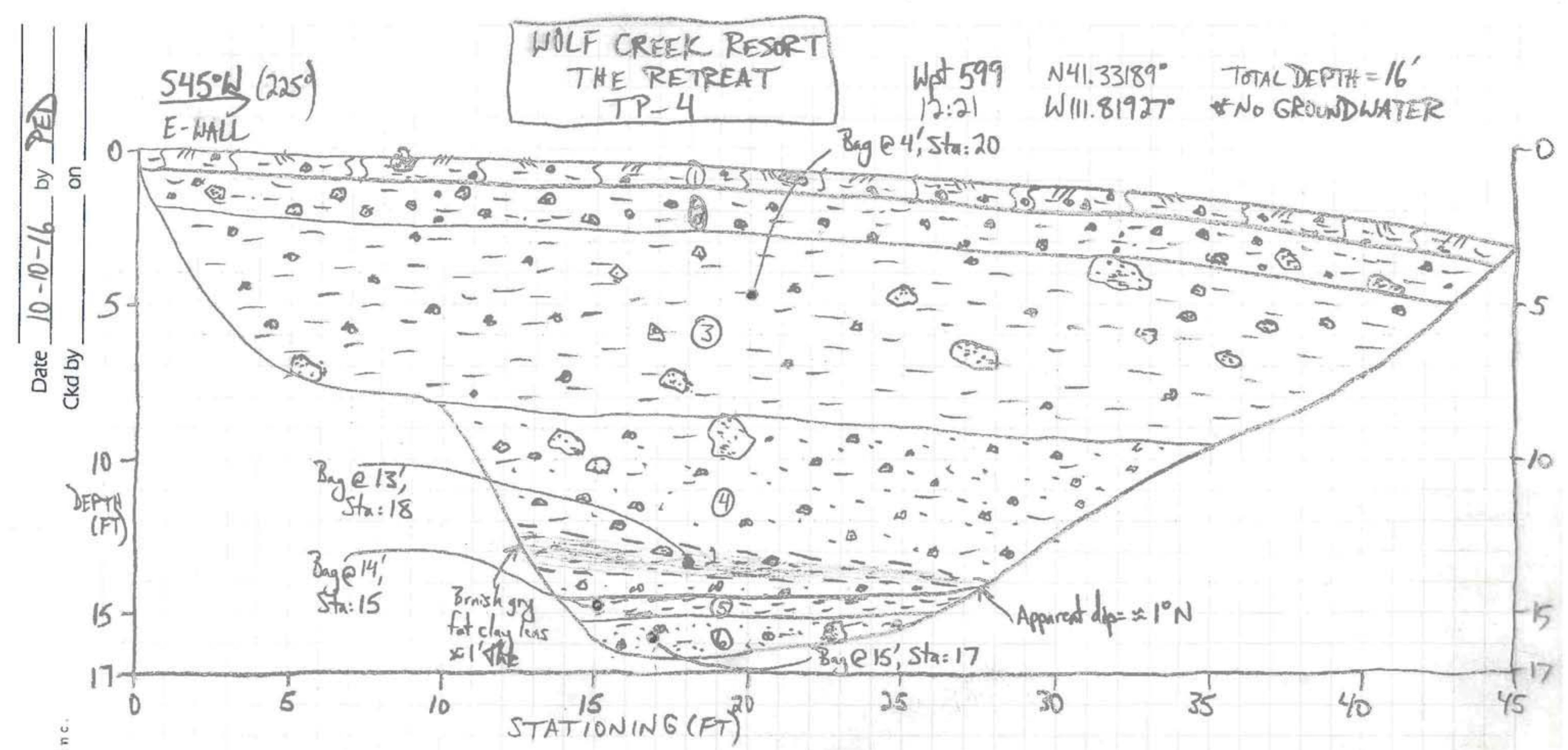
THE RETREAT SUBDIVISION

GEOLOGIC
HAZARD ASSESSMENT

WOLF CREEK RESORT

EDEN, UTAH

DATE: 11/18/2016
PROJECT: 02348-002
SCALE: 1"=5'
IGES



LITHOLOGIC UNIT DESCRIPTIONS:

1. A/B Soil Horizon: ~6" thick; brownish black (5YR 2/1) lean CLAY with gravel (CL), loose to medium-stiff, moist, low plasticity, massive; silty; gravel and larger sized clasts comprise ~15% of unit; clasts entirely subrounded to subangular moderate orange pink (10R 7/4) to medium gray (N5) quartzite up to 2' in diameter, though mode size ~6"; abundant plant and tree roots; gradational, irregular basal contact.

2. Colluvium: ~1-1.5' thick; grayish brown (5Y 3/2) to dark yellowish brown (10YR 4/2) lean CLAY with gravel (CL) gradational to gravelly fat CLAY (CH), medium stiff to loose, moist, moderate plasticity, massive; no reddish brown component as seen in other test pits, though some fat clay present; gravel and larger sized clasts comprise ~30% of unit; clasts entirely quartzite as above up to 2' in diameter, though mode size ~4-6"; matrix-supported, with matrix largely topsoil; silty; occasional to common plant and tree roots; sharp, irregular basal contact.

3. Shallow Landslide 1: ~5-5.5' thick; light brownish gray (5YR 6/1) fat CLAY with gravel (CH), very stiff to stiff, slightly moist, high plasticity, massive; sandy in part, associated with oxidized sandstone clasts which give a dark yellowish orange (10YR 6/6) mottled appearance; very similar to as seen in other test pits, except sandier; poorly sorted; gravel and larger sized clasts comprise ~15-20% of unit; clasts are subangular to subrounded quartzite as above and white (N9) hydrothermally altered sandstone up to 14" in diameter, though mode size ~2-4"; blocky texture and occasional natural slickensides, though not well developed; becomes darker and sand/gravel component increases with depth; gradational, irregular basal contact.

4. Shallow Landslide 2: ~5.5-6' thick; dark yellowish brown (10YR 4/2) to brownish gray (5YR 4/1) to moderate reddish orange (10R 6/6) gravelly SAND with clay (SC) gradational to sandy GRAVEL with clay (GC), dense to very dense, slightly moist, massive; appears like a combination of both transitional and alluvial units underlying shallow landslide clay seen in other test pits, except more chaotic and clayey throughout; gravel and larger-sized clasts comprise ~50-60% of unit, and are up to 1.5' in diameter; clasts entirely quartzite and sandstone as above; slickensides are present where clayey, but discontinuous; largely reversely graded; sharp, planar basal contact.

5. Shear Plane: ~1' thick; light brownish gray (5YR 6/1) sandy fat CLAY (CH), very stiff, moist, high plasticity, massive; blocky texture; well-developed slide surfaces with slickensides at top and bottom contacts; common organic smear; sharp, planar basal contact.

6. Alluvium: >1.5' thick; dark yellowish orange (10YR 6/6) clayey SAND with gravel (SC), dense, moist, low to moderate plasticity, weakly bedded; gravel and larger sized clasts comprise ~15-20% of unit and are up to 1' in diameter; clasts are subangular quartzite and sandstone as above, and commonly highly oxidized and bleached to white (N9) and light brownish gray (5YR 6/1); poorly sorted; clay component is partly fat.

FIGURE A-9
TP-4 LOG

THE RETREAT SUBDIVISION

GEOLOGIC
HAZARD ASSESSMENT

WOLF CREEK RESORT

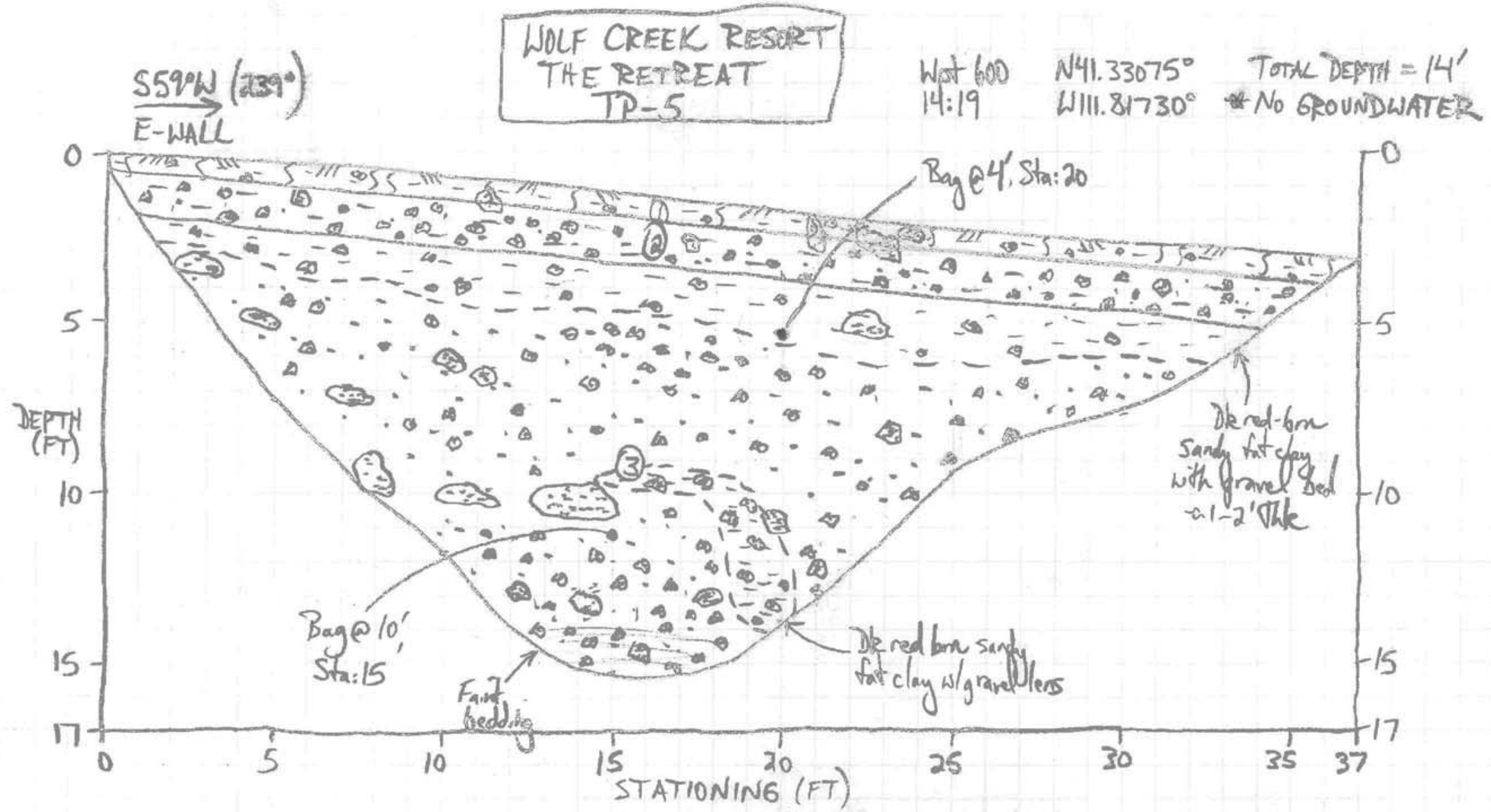
EDEN, UTAH

DATE: 11/18/2016
PROJECT: 02348-002
SCALE: 1"=5'
IGES

Project No. 02348-002

Date 10-10-16 by PED

Ckd by ______ on ______



LITHOLOGIC UNIT DESCRIPTIONS:

1. A/B Soil Horizon: ~4-6" thick; brownish black (5YR 2/1) lean CLAY with gravel (CL), loose to medium-stiff, moist, low plasticity, massive; silty; gravel and larger sized clasts comprise ~30% of unit; clasts entirely subrounded to subangular moderate orange pink (10R 7/4) to medium gray (N5) quartzite up to 2' in diameter, though mode size ~6"; abundant plant and tree roots; gradational, irregular basal contact.

2. Colluvium: ~1-1.5' thick; dark yellowish brown (10YR 4/2) to dark reddish brown (10R 3/4) lean CLAY with gravel (CL), medium stiff to loose, moist, low to moderate plasticity, massive; top ~1/2 of unit is topsoil matrix, while basal ~1/2 of unit is dark reddish brown sandy clay that looks and feels like Wasatch Formation; gravel and larger sized clasts comprise ~40% of unit; clasts entirely subrounded to subangular medium gray (N5) to moderate orange pink (10R 7/4) quartzite up to 1.5' in diameter, though mode size ~3-4"; common plant and tree roots; gradational, planar basal contact.

3. Wasatch Formation?: >12' thick; dark reddish brown (10R 3/4) to dark yellowish orange (10YR 6/6) gravelly SAND (SW) gradational to sandy GRAVEL (GW), dense to very dense, slightly moist, massive; gravel and larger sized clasts comprise ~50-75% of unit; clasts entirely subrounded to subangular quartzite as above and white (N9) hydrothermally altered sandstone up to 2' in diameter, though mode size ~3-6" and tend to be coarser; moderately sorted and weakly bedded with depth; dark reddish brown sandy fat clay with gravel lenses found at top of unit and as irregular lens in middle of unit, and may represent depositional facies changes; gravel content increases with depth; though some fat clay present, no natural slickensides observed.

FIGURE A-10
TP-5 LOG

THE RETREAT SUBDIVISION

GEOLOGIC
HAZARD ASSESSMENT

WOLF CREEK RESORT

EDEN, UTAH

DATE: 11/18/2016	SCALE:
PROJECT: 02348-002	1"=5'

APPENDIX B

Water Content and Unit Weight of Soil

(In General Accordance with ASTM D7263 Method B and D2216)

Project: Wolf Creek Resort/The Retreat
No: 02348-002
Location: Eden, UT
Date: 10/26/2016
By: BSS & BRR

Sample Info.	Boring No.	TP-1	TP-2	TP-2	TP-4				
	Sample								
	Depth	10.0'	5.0'	9.0'	14.0'				
	Split	Yes	No	Yes	No				
	Split sieve	No.4		No.4					
	Total sample (g)	2148.00		3384.76					
	Moist coarse fraction (g)	1221.83		126.39					
	Moist split fraction (g)	926.17		3258.37					
	Sample height, H (in)								
	Sample diameter, D (in)								
	Mass rings + wet soil (g)								
	Mass rings/tare (g)								
	Moist unit wt., γ_m (pcf)								
Coarse Fraction	Wet soil + tare (g)	1534.68		247.88					
	Dry soil + tare (g)	1522.61		245.66					
	Tare (g)	312.85		121.49					
	Water content (%)	1.0		1.8					
Split Fraction	Wet soil + tare (g)	1222.50	551.92	478.15	540.16				
	Dry soil + tare (g)	1064.01	470.50	402.44	409.61				
	Tare (g)	328.29	126.94	121.43	123.06				
	Water content (%)	21.5	23.7	26.9	45.6				
	Water Content, w (%)	**8.9**	**23.7**	**25.8**	**45.6**				
	Dry Unit Wt., γ_d (pcf)								

Entered by:___________

Reviewed:___________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: Wolf Creek Resort/The Retreat
No: 02348-002
Location: Eden, UT
Date: 10/27/2016
By: BRR

