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GEOTECHNICAL AND GEOLOGIC HAZARD INVESTIGATION
Proposed Hastings Residence
Lot 14R of Summit Eden Phase 1A
Summit Powder Mountain Resort
Weber County, Utah

IGES Project No. 02693-001

March 8, 2018

Prepared for:

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE OF WORK

This report presents the results of a geotechnical and geologic hazard investigation conducted for Lot 14R of Summit Eden Phase 1A, part of the currently on-going expansion at the Summit Powder Mountain Ski Resort in Weber County. The purpose of our investigation was to assess the nature and engineering properties of the subsurface soils at the project site and to provide recommendations for the design and construction of foundations, grading, and drainage. In addition, geologic hazards have been assessed for the property. The scope of work completed for this study included literature review, site reconnaissance, subsurface exploration, engineering analyses, and preparation of this report.

Our services were performed in accordance with our proposal dated November 3, 2017, and your signed authorization. The recommendations presented in this report are subject to the limitations presented in the "Limitations" section of this report (Section 6.1).

1.2 PROJECT DESCRIPTION

Our understanding of the project is based primarily on the preliminary site plan prepared by MacKay-Lyons Sweetapple Architects (MLS) dated February 2, 2018, plus our previous involvement with the Summit Powder Mountain Resort project, which included two geotechnical investigations for the greater 200-acre Powder Mountain Resort expansion project (IGES, 2012a and 2012b) and subsequent geotechnical consulting for several other aspects of the project.

The Summit Powder Mountain Resort expansion project is located southeast of SR-158 (Powder Mountain Road), south of previously developed portions of Powder Mountain Resort, in unincorporated Weber County, Utah. The Summit Powder Mountain project area is accessed by Powder Ridge Road. Lot 14R is located within Phase 1A of the Powder Mountain expansion project (Summit Eden), on the south side of Horizon Run Road (Figure A-1 in Appendix A, *Site Vicinity Map*). The roughly 4.3-acre residential lot has an approximate buildable area (building envelope) of 15,300 square feet. The proposed improvements will include a single-family home with a structural footprint of approximately 3,900 sqft, with associated improvements such as utilities and hardscape. We anticipate the new home will be a two- to three-level structure, the lowest story consisting of a partial walk-out basement, founded on conventional spread footings. Foundation loads are expected to be on the order of 1,500 psf or less. The development will likely include retaining walls or rockeries to accommodate the natural ~3.5H:1V gradient of the lot.

2.0 METHODS OF STUDY

2.1 LITERATURE REVIEW

2.1.1 Geotechnical

The earliest geotechnical report for the area is by AMEC (2001), which was a reconnaissance-level geotechnical and geologic hazard study. IGES later completed a geotechnical investigation for the Powder Mountain Resort expansion in 2012 (2012a, 2012b). Our previous work included twenty-two test pits and one soil boring excavated at various locations across the 200-acre development; as a part of this current study, the logs from relevant nearby test pits and other data from our reports were reviewed.

2.1.2 Geological

Several pertinent publications were reviewed as part of this assessment. Sorensen and Crittenden, Jr. (1979) provides 1:24,000 scale geologic mapping of the Huntsville Quadrangle, and Crittenden, Jr. (1972) provides 1:24,000 scale geologic mapping of the Brown's Hole Quadrangle (Figure A-2, *Regional Geology Map 1*). Coogan and King (2001) provide more recent geologic mapping of the area, but at a 1:100,000 scale. Western Geologic (2012) conducted a reconnaissance-level geologic hazard study for the greater 200-acre Powder Mountain expansion project, including the Lot 14 area (Figure A-3, *Regional Geology Map 2*). The Western Geologic (2012) study modified some of the potential landslide hazard boundaries that had previously been mapped at a regional scale (1:100,000) by Coogan and King (2001) and Elliott and Harty (2010). 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 (Figure A-4, *Regional Geology Map 3*). The corresponding United States Geological Survey (USGS) topographic maps for the Huntsville and Brown's Hole Quadrangles (2014) provide physiographic and hydrologic data for the project area. 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), and liquefaction (Christenson and Shaw, 2008c; Anderson et al., 1994) that cover the project area were also reviewed. The Quaternary Fault and Fold Database (USGS and UGS, 2006), was reviewed to identify the location of proximal faults that have had associated Quaternary-aged displacement.

Stereo-paired aerial imagery for the project site and recent and historic Google Earth imagery was also reviewed to assist in the identification of potential adverse geologic conditions. The aerial photographs reviewed are documented in the *References* section of this report.

2.2 FIELD INVESTIGATION

Subsurface soils were investigated by excavating two test pits at representative locations across the property. The approximate location of the test pits are illustrated on the *Geotechnical & Local*

Geology Map (Figure A-5 in Appendix A). The soil types were visually logged at the time of our field work in general accordance with the *Unified Soil Classification System* (USCS). Soil classifications and descriptions are included on the test pit logs, Figures A-6 and A-7 in Appendix A. A key to USCS symbols and terminology is included as Figure A-8, and a key to physical rock properties is included as Figure A-9.

2.3 LABORATORY TESTING

Samples retrieved during the subsurface investigation were transported to the IGES laboratory for evaluation of engineering properties. Specific laboratory tests included:

- Atterberg Limits (ASTM D4318)
- Grain-Size Distribution (ASTM D6913)
- Fines Content (ASTM D1140)
- In situ Moisture Content (ASTM D7263)
- Direct Shear (ASTM D3080)

Results of the laboratory testing are discussed in this report and presented in Appendix B. Some test results, including moisture content, gradation, and Atterberg Limits, have been incorporated into the test pit logs (Figures A-6 and A-7).

3.0 GEOLOGIC CONDITIONS

3.1 GENERAL GEOLOGIC SETTING

The Lot 14R property is situated in the western portion of the northern Wasatch Mountains, approximately 4 miles north of Ogden Valley. 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.

The Wasatch Fault and its associated segments are part of an approximately 230-mile long zone of active normal faulting referred to as the Wasatch Fault Zone (WFZ), which has well-documented evidence of late Pleistocene and Holocene (though not historic) movement (Lund, 1990; Hintze, 1988). The faults associated with the WFZ are almost all normal faults, exhibiting block movement down to the west of the fault and up to the east. The WFZ is contained within a greater area of active seismic activity known as the Intermountain Seismic Belt (ISB), which runs approximately north-south from northwestern Montana, along the Wasatch Front of Utah, through southern Nevada, and into northern Arizona. In terms of earthquake risk and potential associated damage, the ISB ranks only second in North America to the San Andreas Fault Zone in California (Stokes, 1987).

The WFZ consists of a series of ten segments of the Wasatch Fault that each display different characteristics and past movement and are believed to have movement independent of one another (UGS, 1996). The Lot 14 property is located approximately 9.4 miles to the northeast of the Weber Segment of the Wasatch Fault, which is the closest documented Holocene-aged (active) fault to the property and trends north-south along the Wasatch Front (USGS and UGS, 2006).

3.2 SURFICIAL GEOLOGY FROM LITERATURE

According to Sorensen and Crittenden, Jr. (1979), the property is entirely underlain by undifferentiated Holocene-aged colluvium[1], slopewash, and landslide deposits, with the northern margin of the property mapped as being near the contact with the undivided Tertiary/Cretaceous Wasatch and Evanston Formations (TKwe), described as "unconsolidated pale-reddish-brown pebble, cobble, and boulder conglomerate, forms boulder-covered slopes. Clasts are mainly Precambrian quartzite and are tan, gray, or purple; matrix is mainly poorly consolidated sand and silt." This map forms the basemap for the *Regional Geology Map 1* (Figure A-2). Coogan and King (2001) produced a regional-scale geologic map that covered the property; this map shows the entire property to be underlain by undivided mass-movement deposits. Western Geologic (2012) identified a number of landslide deposits contained within the Powder Mountain Resort expansion area (Figure A-3). In this map, the entire property is shown to be underlain by deposits mapped as "mixed slope colluvium, shallow landslides, and talus." Finally, Coogan and King (2016) updated their 2001 map, which shows the property to be situated on landslide deposits (unit Qms), with the northern margin of the property at or adjacent to the contact with undivided landslide and colluvial deposits (unit Qmc) (Figure A-4).

3.3 HYDROLOGY

The USGS topographic maps for the Huntsville and Brown's Hole Quadrangles (2014) show that the Lot 14R project area is situated on a slope, with the topographic gradient down to the south towards a west-trending unnamed drainage locally known as Lefty's Canyon (see Figure A-1). No active or ephemeral stream drainages are found on the property, and 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 runoff.

Baseline groundwater depths for the Lot 14 property are currently unknown, but are anticipated to fluctuate both seasonally and annually. Groundwater was not encountered in the two test pits excavated in this investigation.

3.4 GEOLOGIC HAZARDS FROM LITERATURE

Based upon the available geologic literature, regional-scale geologic hazard maps that cover the Lot 14R project area have been produced for landslide, fault, debris-flow, and liquefaction hazards. The following is a summary of the data presented in these regional geologic hazard maps.

[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)

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 underlain by south-trending landslide deposits. Elliott and Harty (2010) shows the entire property to be underlain by deposits mapped as "Landslide undifferentiated from talus and/or colluvial deposits." As noted above, on a site-specific basis, Western Geologic (2012) mapped the area underlying the property as "mixed slope colluvium, shallow landslides, and talus" (Figure A-3), while most recently Coogan and King (2016) on a regional scale show the property to be entirely situated upon landslide deposits (Figure A-4).

3.4.2 Faults

Neither Christenson 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 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 9.4 miles southwest of the western margin of the property (USGS and UGS, 2006).

3.4.3 Debris Flows

Christenson 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 Christenson and Shaw (2008c) both show the project area to be located in an area with very low potential for liquefaction.

3.5 REVIEW OF AERIAL IMAGERY

A series of aerial photographs that cover project area were taken from the UGS Aerial Imagery Collection and analyzed stereoscopically for the presence of adverse geologic conditions across the property. This included a review of photos collected from the years 1947, 1953, and 1963. A table displaying the details of the aerial photographs reviewed can be found in the *References* section at the end of this report.

No definitive geologic lineaments, fault scarps, landslide headscarps, or landslide deposits were observed in the aerial photography on the subject property, though irregular topography was observed in the vicinity of the property.

Google Earth imagery of the property from between the years of 1993 and 2017 were also reviewed. No landslide or other geological hazard features were noted in the imagery. The property was observed to be patchily to densely covered in trees and bushes. Some surficial gravel, cobbles, and boulders were observed, though the property does not contain any drainages. No notable changes to the property, either human or natural, were observed in the aerial imagery across this time frame, aside from the cutting in of Horizon Run between September of 2011 and October of 2014.

At the time of this report, no LiDAR data for the project area was available to be reviewed.

3.6 SEISMICITY

Following the criteria outlined in the 2015 International Building Code (IBC, 2015), spectral response at the site was evaluated for the *Maximum Considered Earthquake* (MCE) which equates to a probabilistic seismic event having a two percent probability of exceedance in 50 years (2PE50). Spectral accelerations were determined based on the location of the site using the *U.S. Seismic "DesignMaps" Web Application* (USGS, 2012/15); this software incorporates seismic hazard maps depicting probabilistic ground motions and spectral response data developed for the United States by the U. S. Geological Survey as part of NEHRP/NSHMP (Frankel et al., 1996). These maps have been incorporated into both *NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures* (FEMA, 1997) and the *International Building Code* (IBC) (International Code Council, 2015).

Table 3.6
Short- and Long-Period Spectral Accelerations for MCE

Parameter	Short Period (0.2 sec)	Long Period (1.0 sec)
MCE Spectral Response Acceleration (g)	$S_S = 0.831$	$S_1 = 0.277$
MCE Spectral Response Acceleration Site Class C (g)	$S_{MS} = S_sF_a = 0.887$	$S_{M1} = S_1F_v = 0.421$
Design Spectral Response Acceleration (g)	$S_{DS} = S_{MS}*{}^2/_3 = 0.592$	$S_{D1} = S_{M1}*{}^2/_3 = 0.281$

To account for site effects, site coefficients that vary with the magnitude of spectral acceleration and *Site Class* are used. Site Class is a parameter that accounts for site amplification effects of soft soils and is based on the average shear wave velocity of the upper 100 feet; based on our field exploration and our understanding of the geology in this area, the subject site is appropriately classified as Site Class C (*very dense soil/soft rock*). Based on IBC criteria, the short-period (F_a) coefficient is 1.067 and the long-period (F_v) site coefficient is 1.523. Based on the design spectral response accelerations for a *Building Risk Category* of I, II or III, the site's *Seismic Design Category* is D. The short- and long-period *Design Spectral Response Accelerations* are presented in Table 3.6; a summary of the *Design Maps* analysis is presented in Appendix B. The *peak ground acceleration* (PGA) may be taken as $0.4*S_{MS}$.

3.7 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 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, depending on location and construction specifics, as well as 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 or currently does adversely affect 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 always require additional site-specific hazard investigations and associated mitigation practices where the location and construction specifics are directly impacted by the hazard. For areas with a high-risk geologic hazard, simple avoidance is often considered.

The following is a summary of the geologic hazard assessment for the Lot 14R property.

3.7.1 Landslides/Mass-Movement

The landslide hazard constitutes the greatest geologic hazard risk associated with the property. According to the several most recent geologic maps produced that cover the property, the lot is entirely situated on mapped landslide or other mass-movement deposits (Coogan and King, 2016; Western Geologic, 2012; Elliott and Harty, 2010). Additionally, characteristic hummocky topography associated with landslide deposits and small landslide headscarps were observed south and downslope of the building envelope during the site reconnaissance (see Figure A-5).

Within TP-2, located south of the building envelope, both younger and older landslide deposits were observed in the form of erratic, heterogeneous units with pinhole voids and irregular clay lenses. A clay-rich basal unit in TP-2 may represent weathered Nounan Dolomite bedrock that provided the slip plane for the older landslide deposits, though no natural slickensides were observed within this unit. In TP-1, an identified colluvial unit may include shallow landslide deposits. Based upon surficial morphology and the test pit data, the older landslide deposits may extend into the southern portion of the building envelope (see Figure A-5).

Within the building envelope, the property was observed to have the gentlest grade and not exhibit hummocky topography. Wasatch Formation was found beneath surficial colluvium deposits in TP-1, and it is believed that this bedrock unit underlies most of the building envelope.

Given the geologic data alone, the risk associated with landslide hazards on the property is considered to be moderate to high for all parts of the property except the building envelope, which is considered to be low to moderate. However, slope stability analyses have indicated the slope is stable under the current conditions, as well as a hypothetical scenario with a home with a walk-out basement (see Section 4.3). As such, the corresponding landslide and slope stability hazard risk is considered to be moderate to low.

3.7.2 Rockfall

Though the property is on a slope, no bedrock outcrops are exposed upslope of the property. As such, the rockfall hazard associated with the property is considered to be low.

3.7.3 Surface-Fault Rupture and Earthquake-Related Hazards

No faults are known to be present on or project across the property, and the closest active fault to the property is the Weber Segment of the Wasatch Fault Zone, located approximately 9.4 miles to the west 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.

3.7.4 Liquefaction

The site is underlain at least in part by the Wasatch Formation, a poorly consolidated sedimentary rock unit (conglomerate). Rock units such as these are not considered susceptible to liquefaction; as such, the potential for liquefaction occurring at the site is considered low.

3.7.5 Debris-Flows and Flooding Hazards

The property does not contain and is not located adjacent to any active or ephemeral drainages. Additionally, there are no debris-flow source areas upslope of the property, and the property is on a consistent slope downhill to the south. Given these conditions, the debris-flow and flooding hazard associated with the property is considered to be low.

3.7.6 Shallow Groundwater

Groundwater was not encountered in either of the two test pits excavated as part of this investigation. The test pits were excavated in late November, and the groundwater level was likely to be on its way down to its annual low. No springs were observed on the property, and no plants indicative of shallow groundwater conditions were observed on the property. However, shallow groundwater conditions have been observed at the nearby *Horizon Neighbourhood* property (IGES, 2016).

Given the existing data, it is expected that groundwater levels will fluctuate both seasonally and annually, and the risk associated with shallow groundwater hazards is considered low to moderate. Spring thaw and runoff are likely to significantly contribute to elevated groundwater conditions (localized perched conditions). However, shallow groundwater issues can be mitigated through appropriate grading measures and/or the avoidance of the construction of basement levels, or constructing basements with foundation drains.

4.0 GENERALIZED SITE CONDITIONS

4.1 SITE RECONNAISSANCE

Mr. Peter E. Doumit, P.G., C.P.G., of IGES conducted reconnaissance of the site and the immediate adjacent properties on November 13, 2017. 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 map the surficial geology of the area. Figure A-5 is a site-specific geologic map of the Lot 14R property and adjacent areas.

At the time of the site reconnaissance, the property had patchy snow on the ground, but the surficial morphology was still able to be discerned. In general, the property was observed to have highly irregular, possibly hummocky surface topography with common breaks in slope in various parts. The proposed building envelope was observed to have the gentlest grade and appeared to be a localized topographic high. South of the building envelope, hummocky topography and corresponding landslide deposits were observed (see Figure A-5). Dense to patchy vegetation in the form of aspen trees and low-lying bushes was observed across much of the property. The aspens displayed evidence of moderate to strong soil creep, especially in areas of steeper slope.

Variously-sized boulders and cobbles were found scattered across the property, as part of the surficial colluvial geologic unit derived from weathered Wasatch Formation. These were typically subrounded to rounded and were found to be as large as 8 feet in diameter. The rock clasts[2] were found to be comprised entirely of massive, coarsely crystalline quartzite, which was medium gray in color when unweathered, but commonly weathered to dark reddish orange. The clasts were observed to be weathering out of a sandy lean clay topsoil.

No springs, seeps, or running water were observed on the property at the time of the site visit.

Near the southern margin of the property a distinct landslide toe was observed, evidenced by a sharp break in slope and common boulders and cobbles weathering out of the slope break. This landslide toe was observed to have two lobes, separated by a small headscarp. At the southern margin of the property, the grade levels out and an open area with low-lying bushes and few trees was observed, possibly indicative of a more recent landslide deposit at least in part associated with the headscarp.

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[2] Clast: An individual constituent, grain, or fragment of a sediment or rock, produced by the mechanical or chemical disintegration or a larger rock mass. (AGI, 2005)

4.2 SUBSURFACE CONDITIONS

On November 22, 2017, two exploration test pits were excavated at representative locations near the proposed building envelope on the lot (see Figure A-5). The test pits were excavated to depths ranging between 10½ and 12 feet below existing grade with the aid of a Caterpillar 320F tracked excavator. Upon completion of logging, the test pits were backfilled without compactive effort. Detailed logs for the test pits are displayed in Figure A-6 and Figure A-7, respectively. Six distinct geologic units were encountered in the subsurface, with only one of the units (A/B Soil Horizon) being found in both of the test pits. The soil and moisture conditions encountered during our investigation are discussed in the following paragraphs.

4.2.1 Earth Materials

A/B Soil Horizon: This topsoil unit was found to be between approximately 1 to 2 feet thick in both test pits. The unit was a brownish black, loose to medium stiff, moist to wet, sandy lean CLAY with gravel (CL), with gravel and larger-sized quartzite clasts comprising between approximately 5 and 25% of the unit. The unit contained abundant plant and tree roots and had a very wavy basal contact.

Colluvium (Qc): This unit was only encountered in TP-1, being between approximately 1 and 3 feet thick. The unit was variegated between a moderate yellowish brown to light brown to pale yellowish orange color, and consisted of a medium dense, slightly moist, silty, clayey SAND with gravel (SM-SC). Gravel and larger-sized subrounded to subangular quartzite clasts comprised approximately 20% of the unit, with individual clasts up to 8 inches in diameter, though the mode clast size was approximately 1 to 2 inches in diameter. The unit contained abundant 1 to 2 mm diameter pinhole voids throughout, though the fines content had a low plasticity. Occasional calcium carbonate matrix flour was also observed. This unit may be representative of a shallow, surficial landslide deposit, given the highly irregular nature of the upper contact.

Wasatch Formation (Tw): This unit was observed in TP-1 only, being more than 5.5 feet thick and extending to the maximum depth of exploration within the test pit. The unit consisted of weakly consolidated conglomerate bedrock that had been largely disaggregated into a pale yellowish orange to dark reddish brown, dense to very dense, slightly moist mixture of clay, sand, and gravel that collectively classifies as clayey GRAVEL with sand (GC). Gravel and larger-sized subangular to subrounded quartzite clasts comprised between approximately 30 and 60% of the unit, with individual clasts up to 3 feet in diameter, with a mode clast size of 4 to 6 inches. Where clayey, the unit exhibited common pinholes between 1 and 2 mm in diameter.

Young Landslide (Qlsy): This unit was observed in TP-2 only and was found to be between 2 and 4 feet thick. The unit consisted of a highly variegated, dark yellowish brown to black to dark yellowish orange, loose to medium dense, moist to wet, clayey SAND with gravel (SC) gradational to sandy lean CLAY with gravel (CL). Gravel and larger-sized subrounded quartzite clasts comprised between approximately 10 and 15% of the unit, with individual clasts up to 14 inches in diameter, though the mode clast size was 2 inches and clast sizes were highly variable. The unit was found to be a highly erratic, heterogeneous unit, though no evident basal slide plane was observed.

Older Landslide (Qlso): This unit was observed in TP-2 only, being between 2 and more than 10 feet thick, extending to the maximum depth of exploration in portions of the test pit. The unit consisted of a moderate yellowish brown to light brown, medium dense, slightly moist, clayey SAND with gravel (SC). Gravel and larger-sized subrounded quartzite clasts comprised between approximately 30 and 40% of the unit, with individual clasts up to 2 feet in diameter, though the mode clast size was 1 to 2 inches. Abundant pinhole voids between 1 and 2 mm in diameter were observed. The unit appeared very similar to the colluvium unit observed in TP-1, and contained a sharp, highly irregular basal contact.