Boring No.: TP-1
Sample:
Depth: 10.0'
Description: Reddish brown fat clay

Preparation method: Wet
Liquid limit test method: Multipoint

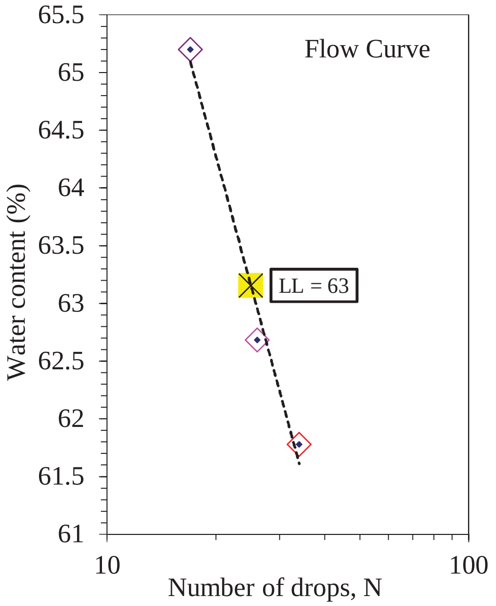
Plastic Limit

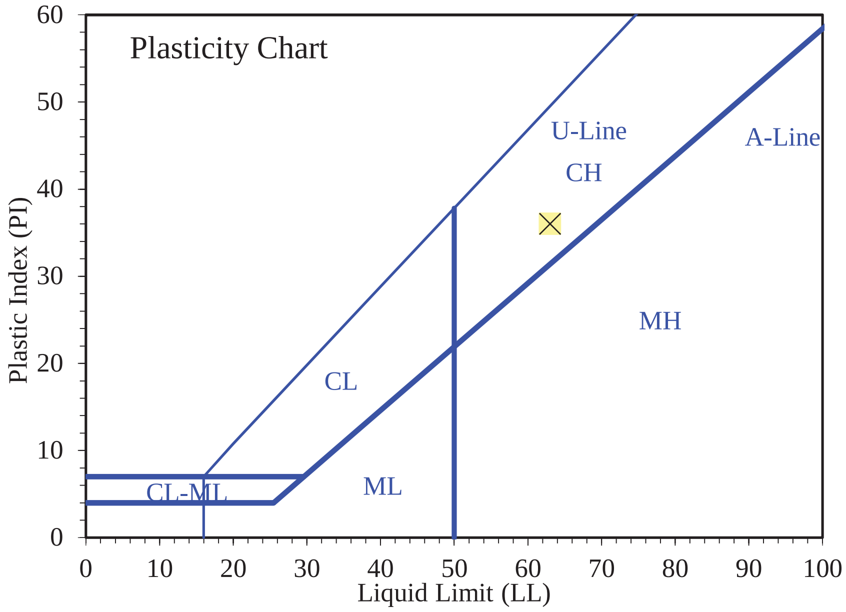
Determination No	1	2			
Wet Soil + Tare (g)	28.84	27.88			
Dry Soil + Tare (g)	27.39	26.59			
Water Loss (g)	1.45	1.29			
Tare (g)	21.96	21.75			
Dry Soil (g)	5.43	4.84			
Water Content, w (%)	26.70	26.65			

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	34	26	17			
Wet Soil + Tare (g)	28.25	29.82	29.81			
Dry Soil + Tare (g)	25.89	26.83	26.55			
Water Loss (g)	2.36	2.99	3.26			
Tare (g)	22.07	22.06	21.55			
Dry Soil (g)	3.82	4.77	5.00			
Water Content, w (%)	61.78	62.68	65.20			
One-Point LL (%)		63				

Liquid Limit, LL (%)	**63**
Plastic Limit, PL (%)	**27**
Plasticity Index, PI (%)	**36**





Entered by:___________
Reviewed:___________

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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: Wolf Creek Resort/The Retreat
No: 02348-002
Location: Eden, UT
Date: 10/27/2016
By: BRR

Boring No.: TP-2
Sample:
Depth: 5.0'
Description: Brown fat clay

Preparation method: Wet
Liquid limit test method: Multipoint

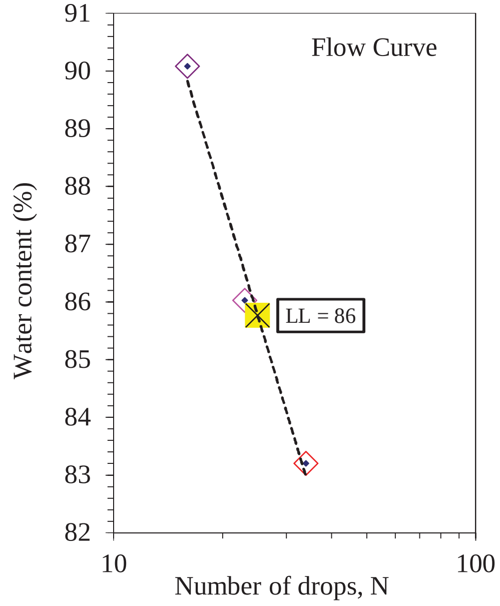
Plastic Limit

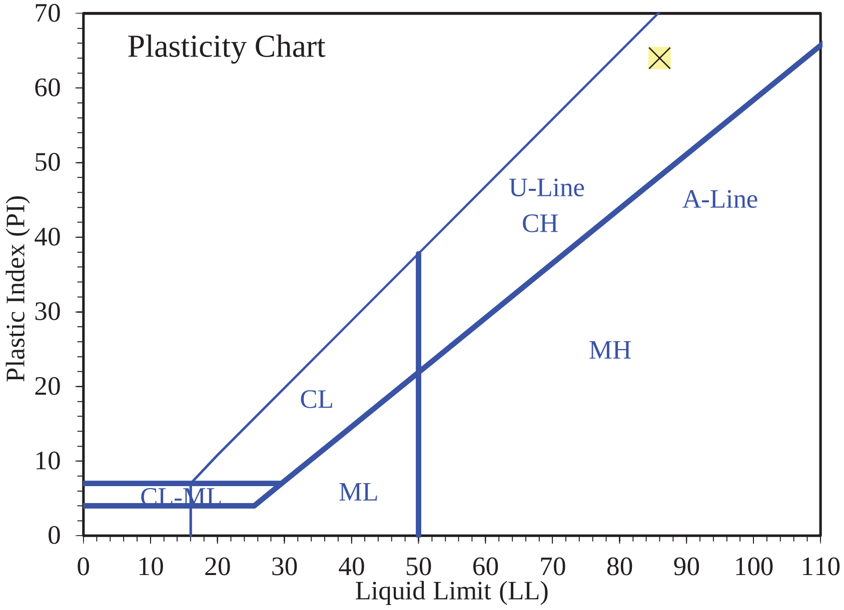
Determination No	1	2				
Wet Soil + Tare (g)	28.07	28.43				
Dry Soil + Tare (g)	26.92	27.27				
Water Loss (g)	1.15	1.16				
Tare (g)	21.52	22.02				
Dry Soil (g)	5.40	5.25				
Water Content, w (%)	21.30	22.10				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	34	23	16			
Wet Soil + Tare (g)	28.81	28.93	29.07			
Dry Soil + Tare (g)	25.59	25.79	25.80			
Water Loss (g)	3.22	3.14	3.27			
Tare (g)	21.72	22.14	22.17			
Dry Soil (g)	3.87	3.65	3.63			
Water Content, w (%)	83.20	86.03	90.08			
One-Point LL (%)		85				

Liquid Limit, LL (%)	**86**
Plastic Limit, PL (%)	**22**
Plasticity Index, PI (%)	**64**





Entered by:____________
Reviewed:____________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: Wolf Creek Resort/The Retreat
No: 02348-002
Location: Eden, UT
Date: 10/27/2016
By: BRR

Boring No.: TP-4
Sample:
Depth: 14.0'
Description: Light brown fat clay

Preparation method: Wet
Liquid limit test method: Multipoint

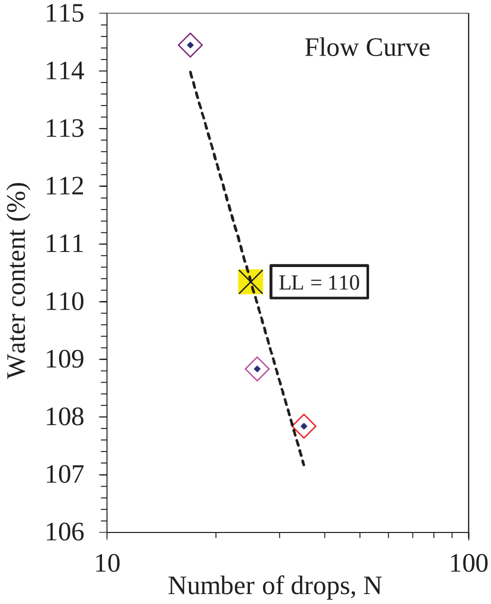
Plastic Limit

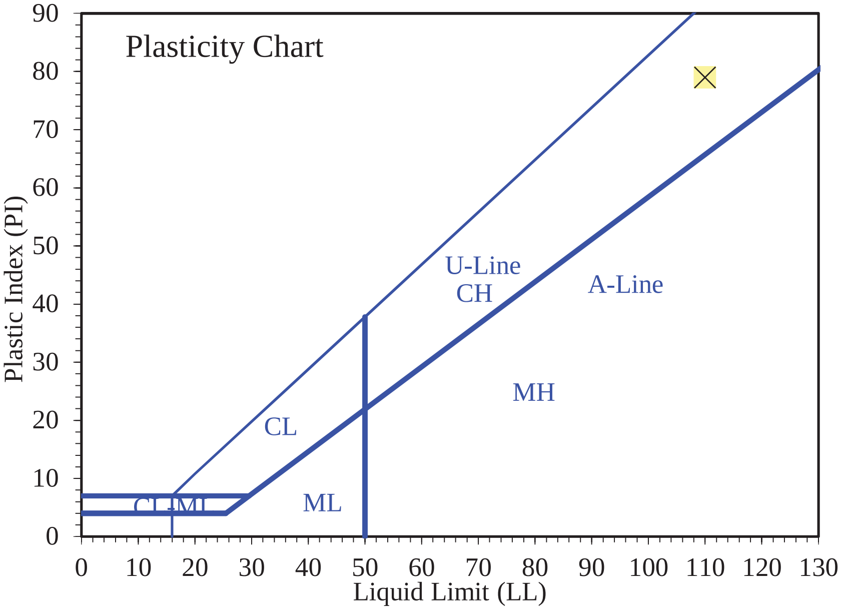
Determination No	1	2				
Wet Soil + Tare (g)	28.78	27.94				
Dry Soil + Tare (g)	27.15	26.53				
Water Loss (g)	1.63	1.41				
Tare (g)	21.85	21.91				
Dry Soil (g)	5.30	4.62				
Water Content, w (%)	30.75	30.52				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	35	26	17			
Wet Soil + Tare (g)	28.14	28.54	29.15			
Dry Soil + Tare (g)	24.84	25.09	25.19			
Water Loss (g)	3.30	3.45	3.96			
Tare (g)	21.78	21.92	21.73			
Dry Soil (g)	3.06	3.17	3.46			
Water Content, w (%)	107.84	108.83	114.45			
One-Point LL (%)		109				

Liquid Limit, LL (%)	**110**
Plastic Limit, PL (%)	**31**
Plasticity Index, PI (%)	**79**





Entered by:____________
Reviewed:____________

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Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

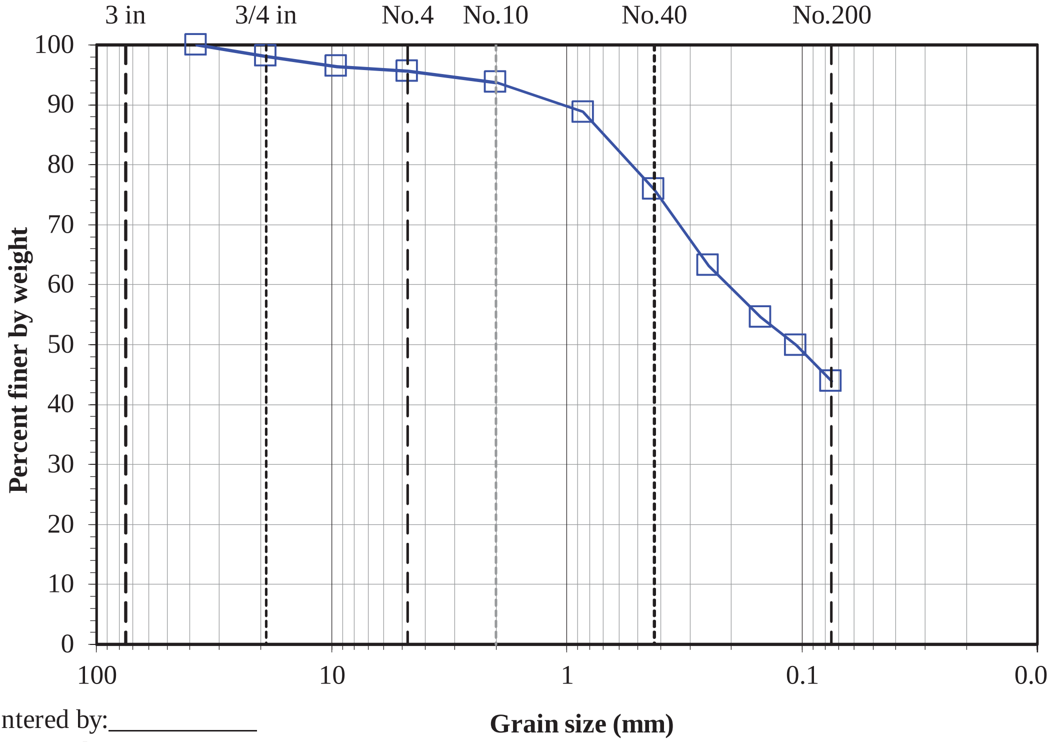
Project: Wolf Creek Resort/The Retreat
No: 02348-002
Location: Eden, UT
Date: 10/27/2016
By: JDF

Boring No.: TP-2
Sample:
Depth: 9.0'
Description: Brown clayey sand

Split:	Yes	
Split sieve:	#4	
	Moist	Dry
Total sample wt. (g):	3258.37	2589.35
+#4 Coarse fraction (g):	115.74	113.71
-#4 Split fraction (g):	356.72	281.01
Split fraction:	0.956	

Water content data	C.F.(+#4)	S.F.(-#4)
Moist soil + tare (g):	247.88	478.15
Dry soil + tare (g):	245.66	402.44
Tare (g):	121.49	121.43
Water content (%):	1.7879	26.9

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	-	
1.5"	-	37.5	100.0	
3/4"	48.97	19	98.1	
3/8"	93.63	9.5	96.4	
No.4	113.71	4.75	95.6	←Split
No.10	5.57	2	93.7	
No.20	20.11	0.85	88.8	
No.40	58.00	0.425	75.9	
No.60	95.41	0.25	63.1	
No.100	120.70	0.15	54.5	
No.140	134.41	0.106	49.9	
No.200	152.10	0.075	43.9	



Gravel (%): 4.4
Sand (%): 51.7
Fines (%): 43.9

Entered by:___________
Reviewed:___________

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

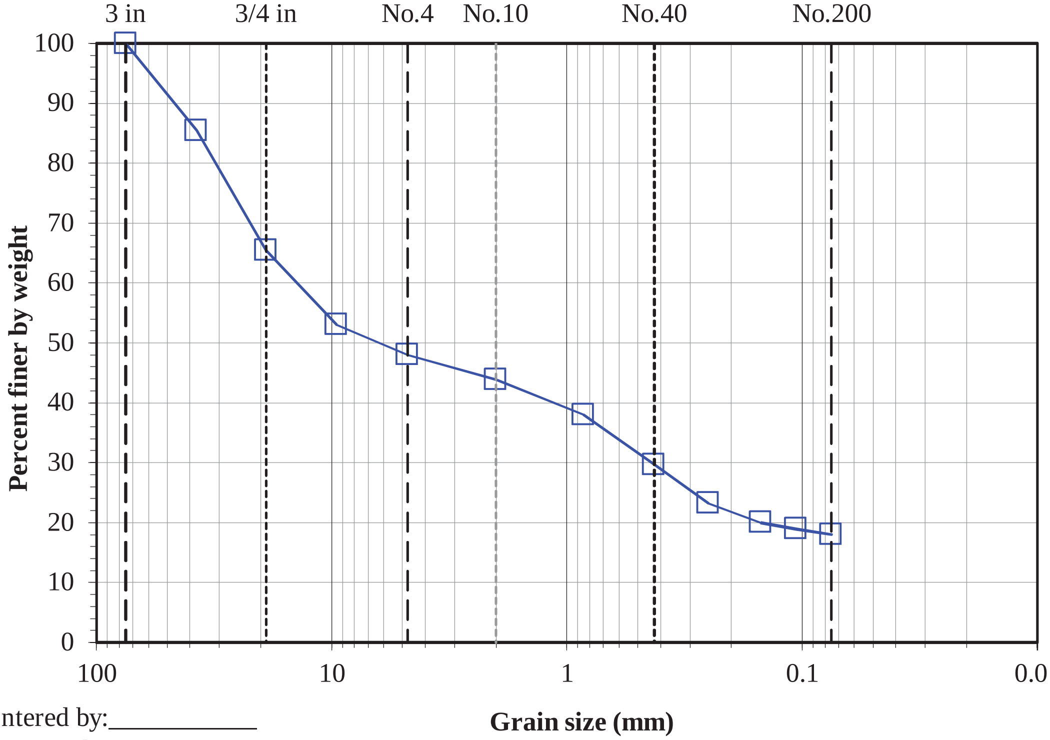
Project: Wolf Creek Resort/The Retreat
No: 02348-002
Location: Eden, UT
Date: 10/27/2016
By: BSS

Boring No.: TP-3
Sample:
Depth: 8.5'
Description: Reddish brown clayey gravel with sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	4585.19	4385.20
+3/8" Coarse fraction (g):	2069.59	2060.69
-3/8" Split fraction (g):	803.28	742.26
Split fraction:	0.530	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	2401.05	1113.92
Dry soil + tare (g):	2392.15	1052.90
Tare (g):	331.46	310.64
Water content (%):	0.4	8.2

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	637.27	37.5	85.5	
3/4"	1513.75	19	65.5	
3/8"	2060.69	9.5	53.0	←Split
No.4	70.30	4.75	48.0	
No.10	128.42	2	43.8	
No.20	210.37	0.85	38.0	
No.40	326.61	0.425	29.7	
No.60	416.92	0.25	23.2	
No.100	461.76	0.15	20.0	
No.140	477.25	0.106	18.9	
No.200	490.51	0.075	18.0	



Gravel (%): 52.0
Sand (%): 30.0
Fines (%): 18.0

Entered by:___________
Reviewed:___________

Amount of Material in Soil Finer than the No. 200 (75µm) Sieve

(ASTM D1140)

IGES

Project: **Wolf Creek Resort/The Retreat**
No: **02348-002**
Location: Eden, UT
Date: 10/27/2016
By: BSS

Sample Info.	Boring No.	TP-1	TP-4	TP-5					
	Sample								
	Depth	14.0'	15.0'	10.0'					
	Split	Yes	Yes	Yes					
	Split Sieve*	3/8"	3/8"	3/8"					
	Method	B	B	B					
	Specimen soak time (min)	420	450	430					
	Moist total sample wt. (g)	4027.60	2826.65	3143.99					
	Moist coarse fraction (g)	1720.60	1307.73	1593.99					
	Moist split fraction + tare (g)	878.97	767.62	711.73					
	Split fraction tare (g)	310.40	410.38	326.66					
	Dry split fraction (g)	536.70	300.31	361.48					
	Dry retained No. 200 + tare (g)	752.90	588.65	590.02					
	Wash tare (g)	310.40	410.38	326.66					
	No. 200 Dry wt. retained (g)	442.50	178.27	263.36					
	Split sieve* Dry wt. retained (g)	1708.75	1286.13	1581.63					
	Dry total sample wt. (g)	3886.44	2562.99	3036.67					
Coarse Fraction	Moist soil + tare (g)	2031.62	1739.12	2002.72					
	Dry soil + tare (g)	2019.77	1715.81	1990.36					
	Tare (g)	311.02	328.07	408.73					
	Water content (%)	0.69	1.68	0.78					
Split Fraction	Moist soil + tare (g)	878.97	767.62	711.73					
	Dry soil + tare (g)	847.10	710.69	688.14					
	Tare (g)	310.40	410.38	326.66					
	Water content (%)	5.94	18.96	6.53					
	Percent passing split sieve* (%)	**56.0**	**49.8**	**47.9**					
	Percent passing No. 200 sieve (%)	**9.8**	**20.2**	**13.0**					

Entered by:___________
Reviewed:___________

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: Wolf Creek Resort/The Retreat
No: 02348-002
Location: Eden, UT
Date: 10/27/2016
By: JDF

Boring No.: TP-2
Sample:
Depth: 9.0'
Sample Description: Brown clayey sand
Sample type: Arbitrary remold

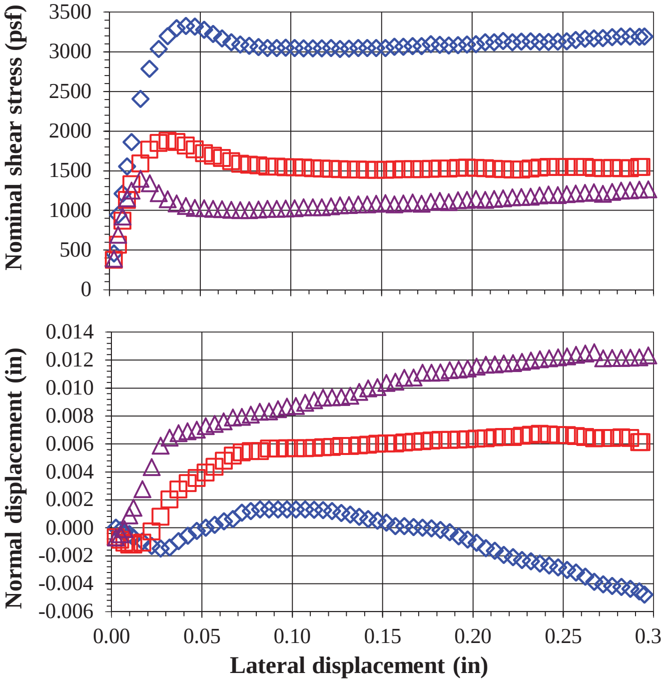
Test type: Inundated
Lateral displacement (in.): 0.3
Shear rate (in./min): 0.0007
Specific gravity, Gs: 2.70 Assumed

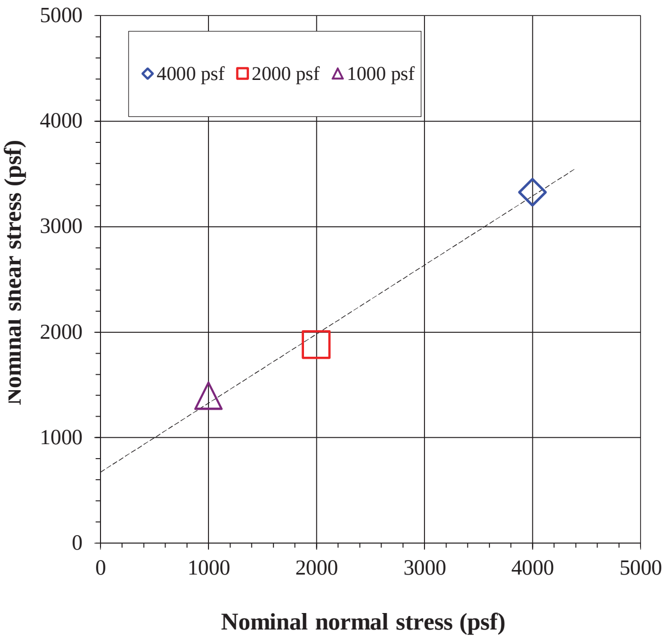
	Sample 1		Sample 2		Sample 3	
Nominal normal stress (psf)	4000		2000		1000	
Peak shear stress (psf)	3325		1879		1396	
Lateral displacement at peak (in)	0.042		0.032		0.017	
Load Duration (min)	896		935		965	
	Initial	Pre-shear	Initial	Pre-shear	Initial	Pre-shear
Sample height (in)	1.0000	0.9798	1.0000	0.9910	1.0000	0.9971
Sample diameter (in)	2.416	2.416	2.416	2.416	2.416	2.416
Wt. rings + wet soil (g)	184.32	187.27	183.34	187.14	183.03	187.29
Wt. rings (g)	44.14	44.14	43.16	43.16	42.85	42.85
Wet soil + tare (g)	478.15		478.15		478.15	
Dry soil + tare (g)	402.44		402.44		402.44	
Tare (g)	121.43		121.43		121.43	
Water content (%)	26.9	29.6	26.9	30.4	26.9	30.8
Dry unit weight (pcf)	91.8	93.6	91.8	92.6	91.8	92.0
Void ratio, e, for assumed Gs	0.84	0.80	0.84	0.82	0.84	0.83
Saturation (%)*	86.9	100.0	86.9	100.0	86.9	100.0

ϕ' (deg)	33
c' (psf)	673

Average of 3 samples	Initial	Pre-shear
Water content (%)	26.9	30.3
Dry unit weight (pcf)	91.8	92.7

*Pre-shear saturation set to 100% for phase calculations





Comments:
Specimens swelled upon inundation.

Entered by:___________
Reviewed:___________

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: Wolf Creek Resort/The Retreat
No: 02348-002
Location: Eden, UT

Boring No.: TP-2
Sample:
Depth: 9.0'

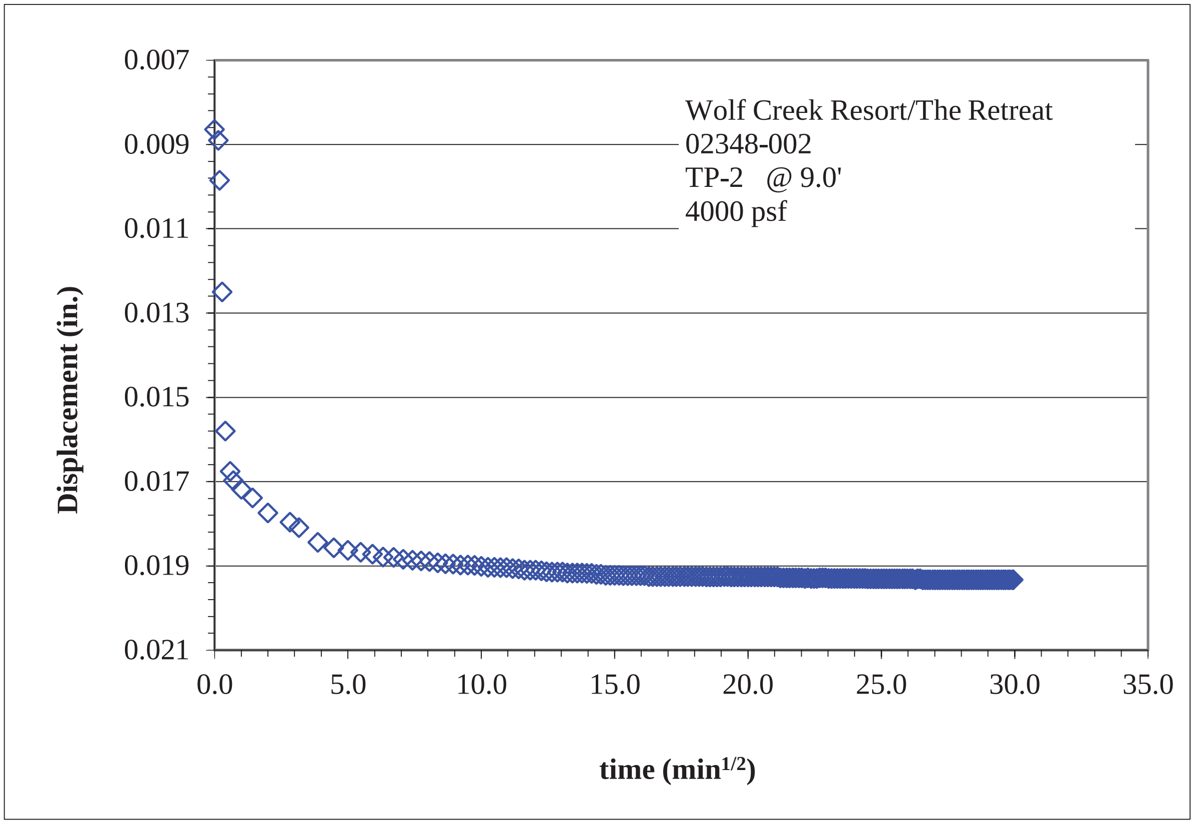
Nominal normal stress = 4000 psf			Nominal normal stress = 2000 psf			Nominal normal stress = 1000 psf		
Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)
0.002	457	0.000	0.002	375	-0.001	0.002	388	-0.001
0.005	942	0.000	0.005	566	-0.001	0.005	690	0.000
0.007	1210	0.000	0.007	870	-0.001	0.007	923	0.000
0.010	1553	0.000	0.010	1133	-0.001	0.010	1153	0.001
0.012	1860	-0.001	0.012	1329	-0.001	0.012	1249	0.001
0.017	2407	-0.001	0.017	1590	-0.001	0.017	1396	0.003
0.022	2784	-0.001	0.022	1765	0.000	0.022	1342	0.004
0.027	3034	-0.001	0.027	1849	0.001	0.027	1216	0.006
0.032	3196	-0.001	0.032	1879	0.002	0.032	1141	0.006
0.037	3297	-0.001	0.037	1862	0.003	0.037	1085	0.007
0.042	3325	-0.001	0.042	1817	0.003	0.042	1053	0.007
0.047	3320	0.000	0.047	1768	0.004	0.047	1032	0.007
0.052	3279	0.000	0.052	1722	0.004	0.052	1027	0.007
0.057	3225	0.000	0.057	1689	0.004	0.057	1017	0.007
0.062	3171	0.000	0.062	1659	0.005	0.062	1012	0.008
0.067	3122	0.001	0.067	1621	0.005	0.067	1006	0.008
0.072	3093	0.001	0.072	1588	0.005	0.072	1001	0.008
0.077	3075	0.001	0.077	1574	0.005	0.077	1003	0.008
0.082	3062	0.001	0.082	1566	0.005	0.082	1011	0.008
0.087	3049	0.001	0.087	1551	0.006	0.087	1017	0.008
0.092	3049	0.001	0.092	1549	0.006	0.092	1019	0.008
0.097	3052	0.001	0.097	1543	0.006	0.097	1023	0.009
0.102	3047	0.001	0.102	1542	0.006	0.102	1027	0.009
0.107	3042	0.001	0.107	1540	0.006	0.107	1037	0.009
0.112	3044	0.001	0.112	1529	0.006	0.112	1038	0.009
0.117	3044	0.001	0.117	1526	0.006	0.117	1037	0.009
0.122	3047	0.001	0.122	1521	0.006	0.122	1052	0.009
0.127	3036	0.001	0.127	1520	0.006	0.127	1063	0.009
0.132	3039	0.001	0.132	1514	0.006	0.132	1068	0.009
0.137	3047	0.001	0.137	1514	0.006	0.137	1074	0.010
0.142	3047	0.001	0.142	1511	0.006	0.142	1074	0.010
0.147	3047	0.001	0.147	1509	0.006	0.147	1081	0.010
0.152	3047	0.000	0.152	1512	0.006	0.152	1089	0.010
0.157	3065	0.000	0.157	1515	0.006	0.157	1076	0.010
0.162	3065	0.000	0.162	1517	0.006	0.162	1088	0.011
0.167	3072	0.000	0.167	1518	0.006	0.167	1098	0.011
0.172	3072	0.000	0.172	1519	0.006	0.172	1084	0.011
0.177	3096	0.000	0.177	1521	0.006	0.177	1106	0.011
0.182	3088	0.000	0.182	1526	0.006	0.182	1117	0.011
0.187	3080	0.000	0.187	1528	0.006	0.187	1103	0.011
0.192	3083	-0.001	0.192	1535	0.006	0.192	1126	0.011
0.197	3091	-0.001	0.197	1537	0.006	0.197	1133	0.011
0.202	3098	-0.001	0.202	1536	0.006	0.202	1145	0.012
0.207	3119	-0.001	0.207	1531	0.006	0.207	1131	0.012
0.212	3122	-0.002	0.212	1522	0.006	0.212	1142	0.012
0.217	3137	-0.002	0.217	1520	0.006	0.217	1152	0.012
0.222	3122	-0.002	0.222	1514	0.006	0.222	1162	0.012
0.227	3129	-0.002	0.227	1513	0.007	0.227	1166	0.012
0.232	3132	-0.002	0.232	1525	0.007	0.232	1170	0.012
0.237	3124	-0.003	0.237	1540	0.007	0.237	1187	0.012
0.242	3124	-0.003	0.242	1546	0.007	0.242	1199	0.012
0.247	3129	-0.003	0.247	1548	0.007	0.247	1190	0.012
0.252	3134	-0.003	0.252	1548	0.007	0.252	1204	0.012
0.257	3147	-0.003	0.257	1547	0.007	0.257	1211	0.012
0.262	3165	-0.004	0.262	1547	0.006	0.262	1221	0.012
0.267	3171	-0.004	0.267	1536	0.006	0.267	1226	0.013
0.272	3173	-0.004	0.272	1529	0.006	0.272	1209	0.012
0.277	3186	-0.004	0.277	1535	0.006	0.277	1230	0.012
0.282	3194	-0.004	0.282	1531	0.006	0.282	1248	0.012
0.287	3194	-0.004	0.287	1531	0.006	0.287	1253	0.012
0.292	3191	-0.005	0.292	1545	0.006	0.292	1262	0.012
0.295	3194	-0.005	0.293	1548	0.006	0.297	1265	0.012
						0.300	1266	0.012