Weathered Bedrock? (Cn?): This unit was observed in TP-2 only, being at least 1.5 feet thick and extending to the maximum depth of exploration in most of the test pit. The unit consisted of a dark reddish brown, stiff to very stiff, slightly moist, sandy lean CLAY with gravel (CL). Gravel and larger-sized subrounded to subangular quartzite clasts comprised approximately 10% of the unit, with individual clasts up to 2.5 feet in diameter, though the mode clast size was 1 to 2 inches. The unit was observed to have occasional discontinuous, poorly developed mechanically-induced slickensides when broken, but not in situ. The unit appeared similar to weathered Nounan Dolomite bedrock seen in other places of Powder Mountain, though dolomite clasts were not observed within the unit. It is possible that this unit could represent a possible slide plane for the older landslide deposits.

4.2.2 Groundwater

Groundwater was not encountered in either of the test pits excavated for this project; however, it should be noted that groundwater has been encountered in several test pit excavations located east of the subject lot in the *Horizon Neighbourhood* property (IGES, 2016). Additionally, the young landslide unit observed in TP-2 was wet in places, and it is quite possible that groundwater, or local seeps, could be encountered locally in excavations that exceed a depth of 12 feet below existing grade.

4.2.3 Strength of Earth Materials

One consolidated-drained direct shear test was completed under drained conditions on a remolded sample obtained the prevailing coarse, granular soils – the sample was obtained from TP-1 at a depth of 3½ feet from colluvium deposits that classifies as Clayey SAND with gravel (SC). The test results indicate that the soil tested has a friction angle of 30 degrees and a cohesion of 54 psf. A summary of the direct shear test is presented in Appendix B.

4.3 SLOPE STABILITY

4.3.1 Global Stability

The stability of the existing natural slope has been assessed in accordance with methodologies set forth in Blake et al. (2002) and AASHTO LRFD for Bridge Design Specifications with respect to a representative cross-section, illustrated on Figure D-1 in Appendix D (the section is identified in plan-view on Figure A-5). 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 a rotational-type failure occurring through surficial soils (colluvium and shallow landslide deposits), just above the underlying conglomerate bedrock. Analysis was performed for both static and seismic (pseudo-static) cases. The slope was modeled under both existing conditions and assuming a basement excavation with a typical residential foundation load (estimated, since grading plans are not yet available).

Groundwater, e.g. a piezometric groundwater surface, was not encountered during our subsurface investigation; however, seepage was noted in test pits on nearby properties (IGES, 2016). Accordingly, groundwater was not modeled in our limit-equilibrium analysis. Saturated parallel seepage has been modeled in a separate analysis (see Section 4.3.2).

Soil strength parameters were selected based on soil types observed, local experience, correlation with index properties (Atterberg Limits, fines content), site-specific strength testing (direct shear test), and comparisons with soil strength laboratory data from a nearby site (IGES, 2016). Based on this assessment, the following soil strength parameters were selected for this analysis:

Table 4.3.1a
Soil Strength Parameters

Earth Materials	Friction angle (degrees)	Cohesion (psf)	Unit Weight (pcf)
Colluvium	30	100	120
Bedrock (Tw)	40	100	130
Undocumented Fill (Af)	35	75	125
Old Landslide (Qlso)	30	100	120
Young Landslide (Qlsy)	30	100	120
Nounan Formation (Cn)	25	1,500	120

Pseudo-static (seismic screening) analysis of the proposed slope was performed in general conformance with Blake et al. (2002), ASCE 7-10 and AASHTO LRFD for Bridge Design Specifications. 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 on the USGS website ground motion calculator, the Peak Ground Acceleration (PGA) associated with a 2PE50 event is estimated to be 0.36g. Half of the PGA, (0.177g), was taken as the horizontal seismic coefficient (k_h) (Hynes and Franklin, 1984), and used in the pseudo-static seismic screen analysis. The results of the analyses have been summarized in Table 4.3.1b.

Table 4.3.1b
Results of Slope Stability Analyses

Section	Static Factor of Safety	Pseudo-Static Factor of Safety
Existing Condition	1.88	1.23
Estimated Grading	2.56	1.62

The results of the analysis indicated the existing conditions meet the minimum required factors-of-safety of 1.5 and 1.0 for both the static and seismic (pseudo-static) case, respectively. The planned improvements will include a basement level, which would tend to unload the slope and further improve the stability of the slope; significant fill placement on the slope, which would tend to load the slope and decrease stability, is not anticipated. A summary of the slope stability analysis is presented in Appendix D.

4.3.2 Surficial Stability

Our subsurface investigation indicates that the near-surface soils generally consist of clayey sand with gravel (SC). Material identified as 'topsoil' (A/B Horizon) generally ranges in thickness from 1 to 2 feet; the topsoil has developed on the prevailing colluvial cover identified within the building envelope, and therefore consists largely of clayey sand with gravel, but with a higher organic component (abundant roots).

IGES assessed the potential for the upper three feet to become mobilized under saturated parallel seepage conditions. Our assessment assumes three feet of coarse colluvium or topsoil, fully saturated, and a 3.5H:1V slope (this would be a transient condition that could occur during primary spring run-off and snowmelt). Our model assumes an estimated effective friction angle of 30 degrees and a cohesion of 50 psf, and a saturated unit weight of 135 pcf. Based on this model, a factor-of-safety of 1.56 results. Sample calculations are presented in Appendix D.

Our calculations do not take into account the beneficial effects of plant roots, which were commonly observed throughout the topsoil units. Many of the existing natural slopes are thickly vegetated, which is expected to reduce the likelihood of shallow surficial slope instability. Conversely, slopes that have been grubbed, or new fill slopes constructed steeper than about 2.5H:1V, may experience localized shallow surficial failures during spring snowmelt until vegetation is established.

Based on our infinite slope model, and the foregoing discussion, IGES considers the potential for surficial slope instability impacting natural, vegetated slopes on this site to be low.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 GENERAL CONCLUSIONS

Based on the results of the field observations, literature review, and slope stability analyses, **the subsurface conditions are considered suitable for the proposed development provided that the recommendations presented in this report are incorporated into the design and construction of the project.**

Supporting data upon which the following conclusions and recommendations are based have been presented in the previous sections of this report. The recommendations presented herein are governed by the physical properties of the earth materials encountered in the subsurface explorations. If subsurface conditions other than those described herein are encountered in conjunction with construction, and/or if design and layout changes are initiated, IGES must be informed so that our recommendations can be reviewed and revised as deemed necessary.

5.2 GEOLOGIC CONCLUSIONS AND RECOMMENDATIONS

Based upon the data collected and reviewed as part of the geologic hazard assessment, IGES makes the following conclusions regarding the geological hazards present at the Lot 14R project area:

- **The Lot 14R project area appears to have geological hazards that are capable of adversely impacting the development as currently proposed under the existing conditions, in the form of landslide deposits. However, engineered mitigation practices for the proposed development are capable of reducing the landslide hazard risk to a level that is considered to be suitable from a geologic hazards perspective.**

- Landsliding represents the greatest geologic risk to the property. The property is located on mapped landslide deposits, and landslide deposits and a headscarp was observed in the southern part of the property. In addition, both younger and older landslide deposits were observed in the subsurface in TP-2, and the older landslide deposits may extend into the southern part of the building envelope. However, geologic evidence indicative of active movement was not observed within the building envelope, and the slope stability analysis indicates a stable slope for the property in the vicinity of the building envelope. As such, the landslide hazard for the property is considered to be moderate to low, as there is always some inherent risk when developing on known landslide deposits.

- Earthquake ground shaking is the only other identified hazard that may potentially affect all parts of the project area and is considered to pose a moderate risk.

- Shallow groundwater conditions were not observed in either of the two test pits, though groundwater seepage has been observed in test pits on nearby properties and are common within landslide deposits; therefore, shallow groundwater hazards are considered to be low to moderate for the property.

- Rockfall, surface-fault-rupture, liquefaction, debris-flow, and flooding hazards are considered to be low for the property.

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

- Because landslide deposits are noted on the property, an IGES engineering geologist or geotechnical engineer should observe the foundation excavation to assess the absence (or presence) of landslide-induced shearing.

- Development should not take place on landslide deposits; over-excavation of the landslide deposits (if present) to competent native materials (Wasatch Formation) should be performed within the building envelope.

- The contact between the older landslide deposits and the Wasatch Formation may be within the southern part of the building envelope. As such, it is recommended that the northern portion of the building envelope be utilized for the proposed development in order to avoid the landslide deposits and the associated landslide mitigation. In the event that the southern portion of the building envelope is to be used for the development, an IGES engineering geologist should be present to identify the contact, note its trend, and provide recommendations for over-excavation of the landslide deposits and the placement of structural fill, if necessary.

- Effort should be made to limit the introduction of water into the subsurface near the proposed residence. Appropriate grading and drainage away from the home and xeriscape or natural landscaping will assist in reducing the risk of landsliding.

- Young landslide deposits associated with a notable scarp are located within 50 feet of the southern margin of the building envelope. If tension cracks or other ground deformation is observed near this area, or near the building envelope, IGES should be contacted to evaluate the ground deformation and assess whether mitigation is needed.

5.3 EARTHWORK

5.3.1 General Site Preparation and Grading

Below proposed structures, fills, and man-made improvements, all vegetation, topsoil, debris and undocumented fill (if any) should be removed. Any existing utilities should be re-routed or protected in place. The exposed native soils should then be proof-rolled with heavy rubber-tired equipment such as a scraper or loader*. Any soft/loose areas identified during proof-rolling should be removed and replaced with structural fill. All excavation bottoms should be observed by an IGES representative during proof-rolling or otherwise prior to placement of engineered fill to evaluate whether soft, loose, or otherwise deleterious earth materials have been removed, and to assess compliance with the recommendations presented in this report.

*not required where bedrock is exposed in the foundation subgrade

5.3.2 Excavations

Soft, loose, or otherwise unsuitable soils beneath structural elements, hardscape or pavements may need to be over-excavated and replaced with structural fill. This includes landslide deposits, if encountered in the subsurface. If over-excavation is required, the excavations should extend one foot laterally for every foot of depth of over-excavation. Excavations should extend laterally at least two feet beyond flatwork, pavements, and slabs-on-grade. Structural fill should consist of granular materials and should be placed and compacted in accordance with the recommendations presented in this report.

Prior to placing structural fill, all excavation bottoms should be scarified to at least 6 inches, moisture conditioned as necessary at or slightly above optimum moisture content (OMC), and compacted to at least 90 percent of the maximum dry density (MDD) as determined by ASTM D-1557 (Modified Proctor). Scarification is not required where hard bedrock is exposed.

5.3.3 Excavation Stability

The contractor is responsible for site safety, including all temporary trenches excavated at the site and the design of any required temporary shoring. The contractor is responsible for providing the "competent person" required by Occupational Safety and Health (OSHA) standards to evaluate soil conditions. For planning purposes, Soil Type C is expected to predominate at the site (sands and gravels). Close coordination between the competent person and IGES should be maintained to facilitate construction while providing safe excavations.

Based on OSHA guidelines for excavation safety, trenches with vertical walls up to 5 feet in depth may be occupied. Where very moist soil conditions or groundwater is encountered, or when the trench is deeper than 5 feet, we recommend a trench-shield or shoring be used as a protective system to workers in the trench. As an alternative to shoring or shielding, trench walls may be laid back at one and one-half horizontal to one vertical (1½H:1V) (34 degrees) in accordance with OSHA Type C soils. Trench walls may need to be laid back at a steeper grade pending evaluation of soil conditions by the geotechnical engineer. Soil conditions should be evaluated in the field on a case-by-case basis. Large rocks exposed on excavation walls should be removed (scaled) to minimize rock fall hazards.

5.3.4 Structural Fill and Compaction

All fill placed for the support of structures, flatwork or pavements should consist of structural fill. Structural fill should consist of granular native soils, which may be defined as soils with less than 25% fines, 10-60% sand, and contain no rock larger than 4 inches in nominal size (6 inches in greatest dimension). Structural fill should also be free of vegetation and debris. All structural fill should be 1-inch minus material when within 1 foot of any base coarse material. Soils not meeting these criteria may be suitable for use as structural fill; however, such soils should be evaluated on a case by case basis and should be approved by IGES prior to use.

All structural fill should be placed in maximum 4-inch loose lifts if compacted by small hand-operated compaction equipment, maximum 6-inch loose lifts if compacted by light-duty rollers, and maximum 8-inch loose lifts if compacted by heavy duty compaction equipment that is capable of efficiently compacting the entire thickness of the lift. Additional lift thickness may be allowed by IGES provided the Contractor can demonstrate sufficient compaction can be achieved with a given lift thickness with the equipment in use. We recommend that all structural fill be compacted on a horizontal plane, unless otherwise approved by IGES. Structural fill underlying all shallow footings and pavements should be compacted to at least 95 percent of the MDD as determined by ASTM D-1557. **The moisture content should be at, or slightly above, the OMC for all structural fill**. Any imported fill materials should be approved prior to importing. Also, prior to placing any fill, the excavations should be observed by IGES to confirm that unsuitable materials have been removed. In addition, proper grading should precede placement of fill, as described in the General Site Preparation and Grading subsection of this report.

Specifications from governing authorities such as Weber County and/or special service districts having their own precedence for backfill and compaction should be followed where more stringent.

5.3.5 Oversize Material

Based on our observations, there is a significant potential for the presence of oversize materials (larger than 6 inches in greatest dimension). Large rocks, particularly boulders (>12 inches), may require special handling, such as segregation from structural fill, and disposal.

5.3.6 Utility Trench Backfill

Utility trenches should be backfilled with structural fill in accordance with Section 5.3.4 of this report. Utility trenches can be backfilled with the onsite soils free of debris, organic and oversized material. Prior to backfilling the trench, pipes should be bedded in and shaded with a uniform granular material that has a Sand Equivalent (SE) of 30 or greater. Pipe bedding may be water-densified in-place (jetting). Alternatively, pipe bedding and shading may consist of clean ¾-inch gravel. Native earth materials can be used as backfill over the pipe bedding zone. All utility trenches backfilled below pavement sections, curb and gutter, and hardscape, should be backfilled with structural fill compacted to at least 95 percent of the MDD as determined by ASTM D-1557.

All other trenches should be backfilled and compacted to approximately 90 percent of the MDD (ASTM D-1557). However, in all cases the pipe bedding and shading should meet the design criteria of the pipe manufacturer. Specifications from governing authorities having their own precedence for backfill and compaction should be followed where they are more stringent.

5.4 FOUNDATION RECOMMENDATIONS

Based on our field observations and considering the presence of relatively competent native earth materials, we recommend that the footings for proposed single-family home be founded either *entirely* on competent native soils or *entirely* on structural fill. Native/fill transition zones are not allowed. Where soft, loose, or otherwise deleterious earth materials (such as landslide deposits or undocumented fill) are exposed on the foundation subgrade, IGES recommends a minimum over-excavation of 2 feet and replacement with structural fill. Alternatively, the foundations may be extended such that the foundations bear directly on competent earth materials (Wasatch Formation, e.g. conglomerate bedrock). We recommend that IGES assess the bottom of the foundation excavation prior to the placement of steel or concrete, or structural fill, to identify the competent native earth materials as well as any unsuitable soils or transition zones. Additional over-excavation may be required based on the actual subsurface conditions observed.

Shallow spread or continuous wall footings constructed entirely on structural fill, or entirely on competent, uniform native earth materials (Wasatch Formation conglomerate) may be proportioned utilizing a maximum net allowable bearing pressure of **3,200 pounds per square foot (psf)** for dead load plus live load conditions. The net allowable bearing values presented above are for dead load plus live load conditions. The allowable bearing capacity may be increased by one-third for short-term loading (wind and seismic). The minimum recommended footing width is 20 inches for continuous wall footings and 30 inches for isolated spread footings.

All conventional foundations exposed to the full effects of frost should be established at a minimum depth of 42 inches below the lowest adjacent final grade. Interior footings, not subjected to the full effects of frost (i.e., *a continuously heated structure*), may be established at higher elevations, however, a minimum depth of embedment of 12 inches is recommended for confinement purposes.

Foundation drains should be installed around below-ground foundations (e.g., basement walls) to minimize the potential for flooding from shallow groundwater or seepage, which may be present at various times during the year, particularly spring run-off.

5.5 SETTLEMENT

5.5.1 Static Settlement

Static settlements of properly designed and constructed conventional foundations, founded as described in Section 5.4, are anticipated to be on the order of 1 inch or less. Differential settlement is expected to be half of total settlement over a distance of 30 feet.

5.5.2 Dynamic Settlement

Dynamic settlement (or seismically-induced settlement) consists of dry dynamic settlement of unsaturated soils (above groundwater) and liquefaction-induced settlement (below groundwater). During a strong seismic event, seismically-induced settlement can occur within loose to moderately dense sandy soil due to reduction in volume during, and shortly after, an earthquake event. Settlement caused by ground shaking is often non-uniformly distributed, which can result in differential settlement.

Based on the subsurface conditions encountered, dynamic settlement arising from a MCE seismic event is expected to be low; for design purposes, settlement on the order of ½ inch over 40 feet may be assumed.

5.6 EARTH PRESSURES AND LATERAL RESISTANCE

Lateral forces imposed upon conventional foundations due to wind or seismic forces may be resisted by the development of passive earth pressures and friction between the base of the footing and the supporting soils. In determining the frictional resistance against concrete, a coefficient of friction of 0.45 for sandy/gravelly native soils or structural fill should be used.

Ultimate lateral earth pressures from *granular* backfill acting against retaining walls, temporary shoring, or buried structures may be computed from the lateral pressure coefficients or equivalent fluid densities presented in Table 5.6. These lateral pressures should be assumed even if the backfill is placed in a relatively narrow gap between a vertical bedrock cut and the foundation wall. These coefficients and densities assume no buildup of hydrostatic pressures. The force of water should be added to the presented values if hydrostatic pressures are anticipated.

Clayey soils drain poorly and may swell upon wetting, thereby greatly increasing lateral pressures acting on earth retaining structures; therefore, clayey soils should not be used as retaining wall backfill. Backfill should consist of native granular soil with an Expansion Index (EI) less than 20.

Walls and structures allowed to rotate slightly should use the active condition. If the element is to be constrained against rotation (i.e., a basement wall), the at-rest condition should be used. These values should be used with an appropriate factor of safety against overturning and sliding. A value of 1.5 is typically used. Additionally, if passive resistance is calculated in conjunction with frictional resistance, the passive resistance should be reduced by ½.

Table 5.6
Lateral Earth Pressure Coefficients

Condition	Level Backfill		2H:1V Backfill	
	Lateral Pressure Coefficient	**Equivalent Fluid Density (pcf)**	**Lateral Pressure Coefficient**	**Equivalent Fluid Density (pcf)**
Active (Ka)	0.33	41.7	0.53	66.5
At-rest (Ko)	0.50	55	0.80	85
Passive (Kp)	3.0	375	—	—
Seismic Active	0.12	15.1	0.38	47.4
Seismic Passive	-0.33	-40.8	—	—
Seismic At-rest	0.18	22.5	0.57	71.7

For seismic analyses, the *active* earth pressure coefficient provided in the table is based on the Mononobe-Okabe pseudo-static approach and only accounts for the dynamic horizontal thrust produced by ground motion. Hence, the resulting dynamic thrust pressure *should be added* to the static pressure to determine the total pressure on the wall. The pressure distribution of the dynamic horizontal thrust may be closely approximated as an inverted triangle with stress decreasing with depth and the resultant acting at a distance approximately 0.6 times the loaded height of the structure, measured upward from the bottom of the structure.

5.7 CONCRETE SLAB-ON-GRADE CONSTRUCTION

To minimize settlement and cracking of slabs, and to aid in drainage beneath the concrete floor slabs, all concrete slabs should be founded on a minimum 4-inch layer of compacted gravel overlying properly prepared subgrade. The gravel should consist of free-draining gravel or road base with a 3/4-inch maximum particle size and no more than 5 percent passing the No. 200 mesh sieve. The layer should be compacted to at least 95 percent of the MDD as determined by ASTM D-1557.

All concrete slabs should be designed to minimize cracking as a result of shrinkage. Consideration should be given to reinforcing the slab with a welded wire fabric, re-bar, or fibermesh. Slab reinforcement should be designed by the structural engineer; however, as a minimum, slab reinforcement should consist of 4’’×4’’ W2.9×W2.9 welded wire mesh within the middle third of the slab. We recommend that concrete be tested to assess that the slump and/or air content is in compliance with the plans and specifications. We recommend that concrete be placed in general accordance with the requirements of the American Concrete Institute (ACI). A Modulus of Subgrade Reaction of **250 psi/inch** may be used for design.

A moisture barrier (vapor retarder) consisting of 10-mil thick Visqueen (or equivalent) plastic sheeting should be placed below slabs-on-grade where moisture-sensitive floor coverings or equipment is planned. Prior to placing this moisture barrier, any objects that could puncture it, such as protruding gravel or rocks, should be removed from the building pad. Alternatively, the subgrade may be covered with 2 inches of clean sand**.**

5.8 MOISTURE PROTECTION AND SURFACE DRAINAGE

Surface moisture should not be allowed to infiltrate into the soils in the vicinity of the foundations. As such, design strategies to minimize ponding and infiltration near the structures should be implemented.

We recommend roof runoff devices be installed to direct all runoff a minimum of 10 feet away from foundations. The builder should be responsible for compacting the exterior backfill soils around the foundation; failure to properly compact the basement backfill can result in excessive settlement and damage to exterior improvements such as pavement or other flatwork. Additionally, the ground surface within 10 feet of the structures should be constructed so as to slope a minimum of **five** percent away from the structure. Irrigation valves should be placed a minimum of 5 feet from foundation walls and must not be placed within the basement backfill zone. Over-watering near the foundation walls is discouraged; use of Xeriscape and/or a drip irrigation system should be considered. Pavement sections should be constructed to divert surface water off the pavement into storm drains, curb/gutter, or another suitable location.