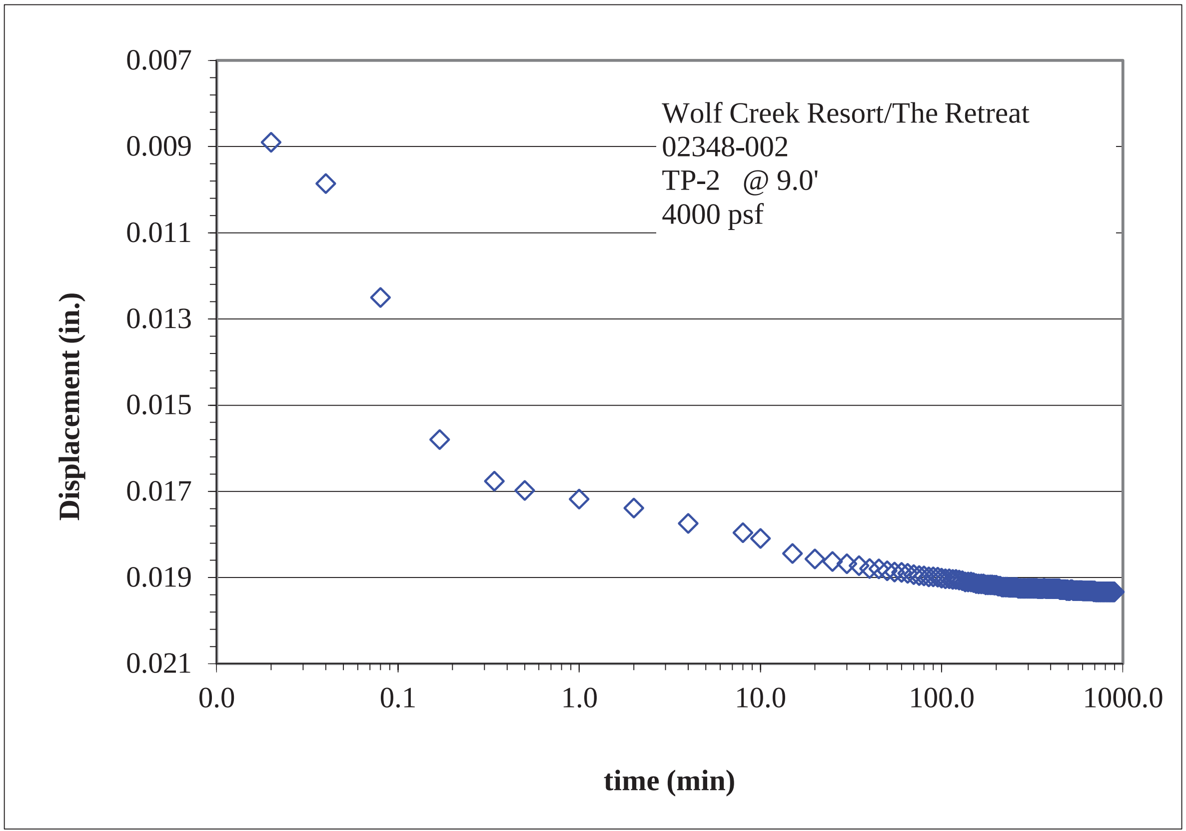
Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: Wolf Creek Resort/The Retreat
No: 02348-002
Location: Eden, UT

Boring No.: TP-2
Sample:
Depth: 9.0'





Drained Repeated Direct Shear

(In general accordance with ASTM D3080)

Project: Wolf Creek Resort/The Retreat
No: 02348-002
Location: Eden, UT
Date: 11/9/2016
By: JDF/NB

Boring No: TP-1
Sample:
Depth: 10.0'
Sample Description: Light brown clay
Specific gravity, Gs: 2.85 Assumed

	Sample 1		Sample 2		Sample 3	
	Initial	Pre-Shear	Initial	Pre-Shear	Initial	Pre-Shear
Sample height (in)	1.0000	0.9800	1.0000	0.9800	1.0000	0.9800
Wet unit weight (pcf)	106.2	120.6	106.2	120.6	106.2	120.6
Water content (%)	20.9	34.5	20.9	34.5	20.9	34.5
Dry unit weight (pcf)	87.9	89.7	87.9	89.7	87.9	89.7
Void ratio, e, for assumed Gs	1.02	0.98	1.02	0.98	1.02	0.98
Saturation (%)*	99.5	100.0	99.5	100.0	99.5	100.0

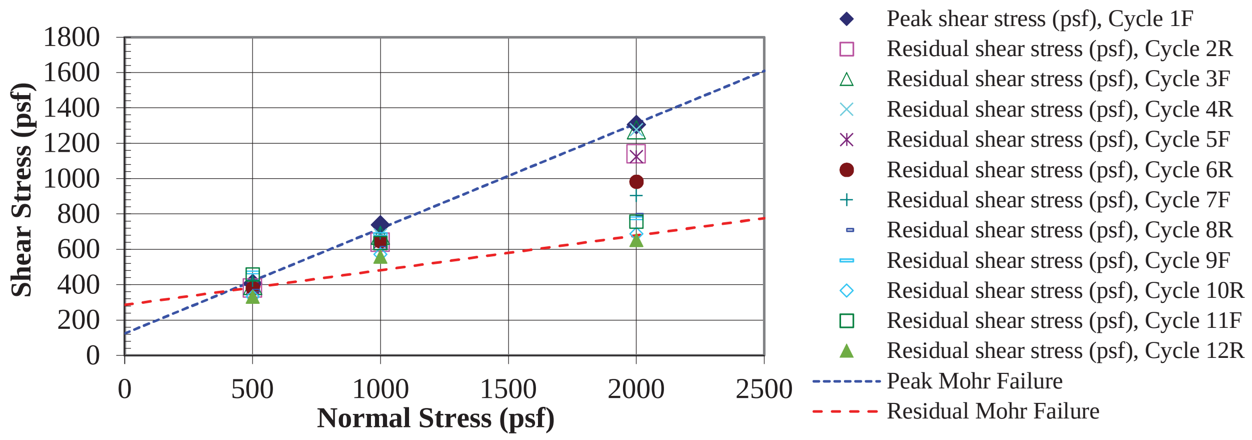
*Pre-shear saturation set to 100% for phase calculations

Average of 3 samples	Initial	Final
Water content (%)	20.9	34.5
Dry unit weight (pcf)	87.9	89.7
Shear rate (in/min)	3.47E-04	

Test specimens consist of minus No. 4 sieve material remolded to an arbitrary unit weight and water content.

Summary of Shear Strength Results	Sample 1	Sample 2	Sample 3	ϕ (deg)	c (psf)
Normal stress (psf)	2000	1000	500		
Peak shear stress (psf), Cycle 1F	1305	739.5	406.8	30.7	124.1
Residual shear stress (psf), Cycle 2R	1140	641.1	381.6	26.8	132.2
Residual shear stress (psf), Cycle 3F	1277	680.3	395.9	30.5	97.5
Residual shear stress (psf), Cycle 4R	1277	680.3	395.9	30.5	97.5
Residual shear stress (psf), Cycle 5F	1125	641.9	385.8	26.2	144.3
Residual shear stress (psf), Cycle 6R	982.9	646.9	381.6	21.4	213.6
Residual shear stress (psf), Cycle 7F	905.5	693.6	424.4	17.0	318.5
Residual shear stress (psf), Cycle 8R	797.1	610.2	366.5	15.3	273.1
Residual shear stress (psf), Cycle 9F	776.5	688.6	470.5	10.6	426.6
Residual shear stress (psf), Cycle 10R	688.8	572.7	333	12.4	275.0
Residual shear stress (psf), Cycle 11F	758.4	636.9	460.4	10.6	399.7
Residual shear stress (psf), Cycle 12R	652.7	558.6	333	11.1	286.0
Minimum shear stress (psf)	652.7	558.6	333	11.1	286.0

F - Forward cycle; R - Reverse cycle



Tested by:___________

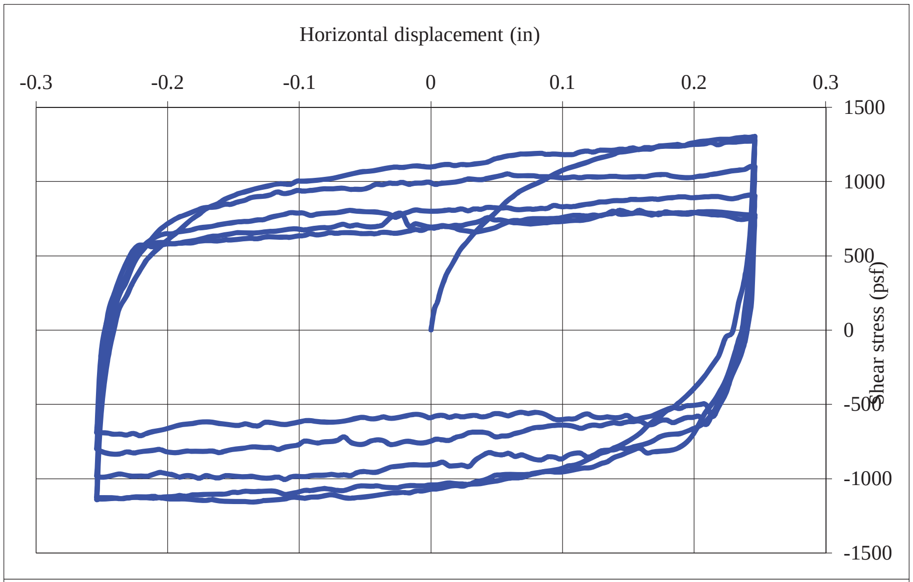
Reviewed:___________

Drained Repeated Direct Shear

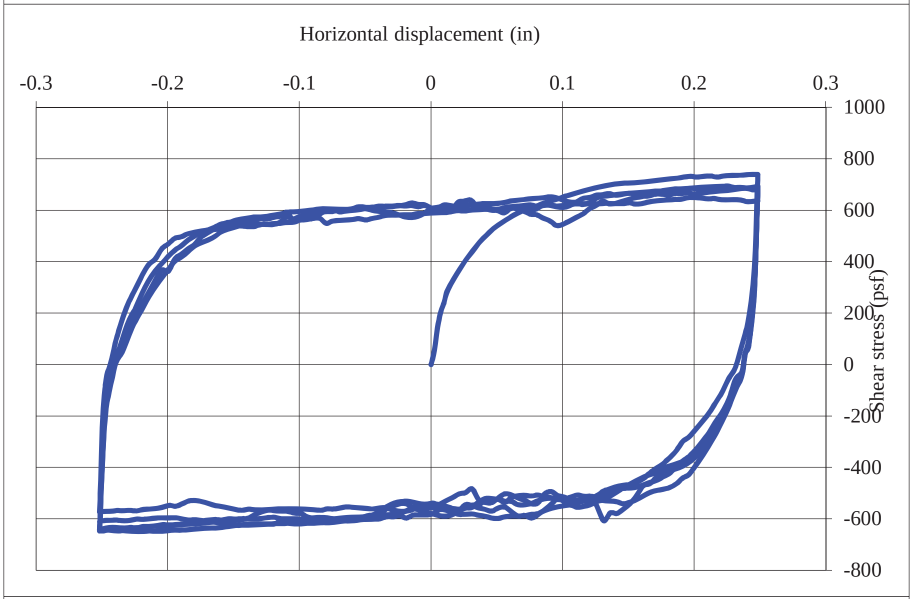
(In general accordance with ASTM D3080)

Project: Wolf Creek Resort/The Retreat
No: 02348-002
Location: Eden, UT
Boring No: TP-1
Sample:
Depth: 10.0'

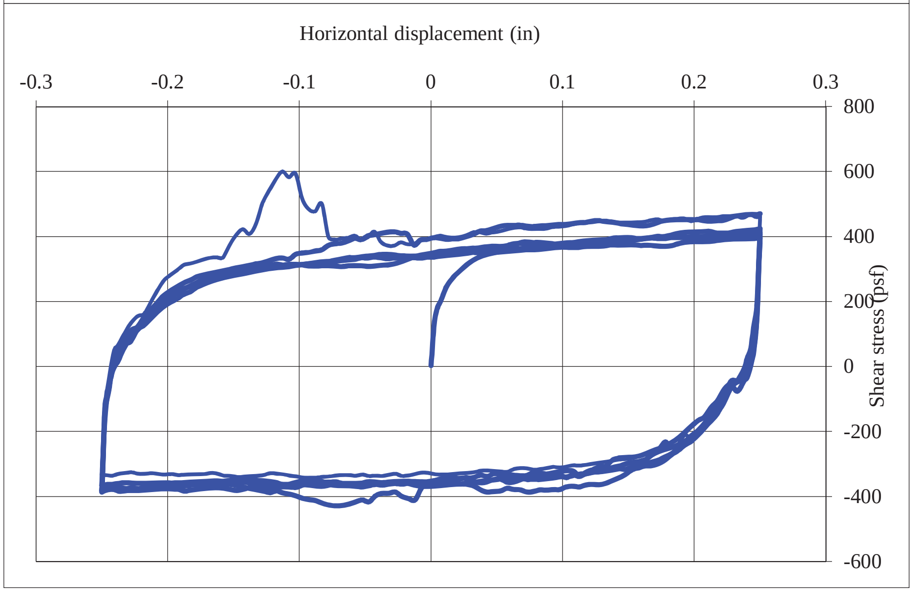
2000 (psf)



1000 (psf)



500 (psf)



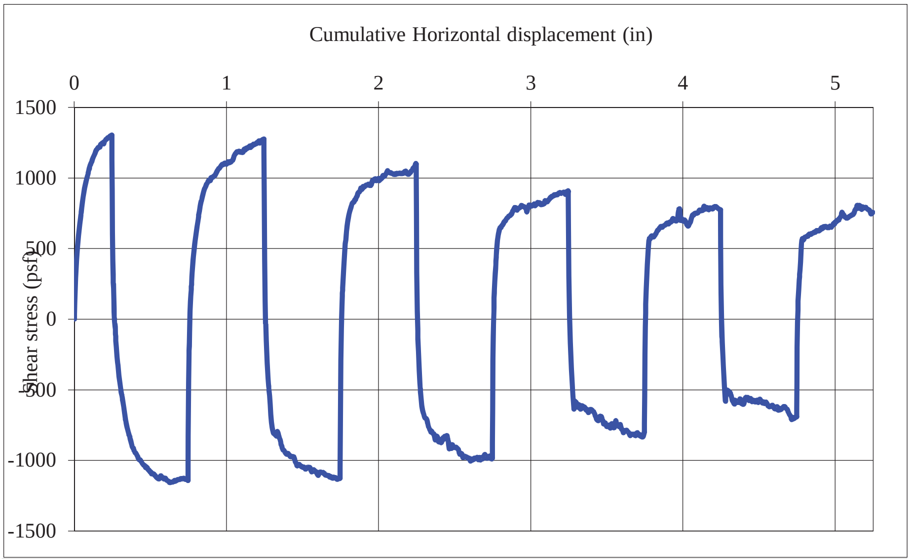
Drained Repeated Direct Shear

(In general accordance with ASTM D3080)