Where basements are planned, IGES recommends a perimeter foundation drain be constructed in accordance with the International Residential Code (IRC).

5.9 SOIL CORROSION POTENTIAL

Laboratory testing of representative soil samples obtained during previous nearby investigations (IGES, 2017, 2012b) indicated that the soil samples tested had sulfate contents less than 100 ppm. Accordingly, the soils in this area are appropriately classified as having a ‘low potential’ for deterioration of concrete due to the presence of soluble sulfate. As such, conventional Type II Portland cement may be used for all concrete in contact with site soils.

To evaluate the corrosion potential of ferrous metal in contact with onsite native soil, we have reviewed laboratory tests conducted for nearby soil samples obtained during previous nearby geotechnical investigation (IGES, 2017, 2012b). Three samples were tested for soil resistivity (AASHTO T288), soluble chloride content, and pH. The tests indicated that the onsite soil tested had a minimum soil resistivity of ranging from 980 to 5,311 OHM-cm, soluble chloride content ranging from 6 to 12 ppm, and a pH ranging from 6.3 to 6.6. Based on this result, the onsite native soil is considered *severely* corrosive to ferrous metal. Consideration should be given to retaining the services of a qualified corrosion engineer to provide an assessment of any metal that will be in contact with native clay soils.

5.10 CONSTRUCTION CONSIDERATIONS

5.10.1 Over-Size Material

Large boulders (up to 36 inches in diameter) were observed on the surface and within the test pits; as such, excavation of the basement may generate an abundance of over-size material that may require special handling, processing, or disposal.

6.0 CLOSURE

6.1 LIMITATIONS

The concept of risk is a significant consideration of geotechnical analyses. The analytical means and methods used in performing geotechnical analyses and development of resulting recommendations do not constitute an exact science. Analytical tools used by geotechnical engineers are based on limited data, empirical correlations, engineering judgment and experience. As such the solutions and resulting recommendations presented in this report cannot be considered risk-free and constitute IGES's best professional opinions and recommendations based on the available data and other design information available at the time they were developed. IGES has developed the preceding analyses, recommendations and designs, at a minimum, in accordance with generally accepted professional geotechnical engineering practices and care being exercised in the project area at the time our services were performed. No warrantees, guarantees or other representations are made.

The information contained in this report is based on limited field testing and understanding of the project. The subsurface data used in the preparation of this report were obtained largely from the explorations made for the Lot 14R project. It is very likely that variations in the soil, rock, and groundwater conditions exist between and beyond the points explored. The nature and extent of the variations may not be evident until construction occurs and additional explorations are completed. If any conditions are encountered at this site that are different from those described in this report, IGES must be immediately notified so that we may make any necessary revisions to recommendations presented in this report. In addition, if the scope of the proposed construction or grading changes from those described in this report, our firm must also be notified.

Landslide deposits were observed in the subsurface south of the building envelope of the property and may possibly extend into the southernmost extent of the building envelope. Although the current plans indicate the new home will be constructed within the northern half of the building envelope, and therefore outside of the identified landslide deposits, there is always a risk of the existing landslide to become reactivated and subsequently propagate uphill toward the home. It should be noted that while the slope stability assessment as performed as part of this investigation indicate that the slope is currently stable and anticipated to be stable following development, the landslide risk cannot be assumed to be zero.

This report was prepared for our client's exclusive use on the project identified in the foregoing. Use of the data, recommendations or design information contained herein for any other project or development at or near the subject site *not as specifically described in this report* is at the user's sole risk and without the approval of IGES, Inc. It is the client's responsibility to see that all parties to the project including the designer, 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.

We recommend that IGES be retained to review the final design plans, grading plans and specifications to determine if our engineering recommendations have been properly incorporated in the project development documents. We also recommend that IGES be retained to evaluate construction performance and other geotechnical aspects of the project as construction initiates and progresses through its completion.

6.2 ADDITIONAL SERVICES

The recommendations made in this report are based on the assumption that an adequate program of tests and observations will be made during the construction. IGES staff or other qualified personnel should be on site to verify compliance with these recommendations. These tests and observations should include at a minimum the following:

- Observations and testing during site preparation, earthwork and structural fill placement.
- Consultation as may be required during construction.
- Quality control on concrete placement to verify slump, air content, and strength.

We also recommend that project plans and specifications be reviewed by us to verify compatibility with our conclusions and recommendations. Additional information concerning the scope and cost of these services can be obtained from our office.

We appreciate the opportunity to be of service on this project. Should you have any questions regarding the report or wish to discuss additional services, please do not hesitate to contact us at your convenience at (801) 748-4044.

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U.S. Geological Survey, 2014, Topographic Map of the Huntsville Quadrangle, Huntsville, Utah: Scale 1:24,000.

U.S. Geological Survey, 2014, Topographic Map of the Brown's Hole Quadrangle, Brown's Hole, Utah: Scale 1:24,000.

U.S. Geological Survey and Utah Geological Survey, 2006, Quaternary fault and fold database for the United States, accessed 11-20-17, from USGS website: http://earthquakes.usgs.gov/regional/qfaults

Utah Geological Survey, 2018, Utah Geological Survey Aerial Imagery Collection **https://geodata.geology.utah.gov/imagery/**

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

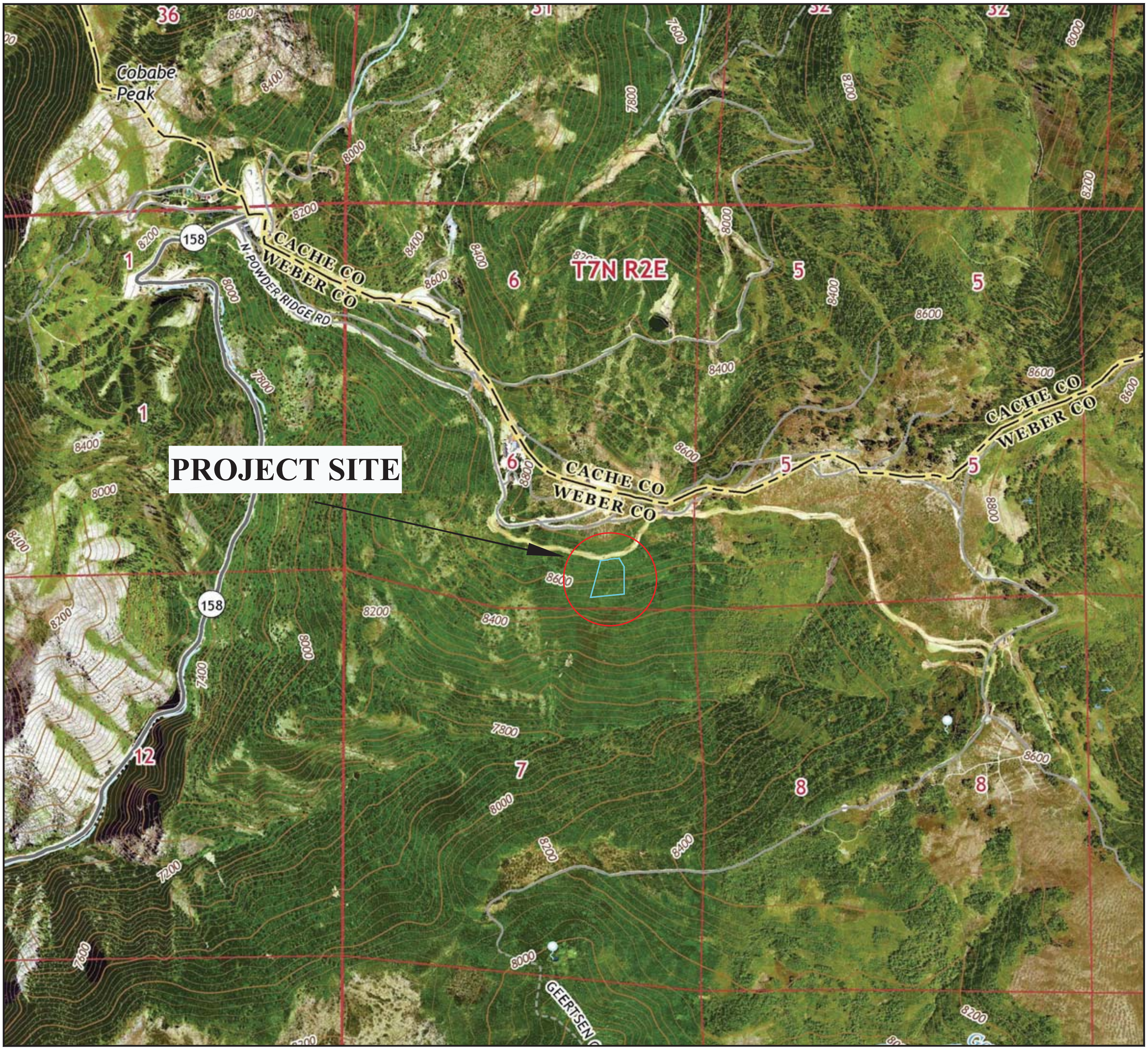
Western Geologic, 2012, Report: Geologic Hazards Reconnaissance, Proposed Area 1 Mixed-Use Development, Powder Mountain Resort, Weber County, Utah, dated August 28, 2012.

AERIAL PHOTOGRAPHS

Data Set	Date	Flight	Photographs	Scale
1947 AAJ	August 10, 1946	AAJ_1B	88, 89, 90	1:20,000
1953 AAI	September 14, 1952	AAI_4K	34, 35, 36	1:20,000
1963 ELK	June 25, 1963	ELK_3	57, 58, 59	1:15,840

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

APPENDIX A



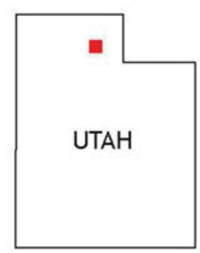
BASE MAPS:

-USGS HUNTSVILLE, BROWN'S HOLE, JAMES PEAK AND SHARP MOUNTAIN 7.5-MINUTE QUADRANGLE TOPOGRAPHIC MAPS (2017)

N

0 1000 2000 3000
FEET

1" = 2000'



QUADRANGLE LOCATION

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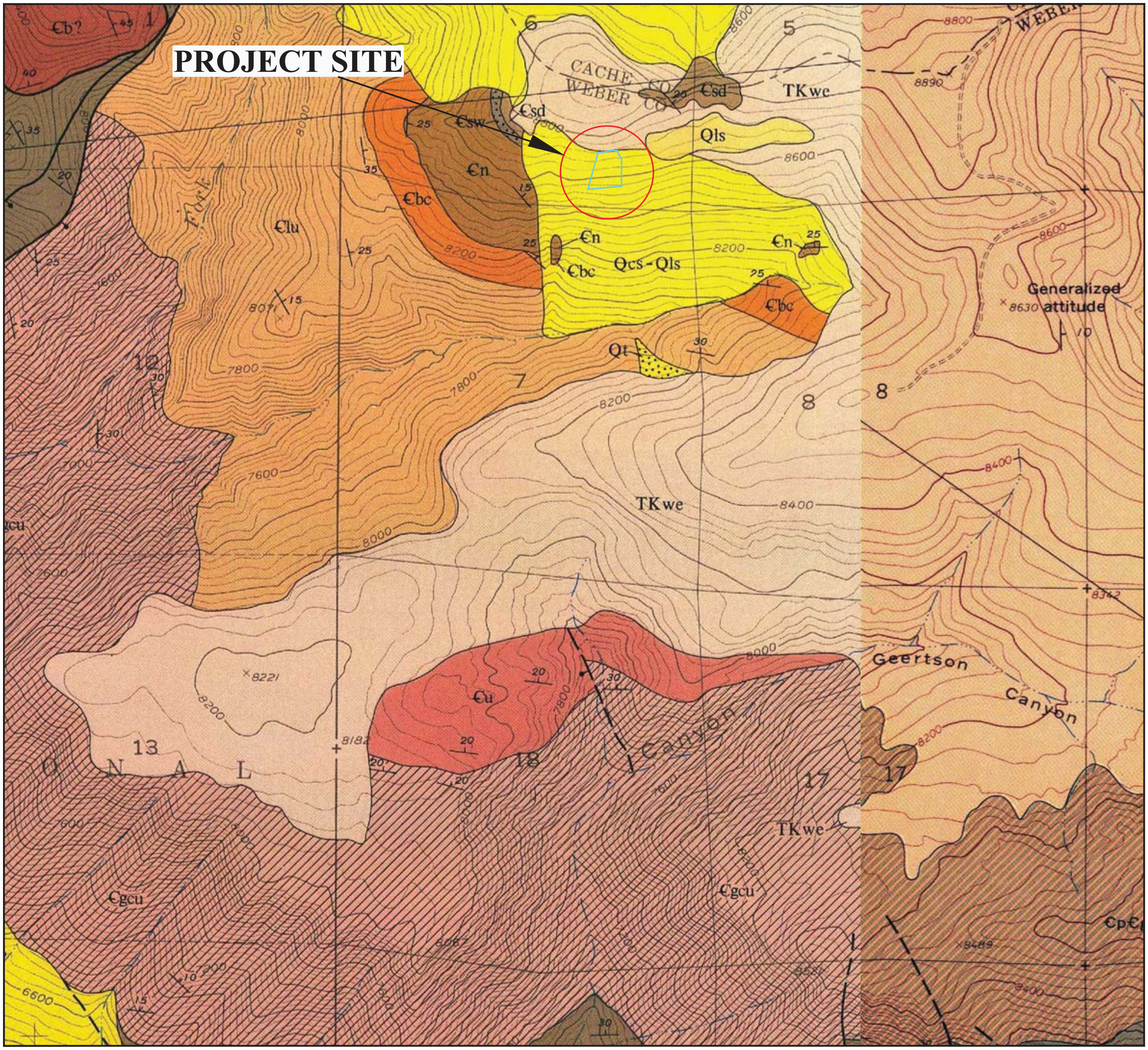
GEOTECHNICAL AND GEOLOGIC HAZARDS ASSESSMENT
LOT 14R OF SUMMIT EDEN PHASE 1A
POWDER MOUNTAIN RESORT
WEBER COUNTY, UT

SITE VICINITY MAP

FIGURE

A-1



BASE MAPS:

-USGS HUNTSVILLE 7.5-MINUTE GEOLOGIC QUADRANGLE MAP (GQ-1503), SORENSEN AND CRITTENDEN, JR. (1979)

-USGS BROWN'S HOLE 7.5-MINUTE GEOLOGIC QUADRANGLE MAP (GQ-968), CRITTENDEN, JR. (1972)

N

0 1000 2000 3000
FEET

1" = 2000'

QUADRANGLE LOCATION

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GEOTECHNICAL AND GEOLOGIC HAZARDS ASSESSMENT
LOT 14R OF SUMMIT EDEN PHASE 1A
POWDER MOUNTAIN RESORT
WEBER COUNTY, UT

REGIONAL GEOLOGY MAP 1

FIGURE

A-2a

MAP LEGEND

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
Qls	LANDSLIDE DEPOSITS (Holocene) – thickness 0-6 m
Qt	TALUS DEPOSITS (Holocene) – thickness 0-6 m
TKwe	WASATCH AND EVANSTON(?) FORMATIONS, UNDIVIDED (Eocene, Paleocene, and Upper Cretaceous?) – Unconsolidated pale-reddish-brown pebble, cobble, and boulder conglomerate; forms boulder-covered slopes. Clasts are mainly Precambrian quartzite and are tan, gray, or purple; matrix is mainly poorly consolidated sand and silt; thickness 0-150 m
	ST. CHARLES LIMESTONE (Upper Cambrian) – Includes:
€sd	Dolomite member – Thin- to thick-bedded, finely to medium crystalline, light- to medium-gray, white- to light-gray-weathering, cliff-forming dolomite; linguloid brachiopods common in basal 15 m; thickness 150-245 m
€sw	Worm Creek Quartzite Member – Thin-bedded, fine- to medium-grained, medium- to dark-gray, tan- to brown-weathering calcareous quartzitic sandstone; detrital grains well-sorted and well-rounded; thickness 6 m
€n	NOUNAN DOLOMITE (Upper and Middle Cambrian) – Thin- to thick-bedded, finely crystalline, medium-gray, light- to medium-gray-weathering, cliff-forming dolomite; white twiggy structures common throughout unit; thickness 150-230 m
€bc	CALLS FORT SHALE MEMBER OF BLOOMINGTON FORMATION (Middle Cambrian) – Olive-drab to light-brown shale and light- to dark-blue-gray limestone with intercalated orange to rusty-brown silty limestone; intraformational conglomerate common throughout unit; thickness 23-90 m

MAP LEGEND

Ꞓlu CAMBRIAN LIMESTONES, UNDIVIDED (Middle Cambrian) – Includes limestone and Hodges Shale Members of Bloomington Formation, and Blacksmith and Ute Limestones

Ꞓu UTE LIMESTONE (Middle Cambrian) – Medium- to thin-bedded, finely crystalline, light- to dark-gray silty limestone with irregular wavy partings, mottled and streaked surfaces, worm tracks, and twiggy structures common throughout unit; oolites and *Girvanella* in many beds; olive-drab fissile shale interbedded throughout unit. Includes thin-bedded, gray-weathering, pale-tan to brown dolomite exposed at base of unit, 18-24 m at head of Geertsen Canyon and 0-3 m elsewhere; thickness 245? m

BRIGHAM GROUP (Crittenden and others, 1971) – Includes:

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

Contact

Dashed where approximately located; dotted where concealed

Fault showing dip

Dashed where approximately located; dotted where concealed; queried where doubtful; bar and ball on downthrown side; arrows show direction of relative displacement

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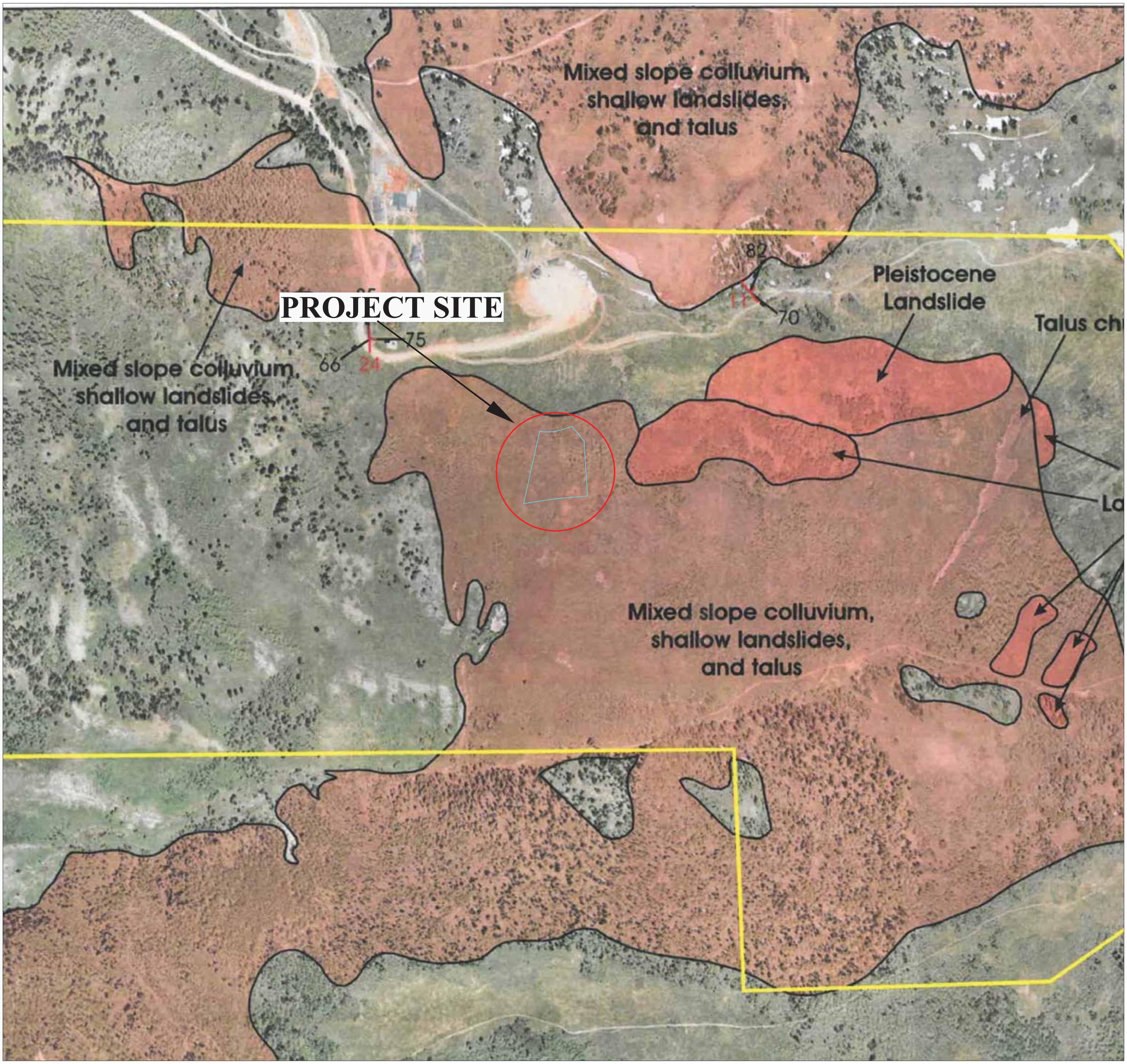
GEOTECHNICAL AND GEOLOGIC HAZARDS ASSESSMENT
LOT 14R OF SUMMIT EDEN PHASE 1A
POWDER MOUNTAIN RESORT
WEBER COUNTY, UT

REGIONAL GEOLOGY MAP 1

FIGURE

A-2c



BASE MAP:

-WESTERN GEOLOGIC (2012)
GEOLOGIC HAZARDS
RECONNAISSANCE REPORT, FIGURE 3

1" = 1000'

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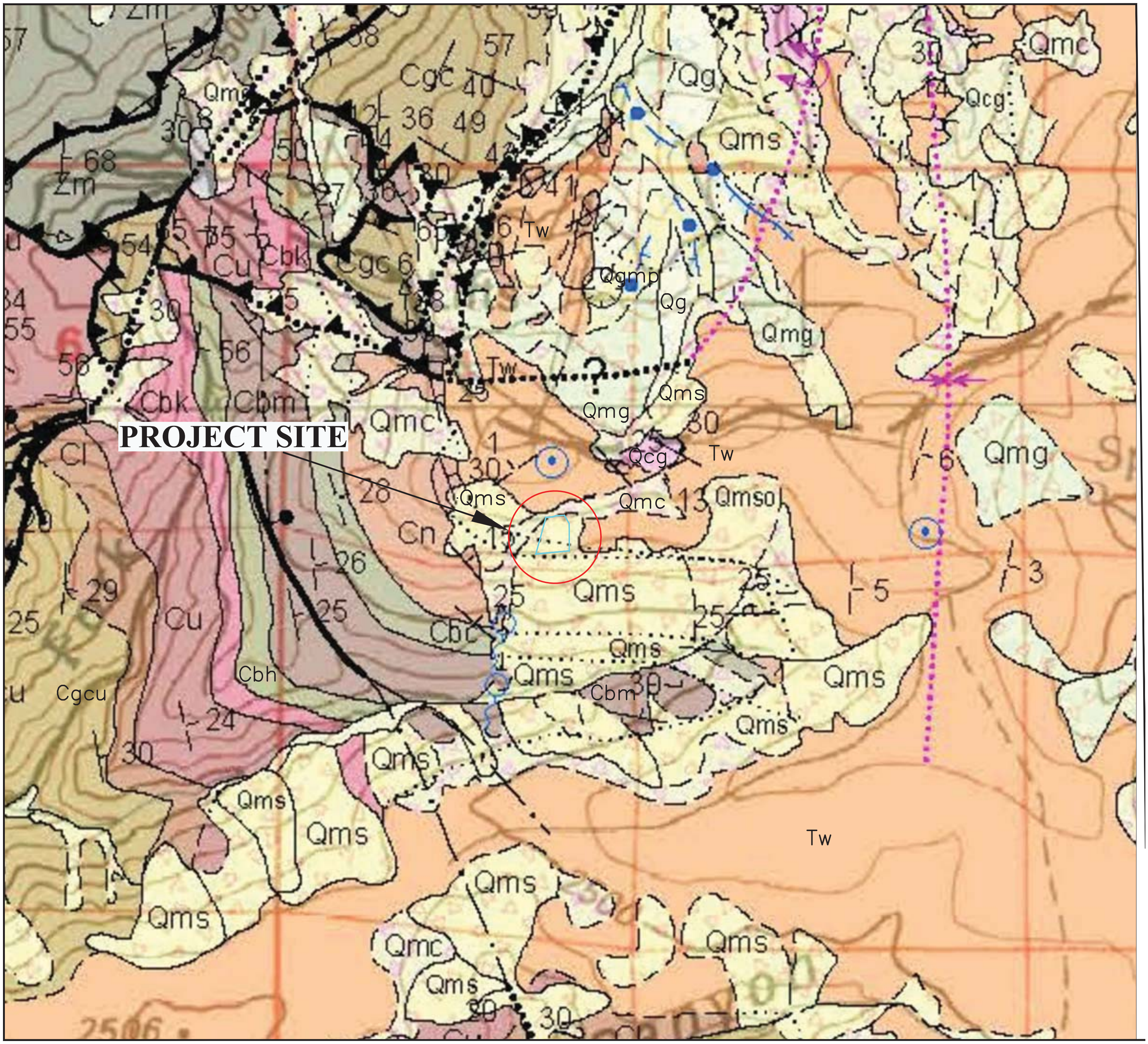
GEOTECHNICAL AND GEOLOGIC HAZARDS ASSESSMENT
LOT 14R OF SUMMIT EDEN PHASE 1A
POWDER MOUNTAIN RESORT
WEBER COUNTY, UT

REGIONAL GEOLOGY MAP 2

FIGURE

A-3



BASE MAP:

-UGS OGDEN 30'x 60' GEOLOGIC
QUADRANGLE MAP (OFR-653DM, PLATE 1)
COOGAN AND KING (2016)

N

0 1000 2000 3000
FEET

1" = 2000'

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GEOTECHNICAL AND GEOLOGIC HAZARDS ASSESSMENT
LOT 14R OF SUMMIT EDEN PHASE 1A
POWDER MOUNTAIN RESORT
WEBER COUNTY, UT

REGIONAL GEOLOGY MAP 3

FIGURE

A-4a

MAP LEGEND

Qg, Qg?, Qgm, Qgm?, Qga, Qga?

Glacial till and outwash, undivided age (Holocene and upper and middle? Pleistocene) – Qg is undivided glacial deposits (till and outwash) of various ages; till is non-stratified, poorly sorted clay, silt, sand, and gravel, to boulder size; Qgm is moraines of unknown age that are mapped where distinct shapes of end, recessional and lateral moraines are visible; outwash (Qga) is stratified and variably sorted, but better sorted and bedded than till due to alluvial reworking; Qga is mapped directly downslope from other glacial deposits where it is thick enough to obscure older deposits and bedrock, and where it can be separated from ground moraine (mapped as Qg) and alluvium (mapped as Qa_); locally include mass-movement (Qms, Qmt, Qct) and rock glacier deposits that are too small to show separately at map scale; 6 to 150 feet (2-45 m) thick. Undivided because age uncertain or where deposits with multiple ages cannot be shown separately at map scale; queried where interpretation as glacial deposits is uncertain. Glacial deposits are prone to slope failures.

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.

Qmc **Landslide and colluvial deposits, undivided (Holocene and Pleistocene)** – Poorly sorted to unsorted clay- to boulder-sized material; mapped where landslide deposits are difficult to distinguish from colluvium (slopewash and soil creep) and where mapping separate, small, intermingled areas of landslide and colluvial deposits is not possible at map scale; locally includes talus and debris flow and flood deposits; typically mapped where landslides are thin ("shallow"); also mapped where the blocky or rumpled morphology that is characteristic of landslides has been diminished ("smoothed") by slopewash and soil creep; composition depends on local sources; 6 to 40 feet (2-12 m) thick. These deposits are as unstable as other landslide units (Qms, Qmsy, Qmso).

Qcg **Gravelly colluvial deposits (Holocene and Pleistocene)** – Gravelly materials present downslope from gravel-rich deposits of various ages (for example units Keh, Tw, Tcg, Thv, QTaf, QTa, Qafoe, Qaoe, Qafo, and Qa); may contain residual deposits; typically differentiated from colluvium and residual gravel (Qc, Qng) by prominent stripes trending downhill on aerial photographs; stripes are concentrations of gravel up to boulder size; generally 6 to 20 feet (2-6 m) thick.

Qmg, Qmg?

Mass-movement and glacial deposits, undivided (Holocene and Pleistocene) – Unsorted and unstratified clay, silt, sand, and gravel; mapped where glacial deposits lack typical moraine morphology, and appear to have failed or moved down slope; also mapped in upper Strawberry Bowl (Snow Basin quadrangle) where glacial deposits have lost their distinct morphology and the contacts between them and colluvium and talus in the cirques cannot be mapped; likely less than 30 feet (9 m) thick, but may be thicker in Mantua, James Peak, North Ogden, Huntsville, and Peterson quadrangles.

MAP LEGEND

Tw, Tw?

Wasatch Formation (Eocene and upper Paleocene) – Typically red to brownish-red sandstone, siltstone, mudstone, and conglomerate with minor gray limestone and marlstone locally (see Twl); lighter shades of red, yellow, tan, and light gray present locally and more common in uppermost part, complicating mapping of contacts with overlying similarly colored Norwood and Fowkes Formations; clasts typically rounded Neoproterozoic and Paleozoic sedimentary rocks, mainly Neoproterozoic and Cambrian quartzite; basal conglomerate more gray and less likely to be red, and containing more locally derived angular clasts of limestone, dolomite and sandstone, typically from Paleozoic strata, for example in northern Causey Dam quadrangle; sinkholes indicate karstification of limestone beds; thicknesses on Willard thrust sheet likely up to about 400 to 600 feet (120-180 m) in Sharp Mountain, Dairy Ridge, and Horse Ridge quadrangles (Coogan, 2006a-b), about 1300 feet (400 m) in Monte Cristo Peak quadrangle, about 1100 feet (335 m) in northeast Browns Hole quadrangle, about 2200 feet (670 m) in southwest Causey Dam quadrangle, about 2600 feet (800 m) at Herd Mountain in Bybee Knoll quadrangle, and about 1300 feet (400 m) in northwest Lost Creek Dam quadrangle, estimated by elevation differences between pre-Wasatch rocks exposed in drainages and the crests of gently dipping Wasatch Formation on adjacent ridges (King); thickness varies locally due to considerable relief on basal erosional surface, for example along Right Fork South Fork Ogden River, and along leading edge of Willard thrust; much thicker, about 5000 to 6000 feet (1500-1800 m), south of Willard thrust sheet near Morgan. Wasatch Formation is queried (Tw?) where poor exposures may actually be surficial deposits. The Wasatch Formation is prone to slope failures. Other information on the Wasatch Formation is in Tw descriptions under the heading "Sub-Willard Thrust - Ogden Canyon Area" since Tw strata are extensive near Morgan Valley and cover the Willard thrust, Ogden Canyon, and Durst Mountain areas.

Contact, approximately located

Contact, approximately located, queried

Contact, concealed

Contact, concealed, queried

Contact, scratch, used where map units combined

Contact, well located

Normal fault, well located

Thrust fault, concealed

Thrust fault, well located

Syncline, overturned, concealed

Bedding, strike & dip, upright

Select spring

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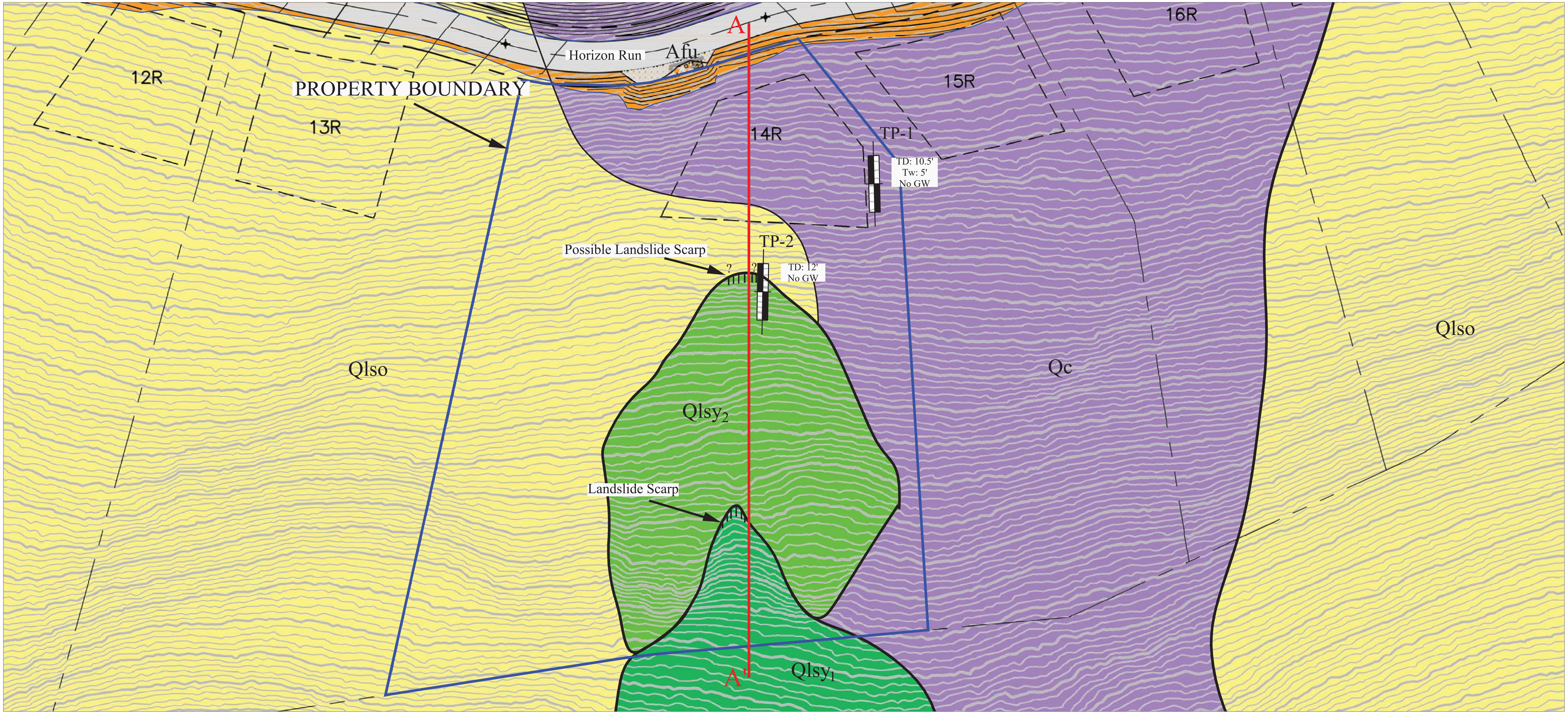
GEOTECHNICAL AND GEOLOGIC HAZARDS ASSESSMENT
LOT 14R OF SUMMIT EDEN PHASE 1A
POWDER MOUNTAIN RESORT
WEBER COUNTY, UT

REGIONAL GEOLOGY MAP 2

FIGURE

A-4c



LEGEND

BASE MAP:

-UNDATED 100-SCALE MAP OF PHASE 1A PREPARED BY NV5

CONTOUR INTERVAL: 2'

$Qlsy_1$	YOUNG LANDSLIDE UNIT 1
$Qlsy_2$	YOUNG LANDSLIDE UNIT 2
Qlso	OLD LANDSLIDE DEPOSIT
Qc	COLLUVIUM
Afu	UNDOCUMENTED FILL
	PROPERTY BOUNDARY
TP-1	TEST PITS
	APPROXIMATE GEOLOGIC CONTACTS
A – A'	CROSS SECTION

N

0 80 160

FEET

1" = 80'

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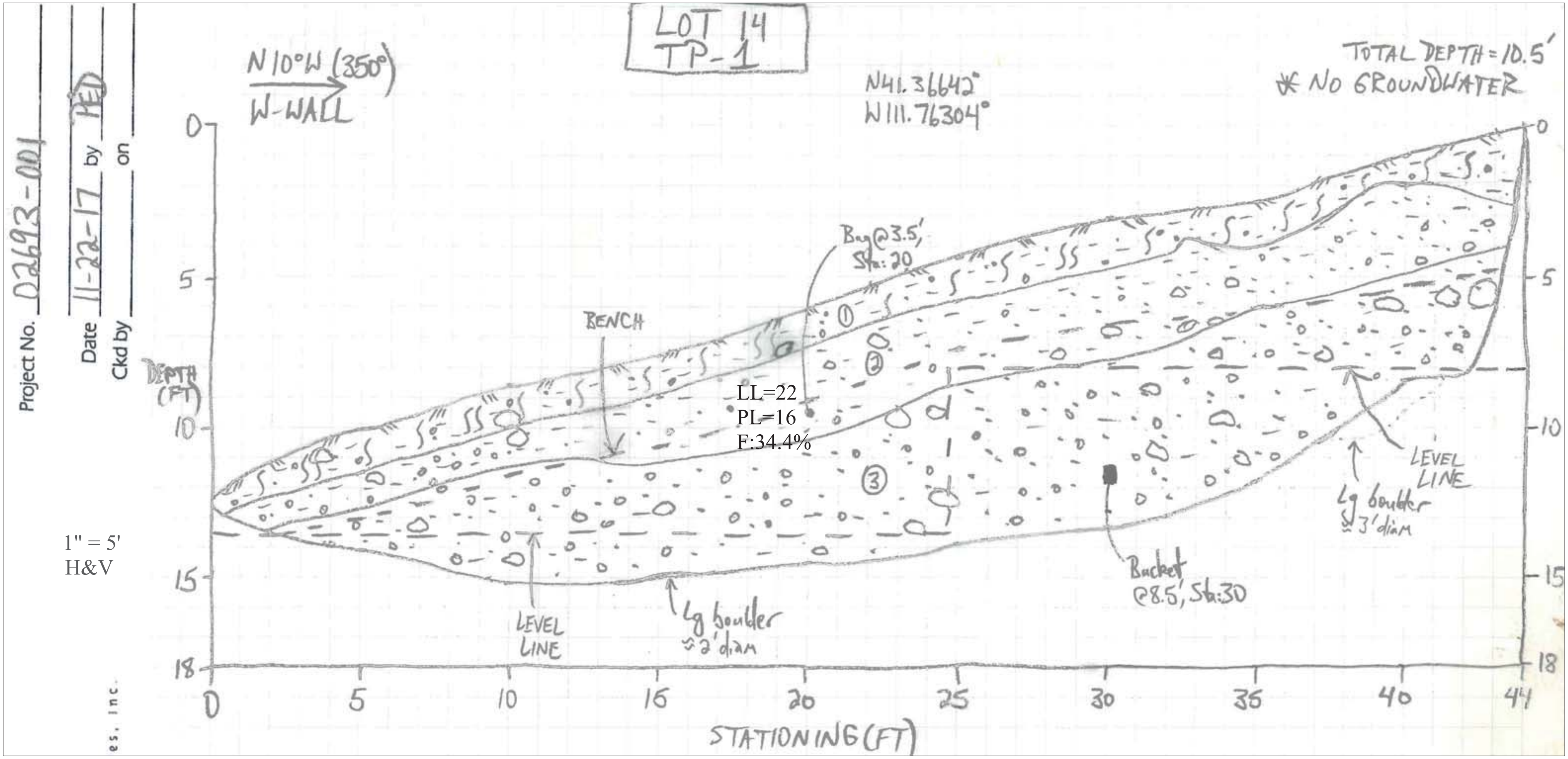
GEOTECHNICAL AND GEOLOGIC HAZARDS ASSESSMENT
LOT 14R OF SUMMIT EDEN PHASE 1A
POWDER MOUNTAIN RESORT
WEBER COUNTY, UTAH

GEOTECHNICAL AND LOCAL GEOLOGY MAP

FIGURE A-5



LITHOLOGIC UNIT DESCRIPTIONS:

1. A/B Soil Horizon:~1-2' thick; brownish black (5YR $\frac{2}{1}$) sandy lean CLAY with gravel (CL), medium stiff to loose, moist to wet, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts entirely pale yellowish orange (10YR $\frac{8}{6}$) to medium gray (N5) quartzite, subrounded to subangular and up to 10" in diameter, though mode size is ~2"; abundant plant and tree roots; grades to dark yellowish brown (10YR $\frac{4}{2}$) with depth; sharp, highly irregular basal contact.

2. Colluvium (Shallow Landslide?): ~1-3' thick; moderate yellowish brown (10YR $\frac{5}{4}$) to light brown (5YR $\frac{6}{4}$) to pale yellowish orange (10YR $\frac{8}{6}$) silty, clayey SAND with gravel (SC-SM) gradational to sandy lean CLAY with gravel (CL), medium dense, slightly moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts entirely subrounded to subangular quartzite as above, up to 8" in diameter, though mode size is ~1-2"; abundant 1-2mm diameter pinhole voids throughout; occasional calcium carbonate matrix flour; occasional plant and tree roots; gradational, irregular basal contact.

3. Wasatch Formation: >5.5' thick; weakly consolidated conglomerate bedrock, readily disaggregates to pale yellowish orange (10YR $\frac{8}{6}$) to dark reddish brown (10R $\frac{3}{4}$) clayey GRAVEL with sand (GC) gradational to well-graded sandy GRAVEL (GW), dense to very dense, slightly moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~30-60% of the unit; clasts entirely subangular to subrounded quartzite as above, up to 3' in diameter, though mode size is ~4-6"; common 1-2mm diameter pinholes where clayey; occasional to few plant and tree roots; poorly sorted and heterogenous unit; matrix supported.