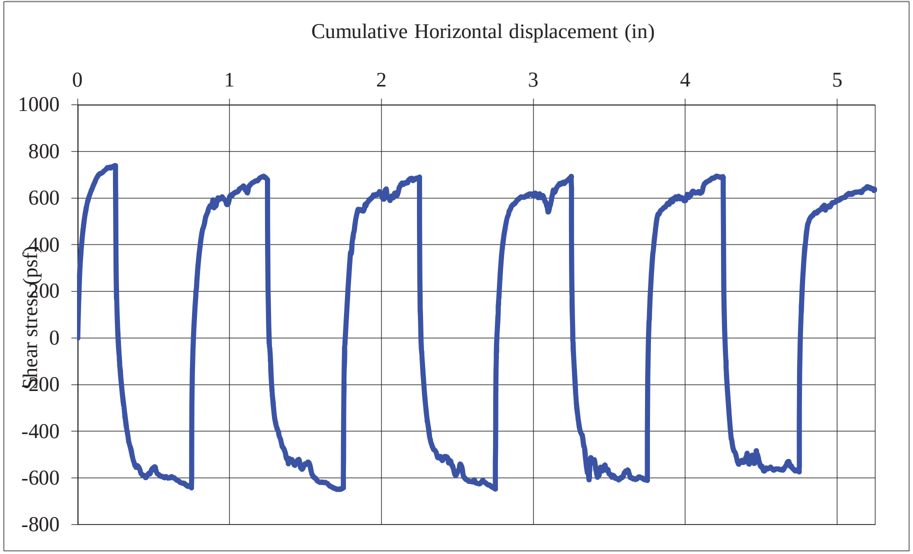
Project: Wolf Creek Resort/The Retreat
No: 02348-002
Location: Eden, UT

Boring No: TP-1
Sample:
Depth: 10.0'

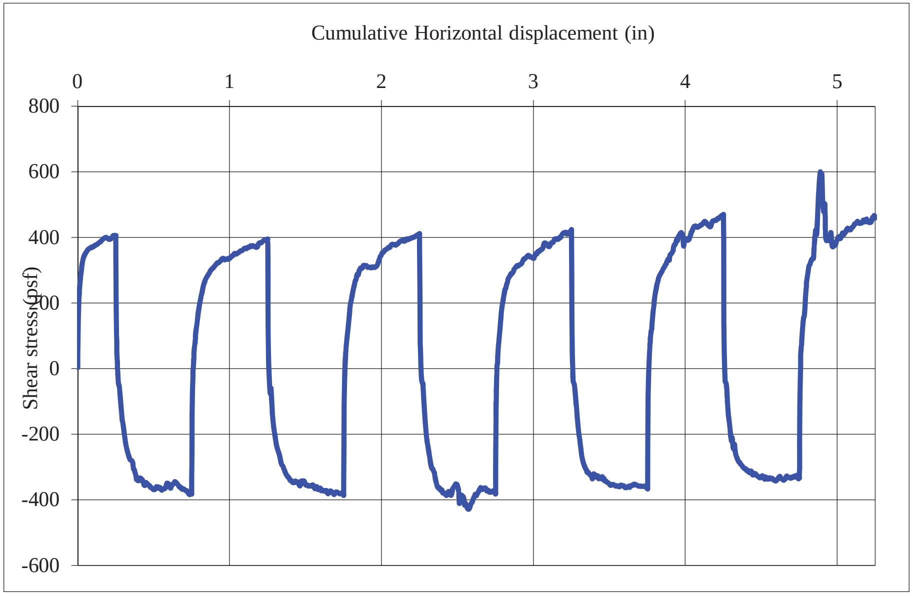
2000 (psf)



1000 (psf)

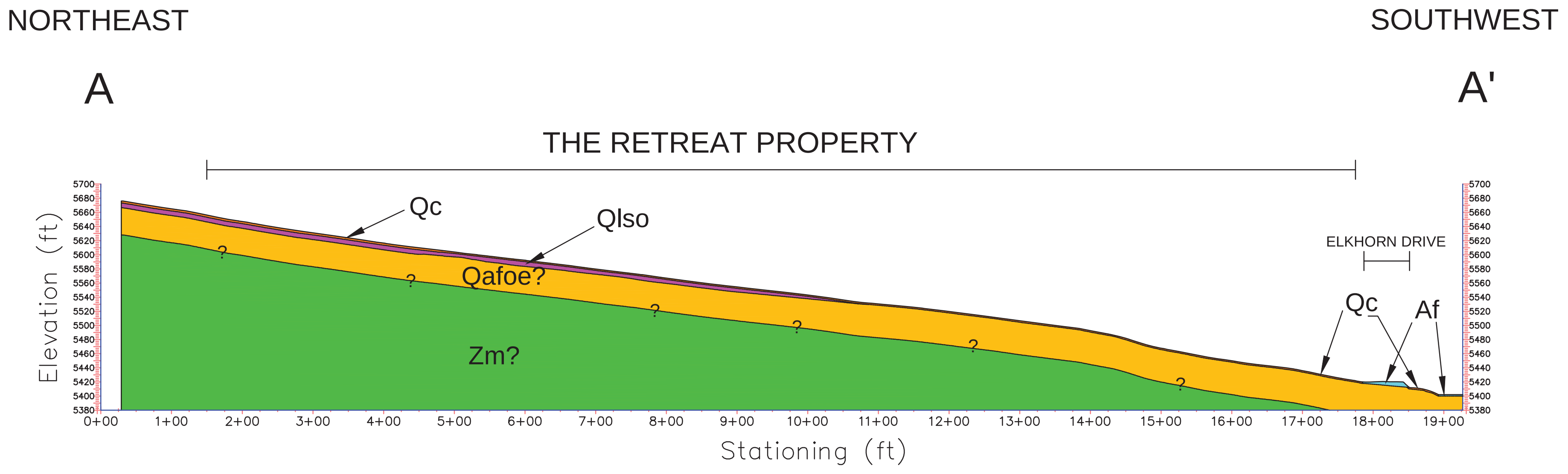


500 (psf)



APPENDIX C

CROSS-SECTION A - A'



🟦 Af ARTIFICIAL FILL

🟧 Qc COLLUVIUM (HOLOCENE-PLEISTOCENE)

🟪 Qlso SHALLOW LANDSLIDE DEPOSITS
(PLEISTOCENE); IN SUBSURFACE ONLY

🟨 Qafoe? ERODED OLDER ALLUVIAL FAN DEPOSITS
(PLEISTOCENE); IN SUBSURFACE ONLY

🟩 Zm? MUTUAL FORMATION (PRECAMBRIAN);
IN SUBSURFACE ONLY

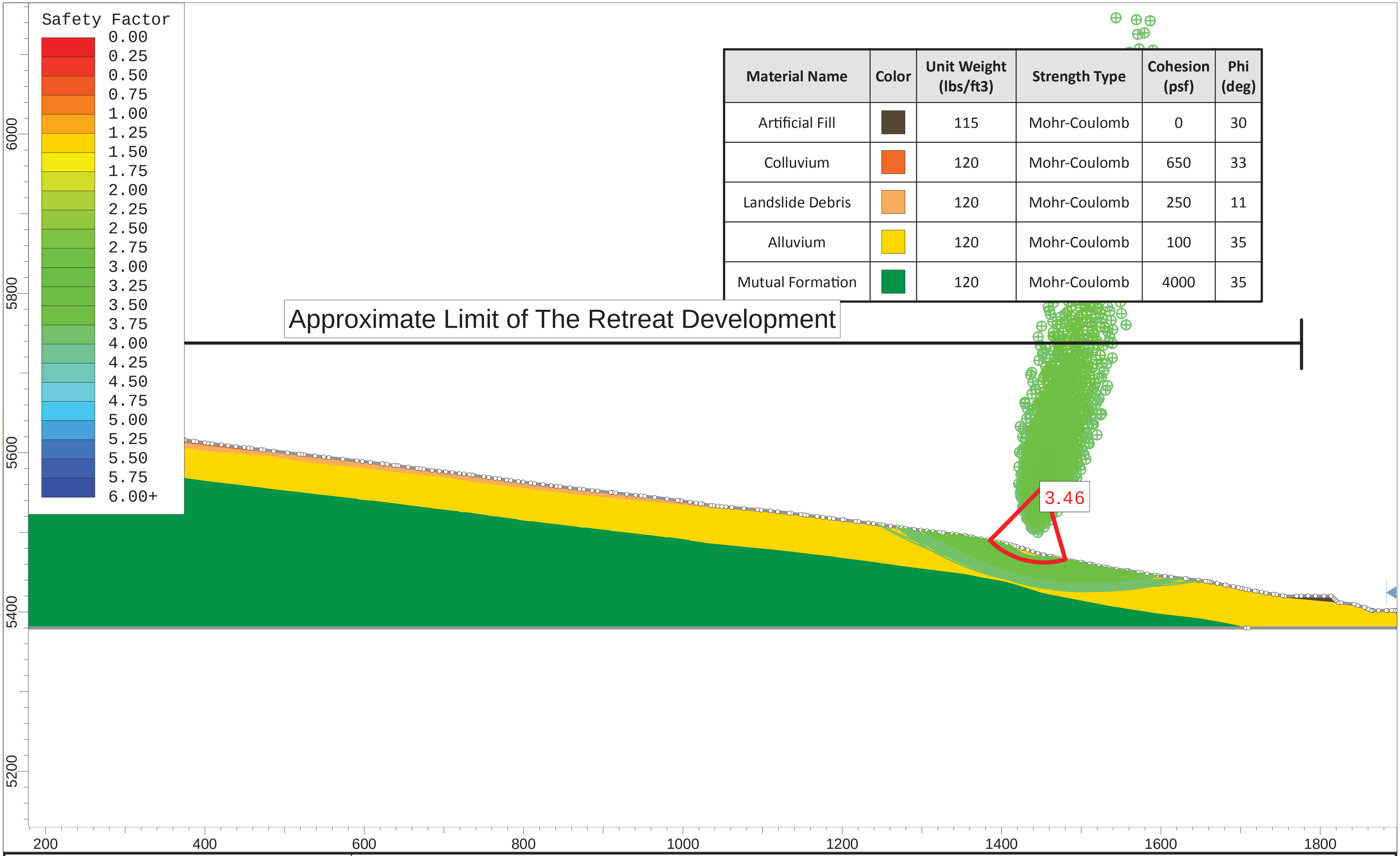
NO VERTICAL EXAGGERATION

0 150 300
FEET

FIGURE C-1

CROSS-SECTION A - A'
THE RETREAT SUBDIVISION
GEOLOGIC HAZARD ASSESSMENT
WOLF CREEK RESORT
EDEN, UTAH

DATE: 12/01/2016
PROJECT: 02348-002
SCALE: 1"=150'
IGES

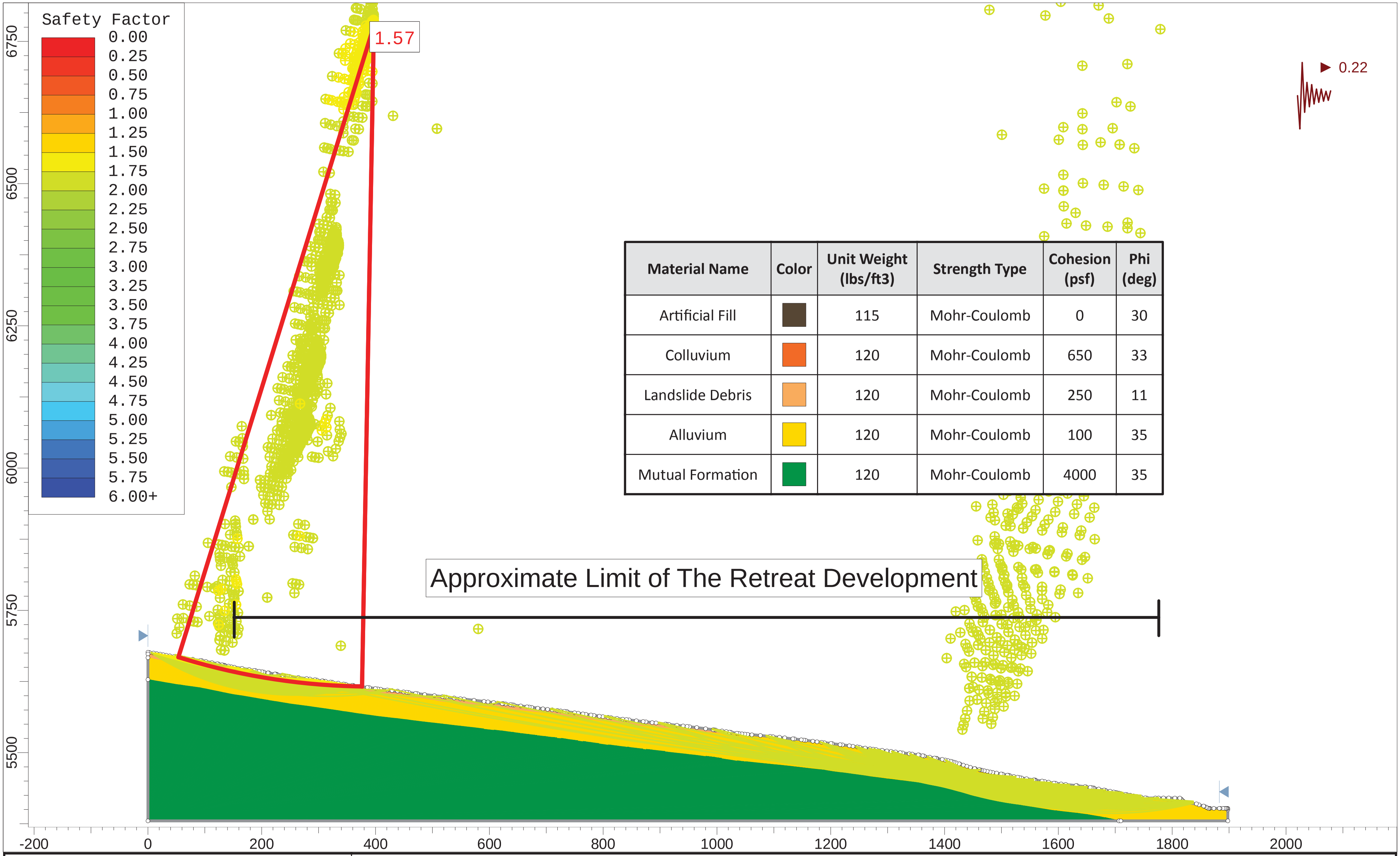


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Artificial Fill	■	115	Mohr-Coulomb	0	30
Colluvium	🟧	120	Mohr-Coulomb	650	33
Landslide Debris	🟧	120	Mohr-Coulomb	250	11
Alluvium	🟨	120	Mohr-Coulomb	100	35
Mutual Formation	🟩	120	Mohr-Coulomb	4000	35

IGES®

SLIDEINTERPRET 7.020

Project	The Retreat - Section A-A'		
Analysis Description	Global Stability - Circular		
Drawn By	TQH	*Scale* 1:2000	*Company* IGES, Inc.
Date	12/1/2016	*File Name*	The Retreat Global - Static.slim