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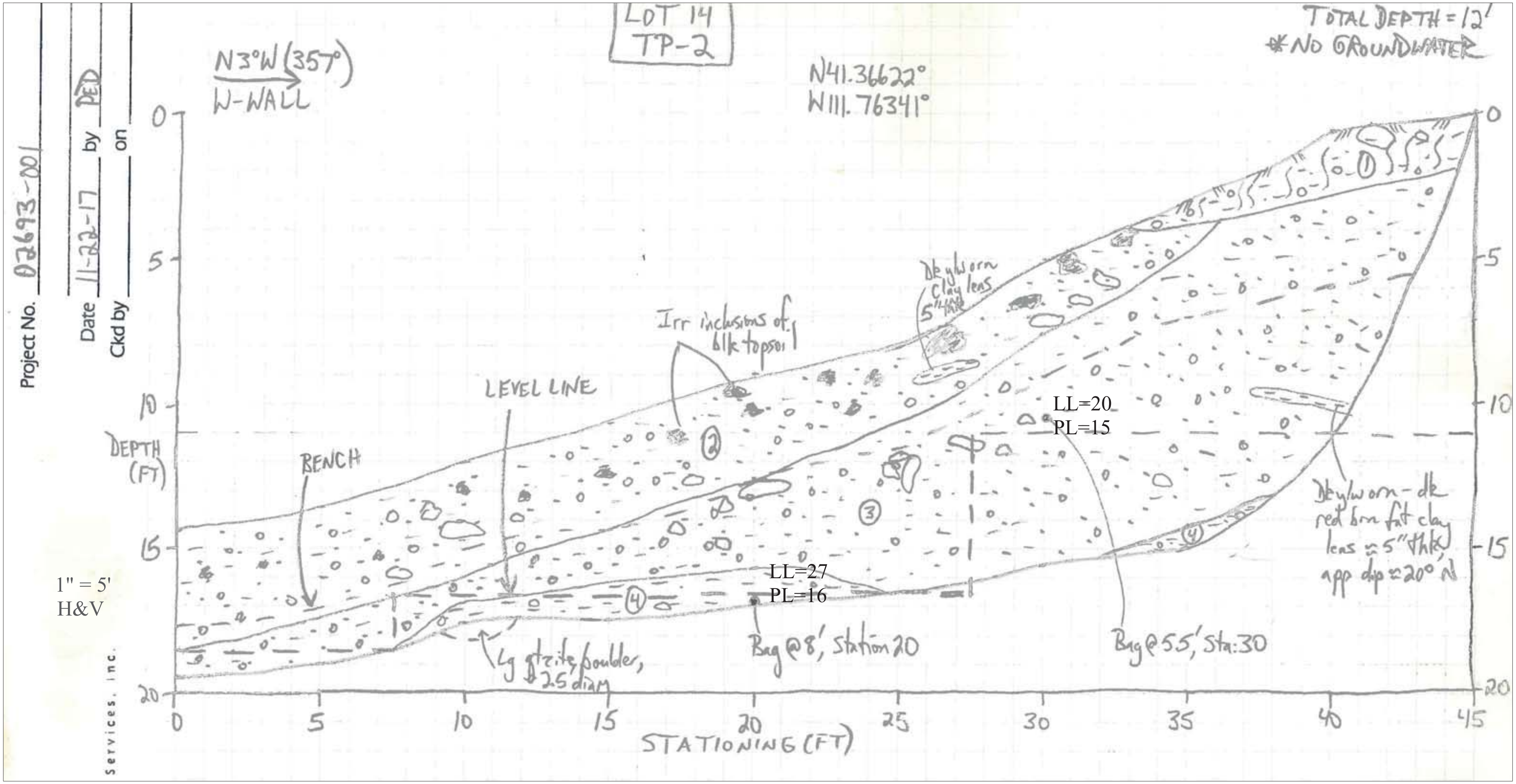
GEOTECHNICAL AND GEOLOGIC HAZARDS ASSESSMENT
LOT 14R OF SUMMIT EDEN PHASE 1A
POWDER MOUNTAIN RESORT
WEBER COUNTY, UT

TEST PIT 1 LOG

FIGURE
A-6



LITHOLOGIC UNIT DESCRIPTIONS
ON FIGURE A-7b

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GEOTECHNICAL AND GEOLOGIC HAZARDS ASSESSMENT
LOT 14R OF SUMMIT EDEN PHASE 1A
POWDER MOUNTAIN RESORT
WEBER COUNTY, UT

TEST PIT 2 LOG

FIGURE

A-7a

LITHOLOGIC UNIT DESCRIPTIONS:

1. A/B Soil Horizon:~ Up to 2' thick; black (N1) to brownish black (5YR $\frac{2}{1}$) sandy lean CLAY with gravel (CL), loose, wet, low plasticity, massive; gravel and larger sized clasts comprise ~25% of unit; clasts entirely medium gray (N5) to pale yellowish orange (10YR $\frac{8}{6}$) quartzite up to 1.5' diameter, though mode size is ~2-4"; clasts are subrounded; abundant plant and tree roots; sharp, planar basal contact; becomes erratically incorporated into Unit 2 downslope.

2. Young Landslide: ~2-4' thick; highly variegated between dark yellowish brown (10YR $\frac{4}{2}$), black (N1), and dark yellowish orange (10YR $\frac{6}{6}$), clayey SAND with gravel (SC) gradational to sandy lean clay (CL), loose to medium dense, moist to wet, low plasticity fines, massive; gravel and larger sized clasts comprise up to ~10-15% of the unit; clasts all subrounded quartzite as above, up to 14" in diameter, though mode size is ~2', though highly variable; highly erratic, heterogenous unit; sharp, irregular basal contact; no evident basal shear plane.

3. Old Landslide: ~2-10' + thick; moderate yellowish brown (10YR $\frac{5}{4}$) to light brown (5YR $\frac{6}{4}$) clayey SAND with gravel (SC), medium dense, slightly moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts entirely subangular to subrounded quartzite as above, up to 2' in diameter, though mode size is ~1-2"; abundant 1-2mm pinholes throughout; matrix-supported and poorly sorted; common to occasional plant and tree roots; similar to Unit 2 in TP-1; sharp, irregular basal contact.
*~1' thick dark yellowish orange (10YR $\frac{6}{6}$) fat CLAY (CH) seam observed in the middle of Unit 3 on the east wall that was not observed on the west wall.

4. Weathered Bedrock (Slide Plane?): >1.5' thick; dark reddish brown (10R $\frac{3}{4}$) sandy lean CLAY with gravel (CL), stiff to very stiff, slightly moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit, all quartzite as above up to 2.5' in diameter, though mode size is ~1-2"; occasional discontinous, poorly developed slickensides observed when broken, but not in-situ.

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			USCS SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS (More than half of material is larger than the #200 sieve)	GRAVELS (More than half of coarse fraction is larger than the #4 sieve)	CLEAN GRAVELS WITH LITTLE OR NO FINES	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
			GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
		GRAVELS WITH OVER 12% FINES	GM	SILTY GRAVELS, GRAVEL-SILT-SAND MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SANDS (More than half of coarse fraction is smaller than the #4 sieve)	CLEAN SANDS WITH LITTLE OR NO FINES	SW	WELL-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
			SP	POORLY-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
		SANDS WITH OVER 12% FINES	SM	SILTY SANDS, SAND-GRAVEL-SILT MIXTURES
			SC	CLAYEY SANDS SAND-GRAVEL-CLAY MIXTURES
FINE GRAINED SOILS (More than half of material is smaller than the #200 sieve)	SILTS AND CLAYS (Liquid limit less than 50)		ML	INORGANIC SILTS & VERY FINE SANDS, SILTY OR CLAYEY FINE SANDS, CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS (Liquid limit greater than 50)		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM-TO-HIGH PLASTICITY
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

LOG KEY SYMBOLS

- BORING SAMPLE LOCATION
- TEST-PIT SAMPLE LOCATION
- WATER LEVEL (level after completion)
- WATER LEVEL (level where first encountered)

CEMENTATION

DESCRIPTION	DESCRIPTION
WEAKELY	CRUMBLES OR BREAKS WITH HANDLING OR SLIGHT FINGER PRESSURE
MODERATELY	CRUMBLES OR BREAKS WITH CONSIDERABLE FINGER PRESSURE
STRONGLY	WILL NOT CRUMBLE OR BREAK WITH FINGER PRESSURE

OTHER TESTS KEY

C	CONSOLIDATION	SA	SIEVE ANALYSIS
AL	ATTERBERG LIMITS	DS	DIRECT SHEAR
UC	UNCONFINED COMPRESSION	T	TRIAXIAL
S	SOLUBILITY	R	RESISTIVITY
O	ORGANIC CONTENT	RV	R-VALUE
CBR	CALIFORNIA BEARING RATIO	SU	SOLUBLE SULFATES
COMP	MOISTURE/DENSITY RELATIONSHIP	PM	PERMEABILITY
CI	CALIFORNIA IMPACT	-200	% FINER THAN #200
COL	COLLAPSE POTENTIAL	Gs	SPECIFIC GRAVITY
SS	SHRINK SWELL	SL	SWELL LOAD

MODIFIERS

DESCRIPTION	%
TRACE	<5
SOME	5 - 12
WITH	>12

MOISTURE CONTENT

DESCRIPTION	FIELD TEST
DRY	ABSENCE OF MOISTURE, DUSTY, DRY TO THE TOUCH
MOIST	DAMP BUT NO VISIBLE WATER
WET	VISIBLE FREE WATER, USUALLY SOIL BELOW WATER TABLE

STRATIFICATION

DESCRIPTION	THICKNESS	DESCRIPTION	THICKNESS
SEAM	1/16 - 1/2"	OCCASIONAL	ONE OR LESS PER FOOT OF THICKNESS
LAYER	1/2 - 12"	FREQUENT	MORE THAN ONE PER FOOT OF THICKNESS

GENERAL NOTES

1. Lines separating strata on the logs represent approximate boundaries only. Actual transitions may be gradual.
2. No warranty is provided as to the continuity of soil conditions between individual sample locations.
3. Logs represent general soil conditions observed at the point of exploration on the date indicated.
4. In general, Unified Soil Classification designations presented on the logs were evaluated by visual methods only. Therefore, actual designations (based on laboratory tests) may vary.

APPARENT / RELATIVE DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPT (blows/ft)	MODIFIED CA. SAMPLER (blows/ft)	CALIFORNIA SAMPLER (blows/ft)	RELATIVE DENSITY (%)	FIELD TEST
VERY LOOSE	<4	<4	<5	0 - 15	EASILY PENETRATED WITH 1/2-INCH REINFORCING ROD PUSHED BY HAND
LOOSE	4 - 10	5 - 12	5 - 15	15 - 35	DIFFICULT TO PENETRATE WITH 1/2-INCH REINFORCING ROD PUSHED BY HAND
MEDIUM DENSE	10 - 30	12 - 35	15 - 40	35 - 65	EASILY PENETRATED A FOOT WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER
DENSE	30 - 50	35 - 60	40 - 70	65 - 85	DIFFICULT TO PENETRATED A FOOT WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER
VERY DENSE	>50	>60	>70	85 - 100	PENETRATED ONLY A FEW INCHES WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER

CONSISTENCY - FINE-GRAINED SOIL

CONSISTENCY	SPT (blows/ft)	TORVANE UNTRAINED SHEAR STRENGTH (tsf)	POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH (tsf)	FIELD TEST
VERY SOFT	<2	<0.125	<0.25	EASILY PENETRATED SEVERAL INCHES BY THUMB. EXUDES BETWEEN THUMB AND FINGERS WHEN SQUEEZED BY HAND.
SOFT	2 - 4	0.125 - 0.25	0.25 - 0.5	EASILY PENETRATED ONE INCH BY THUMB. MOLDED BY LIGHT FINGER PRESSURE.
MEDIUM STIFF	4 - 8	0.25 - 0.5	0.5 - 1.0	PENETRATED OVER 1/2 INCH BY THUMB WITH MODERATE EFFORT. MOLDED BY STRONG FINGER PRESSURE.
STIFF	8 - 15	0.5 - 1.0	1.0 - 2.0	INDENTED ABOUT 1/2 INCH BY THUMB BUT PENETRATED ONLY WITH GREAT EFFORT.
VERY STIFF	15 - 30	1.0 - 2.0	2.0 - 4.0	READILY INDENTED BY THUMBNAIL.
HARD	>30	>2.0	>4.0	INDENTED WITH DIFFICULTY BY THUMBNAIL.

KEY TO SOIL SYMBOLS AND TERMINOLOGY

Project No. 02693-001
Engr. DAG
Drafted By DAG
Date March 2018

IGES
Intermountain Geo-Environmental Services, Inc.

Figure A-8

Rock Classification Should Include:

1. Rock name (or classification)
2. Color
3. Weathering
4. Fracturing
5. Competency
6. Additional comments indicating rock characteristics which might affect engineering properties

Weathering

Weathering	Field Test
Fresh	No visible sign of decomposition or discoloration. Rings under hammer impact.
Slightly Weathered	Slight discoloration inwards from open fractures, otherwise similar to Fresh.
Moderately Weathered	Discoloration throughout. Weaker minerals such as feldspar are decomposed. Strength somewhat less than fresh rock but cores cannot be broken by hand or scraped with a knife. Texture preserved.
Highly Weathered	Most minerals somewhat decomposed. Specimens can be broken by hand with effort or shaved with a knife. Core stones present in rock mass. Texture becoming indistinct but fabric preserved.
Completely Weathered	Minerals decomposed to soil but fabric and structure preserved. Specimens easily crumble or penetrated.

Fracturing

Spacing	Description
>6 ft	Very Widely
2-6 ft	Widely
8-24 in	Moderately
2 ½-8 in	Closely
¾-2 ½ in	Very Closely

Bedding of Sedimentary Rocks

Splitting Property	Thickness	Stratification
Massive	>4.0 ft	Very thick bedded
Blocky	2.0-4.0 ft	Thick-bedded
Slabby	2 ½-24 in	Thin-bedded
Flaggy	½-2 ½ in	Very thin-bedded
Shaly or platy	⅛ – ½ in	Laminated
Papery	< ⅛ in	Thinly laminated

RQD

RQD (%)	Rock Quality
90-100	Excellent
75-90	Good
50-75	Fair
25-50	Poor
0-25	Very Poor

Competency

Class	Strength	Field Test	Approximate Range of Unconfined Compressive Strength (tsf)
I	Extremely Strong	Many blows with geologic hammer required to break intact specimen.	>2000
II	Very Strong	Hand-held specimen breaks with pick end of hammer under more than one blow.	2000-1000
III	Strong	Cannot by scraped or peeled with knife, hand-held specimen can be broken with single moderate blow with pick end of hammer	1000-500
IV	Moderately Strong	Can just be scraped or peeled with knife. Indentations 1-3 mm show in specimen with moderate blow with pick end of hammer.	500-250
V	Weak	Material crumbles under moderate blow with pick end of hammer and can be peeled with a knife, but is hard to hand-trim for triaxial test specimen.	250-10
VI	Friable	Material crumbles in hand.	N/A

KEY TO PHYSICAL ROCK PROPERTIES

Project No. 02693-001
Engr. DAG
Drafted By DAG
Date March 2018

IGES
Intermountain Geo-Environmental Services, Inc.

Figure A-9

APPENDIX B

Water Content and Unit Weight of Soil

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

IGES

Project: **Dee Lot 14**
No: **02693-001**
Location: Powder Mountain, UT
Date: 1/16/2018
By: JDF/EH/BRR

Sample Info.	Boring No.	TP-1	TP-2	TP-2					
	Sample								
	Depth	3.5'	5.5'	8.0'					
	Split	Yes	Yes	Yes					
	Split sieve	No.4	3/8"	3/8"					
	Total sample (g)	3192.39	4130.78	3911.20					
	Moist coarse fraction (g)	663.25	1846.48	539.05					
	Moist split fraction (g)	2529.14	2284.30	3372.15					
	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)	952.00	2195.00	753.20					
	Dry soil + tare (g)	944.46	2182.54	749.63					
	Tare (g)	221.88	309.46	214.14					
	Water content (%)	1.0	0.7	0.7					
Split Fraction	Wet soil + tare (g)	379.63	349.91	525.69					
	Dry soil + tare (g)	369.83	340.96	497.01					
	Tare (g)	123.04	121.47	117.94					
	Water content (%)	4.0	4.1	7.6					
	Water Content, w (%)	**3.3**	**2.5**	**6.6**					
	Dry Unit Wt., γ_d (pcf)								

Entered by:___________

Reviewed:___________

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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: Dee Lot 14
No: 02693-001
Location: Powder Mountain, UT
Date: 1/16/2018
By: BRR

Boring No.: TP-1
Sample:
Depth: 3.5'
Description: Reddish brown silty clay

Grooving tool type: Plastic
Liquid limit device: Mechanical
Rolling method: Hand

Preparation method: Air Dry
Liquid limit test method: Multipoint
Screened over No.40: Yes
Larger particles removed: Dry sieved
Approximate maximum grain size: 3/4"
Estimated percent retained on No.40: See Particle Size Distribution
As-received water content (%): 3.3

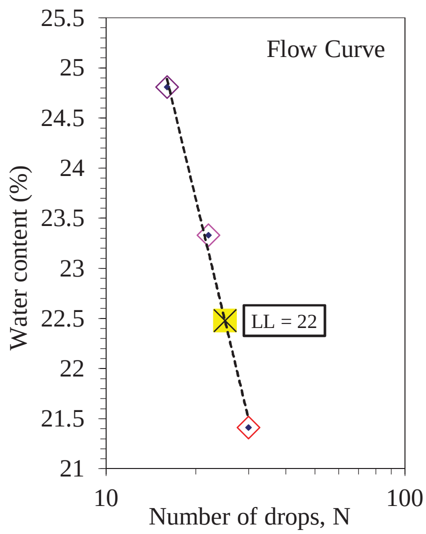
Plastic Limit

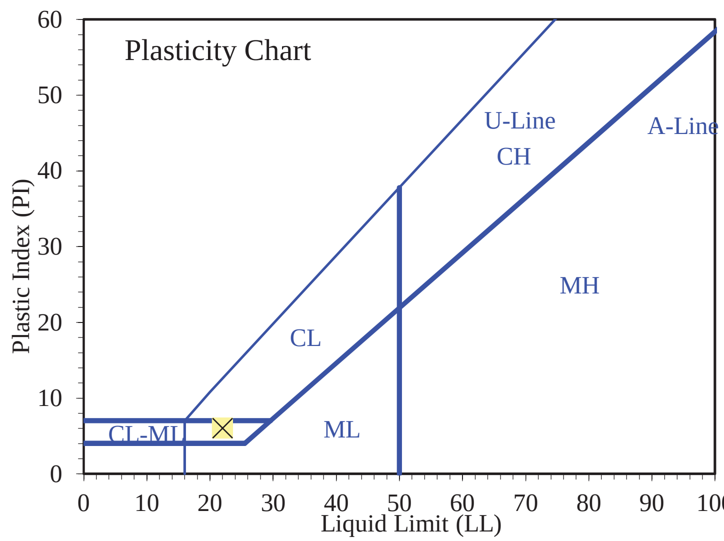
Determination No	1	2				
Wet Soil + Tare (g)	29.37	28.46				
Dry Soil + Tare (g)	28.35	27.56				
Water Loss (g)	1.02	0.90				
Tare (g)	21.90	22.00				
Dry Soil (g)	6.45	5.56				
Water Content, w (%)	15.81	16.19				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	30	22	16			
Wet Soil + Tare (g)	31.86	30.99	29.86			
Dry Soil + Tare (g)	30.13	29.21	28.24			
Water Loss (g)	1.73	1.78	1.62			
Tare (g)	22.05	21.58	21.71			
Dry Soil (g)	8.08	7.63	6.53			
Water Content, w (%)	21.41	23.33	24.81			
One-Point LL (%)	22	23				

Liquid Limit, LL (%)	**22**
Plastic Limit, PL (%)	**16**
Plasticity Index, PI (%)	**6**





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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: Dee Lot 14
No: 02693-001
Location: Powder Mountain, UT
Date: 1/16/2018
By: BRR

Boring No.: TP-2
Sample:
Depth: 5.5'
Description: Brown silty clay

Grooving tool type: Plastic
Liquid limit device: Mechanical
Rolling method: Hand

Preparation method: Air Dry
Liquid limit test method: Multipoint
Screened over No.40: Yes
Larger particles removed: Dry sieved
Approximate maximum grain size: 3/8"
Estimated percent retained on No.40: Not requested
As-received water content (%): 2.5

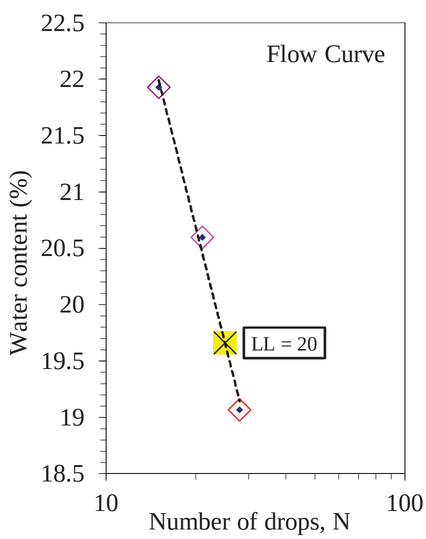
Plastic Limit

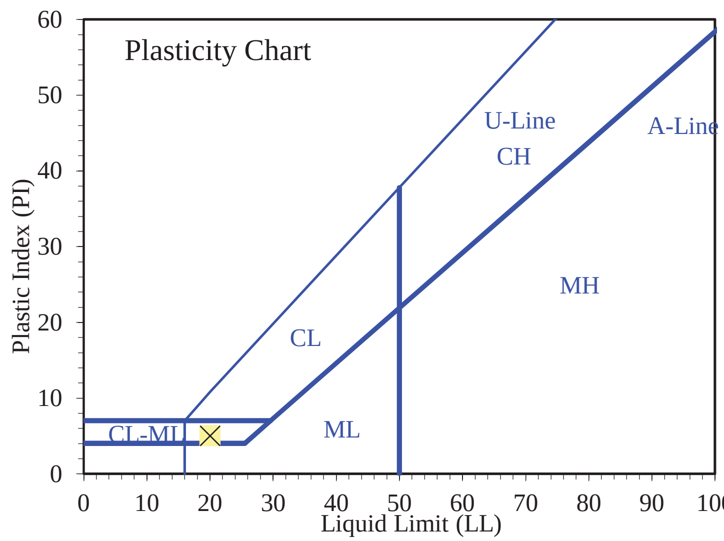
Determination No	1	2				
Wet Soil + Tare (g)	30.40	28.75				
Dry Soil + Tare (g)	29.30	27.80				
Water Loss (g)	1.10	0.95				
Tare (g)	21.78	21.35				
Dry Soil (g)	7.52	6.45				
Water Content, w (%)	14.63	14.73				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	28	21	15			
Wet Soil + Tare (g)	33.97	29.65	31.58			
Dry Soil + Tare (g)	32.05	28.27	29.85			
Water Loss (g)	1.92	1.38	1.73			
Tare (g)	21.98	21.57	21.96			
Dry Soil (g)	10.07	6.70	7.89			
Water Content, w (%)	19.07	20.60	21.93			
One-Point LL (%)	19	20				

Liquid Limit, LL (%)	**20**
Plastic Limit, PL (%)	**15**
Plasticity Index, PI (%)	**5**





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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

IGES

Project: Dee Lot 14
No: 02693-001
Location: Powder Mountain, UT
Date: 1/16/2018
By: BRR

Boring No.: TP-2
Sample:
Depth: 8.0'
Description: Reddish brown lean clay

Grooving tool type: Plastic
Liquid limit device: Mechanical
Rolling method: Hand

Preparation method: Air Dry
Liquid limit test method: Multipoint
Screened over No.40: Yes
Larger particles removed: Dry sieved
Approximate maximum grain size: 1-1/2"
Estimated percent retained on No.40: Not requested
As-received water content (%): 6.6

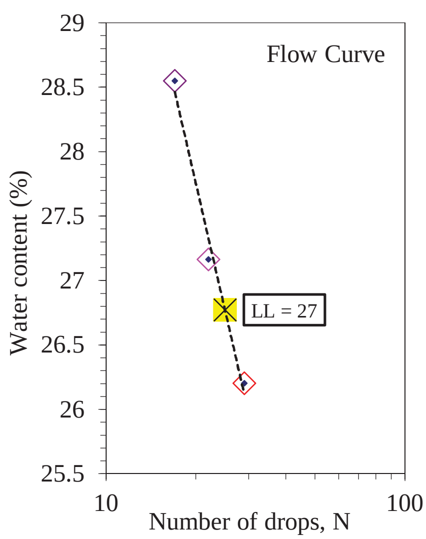
Plastic Limit

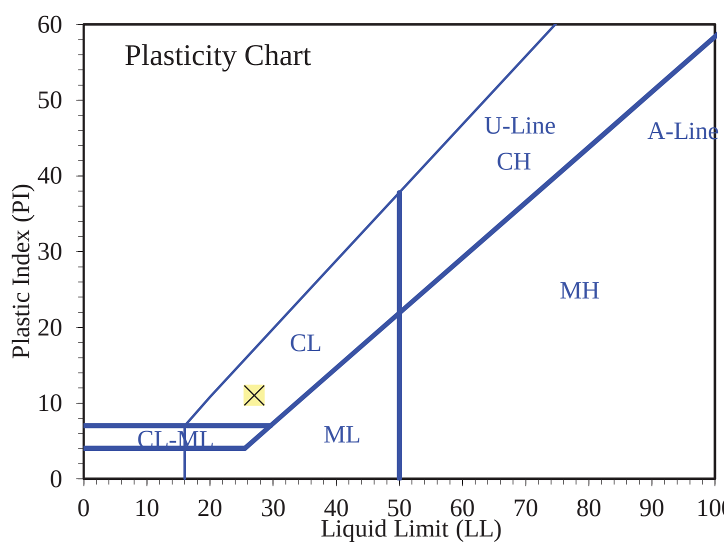
Determination No	1	2				
Wet Soil + Tare (g)	29.01	30.64				
Dry Soil + Tare (g)	27.98	29.43				
Water Loss (g)	1.03	1.21				
Tare (g)	21.42	21.75				
Dry Soil (g)	6.56	7.68				
Water Content, w (%)	15.70	15.76				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	29	22	17			
Wet Soil + Tare (g)	31.73	30.83	29.92			
Dry Soil + Tare (g)	29.66	28.82	28.11			
Water Loss (g)	2.07	2.01	1.81			
Tare (g)	21.76	21.42	21.77			
Dry Soil (g)	7.90	7.40	6.34			
Water Content, w (%)	26.20	27.16	28.55			
One-Point LL (%)	27	27				

Liquid Limit, LL (%)	**27**
Plastic Limit, PL (%)	**16**
Plasticity Index, PI (%)	**11**





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

(ASTM D6913)

IGES

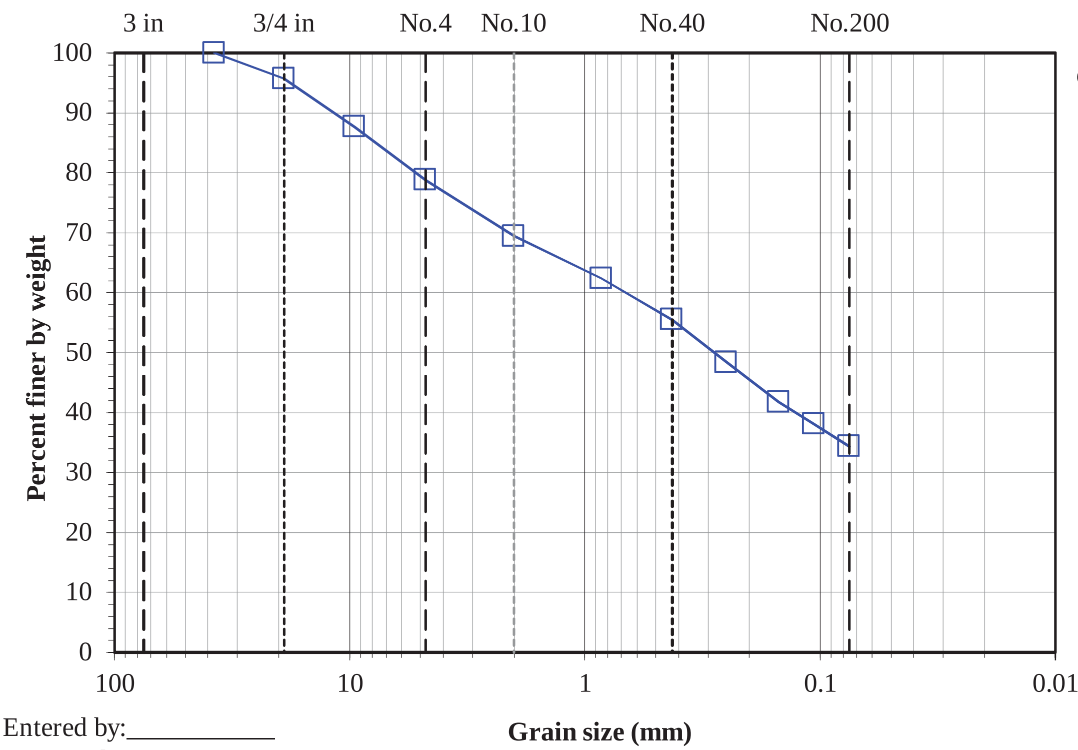
Project: Dee Lot 14
No: 02693-001
Location: Powder Mountain, UT
Date: 1/16/2018
By: JDF

Boring No.: TP-1
Sample:
Depth: 3.5'
Description: Reddish brown silty, clayey sand with gravel

Split:	Yes	
Split sieve:	No.4	
	Moist	Dry
Total sample wt. (g):	3192.39	3088.94
+No.4 Coarse fraction (g):	663.25	656.40
-No.4 Split fraction (g):	256.59	246.79
Split fraction:	0.788	

Water content data	C.F.(+No.4)	S.F.(-No.4)
Moist soil + tare (g):	952.00	379.63
Dry soil + tare (g):	944.46	369.83
Tare (g):	221.88	123.04
Water content (%):	1.0	4.0

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"	132.05	19	95.7	
3/8"	382.03	9.5	87.6	
No.4	656.40	4.75	78.8	←Split
No.10	29.21	2	69.4	
No.20	51.40	0.85	62.3	
No.40	72.98	0.425	55.5	
No.60	95.18	0.25	48.4	
No.100	115.98	0.15	41.7	
No.140	127.45	0.106	38.1	
No.200	139.13	0.075	34.4	



Gravel (%): 21.2
Sand (%): 44.4
Fines (%): 34.4

Entered by:___________
Reviewed:___________

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

(ASTM D6913)

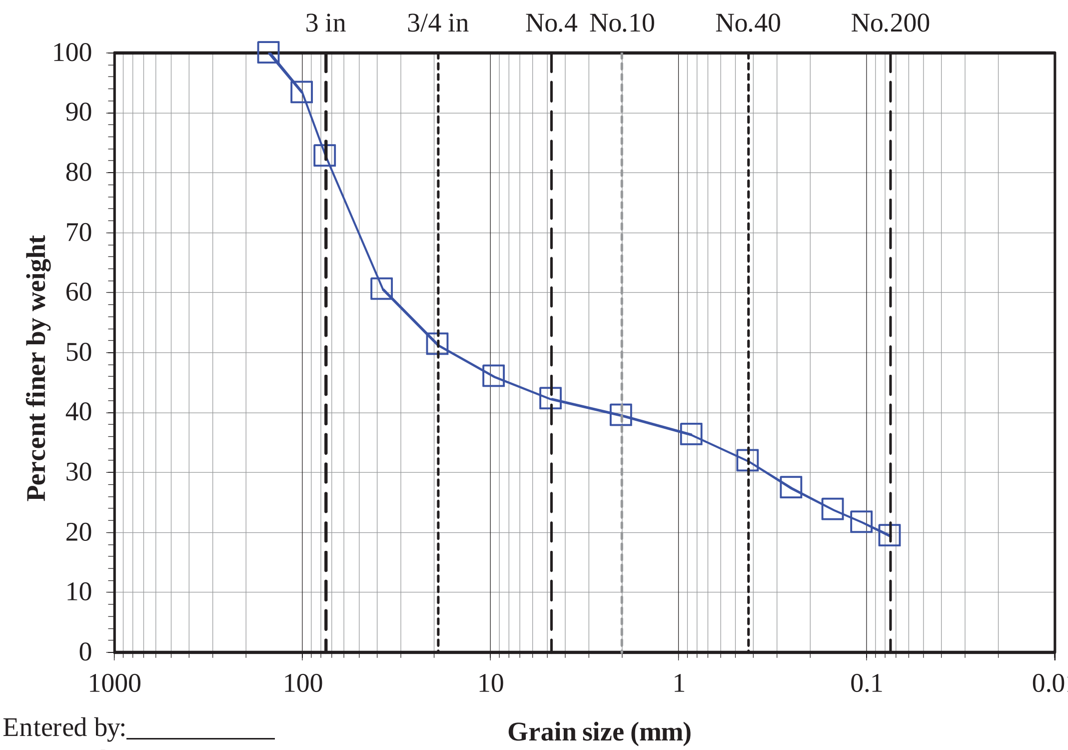
Project: Dee Lot 14
No: 02693-001
Location: Powder Mountain, UT
Date: 1/15/2018
By: DKS/BSS

Boring No.: TP-1
Sample:
Depth: 8.5'
Description: Brown clayey gravel with sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	26357.30	25774.38
+3/8" Coarse fraction (g):	13969.20	13927.65
-3/8" Split fraction (g):	551.25	527.16
Split fraction:	0.460	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	4170.13	959.14
Dry soil + tare (g):	4158.94	935.05
Tare (g):	408.47	407.89
Water content (%):	0.3	4.6

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	100.0	
4"	1709.90	100	93.4	
3"	4460.59	75	82.7	
1.5"	10167.66	37.5	60.6	
3/4"	12547.26	19	51.3	
3/8"	13927.65	9.5	46.0	←Split
No.4	42.68	4.75	42.2	
No.10	74.99	2	39.4	
No.20	111.18	0.85	36.3	
No.40	161.87	0.425	31.8	
No.60	212.94	0.25	27.4	
No.100	255.01	0.15	23.7	
No.140	278.63	0.106	21.7	
No.200	304.55	0.075	19.4	



Gravel (%): 57.8
Sand (%): 22.8
Fines (%): 19.4

Entered by:___________
Reviewed:___________

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

(ASTM D1140)

IGES

Project: **Dee Lot 14**
No: **02693-001**
Location: Powder Mountain, UT
Date: 1/17/2018
By: EH

Sample Info.	Boring No.	TP-2							
	Sample								
	Depth	5.5'							
	Split	Yes							
	Split Sieve*	3/8"							
	Method	B							
	Specimen soak time (min)	240							
	Moist total sample wt. (g)	4130.78							
	Moist coarse fraction (g)	1846.48							
	Moist split fraction + tare (g)	349.91							
	Split fraction tare (g)	121.47							
	Dry split fraction (g)	219.49							
	Dry retained No. 200 + tare (g)	240.03							
	Wash tare (g)	121.47							
	No. 200 Dry wt. retained (g)	118.56							
	Split sieve* Dry wt. retained (g)	1834.28							
	Dry total sample wt. (g)	4029.08							
Coarse Fraction	Moist soil + tare (g)	2195.00							
	Dry soil + tare (g)	2182.54							
	Tare (g)	309.46							
	Water content (%)	0.67							
Split Fraction	Moist soil + tare (g)	349.91							
	Dry soil + tare (g)	340.96							
	Tare (g)	121.47							
	Water content (%)	4.08							
	Percent passing split sieve* (%)	**54.5**							
	Percent passing No. 200 sieve (%)	**25.0**							

Entered by:___________
Reviewed:___________

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: Dee Lot 14
No: 02693-001
Location: Powder Mountain, UT
Date: 1/17/2018
By: EH

Boring No.: TP-1
Sample:
Depth: 3.5'
Sample Description: Reddish brown silty, clayey sand with gravel
Sample type: Arbitrary remold

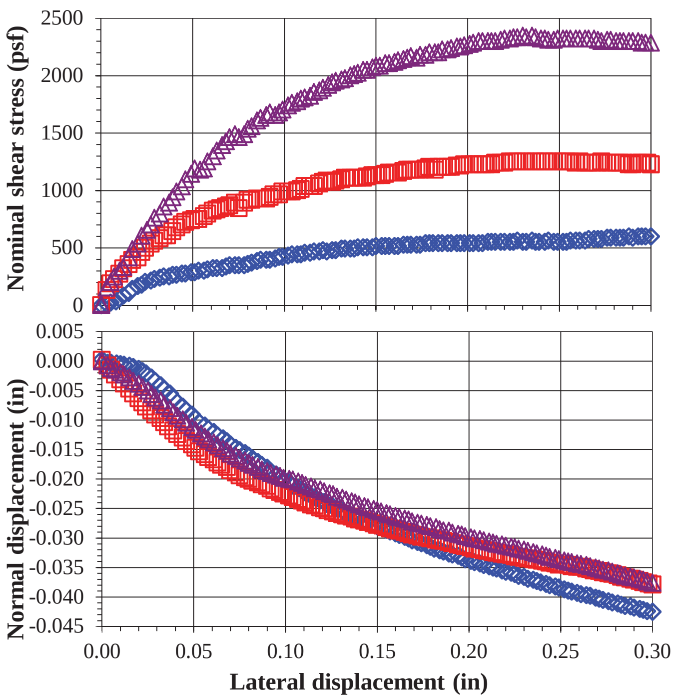
Test type: Inundated
Lateral displacement (in.): 0.3
Shear rate (in./min): 0.0058
Specific gravity, Gs: 2.70 Assumed

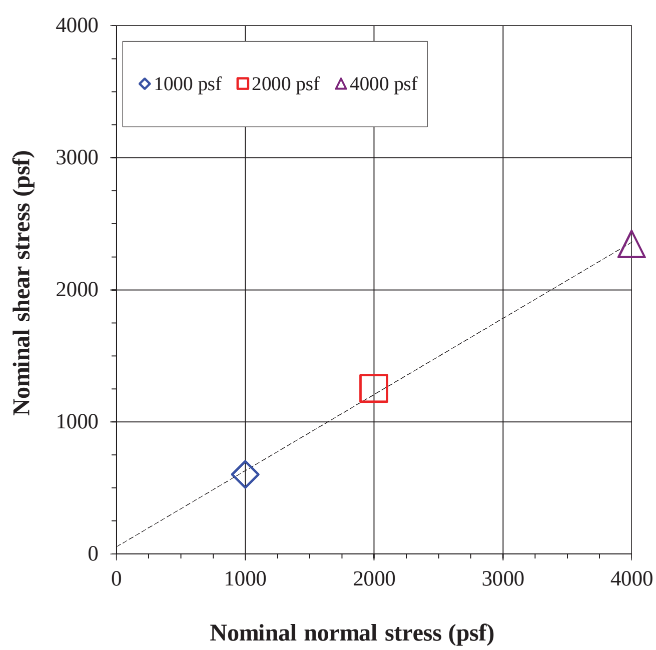
	Sample 1		Sample 2		Sample 3	
Nominal normal stress (psf)	1000		2000		4000	
Peak shear stress (psf)	601		1252		2346	
Lateral displacement at peak (in)	0.288		0.223		0.230	
Load Duration (min)	1026		1121		271	
	Initial	Pre-shear	Initial	Pre-shear	Initial	Pre-shear
Sample height (in)	0.9990	0.9793	0.9950	0.9493	0.9990	0.9330
Sample diameter (in)	2.413	2.413	2.424	2.424	2.425	2.425
Wt. rings + wet soil (g)	188.28	200.98	186.31	197.10	186.81	196.12
Wt. rings (g)	44.86	44.86	42.14	42.14	41.93	41.93
Wet soil + tare (g)	243.82		243.82		243.82	
Dry soil + tare (g)	233.24		233.24		233.24	
Tare (g)	117.47		117.47		117.47	
Water content (%)	9.1	18.8	9.1	17.3	9.1	16.2
Dry unit weight (pcf)	109.6	111.7	109.6	114.8	109.6	117.3
Void ratio, e, for assumed Gs	0.54	0.51	0.54	0.47	0.54	0.44
Saturation (%)*	45.8	100.0	45.9	100.0	45.9	100.0

φ' (deg)	30
c' (psf)	54

Average of 3 samples	Initial	Pre-shear
Water content (%)	9.1	17.4
Dry unit weight (pcf)	109.6	114.6

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





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Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: Dee Lot 14
No: 02693-001
Location: Powder Mountain, UT

Boring No.: TP-1
Sample:
Depth: 3.5'

Nominal normal stress = 1000 psf			Nominal normal stress = 2000 psf			Nominal normal stress = 4000 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.)
0.000	0	0.000	0.000	0	0.000	0.000	0	0.000
0.003	12	0.000	0.003	131	-0.001	0.000	12	0.000
0.005	24	0.000	0.005	191	-0.002	0.003	155	-0.001
0.008	36	0.000	0.007	226	-0.002	0.005	202	-0.001
0.010	60	-0.001	0.010	274	-0.003	0.007	250	-0.002
0.012	84	-0.001	0.012	322	-0.004	0.010	298	-0.002
0.015	108	-0.001	0.015	358	-0.005	0.012	333	-0.002
0.017	144	-0.001	0.017	393	-0.006	0.015	417	-0.003
0.020	168	-0.001	0.020	417	-0.006	0.017	488	-0.003
0.022	180	-0.002	0.022	465	-0.007	0.020	536	-0.004
0.024	204	-0.002	0.024	501	-0.008	0.022	607	-0.004
0.027	217	-0.003	0.027	536	-0.008	0.025	655	-0.005
0.029	229	-0.003	0.029	560	-0.009	0.027	703	-0.006
0.032	241	-0.004	0.032	584	-0.010	0.029	762	-0.006
0.034	253	-0.005	0.034	608	-0.010	0.032	798	-0.007
0.037	253	-0.006	0.036	608	-0.011	0.034	858	-0.007
0.039	265	-0.006	0.039	644	-0.012	0.037	893	-0.008
0.041	265	-0.007	0.041	679	-0.012	0.039	941	-0.009
0.044	277	-0.008	0.044	703	-0.013	0.041	989	-0.009
0.046	277	-0.008	0.046	727	-0.014	0.044	1036	-0.010
0.049	289	-0.009	0.049	739	-0.014	0.046	1096	-0.011
0.051	289	-0.010	0.051	751	-0.015	0.049	1143	-0.011
0.053	301	-0.010	0.053	751	-0.015	0.051	1191	-0.012
0.056	301	-0.011	0.056	775	-0.016	0.054	1179	-0.012
0.058	313	-0.012	0.058	799	-0.016	0.056	1191	-0.013
0.061	325	-0.012	0.061	822	-0.017	0.058	1251	-0.013
0.063	325	-0.013	0.063	834	-0.017	0.061	1298	-0.014
0.066	325	-0.013	0.065	846	-0.018	0.063	1346	-0.014
0.068	337	-0.014	0.068	858	-0.018	0.066	1394	-0.015
0.070	349	-0.014	0.070	870	-0.019	0.068	1429	-0.015
0.073	349	-0.015	0.073	894	-0.019	0.070	1465	-0.016
0.075	349	-0.015	0.075	846	-0.019	0.073	1489	-0.016
0.078	349	-0.016	0.078	894	-0.020	0.075	1465	-0.017
0.080	361	-0.016	0.080	918	-0.020	0.078	1489	-0.017
0.082	373	-0.017	0.082	918	-0.020	0.080	1536	-0.017
0.085	385	-0.017	0.085	930	-0.021	0.082	1560	-0.018
0.087	397	-0.018	0.087	930	-0.021	0.085	1608	-0.018
0.090	397	-0.018	0.090	930	-0.021	0.087	1632	-0.018
0.092	397	-0.019	0.092	942	-0.022	0.090	1656	-0.019
0.095	409	-0.019	0.094	966	-0.022	0.092	1679	-0.019
0.097	421	-0.020	0.097	966	-0.022	0.095	1656	-0.019
0.099	421	-0.020	0.099	989	-0.023	0.097	1679	-0.020
0.102	433	-0.021	0.102	989	-0.023	0.099	1703	-0.020
0.104	445	-0.021	0.104	989	-0.023	0.102	1739	-0.020
0.107	445	-0.022	0.107	1001	-0.023	0.104	1763	-0.020
0.109	445	-0.022	0.109	1013	-0.024	0.107	1775	-0.020
0.111	457	-0.022	0.111	1037	-0.024	0.109	1798	-0.021
0.114	457	-0.023	0.114	1037	-0.024	0.111	1810	-0.021
0.116	469	-0.023	0.116	1037	-0.025	0.114	1822	-0.021
0.119	469	-0.024	0.119	1061	-0.025	0.116	1858	-0.022
0.121	481	-0.024	0.121	1073	-0.025	0.119	1870	-0.022
0.123	469	-0.024	0.123	1085	-0.025	0.121	1894	-0.022
0.126	481	-0.025	0.126	1073	-0.026	0.124	1918	-0.022
0.128	481	-0.025	0.128	1085	-0.026	0.126	1941	-0.023
0.131	493	-0.025	0.131	1097	-0.026	0.128	1953	-0.023
0.133	493	-0.026	0.133	1109	-0.026	0.131	1965	-0.023
0.136	493	-0.026	0.136	1109	-0.026	0.133	1977	-0.024
0.138	493	-0.026	0.138	1109	-0.027	0.136	2001	-0.024
0.140	505	-0.027	0.140	1109	-0.027	0.138	2013	-0.024
0.143	505	-0.027	0.143	1109	-0.027	0.140	2025	-0.024
0.145	505	-0.027	0.145	1120	-0.027	0.143	2049	-0.025
0.148	505	-0.028	0.148	1132	-0.028	0.145	2049	-0.025
0.150	517	-0.028	0.150	1132	-0.028	0.148	2072	-0.025
0.153	517	-0.028	0.153	1132	-0.028	0.150	2084	-0.025
0.155	517	-0.029	0.155	1144	-0.028	0.152	2084	-0.026