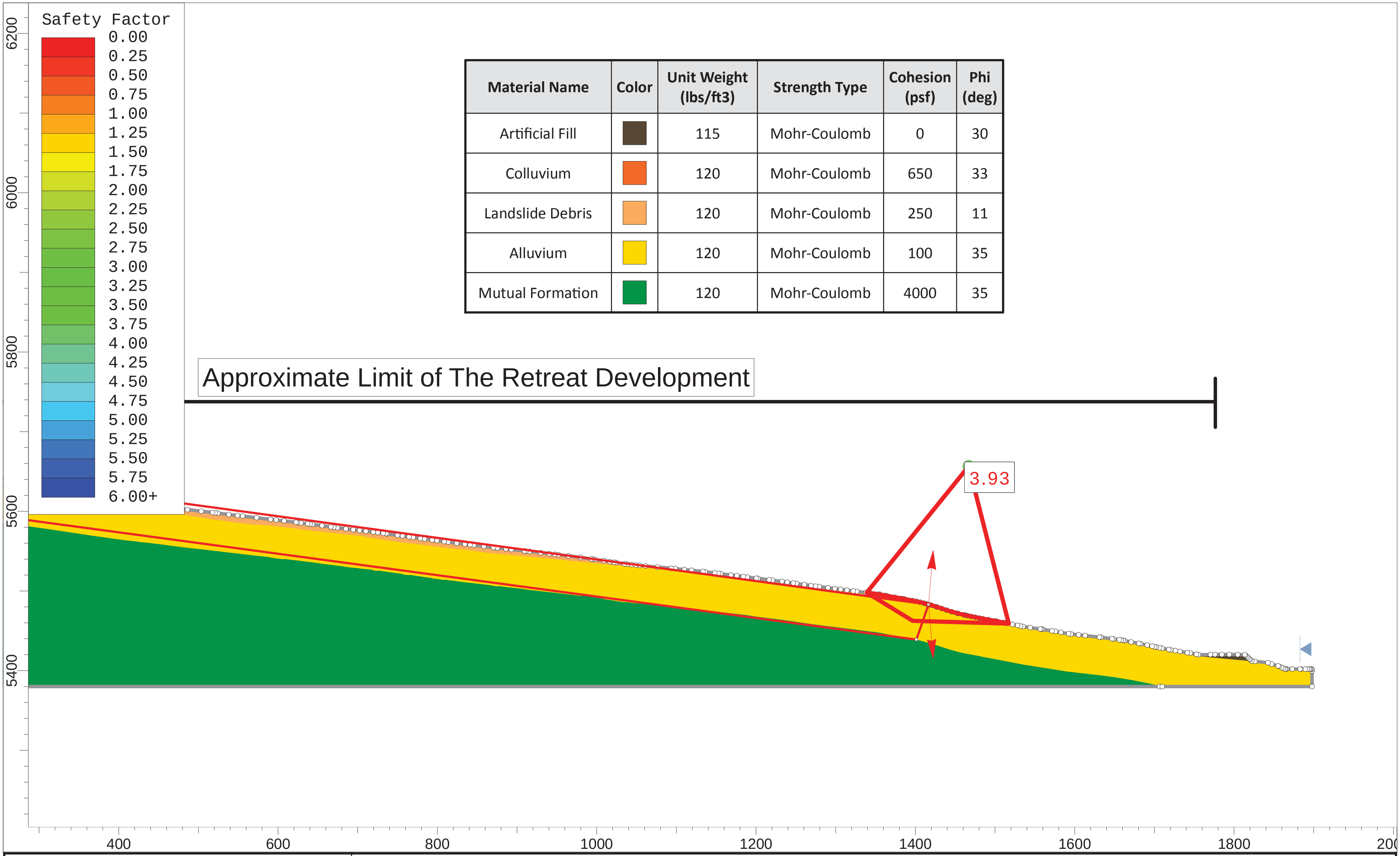
Approximate Limit of The Retreat Development

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Artificial Fill	■	115	Mohr-Coulomb	0	30
Colluvium	🟧	120	Mohr-Coulomb	650	33
Landslide Debris	🟧	120	Mohr-Coulomb	250	11
Alluvium	🟨	120	Mohr-Coulomb	100	35
Mutual Formation	🟩	120	Mohr-Coulomb	4000	35

IGES®

SLIDEINTERPRET 7.020

Project	The Retreat - Section A-A'
Analysis Description	Global Stability - Circular - Seismic
Drawn By	TQH
Scale	1:2800
Company	IGES, Inc.
Date	12/1/2016
File Name	The Retreat Global - Static.slim

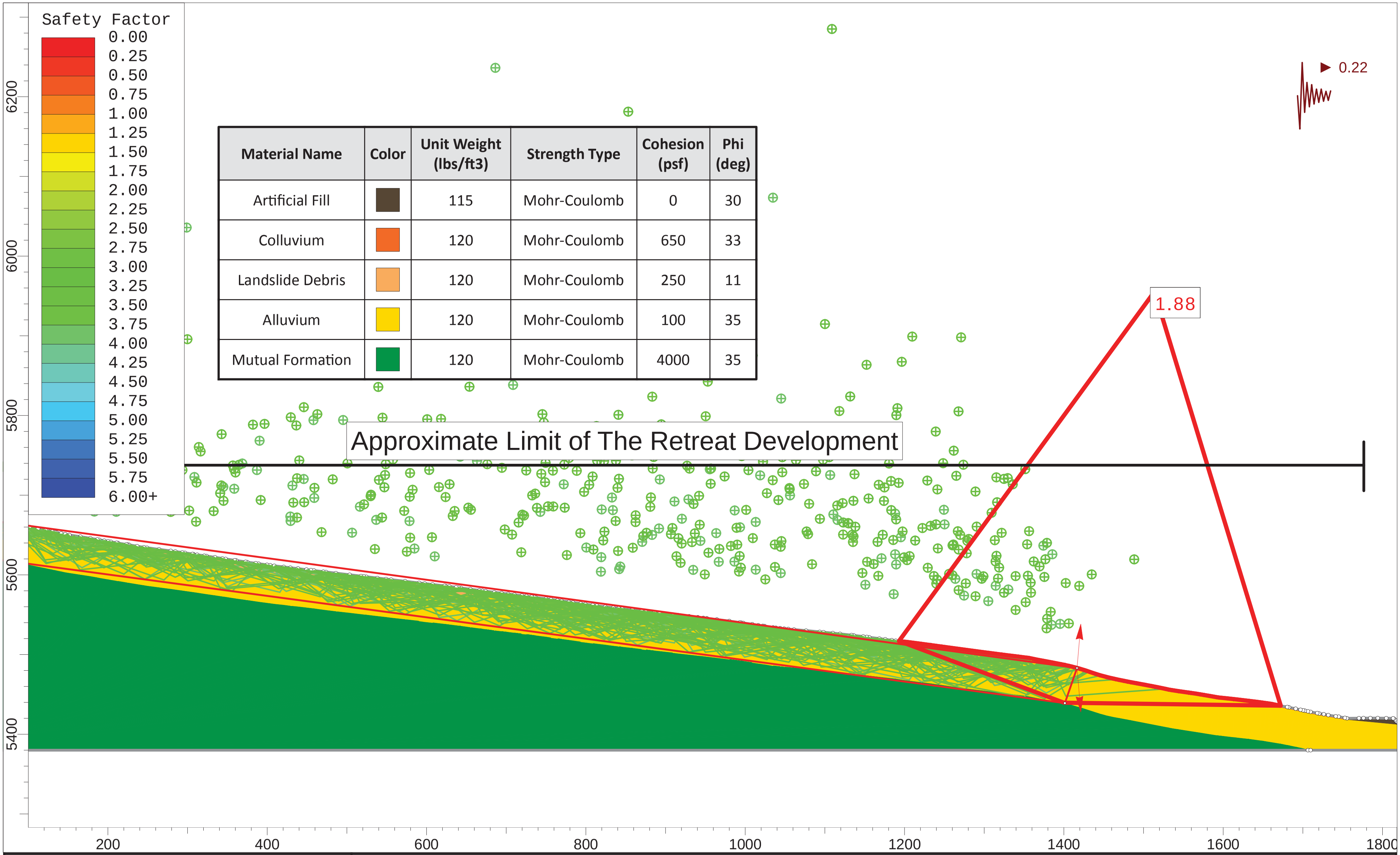


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Artificial Fill	■	115	Mohr-Coulomb	0	30
Colluvium	■	120	Mohr-Coulomb	650	33
Landslide Debris	■	120	Mohr-Coulomb	250	11
Alluvium	■	120	Mohr-Coulomb	100	35
Mutual Formation	■	120	Mohr-Coulomb	4000	35

IGES®

SLIDEINTERPRET 7.020

Project	The Retreat - Section A-A'
Analysis Description	Global Stability - Wedge
Drawn By	TQH
Scale	1:2000
Company	IGES, Inc.
Date	12/1/2016
File Name	The Retreat Global - Static.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Artificial Fill	■	115	Mohr-Coulomb	0	30
Colluvium	■	120	Mohr-Coulomb	650	33
Landslide Debris	■	120	Mohr-Coulomb	250	11
Alluvium	■	120	Mohr-Coulomb	100	35
Mutual Formation	■	120	Mohr-Coulomb	4000	35

IGES®

SLIDEINTERPRET 7.020

Project The Retreat - Section A-A'

Analysis Description Global Stability - Wedge - Seismic

Drawn By TQH

Scale 1:2000

Company IGES, Inc.

Date 12/1/2016

File Name The Retreat Global - Static.slim

Earthtec Engineering, Inc.

133 North 1330 West
Orem, Utah - 84057
Phone (801) 225-5711
Fax (801) 225-3363

1596 W. 2650 S. #108
Ogden, Utah - 84401
Phone (801) 399-9516
Fax (801) 399-9842

GEOTECHNICAL STUDY
WOLFCREEK PARCEL 7
EDEN, UTAH

Prepared By:

Earthtec Engineering Inc.

1596 West 2650 South #108
Ogden, Utah 84401
(801) 399-9516

Job No. 081261

Prepared for:
Wolfcreek Properties
2595 N Hwy 162
PO Box 658
Eden, Utah 84310

September 12, 2008

Table of Contents
Wolfcreek Parcel 7
EEI Job 08-1261

1.0 INTRODUCTION

We understand that a new residential development is planned for a parcel of land located at Parcel 7, within the Wolf Creek resort, in Eden, Utah as shown on the Vicinity Map, Figure 1.

This study was made to assist in evaluating the subsurface conditions and engineering characteristics of the foundation soils and in developing our opinions and recommendations concerning appropriate foundation types, floor slabs and pavement sections. This report presents the results of our geotechnical investigation including field exploration, laboratory testing, engineering analysis, and our opinions and recommendations. Data from the study is summarized on Figures 3 through 13 and in Table 1.

2.0 CONCLUSIONS

1. Based upon the seven test pits excavated for this study, the site is generally free of topsoil. Soils at the site consist of dense to very dense clayey gravel with sand (GC), very dense clayey gravel with sand and cobbles (GC), very dense silty gravel with sand (GM), stiff to hard elastic silt (MH) and soft elastic silt with sand (MH). Groundwater was not encountered in the test pits at the time of our investigation.

2. Expansive soils were encountered at the site. Spread footings founded on at least 2 feet of structural fill should provide adequate support for the proposed structures. A maximum allowable bearing capacity of 2000 psf should be used.

3. Foundation drains should be installed around any basements which extend below existing grades to prevent seepage from perched water and to prevent accumulation of water below structures on the potentially expansive soils.

4. Pavements should consist of 3 inches of asphaltic concrete over 8 inches of untreated aggregate base.

3.0 PROPOSED CONSTRUCTION

It is our understanding that this project will consist of a 35.75 acre residential subdivision. The homes will be one to two story wood frame structures possibly with basements. Miscellaneous concrete flatwork and asphalt access roads are also planned. For design purposes it was assumed that structural loads would be 1 to 3 kips per lineal foot for wall loads and less than 100 pounds per square foot for floor loads. For pavement design we assumed a daily traffic number of 5 which is common for residential access roads. If structural or traffic loads are different than those assumed, we should be notified and allowed to reevaluate our recommendations.

4.0 SITE CONDITIONS

The subject site is undeveloped land covered by sparse weeds, grasses and brush. The property slopes down to the south-southwest at grades estimated at 10 to 15 percent. The site is bound by a residential subdivision to the south and open land on all other sides.

5.0 FIELD INVESTIGATION

The field investigation consisted of excavating seven test pits to depths of 5 ½ to 11 feet below current site grades. Boulders prevented advancing all pits to the desired 10-foot depth. The approximate test pit locations are shown on Figure 2. The soils encountered at the site were logged by personnel from our office. Samples were obtained and returned to our laboratory for testing.

6.0 LABORATORY TESTING

The samples obtained during the field investigation were sealed and returned to our laboratory where representative samples were selected for laboratory testing. Laboratory tests included natural moisture and density determinations, mechanical gradations tests, Atterberg Limits tests and swell/consolidation tests. The results of these tests are shown on Figures 3 through 12 and in Table 1, attached.

Samples will be retained in our laboratory for 30 days following the date of this report at which time they will be disposed of unless a written request for additional holding time is received prior to the disposal date.

7.0 SUBSURFACE CONDITIONS

Based upon the seven test pits excavated for this study, the site is generally free of topsoil. Soils at the site consist of dense to very dense clayey gravel with sand (GC), very dense clayey gravel with sand and cobbles

(GC), very dense silty gravel with sand (GM), stiff to hard elastic silt (MH) and soft elastic silt with sand (MH). Groundwater was not encountered in the test pits at the time of our investigation.

8.0 SITE GRADING

8.1 General Site Grading

Topsoil, man-made fill (if encountered) and soils loosened by construction activities should be removed (stripped) from the building pads and below concrete flatwork and pavements prior to foundation excavation and placement of site grading fills. Following stripping and excavation to design grades, the subgrade should be proof rolled to a firm, non-yielding surface with an approved non-vibratory roller. Soft areas detected during the proof rolling operation should be removed and replaced with structural fill. If the soft soils extend more than 18 inches deep, stabilization may be considered. The use of stabilization should be approved by the geotechnical engineer and would likely consist of over-excavating the area by 18 inches, a geotextile, such as Mirafi 600X, is placed at the bottom of the excavation over which a stabilizing fill consisting of angular coarse gravel with cobbles is placed up to the design subgrade.

Test pits were used at this site to identify the subsurface soils and the pits were backfilled with uncompacted native soils. The contractor should identify the pit areas. If any portion of the homes or roadways extend over a test pit then the backfill soils should be removed and replaced with structural fill.

Expansive soils were encountered in the test pits excavated for this project. Excavation for footings should extend at least 2 feet below intended grades and 2 feet of structural fill placed to bring the excavations to footing grade.

8.2 Structural Fill and Compaction

All fill placed below the buildings, pavements and concrete flatwork should be structural fill. All other fills should be considered as backfill. The native clays and silts may not be used as structural fill. Imported structural fill materials should consist of well-graded gravels with a maximum particle size of 3 inches and

15 to 25 percent fines (materials passing the No. 200 sieve). The liquid limit of the fines should not exceed 35 and the plasticity index should be below 15. All fill soils should be free from topsoils, frosted or frozen soils, highly organic soils, debris, and other deleterious materials. Structural fill should be placed in lifts appropriate to the compaction equipment used. We recommend a maximum loose lift thickness of 4 inches for hand operated equipment, 6 inches for most “trench compactors”, and 8 inches for larger rollers. The soils should be placed at a moisture content within 2 percent of optimum and compacted to at least 95 percent of maximum density (ASTM D 1557). Frequent soil compaction testing should be performed during structural fill placement to ensure proper compaction. If fill depths exceed 5 feet we recommend required compaction be increased to 98 percent (ASTM D 1557) and that full time inspection be provided.

8.3 Backfill

The native soils may be used as backfill in utility trenches and against the outside of foundation walls. Backfill should be placed in lifts heights suitable to the compaction equipment used and compacted to at least 90 percent of the maximum dry density (ASTM D 1557). Where backfill will support concrete flatwork, pavements, or other structures, the fill should meet structural fill requirements.

8.4 Excavations

Excavations can be made with standard excavation equipment. Temporary construction excavations at the site which are above the water table and less than four feet deep should stand with ½ :1 (horizontal:vertical) slopes. All excavations which are advanced deeper than four feet below site grades or where water is encountered should be sloped or braced in accordance with OSHA[1] requirements for type C soil.

---

[1] OSHA Health and Safety Standards, final rule, CFR 29, Part 1926.

9.0 SEISMIC CONSIDERATIONS

9.1 Faulting

Based on published data, no active faults are known to traverse the area and no faulting was indicated on the property during our field investigation. The Ogden Valley Northeast Margin Fault is located approximately 1 mile north of the site[2].

9.2 Seismic Design Criteria

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.

The site is located at approximately 41.33 degrees latitude and -111.82 degrees longitude. The IRC site value for this property is 0.74g as shown in the table below.

Table No. 2: Design Acceleration for Short Period

S_S	F_a	Site Value
		$2/3(S_S*F_a)$
1.02g	1.09	0.74 g

9.3 Liquefaction

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. According to the Utah Geologic Survey Weber County hazards map[2], this site is in an area classified as having a very low potential for liquefaction.

---

[2] Utah Geological Survey, Selected Critical Facilities and Geologic Hazards, Weber County, Utah

10.0 FOUNDATIONS

10.1 Footing Design

Spread footings founded on 2 feet of structural fill should provide adequate support for the proposed buildings. The recommendations presented below should be utilized during design and construction of this project:

1. Spread footings founded on at least 2 feet of structural fill should be designed for a maximum allowable bearing capacity of 2000 psf. A one-third increase is allowed for short term transient loads such as wind and seismic events.

2. Footings should be uniformly loaded.

3. Continuous footings should have a minimum width of 18 inches.

4. Exterior footings should be placed below frost depth which is determined by local building codes. Generally 30 inches is adequate in the area. Interior footing should extend at least 18 inches below the lowest adjacent final grade.

5. 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.

6. The bottom of footing excavations should be cleaned of all soils loosened during excavation and should be proof rolled to identify soft spots prior to placement of structural fill. If soft areas are encountered during the proof rolling operation they should be removed and replaced with structural fill or stabilized as recommended in Section 8.1.

7. Footing excavations should be observed by the geotechnical engineer prior to construction of footings to evaluate whether suitable bearing soils have been exposed and free of fill or disturbed soils.

8. Basements which extend below existing grades should be provided with a foundation drain to intercept perched ground water to aid in keeping moisture from penetrating to the expansive soils below. In addition an outlet should be provided for the fill placed under the footings to prevent ponding of water on the fill.

10.2 Estimated Settlement

If footings are designed and constructed in accordance with the recommendations presented above, the risk of total settlement exceeding 1 inch and differential settlement exceeding 0.5 inch for a 25-foot span will be low. Additional settlement should be expected during a strong seismic event.

11.0 FLOOR SLABS

A minimum 4 inch thick layer of free-draining gravel should be placed immediately below the floor slab to help distribute floor loads, break the rise of capillary water, and aid in the concrete curing process. Floor slabs may be designed using a modulus of subgrade reaction of 180 psi/in. To help control normal shrinkage and stress cracking the floor slabs should have adequate reinforcement for the anticipated floor loads with the reinforcement continuous through interior floor joints and we recommend using adequate crack control joints.

Special precautions should be taken during placement and curing of the concrete slabs. Excessive slump (high water-cement ratios) of the concrete and/or improper finishing and curing procedures may lead to excessive shrinkage, cracking, spalling or curling of the slabs. We recommend all concrete placement and curing operations be performed in compliance with ACI[3] standards.

12.0 BASEMENT WALLS

Basement walls should be designed to resist the lateral loads imposed by the soils retained. The lateral earth pressures on the below grade walls and the distribution of those pressures depends upon the type of structure, hydrostatic pressures, in-situ soils, backfill, and tolerable movements. Basement and retaining walls are usually designed with triangular stress distributions known as equivalent fluid pressure based on lateral earth pressure coefficients. If soils similar to the native soils are used to backfill basement walls then the walls may be designed using the following ultimate values:

---

[3] American Concrete Institute (ACI) Standards

Condition	Lateral Pressure Coefficient	Equivalent Fluid Weight (PCF)
At Rest	0.55	64
Active	0.35	41
Passive	2.88	337

We recommend that the lateral earth pressures for walls which allow little or no wall movement be based on "at rest" conditions. Walls allowed to rotate 0.4 percent of the wall height may be designed with "active pressures". These values assume level backfill extending horizontally for a distance at least as far as the wall height and that water will not accumulate behind walls. Any surcharge load 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. Backfill should be placed in accordance with the requirements discussed in Section 8.3. Lateral pressures approximately 30 percent higher may occur during backfill placement, and bracing may be called for until the backfilling operation is completed.

Lateral building loads will be resisted by frictional resistance between the footings and the foundation soils and by passive pressure developed by backfill against the wall. For footings on native soils we recommend a friction coefficient of 0.28 be used. The lateral earth coefficients presented above are ultimate values; therefore, an appropriate factor of safety should be applied in resistance calculations.

13.0 SURFACE DRAINAGE

Wetting of the foundation soils will likely cause some degree of volume change within the soil and should be prevented both during and after construction. We recommend that the following precautions be taken at this site:

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

2. Roof runoff should be collected in rain gutters with down spouts designed to discharge well outside of the backfill limits.

3. Sprinkler heads should be aimed away and kept at least 12 inches from foundation walls.

4. Provide adequate compaction of backfill with a minimum 90% density (ASTM D 1557). Water consolidation methods should not be used.

5. Other precautions which may become evident during design and construction should be taken.

14.0 FOUNDATION DRAIN

Although no groundwater was encountered during the investigation, it has been our experience that perched groundwater can develop in this area during wet spring seasons. Additionally, expansive soils were encountered in the test pits. The International Residential Code (IRC) which govern development in Utah, requires a foundation drain when buildings are founded in low permeability soils, such as the clays and silts encountered at this site. Therefore, we recommend that any basement which extends below existing grade incorporate a foundation drain. The recommendations presented below should be followed during design and construction of the foundation drain:

1. The foundation drains should consist of a 4 inch diameter, slotted pipe encased in at least 12 inches of free draining gravel. A filter fabric such as Mirafi 140N should separate the gravel from the native soils. The pipe should be graded to drain to a storm drain or other free gravity outfall unless provisions for a pumped sump are made. The gravel should extend up the foundation wall to within 18 inches of final grade. The gravel extending up the wall may be replaced with a composite drain such as miradrain or equivalent.

2. The highest point of the 4 inch perforated pipe within the foundation drain should be placed at least 10 inches below the floor slab. The pipe should be graded to drain to a free gravity outlet.

3. To facilitate basement drainage, clean gravel placed below the basement floor slab should be increased to at least 6 inches thick.

4. Connections through the foundation should be made between the subfloor gravel and the foundation drain. The connections should be made in such a way to allow any water collected below the floor slabs to gravity flow to the foundation drains.

5. Appropriately spaced clean outs should be installed so that the foundation drains may be cleaned as necessary.

15.0 PAVEMENTS

We understand that a flexible pavement is desired for the access roads in this development. Unless a more stringent local code is required, we recommend a pavement section consisting of 3 inches of asphaltic concrete over 8 inches of untreated aggregate base. The design recommendations utilized an assumed CBR value of 10 (see Figure 8), AASHTO design methods, and the following assumptions:

1. The subgrade is prepared by proof rolling to a firm, non-yielding surface and soft areas are stabilized as discussed in Section 8.1;
2. Site grading fills below the pavements meet structural fill material and placement requirements as defined in Section 8.2;
3. Asphaltic concrete should meet Weber County requirements for secondary roads and aggregate base should meet UDOT specification requirements;
4. Aggregate base is compacted to at least 95 percent of maximum dry density (ASTM D 1557);
5. Asphaltic concrete is compacted to at least 96 percent of the laboratory Marshal mix design density (ASTM D 1559);
6. Traffic loading, estimated based on the type of use, as discussed in Section 3.0 of this report; and
7. Pavement design life of 20 years.

16.0 GENERAL CONDITIONS

The exploratory data presented in this report were collected to provide geotechnical design recommendations for this project. Test pits were widely spaced and may not be indicative of subsurface conditions between the test pits or outside the study area and thus have limited value in depicting subsurface conditions for contractor bidding. If it is necessary to define subsurface conditions in sufficient detail to allow accurate bidding we recommend an additional study be conducted which is designed for that purpose.

Variations from the conditions portrayed in the test pits often occur which are sometimes sufficient to require modifications in the design. If during construction, conditions are found to be different than those presented in this report, please advise us so that the appropriate modifications can be made. An experienced geotechnical engineer or technician should observe fill placement and conduct testing as required to confirm the use of proper structural fill materials and placement procedures.

The geotechnical study as presented in this report was conducted within the limits prescribed by our client, with the usual thoroughness and competence of the engineering profession in the area. No other warranty or representation, either expressed or implied, is intended in our proposals, contracts or reports.

We appreciate the opportunity of providing our services on this project. If we can answer questions or be of further service, please call.

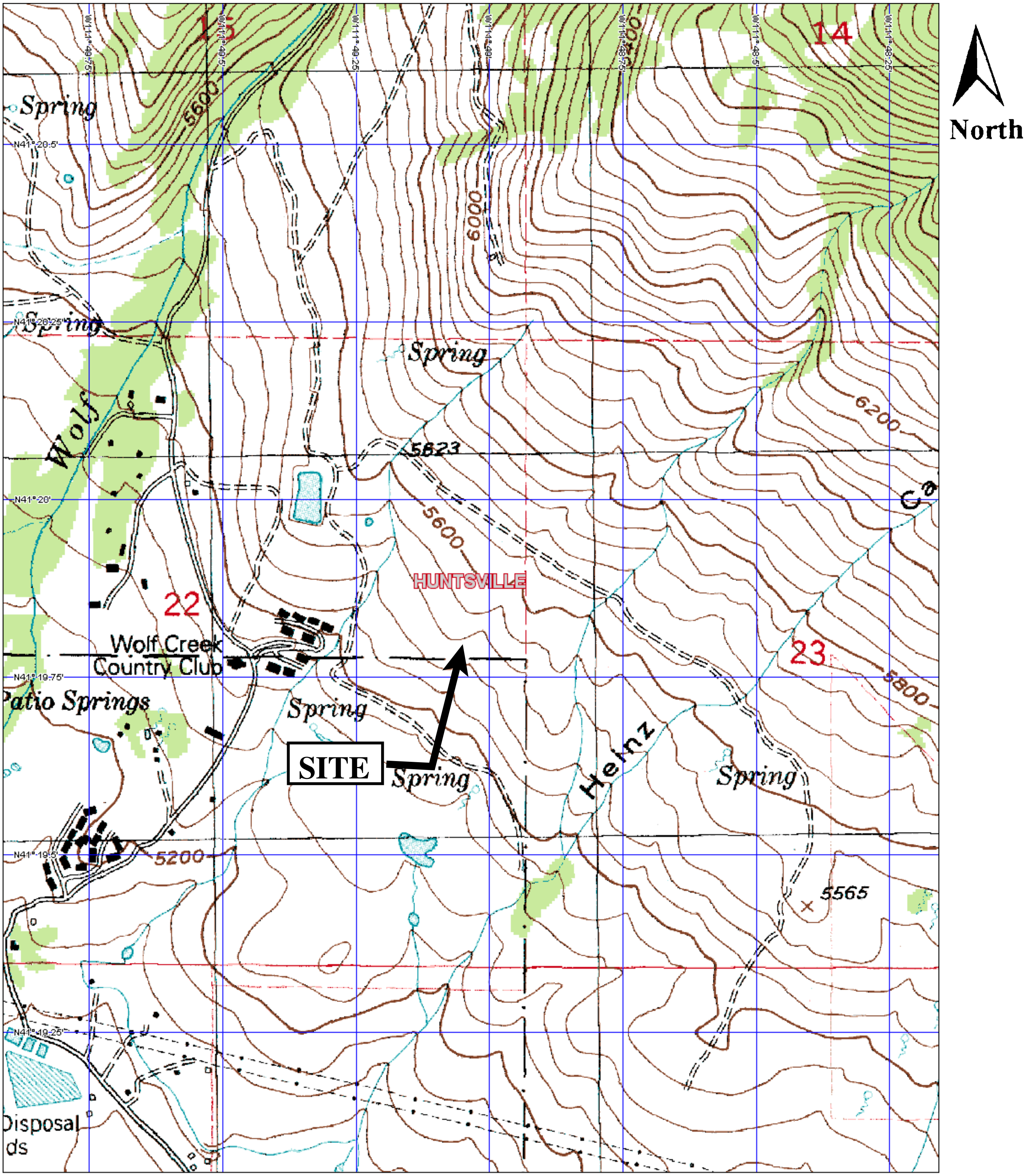
Respectfully;
EARTHTEC ENGINEERING, INC.

LICENSED PROFESSIONAL ENGINEER
RUSSELL JOHN TOPHAM
No. 319204
STATE OF UTAH

Russell J. Topham, P.E.
Project Geotechnical Engineer

REV:REB

EARTHTEC ENGINEERING, INC.



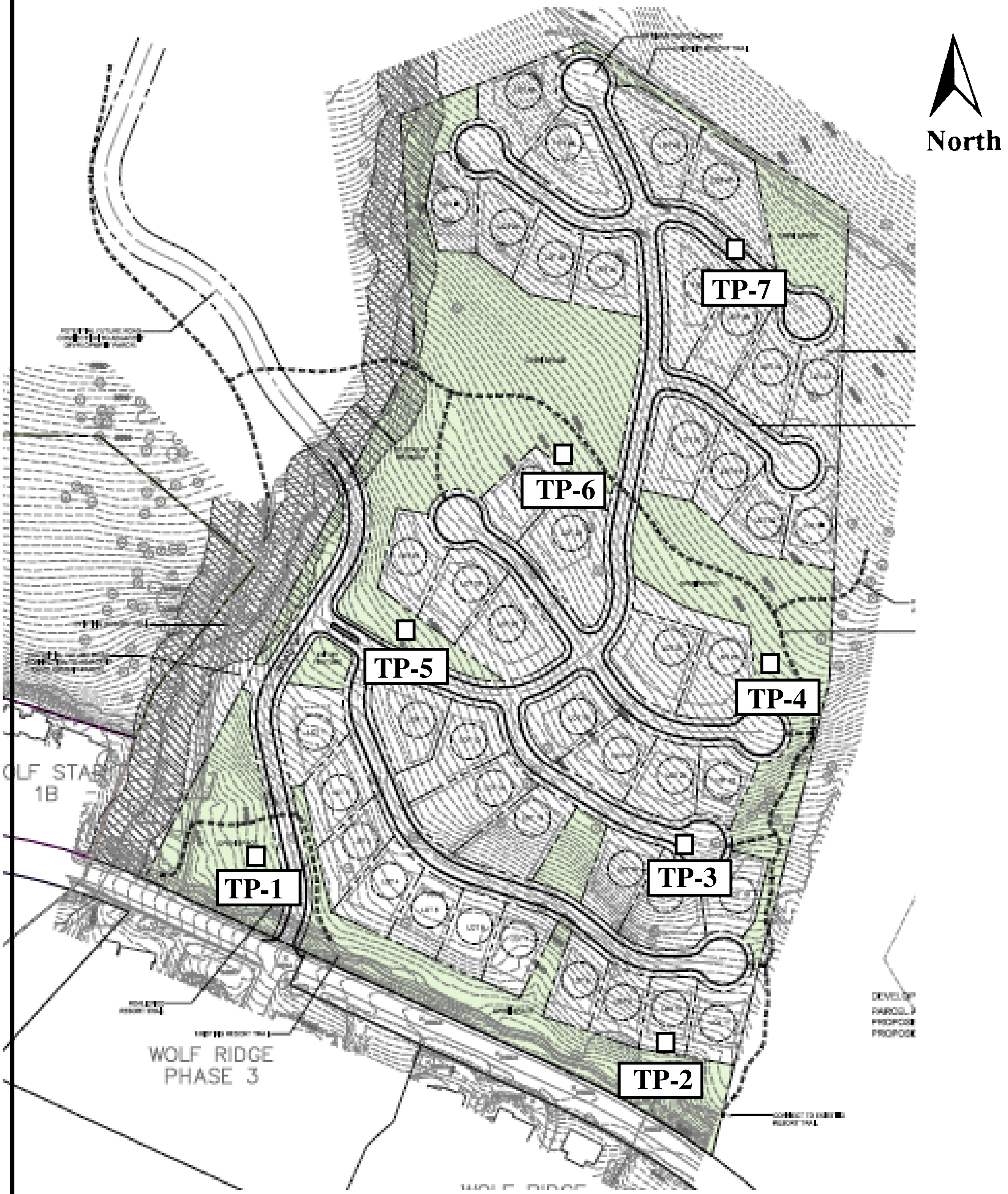
3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS

350 ft Scale: 1 : 12,800 Detail: 14-0 Datum: WGS84

BASE MAP TAKEN FROM DELORME DOCS
"HUNTSVILLE" QUAD

EEI Job No. 08-1261 **VICINITY MAP** **Figure 1**

EARTHTEC ENGINEERING, INC



BASE MAP PROVIDED BY CLIENT

SITE PLAN SHOWING LOCATION OF TEST PITS

EEI Job No. 08-1261 **Figure 2**

TEST PIT LOG

NO.: TP-1

PROJECT: Wolf Creek Parcel 7
CLIENT: Wolfcreek Properties
LOCATION: See Figure 2
OPERATOR: Client Provided
EQUIPMENT: Bobcat 337 Mini Excavator
DEPTH TO WATER; INITIAL ∇:

PROJECT NO.: 08-1261
DATE: 08/27/08
ELEVATION: Not Measured
LOGGED BY: CAP
AT COMPLETION ▼:

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS							
					Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0 1		GC	Clayey gravel with sand, dense, dry, brown									
2		MH	Elastic silt with occasional gravels, hard, moist, brown to yellow brown	☒								
3				☒	88	33	37	72	2	16	82	C
4 5		GC	Clayey gravel, cobble bed ranging from 1-3 inches, angular to sub rounded in clay matrix, very dense, dry, brown									
6		MH	Elastic silt (weathered tuffaceous siltstone) with sand and gravel, soft, moist, yellow									
7 8				☒		47	23	72	0	30	70	
9												
10 11 12 13 14 15			PRACTICAL REFUSAL DUE TO BOULDERS									

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.: 08-1261

FIGURE NO.: 3

TEST PIT LOG

NO.: TP-2

PROJECT: Wolf Creek Parcel 7
PROJECT NO.: 08-1261
CLIENT: Wolfcreek Properties
DATE: 08/27/08
LOCATION: See Figure 2
ELEVATION: Not Measured
OPERATOR: Client Provided
LOGGED BY: CAP
EQUIPMENT: Bobcat 337 Mini excavator
DEPTH TO WATER; INITIAL ▽:
AT COMPLETION ▼:

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0	○	GM	Silty gravel with sand, very dense, dry, brown									
8	▥	MH	Elastic silt (highly weathered tuffaceous siltstone), stiff to hard, moist, green									
9				☒		10			50	24	26	
11												
15												

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.: 08-1261

Earthtec Engineering Inc.