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: Dee Lot 14 **Boring No.:** TP-1
No: 02693-001 **Sample:**
Location: Powder Mountain, UT **Depth:** 3.5'

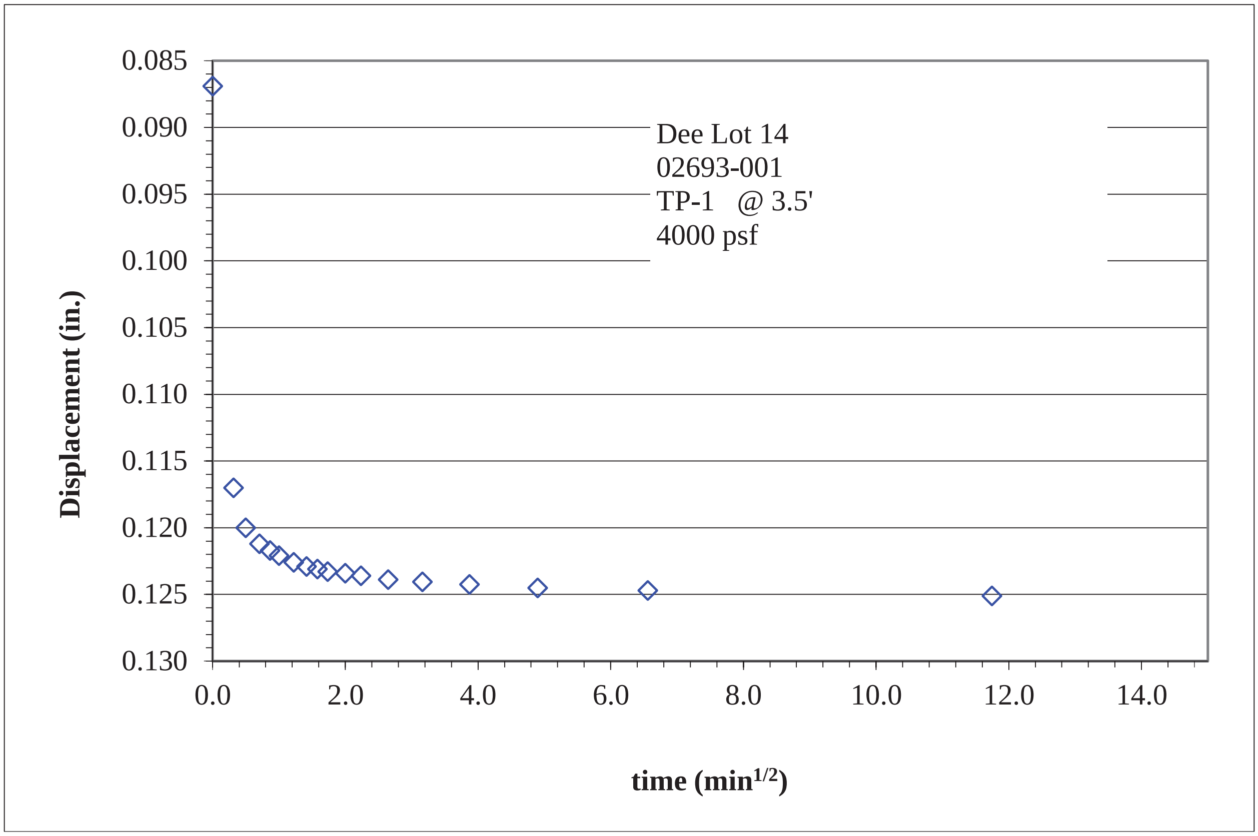
Nominal normal stress = 1000 psf			Nominal normal stress = 2000 psf			Nominal normal stress = 4000 psf		
Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)
0.157	517	-0.029	0.157	1156	-0.028	0.155	2108	-0.026
0.160	517	-0.029	0.160	1156	-0.029	0.157	2108	-0.026
0.162	517	-0.030	0.162	1156	-0.029	0.160	2120	-0.026
0.165	529	-0.030	0.165	1168	-0.029	0.162	2132	-0.027
0.167	529	-0.030	0.167	1180	-0.029	0.165	2144	-0.027
0.169	529	-0.030	0.169	1180	-0.029	0.167	2156	-0.027
0.172	529	-0.031	0.172	1180	-0.030	0.169	2168	-0.027
0.174	529	-0.031	0.174	1180	-0.030	0.172	2156	-0.027
0.177	541	-0.031	0.177	1192	-0.030	0.174	2180	-0.028
0.179	541	-0.032	0.179	1204	-0.030	0.177	2180	-0.028
0.181	541	-0.032	0.182	1180	-0.030	0.179	2203	-0.028
0.184	541	-0.032	0.184	1204	-0.030	0.182	2203	-0.028
0.186	541	-0.032	0.186	1204	-0.031	0.184	2203	-0.029
0.189	541	-0.033	0.189	1204	-0.031	0.186	2227	-0.029
0.191	541	-0.033	0.191	1204	-0.031	0.189	2227	-0.029
0.194	541	-0.033	0.194	1216	-0.031	0.191	2239	-0.029
0.196	541	-0.033	0.196	1216	-0.031	0.194	2251	-0.029
0.198	541	-0.034	0.198	1228	-0.031	0.196	2251	-0.029
0.201	541	-0.034	0.201	1228	-0.032	0.198	2263	-0.030
0.203	541	-0.034	0.203	1228	-0.032	0.201	2275	-0.030
0.206	541	-0.034	0.206	1228	-0.032	0.203	2287	-0.030
0.208	541	-0.035	0.208	1228	-0.032	0.206	2299	-0.030
0.211	553	-0.035	0.210	1228	-0.032	0.208	2299	-0.030
0.213	553	-0.035	0.213	1228	-0.032	0.211	2299	-0.031
0.215	553	-0.035	0.215	1240	-0.033	0.213	2299	-0.031
0.218	553	-0.036	0.218	1240	-0.033	0.215	2299	-0.031
0.220	553	-0.036	0.220	1240	-0.033	0.218	2311	-0.031
0.223	553	-0.036	0.223	1252	-0.033	0.220	2323	-0.031
0.225	553	-0.036	0.225	1252	-0.033	0.223	2323	-0.032
0.227	565	-0.036	0.227	1252	-0.033	0.225	2334	-0.032
0.230	553	-0.037	0.230	1252	-0.033	0.227	2334	-0.032
0.232	553	-0.037	0.232	1252	-0.034	0.230	2346	-0.032
0.235	565	-0.037	0.235	1252	-0.034	0.232	2334	-0.032
0.237	553	-0.037	0.237	1252	-0.034	0.235	2346	-0.032
0.239	553	-0.038	0.240	1252	-0.034	0.237	2334	-0.033
0.242	553	-0.038	0.242	1252	-0.034	0.240	2323	-0.033
0.244	565	-0.038	0.244	1252	-0.034	0.242	2323	-0.033
0.247	553	-0.038	0.247	1252	-0.034	0.244	2311	-0.033
0.249	553	-0.038	0.249	1252	-0.035	0.247	2311	-0.033
0.252	553	-0.039	0.252	1252	-0.035	0.249	2323	-0.034
0.254	553	-0.039	0.254	1252	-0.035	0.252	2323	-0.034
0.256	565	-0.039	0.256	1252	-0.035	0.254	2323	-0.034
0.259	565	-0.039	0.259	1240	-0.035	0.256	2323	-0.034
0.261	565	-0.040	0.261	1252	-0.035	0.259	2323	-0.034
0.264	565	-0.040	0.264	1240	-0.035	0.261	2323	-0.034
0.266	577	-0.040	0.266	1240	-0.035	0.264	2323	-0.035
0.269	577	-0.040	0.268	1240	-0.036	0.266	2323	-0.035
0.271	577	-0.040	0.271	1240	-0.036	0.269	2323	-0.035
0.273	577	-0.041	0.273	1252	-0.036	0.271	2311	-0.035
0.276	589	-0.041	0.276	1240	-0.036	0.273	2299	-0.035
0.278	589	-0.041	0.278	1240	-0.036	0.276	2311	-0.036
0.281	589	-0.041	0.281	1240	-0.036	0.278	2311	-0.036
0.283	589	-0.041	0.283	1240	-0.037	0.281	2299	-0.036
0.285	589	-0.042	0.285	1240	-0.037	0.283	2299	-0.036
0.288	601	-0.042	0.288	1228	-0.037	0.285	2299	-0.036
0.290	589	-0.042	0.290	1228	-0.037	0.288	2299	-0.037
0.293	601	-0.042	0.293	1240	-0.037	0.290	2299	-0.037
0.295	601	-0.042	0.295	1240	-0.038	0.293	2299	-0.037
0.297	601	-0.042	0.298	1240	-0.038	0.295	2287	-0.037
0.300	601	-0.043	0.300	1228	-0.038	0.297	2287	-0.037
0.300	601	-0.043	0.300	1228	-0.038	0.300	2287	-0.038

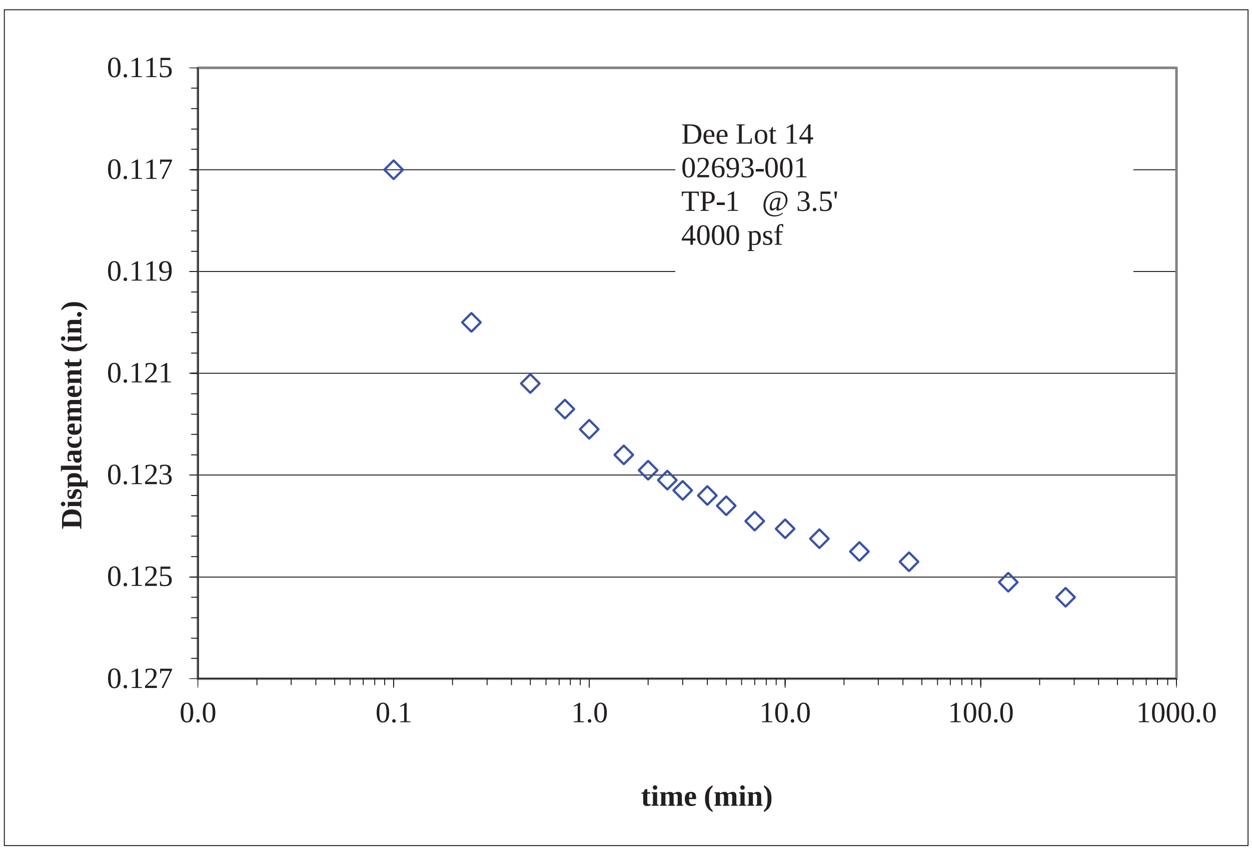
Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: Dee Lot 14
No: 02693-001
Location: Powder Mountain, UT

Boring No.: TP-1
Sample:
Depth: 3.5'





APPENDIX C

USGS Design Maps Summary Report

User–Specified Input

Report Title Lot 14R
Thu March 1, 2018 20:06:25 UTC

Building Code Reference Document 2012/2015 International Building Code
(which utilizes USGS hazard data available in 2008)

Site Coordinates 41.36642°N, 111.76304°W

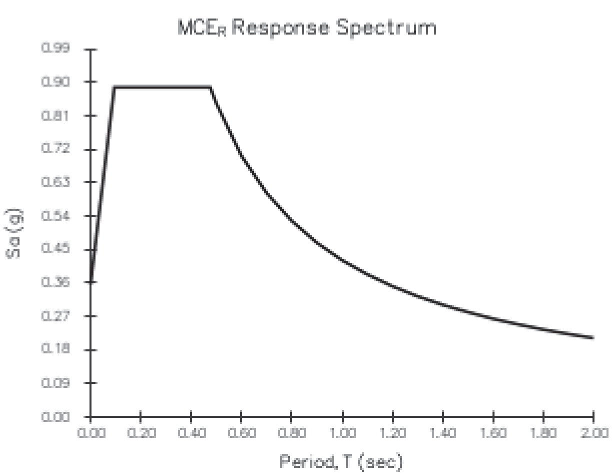
Site Soil Classification Site Class C – "Very Dense Soil and Soft Rock"

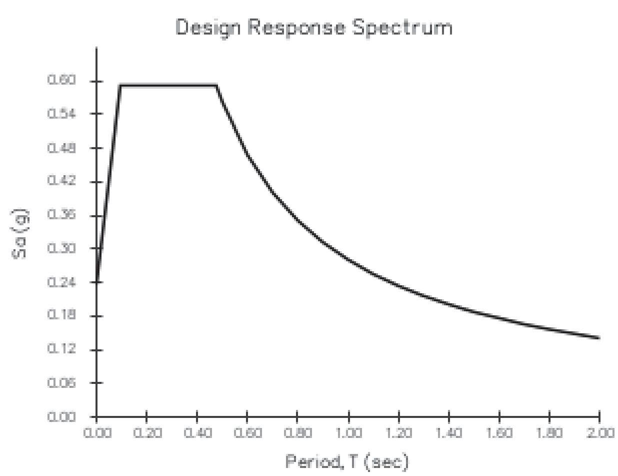
Risk Category I/II/III

USGS–Provided Output

S_S =	0.831 g	S_{MS} =	0.887 g	S_{DS} =	0.592 g
S_1 =	0.277 g	S_{M1} =	0.421 g	S_{D1} =	0.281 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.





Although this information is a product of the U.S. Geological Survey, we provide no warranty, expressed or implied, as to the accuracy of the data contained therein. This tool is not a substitute for technical subject-matter knowledge.

USGS Design Maps Detailed Report

2012/2015 International Building Code (41.36642°N, 111.76304°W)

Site Class C – "Very Dense Soil and Soft Rock", Risk Category I/II/III

Section 1613.3.1 — Mapped acceleration parameters

Note: Ground motion values provided below are for the direction of maximum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 (to obtain S_S) and 1.3 (to obtain S_1). Maps in the 2012/2015 International Building Code are provided for Site Class B. Adjustments for other Site Classes are made, as needed, in Section 1613.3.3.

From Figure 1613.3.1(1) [1]	S_S = 0.831 g
From Figure 1613.3.1(2) [2]	S_1 = 0.277 g

Section 1613.3.2 — Site class definitions

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class C, based on the site soil properties in accordance with Section 1613.

2010 ASCE-7 Standard – Table 20.3-1
SITE CLASS DEFINITIONS

Site Class	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the characteristics: • Plasticity index *PI* > 20, • Moisture content *w* ≥ 40%, and • Undrained shear strength $\bar{s}_u$ < 500 psf		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

Section 1613.3.3 — Site coefficients and adjusted maximum considered earthquake spectral response acceleration parameters

TABLE 1613.3.3(1)
VALUES OF SITE COEFFICIENT F_a

Site Class	Mapped Spectral Response Acceleration at Short Period				
	$S_S \le 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \ge 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_S

For Site Class = C and S_S = 0.831 g, F_a = 1.067

TABLE 1613.3.3(2)
VALUES OF SITE COEFFICIENT F_v

Site Class	Mapped Spectral Response Acceleration at 1–s Period				
	$S_1 \le 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \ge 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_1

For Site Class = C and S_1 = 0.277 g, F_v = 1.523

Equation (16-37): $S_{MS} = F_a S_S = 1.067 \times 0.831 = 0.887$ g

Equation (16-38): $S_{M1} = F_v S_1 = 1.523 \times 0.277 = 0.421$ g

Section 1613.3.4 — Design spectral response acceleration parameters

Equation (16-39): $S_{DS} = ⅔ S_{MS} = ⅔ \times 0.887 = 0.592$ g

Equation (16-40): $S_{D1} = ⅔ S_{M1} = ⅔ \times 0.421 = 0.281$ g

Section 1613.3.5 — Determination of seismic design category

TABLE 1613.3.5(1)
SEISMIC DESIGN CATEGORY BASED ON SHORT-PERIOD (0.2 second) RESPONSE ACCELERATION

VALUE OF S_{DS}	RISK CATEGORY		
	I or II	**III**	**IV**
$S_{DS} < 0.167g$	A	A	A
$0.167g \le S_{DS} < 0.33g$	B	B	C
$0.33g \le S_{DS} < 0.50g$	C	C	D
$0.50g \le S_{DS}$	D	D	D

For Risk Category = I and S_{DS} = 0.592 g, Seismic Design Category = D

TABLE 1613.3.5(2)
SEISMIC DESIGN CATEGORY BASED ON 1-SECOND PERIOD RESPONSE ACCELERATION

VALUE OF S_{D1}	RISK CATEGORY		
	I or II	**III**	**IV**
$S_{D1} < 0.067g$	A	A	A
$0.067g \le S_{D1} < 0.133g$	B	B	C
$0.133g \le S_{D1} < 0.20g$	C	C	D
$0.20g \le S_{D1}$	D	D	D

For Risk Category = I and S_{D1} = 0.281 g, Seismic Design Category = D

Note: When S_1 is greater than or equal to 0.75g, the Seismic Design Category is **E** for buildings in Risk Categories I, II, and III, and **F** for those in Risk Category IV, irrespective of the above.

Seismic Design Category ≡ "the more severe design category in accordance with Table 1613.3.5(1) or 1613.3.5(2)" = D

Note: See Section 1613.3.5.1 for alternative approaches to calculating Seismic Design Category.