FIGURE NO.: 4

TEST PIT LOG
NO.: TP-3

PROJECT: Wolf Creek Parcel 7
CLIENT: Wolfcreek Properties
LOCATION: See Figure 2
OPERATOR: Client Provided
EQUIPMENT: CAT 330D
DEPTH TO WATER; INITIAL ▽:

PROJECT NO.: 08-1261
DATE: 08/27/08
ELEVATION: Not Measured
LOGGED BY: CAP
AT COMPLETION ▼:

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS							
					Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0	▨	GC	Clayey gravel with sand, very dense, dry, brown									
1												
2				☒								
3												
4												
5												
			PRACTICAL REFUSAL DUE TO BOULDERS									
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												

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.: 08-1261

FIGURE NO.: 5

TEST PIT LOG

NO.: TP-4

PROJECT: Wolf Creek Parcel 7
PROJECT NO.: 08-1261
CLIENT: Wolfcreek Properties
DATE: 08/27/08
LOCATION: See Figure 2
ELEVATION: Not Measured
OPERATOR: Client Provided
LOGGED BY: CAP
EQUIPMENT: CAT 330D
DEPTH TO WATER; INITIAL ▽:
AT COMPLETION ▼ :

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0	▨	GC	Clayey gravel with sand, very dense, dry, brown									
1	▨											
2	▨			☒								
3	▨											
4	▨											
5	▨											
6			PRACTICAL REFUSAL DUE TO BOULDERS									
7												
8												
9												
10												
11												
12												
13												
14												
15												

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.: 08-1261

Earthtec Engineering Inc.

FIGURE NO.: 6

TEST PIT LOG

NO.: TP-5

PROJECT: Wolf Creek Parcel 7
CLIENT: Wolfcreek Properties
LOCATION: See Figure 2
OPERATOR: Client Provided
EQUIPMENT: CAT 330D
DEPTH TO WATER; INITIAL ▽:

PROJECT NO.: 08-1261
DATE: 08/27/08
ELEVATION: Not Measured
LOGGED BY: CAP
AT COMPLETION ▼ :

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS							
					Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0	▨	GC	Clayey gravel with sand containing cobbles 3 to 5 inches in size, high plastic clay, very dense, dry, brown with iron oxide staining at 3 feet									
1												
2												
3				☒	99	29	27	54	2	29	69	
4												
5												
6			PRACTICAL REFUSAL DUE TO BOULDERS									
7												
8												
9												
10												
11												
12												
13												
14												
15												

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.: 08-1261

Earthtec Engineering Inc.

FIGURE NO.: 7

TEST PIT LOG
NO.: TP-6

PROJECT: Wolf Creek Parcel 7
CLIENT: Wolfcreek Properties
LOCATION: See Figure 2
OPERATOR: Client Provided
EQUIPMENT: Bobcat 337 Mini excavator
DEPTH TO WATER; INITIAL ▽:

PROJECT NO.: 08-1261
DATE: 08/27/08
ELEVATION: Not Measured
LOGGED BY: CAP
AT COMPLETION ▼ :

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS							
					Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0	▨		Clayey gravel with sand containing cobbles 3 to 5 inches in size, very dense, dry, brown									
1												
2				☒								
3		GC										
4												
5												
			PRACTICAL REFUSAL DUE TO BOULDERS									
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												

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.: 08-1261

Earthtec Engineering Inc.

FIGURE NO.: 8

TEST PIT LOG

NO.: TP-7

PROJECT: Wolf Creek Parcel 7
CLIENT: Wolfcreek Properties
LOCATION: See Figure 2
OPERATOR: Client Provided
EQUIPMENT: Bobcat 337 Mini excavator
DEPTH TO WATER; INITIAL ▽:

PROJECT NO.: 08-1261
DATE: 08/27/08
ELEVATION: Not Measured
LOGGED BY: CAP
AT COMPLETION ▼ :

Depth (Ft.)	Graphic Log	USCS	Description	Samples	TEST RESULTS							
					Dry Dens. (pcf)	Water Cont. (%)	PI	LL	Gravel (%)	Sand (%)	Fines (%)	Other Tests
0	▨	GC	Clayey gravel with sand containing cobbles 3 to 5 inches in size, very dense, dry, brown									
1												
2				☒		3			48	28	24	
3												
4												
5												
6												
			PRACTICAL REFUSAL DUE TO BOULDERS									
7												
8												
9												
10												
11												
12												
13												
14												
15												

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.: 08-1261

FIGURE NO.: 9

LEGEND

PROJECT: Wolf Creek Parcel 7
CLIENT: Wolfcreek Properties
DATE: 08/27/08
LOGGED BY: CAP

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 (2½ 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.

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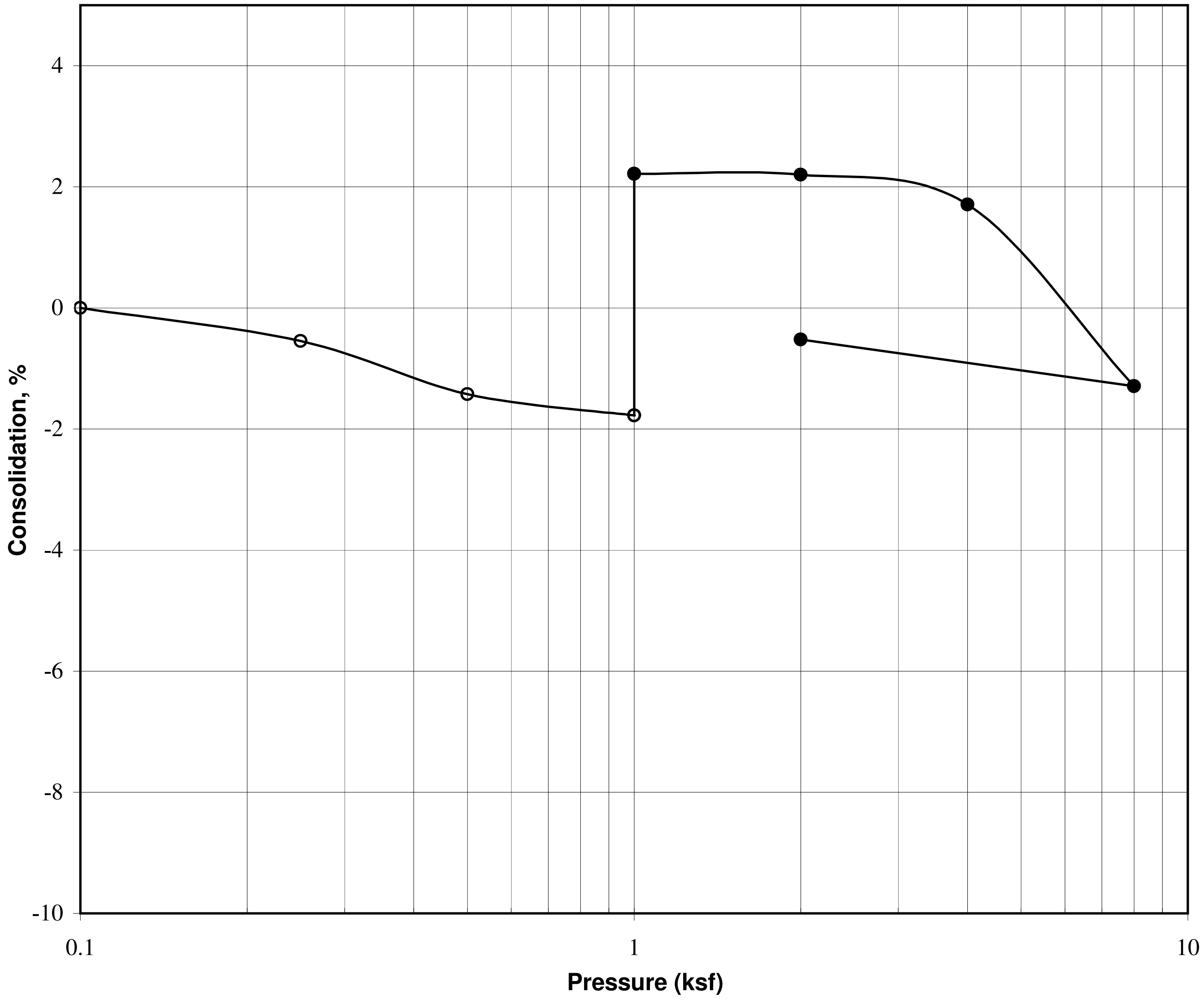
Earthtec Engineering Inc.

FIGURE NO.: 10

CONSOLIDATION - SWELL TEST



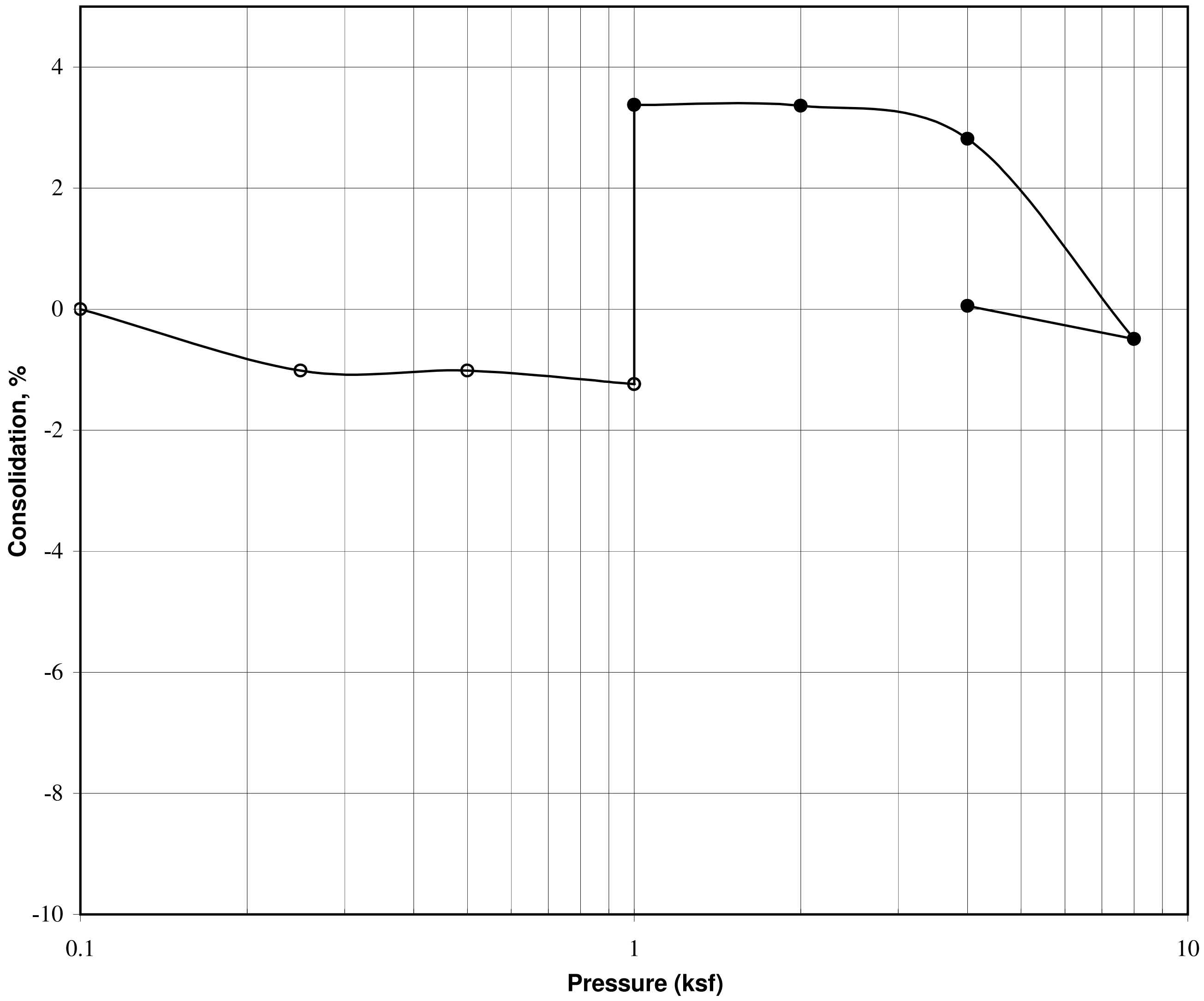
Project:	Wolf Creek Parcel 7
Location:	1
Sample Depth:	3
Description:	bag
Soil Type:	MH
Natural Moisture, %:	33
Dry Density, pcf:	88
Liquid Limit:	72
Plasticity Index:	37
Water Added at:	1 ksf
Percent Swell:	4.0

PROJECT NO.: 08-1261

Earthtec Engineering Inc.

FIGURE NO.: 11

CONSOLIDATION - SWELL TEST



Project:	Wolf Creek Parcel 7
Location:	5
Sample Depth:	3
Description:	bag
Soil Type:	CH
Natural Moisture, %:	29
Dry Density, pcf:	99
Liquid Limit:	54
Plasticity Index:	27
Water Added at:	1 ksf
Percent Swell:	4.6

PROJECT NO.: 08-1261

Earthtec Engineering Inc.

FIGURE NO.: 12

TABLE 1
SUMMARY OF LABORATORY DATA

TEST	DEPTH	DRY DENSITY	MOISTURE	(%) GRADATION			ATTERBERG LIMITS		SOIL TYPE
PIT/HOLE	(FT)	(PCF)	(%)	GRAVEL	SAND	SILT/CLAY	LIQUID LIMIT	PI	
TP-1	3	88.2	32.7	2	16	82	72	37	Elastic SILT (MH)
TP-1	7		47.2	0	30	70	72	23	Elastic SILT (MH)
TP-2	9		10.0	50	24	26			Elastic SILT (MH)
TP-5	3	98.7	29.0	2	29	69	54	27	CLAYEY Gravel with sand (GC)
TP-7	2		3.3	48	28	24			CLAYEY Gravel with sand (GC)

WOLF CREEK PARCEL 7 **ETE JOB NO. 08-1261**