References

1. *Figure 1613.3.1(1)*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/IBC-2012-Fig1613p3p1(1).pdf
2. *Figure 1613.3.1(2)*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/IBC-2012-Fig1613p3p1(2).pdf

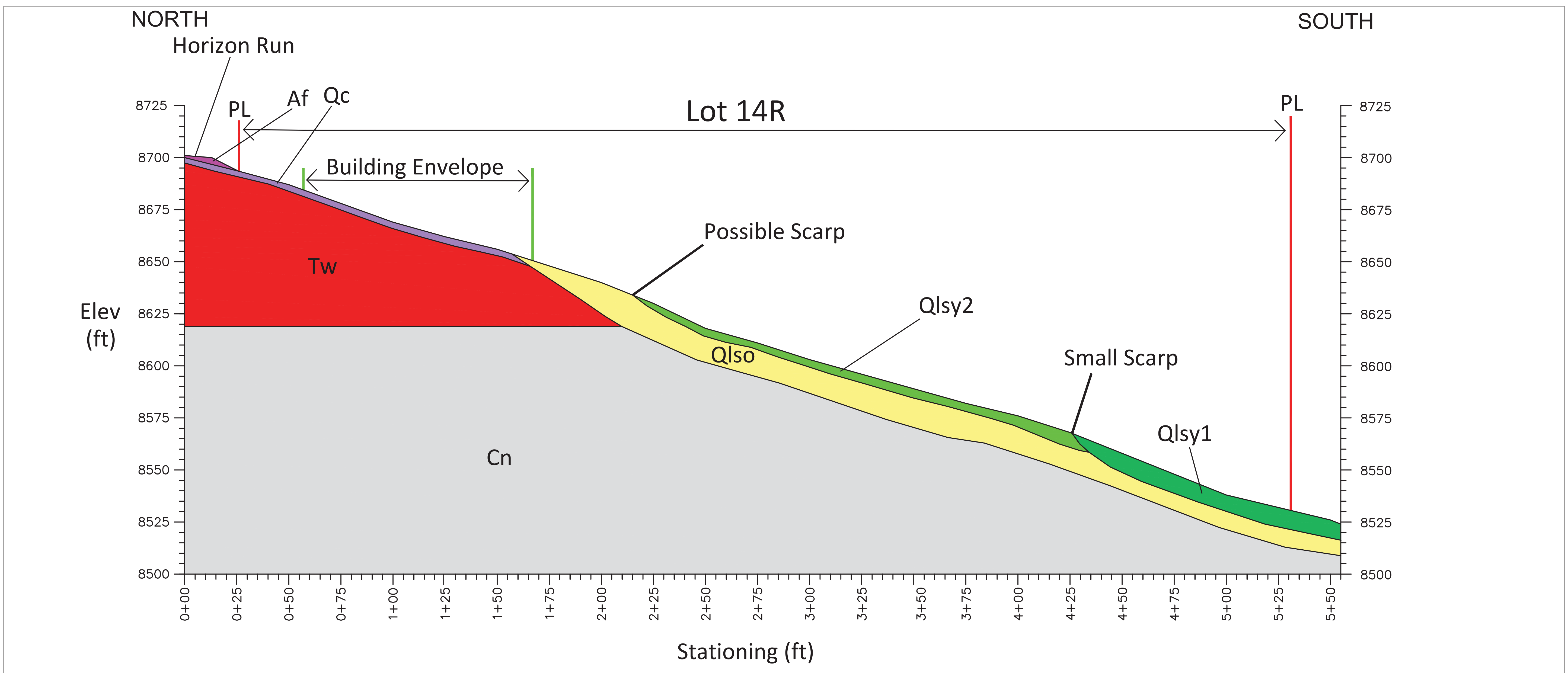
APPENDIX D

A

DUE S (180°)

CROSS-SECTION A - A'

A'



LEGEND

- Af = Artificial Fill
- Qlsy1 = Youngest Landslide Deposits
- Qlsy2 = Young Landslide Deposits
- Qlso = Old Landslide Deposits
- Qc = Colluvium
- Tw = Wasatch Formation
- Cn = Nounan Dolomite

NO VERTICAL EXAGGERATION

VIEW EAST

0 25 50

FEET

1" = 50' (H&V) (11" x 17" Only)

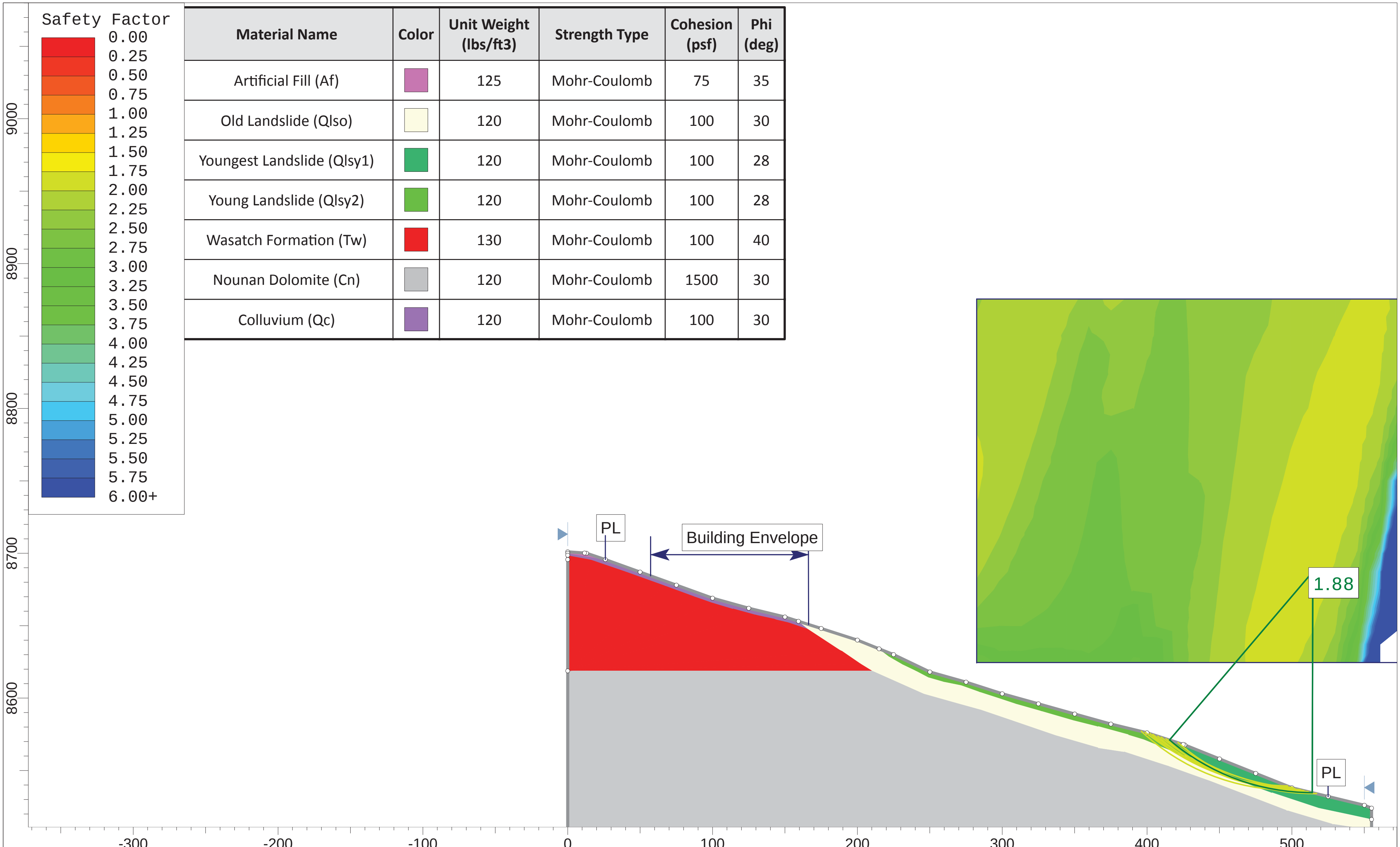
FIGURE D-1

CROSS-SECTION A - A'

GEOTECHNICAL AND GEOLOGIC HAZARDS INVESTIGATION
LOT 14R OF SUMMIT EDEN PHASE 1A
POWDER MOUNTAIN RESORT
WEBER COUNTY, UTAH

DATE: 3/05/2018
PROJECT:02693-001
SCALE: 1"=50'
IGES

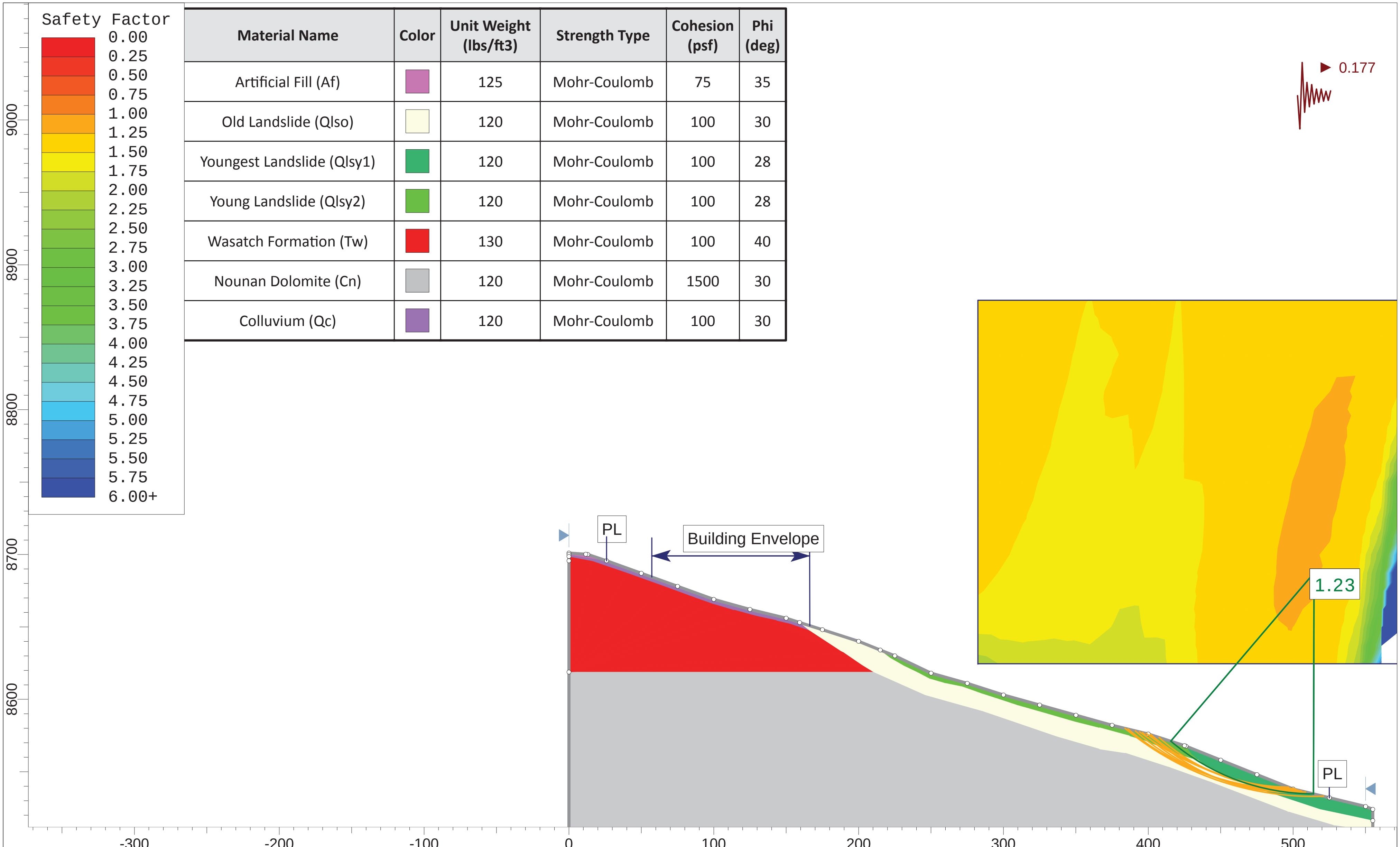
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Artificial Fill (Af)		125	Mohr-Coulomb	75	35
Old Landslide (Qlso)		120	Mohr-Coulomb	100	30
Youngest Landslide (Qlsy1)		120	Mohr-Coulomb	100	28
Young Landslide (Qlsy2)		120	Mohr-Coulomb	100	28
Wasatch Formation (Tw)		130	Mohr-Coulomb	100	40
Nounan Dolomite (Cn)		120	Mohr-Coulomb	1500	30
Colluvium (Qc)		120	Mohr-Coulomb	100	30



IGES®

SLIDEINTERPRET 7.029

Project	Lot 14R
Analysis Description	Slope Stability
Drawn By	EBF
Scale	1:1100
Company	IGES Inc.
Date	3/6/2018, 7:57:47 AM
File Name	02693-001 Dee Lot 14R.slim

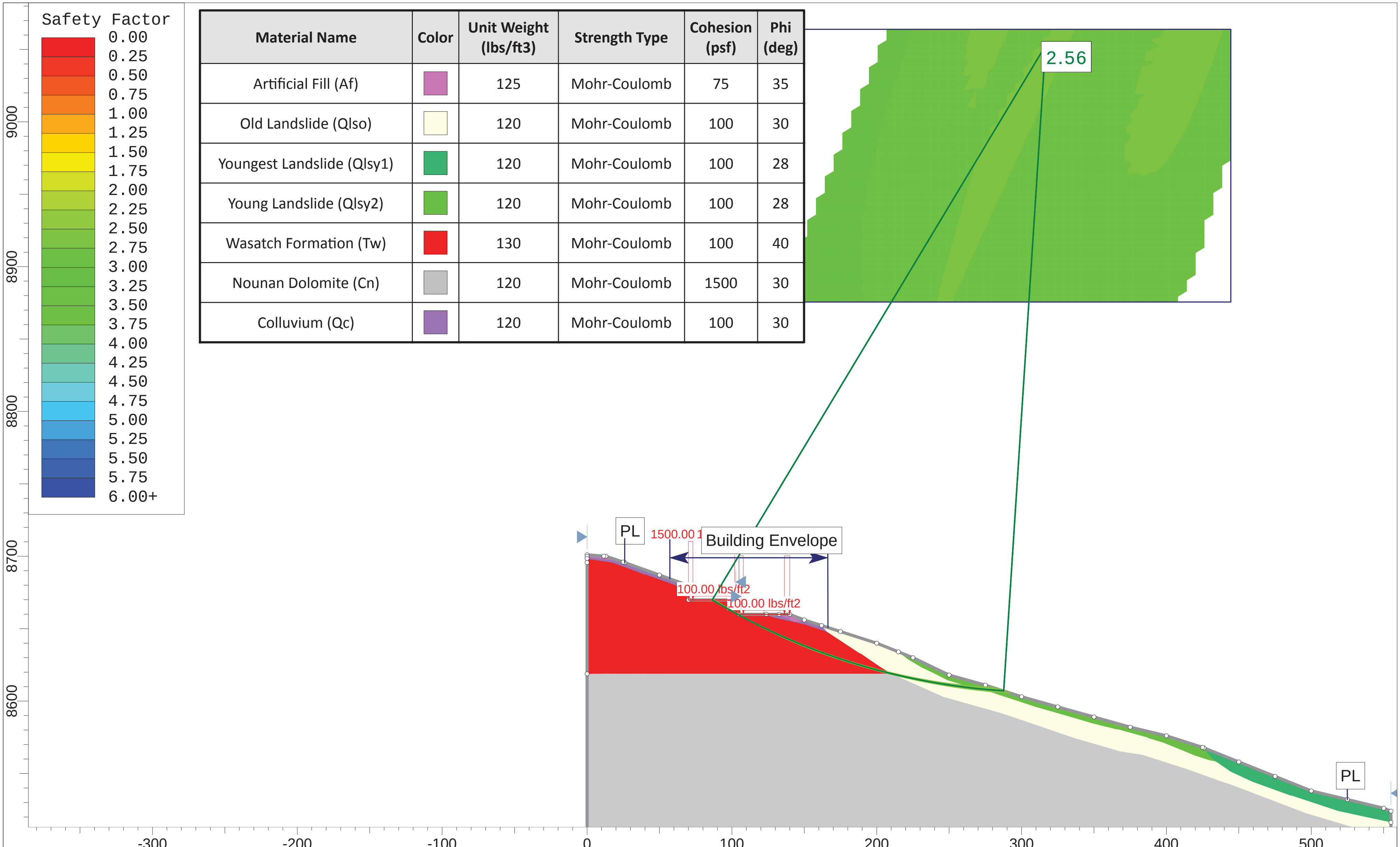


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Artificial Fill (Af)		125	Mohr-Coulomb	75	35
Old Landslide (Qlso)		120	Mohr-Coulomb	100	30
Youngest Landslide (Qlsy1)		120	Mohr-Coulomb	100	28
Young Landslide (Qlsy2)		120	Mohr-Coulomb	100	28
Wasatch Formation (Tw)		130	Mohr-Coulomb	100	40
Nounan Dolomite (Cn)		120	Mohr-Coulomb	1500	30
Colluvium (Qc)		120	Mohr-Coulomb	100	30

IGES®

SLIDEINTERPRET 7.029

Project	Lot 14R		
Analysis Description	Slope Stability		
Drawn By	EBF	*Scale* 1:1100	*Company* IGES Inc.
Date	3/6/2018, 7:57:47 AM	*File Name*	02693-001 Dee Lot 14R.slim

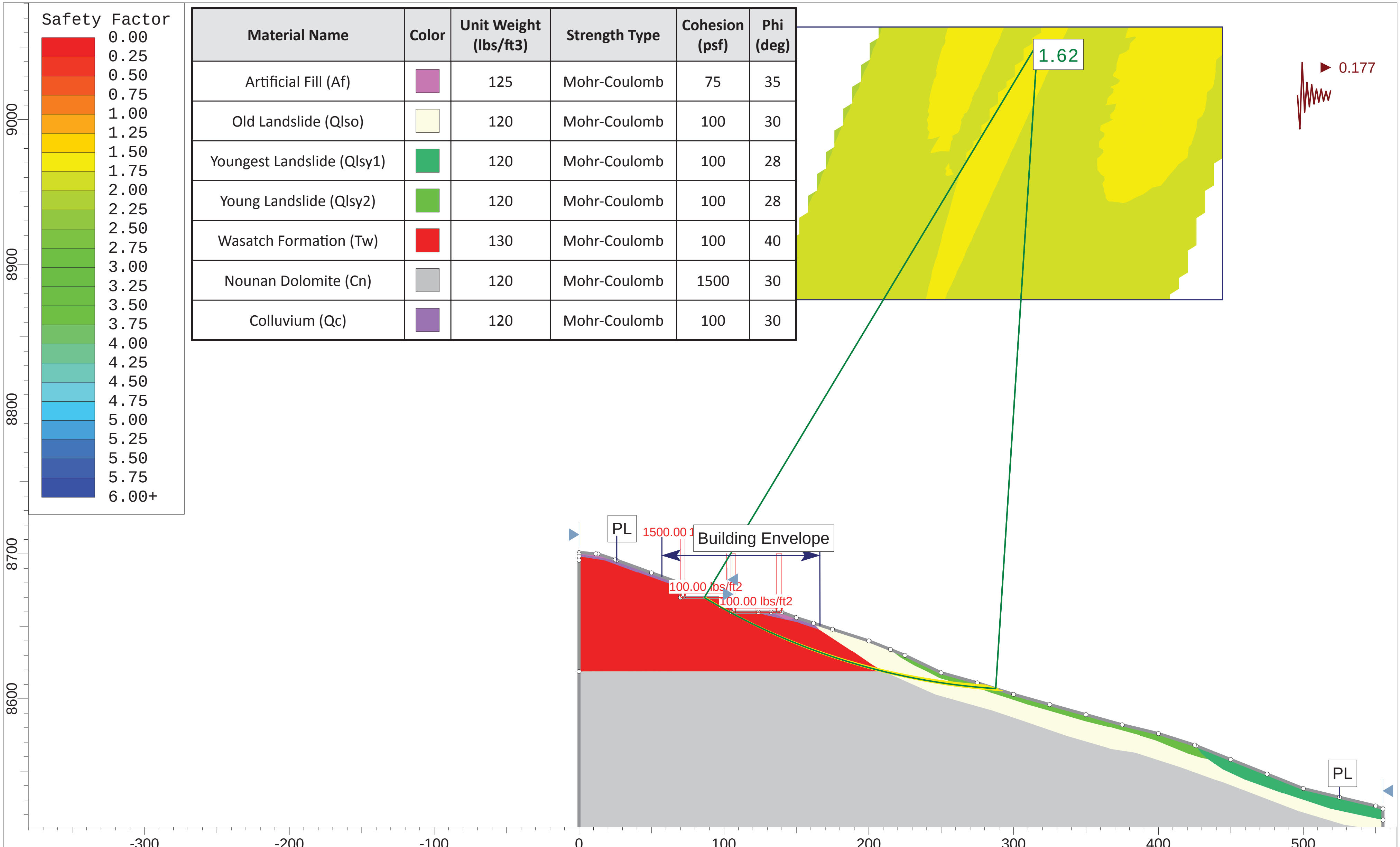


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Artificial Fill (Af)		125	Mohr-Coulomb	75	35
Old Landslide (Qlso)		120	Mohr-Coulomb	100	30
Youngest Landslide (Qlsy1)		120	Mohr-Coulomb	100	28
Young Landslide (Qlsy2)		120	Mohr-Coulomb	100	28
Wasatch Formation (Tw)		130	Mohr-Coulomb	100	40
Nounan Dolomite (Cn)		120	Mohr-Coulomb	1500	30
Colluvium (Qc)		120	Mohr-Coulomb	100	30

IGES®

SLIDEINTERPRET 7.029

Project	Lot 14R		
Analysis Description	Slope Stability		
Drawn By EBF	*Scale* 1:1100	*Company*	IGES Inc.
Date	3/6/2018, 7:57:47 AM	*File Name*	02693-001 Dee Lot 14R.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Artificial Fill (Af)		125	Mohr-Coulomb	75	35
Old Landslide (Qlso)		120	Mohr-Coulomb	100	30
Youngest Landslide (Qlsy1)		120	Mohr-Coulomb	100	28
Young Landslide (Qlsy2)		120	Mohr-Coulomb	100	28
Wasatch Formation (Tw)		130	Mohr-Coulomb	100	40
Nounan Dolomite (Cn)		120	Mohr-Coulomb	1500	30
Colluvium (Qc)		120	Mohr-Coulomb	100	30

IGES®

SLIDEINTERPRET 7.029

Project	Lot 14R		
Analysis Description	Slope Stability		
Drawn By	EBF	*Scale*	1:1100
Company	IGES Inc.		
Date	3/6/2018, 7:57:47 AM	*File Name*	02693-001 Dee Lot 14R.slim

Dee/Lot 14R
02693-001
3/7/2018

c'	50	psf	Effective Cohesion
φ'	30	deg	Effective Friction Angle
γ_{sat}	135	pcf	Saturated Unit Weight of Soil
γ_w	62.4	pcf	Unit weight of water
h	3	ft	Depth to shear surface
β	15.9	deg	Slope Gradient (3.5H:1V)

FS 1.56

Input Variable
Calculated Value

This model assumes c>0 and the face of the slope is saturated to depth h